Environment Waikato Technical Report 2000/10

Community Groundwater Supply Source Protection

John Hadfield & Debbie Nicole

For:
Environment Waikato
PO Box 4010
HAMILTON EAST

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Environment Waikato
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Executive Summary

Community groundwater supply source protection makes good public health, economic and environmental sense. Groundwater resources are vulnerable to contamination. Cleaning up contaminated groundwater is complicated, costly, and sometimes may be practically impossible. By comparison source water protection costs very little. It is in the interests of the community, Environment Waikato, health and other local government authorities, to work together for more effective groundwater supply source protection.

Community groundwater supplies in the Waikato region include about 90 school and 28 district council managed supplies, as well as numerous motor camp water supplies. Nearly 90 % of the registered school supplies in the Health Waikato area draw water from the ground. In 1998, only 1% of non-urban school supplies complied with the drinking water standards mainly as a result of insufficient monitoring.

There are many potential sources of groundwater contamination including human and animal effluent, industrial wastewater, landfill leachate, fertilisers and pesticides, leakage from pipelines and underground storage tanks. Contamination of groundwater usually happens gradually and can go unnoticed for some time. Shallow, water table aquifers with thin soil cover are most vulnerable to contamination, which generally enters from the ground surface. This highlights the need for proper well-head completion by sealing around the top of well casing with concrete to avoid direct access of contaminants e.g. micro-organisms.

The vulnerability of individual community groundwater supplies to contamination from the ground surface was assessed, where possible, using DRASTIC. This is an evaluation system for assessing the hydrogeologic setting and provides an index of relative vulnerability based on seven factors including depth and soil cover. About 25% of the school sites assessed were considered vulnerable (DRASTIC index > 150) with 17% being less than 10 m deep. Only four of the 28 district water supply wells had DRASTIC scores above 150. There was insufficient information to assess many of the supplies.

School groundwater supplies were sampled at source for routine water quality analyses in 2000. Eight supplies (9%) were found to have determinands which transgressed drinking water guidelines. Five of the transgressions were for manganese. Other transgressions were for nitrate, boron and copper. A further ten sites had determinands (mostly nitrate) over 50% of the drinking water guideline. Many sites had chemical concentrations that exceeded aesthetic guidelines, which relate to nuisance rather than health concerns. Common examples were high iron and manganese concentrations. The pH was also often outside aesthetic guidelines.

There is a plethora of legislation relating to drinking water management with health authorities, district councils and Environment Waikato all having responsibilities for aspects of community groundwater supply protection. Supply owners most importantly have responsibility to comply with requirements for potable water supply and a vested interest to ensure the wellbeing of supply users. Management and monitoring of the quality of a community supply is generally the supplier's responsibility. Environment Waikato's responsibilities relate to source water protection.

Community groundwater supplies should be registered with the Ministry of Health and monitored for compliance with drinking water standards. This is currently voluntary but likely to become mandatory with imminent changes in health legislation. The drinking water standards for New Zealand list maximum acceptable values for microbial (priority 1), chemical (priority 2) and aesthetic contaminants. Monitoring regimes are stipulated

and are less onerous for supplies which can be demonstrated to be secure. Many community water supplies currently can not demonstrate compliance with drinking water standards.

Public health risk management plans are likely to be required by the Ministry of Health to address not only source protection but wider aspects such as treatment and reticulation. Well-head protection areas (WHPAs) are suggested in this report as an effective mechanism for groundwater supply source protection. Indicative WHPAs are included for some supplies to promote discussion.

Environment Waikato manages groundwater resources to maintain or enhance quality using a range of methods including: regulation of discharges; controlling well construction; working with industry in guideline development; quality monitoring; issue investigation and environmental education.

Opportunities exist in the protection of community water supply sources for mutual benefit through further co-operation and partnership. It is in the interests of health and environmental agencies as well as the communities to work together for safe drinking water supplies. Benefits of co-operation include information sharing; better understanding of contamination prevention; more effective protection measures and educational opportunities. Water quality information from school and district supplies required to demonstrate compliance with health standards is, for example, also useful as an environmental indicator.

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1 Introduction

The objectives of this report are to detail community groundwater supplies in the region and discuss a strategy for their protection.

A plentiful supply of high quality drinking water is often taken for granted. When we turn on tap we expect the water to be safe to drink. Whether the drinking water is from groundwater or surface water, however, it is a vulnerable natural resource that needs to be protected. If the water source is not protected, contamination can cause a community significant expense as well as put the environment and people's health in danger.

Cleaning up contaminated drinking water is complicated, costly, and sometimes for groundwater may be practically impossible. It may involve installing new treatment facilities or constructing new wells and systems. Other costs could include decreased property values, loss of tax base, and loss of confidence in drinking water supplies and community leaders. By comparison source water protection costs very little and is a common sense approach to guarding public health and the environment.

Communities and schools depend on safe drinking water and therefore protecting drinking water supplies should be a local priority. Water source protection aims to prevent contaminants from reaching drinking water supplies. It is therefore successful if contamination does not occur. Groundwater protection measures enable communities to act proactively to protect the environment and public health rather than reacting after a problem occurs.

Much of the Waikato community, particularly rural, is dependent on groundwater for drinking, stock and industrial water supplies. Nearly 90 % of the 42 school supplies currently registered in the Health Waikato area draw water from the ground (MoH, 1999).

This report summarises information available about the 90 school (Section 3) and 28 district council managed community groundwater supplies (Section 4) in the Waikato region. The vulnerability of these supplies is also assessed, where possible, from available information and examples of protection measures described. The advantages of information sharing between supply managers, health and environmental agencies are also discussed. Other community groundwater supplies such as those for motor camp supplies, which are privately owned, are not addressed in this report.

Effective groundwater protection requires the consideration and balancing of economic, political, social and environmental concerns to achieve the goal of protecting human health and the environment. There are many different approaches available to protect groundwater quality. These include the use of non-degradation policies, regional rules and resource consent conditions, as well as the promotion of best management practices and environmental education.

Wellhead protection zones (WHPA) are one mechanism of groundwater protection discussed in this report. There are currently no restrictions on land-uses such as the storage or use of hazardous substances within the capture zones of community groundwater supplies. Considerable public consultation would be required particularly involving district councils before such zones could be introduced. Consideration of WHPAs in this report should however aid in this discussion.

WHPAs are focused on community drinking water protection and are consistent with wider aspects of environmental protection. They provide a focus to raise awareness of potentially hazardous land-uses and activities. Regional rules currently require separation distances between water supplies and from activities such as dairy effluent irrigation and domestic wastewater discharge.

2 Groundwater vulnerability

2.1 Potential for contamination

There are many potential sources of groundwater contamination. These include human and animal effluent, industrial wastewater disposal, landfill leachate, fertilisers and pesticides and, leakage from pipelines and underground storage tanks, mining and saltwater intrusion (Figure 1).

It is helpful to have an understanding of mechanisms of groundwater contamination when considering protection measures. Contamination of groundwater usually occurs much more gradually and inconspicuously than surface water. Contaminants may enter groundwater by accident, design or neglect. Most contaminants are introduced at or near the ground surface. As a result shallow groundwater resources are generally initially impacted.

Mechanisms of groundwater contamination include infiltration, direct migration, surface water recharge and inter-aquifer exchange. Water recharging aquifers infiltrates through the soil. Contaminants dissolved during this process of downward percolation form leachate. Upon reaching the saturated zone the leachate can migrate with groundwater flow. This is probably the most common mechanism of groundwater contamination.

Direct migration of contaminants into groundwater can occur form underground sources such as leaking storage tanks or pipelines within the saturated zone. Landfills and storage sites excavated to a depth near or at the water table can also allow direct contaminant access. Such contamination can occur at much greater concentrations.

Contamination can also occur from polluted surface waters. This requires a positive hydraulic gradient from a stream to the groundwater aquifer (i.e. a losing stream). Inter-aquifer exchange can also result in the introduction of contaminated groundwater from e.g. a shallow aquifer to a deeper ‘clean’ aquifer unit. This process may be the result of abandoned or poorly designed wells which enable leakage between naturally isolated aquifers.

Once contaminants enter saturated groundwater they are transported through processes including advection, dispersion and diffusion. Point sources in aquifers tend to form plumes which spread with movement down-gradient, primarily as a result of dispersion.

Contaminants with a density lighter than groundwater tend to accumulate in the upper portions of an aquifer. Denser non-aqueous phase liquids (DNAPLs) tend to migrate downwards. There are a number of physical and chemical transformation processes which tend to retard and attenuate contaminants during transport.

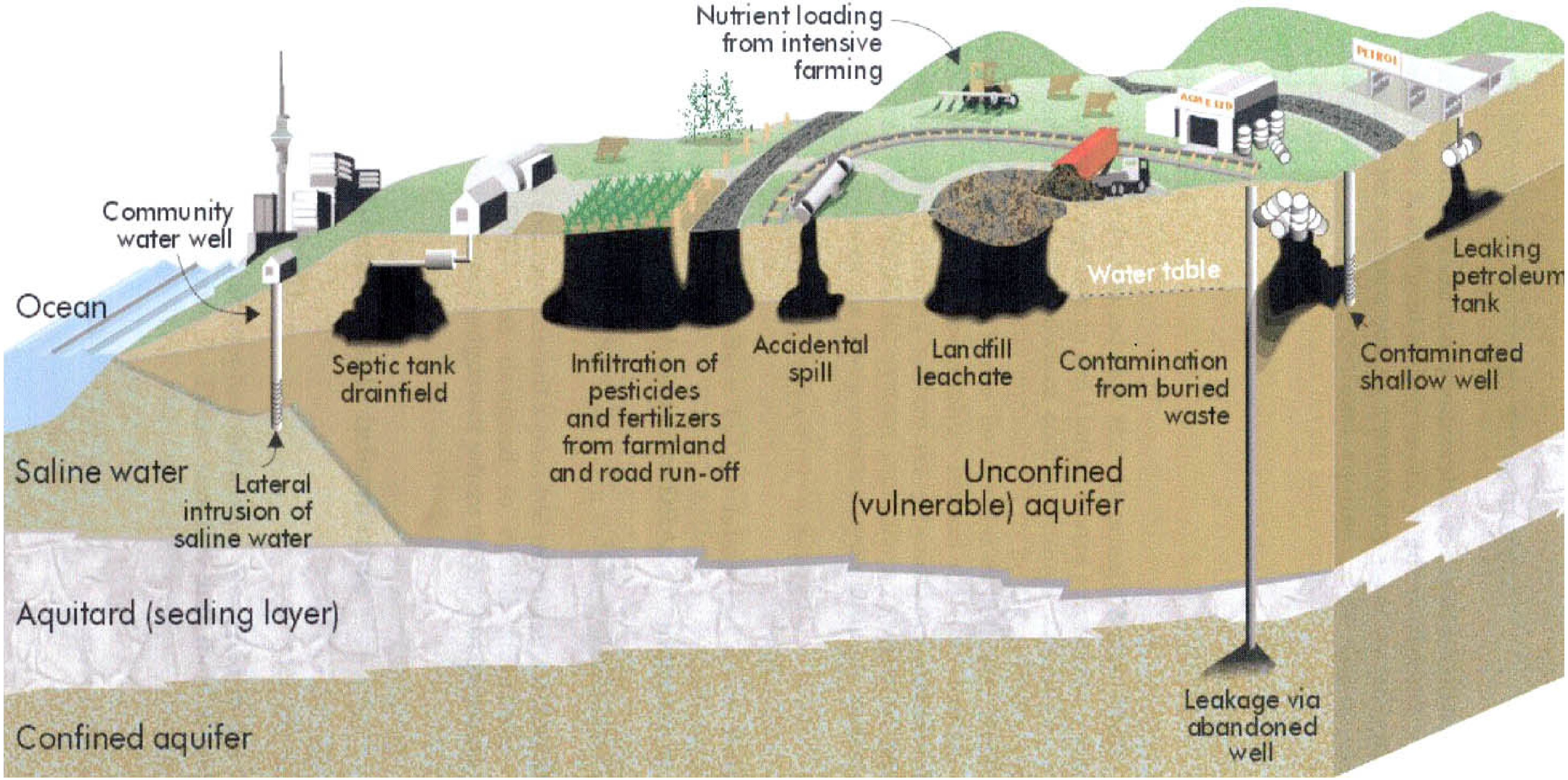

Figure 1: Mechanisms of groundwater contamination

Shallow, unconfined aquifers are more vulnerable to contamination from the ground surface than confined aquifers. A confined aquifer is one which is overlain by relatively impermeable or aquitard material. The aquitard acts as a protective layer by reducing or preventing vertical leakage of groundwater into the confined aquifer. The degree of confinement may be indicated by pumping tests, static water levels and well construction, and may be reflected in water chemistry analyses.

2.2 Drastic

DRASTIC is a system developed by the National Water Well Association and the Environmental Protection Agency in the United States to provide a standardised method for estimating the potential for groundwater contamination. DRASTIC is an acronym derived from the seven hydrogeologic factors considered to be the primary controls of groundwater contamination (Aller et al.,1987). These factors are as follows: **D**epth to water, **R**echarge, **A**quifer media, **S**oil media, **T**opography, **I**mpact of the vadose zone and hydraulic **C**onductivity. A numerical ranking system for groundwater vulnerability has been devised using these factors. The DRASTIC system includes a number of weights$_{(w)}$ and ratings$_{(R)}$ which are assigned to ranges of the seven selected hydrogeologic factors.

The equation for determination of the DRASTIC index is :

$$D_R D_W + R_R R_W + A_R A_W + S_R S_W + T_R T_W + I_R I_W + C_R C_W = \text{Pollution Potential}$$

The equation including weights for the standard DRASTIC index are as follows:

$$5D_R + 4R_R + 3A_R + 2S_R + T_R + 5I_R + 3C_R = \text{Pollution Potential}$$

As the DRASTIC scores increase toward a possible maximum of 230, the vulnerability of the aquifer increases. DRASTIC was designed to enable subjective estimation for some parameters based on professional judgement where data is not available.

3 School groundwater supply information

3.1 Information Availability

A total of 90 school groundwater supplies have been identified in the Waikato region. Their locations are illustrated in Figure 2. These supplies and their associated information are summarised in Table 1.

The level of information available regarding these supplies is variable. Only 56% of the sites identified have detailed bore construction, geology, water quality and pumpage information from bore logs. Some, particularly the older sites, have only sparse information.

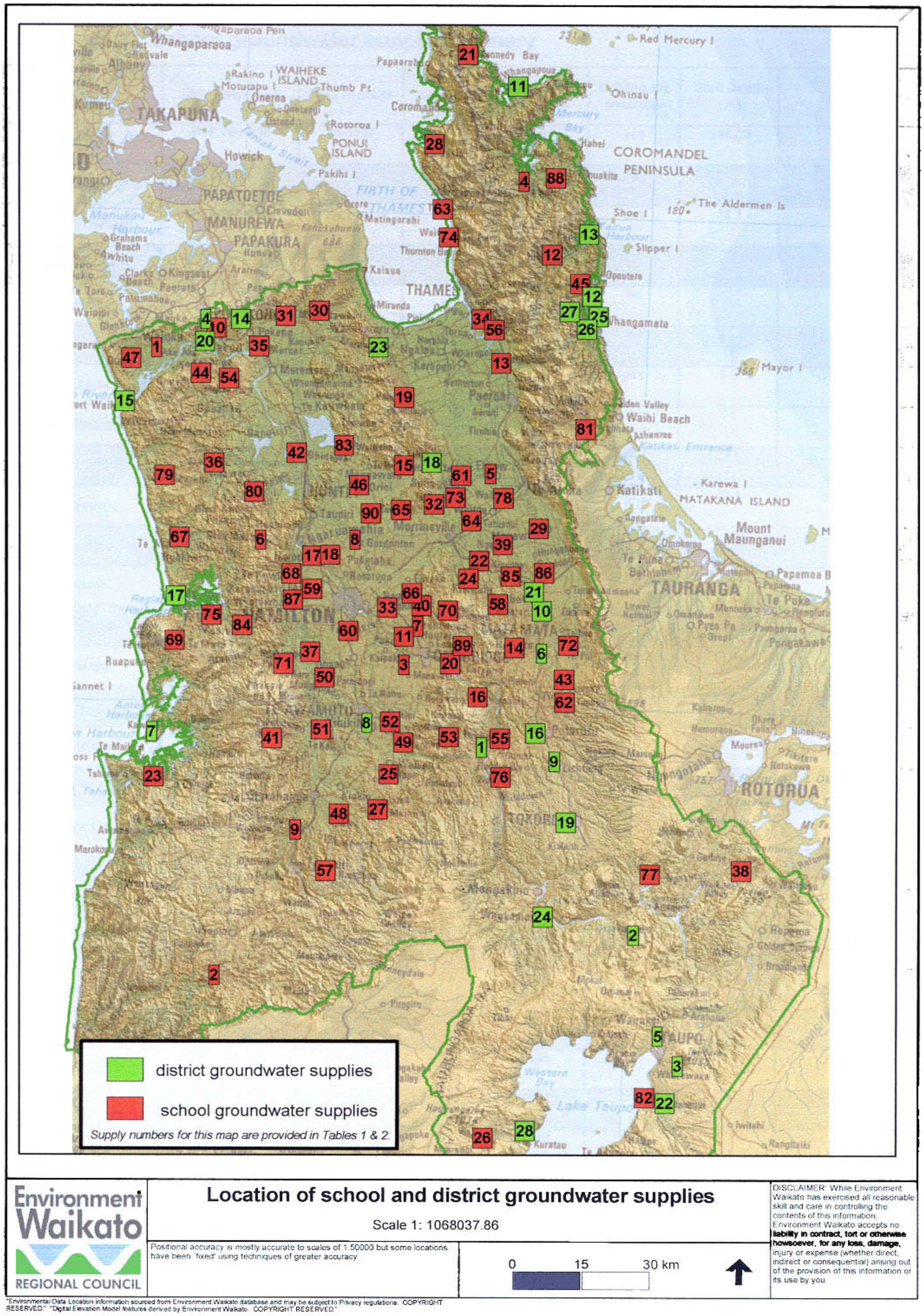

Figure 2: Location of school and district groundwater supplies

Table 1: School groundwater supply summary

School	Map Reference	Well Number	Estimated number of children	Registered Supply	Drilling log available	Well Depth (m)	Treatment
Aka Aka	R12:704-338	61.1727	127	yes	yes	146.22	None
Aria	R17:832-916	71.63	52	no	no		None
Capernwray	S15:245-619	70.1187	50	no	yes	38.1	None
Coroglen	T11:508-717	60.136	47	no	yes	98	Filter
Elstow	T13:435-053	64.993	117	no	no		None
Glen Massey	S14:932-903	69.2071	103	no	no		None
Goodwood	S14:276-707	70.370	200	no	yes	8.5	None
Gordonton	S14:139-903	69.912	179	no	yes	11	None
Hangatiki	S16:009-245	71.59	52	no	yes	22.5	None
Harrisville	R12:835-384	61.761	165	yes	no	13.1	Sand filter
Hautapu	S15:246-683	70.453	185	no	yes	17.07	None
Hikuai	T12:569-551	60.198	115	no	yes	45	None
Hikutaia	T12:459-304	63.152	115	no	yes	36	Sand and ozone filter
Hinuera	T15:527-653	64.879	140	no	yes	9.6	None
Hoe-O-Tainui	S13:246-072	64.32	36	yes	yes	12	Filters
Horahora	T15:408-546	70.116	49	yes	yes	28	None
Horotiu	S14:046-867	69.2187	140	yes	no		None
Horsham Downs	S14:085-869	69.1349	130	yes	yes	49	None
Kaihere	S13:246-227	63.39	65	no	no		None
Karapiro	T15:347-622	70.116	89	no	no		None
Kennedy Bay	T10:385-005	60.215	20	yes	yes	41	Filter
Kereone	T14:411-855	64.88	62	yes	yes	25.2	None
Kinohaku	R16:698-366	71.6	25	yes	yes	52	Filter
Kiwitahi	T14:387-815	64.456	41	yes	yes	60	None
Korakonui	S16:213-371	65.269	140	no	no		None
Kuratau	T18:420-547	68.1(spring)	64	yes	no		Filters
Maihihi	S16:190-291	65.142	62	no	yes	64.5	None
Manaia	T11:313-802	60.236	50	no	yes	5.5	None
Manawaru	T14:541-929	64.5	45	yes	yes	11	None
Mangatangi	S12:061-423	61.1730	87	yes	no		Conditioner and potash
Mangatawhiri	S12:987-411	61.1731	110	yes	no		Carbon filter
Mangateparu	T14:312-984	64.881	41	yes	no		Inline filter
Matangi	S14:210-749	69.2072	120	no	no		None

School	Map Reference	Well Number	Estimated number of children	Registered Supply	Drilling log available	Well Depth (m)	Treatment
Matatoki	T12:416-404	60.478	60	no	no		Filter
Mercer	S12:928-343	61.1728	32	yes	yes	54	None
Naike	R13:831-078	61.1679	25	yes	yes	91.6	None
Ngahinapouri	S15:041-648	70.1158	151	no	no		Filter
Ngakuru	U16:983-153	66.95 (spring)	55	yes	no		UV lights
Ngarua	T14:462-892	64.994	41	yes	yes	7.5	Filter
Ngati Haua	S14:285-753	69.2073	45	no	no		Filter
Ngutunui	S15:957-453	65.285	50	no	no		Filter
Ohinewai	S13:011-100	69.1446	63	no	yes	18.3	None
Okoroire	T15:596-586	67.565	50	no	yes	34.5	None
Onewhero	R13:801-282	61.182	270	yes	no	180.85	None
Opoutere	T12:631.485	60.290	75	no	yes	44.6	None
Orini	S13:148-027	69.2074	110	no	no		UV light/2 filters
Otaua	R12:648.316	61.1729	143	yes	no		None
Otewa	S16:105-281	65.27	60	no	yes	45.3	None
Parawera	S15:245-443	70.1159	48	no	no		None
Paterangi	S15:073-590	70.778	104	yes	yes	51	None
Pokuru	S15:065-472	70.794	120	no	yes	44.3	None
Puahue	S15:216-490	70.1164	71	no	yes	74.3	None
Pukeatua	T15:345-455	70.804	71	no	yes	147.8	None
Pukekawa	R13:863.270	61.1255	148	yes	yes	>95.5	Filter
Puketurua	T15:456-452	69.602	62	no	no		None
Puriri Valley	T12:444-380	60.314	57	no	yes	66	Filter
Rangitoto	S16:075-152	71.61	28	no	no		None
Richmond Downs	T14:451-757	64.883	41	yes	no		Filter
Rotokauri	S14:045-791	69.2075	187	no	no		None
Rukuhia	S15:125-696	70.1161	91	no	yes	35.4	Floculate system
Springdale	T13:371-049	64.72	49	yes	yes	6	UV light
Tapapa	T15:597-534	67.566	33	no	no		None
Tapu	T11:330-654	60.260	45	no	yes	9	None
Tatuanui	T14:394-946	64.884	34	yes	yes	6.9	Filters
Tauhei	S14:240-971	64.744	100	yes	yes	27.43	None
Tauwhare	S14:263-782	69.1809	45	no	yes	4.2	None
Te Akau	R14:755-909	69.2076	57	no	no		Filter & Sand

School	Map Reference	Well Number	Estimated number of children	Registered Supply	Drilling log available	Well Depth (m)	Treatment
Te Kowhai	S14:000-826	69.2077	170	no	no		None
Te Mata	R15:744-675	69.1816	58	no	yes	51.5	None
Te Miro	T14:343-742	70.951	30	no	yes	67	None
Te Pahu	S15:983-622	70.952	160	no	no		None
Te Poi	T15:606-663	64.996	73	yes	yes	34.5	UV light pH adjusted
Te Puninga	T14:359-999	64.751	37	yes	yes	7.7	Chlorine
Te Puru	T12:344-590	60.426	179	no	no		None
Te Uku	R14:825-732	69.2078	137	no	no		Filter
Te Waotu	T16:458-364	67.567	44	no	no	~90	None
Upper Atiamuri	U16:784-145	66.94 (spring)	85	yes	no		Filter UV light
Waihou	T14:464-998	64.885	34	yes	no		None
Waikaretu	R13:722-050	61.168	15	yes	yes	44.1	None
Waikokowai	S13:918-012	69.1897	25 – 35	no	yes	61	Bleach
Waimata	T13:643-155	63.392	94	no	no		None
Waitahanui	U18:773-638	68.794	45	yes	yes	26	None
Waiterimu	S13:115-117	69.1902	22	no	yes	90.2	None
Waitetuna	R14:892-709	69.2079	45	no	yes	184.8	None
Walton	T14:480-820	64.807	100	yes	yes	50	None
Wardville	T14:552-828	64.995	43	yes	no		None
Whatawhata	S14:003-767	69.208	100	no	yes	18	None
Whenuakite	T11:578-725	60.382	130	no	yes	90	None
Whitehall	T15:375-662	70.1162	28	no	no		None
Whitikahu	S14:173-963	69.2081	45	no	no		None

It is important to have sufficient information regarding school groundwater supplies to enable informed management and confident supply of acceptable quality water to the consumers. A quality management approach is espoused in the Ministry of Health guidelines (1995b). Requirements for groundwater quality monitoring of these supplies are outlined in this document. Contamination of groundwater is much less likely to be intermittent than surface water contamination. Less frequent sampling may hence be justified. If a groundwater supply can be shown to be ‘secure’ monitoring requirements are less stringent.

3.2 Well Construction

The depths of school water supply wells range from 4.2 metres to 150 metres deep. Most (84%) of the wells are shallower than 70m and 20% are shallower than 10m. The latter penetrate unconfined aquifers. About 6% of the school bores are deeper than 100m and known to tap confined aquifers.

More than half (70%) of the school groundwater wells with log information have been constructed since 1979. These more recent wells generally have proper wellhead completion (section 6) and are generally sited in clean surroundings. Older wells although generally properly completed were often found to be oily from the long-term operation of deep well cylinder pumps. Instances were noted of oil posing risks to water supplies. Oil was found covering well-heads, pumping equipment and in some instances leaking out of the pump shed seeping into the ground.

3.3 Hydrogeologic Settings And DRASTIC Vulnerability Evaluation

DRASTIC evaluation of groundwater vulnerability for the school water supplies has been undertaken, where possible, as summarised in Appendix I. There is a lack of data on the hydrogeologic settings of some of these sites, however, DRASTIC accommodates estimates in lieu of some information. It is important to recognise the current state of knowledge when considering the vulnerability of these water supplies.

The calculated DRASTIC indices range from 66 to 190. The lowest score is for a deep, confined, greywacke aquifer at Waiterimu. The site considered to be most vulnerable (DRASTIC score of 190) is the shallow, unconfined groundwater supply for Tauwhare School from a sand and gravel aquifer. The maximum possible DRASTIC vulnerability index is 230.

Deeper confined aquifers are naturally better protected from potential surface contamination. In unconfined situations the depth to water considered in DRASTIC is the depth from the ground surface to the water table. In confined situations it is the depth to the bottom of the aquifers overlying confining layer, which is often considerably deeper. In discharging hydraulic regimes the recharge value for aquifers with some confinement is zero. This reflects the reduced risk of contamination in areas where water is tending to have an upward component of flow.

DRASTIC vulnerability could only be reasonably estimated for 34 of the 90 schools considered. Of these 24% are considered vulnerable with DRASTIC numbers higher than 150 and are most deserving of consideration for wellhead protection. These sites are Goodwood, Hautapu, Hoe O Tainui, Manawaru, Puriri Valley, Tapu, Tauwhare and Waitahanui. These sites will be used to trial the delineation of wellhead protection areas for supply protection.

Shallow groundwater supplies are less expensive to construct. In many parts of the Waikato shallow groundwater also has lower iron concentrations and therefore can be more palatable. Contamination of groundwater, however, predominantly occurs from the ground surface. Although contamination is more likely in vulnerable aquifer settings, it is dependent on sources of contamination being present (Figure 1). Potential contaminant sources have been identified near about a third of the 90 schools. These include service stations, septic tanks and dairy shed discharges and are listed on each water supply site sheet (e.g. Appendix 3).

3.4 Supply Registration

Community drinking-water supplies are defined by the Ministry of Health as those supplies which serve more than 25 people for more than 60 days a year. Although all but three of the 90 school groundwater supplies discussed are defined as community supplies by this definition only 47 are currently registered as community supplies. Imminent health legislation is likely to require registration and monitoring compliance.

Schools have not been required to have resource consent under Environment Waikato's Transitional Regional Plan to take groundwater. This is because, under General Authorisation No 3, take or use of up to 15 m^3 d^{-1} of groundwater for reasonable domestic needs has been considered a permitted activity provided that there is no adverse effects on other users or the environment.

3.5 Groundwater Quality

Existing groundwater quality information was collated from many of the school groundwater supplies identified. Comments or information on general water quality was obtained from the school representative for all sites visited. Water quality analyses were obtained from the school for 9 of the 90 schools (10%).

Water quality problems were identified at nearly a quarter of schools. The most common concern was excessive iron concentration. This is however a natural occurrence and therefore can only be addressed by treatment, possibly improved well design or alternative resource development. Maximum Acceptable Values (MAV) for drinking water supply set by the Ministry of Health (1995) were exceeded for faecal coliforms at one school and arsenic at another. The health authorities occasionally check compliance of drinking water supplies against these standards.

A total of 42 of the 90 schools (47%) currently treat their groundwater. The most common forms of treatment systems installed are aerators and filters, however UV lights and chlorination are also used. About 70% of schools currently monitor their groundwater supplies, generally by sampling annually for microbial occurrence.

3.5.1 Groundwater Quality Survey 2000

All school groundwater supplies in the region were sampled in 2000 for routine water quality analysis comprising 19 parameters which are listed along with their analyses methods and detection limits in (Table 2). Sampling was carried out in accordance with standard groundwater sampling guidelines (Rosen et al., 1999), and involved purging at least three annular well volumes.

Analysis was also undertaken for dissolved petroleum hydrocarbons at two sites where oil was found around the well-head. No hydrocarbons were however detected in water sampled from these sites.

The chemical character of the groundwaters sampled, is expressed in major ion chemistry in the piper diagram in Figure 3. It is apparent that there is a considerable spread in character reflecting the diverse range of hydrogeological settings and depths. Although most of the waters are relatively sodium bicarbonate rich some more saline waters and waters with temporary hardness are also represented.

A total of eight supplies (~9 %) transgressed maximum acceptable values (MAVs) for drinking water. Five of the transgressions were for manganese including one at which the concentration was over twice the MAV of 0.5 ppm. The high manganese concentrations are often associated with high iron concentrations and can be expected to result in harsh tasting water and staining of pipework. Health concerns are not well defined in the drinking water guidelines (MoH, 1995). The most effective treatment is aeration.

The MAV of 50 ppm for nitrate (or 11.3 ppm as nitrate-N) in drinking water was transgressed at one site. A further eight sites had nitrate concentrations over half the MAV. The average nitrate concentration was 1.57 ppm. Excessive nitrate concentrations are linked to a blood disorder know as methaemoglobinaemia or 'blue baby' syndrome. Those at most risk are bottle fed infants. High nitrates result from intensive land-use activities and there is no practical water treatment.

Table 2: Groundwater chemical parameters analysed, methods and detection limits (Hill Laboratories, Routine Water Methods)

Parameter	**Method Used**	**Detection Limit**
PH (7.0 – 8.5)	pH meter APHA 4500-H^+ B 20th ed. 1998	0.1 pH Units
Electrical Conductivity	Conductivity meter, 25C APHA 2510 B 20th ed. 1998	1 µS/cm
Approx Total Dissolved Salts (1000)	Calculation: from Electrical Conductivity	2 $g.m^{-3}$
Alkalinity	Titration to pH 4.5 APHA 2320 B (Modified for alk <20) 20th ed. 1998	1 $g.m^{-3}$ as $CaCO_3$
Free carbon dioxide	Calculation: from alkalinity and pH APHA 4500-CO_2 D 20th ed. 1998	1 $g.m^{-3}$
Calcium	Boiling nitric acid digestion. ICP-OES or ICP-MS APHA 3125 B 20th ed. 1998	0.02 $g.m^{-3}$
Magnesium	Boiling nitric acid digestion. ICP-OES or ICP-MS APHA 3125 B 20th ed. 1998	0.005 $g.m^{-3}$
Total Hardness (200)	Calculation: from Ca and Mg	1 $g.m^{-3}$ as $CaCO_3$
Sodium (200)	Boiling nitric acid digestion. ICP-OES or ICP-MS APHA 3125 B 20th ed. 1998	0.5 $g.m^{-3}$
Potassium	Boiling nitric acid digestion. ICP-OES or ICP-MS APHA 3125 B 20th ed. 1998	0.1 $g.m^{-3}$
Nitrate-N [11.3]	Filtered sample. Ion Chromatography. APHA 4110 B 20th ed. 1998	0.02 $g.m^{-3}$
Chloride (250)	Filtered sample. Ion Chromatography. APHA 4110 B 20th ed. 1998	0.5 $g.m^{-3}$
Sulphate (250)	Filtered sample. Ion Chromatography. APHA 4110 B 20th ed. 1998	0.2 $g.m^{-3}$
Boron [1.4]	Boiling nitric acid digestion. ICP-OES or ICP-MS APHA 3125 B 20th ed. 1998	0.005 $g.m^{-3}$
Total Iron (0.2)	Boiling nitric acid digestion. ICP-OES or ICP-MS APHA 3125 B 20th ed. 1998	0.02 $g.m^{-3}$
Total Manganese [0.5] (0.05)	Boiling nitric acid digestion. ICP-OES or ICP-MS APHA 3125 B 20th ed. 1998	0.005 $g.m^{-3}$
Total Copper [2] (1)	Boiling nitric acid digestion. ICP-OES or ICP-MS APHA 3125 B 20th ed. 1998	0.01 $g.m^{-3}$
Total Zinc (3)	Boiling nitric acid digestion. ICP-OES or ICP-MS APHA 3125 B 20th ed. 1998	0.005 $g.m^{-3}$

Note. Values given in square brackets are maximum acceptable values for drinking water (MoH, 2000). Rounded brackets provide maximum acceptable aesthestic values.

Boron was also found well in excess (7.2 ppm) of the MAV of 1.4 ppm at one site and three further sites had concentrations over the half the MAV. Health concerns listed by the MoH include mild gastrointestinal irritation and potential testicular atrophy (MoH, 1995).

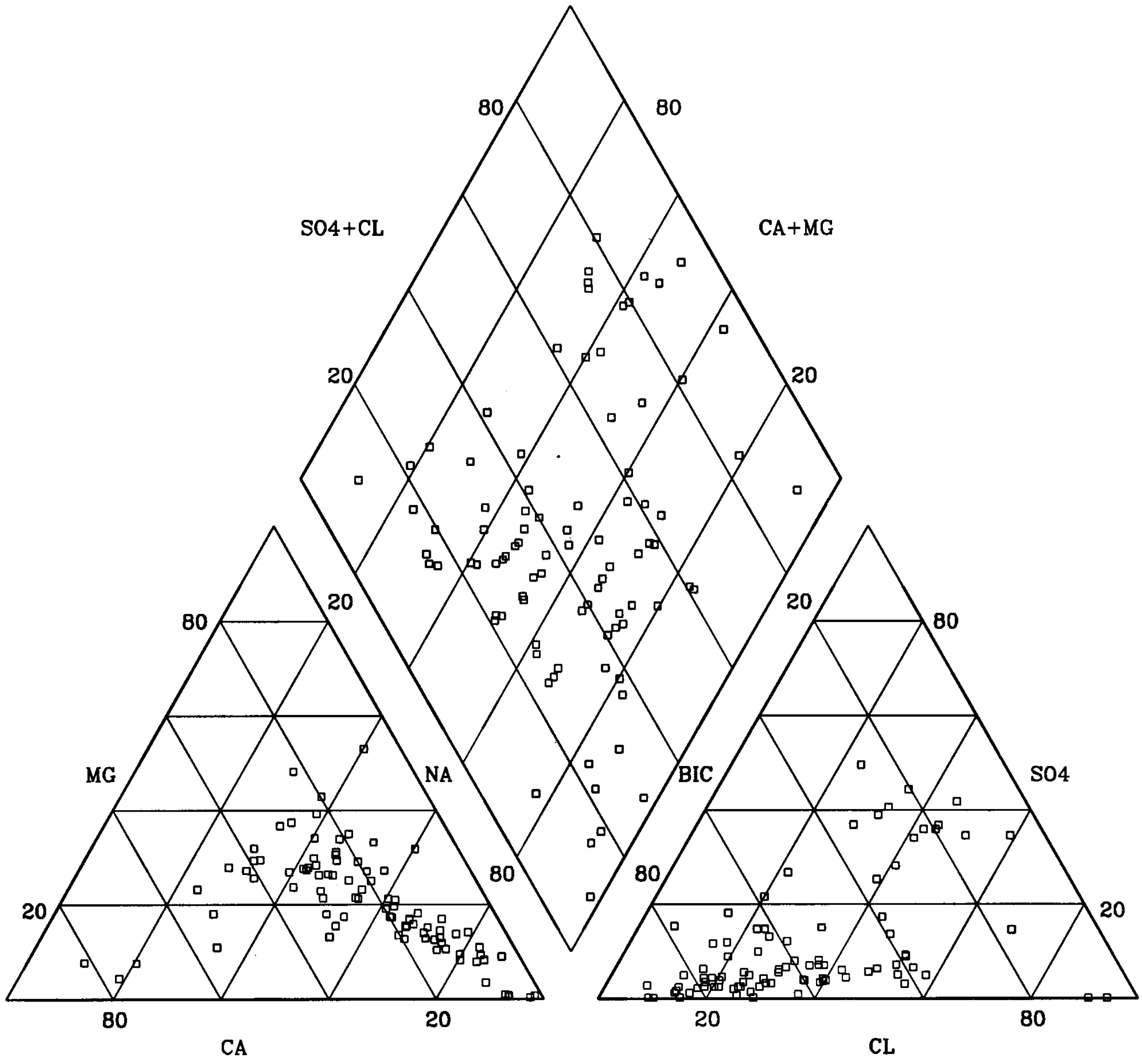

Figure 3: Piper trilinear plot of school supply major ion chemistry

Copper was found to transgress the drinking water MAV of 2 ppm at one site (4.2 ppm). Another site had a copper concentration over half the MAV. High copper concentrations are generally a result of corrosion of pipe-work in acid waters. The pH was, however, alkaline at the supply which exceeded the MAV.

Apart from the eight sites which transgressed the MAVs for drinking water, a further 10 sites had determinands greater than 50 % of the MAV. Most of these were due to high nitrate concentrations.

Many of the school groundwater supplies have chemical constituents which do not fall within aesthetic guidelines (MoH, 2000). These guidelines are related to nuisance such as problems with taste, odour or staining, rather than health concern. For example, about two thirds of supplies have pH outside the aesthetic guideline of 7 to 8. Low pH can lead to problems with corrosion and high pH to taste and disinfection problems.

The other common nuisance constituent exceeding aesthetic guidelines again at about two thirds of sites is iron. High iron concentrations cause staining of laundry and hardware as well as a harsh taste. The most common and effective treatment is aeration. There are also other much less common exceedences of aesthetic guidelines e.g. for chloride, sodium, and hardness.

4 District Groundwater Supplies

4.1 Introduction

A total of 28 community groundwater supplies operated by territorial local authorities have been identified in the Waikato region. Their locations are illustrated in Figure 2. These supplies and their respective territorial local authorities are summarised in Table 3.

Water supplies range in significance from those servicing small communities to provision for towns such as Tokoroa and Putaruru. The information available regarding these supplies is equally variable. Some sites have detailed bore construction, geology, water quality and aquifer test and pumping information, whilst there is only sparse information for some others, particularly the older and smaller sites.

It is important that there is sufficient information about community groundwater supplies to enable informed management and confident supply of acceptable quality water to consumers. A quality management approach is espoused in the Ministry of Health guidelines (1995). Requirements for groundwater quality monitoring of these supplies are outlined in the guideline document. All the above supplies are registered and water quality information should be provided to the Health Waikato WNZ database.

Table 3: District groundwater supplies

Water supply	District Council	Map Ref.	Well no.	Map no	Depth (m)	Max. ta m^3(
Arapuni	South Waikato	T15:415-432	72.196	1	170	355
Atiamuri Village	Taupo	U17:748-007	68.711, 68.911	2	204, 180	225
Bonshaw Park	Taupo	U18:845-711	68.930-2	3	82, 92, 91	390
Buckland	Franklin	R12:812-404	61.446	4	166.4	311
Centennial Drive	Taupo	U18:801-778	68.933-5	5	31, 18, 25.6	1200
Hinuera	Matamata Piako	T15:529-647	64.871-2	6	61, 76	60
Kawhia	Otorohonga	R15:694-468	65.7	7		318
Kihikihi	Waipa	S15:170-490	70.1005; 70.590	8	122.2, 110	2200
Lichfield	South Waikato	T15:575-400	67.418	9	160	32
Matamata	Matamata Piako	T14:548-741	64.511	10	60	1500
Matarangi Beach	Thames Coromandel	T10:483-930	72.233-6	11	6.4, 12.2 9.1, 12.2	400
Onemana	Thames Coromandel	T12:658-458	60.285, 60.391	12	110.3	240
Pauanui	Thames Coromandel	T12:651-597	60.311	13	9.7	800
Pokeno	Franklin	R12:889-404	61.1233	14	129	200
Port Waikato	Franklin	R13:634-218	61.1643, 65.52	15	92.6, 52	160
Putaruru	South Waikato	T15:533-456	67.343-6	16	134.7, 91.4 , 95.1 , 102.7	2600
Raglan	Waikato	R14:747-776	69.1892	17	125	68
Tahuna	Matamata Piako	T13:307-078	64.389	18	41.5	65
Tokoroa	South Waikato	T16:596-268	67.441-8	19	36 - 73	15000
Tuakau	Franklin	R12:811-354	61.270	20	84	1082

Water supply	District Council	Map Ref.	Well no.	Map no.	Depth (m)	Max. t… m³…
Waharoa	Matamata Piako	T14:531-784	64.550, 64.785	21	12, 9	400
Waitahanui	Taupo	U18:774-629	68.710, 68.723	22	44.5, 22	195
Waitakaruru	Hauraki	S12:191-340	63.17-20	23	15 - 44	4800
Whakamaru Village	Taupo	T17:550-048	68.268	24	125	200
Whangamata	Thames Coromandel	T12:639-410	60.378-9	25	150, 104	3000
Whangamata (Beverley Hills)	Thames Coromandel	T12:646-382	60.100-2	26	100, 103, 60	1300
Whangamata (Moana Point)	Thames Coromandel	T12:642-413	60.359	27	120	666
Whareroa Village	Taupo	T18:513-563	72.337	28	10.8	682

Contamination of groundwater is much less likely to be intermittent than surface water contamination. Less frequent sampling may hence be justified. If the district groundwater supply can be shown to be 'secure' monitoring requirements are less stringent.

4.2 Hydrogeologic Settings And DRASTIC Vulnerability Evaluation

DRASTIC evaluation of groundwater vulnerability for each of the community water supplies has been undertaken, where possible, as summarised in Appendix II. There is also a lack of data on the hydrogeologic settings of some of these sites. These were however able to be reasonably estimated using DRASTIC but it is again important to recognise the current state of knowledge when considering the 'security' of these water supplies.

The calculated DRASTIC indices range from 42 to 200. The maximum DRASTIC vulnerability index is 230. The lowest score is for a deep, confined, greywacke aquifer at Pokeno. The site with the highest index and hence considered to be most vulnerable is the shallow groundwater supply at Whareroa. This supply is from shallow, water table wells adjacent to Lake Taupo.

Only four water supply aquifers have calculated DRASTIC scores above 150. These are the supplies most deserving of consideration for well protection. These sites are Matarangi Pauanui, Waharoa, Waitahanui and Whareroa. An indication of vulnerability may be provided by water quality but this is dependent on local land-use and hazards. Well protection zones have been considered for these four sites (Section 7).

4.3 Groundwater Quality

District groundwater supply sampling regimes vary considerably particularly in respect to sampling at source. Environmental Science and Research carried out comprehensive monitoring for the Ministry of Health in the period from 1988 to 1992 (Ministry of Health, 1998). The most recent analyses from this work have been collated but are not presented in this report.

5 Supply Security

The Ministry of Health (2000) defines secure groundwater as water contained beneath the land surface, which is abstracted via a secure well-head or similarly proven structure. It must not be under the direct influence of surface water or demonstrate any significant and rapid shifts in characteristics such as turbidity, temperature, conductivity or pH which closely correlate to any climatological, surface water conditions or land use practices, as demonstrated by:

- less than 0.005 percent of the water having been present in the aquifer for less than one year (demonstrated by the tritium and CFC methods) and/or;
- variations in the groundwater characteristics not exceeding a coefficient of variation of more than:
    3.0 percent in conductivity
    4.0 percent in chloride concentration
    2.5 percent in nitrate concentration.

There must also be no insects or other macro-organisms such as algae, organic debris or large diameter pathogens or e-coli in 12 successive samples.

Some sources of groundwater such as river / lake galleries, and very shallow unconfined aquifers are not regarded as secure. The process for establishing that a groundwater supply is secure considers the following three main aspects:

(i) wellhead security;
(ii) groundwater quality, and ;
(iii) groundwater residence time.

A groundwater supply, which can be demonstrated is ‘secure’ against contamination attains a higher public health grading. Less frequent sampling is then required to demonstrate compliance with New Zealand drinking water standards. Regular checking of the security status of a groundwater supply is required in case of potential changes e.g. casing failure or breach of aquitards.

6 Sanitary Wellhead Completion

Proper wellhead completion substantially reduces the chance of groundwater supply contamination particularly from micro-organisms. Most potential contaminants infiltrate from the ground surface and are removed or largely attenuated during transport through the soil and unsaturated formation. Where conduits exist, such as poorly completed wells, however, contamination is much more likely.

Minimum construction requirements for water wells are described by the Agriculture and Resource Management Council of Australia and New Zealand (1997) and the proposed New Zealand National Drilling Standards (in prep.). Measures for proper wellhead completion are described below.

- A concrete pad should be constructed around the wellhead casing to prevent leakage into the annulus and prevent movement of the casing. It is recommended that the pad be at least 100 mm thick and 1 m square. A concrete plug should extend below this for at least 0.5 m.

- It is recommended that the wellhead casing extend at least 0.3 m above the ground surface to prevent surface contaminant ingress.

- All holes or openings in the top of the casing should be covered/sealed to prevent the entry of foreign material. This includes a plug for the access hole (~12 mm) which should be available in the casing head flange for water level monitoring.

- Protection should be provided at the wellhead to prevent access of stock, unauthorised personal or other possible interference or damage e.g. from vehicles. This may be achieved by construction of pump-sheds or barriers.

- If final well completion is not possible immediately following well construction a temporary effective seal should be achieved.

Wells should also be constructed of materials of sufficient quality and strength for the lifetime of its use. These and other aspects such as well design and down-hole, inter-aquifer sealing are discussed in the documents mentioned above. Similarly it is common sense not to store or mix chemicals such as pesticides or fertilisers near the well.

Figure 4: An example of sanitary wellhead completion

7 Wellhead Protection Areas

7.1 Background

Wellhead protection areas have been used for community groundwater supply protection in countries such as the United States, Germany and Switzerland for many years (USEPA, 1994; Zuur, 1989).

Wellhead protection areas (WHPA) may be introduced with the objectives of protecting wells from:

(i) direct introduction of contaminants via poorly completed wells, spills, and accidents;
(ii) microbial contamination (e.g. bacteria and viruses); and,
(iii) a range of chemical contaminants, including inorganic natural or synthetic organic chemicals.

The first objective may be achieved through sanitary wellhead completion (Section 6). Protection from microbial contamination may be achieved by introducing a buffer zone. This zone should be of sufficient distance to ensure that micro-organisms have died-off or been removed through mechanisms such as filtration. The third category is most challenging both technically and administratively. Toxic chemicals can persist for a long time and travel large distances in groundwater. The potential threat to water supplies from these chemicals generally defines the extent of wellhead protection requirements (USEPA, 1993).

The criteria for delineating WHPAs relate to a number of processes. Advection, dispersion and retardation are processes, which determine the way contaminants travel in ground water. Advection is the bulk movement of the water and contaminants (plug flow) for example toward a well. Dispersion is a physical spreading mechanism which, causes contaminants to spread over a greater area and arrive earlier than would be predicted from advection and velocity alone. Some contaminants move relatively slower than groundwater due to sorption processes. This phenomenon is known as retardation. Contaminant pathways are related to factors including flow conditions, aquifer confinement, permeability and contaminant properties. The more of these factors that are taken into account the more specific the prediction becomes. Facilitated transport can also occur with relatively immobile contaminants are sometimes found at great distances from their source.

The release of inorganic chemicals into groundwater results in common and mobile contaminants such as nitrate, ammonia, sodium, and chloride. Movement is primarily controlled by physical processes of advection and dispersion but clay can for example readily adsorb heavy metals.

Most organic chemicals are more readily attenuated and removed. Their concentrations are reduced by chemical reactions and microbial degradation and they may be metabolised and destroyed depending on volume, miscibility, solubility in water, temperature, oxygen content and availability of certain organic and inorganic materials. Organic contaminants can also however be very persistent and highly toxic. The persistence of organic contaminants, such as pesticides, is longer in ground water than in soil.

7.2 Delineation criteria and methods

WHPAs are generally designed to provide the following three zones:

(i) a management zone close to the well,
(ii) an attenuation zone of a distance to enable contaminants to reduce to desired levels, and
(iii) a larger zone to provide for remedial action.

Design criteria for WHPAs include specified distance, drawdown, travel time, flow system boundaries, or the capacity of the aquifer to assimilate contaminants, as follows:

i) <u>Distance:</u> a simple radius from the groundwater source to the well e.g. to establish buffer rules for general microbial protection. This is a first step delineation usually selected on non-technical grounds.
ii) <u>Drawdown:</u> the extent to which pumping lowers the water table of an unconfined aquifer or the potentiometric surface of the confined aquifer by a specified amount (e.g. 0.3 m). It defines the cone of depression and may vary from a few tens of metres to tens of kilometres in extent (e.g. Pauanui).
iii) <u>Travel time:</u> a specified time taken for a contaminant to reach a community supply well illustrated by isochrones.
iv) <u>Flow boundaries:</u> use of groundwater divides or other hydrogeologic features that control ground water flow.
v) <u>Assimilative capacity:</u> the ability of saturated or unsaturated zones to attenuate contaminants (generally too complex for most WHPAs).

There is also a range of methods for delineating zones within WHPAs once criteria have been selected. They range from a simple fixed radius (little scientific basis), to the application of more sophisticated numerical modelling techniques and include the following USEPA (1994).

i) Arbitrary fixed radius method draws a circle of a specified radius around a well being protected. It is the most simple and uncertain of the methods.
ii) Calculated fixed radius draws a circle for a specified travel time. A simple calculation is used based on the volume of water drawn to the well during the specified time.
iii) Simplified variable shapes is a method based on generating standardized forms using analytical models. The form is derived from hydrogeologic and pumping figures modelled on conditions similar to those at the wellhead and oriented according to ground water flow patterns.
iv) Analytical methods use equations to define groundwater flow and contaminant transport. They require hydrogeologic parameter input e.g. hydraulic gradient, porosity, hydraulic conductivity, and the saturation thickness of the aquifer. It is more certain than the first three methods, and is widely used.
v) Hydrogeologic mapping requires specialized expertise in geological and physical mapping and dye tracing methods as well as significant judgment on likely flow boundaries.
vi) Numerical flow and transport models can be used to predict the dynamic aspects of the WHPA.

The selection of criteria and methods for delineating WHPAs require consideration of site-specific conditions, relative accuracy, ease of application and cost. Technical considerations include ease of applicability, extent of use, simplicity of data, suitability to the area's hydrogeologic character, and accuracy. Policy considerations include ease of understanding, economy of application, defensibility, and relevance to the protection goal.

7.3 Literature Examples Of WHPAs

The Utah groundwater protection strategy includes delineation of WHPAs for community supplies (Carpenter and Mize, 1997). Three management zones are delineated as follows:

Zone 1 30 m (100 ft) fixed radius zone around the well as an accident prevention and annulus protection zone
Zone 2 250 day travel time isochron attenuation zone
Zone 3 15 year isochron remedial action zone.

An inventory of all potential contaminant sources is required for all zones. These are then ranked according to risk. A management plan for each potential contaminant source is required.
Potential pollution sources are excluded from Zone 1 of all new community wells and zone 2 in unconfined settings. Pollution sources include hazardous substance stores, septic tanks, landfills, drains and sewer lines.
A wellfield protection program was introduced in Browed County, Florida in 1981. WHPAs were defined based on computer modeling of travel times induced during pumping using the random walk method (Shair and Ahmed, 1997). Three zones were defined:

Zone 1 10 day travel time isochron;
Zone 2 30 day isochron;
Zone 3 210 day isochron or 0.3 m contour, whichever is larger.

Typically zone 1 is about 100 m in diameter and the 0.3 m drawdown contour for a large wellfield is about 1.6 kms.

Sources of toxic and hazardous water supply contaminants in Browed County were identified including pesticides, fertilizers, urban runoff, leaking underground fuel tanks, septic tanks, industrial and municipal activities, landfills and land spreading areas. Enforcement powers rather than land-use restrictions were used to enable prohibition or control of specific substances associated with land-uses, which would be impractical to restrict. The following prohibitions or requirements were introduced:

Zone 1 Non-residential activities involving storage or use of regulated substances to cease within two years.

Zone 2 Quarterly inventory of regulated substances, containment and daily surveillance.

Zone 3 Quarterly inventory, daily monitoring for breakage or spillage (in which case zone 2 applies).

In four cases activities such as petrol stations and public works were moved and in others it was the wellfields that were relocated.

USEPA (1993) give the example of WHPA design in Cottage Grove, Wisonsin. This village is dependent on groundwater supply from a sandstone aquifer. Wells serving the village are about 200 m deep and the hydraulic conductivity of the aquifer is about 0.05 m d^{-1}. Two chemical companies were located within 800 m of the water supply wells and contamination was documented and being investigated at one of these sites. Information from this and other investigations was useful for delineating the WHPAs illustrated in figure 5. The WHPAs were constructed using the USEPA semi-analytical WHPA computer code (USEPA, 1994) and include 1, 5, 50 and 100 year isochron zones. The 50 year isochron extends about 2.5 kms up-gradient to the north-west and the influence of pumping results in its extension about 180 m to the south-east. A flow divide restricts the WHPA toward the west.

The process of introducing WHPAs at Cottage Grove involved the whole community and is well described in the USEPA guide (1993). Various land use restrictions were imposed within the various zones and enforcement mechanisms outlined.

7.4 Indicative WHPAs for selected vulnerable Waikato groundwater supplies

Indicative WHPAs were constructed for selected Waikato groundwater supplies from vulnerable, unconfined aquifers. These are examples for discussion of potential local use of this management tool. The WHPAs are divided into three zones, similar to the previous examples and comprise the following:

Zone 1 An arbitrary fixed radius control zone of 30 m. This immediate area is to ensure no direct access of contaminants from leakage spills or accident. In this zone there would be no:

- no storage of chemicals, hazardous substances or any potential contaminant sources
- no domestic or animal effluent discharge

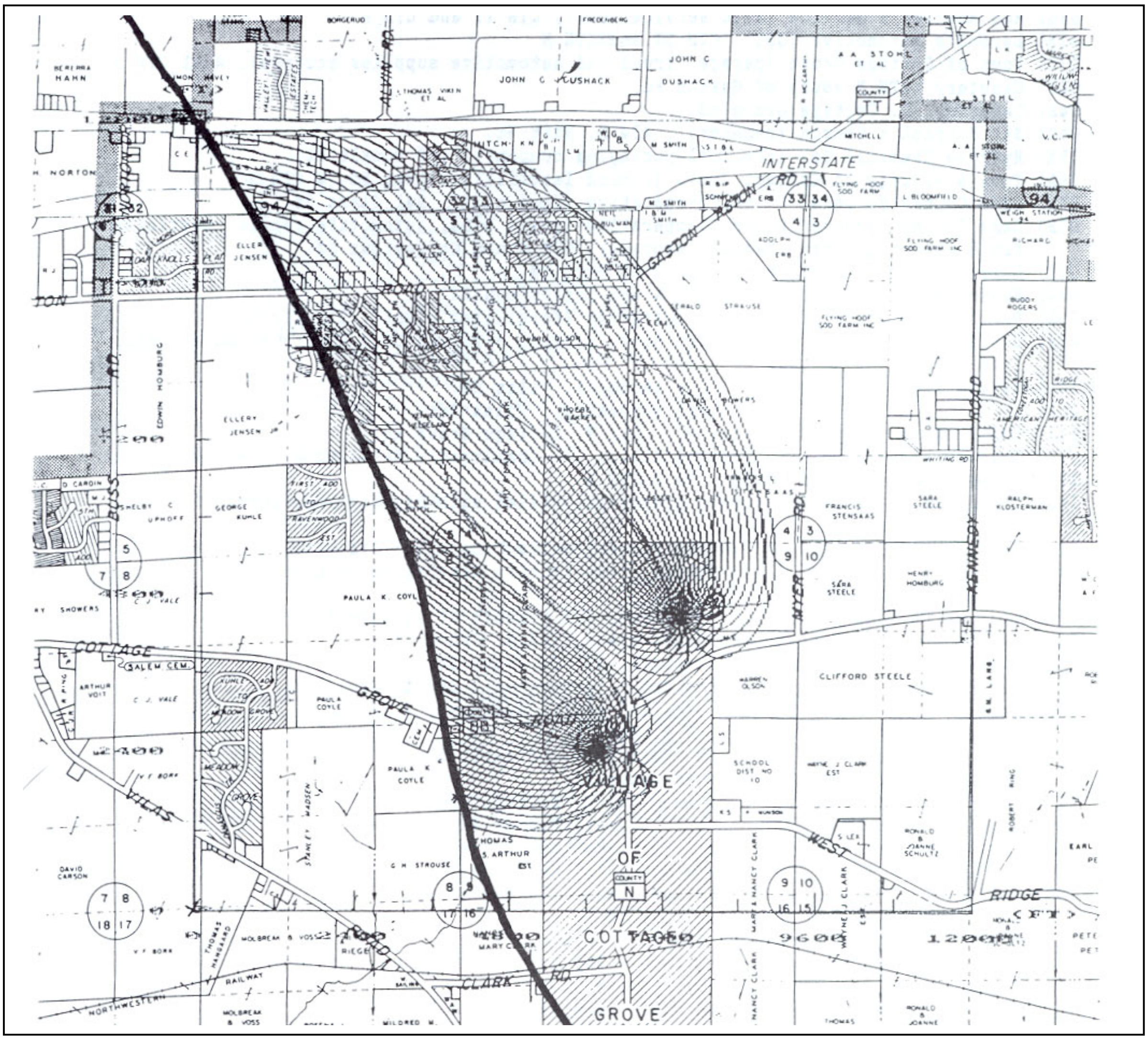

Figure 5: Cottage Grove, Wisconsin wellhead protection areas

Zone 2 Attenuation / microbial buffer zone defined by a 100 day travel time isochron.

The criteria for this zone is based primarily on the provision of sufficient travel time for microbial die-off (Bitton and Gerber, 1984). It also ensures substantial dispersion beyond this zone. In this zone there would be:

- no storage of hazardous substances
- no domestic or animal effluent discharge

Zone 3 Larger potential remedial zone defined by a 2 year isochron (a 5 year alternative should be considered). This zone is to provide sufficient time for remedial action or supply replacement. The use of a five year isochron would provide greater protection and reflect a commonly used criteria for the remediation zone from overseas literature.

- no storage of hazardous substances without secondary containment
- inventory and review of potential contaminant sources

There are numerous wellhead protection tools both regulatory and non-regulatory, which could be invoked (USEPA, 1994). The most likely hazards within the first and second WHPA zones of school supplies are discharges from their own septic tanks. The need to understand groundwater flow direction and pumping influence when locating water supplies and wastewater disposal systems is emphasised by the indicative examples that follow.

WHPAs have been constructed, as examples, for five community groundwater supplies. They comprise supplies for Waharoa, Pauanui and the Goodwood, Hautapu and Manawaru schools. The extent and shape of each of the WHPAs varies predominantly due to changes in aquifer permeability and pumping rate. The attenuation and remedial zones were constructed using the ASMWIN finite difference numerical groundwater model of Chiang et al. (1998). Requirements for the predictions include hydraulic conductivity, gradient, an estimate of effective porosity, flow direction, aquifer thickness and pumping rate. The parameter most open to error is hydraulic conductivity, which emphasises the importance of pumping test information.

The indicative WHPA for Waharoa is illustrated in Figure 6. The remedial zone extends for about 1.5 kms reflecting the relatively high hydraulic conductivity of about 200 m d^{-1}. The orientation of the capture zone is important particularly due to its narrow shape. Flow direction has been estimated from a large-scale piezometric surface. More detailed local information would improve the confidence of this prediction.

Figure 6: Indicative WHPA for the Waharoa community water supply

The other district council managed groundwater supply for which an indicative WHPA is illustrated is Pauanui. At this site there is a wellfield of four wells, three of which are illustrated in figure 7. Wastewater for this area is reticulated and some of it is 're-injected' into the water table aquifer via rapid infiltration beds about 500 m to 800 m to the west. A condition of this discharge back to the ground is that a positive groundwater gradient is maintained away from the water supply wells toward the coast.

It is noted that such influences may have the potential to temporally vary contamination risk to a supply. Temporal variations in the orientation of WHPAs from changes in water table contour are however generally expected to be very minor. Figure 7, shows that the WHPA for the community groundwater supply at Pauanui extends southward about 420 m rather than toward the wastewater discharge area.

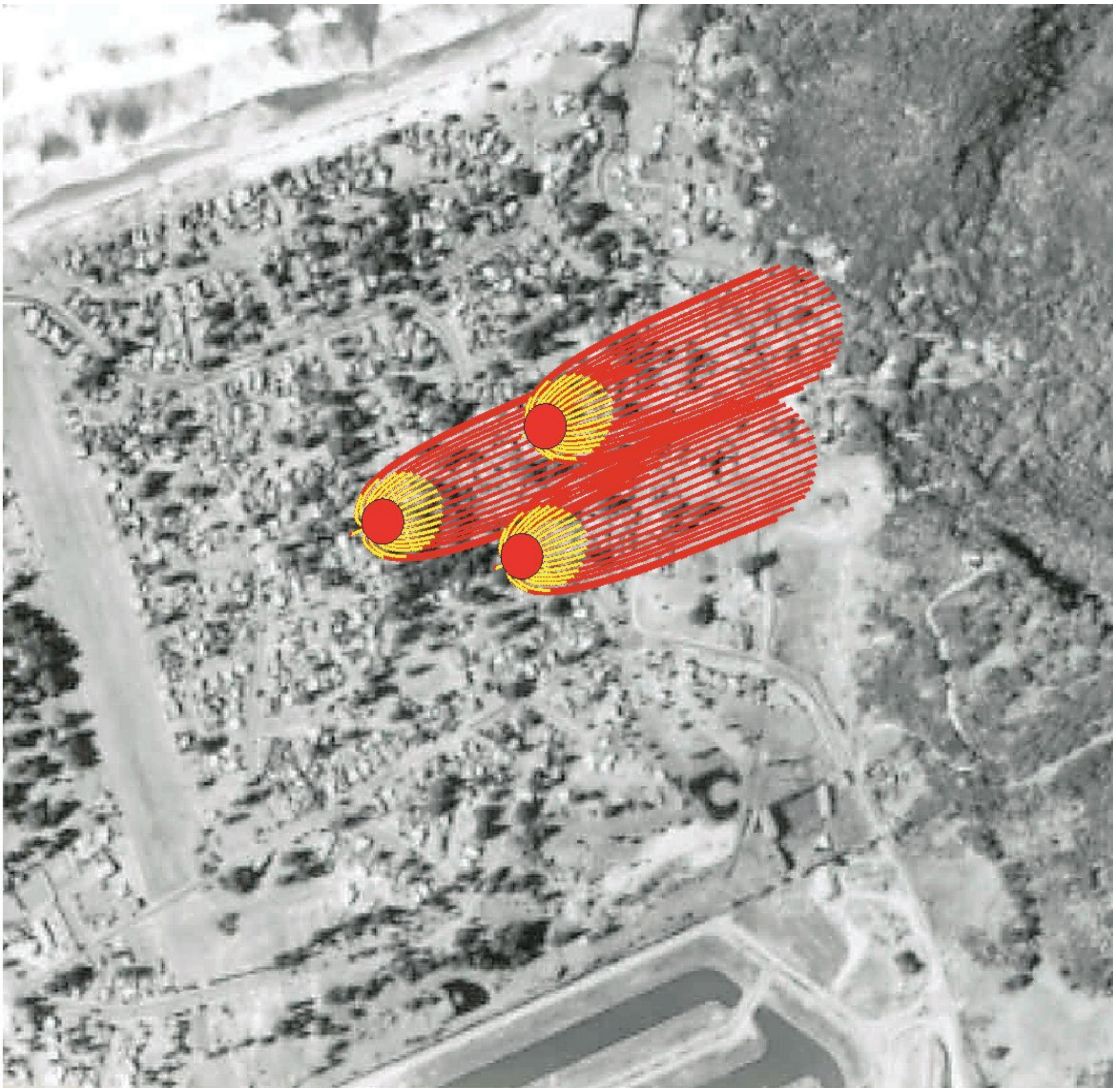

Figure 7: An indicative WHPA for Pauanui community groundwater supply

The Goodwood School WHPA defined by a two year isochron is predicted to extend about 120 m up-gradient and is some 100 m in width (Figure 8). The most likely contaminant sources to be intercepted by the school capture zones are their own septic outfalls**.**

WHPAs for Hautapu and Manawaru schools are presented in Figures 9 and 10. They are both relatively restricted due to low aquifer hydraulic conductivities and low pumping rates. The most significant parameters used in the ASMWIN modelling of the WHPAs for the five sites described are listed in table 4. All of the aquifers for these supplies comprise alluvial Hinuera Formation sands with the exception of Pauanui which has a beach barrier dune sand origin.

Figure 8: An indicative WHPA for the Goodwood School supply

Table 4: Significant parameters in WHPA modelling

Supply	Hydraulic conductivity	Aquifer Thickness	gradient	Pumping rate	Flow direction
Pauanui	**15**	**15**	**0.007**	**200 (x3)**	**N-NW**
Waharoa	**202**	**8**	**0.0018**	**200 (x2)**	**NNW**
Goodwood School	**15**	**5.9**	**0.0015**	**15**	**NW**
Hautapu School	**0.8**	**3.1**	**0.0015**	**15**	**NW**
Manawaru School	**2.9**	**3.7**	**0.0018**	**15**	**NNW**

The indicative WHPAs illustrated indicate the importance of understanding aquifer behaviour in considering supply protection and the potential contaminant threat. Parameters such as hydraulic conductivity and groundwater flow direction are required before WHPAs can be confidently delineated and management issues discussed with the community.

Figure 9: An indicative WHPA for the Hautapu School supply

Figure 10: An indicative WHPA for the Manawaru School supply

8 Agency Responsibilities And Opportunities For Partnerships

8.1 Agency Responsibilities

There is a plethora of legislation relating to drinking water including 16 acts and 20 regulations. Health Authorities (e.g. Health Waikato), District Councils and Environment Waikato all have responsibilities for aspects of community groundwater supply protection. Supply owners most importantly have responsibility to comply with requirements for potable water supply and a vested interest to ensure the wellbeing of supply users. Management and monitoring of the quality of a community supply is generally the supplier's responsibility.

The Health Act, 1956 gives the Ministry of Health responsibility for the regulation of public health, for which a safe drinking water supply is fundamental. Changes to this legislation are imminent which should clarify statutory responsibility for the various categories of community drinking water supplies.

Drinking Water Standards (MoH, 2000) and Guidelines (MoH, 1995) are currently voluntary measures developed for water supply management. Compliance with the standards is audited by Health Protection Officers (Health Waikato) and reported in public health grading of the supplies. The Ministry of Health maintains a national database (WINZ) with relevant information for public health grading of community supplies. Information from this database is used to compile the Register of Community Drinking Water supplies. It is likely that compliance with these standards will be mandatory with pending legislative changes.

District Councils have powers and responsibilities under the Building, Health, and Resource Management Acts (RMA) and others including the Local Government Act 1974 to audit, manage and provide for community water supplies. This includes ensuring that new dwellings have potable water supplies.

Environment Waikato has responsibilities for source water protection and environmental management generally under the Resource Management Act. They include the following functions:

- controlling the use of land to protect the quality of water (s.30 (1)c);
- taking and use of water (s.30 (1) (e));
- controlling discharge of contaminants onto land and into water (s.30 (1) (f))

Section 3.10.2 of Environment Waikato's Regional Policy Statement delegates responsibility for s30 functions in respect to hazardous substances to district councils to clarify responsibilities and avoid duplication.

Environment Waikato's responsibilities relate to source water protection rather than wider aspects of safe supply such as treatment and reticulation. Health and environmental interests are very much aligned.

8.2 Monitoring Requirements For Community Supplies

The New Zealand Drinking-Water Standards (MoH, 2000) define community drinking-water supplies as those serving 25 people or more for at least 60 days per year. Monitoring specified in the standards and associated guideline document (MoH, 1995) is based on the principle that it is more effective to test for a narrow range of key determinands more frequently supplementing this with sanitary surveys, than to conduct comprehensive but lengthy (and possible largely irrelevant) analyses less often. In addition to health-related determinands, small communities need to include other analyses relevant to the operation and maintenance of drinking-water treatment and distribution systems.

To demonstrate compliance with the drinking water standards, priority 1 and priority 2 determinands must be monitored according to stated protocols. Priority 1 (P1) determinands are e-coli, giardia and cryptosporidium. Priority 2 (P2) determinands include chemical determinands which exceed 50 % of health guidelines, including those introduced by treatment processes, and health significant micro-organisms shown to be present in the supply. The P2 programme operated for the Ministry of Health has been limited to supplies serving at least 100 people.

Monitoring is generally required monthly and weekly for microbial composition in non-secure, non-chlorinated small community groundwater supplies (defined as serving less than 500 people). After 12 months of monitoring the supply manager can apply for P3 status and thereby reduce monitoring providing constituents do not exceed 50 % of the MAV.

As a minimum MoH recommend that small community drinking-water supplies should be monitored for *e-coli;* pH; disinfectant residual and turbidity to establish the hygienic state of the water and the potential for other problems to occur.

Many community water supplies currently don’t comply with the national drinking water standards. This is generally because they are not monitored often enough, rather than contaminant levels being above the standards. In 1998 only 1% of non-urban school supplies complied with the drinking water standards (Ministry of Education, 2000).

8.3 Opportunities For Partnership

There are considerable opportunities in community groundwater supply source protection for mutual benefit through co-operation and partnerships. It is in the interests of Environment Waikato, health authorities, district councils and communities to have safe drinking water supplies. Benefits include co-operation in respect to:

i) information sharing (site and quality);
ii) understanding contamination prevention;
iii) demonstration of supply security;
iv) effective protection implementation, and;
v) educational opportunities.

An example of mutual benefit is that information required from school and district supplies to demonstrate compliance with health standards is also useful as environmental indicators.

9 Strategies For Community Groundwater Supply Protection

Community based strategies for groundwater protection have been found overseas to be very effective. The Groundwater Foundation (1999) in the United States provides useful examples of community based initiatives and guidelines for source water assessment and protection. Community involvement is fundamental to the success of these water supply protection works.

Community groundwater supplies should be registered with the Ministry of Health and monitored for compliance with drinking water standards. Public health risk management plans, likely to be required by the Ministry of Health, are another useful mechanism for supply protection. These will address not only source protection but also wider aspects such as treatment and reticulation.

The development of well-head protection areas (WHPAs) is suggested as an effective and proactive mechanism for groundwater supply source protection. Examples have been provided for selected supplies to promote discussion. It is important that there be community involvement in the development of such measures to increase their effectiveness. Development of WHPAs involves formation of a community planning team; zone delineation; identification of potential contaminant sources; management of WHPAs involving both regulatory and non-regulatory methods, review and contingency planning.

A fundamental action to avoid direct supply protection is to ensure that well-heads are effectively sealed from the ground surface. This is a current requirement of land-use consents for well construction.

Apart from advocating for risk management, development of well-head protection areas and sanitary well-head completion there is also considerable benefit from information sharing. Annual routine source water quality monitoring of school groundwater supplies could be undertaken by Environment Waikato in association with the schools. This information would also be of interest to health authorities and district councils. Information on groundwater quality of district supply sources could be similarly shared. Data collected to demonstrate compliance with health guidelines for drinking water is also useful as environmental indicators.

Finally environmental education initiatives should be progressed in partnership with health authorities and district councils to promote awareness of the need for groundwater source protection and appropriate land use particularly near groundwater supplies. Schools are an obvious focus for such initiatives.

Preventing community groundwater supply contamination at the source makes good public health, economic and environmental sense. It is in interests of the community, Environment Waikato, health and other local government authorities, to work together for more effective groundwater supply source protection.

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Appendix I: DRASTIC Analysis Of The 90 Identified Schools In The Region

School	*Otaua*	*Aka Aka*	*Harrisville*	*Waikaretu*	*Onewhero*	*Naike*	*Pukekawa*	*Te Akau*	*Te Uku*	*Waitetuna*	*Te Mata*
Map Reference	R12:648-316	R12:704-338	R12:835-384	R13:722-050	R13:801-282	R13:831-078	R13:863-270	R14:755-909	R14:825-732	R14:892-709	R15:744-675
Site (Hydrol) No.	61.1729	61.1723	61.761	61.168	61.182	61.1679	61.1255	69.2076	69.2078	69.2079	69.1816
Depth to water (m)	-	118	7.155 (P)	5.665	13.74	60.19	-	-	-	6.89	36
D rating		1	7	8	5	1				7	1
D Index		**5**	**35**	**40**	**25**	**5**				**35**	**5**
Net Recharge (mm y^{-1})	528	52.8	683	1011	758	743	831	774	947	851	609
R rating	9	2	9	9	9	9	9	9	9	9	9
R Index	**36**	**8**	**36**	**36**	**36**	**36**	**36**	**36**	**36**	**36**	**36**
Aquifer media	Fine alluvium	Sands and gravels	Ashes older than Taupo Ash	Ashes older than Taupo Ash	Ashes older than Taupo ash	Limestone	Ashes older than Taupo ash	Ashes older than Taupo ash	Sands and gravels	Sands and gravels	Mudstone
A rating	9	9	5	5	5	6	5	5	9	9	2
A Index	**27**	**27**	**15**	**15**	**15**	**18**	**15**	**15**	**27**	**27**	**6**
Soil media	Gley	Silt loam	Sandy loam	Loam	Clay loam	Clay and silt loam	Clay loam	Silt loam	Loam	Loam	Silt loam
S Rating	9	4	6	5	3	4	3	4	5	5	4
S Index	**18**	**8**	**12**	**10**	**6**	**8**	**6**	**8**	**10**	**10**	**8**
Topography (% slope)	Gently rolling	Flat	Flat	Gently rolling	Gently rolling	Strongly rolling	Gently rolling	Rolling	Gently rolling	Strongly rolling	Rolling
T rating	9	10	10	9	9	3	9	5	9	3	5
T Index	**9**	**10**	**10**	**9**	**9**	**3**	**9**	**5**	**9**	**3**	**5**
Impact of Vadose		Sandy silt				Mud and clay					Rhyolite
I rating		5				3					2
I Index		**25**				**15**					**10**
Hydraulic Cond (K) (md^{-1})	1	30	1	1	1	10	1	1	30	30	1
C rating	1	5	1	1	1	2	1	1	5	5	1
C Index	**3**	**15**	**3**	**3**	**3**	**6**	**3**	**3**	**15**	**15**	**3**
Drastic Index	Not complete	**98**	Not complete	Not complete	Not complete	**91**	Not complete	Not complete	Not complete	Not complete	**73**

School	***Kinohaku***	***Aria***	***Mangatangi***	***Mercer***	***Mangatawhiri***	***Ohinewai***	***Waiterimu***	***Orini***	***Hoe-O-Tainui***	***Kaihere***
Map Reference	R16:698-366	R17:832-916	S12:061-423	S12:928-343	S12:987-411	S13:011-100	S13:115-117	S13:148-027	S13:246-072	S13:246-227
Site (Hydrol) No.	71.60	71.63	61.1731	61.1728	61.173	69.1446	69.1902	69.2074	64.32	63.39
Depth to water (m)	-	-		10.7		-	38.4	8.86	2.8	
D rating				6			1	7	9	
D Index				**30**			**5**	**35**	**45**	
Net Recharge (mm y^{-1})	792	1237	727	356.4	555	663	84.1	655	686	625
R rating	9	9	9	9	9	9	3	9	9	9
R Index	**36**	**36**	**36**	**36**	**36**	**36**	**12**	**36**	**36**	**36**
Aquifer media	Greywacke	Ashes older than Taupo ash	Sands and gravels	Basalt	Sands and gravels	Fine alluvium	Greywacke	Sands and gravels	Gravel/alluvium	Sands and gravels
A rating	3	5	9	9	9	9	3	9	9	9
A Index	**9**	**15**	**27**	**27**	**27**	**27**	**9**	**27**	**27**	**27**
Soil media	Clay loam	Silt loam	Silt loam	Clay loam	Silt loam	Alluvial sands	Silt loam	Loam	Clay loam	Silt loam
S Rating	3	4	4	3	4	9	4	5	3	4
S Index	**6**	**8**	**8**	**6**	**8**	**18**	**8**	**10**	**6**	**8**
Topography (% slope)	Mod steep	Gently rolling	Gently rolling	Strongly rolling	Gently rolling	Flat	Rolling	Flat	Gently rolling	Rolling
T rating	1	9	9	3	9	10	4	10	9	5
T Index	**1**	**9**	**9**	**3**	**9**	**10**	**4**	**10**	**9**	**5**
Impact of Vadose				Vol clays and ash			Sandy silt		Sand and gravel	
I rating				3			5		9	
I Index				**15**			**25**		**45**	
Hydraulic Cond (K) (md^{-1})	1	1	30	2.4	30	1	1	30	30	30
C rating	1	1	5	1	5	1	1	5	5	5
C Index	**3**	**3**	**15**	**3**	**15**	**3**	**3**	**15**	**15**	**15**
Drastic Index	Not complete	Not complete	Not complete	**120**	Not complete	Not complete	**66**	Not complete	**183**	Not complete

School	***Waikokowai***	***Te Kowhai***	***Whatawhata***	***Rotokauri***	***Horotiu***	***Horsham Downs***	***Gordonton***	***Whitikahu***	***Matangi***	***Tauhei***
Map Reference	S13:918-012	S14:000-826	S14:003-767	S14:045-791	S14:046-867	S14:085-869	S14:139-903	S14:173-963	S14:210-749	S14:248-971
Site (Hydrol) No.	69.1897	69.2077	69.2080	69.2075	69.2187	69.1349	69.912	69.2081	69.2072	64.744
Depth to water (m)	28.175	-	-	-	10.95 (PWL)	20	2.83	-	-	-
D rating	2				6	3	9			
D Index	**10**				**30**	**15**	**45**			
Net Recharge (mm y^{-1})	677	824	712	668	791	379.2	409.8	494	589	331.8
R rating	9	9	9	9	9	9	9	9	9	9
R Index	**36**	**36**	**36**	**36**	**36**	**36**	**36**	**36**	**36**	**36**
Aquifer media	Ashes older than Taupo	Sands and gravels	Sands and gravels	Ashes older than Taupo ash	Fine alluvium	Unconsolidated sediments	Pumice and Sands	Ashes older than Taupo	Sands and gravels	Pumice and Sands
A rating	5	9	9	5	9	9	9	5	9	9
A Index	**15**	**27**	**27**	**15**	**27**	**27**	**27**	**15**	**27**	**27**
Soil media	Silt loam	Sandy loam	Clay loam	Clay loam	Alluvial sands	Clay loam	Sandy loam	Loamy peat	Sandy loam	Clay loam
S Rating	4	6	3	3	9	3	6	7	6	3
S Index	**8**	**12**	**6**	**6**	**18**	**6**	**12**	**14**	**12**	**6**
Topography (% slope)	Rolling	Flat	Flat	Gently rolling	Gently rolling	Gently rolling	Flat	Flat	Flat	Strongly rolling
T rating	5	10	10	9	9	9	10	10	10	3
T Index	**5**	**10**	**10**	**9**	**9**	**9**	**10**	**10**	**10**	**3**
Impact of Vadose	Clay					Sandy clay	Clay			Sandy clay
I rating	3					3	3			3
I Index	**15**					**15**	**15**			**15**
Hydraulic Cond (K) (md^{-1})	1	30	30	1	1	30	1.02	1	30	0.834
C rating	1	5	5	1	1	5	1	1	5	1
C Index	**3**	**15**	**15**	**3**	**3**	**15**	**3**	**3**	**15**	**3**
Drastic Index	**92**	Not complete	Not complete	Not complete	Not complete	**123**	**148**	Not complete	Not complete	Not complete

School	***Tauwhare***	***Goodwood***	***Ngati Haua***	***Glen Massey***	***Ngahinapouri***	***Pokuru***	***Paterangi***	***Rukuhia***	***Puahue***
Map Reference	S14:263-782	S14:276-707	S14:285-753	S14:932-903	S15:041-648	S15:065-472	S15:073-590	S15:125-696	S15:216-490
Site (Hydrol) No.	69.1809	70.1231	69.2073	69.2071	70.1158	70.794	70.778	70.1161	70.1164
Depth to water (m)	2.5	2.7	-		5.4	13	44	11.71	20.7
D rating	9	9			8	5	1	5	3
D Index	**45**	**45**			**40**	**25**	**5**	**25**	**15**
Net Recharge (mm y^{-1})	558	555	475	988	838	926	82.5	518	486.6
R rating	9	9	9	9	9	9	3	9	9
R Index	**36**	**36**	**36**	**36**	**36**	**36**	**12**	**36**	**36**
Aquifer media	Sands and Gravels	Pumice and Sands	Ashes older than Taupo	Sands and gravels	Sands and gravels	Sands	Pumice	Sands and gravels	Sand and Pumice
A rating	9	9	5	9	9	9	5	9	7
A Index	**27**	**27**	**15**	**27**	**27**	**27**	**15**	**27**	**21**
Soil media	Sandy loam	Loam	Clay loam	Silt loam	Sandy loam	Silt loam	Silt loam	Loamy peat	Silt loam
S Rating	6	5	3	4	6	4	4	7	4
S Index	**12**	**10**	**6**	**8**	**12**	**8**	**8**	**14**	**8**
Topography (% slope)	Flat	Flat	Rolling	Mod steep	Flat	Gently rolling	Gently rolling	Flat	Gently rolling
T rating	10	10	5	1	10	9	9	10	9
T Index	**10**	**10**	**5**	**1**	**10**	**9**	**9**	**10**	**9**
Impact of Vadose	Sand and Gravel	Sands and gravel				Sand and Pumice	Sand and Pumice		Sand and Pumice
I rating	9	9				7	7		7
I Index	**45**	**45**				**35**	**35**		**35**
Hydraulic Cond (K) (md^{-1})	30	15.46	1	30	30	7	3.62	30	0.05
C rating	5	3	1	5	5	3	1	5	1
C Index	**15**	**9**	**3**	**15**	**15**	**9**	**3**	**15**	**3**
Drastic Index	**190**	**182**	Not complete	Not complete	Not complete	**149**	**87**	Not complete	**127**

School	***Parawera***	***Capernwray***	***Hautapu***	***Ngutunui***	***Te Pahu***	***Hangatiki***	***Rangitoto***	***Otewa***	***Maihihi***	***Korakonui***
Map Reference	S15:245-443	S15:245-619	S15:246-683	S15:957-453	S15:983-622	S16:009-245	S16:075-152	S16:105-281	S16:190-291	S16:213-371
Site (Hydrol) No.	70.1159	70.1187	70.453	65.285	70.952	71.59	71.61	65.271	65.142	65.27
Depth to water (m)		12.8	4.87		-	3.75	8.16	18.445	5.88	7.775
D rating		5	8			9	7	3	8	7
D Index		**25**	**40**			**45**	**35**	**15**	**40**	**35**
Net Recharge (mm y^{-1})	891	198.9	588	1516	919	861	1156	904	984	853
R rating	9	7	9	9	9	9	9	9	9	9
R Index	**36**	**28**	**36**	**36**	**36**	**36**	**36**	**36**	**36**	**36**
Aquifer media	Ashes older than Taupo	Sand and Pumice	Sands and gravels	Ashes older than Taupo ash	Fine alluvium	Fine alluvium	Ashes older than Taupo ash		Rhyolite	Ashes older than Taupo
A rating	5	9	9	5	9	9	5		3	5
A Index	**15**	**27**	**27**	**15**	**27**	**27**	**15**		**9**	**15**
Soil media	Silt loam	Sandy loam	Sandy loam	Silt loam	Loam	Silt and clay loam	Silt loam	Silt loam	Silt loam	Silt loam
S Rating	4	6	6	4	5	4	4	4	4	4
S Index	**8**	**12**	**12**	**8**	**10**	**8**	**8**	**8**	**8**	**8**
Topography (% slope)	Gently rolling	Flat	Flat	Gently rolling	Gently rolling	Rolling	Gently rolling	Rolling	Rolling	Gently rolling
T rating	9	10	10	9	9	8	9	5	5	9
T Index	**9**	**10**	**10**	**9**	**9**	**8**	**9**	**5**	**5**	**9**
Impact of Vadose		Sandy silt	Sand and Gravel						Sand and pumice	
I rating		5	9						7	
I Index		**25**	**45**						**35**	
Hydraulic Cond (K) (md^{-1})	1	0.11	0.77	1	1	1	1		1	1
C rating	1	1	1	1	1	1	1		1	1
C Index	**3**	**3**	**3**	**3**	**3**	**3**	**3**		**3**	**3**
Drastic Index	71	**130**	**173**	Not complete	Not complete	Not complete	Not complete	Not complete	**136**	Not complete

School	***Kennedy Bay***	***Manaia***	***Tapu***	***Coroglen***	***Whenuakite***	***Te Puru***	***Matatoki***	***Puriri Valley***	***Hikutaia***	***Hikuai***
Map Reference	T10:385-005	T11:313-802	T11:330-654	T11:508-717	T11:578-725	T12:344-590	T12:416-404	T12:444-380	T12:459-304	T12:569-551
Site (Hydrol) No.	60.215	60.236	60.26	60.136	60.382	60.426	60.478	60.314	63.152	60.198
Depth to water (m)	31		4	20.5	16		7.04	5	23.5	11
D rating	1		9	3	4		7	8	2	5
D Index	**5**		**45**	**15**	**20**		**35**	**40**	**10**	**25**
Net Recharge (mm y^{-1})	109.9	999	791	334.8	117.3	820	630	892	118.5	355.5
R rating	4	9	9	9	4	9	9	9	4	9
R Index	**16**	**36**	**36**	**36**	**16**	**36**	**36**	**36**	**16**	**36**
Aquifer media	Rhyolite	Fine Alluvium	Sands	Fine Alluvium	Mudstone	Lavas/welded ignimbrites	Sands and gravels	Rhyolite Gravel	Alluvium	Fine alluvium
A rating	3	9	9	9	2	5	9	9	9	9
A Index	**9**	**27**	**27**	**27**	**6**	**15**	**27**	**27**	**27**	**27**
Soil media	Sand	Silt and clay loam	Clay loam	Silt and clay loam	Silt and clay loam	Clay	Silt loam	Sandy loam	Silt and clay loam	Silt and clay loam
S Rating	9	4	3	4	4	1	4	6	4	4
S Index	**18**	**8**	**6**	**8**	**8**	**2**	**8**	**12**	**8**	**8**
Topography (% slope)	Flat	Flat	Moderately steep	Flat	Flat	Steep	Rolling	Rolling	Flat	Gently rolling
T rating	10	10	1	10	10	1	5	5	10	9
T Index	**10**	**10**	**1**	**10**	**10**	**1**	**5**	**5**	**10**	**9**
Impact of Vadose	Sandy silt	Clay	Gravels, sands	Clay	Gravels			Clay	Clay	Silt
I rating	5	3	9	3	10			3	3	4
I Index	**25**	**15**	**45**	**15**	**50**			**15**	**15**	**20**
Hydraulic Cond (K) (md^{-1})	1	1	7	1	1	1	30	65	30	15
C rating	1	1	2.5	1	1	1	5	8	5	3
C Index	**3**	**3**	**7.5**	**3**	**3**	**3**	**15**	**24**	**15**	**9**
Drastic Index	**86**	Not complete	**167.5**	**114**	**113**	Not complete	Not complete	**159**	**101**	**134**

School	***Opoutere***	***Springdale***	***Elstow***	***Waimata***	***Mangateparu***	***Te Miro***	***Te Puninga***	***Kiwitahi***	***Tatuanui***	***Kereone***
Map Reference	T12:631-485	T13:371-049	T13:435-053	T13:643-155	T14:312-984	T14:343-742	T14:359-999	T14:387-815	T14:394-946	T14:411-855
Site (Hydrol) No.	60.290	64.72	64.993	63.392	64.881	70.951	64.751	64.456	64.884	64.880
Depth to water (m)	7.615	2	-		-	17.37	2	30.3	2.03	-
D rating	7	9				3	9	2	9	
D Index	**35**	**45**				**15**	**45**	**10**	**45**	
Net Recharge (mm y^{-1})	129.7	504	499	1630	480	141.4	611	48.6	545	682
R rating	5	9	9	9	9	5	9	1	9	9
R Index	**20**	**36**	**36**	**36**	**36**	**20**	**36**	**4**	**36**	**36**
Aquifer media	Rhyolites	Sand, Pumice and Gravel	Sands and gravels	Ashes older than Taupo ash	Ashes older than Taupo	Rhyolite	Pumice	Sand and Pumice	Sands and gravels	Brown gravels and sands
A rating	3	9	9	5	5	3	5	7	9	9
A Index	**9**	**27**	**27**	**15**	**15**	**9**	**15**	**21**	**27**	**27**
Soil media	Silt and clay loam	Silt loam	Silt loam	Sandy loam	Clay loam	Silt loam	Sandy loam	Clay loam	Loam	Silt loam
S Rating	4	4	4	6	3	4	6	3	5	4
S Index	**8**	**8**	**8**	**12**	**6**	**8**	**12**	**6**	**10**	**8**
Topography (% slope)	Flat	Flat	Flat	Gently rolling	Gently rolling	Strongly rolling	Flat	Gently rolling	Flat	Gently rolling
T rating	10	10	10	9	9	3	10	9	10	9
T Index	**10**	**10**	**10**	**9**	**9**	**3**	**10**	**9**	**10**	**9**
Impact of Vadose	Silty clay	Clay				Clay	Clay	Clay		
I rating	3	3				3	3	3		
I Index	**15**	**15**				**15**	**15**	**15**		
Hydraulic Cond (K) (md^{-1})	0.26	3.83	30	1	1	0.12	15	30	30	30
C rating	1	1	5	1	1	1	3	5	5	5
C Index	**3**	**3**	**15**	**3**	**3**	**3**	**9**	**15**	**15**	**15**
Drastic Index	**100**	**144**	Not complete	Not complete	Not complete	**73**	**142**	**80**	Not complete	Not complete

School	*Richmond Downs*	*Ngarua*	*Waihou*	*Walton*	*Manawaru*	*Wardville*	*Pukeatua*	*Karapiro*	*Whitehall*
Map Reference	T14:451-757	T14:462-892	T14:464-998	T14:480-820	T14:541-929	T14:552-828	T15:345-455	T15:347-622	T15:375-662
Site (Hydrol) No.	64.883	64.994	64.885	64.807	64.500	64.995	70.804	70.1157	70.1162
Depth to water (m)	-	4.72	5.065	8.11	4.5	3.135	23.1	-	-
D rating		8	8	7	9	9	2		
D Index		**40**	**40**	**35**	**45**	**45**	**10**		
Net Recharge (mm y^{-1})	616	739	713	70.5	972	972	116.3	659	755
R rating	9	9	9	3	9	9	4	9	9
R Index	**36**	**36**	**36**	**12**	**36**	**36**	**16**	**36**	**36**
Aquifer media	Fine alluvium	Sands and gravels	Sands and gravels	Sand and Pumice	Sand and pumice	Sands and gravels	Sand and pumice	Sands and gravels	Lavas and welded ignimbrites
A rating	9	9	9	7	9	9	9	9	5
A Index	**27**	**27**	**27**	**21**	**27**	**27**	**27**	**27**	**15**
Soil media	Silt and clay loam	Sandy loam	Sandy loam	Silt loam	Silt loam	Silt loam	Sandy loam	Sandy loam	Silt loam
S Rating	4	6	6	4	4	4	6	6	4
S Index	**8**	**12**	**12**	**8**	**8**	**8**	**12**	**12**	**8**
Topography (% slope)	Gently rolling	Flat	Flat	Flat	Flat	Flat	Rolling	Flat	Strongly rolling
T rating	9	10	10	10	10	10	5	10	3
T Index	**9**	**10**	**10**	**10**	**10**	**10**	**5**	**10**	**3**
Impact of Vadose				Clay	Sand and pumice		Sandy silt		
I rating				3	7		5		
I Index				**15**	**35**		**25**		
Hydraulic Cond (K) (md^{-1})	15	30	30	0.25	2.93	30	0.008	30	1
C rating	3	5	5	1	1	5	1	5	1
C Index	**9**	**15**	**15**	**3**	**3**	**15**	**3**	**15**	**3**
Drastic Index	Not complete	Not complete	Not complete	**104**	**164**	Not complete	**98**	Not complete	Not complete

School	***Horahora***	***Puketurua***	***Hinuera***	***Okoroire***	***Tapapa***	***Te Poi***	***Te Waotu***	***Kuratau***	***Upper Atiamuri***	***Ngakuru***	***Waitahanui***
Map Reference	T15:408-546	T15:456-452	T15:527-653	T15:596-586	T15:597-534	T15:606-663	T16:458-364	T18:420-547	U16:784-145	U16:983-153	U18:773-639
Site (Hydrol) No.	70.1156	67.602	64.879	67.565	67.566	64.996	67.567				68.794
Depth to water (m)	4	-	3.41	-	-	7.73					2.8
D rating	9		9			7					9
D Index	**45**		**45**			**35**					**45**
Net Recharge (mm y^{-1})	866	819	816	884	874	873	933	10104	922	954	474
R rating	9	9	9	9	9	9	9	9	9	9	9
R Index	**36**	**36**	**36**	**36**	**36**	**36**	**36**	**36**	**36**	**36**	**36**
Aquifer media	Gravel	Sands and gravels	Fine pumiceous sands	Sands and gravels	Ashes older than Taupo ash	Sands and gravels	Ashes older than Taupo ash	Taupo Pumice	Fractured Ignimbrite	Sands and gravels	Unconsolidated pumice and sands
A rating	9	9	9	9	5	9	5	5	3	9	9
A Index	**27**	**27**	**27**	**27**	**15**	**27**	**15**	**15**	**9**	**27**	**27**
Soil media	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy silt	Sand	Sandy silt	Sandy silt	Loamy peat
S Rating	6	6	6	6	6	6	5	9	5	5	7
S Index	**12**	**12**	**12**	**12**	**12**	**12**	**10**	**18**	**10**	**10**	**14**
Topography (% slope)	Strongly rolling	Flat	Flat	Gently rolling	Rolling	Flat	Rolling	Rolling	Rolling	Gently rolling	Flat
T rating	3	10	10	9	5	10	5	5	5	9	10
T Index	**3**	**10**	**10**	**9**	**5**	**10**	**5**	**5**	**5**	**9**	**10**
Impact of Vadose	Mud										Sand and pumice
I rating	3										7
I Index	**15**										**35**
Hydraulic Cond (K) (md^{-1})	0.87	30	3	30	1	30	1	15	100	30	2.6
C rating	1	5	1	5	1	5	1	3	5	5	1
C Index	**3**	**15**	**3**	**15**	**3**	**15**	**3**	**9**	**25**	**15**	**3**
Drastic Index	**141**	Not complete	Not complete	Not complete	Not complete	Not complete	Not complete	Not complete	Not complete	Not complete	**170**

Appendix II: DRASTIC Vulnerability Of District Supplies

Name	Port Waikato	Buckland	Pokeno	Tuakau	Waitakaruru	Waharoa	Tahuna	Matamata	Hinuera
Map Ref.	R13:634-218	R12:812-404	R12:889-404	R12:811-354	S12:191-340	T14:531-784	T13:307-078	T14:544-741	T15:529-647
Well No.	5215	2331	2307	1437	4476	4779	5840	4743	7718
Depth to water (m)	18.5	98.1	101.4	9.5	31.4	3.3	5	4.5	24.1
D rating	4	1	1	6	1	10	8	9	2
D Index	20	5	5	30	5	50	40	45	10
Net Recharge (mm y^{-1})	**30**	**50**	**30**	**0**	**0**	**300**	**50**	**120**	**100**
R rating	1	2	1	1	1	9	1	5	3
R Index	4	8	4	4	4	36	4	20	12
Aquifer media	greywacke	Kaawa Formation	greywacke	basalt	sand & gravel	sand	sand	gravelly sand	sand
A rating	2	6	2	9	8	8	7	8	7
A Index	6	18	6	27	24	24	21	24	21
Soil media	clay	silty clay	silty clay loam	peaty silt loam	silt	sandy Loam	clay loam	sandy loam	loam
S Rating	2	3	3	6	4	6	3	6	5
S Index	4	6	6	12	8	12	6	12	10
Topography (% slope)	<2	4	15	<2	<2	<2	9	<2	<2
T rating	10	9	3	10	10	10	5	10	10
T Index	10	9	3	10	10	10	5	10	10
Impact of Vadose	mudstone	silty clay	siltstone	ash	silty clay	silty clay	clay	clay	silty clay
I rating	1	3	3	3	3	4	3	2	4
I Index	5	15	15	15	15	20	15	10	20
Hyd Cond (K m d^{-1})	0.12	1.1	*3*	**20**	6.3	202	<1	44.6	**20**
C rating	1	1	1	4	2	10	1	8	4
C Index	3	3	3	12	6	30	3	24	12
Drastic Index	52	64	42	110	72	182	94	145	95

Name	Mamaku	Athol - Kinleith	Lichfield	Tokoroa	Putaruru	Atiamuri	Whakamaru
Map Ref.	U15:797-407	T16:610-229	T15:575-400	T16:596-268	T15:533-456	U17:748-007	T17:550-048
Well No.	6063	1608	5843	1625-34	3015-8	2882	5363
Depth to water (m)	**30**	15	38	18	51	23	23.2
D rating	2	5	1	4	1	2	2
D Index	10	25	5	20	5	10	10
Net Recharge (mm y-1)	**80**	**200**	**80**	**110**	**100**	**100**	**80**
R rating	2	7	2	4	3	3	2
R Index	8	28	8	16	12	12	8
Aquifer media	ignimbrite/gravel	fract ignimbrite	ignimbrite	fract ignimbrite	fract ignimbrite	ignimbite/breccia	ignimbrite
A rating	7	9	7	9	9	5	7
A Index	21	27	21	27	27	15	21
Soil media	loamy sands	Taupo sandy silt	Taupo sandy silt	Taupo sandy silt	sandy loam	sandy silt	sand
S Rating	5	6	6	6	6	6	8
S Index	10	12	12	12	12	12	16
Topography	6	4	6	<2	4	12	<2
T rating	9	9	9	10	9	5	10
T Index	9	9	9	10	9	5	10
Impact of Vadose	tuff/ash	ash	clay	ash	ash	ash/sand	ash/sand
I rating	3	3	3	3	3	6	7
I Index	15	15	15	15	15	30	35
Hyd Cond (K)	**10**	**60**	<1	140	**15**	<1	25
C rating	2	8	1	10	3	1	4
C Index	6	24	3	30	9	3	12
Drastic Index	79	140	73	130	89	87	112

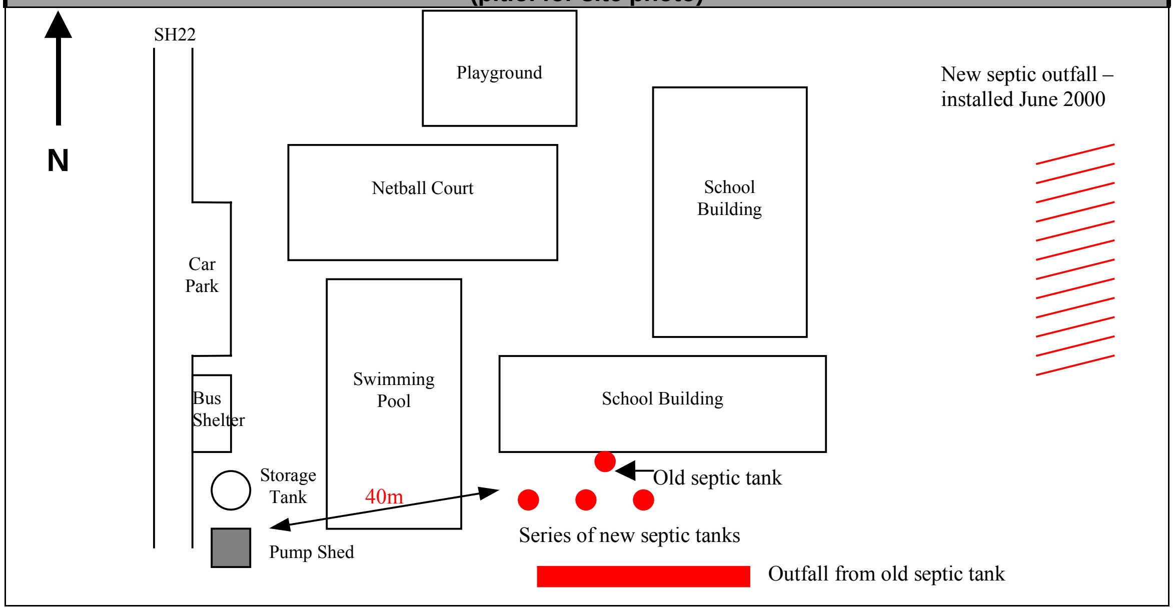
Name	Taupo : Bonshaw Park	Taupo : Centennial Drive	Waitahanui	Whareroa	Onemana	Pauanui	Whangamata
Map Ref.	U18:845-711	U18:801-778	U18:774-629	T18:513-563	T12:658-458	T12:651-597	T12:639-410
Well No.	7866	7871	3447	7872, 7873	2990/6896	4857	5006
Depth to water (m)	47.6	**10**	4.39	**1**	20	1.5	**8**
D rating	1	6	9	10	3	10	7
D Index	5	30	45	50	15	50	35
Net Recharge (mm y-1)	**50**	**50**	360	**360**	**140**	**300**	**80**
R rating	1	1	9	9	4	9	1
R Index	4	4	36	36	16	36	4
Aquifer media	sand/tuff	**sand/tuff**	gravelly sand	gravelly sand	fractured rhyolite	sand	rhyolite
A rating	6	6	8	8	6	8	5
A Index	18	18	24	24	18	24	15
Soil media	pumice soils	pumice soils	sandy loam	sand	sandy loam	sand	sandy loam
S Rating	9	9	6	8	6	9	6
S Index	18	18	12	16	12	18	12
Topography	4	<2	<2	<2	10	<2	3
T rating	9	10	10	10	5	10	9
T Index	9	10	10	10	5	10	9
Impact of Vadose	sand	sand/tuff	sand	sand	clay	sand	clay
I rating	6	5	8	8	3	8	3
I Index	30	25	40	40	15	40	15
Hyd Cond (K)	**2**	**2**	40	**40**	0.4	15	<1
C rating	1	1	8	8	1	3	1
C Index	3	3	24	24	3	9	3
Drastic Index	87	108	191	200	84	187	93

Name	Whangamata : Moana Point	Whangamata : Park Avenue	Matarangi	Kihikihi	Raglan Te Akau Wharf Rd
Map Ref.	T12:642-413	T12:646-382	T10:483-929	S15:170-490	R14:747-776
Well No.	6661	4837	4792	960/1	6600
Depth to water (m)	30	43	2	35	80
D rating	3	1	9	1	1
D Index	15	5	45	5	5
Net Recharge (mm y-1)	**80**	**60**	**300**	**50**	**50**
R rating	2	2	9	1	1
R Index	8	8	36	4	4
Aquifer media	rhyolite	rhyolite	sand	sand	sandstone
A rating	5	5	7	7	6
A Index	15	15	21	21	18
Soil media	sandy loam	sandy loam	sandy loam	silt loam	silty sand
S Rating	6	6	6	4	7
S Index	12	12	12	8	14
Topography	3	6	<2	4	4
T rating	9	8	10	9	2
T Index	9	8	10	9	2
Impact of Vadose	clay	sand and clay	silt	clay	clay
I rating	3	4	4	3	3
I Index	15	20	20	15	15
Hyd Cond (K)	<1	37.8	23	<1	<1
C rating	1	6	4	1	1
C Index	3	18	12	3	3
Drastic Index	77	86	156	65	61

Appendix III: Example Water Supply Site Sheet

Site Name:	**Pukekawa**	**Site (Hydrol) No:**	**61.1255**
Permit Number:		WellNo./Type	1191
Map Reference:	R13:863-270	Bore logs? (y/n)	No
Address:	Sh22	Driller	
	Pukekawa	Year of Construction:	
Person to Contact:	Gary Dent (P)	Depth (m):	95.5 (pump depth)
		Diameter (mm):	76
		Casing depth (m)	
	(09) 233 4784	Casing type:	
Number of People Served:	148 Children	Pump details:	Deep well cylinder
Aquifer Geology:		Sample method:	School taps
Drastic Index:		Sampling regime:	
Registered Supply? (y/n)	yes	Water Quality:	High lead and iron
Land Use:	Agriculture	Topography:	Gently rolling

Site Map
(p.t.o. for site photo)



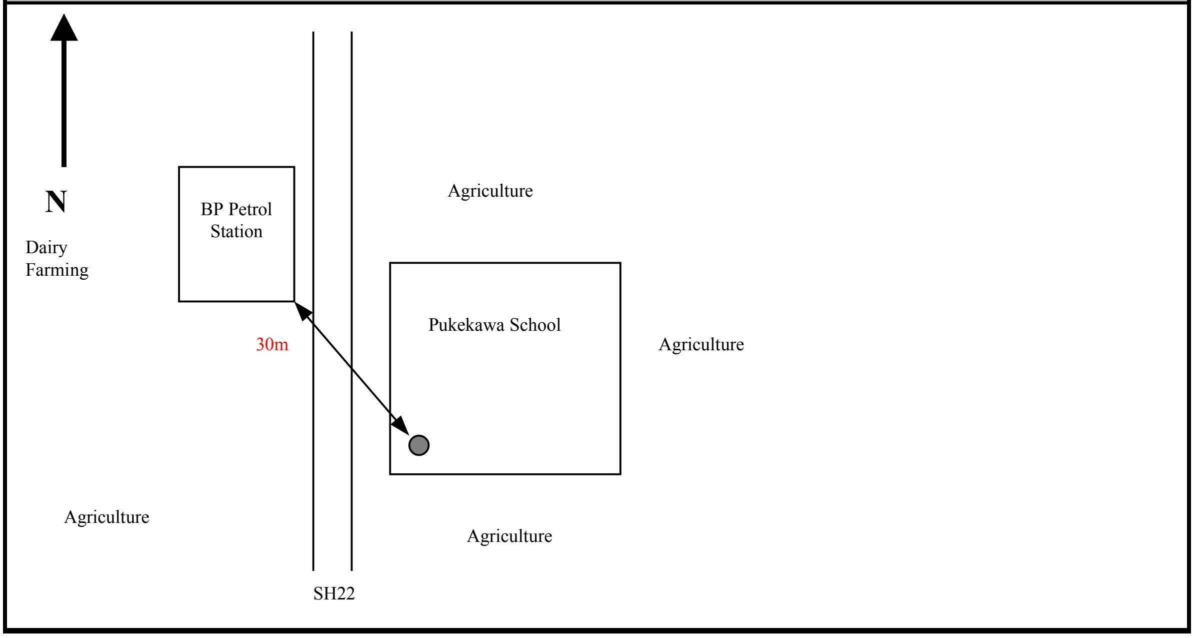
COMMENTS[1]
Bore water is used for everything including drinking. Bore water was sampled and tested at the beginning of 1999 and the end of 1998 by Auckland Health Care – high concentrations of lead showed up. Bore water is filtered, bore head is oily and sealed – no access for water sample or level. To sample – wrap plastic sheeting around tap in pipework in the pump shed. Use float switch in storage tank to start the pump. Turn on tap and flush for 10 to 15 minutes. Sample. Septic tanks redone June 2000 – new outfall into paddocks west of school.

Notes: 1 Current Water Quality Sampling Regime, Sampling Method and Access

OSH HAZARD IDENTIFICATION

Hazards	**Location**	**Risk**	**Action Required**
Children	In driveway and carpark		Keep an eye out

LAND USE[2]



Notes: 2 Potential threats and details regarding distances.

Photograph numbers: 270 to 273

270. Pump

271. Filter and Pressure Tank

272. Landuse and Topography

273. Storage Tank and Pump Shed