Tourism, Water and Waste in Akaroa: Implications of Tourist Demand on Infrastructure

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Executive Summary

There are three components to this research project. The first is the quantitative analysis of the impact of tourist flows to Akaroa on the town's water supply services and wastewater management services. The second is the quantitative analysis of the impact of tourist flows to Akaroa on the town's solid waste management services. The third component is the investigation of the way in which water supply, wastewater and solid waste systems are funded. This analysis investigates whether there are alternative funding systems that are more efficient, moderate demands, and are more equitable than present funding systems. It also considers how best to allocate any additional costs of water supply if there is growth in tourist numbers.

From October 2002 to January 2003, three 4-day intensive surveys were conducted within Akaroa township. These involved working with individual accommodation businesses, to record guest-nights, water consumption and waste production for each day during that study period. A survey of a sample of non-residential properties quantified how many non-permanent people were in town and measured their water use. A survey of pedestrians identified the ratio of day visitors to overnight visitors. Other data included road traffic counts, supermarket foot traffic, etc. We correlated this "tourism" flow data with data on water consumption, wastewater production and solid waste production.

A model of water use and wastewater production was completed to determine the shares of water use and wastewater production attributable to residents, the commercial sector and visitors. Irrigation is identified as a major use of water during peak periods. The model was designed to estimate peak daily flows (important for infrastructure design to safely handle peak flows) as well as monthly mean flows. Lawn and garden watering are likely to be the cause of high water demand during the peak tourist season. Internal water use correlates closely with dry weather wastewater flows. Tourists' demand on Akaroa's water supply could be as high as 60 per cent of the total daily peak water use. However when analysing average monthly demands tourist’s use ranges between five to 40 per cent of the total monthly water use.

Infiltration of the sewer network by runoff following rainfall is identified as a major source of peak wastewater flows.

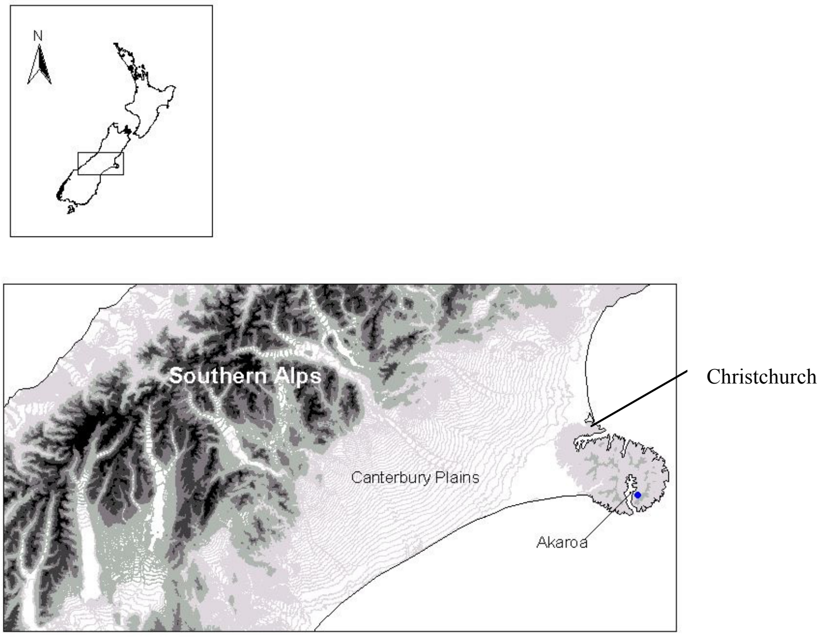
Volumes of waste in street bins are strongly correlated with numbers of visitors to Akaroa.

The systems used by Banks Peninsula District Council (BPDC) to fund Akaroa's water, wastewater and solid waste systems are critiqued against ten criteria and are found to perform poorly. The mix of rates and charges fail to meet efficiency or equity objectives. Residents and holiday homeowners pay disproportionately large shares of the costs of these systems. Water meters have been installed in Akaroa and volumetric water and wastewater charges can be introduced, following further data collection, to reduce peak water use and more accurately allocate costs. This will also lower BPDC operating costs and avoid the need for new water supply capacity.

Chapter 1
Modelling Water and Wastewater in Akaroa

The Tourism Recreation Research and Education Centre (TRREC) at Lincoln University has a long-term research programme on the social, economic and environmental effects of tourism in New Zealand. The Christchurch case study continues the programme and while the main focus is on the city itself, the nearby town of Akaroa provides an ideal setting to obtain a more precise understanding of the impact tourists have on water consumption, solid waste and wastewater production. There are a number of smaller towns like Akaroa in New Zealand that are popular seasonal tourist venues with a weak rating base for funding the high standard of infrastructure demanded by the tourist industry. Consequently research that improves our understanding of the link between tourists and infrastructure is likely to be important in managing the regional impacts of growth in tourism. Akaroa is a small rural town located on the Banks Peninsula, Canterbury, New Zealand see Figure 1. It is a popular tourist resort for both international and New Zealand visitors. The township has a permanent population of 576 residents (www.bankspenisula.com, 2002), but it attracts many visitors throughout the year, and the population swells to approximately 3000 people during the Christmas – New Year period. Visitors to Akaroa impact on operating costs and they may be major contributors to the need for greater capacity in the water and wastewater systems.

Figure 1
Location of Akaroa



An indication of Akaroa's ongoing vulnerability to infrastructure supply problems is contained in a recent headline in the ***Akaroa Mail*** (23 Feb 2003) stating that; *Akaroa's water stress not over*. The article quoted the Akaroa Community Board Chairman, Eric Ryder who pointed out to a recent Board meeting: *even though our water supply is coping, we still have to get over Easter.* The problem of water shortage is sufficiently well established that the Banks Peninsula District Council (BPDC) has a roadside sign visible to all motorists entering Akaroa (see Plate 1). The sign advises when water restrictions apply.

Plate 1
Entrance to Akaroa with Road Sign Warning of Water Shortage

There are three major components to this research project. The first two include the quantitative analysis of the impact of tourist flows to Akaroa on the town's water supply service, wastewater management service and solid waste management service. They both review present infrastructure in Akaroa and provide detailed measurement of tourist flow effects.

The third component is the investigation of the way in which water supply, wastewater and solid waste systems are funded. This analyses whether there are alternative funding systems that are more efficient, moderate demands, and are more equitable than present funding systems. It also considers how best to allocate any additional costs of water supply if there is growth in tourist numbers.

Communities require water for households and businesses. They produce sewage and solid waste, which must be disposed of. These community needs are typically provided in New Zealand by territorial local authorities. Provision of these services involves substantial capital investment in collection, storage, treatment and delivery networks. As well there are ongoing operating expenditures for these systems. If communities grow, demands on the water, sewage and solid waste systems are likely to increase, perhaps leading to a need for further capital expenditures to augment the capacity of these systems. Revenue must be collected to meet the capital and the operating costs of these systems. Users and beneficiaries of these systems pay a variety of rates and charges to meet these costs. The types of rates and charges used influence demand for these services, in the short run affecting operating costs, and in the long run influencing the amounts of investment needed. In this report we examine the charging methods for water, sewage and solid waste in Akaroa Township provided by the Banks Peninsula District Council (BPDC). The report comprises three chapters, each of which addresses the three components noted above. Each chapter is relatively independent and describes fully the research on which it focuses, making its own conclusions including policy recommendations.

Chapter 2
Modelling Water and Wastewater in Akaroa

2.1 Introduction: Akaroa's Water and Wastewater Services

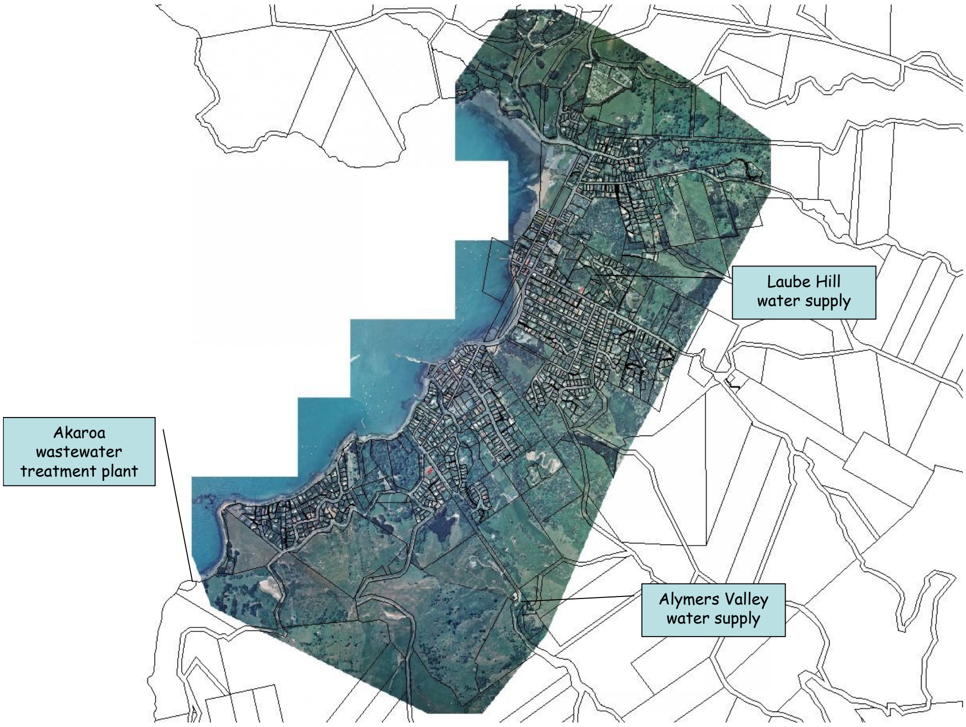
Akaroa has centralised water supply and wastewater services administered by the Banks Peninsula District Council. Akaroa has two water supplies, one with its reservoir and treatment plant at Laube Hill, and the other with treatment and reservoir in Alymers Valley. The Laube Hill site is the main supply and Alymer's Valley is only used when Laube Hill is unable to meet demand. Both water supplies are supplied by rain-fed surface water streams with variable flows. Under drought conditions the three small supply streams provide a combined average stream flow of 7.4 litres per second (Gregor et at., 2002). Total treatment capacity is 2,400 m^3/day (27.6 l/sec) and the total treated storage volume is 2800 m^3. Consented stream water take is 1,729 m^3/day (currently under renewal). Low flow periods tend to correspond with peak water demand from tourist inflows to Akaroa.

The Banks Peninsula District Council (BPDC) reports that the number of water supply connections in Akaroa township is 1010 (BPDC, 2002a pers comm). The situation is documented by Gregor et al. (2002).

> The water shortages have become increasingly frequent and severe, and given the small permanent resident population, limited rating base and limited access to water sources, the District Council has struggled to provide the community with the surety of water supply they desire at an acceptable cost. More recently, the District Council has adopted in principle a ten-year water supply development strategy. While water infrastructure upgrades are planned, focused water conservation measures are intended as an important stopgap and seen by the District Council as instrumental in reducing the cost of infrastructure upgrades. In anticipation of a particularly dry summer, the District Council initiated a save-water campaign in 2001 to augment its existing system of water restrictions.
>
> (Gregor et al., 2002)

The Akaroa Wastewater Treatment Plant (AWTP) is a typical biological treatment plant sited on the southern town boundary on the coastline, discharging to the Akaroa harbour. The peak flow capacity of treatment plant is 60 l/sec and the consented daily discharge volume is 2200 m^3/day (BPDC, 2002a pers comm). The location of the two water supplies and the treatment plant is shown in Figure 2.

Figure 2
Location of Akaroa's Water and Wastewater Services



2.1.1 Types of Properties and Number of Connections

The two primary categories for overnight accommodation for visitors to Akaroa are Commercial accommodation and Non-commercial accommodation. Within the Akaroa serviced area there are about 26 significant commercial tourist accommodation providers. These are made up of:

- Two hotels
- Six motels
- 15 bed and breakfast
- Two backpackers
- One camping ground

It should be noted that it was difficult to obtain exact details of who was providing commercial accommodation; especially bed and breakfast (B&B) accommodation. The BPDC list of rateable commercial properties in the township was used to enumerate the different types of properties. This list was supplemented by observations in the study area. During the course of the study one B&B was sold to become a private home. Another indicated that they were ceasing their commercial B&B activities; however their roadside B&B signboard is still standing. There were a small number of commercial accommodation providers who declined to co-operate with the study.

There are a large number of holiday homes (baches) within the serviced area of Akaroa. The District Council categorises holiday homes as those properties with postal service addresses that differed from that of the property. For the purposes of this study, these were referred to as "official holiday homes (HH) ". The total number of official holiday homes was 387. All remaining homes were called "official permanent residences (PR)" and the number within the serviced area was approximately 545. Thus the total number of private homes is 932. As will be discussed later, it is clear that the actual number of HH was significantly higher than the official number, and the number of PR correspondingly lower. Visitors to Akaroa staying with friends and relations may stay in private and time-share apartments, holiday homes, or in permanent resident homes.

All the above types of accommodation have water meters connected and some of the larger complexes have more than one meter.

The number and category of both water and wastewater connections are listed in Table 1. The total number of water supply connections was 1010 and the total number of wastewater connections was 1007.

Table 1
Number of Water Supply and Wastewater Connections

Total Number of Wastewater Connections		**1007**
Water Supply Connections	Commercial accommodation	26[1]
	Significant[2] small (non-accommodation) businesses and commercial activities.	52
	Private homes (permanent and non-permanent i.e. holiday homes)	932
	Total number of rateable properties registered with the BPDC	1,010

1. This is the number of rateable accommodation businesses. Some of the larger complexes have multiple water supply connections.
2. "Significant" means those businesses sufficiently distinct from a private home and located in the town centre. There are some registered home-based businesses which, for the purposes of this study have been treated as permanent resident homes.

2.2 Research Objectives and Study Method

The first research objective was to obtain sufficient data to be able to carry out a quantitative evaluation of the tourist impact on water supply demand, and wastewater production.

The second research objective was to identify indicators of tourist flow to enable future monitoring of tourist flows in Akaroa without the cost and effort of measuring actual tourist numbers.

These research objectives were achieved by conducting three intensive snapshot studies in October (7-13), December (2-8) and January (13-19). The first two periods are described as shoulder season and the latter is peak season.

For each day of each snapshot study period, a team worked in Akaroa to collect data from within the serviced area. The BPDC provided a detailed GIS plan, to scale, of Akaroa township showing the layout and extent of water supply and wastewater services. This was used to define the boundaries of the survey area. The data collected included indicators of tourist flows, water and wastewater volumes and actual tourist flows. Each is considered in turn.

2.2.1 Actual Tourist Flows: Overnight and Day Visitors

For Commercial Accommodation a full and current listing of commercial accommodation providers for Akaroa, and surrounding area, was provided by the Akaroa Information Centre. Providers located outside the serviced area were deleted from this list. All providers were approached and asked if they would co-operate with providing daily guest night data for each day of the three snapshot study periods. Co-operating providers were then delivered a form at the beginning of each snapshot study. See Appendix A for details of these survey forms. In most cases, nearly all providers co-operated.

The five categories of commercial accommodation providers included, hotels, motels, bed and breakfast (B&B), backpackers and camping ground.

Guest-nights were estimated for those accommodation providers who did not provide actual guest-nights. These estimates were based on the data collected from the other accommodation providers, of the same category, and their corresponding occupancy for each day of the study.

Non-commercial Accommodation was addressed by assuming that holiday home guest-nights are a component of the overnight tourist flow. The other components of informal accommodation are those visitors ("tourists") staying with friends who are permanent residents (PR).

As a means of collecting data on the informal guest-nights, house-to-house surveys were carried out. See Appendix B for the survey forms for both holiday homes (HH) and permanent resident homes (PR). Particular streets were selected and the surveyor visited all houses on one side of that street. The alternative side was surveyed on the next snapshot study period.

A measure of overnight visitors was obtained from the sample of homes surveyed and this ratio of visitors to homes was applied to the total estimated number of both permanent homes and holiday homes within the serviced area of Akaroa.

Day Visitor numbers was estimated by interviewing people walking the street in the town centre area. On most days two people carried out this survey and were able to interview a high percentage of the pedestrians walking along Beach Road. See Appendix C for details of questions contained in the survey. The key information sought was answers to the following questions;

- Were interviewees permanent residents or visitors to Akaroa?
- Were visitors staying overnight or were they a day visitor?
- What type of accommodation were they staying in?

This information was used to determine the ratio of day to overnight visitors. The total number of day visitors was estimated by applying this ratio to the overnight guest night data for each day to the data obtained from the commercial accommodation providers and the house-to-house survey.

2.2.2 Indicators of Tourist Flows

The task was to identify indicators that would accurately reflect tourist flows for the Akaroa township. The criteria for a suitable indicator were:

- Easy and inexpensive to measure
- High correlation to tourist flows
- Could be used again in future.

The four indicators trialed were:

- Door count to Akaroa Information Centre
- Total traffic count into Akaroa
- Door count on public toilets
- Door count on grocery store.

Door counters were installed on the three public toilets within Akaroa (Beach Rd, Jollies Rd and Recreational Park toilets) and on the entrance door of the grocery store. The Akaroa Information Centre already had its own door counter installed. Transit New Zealand's local agent for road counters installed dual counters tapes on Highway 75 on the northern entrance to the town during each snapshot study period.

2.2.3 Water and Wastewater

For all three snapshot study periods there was no need to use the Alymer's Valley water supply as demand was met from the Laube Hill supply. Therefore the water meter at Almer's Valley was not read. There are two water meters at the Laube Hill site. These meters were read on each day of each snapshot study. All commercial properties are fitted with standard water meters and the District Council completed installing water meters for all residential properties during 2002. It was not feasible to read all meters during the snapshot study. Water meters that were read are listed in Table 2. A total of 38 water meters read each day of the snapshot studies.

For each accommodation category, water consumption for accommodation providers whose meters were not recorded were calculated from the values of litres/guest night (L/GN) obtained from those that were measured during the snapshot study.

Table 2
Water Meter Reading

Category	Connection Type	Number of complexes read[1]	Number of complexes in serviced area	Number of meters read[1]
Commercial Accommodation	Hotels	2	2	4
	Motels	6	6	9
	B&B	10	15	10
	Backpackers	2	2	2
	Camping Ground	1	1	1
Small businesses, food supply	Restaurants/café	2	7	2
	Bakery	1	1	1
	Fish and Chips	1	1	1
Small businesses and commercial properties	For example the grocery store	1	48	1
Other	Auto Centre	1	1	1
	Laundry	1	1	1
	Wharf	1	1	3
Reservoir		1	2	2
	Total number of meters read			38

1. The values varied between snapshots (see Table 9). Some accommodation complexes had more than one water meter hence the differences between columns 3 and 5.

Daily wastewater flowcharts were obtained from the wastewater treatment plant operators, City Care.

2.3 Results of Snapshot Studies

The research proceeded by determining how many visitors there were each day to Akaroa, measuring selected indicators of tourist numbers and measuring how much water was used at selected properties and businesses in Akaroa township.

2.3.1 Meter Readings and Accommodation Surveys.

Table 3 lists the total number of accommodation providers who completed forms and it show many water meters of accommodation providers were read.

Table 3
Accommodation Forms and Water Meter Reading

	Total Number of Providers	Accommodation Forms Completed			Water Meters Read		
		10-13 Oct 02	5-8 Dec 02	16-19 Jan 03	10-13 Oct 02	5-8 Dec 02	16-19 Jan 03
Hotels	2	2	2	2	2	2	2
Motels	6	4	5	5	5	5	6
B & B	15	11	12	13	6	10	10
Backpackers	2	2	2	2	2	2	2
Camping ground	1	1	1	1	1	1	1

There were a variety of reasons for the variations between each study period. Some accommodation forms were not completed and there was difficulty in locating some water meters during the first study.

2.3.2 Accommodation

Table 4 presents the results of the survey of the commercial accommodation providers for the three snapshot study periods. The table presents both measured and estimated guest-nights (GN), the latter figure including estimates of GN for those providers for whom survey forms were not completed.

Guest night capacity for the Akaroa serviced area was estimated as:

- Hotels 42
- Motels 284
- Bed and Breakfast 80
- Backpackers 40
- Camping Ground 340
- **Total** **786**

Occupancy

Commercial accommodation occupancy rates for the snapshot periods are listed in Table 4. The values are calculated for guest-nights rather than stay units, as used by Commercial Accommodation Monitor (CAM).

Table 4
Accommodation Occupancy for the Main Accommodation Categories

Accommodation Categories			Thursday	Friday	Saturday	Sunday	Totals
Hotels	Occupancy	Oct	12%	31%	38%	2%	
		Dec	21%	40%	50%	14%	
		Jan	93%	31%	67%	43%	
	Guest-nights (GN)	Oct	5	13	16	1	35
		Dec	9	17	21	6	53
		Jan	39	13	28	18	98
Motels	Occupancy	Oct	25%	57%	63%	19%	
		Dec	42%	55%	62%	32%	
		Jan	54%	72%	71%	54%	
	Measured GN	Oct	72	161	178	54	465
		Dec	119	157	176	90	542
		Jan	153	204	201	154	712
	Estimated GN	Oct	87	194	215	65	562
		Dec	137	197	218	113	663
		Jan	182	249	245	183	859
B and B	Occupancy	Oct	14%	17%	28%	15%	
		Dec	17%	27%	49%	32%	
		Jan	66%	65%	73%	66%	
	Measured GN	Oct	10	12	20	11	53
		Dec	13	21	38	25	97
		Jan	51	50	56	51	208
	Estimated GN	Oct	15	17	28	15	73
		Dec	18	27	49	32	127
		Jan	66	65	73	66	270
Backpackers	Occupancy	Oct	10%	44%	28%	41%	
		Dec	87%	97%	90%	49%	
		Jan	95%	79%	87%	95%	
	Measured GN	Oct	4	17	11	16	48
		Dec	34	38	35	19	126
		Jan	37	31	34	37	139

Using Commercial Accommodation Monitor (CAM) data for guest-nights for Akaroa, overall occupancies (on a monthly basis) are 41 per cent, 56 per cent and 70 per cent for October 02, December 02 and January 03 respectively.

Non-commercial Accommodation

The results of the house-to-house survey are summarised in Table 5, along with the number and types of private residences surveyed. The guest night results are presented in Table 9.

Table 5
House-to-House Survey Details

	Oct	Dec	Jan
a) Total homes inspected (PR + HH) (1)	261	230	232
b) Total number of official HH (2)	387	387	387
c) Total number of official HH inspected (3)	112	84	98
d) Total number of estimated HH inspected (4)	170	173	151
e) Total Number of official PR inspected (3)	149	146	134
f) Total Number of estimated PR inspected (5)	91	57	81
g) Number of HH forms completed	19	17	51
h) Number of PR forms completed	52	32	47
i) Number of likely HH (3)	61	89	53
j) Number of HH that are PR (3)	3	0	0
k) Likely number of "undeclared" HH (6)	211	410	209
l) Potential number of HH (7)	598	797	596
m) Likely number of PR homes (8)	334	135	336
n) Total number of rateable properties	1,010	1,010	1,010
o) Total number of rateable businesses	78	78	78
p) Total number of domestic properties (9)	932	932	932
Ratios			
q) Percent of residences inspected	28.6	24.7	24.9
r) Ratio of LHH/official HH inspected	0.54	1.06	0.54
s) Percent of estimated HH inspected	28.4	21.7	25.3
t) HH forms as percent of estimated HH	3.2	2.1	8.6
u) Percent of estimated PR inspected	27.2	42.2	24.1
v) PR forms as % of estimated PR	15.6	23.7	14.0

Notes:
1. This is the total number of official holiday homes (HH) and official permanent residences (PR) that were inspected.
2. The number of official HH as provided by the District Council.
3. The term "inspected" means that the surveyor visited the home and if there was some adult home, a survey form would have been completed, otherwise the surveyor would have observed whether it was obviously a HH or PR. If it was an official PR that looked like a HH then it would have been designated as LHH. If it was an official HH that was clearly a PR, then was designated LPR.
4. This is calculated as: c + i – j.
5. This is calculated as: e– i + j.
6. The likely number of undeclared HH is calculated as: b x r.
7. The potential number of HH is calculated as; b x (1 + r). This is the estimated number of holiday homes in Akaroa.
8. The likely number of PR homes is calculated as; p – l.
9. Total number of domestic properties is calculated as: n - o.

Many of the properties surveyed in the house-to-house survey were unoccupied, making it difficult to obtain details of occupancy. It was often very obvious if a home was a holiday home. This made it possible to cross check holiday homes with the District Council's official list of holiday homes. The ratio of likely to be holiday homes (LHH) to official holiday homes (row 'r' in Table 5) was 0.54, 1.06, and 0.54 for October, December and January studies respectively. The value of 0.54 was used to estimate the total number of holiday homes and permanent residences in Akaroa.

For the purposes of this study it was therefore estimated that:

- Holiday homes 600
- Permanent residences 300
- Number of homes unoccupied 32
- **Total number of private homes 932**

It should be noted that by these observations and subsequent ratios the number of holiday homes (600) is significantly greater than the official number of holiday homes (387).

2.3.3 Town Centre Street Survey

Pedestrians in the town centre were intercepted and asked various questions. A summary of the results follows in Table 6. More details can be found in Table 9.

Table 6
Summary of Results from Town Centre Street Survey

	Average	Min	Max
Number surveyed per day	204	19	361
Ratio: day visitors/overnighters	1.81	0.87	3.75
Ratio: commercial/non-commercial guest-nights	2	1.19	3.9
Estimated non-commercial guest-nights	193	39	513
Estimated day visitors	975	213	2,194

The survey information was used to determine the ratio of day to overnight visitors. By applying this ratio to the overnight guest night data for each day, obtained from the commercial accommodation providers and the house-to-house survey, it was possible to estimate the number of day visitors to Akaroa.

The average number of people surveyed on each day was 204, varying between a minimum of 19 (a very wet and cold day) and a maximum of 361. Of particular interest were the following ratios:

- Day-visitors to overnight visitors. This ratio was used to estimate the likely number of day visitors to Akaroa by multiplying the number of guest-nights obtained from accommodation surveys. Using this approach the number of day-visitors was estimated and ranged from 213 to 2,194 with an average of 975 per day.
- Commercial to non-commercial accommodation: This ratio was used to check the estimate of non-commercial accommodation from the house-to-house survey. Table 7 compares these ratios.

Table 7
Ratio of Commercial to Non-commercial Accommodation from Town Centre (TC) Survey and House-to-House Survey (H to H)

		Ratio: TC survey	**Ratio: H to H survey**
Oct-02	Thursday 10th	3.17	1.49
	Friday 11th	2.13	2.94
	Saturday 12th	2.07	2.31
Dec-02	Thursday 5th	3.47	4.75
	Friday 6th	3.30	2.66
	Saturday 7th	2.24	2.27
	Sunday 8th	1.67	3.30
Jan-03	Thursday 16th	3.94	0.85
	Friday 17th	1.66	0.87
	Saturday 18th	1.19	0.99
	Sunday 19th	1.46	1.34

Assuming the house-to-house survey is an accurate estimation of non-commercial guest-nights, the low level of agreement between ratios in Table 7, suggests that a TC survey alone would not give an accurate estimate of accommodation types used by visitors to Akaroa.

There was no way of checking the accuracy of the TC survey for determining a reliable day-visitor to overnight visitor ratio.

Importantly, there was no obvious relationship between commercial and non-commercial guest-nights.

2.3.4 Indicators

The results of the indicator data are presented in detail in Table 9. Of primary interest is how well the indicators correlate with some of the key variables. The correlation coefficients (CC) for the various indicators and specific variables are summarised in Table 8.

Table 8
Indicator Correlation Coefficients (CC) and Linear Regression

Variable, y	Indicator, x.	CC	Linear regression equation	Number of data points
Total visitors[1]	Road count	0.790	y = 2.32x - 1107	12
Total guest-nights[2]	Road count	0.827	y = 1.03x – 584	12
Commercial guest-nights	Road count	0.874	y = 0.465x - 186	12
Non-commercial guest-nights	Road count	0.753	y = 0.56x – 398	12
Wastewater production	Road count	0.753	y = 0.094x + 41.1	11
Information Centre door count	Road count	0.797	y = 0.234x – 36.05	12
Grocery store door count	Road count	0.888	y = 1.015x - 250	11
				12
Total guest-nights	Information Centre door count	0.899	y = 3.83x – 295	12
Total visitors	Information Centre door count	0.833	y = 8.33x – 377	12
Day visitors	Information Centre door count	0.706	y = 4.53x - 89.6	12
Wastewater production	Information Centre door count	0.758	y = 0.32x + 73.4	11
Total guest-nights	Grocery store door count	0.900	y = 0.98x – 290	11
Non-commercial guest-nights	Grocery store door count	0.872	y = 0.57x – 269	11
Wastewater production	Grocery store door count	0.989	y = 0.134x + 13.2	9
Day visitors	Total public toilet count	0.639	y = 0.978x – 65	12
Total guest-nights	Total public toilet count	0.862	y = 0.983x – 169	12
Total visitors	Total public toilet count	0.775	y = 0.216 +388	12
Total public toilet count	Road count	0.944	y = 1.368x – 1.69	12
Total guest-nights	Wastewater production	0.904	y = 0.092x + 89	10

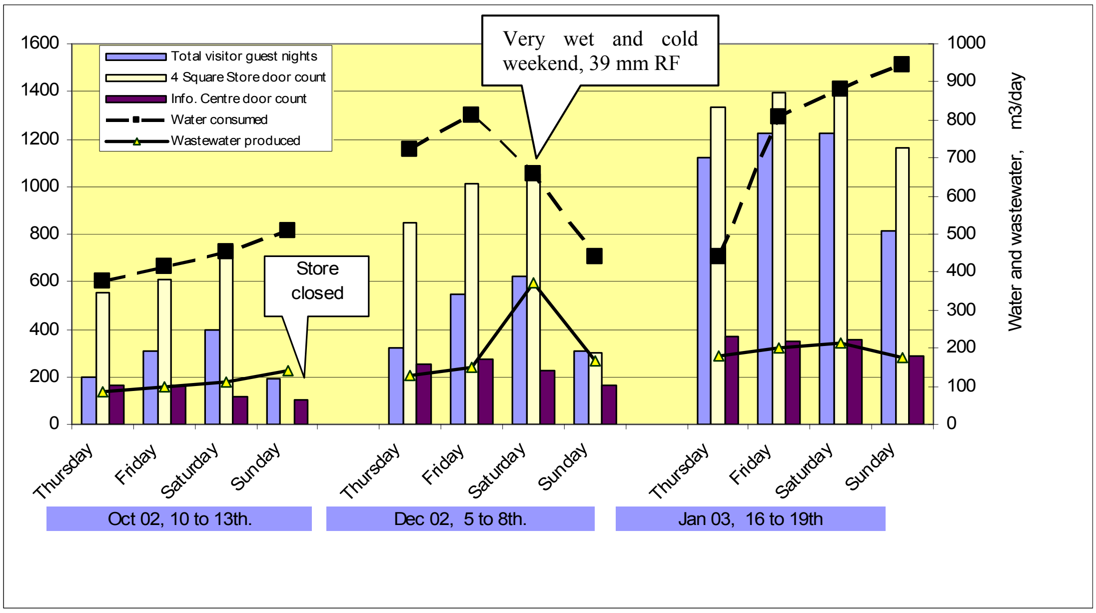
Notes
1. Includes day visitors and overnight visitors
2. Includes commercial and non-commercial guest-nights

It is clear that there are strong correlations between some indicators and variables. Very good correlations (CC>0.85) exist between:

- Commercial guest-nights and road count
- Grocery store door count and road count
- Wastewater production (dry weather flows) and grocery store door count
- Total guest-nights and Information Centre door count
- Total visitors and Information Centre door count
- Total guest night and grocery store door count
- Total guest night and public toilet door count
- Total public toilet use and road count
- Non-Commercial guest-nights and 4 Square door count
- Total guest night and dry weather wastewater flow

Figure 3 illustrates some of the key results for each snapshot study period.

Figure 3
Selected Indicators and Water and Wastewater Volumes from Snapshot Studies



It is noticeable from Figure 3 that water consumed is significantly higher than wastewater flows.

Table 9
Survey Results

		October 2002				December 2002				January 2003			
	Weather	Sunny all day.	Rain in am. Overcast pm.	Morning overcast. Sunny and warm by midday. Cold and raining from 7.30pm.	Overcast and wet in am. Sunny in the pm.	Hot & fine.	Hot & fine.	Hot & fine.	Very wet & cold. 39mm of rainfall.	Hot & fine.	Fine & overcast.	Fine & overcast in am. Sunny & hot pm.	Overcast in am. Fine pm.
	Day	**Thu**	**Fri**	**Sat**	**Sun**	**Thu**	**Fri**	**Sat**	**Sun**	**Thu**	**Fri**	**Sat**	**Sun**
	Date	**10th**	**11th**	**12th**	**13th**	**5th**	**6th**	**7th**	**8th**	**16th**	**17th**	**18th**	**19th**
Accommodation	Guest-nights at holiday homes	55	72	100	55	45	138	162	55	554	637	581	304
	Visitor guest-nights with permanent residents	29	7	22	29	11	11	28	17	51	20	35	43
	Total non-commercial. Guest-nights[1]	**84**	**80**	**122**	**84**	**56**	**149**	**1290**	**72**	**604**	**656**	**616**	**347**
	Hotel guest-nights	5	13	16	1	9	17	21	6	39	13	28	18
	Motel guest-nights	72	161	178	54	137	197	218	113	182	249	245	183
	Bed and Breakfast guest-nights	15	17	28	15	18	27	49	32	66	65	73	66
	Backpackers guest-nights	4	17	11	16	34	38	35	19	37	31	34	37
	Other guest nights	29	26	48	23	68	117	109	67	191	210	230	163
	Total commercial. Guest-nights[2]	**125**	**234**	**281**	**109**	**266**	**396**	**432**	**237**	**515**	**568**	**610**	**467**
	Total commercial. & non-comm. guest-nights	209	314	403	193	322	545	622	309	1,119	1,224	1,226	814
	Ratio - com./non-com.	***1.49***	***2.94***	***2.31***	***1.30***	***4.75***	***2.66***	***2.27***	***3.30***	***0.85***	***0.87***	***0.99***	***1.34***
Town Centre Survey	Number surveyed[3]	105	137	237	19	198	172	238	73	287	299	324	361
	Total commercial. Guest-nights[4]	**38**	**17**	**31**	**0**	**59**	**33**	**65**	**15**	**63**	**83**	**69**	**60**
	Total non-commercial. Guest-nights[5]	***12***	***8***	***15***	***4***	***17***	***10***	***29***	***9***	***16***	***50***	***58***	***41***
	Ratio – com./non-com. Guest-nights	3.17	2.13	2.07	na	3.47	3.30	2.24	1.67	3.94	1.66	1.19	1.46
	Estimated day trippers[6]	213	1,157	588	724	315	1,199	622	476	2,194	1,065	1,619	1,531
Total Visitors (day & overnighters)		**422**	**1,471**	**990**	**916**	**637**	**1,744**	**1,244**	**784**	**3,313**	**2,289**	**2,845**	**2,345**
Water Wastewater	Water consumer, m^3 day[7]	374.2	415.7	454.3	509.7	723	811	660	439	439	806.2	879.3	944.6
	Wastewater produced[8]	84.7	98.2	110	141.6	130	149.1	373.6	168.02	178.2	199.3	213	174
Indicators	Info Centre door count	167	162	115	105	254	271	226	166	367	346	355	290
	Grocery store	551	606	751	Closed	850	1,012	1,055	300	1,334	1,393	1,420	1,160
	Jolie Road toilet count	108	115	243	258	226	168	215	317	525	466	495	506
	Beach Road toilet count	304	278	387	314	468	363	502	292	1,146	629	911	1,033
	Recreation Ground toilet count	107	116	272	281	165	152	344	184	261	227	284	303
	Total toilet count	**519**	**509**	**902**	**853**	**859**	**683**	**1,061**	**793**	**1,932**	**1,322**	**1,690**	**1,842**
	Road count	781	860	961	938	1,042	1,249	1,273	775	1,316	1,407	1,591	1,732

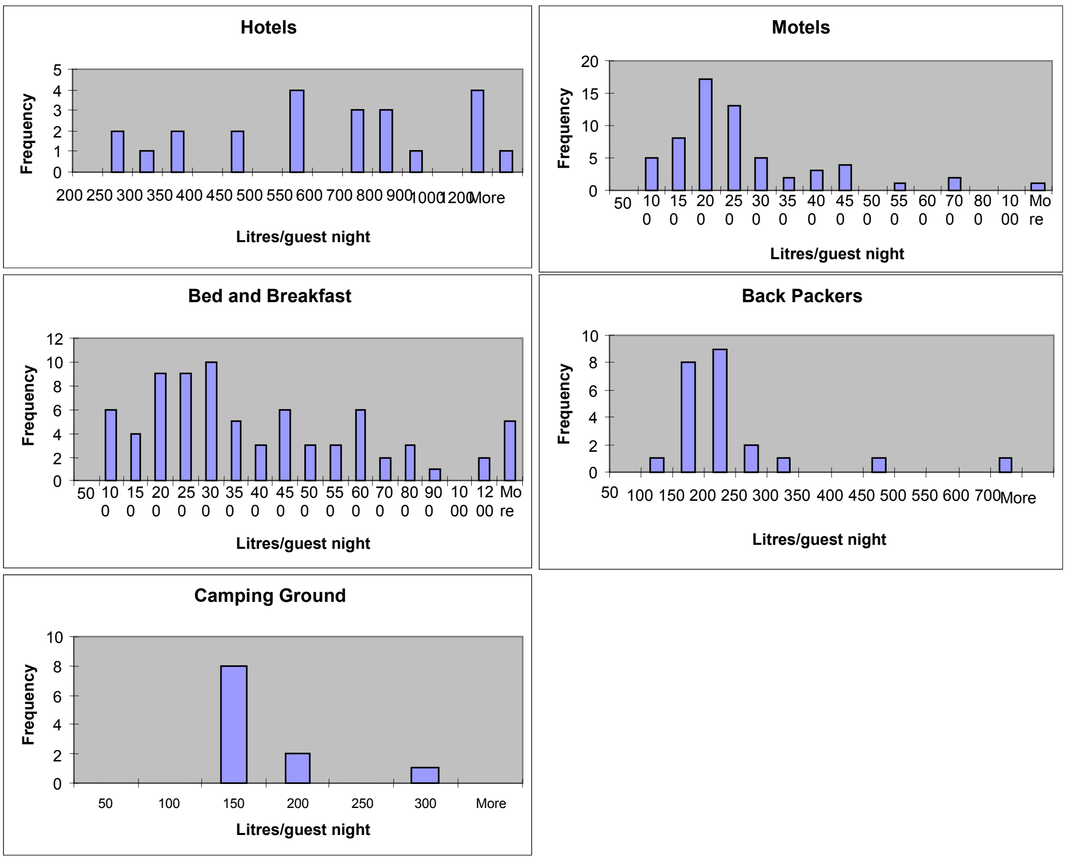
Notes:
1. "Total non-commercial bednights" is the number of visitors and tourists staying overnight in holiday homes or with friends who are permanent residents in Akaroa.
2. "Total commercial guest-nights" is the number of tourists or visitors staying overnight with a registered commercial accommodation provider.
3. "Number surveyed" is the total number of people who provided answers to the "Town Centre survey form" – See Appendix C.
4. "Total commercial guest-nights " is the number of people who said they were accommodated with a commercial provider.
5. "Total non-commercial guest-nights" is the number of people who said they were accommodated in holiday homes or with friends who were permanent residents.
6. "Estimated day trippers" was determined by multiplying "Ratio – day trippers/overnighters" by "Total guest-nights – com. and non-com.
8. Data from the flow measurement charts and the Akaroa wastewater treatment plant (AWTP).

2.3.5 Water Consumption

Accommodation and Businesses

Table 2 lists the 38 water meters that were read each day of the study periods. For accommodation providers in each of the five accommodation categories, the daily data were normalised to litres/guest night. Histograms of these data sets are displayed in Figure 4. The results of these analyses are summarised in Table 10. The hotel data is distorted by the fact that both hotels ran several bars and restaurants. Bar and restaurant activity was highly variable, depending on what, if any events may be on in Akaroa on the day, and the weather which influenced day visitors from Christchurch particularly in the weekend. Water use per guest night for the hotels is highly variable.

Figure 4
Histograms of Average Normalised Water Demand (litres/guest night) for the Commercial Accommodation Providers



For the purposes of this study water use was subdivided into two categories, 'internal' and 'external'. The former referred to water use within the building that should drain to the wastewater system. The latter category includes outside watering activities such as irrigation, car and boat washing and swimming pool and spa pool flushing and cleaning.

It is clear that water demands per connection are highly influenced by irregular high demand external activities. For example in the January study a B&B recorded the normalised water demands of 170, 73, 415 and 3163 litres/guest night for Thursday, Friday, Saturday and Sunday respectively. The very high demand for Sunday was due to a contractor doing water blasting to prepare the building for painting.

Table 10
Statistical Description of Normalised Total Water Use, Litres/Guest Night

	Hotel	Motels	B and B	Back Packers	Camping Ground
Mean	685.9	252.1	482.3	190.3	137.8
Standard Error	99.7	27.5	64.7	23.9	15.1
Standard Deviation	488.5	216.6	571.5	116.9	52.3
Range	2,363.2	1,589.0	3,140.8	572.3	217.0
Minimum	164.3	37.7	22.5	67.7	63.8
Maximum	2,527.5	1,626.7	3,163.3	640.0	280.8
Count	24.0	62.0	78.0	24.0	12.0
Confidence Level (95.0%)	206.3	55.0	128.8	49.4	33.2

High demand outliers were excluded from the analysis in an attempt to find reasonably consistent 'internal' water demand per guest night. The hotels were excluded from this analysis. The results of this analysis are presented in Table 11.

Table 11
Statistical Description of Normalised 'Internal' Water Use, Litres/Guest Night

	Motel	B and B	Back packers	Camping Ground
Mean	183.0	213.9	153.2	137.8
Standard Error	8.5	13.8	7.1	15.1
Standard Deviation	60.6	94.6	32.5	52.3
Range	267.3	367.5	149.8	217.0
Minimum	37.7	22.5	67.7	63.8
Maximum	305.0	390.0	217.5	280.8
Count	51.0	47.0	21.0	12.0
Confidence Level (95.0%)	17.0	27.8	14.8	33.2

Based on the data in Table 11, average 'internal' water demand in litres/guest night for the different categories of accommodation was assigned as follows:

- Hotel (assumed to be similar to motels figure) 185
- Motel 180
- Bed and Breakfast 220

- Backpackers 160
- Camping Ground 140

Note that in determining the litres/guest night, the total water consumption measured for the property was divided by the total number of people drawing on that water. This would include overnight guests plus any permanent residents, e.g., owner and family.

To model water consumed by tourist related businesses the research focused on restaurants, cafés, auto centre, the wharf and the hotel bar/restaurants. The metered water use for these businesses is presented in Table 12. The shaded values for the bakery and fish and chip shop were exceptionally high. The high bakery results were due to a leakage in the water supply line that was subsequently repaired. No explanation has been provided for the high fish and chip shop water use. The water demand at the wharf was primarily for eco-tourism boat and launch washing. Apart from the hotels (which include guests water use), bakery and fish and chip shop, the quantities of water used are relatively small.

Table 12
Water Demand for Tourist Related Businesses.

	October 2002				**December 2002**				**January 2003**			
	Thu 10th	Fri 11th	Sat 12th	Sun 13th	Thu 5th	Fri 6th	Sat 7th	Sun 8th	Thu 16th	Fri 17th	Sat 18th	Sun 19th
Total visitors/day	**422**	**1,417**	**990**	**916**	**637**	**1,744**	**1244**	**784**	**3313**	**2,289**	**2,845**	**2,345**
Total water for hotels (litres)	4,708	8,870	10,980	13,570	13,560	11,130	12,010	10,660	14,850	14,560	15,860	13,030
Restaurants (litres)	840	1,559	2,000	1,950	1,593	2,120	2,097	1,353	2,113	2,243	2,283	1,870
Wharf (litres)	474	1,300	870	260	2,480	2,300	2,110	420	3,840	3,390	2,840	3,390
Fish and chip shop (litres)	248	4,380	1,180	1640	13,140	12,230	12,970	11,760	300	2,960	260	19,250
Bakery, (litres)	9,767	12,410	13,920	14,160	1,140	990	1,140	930	1,820	1,700	1,970	1,490
Laundry, (litres)							3,700	2,650	3,670	2,830	3,660	4,100
Auto centre, (litres)	1,300	1,580	1,200	1,180	1,750	6,030	6,040	7,000	3,550	3,160	4,190	4,680
General Store, (litres)	160	220	130	110	230	200	190	150	180	250	260	200

The analysis then calculated correlation coefficients between water use and visitor numbers, and linear regressions were estimated. The exceptionally high water use values by the bakery and fish and chip shop were excluded in the correlation and linear regression analyses.

In the analyses of the water consumption rates for small tourist related businesses, the food producing businesses, i.e., the restaurants, cafés, bakery and fish and chip shop were treated as one group. As can be seen in Table 13, the correlation coefficients (CC) for water consumption with total visitors for the first two business types (Restaurants/café/fish and chip/bakery, and Hotels, bar/restaurant) are both low at 0.68. The water quantities used by these two business types are relatively small and it was decided to use the resulting linear regression equation for the water use model. The last two CC values (wharf and auto centre) are both larger than 0.80 and linear regression equations for the wharf and auto centre were also used for the water consumption model.

Table 13
Correlation Coefficients (CC) and Linear Regression: Small Business Water Demand

Business category	Linear regression	CC	n
Restaurants/café/fish and chip/bakery	y = 0.311x + 1344	0.680	12
Hotels, bar/restaurant	y = 2.15x + 8597	0.685	12
Wharf	y = 1.138x + 176	0.829	12
Auto Centre	y = 1.155x + 563	0.864	9

Notes : y = litres/day
x = Total visitors/day
n =the number of data sets

Analysis of External Uses

It was clear from the results, as illustrated in Figure 3 that total water use, including external water use, can be very high and unpredictable. Local residents suggested that three likely contributors were garden and lawn watering (irrigation), boat washing and reticulation leakages. Their relative contributions are explored using some simple calculations.

High external water demand corresponded with periods of hot dry weather. Some holiday homeowners commented that because they only visit Akaroa for short periods they felt justified in giving their garden or lawns a good watering during their visits.

Irrigation

The flow rate from two typical single garden and lawn sprinklers were measured and the average flow rate was 15 litres/min. Thus one single garden sprinkler watering for three hours would use 2,700 litres. If ten per cent of Akaroa's permanent residents and holiday home properties irrigated on one day this would use a total of 240 m^3 (240,000 litres).

Some of the larger gardens have several sprinklers running at one time. A B&B property with a very large garden used 9,600 litres in one day and the owners advised the researchers that they had been irrigating their property on that day.

Boat Washing

Several local people noted that many visitors have boats and wash them after use in the Akaroa Harbour. Plate 2 illustrates boat washing in operation at Akaroa. During one day of the survey, six boat-washing activities at the Akaroa boat ramp were observed. The volume of water used per boat wash ranged from 85 litres to 600 litres with an average of 342 litres. The volume of water used depended on how long the washing took and on the faucet setting. If 40 boats were washed in one day this would equate to a total water demand of about 14 m^3 (14,000 litres). On a busy boating day during the January snapshot study 40 boat trailers were observed parked at the boat ramp car park. Boat washing is likely to place a relatively small demand on water use in Akaroa.

Plate 2
Boat Washing

Leakage

It was not possible to measure water uptake due to leakage but occurrences were noted during the shapshot studies and an example is illustrated in Plate 3. The experience with the Bakery (see Table 12) and possibly the fish and chip shop, suggest that leakages may be significant factors in some instances.

Plate 3
Street Leakage

2.3.6 Wastewater

Figure 3 showed that wastewater volumes did not match water consumption, and calculations by the researchers suggest that this is due to significant external water demand. However wastewater volume is impacted by wet weather and can lead to major infiltration of the wastewater system by runoff.

It can be expected that daily wastewater volumes in dry weather will be similar to daily internal water use. This will be discussed later in this report.

Infiltration

Infiltration is a term used to describe the inflow of stormwater to a sewer network as a result of a rainfall event. Infiltration can have a major impact on the flow volume into and out of a centralised wastewater treatment plant. Akaroa's sewer network is susceptible to infiltration. Table 14 shows typical daily outflows when there is no or very little rainfall as compared to when there is a significant rainfall event.

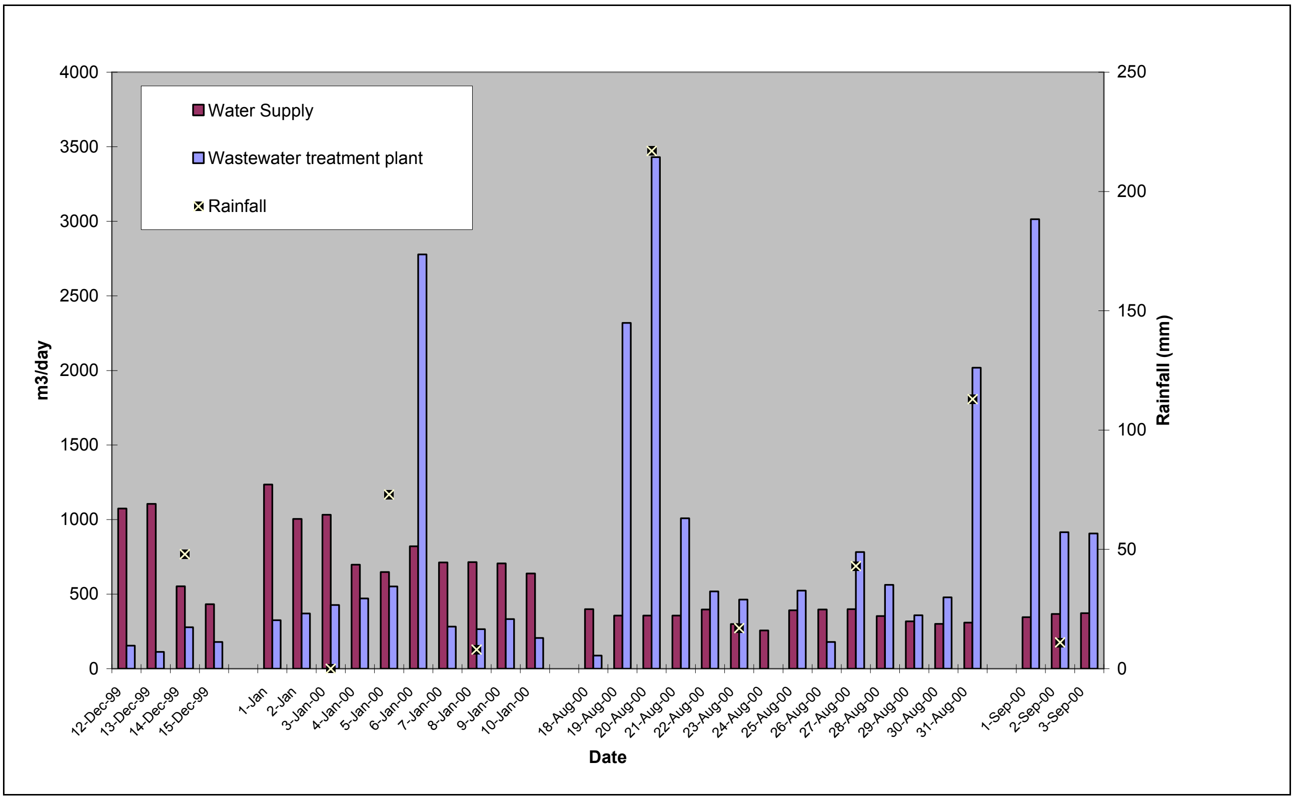
If we assume an average dry weather flow of 150 m^3/day, and a wet weather flow of 3,500 m^3/day as was the case for the 217 mm rainfall event on 20 Aug 2000, then the infiltration peaking factor is 23 (3,500/150), which is very high.

Table 14
Akaroa Wastewater Treatment Plant Outflows During Wet Weather

Date	Mean outflow M^3/day	Rainfall events
9 - 21 Oct 2002	106	12 Oct - 4mm: 13 Oct - 6 mm 13 Oct: 14 Oct - 3 mm
4 - 9 Dec 2002	178	39 mm on 8 Dec resulting in a higher outflow of 374m^3 on that day.
15 - 28 Jan 2003	177	15 Jan - 6mm: 20 Jan – 8 mm: 21 Jan - 6 mm: 22 Jan - 2 mm
Examples of Major Events		
18 - 23 August 2000	88, 2319, 3431, 1009, 519, 464 respectively	The rainfall event that caused this infiltration event was 217 mm over 19 - 20 Aug
30 Aug - 3 Sept 2000	479, 2019, 3014, 916, 907 respectively	The rainfall event that caused this infiltration event was 113 mm on 31st Sept

Figure 5 provides a graphical display of water use, wastewater outflows and rainfall for four selected periods.

Figure 5
Water Usage, WTP Flows and Rainfall



2.4 Modelling Water and Wastewater

2.4.1 Snapshot Modelling

Using the normalised water consumption values and linear regression equations developed in Section 2.5, a spreadsheet model of water use was developed for Akaroa. The model calculates water use and wastewater volume for each day of the three study periods. The output from this model is presented in the following figures and tables.

Figure 6
Total Internal Water Use compared to Actual Water Use and Wastewater Production

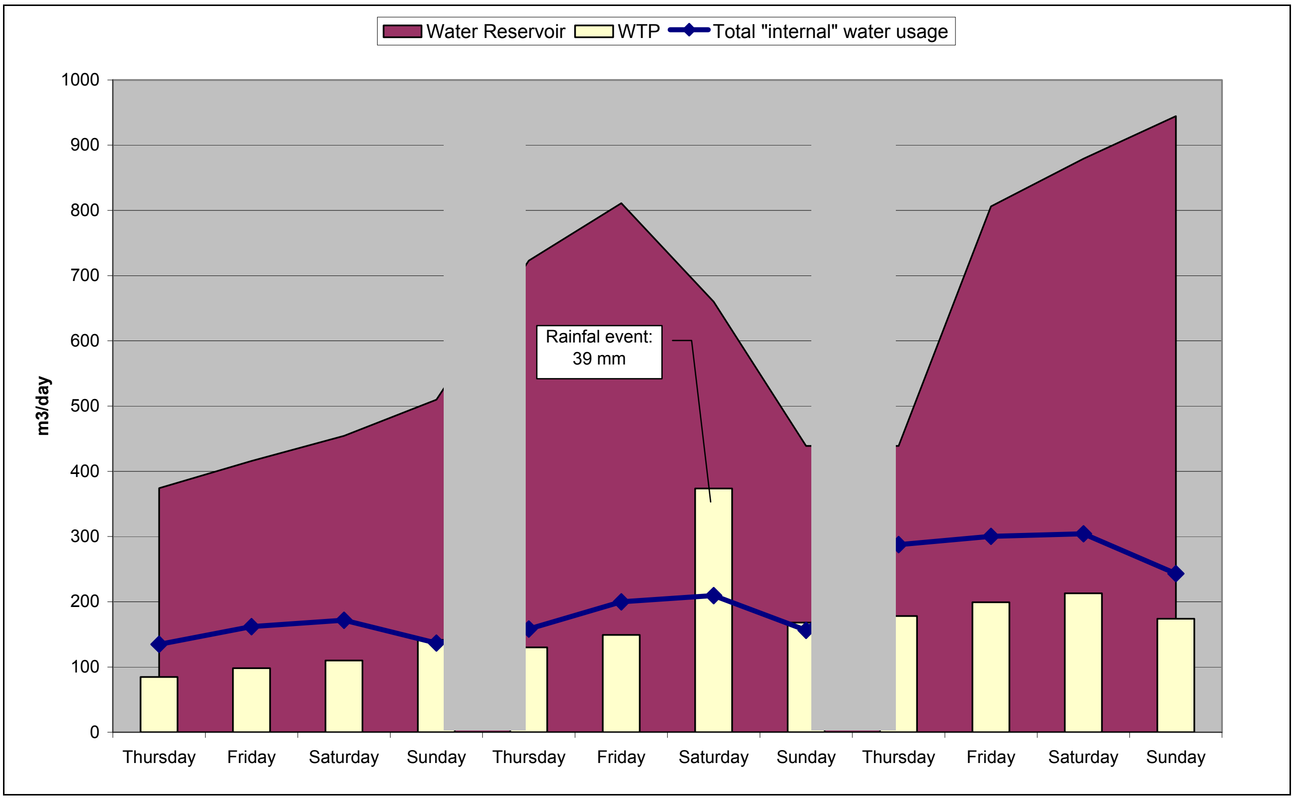


Figure 6 shows internal water use as calculated from the model, as well as the measured water demand for the town and the actual daily wastewater volume. Actual water use is clearly much greater than is internal water use. It was expected that internal water use would be very similar to wastewater volumes from the wastewater treatment plant (WTP). Apart from the infiltration from the rainfall event during the second study period the match is quite good.

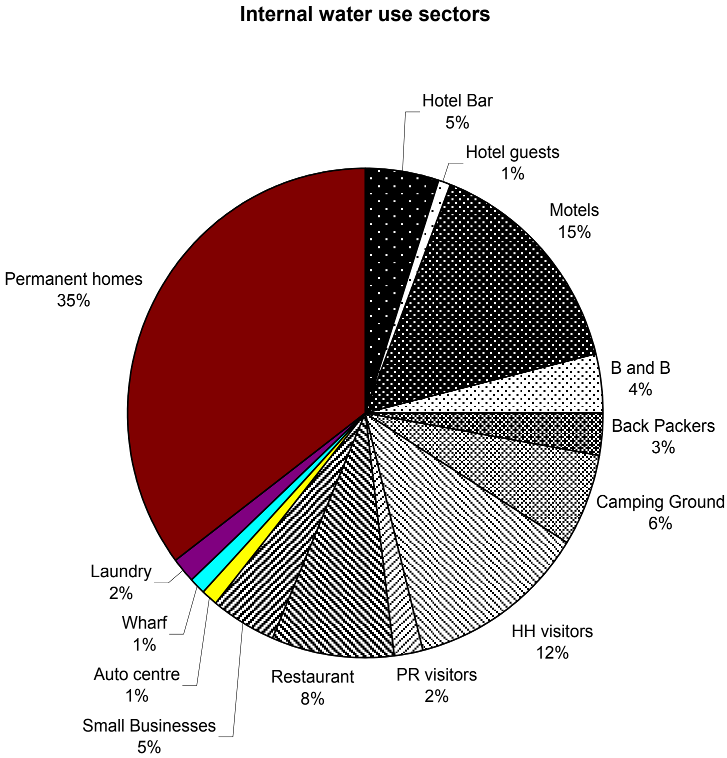
The model was then used to determine the relative shares of internal water consumption between the various users (Table 15). These calculations were based on the four-day water use averages for the three snapshot study periods.

Table 15
Estimated Internal Water Demands by Sectors

	Snapshot Mean, m^3/day			Mean Water Use as Percentage of Total Internal Water Use			
	Oct	**Dec**	**Jan**	**Oct**	**Dec**	**Jan**	**Average**
Hotel Bar	7.40	6.07	5.32	4.9	3.4	1.9	4.9
Hotel guests	1.62	2.45	4.53	1.1	1.4	1.6	1.1
Motels	21.51	30.76	39.73	14.4	17.2	14.2	15.3
B and B	4.13	6.93	14.85	2.8	3.9	5.3	4.0
Back Packers	2.64	6.93	7.65	1.8	3.9	2.7	2.8
Camping Ground	4.10	11.73	25.81	2.7	6.6	9.2	6.2
HH visitors	9.20	13.01	67.46	6.1	7.3	24.2	12.5
PR visitors	3.23	2.49	5.56	2.2	1.4	2.0	1.8
Restaurant	14.76	15.18	19.65	9.9	8.5	7.0	8.5
Small Businesses	8.64	8.64	8.64	5.8	4.8	3.1	4.6
Auto centre	1.66	1.84	3.68	1.1	1.0	1.3	1.2
Wharf	1.26	1.43	3.25	0.8	0.8	1.2	0.9
Laundry	1.97	3.49	5.67	1.3	2.0	2.0	1.8
Permanent homes	67.50	67.50	67.50	45.1	37.8	24.2	35.7
Totals	149.60	178.45	279.28	100.0	100.0	100.0	100.0
WTP flows	108.6	149.0	191.1				
Actual water consumption	438.5	658.3	767.3				
External or unaccounted water use.	289	480	488				

The overall average percentage internal water use by each sector for the snapshot study periods, are presented in Figure 7. Visitors to Akaroa use approximately 50 per cent of all water used in the township.

Figure 7
'Internal' Water Demand in Akaroa by Sector During Three Study Periods.



2.4.2 Peak Sector Demand Modelling

The water use model was also used to predict peak demand by each sector. To complete this analysis the following assumptions were employed:

- Hotel Occupancy Rate 80%
- Motel Occupancy Rate 90%
- Bed and Breakfast Occupancy Rate 75%
- Backpacker Occupancy Rate 80%
- Camping Group Occupancy Rate 85%
- Permanent Residence Visitors Rate 15% (with guests)
- Holiday Home Occupancy Rate 75%
- Number of Day Visitors 3,000

To model external water demand during peak periods, the following assumptions were made:

- 15 per cent of PR and HH homes will irrigate their gardens each day.
- Five per cent of PR and HH will wash their car each day.
- 50 boat washes each day.
- Zero infiltration of sewers by rainfall.

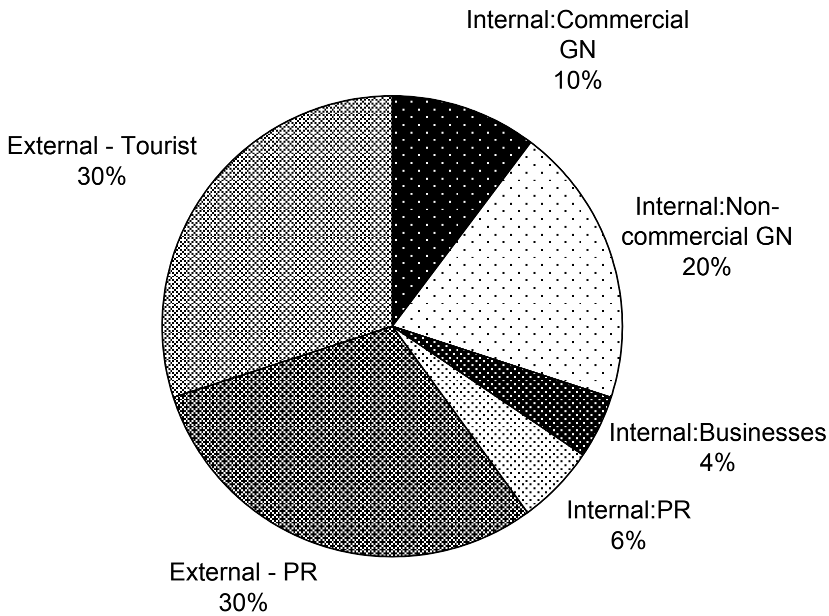
The results of this modelling are illustrated in Table 16 and Figure 8.

Table 16
Peak Flows for Akaroa

	Water m^3/day	Dry weather WTP m^3/day
Internal: Commercial GN	124	124
Internal: Non-commercial GN, i.e. holiday homes and staying with friends	242	242
Internal: Businesses	53	53
Internal: Permanent Residents	89	89
External: Permanent Residents	365	Na
External: Tourists	358	Na
Total	**1,231**	**508**
Infiltration	Na	0
Max Total WTP		**508**

The peak water demands by each sector are displayed in Figure 8.

Figure 8
Sector Peak Water Demands



From Figure 8 it can be seen that during peak water demand periods, the water demand by the various tourist sectors could be as high as 60 per cent of the total. About 37 per cent of total water demand is by permanent residents and the remaining four per cent of demand is due to local businesses.

2.4.3 Monthly Tourist Flows

The snapshot studies and subsequent modelling have enabled a picture to be created of peak water demand and wastewater production. Information on peak flows are useful for the design and capital costing of water and wastewater infrastructure. The capital cost of such infrastructure will be largely determined by peak flow requirements. Operating costs, however, are more closely related to the smoothed or averaged water and wastewater requirements. The snapshot studies and modelling have provided some insight into the contribution to the peak demands of the various tourist and permanent resident sectors.

To obtain an understanding of how the different sectors might contribute to the average demands on water and wastewater, the normalised water demands listed in section 2.5 were applied to the monthly guest-night data for Akaroa provided by the Commercial Accommodation Monitor (CAM).

It was assumed that an average water consumption of 203 l/day for each guest night occurred, based on data provided from the snapshot studies. The 203 litres/day of water includes the guest night share of Akaroa's tourist business water demand.

Using CAM data the water use model's calculated water demand was compared with 35 months (August 1999 to December 2002) of actual water demand.

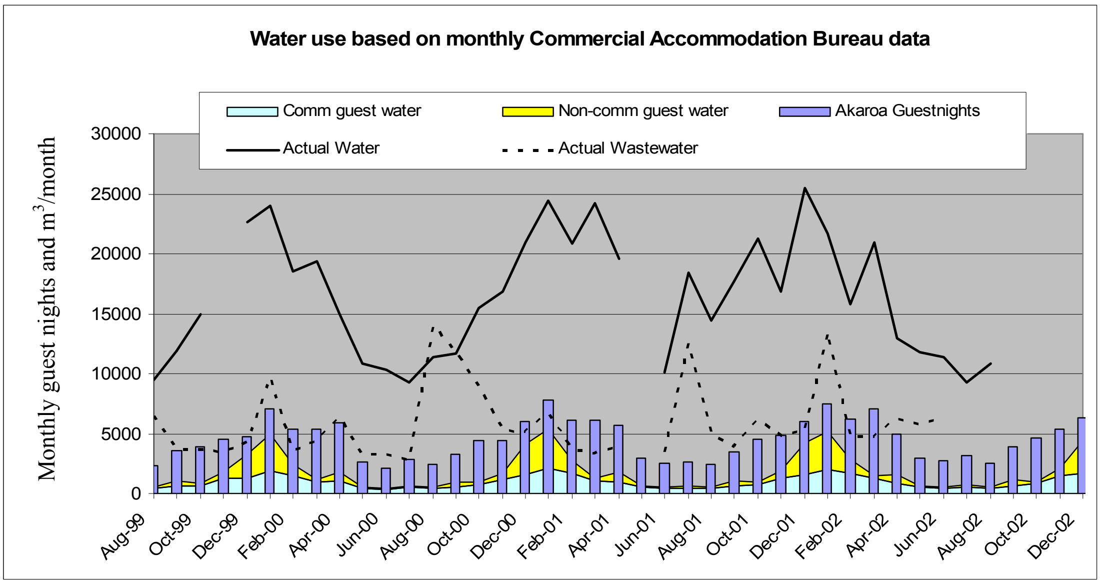
The calculations showed that on a monthly basis, the water demand attributed to commercial guest-nights was on average 4.8 per cent of the total monthly water consumption. The maximum value was 11 per cent and the minimum 2.0 per cent.

Table 17 and Figure 9 present the results of the sector's contribution to monthly water demand.

Table 17
Tourist Sector Contribution to Akaroa's Water Demand Based on Monthly CAM Data (August 99 to December 02)

		Mean	Max	Min
Water	Commercial guest water use as % of actual total water use.	4.8%	11.0%	2.0%
	Non-commercial guest water use as % of actual total water use.	3.9%	17.7%	0.4%
	Total guest water use as % of actual water total water use.	8.6%	28.6%	2.4%
Wastewater	Commercial guest water use as % of actual total wastewater production.	16.9%	38.0%	2.9%
	Non-commercial guest water use as % of actual total wastewater production.	13.7%	56.9%	1.0%
	Total guest water use as % of actual water total wastewater production.	30.6%	92.2%	4.0%

Figure 9
Monthly Water Use Based on CAM Data



Note

- **Comm guest water** is an estimate of water consumed by guests staying in commercial accommodation.
- **Non-comm guest water** is an estimate of water consumed by Akaroa visitors staying in holiday homes and with friends in private homes. Note that these two series are stacked area curves.
- **Akaroa Guest-nights** is the total estimated monthly commercial and non-commercial guest-nights. Monthly commercial is based on actual data obtained from the Commercial Accommodation Monitor (Statistics New Zealand). Non-commercial (holiday home and visitors staying with friends who are permanent residents) was estimated using ratios derived from the three snapshot studies.

2.5 Conclusions

The four key elements of this component of the research were:

1. Monitoring of the number of tourists/visitors staying overnight on each day inclusive of informal or non-commercial guest-nights (i.e., those staying in private holiday homes or with friends who are permanent residents.
2. Monitoring of daily water demand and wastewater production for the whole serviced area of Akaroa and for selected individual connections.
3. Creating a model that demonstrates sector demands on water and wastewater for the Akaroa township.
4. Identifying reliable indicators that would assist with future monitoring and management of water demand, wastewater production in relation to tourist flows.

Non-commercial accommodation such as holiday homes is a very significant provider of guest-nights in Akaroa. The official District Council list of holiday homes underestimated the number of holiday homes by about 200 or over 70 per cent.

Monitoring daily water consumption to individual properties enabled better estimates of normalised water demand (litres/guest night) and demand by small tourist businesses. These values were then used in the water demand models developed for Akaroa.

Total water and wastewater volumes are highly variable and somewhat unpredictable due to high demand external water uses (in particular garden and lawn watering) and rainfall induced infiltration into the town's wastewater sewers. In considering water demand, it was necessary to distinguish between internal water use and external water use. The internal water use correlated well with dry weather wastewater flow, as expected, although the water volume was consistently higher (see Figure 6). Dry weather wastewater flows were predictable, however infiltration from rainfall events can increase wastewater flows by up to 23 fold. External water use was highly variable and is likely to be largely due to garden and lawn watering. High external water demand corresponded to periods of hot dry weather. Car and boat washing placed a small but significant demand on the town's water resource.

A model has been developed that can be used to anticipate, for the different sector users, peak water demand and dry-weather wastewater flows as well as average monthly flows based on CAM tourist data. The model is specific to Akaroa, but it is likely that a similar model could be developed for other small towns so long as sufficient data is available on visitor numbers, and normalised water use rates for each major sector.

Applying the monthly water use model, the tourism sector's share of water use during August 1999 to Dec 2002 was 14.7 per cent on average, but ranged from five per cent to 41 per cent of a month's actual water use (Table 17). The tourism sector's water demand during summer could be as high as 60 per cent of the total peak water demand in Akaroa.

The snapshot studies demonstrated that there are indicators that correlate well with guest-nights and dry weather wastewater flows. In particular road count, grocery store door count and Information Centre doors count showed high level of correlation. Similar indicators are likely to be available in other townships and might be tested to determine how well correlated they are with guest nights and water and wastewater flows.

The insights gained from intensive monitoring of water use and wastewater flows, and the water demand modelling, provide insights that are useful for policy makers. Water demand management issues are examined in the third major section of this report. Improved design and maintenance of the wastewater system is needed to reduce infiltration during high rainfalls.

Chapter 3
Modelling Solid Waste in Akaroa

3.1 Introduction

This chapter examines the impact of tourist flows to Akaroa on the town's solid waste management services.

3.2 Specific Objectives

The specific objectives of the solid waste section of this study were as follows:

- To gather data on representative waste disposal in Akaroa on each of the study days, including the following sectors:
  - Commercial tourism businesses
  - Bed and Breakfast accommodation
  - Street bin and reserve refuse
  - Recycling depot
  - Holiday homes and permanent residents.
- To analyse daily rubbish volumes in terms of the visitor count data.
- To investigate solid waste management practices by business and residents.

3.3 Background on Rubbish Disposal by Tourists in Akaroa

Tourists (visitors) to Akaroa have the opportunity to contribute to the refuse stream in a variety of ways. These include direct disposal such as depositing rubbish in:

- Street-side and reserve bins
- Public-toilet rubbish bins
- Accommodation rubbish facilities
- Commercial tourism activity rubbish bins
- Recycling depot

In addition there is indirect disposal resulting from the use of a service such as:

- Dining in a restaurant
- Purchasing from a souvenir shop
- Partaking in a commercial tourist tour (e.g., wildlife boat cruise).

The refuse stream is serviced by the local council and one private refuse-contractor. Services provided by the Banks Peninsula District Council include:

- A weekly rubbish bag kerbside collection
- A weekly recycling bin kerbside collection
- The Barry's Bay refuse station

- The Akaroa township recycling depot
- Street-side and reserve rubbish bins.

The private contractor provides the following services:

- Wheelie bin hire and collection
- Skip hire and collection
- 44-gallon-drum and woolsack recycling collection.

3.4 Methods

The methods used in the study of solid waste involved recording solid waste volumes and linking these data to visitor counts. In addition questions asked in the surveys described below focused on solid waste management practices.

3.4.1 Obtaining Solid Refuse Volumes

Refuse volumes in cubic metres (m^3) from businesses, street bins, permanent residents, holiday homes and the recycling depot were obtained daily over the specified study periods. This information was derived from both direct measurement and surveys. Appendices contain data on daily volumes of waste from:

- Business refuse
- Street bin and reserve refuse
- Recycling depot.

Commercial Businesses

From a list of all GST-registered businesses in the Akaroa region 76 of these businesses were selected as having primary addresses within the Akaroa town centre and providing services to tourists. The businesses were approached (except Bed and Breakfast accommodation) and permission requested to allow their refuse and recycling to be monitored. Bed and Breakfast refuse information was collected separately by means of a survey sheet developed to collect data on water use, refuse and guest-nights. This survey form was left with the 16 B&B (76% of total) monitored to fill out over each of the study periods.

Business refuse volumes were collected by 21 of 55 (38% total) businesses. The data are limited to those businesses that agreed to the monitoring. All sectors were adequately represented apart from retail/crafts, where only two out of 21 were monitored (Table 18).

Table 18
Numbers of GST-Registered Business in Akaroa According to Business Type

Business Type	Total Number in Akaroa	Total number monitored
Hotels	3	3
Motels	8	4
Backpackers	2	2
Camping Ground	1	1
Bed and Breakfast	21	16
Bakery	1	1
Restaurant/Cafe	8	3
Butchery	1	0
Fish and Chips	1	1
Retail/Crafts	21	2
Dairy/Store	2	1
Supermarket	1	1
Mini Golf	1	0
Small Boats	2	1
Large Boats	1	1
Petrol/Garage	1	0
Transport	1	0
Total	**76**	**37**

The maximum volume of each rubbish container was gathered from known volumes or calculated from container dimensions (Table 19). Each rubbish container was opened, the rubbish levelled, and a mark placed on the container at the level of the rubbish. The distance from the bottom of the bin to the mark was then measured (centimetres). The proportion of the volume of the bin represented by the mark was calculated and then multiplied by the total bin volume to give a value for volume of refuse.

Table 19
Volume of Different Rubbish Containers in Akaroa

Akaroa Rubbish Container Types	m^3	Litres	Dimensions
Plastic rubbish sack	0.05	50	
Supermarket bag	0.02	17	
44 gallon drum	0.2	200	
Front-load skip	4.5	4,500	
Wheelie bin	0.24	240	0.98× 0.54 × 0.49
Plastic bucket (large)	0.02	20	
Modified trailer	4.5	4,500	
Woolsack	0.588	588	
Council recycling bin	0.054	50	0.43 × 0.39 × 0.32

For businesses operating normal business hours measurement was repeated twice daily, in the morning prior to opening and just before closing. For businesses such as a restaurant or hotel, where the clean-up and closing time of the business is nearer midnight, the business measurement was taken once daily in the morning at a time that was early enough for no new refuse to be deposited but late enough that the cleaners have disposed of the previous day's rubbish. There was an exception to this when the bin was due to be emptied. For example, if a restaurant or hotel bin was due to be emptied on Friday morning, then the measurement was taken on the Thursday in the late evening.

Small retailers often used supermarket bags (or similar), which were then put into larger council rubbish bags. These smaller bags cannot be measured using the method described above for containers of fixed dimensions. In this case the retailer was asked to start a new bag each day. At the end of the day the bag was then assessed. Due to the small number using this method the proportion of the bag filled with rubbish was estimated and volume determined. In one case the business rubbish was transferred into a container of known dimensions and the tape measure method used.

Bed and Breakfast Accommodation

As part of the survey described in the water and wastewater section, Bed and Breakfast owners were asked to record details of the number of rubbish containers disposed of in each time period as well as the container type (i.e., council bag, wheelie bin etc.). None of the 16 B & B businesses that were given survey forms to fill out supplied information on their refuse.

Street Bin and Reserve Refuse

Every morning (6 a.m.) the street bin and reserve refuse bags are collected by a commercial waste contractor. It was therefore assumed that the rubbish collected represented the waste produced for the previous day. Any bags partially full were combined so that only full bags were collected. The contractor supplied data for the quantities of bags collected over the study period. These were converted to volume using a factor of 0.05 m^3 per bag (Table 18).

Recycling

The recycling depot uses woolsacks and 44-gallon drums of known volumes and the measuring method described above was used to calculate volume.

Permanent Residents and Holiday Homes Refuse

As part of the water, wastewater and solid waste survey permanent residents and holiday homeowners were asked to supply information on the number of rubbish bags generated over the study period.

Total Akaroa Refuse Volume

Volumes of total refuse and business refuse leaving the Akaroa township destined for landfill were not available as the Barry's Bay refuse station services other parts of Banks Peninsula and the different rubbish streams could not be separated out. Also there was a lack of co-operation by the private waste contractor who did not want to divulge figures that might be commercially sensitive.

3.4.2 Analysis of the Data Against Visitor Counts

The data were analysed to see if there was any significant correlation between refuse volumes measured and the visitor counts described in the water and wastewater section of this report.

The ratio of day visitors to overnight visitors was not included in the analysis because of uncertainty over the reliability of the ratio for peak periods.

3.4.3 Waste Management Practices and Environmental Performance

Businesses that agreed to waste monitoring were questioned on their waste management practices and approaches to environmental management. Specific areas addressed included:

- Participation in recycling
- Use of a waste contractor
- Have they heard of environmental management systems (EMS) (e.g., Green Globe 21, ISO14001, Enviro-Mark®)?
- Do they have an EMS?

Permanent residents and holiday homeowners were asked questions on their waste management practices. These included:

- Their participation in recycling
- Their participation in composting.

The holiday homeowners were also asked about participation in composting.

3.5 Main Findings

3.5.1 Comparison of Street and Business Refuse Volumes

The data collected were limited by the particular 12 days (Thursdays to Sundays) chosen for the study. No attempt was made to establish business-type patterns of waste disposal due to the small size of the sample (n = 12).

Table 20
Comparison of Street Bin Volumes and Business Refuse Volumes

Date	Day	Weather	Street Bin Volume m^3	Business Refuse Volume m^3	Ratio Business Refuse to Street Bin
10/10/02	Thursday	Sunny	0.95	1.64	1.73
11/10/02	Friday	Rain a.m., overcast p.m.	0.80	1.92	2.40
12/10/02	Saturday	Overcast a.m., sunny midday, cold p.m.	1.05	1.72	1.64
13/10/02	Sunday	Overcast/wet a.m., sunny p.m.	0.75	2.34	3.12
5/12/02	Thursday	Hot and fine	0.75	3.56	4.74
6/12/02	Friday	Hot and fine	1.35	2.17	1.61
7/12/02	Saturday	Hot and fine	0.70	1.48	2.11
8/12/02	Sunday	Raining and cold	0.80	2.52	3.15
16/1/03	Thursday	Hot and fine	2.15	2.56	1.19
17/1/03	Friday	Fine and overcast	1.70	4.06	2.39
18/1/03	Saturday	Fine/overcast a.m., sunny/hot p.m.	1.95	1.82	1.07
19/1/03	Sunday	Overcast a.m., fine p.m.	1.80	3.61	2.01

Table 20 shows the business refuse volumes were always higher than the street bin and reserve refuse on each of the study days. The weather influenced the types of activities undertaken by tourists during the study days.

3.5.2 Correlation of Business Refuse, Street Bin Refuse and Visitor Counts

The data on waste volume were correlated with data on visitor counts from 17 different sources as listed in Table 21 for the same study periods.

Table 21
Visitor Count Types (and Abbreviations)

Visitor Counts	Abbreviation
Bednights at holiday homes	Bednights
Overnighters with permanent residents	Overpr
Total non-commercial accommodation.	Totnoncom
Hotel bednights	HBN
Motel bednights	MBN
Bed and Breakfast bednights	BB
Backpackers bednights	BP
Camping ground bednights	CG
Total commercial accommodation	Totcom

Table 21 continued

Visitor Counts	Abbreviation
Number surveyed	NS
Info Centre door-count	IC
grocery store door-count	SS
Jollie Rd toilet door-count	JRT
Beach Rd toilet door-count	BRT
Rec. Ground toilet door-count	RGT
Total toilet door-count	TOTT
Road count	Road

No correlation can be shown between business waste volumes and any of the 17 sources of visitor counts (Table 22). Data from the commercial waste contractor for the other days of the week (Mon - Wed) was not obtained due to its commercial sensitivity and therefore no trends in time lag between disposal and visitor counts could be made.

A correlation was demonstrated with street-bin and reserve-refuse volumes and 13 of the 17 visitor counts (Table 23). The street bin and reserve rubbish bins are predominantly used by tourists and much of the disposable goods purchased in the businesses, such as food packaging, aluminium cans, softdrink bottles, food scraps, paper bags etc., ends up in these bins. These bins are dispersed at convenient intervals along the entire main thoroughfare of the town and reserves. The tourists are only given a choice to recycle at one location (outside the Fish and Chip shop) and this is not effective.

Table 22
Correlation of Business Refuse and Visitor Counts in Akaroa

Refuse		Visitor Counts By Type (see Table 21)																
Date	**Volume**	**Bednights**	**Overpr**	**Totnoncom**	**HBN**	**MBN**	**BB**	**BP**	**CG**	**Totcom**	**NS**	**IC**	**SS**	**JRT**	**BRT**	**RGT**	**TOTT**	**Road**
10/10/2	1.6436	503	28	531	5	60	15	4	29	113	105	167	551	108	304	107	1,070	781
11/10/2	1.9236	661	7	668	13	153	17	17	26	226	137	162	606	115	278	116	1,115	860
12/10/2	1.7236	912	21	933	16	174	28	11	48	277	237	115	751	243	387	272	1,653	961
13/10/2	2.342	503	28	531	1	52	15	16	23	107	19	105	Closed	258	314	281	853	938
5/12/2	3.56	613	4	617	9	137	18	34	68	266	246	254	850	226	468	165	859	1,042
6/12/2	2.17	1,886	4	1,890	17	197	27	38	117	396	218	271	1,012	168	363	152	683	1,249
7/12/2	1.48	2,216	10	2,226	21	218	49	35	109	432	274	226	155	215	502	344	1,061	1,273
8/12/2	2.522	754	6	761	6	113	32	19	67	237	73	166	300	317	292	184	793	775
16/1/3	2.56	1,637	51	1,688	39	182	66	37	191	515	287	367	1,334	525	1,146	261	1,932	1,316
17/1/3	4.065	1,882	20	1,902	13	249	65	31	210	568	341	346	1,393	466	629	227	1,322	1,407
18/1/3	1.82	1,719	35	1,754	28	245	73	34	230	610	363	355	1,420	495	911	284	1,690	1,591
19/1/3	3.61	900	43	943	18	183	66	37	163	304	450	390	1,160	506	1,033	303	1,842	1,732
Correlations with volume		−0.04	0.10	−0.04	−0.09	0.18	0.31	0.40	0.38	0.19	0.41	0.53	0.50	0.51	0.34	0.01	0.11	0.39
	P	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	< 0.1	< 0.1	< 0.1	> 0.1	> 0.1	> 0.1	> 0.1
	N	12	12	12	12	12	12	12	12	12	12	12	11	12	12	12	12	12

Table 23
Correlation of Street Bin Refuse Volumes and Visitor Counts

Refuse		Visitor Counts By Type (see Table 21)																
Date	**Volume**	**SS**	**BRT**	**CG**	**IC**	**BB**	**JRT**	**Road**	**TOTT**	**HBN**	**Overpr**	**Totcom**	**NS**	**MBN**	**BP**	**Totnoncom**	**Bednights**	**RGT**
10/10/2	0.95	551	304	29	167	15	108	781	1,070	5	28	113	05	0	4	531	503	107
11/10/2	0.80	606	278	26	162	17	115	860	1,115	13	7	26	37	53	17	668	661	116
12/10/2	1.05	751	387	48	115	28	243	961	1,653	16	21	77	37	74	11	933	912	272
13/10/2	0.75	Closed	314	23	105	15	258	938	853	1	28	07	9	2	16	531	503	281
5/12/2	0.75	850	468	68	254	18	226	1,042	859	9	4	66	46	37	34	617	613	165
6/12/2	1.35	1,012	363	117	271	27	168	1,249	683	17	4	96	18	97	38	1,890	1,886	152
7/12/2	0.70	155	502	109	226	49	215	1,273	1,061	21	10	32	74	18	35	2,226	2,216	344
8/12/2	0.80	300	292	67	166	32	317	775	793	6	6	37	3	13	19	761	754	184
16/1/3	2.15	1,334	1,146	191	367	66	525	1,316	1,932	39	51	15	87	82	37	1,688	1,637	261
17/1/3	1.70	1,393	629	210	346	65	466	1,407	1,322	13	20	68	41	49	31	1,902	1,882	227
18/1/3	1.95	1,420	911	230	355	73	495	1,591	1,690	28	35	10	63	45	34	1,754	1,719	284
19/1/3	1.80	1,160	1,033	163	390	66	506	1,732	1,842	18	43	04	50	83	37	943	900	303
Correlations with volume		0.8955	0.8805	0.88	0.8518	0.838	0.8366	0.7761	0.7612	0.7481	0.734	0.7277	0.717	0.5866	0.5407	0.489	0.4717	0.3057
	P	<0.01	< 0.01	<0.01	< 0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05	< 0.1	> 0.1	< 0.1	< 0.1
	n	11	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12

3.5.3 Recycling Volumes

The use of the recycling depot is voluntary as the residents and businesses have access to a kerbside recycling collection and the services of a commercial waste contractor collecting recyclables. The general pattern for businesses using the recycling depot is to stockpile recyclables before depositing the collected items. We were not able to correlate visitor counts with daily recycling volume values. No meaningful correlation is likely to exist due to the lagtime from the production of recyclables to their disposal.

Table 34 (Appendix D) shows the correlation of recycling volumes of individual materials for the total 12 days against visitor counts.

3.6 Current Refuse Management Practices in Akaroa

The 21 businesses monitored to determine refuse volumes were also surveyed for information on their recycling and other refuse management practices. Permanent Residences and Holiday Home occupants were also asked a series of questions relating to refuse management. The results are as follows:

Businesses

Of the businesses surveyed:

- 86 per cent participated weekly in recycling
- 14 per cent did not recycle
- 24 per cent collected food refuse for pigs
- Eight per cent had heard of Green Globe 21
- Four per cent had begun implementing Green Globe 21

Of those 86 per cent who recycled:

- 44 per cent dropped off their own recyclables to the township recycling depot
- 28 per cent had their recyclables collected regularly by a refuse contractor
- 28 per cent participated in the council kerbside recycling collection.

The 14 per cent (3) of businesses that did not participate in recycling were aware of the recycling facilities available to them but had decided it was not cost- or time-effective for them at this point in time. The majority of the businesses choosing to take their recycling to the depot do so because it was less expensive than using a waste contractor. Participation in council kerbside collection is limited to those businesses with smaller volumes of refuse.

From observation it was noted that although a high proportion of the monitored businesses participated in recycling (86%), they did not participate fully. One business just recycled cardboard, which it saved up until the pile was an inconvenient size.

No businesses composted, which was surprising given the area of lawn and garden about some of the accommodation providers.

Permanent Residents and Holiday Homes Refuse

Information about permanent residents and holiday homeowners was based on projected estimates from data supplied by those interviewed during this research. The data supplied by the permanent residents and holiday homeowners on waste volumes must be treated cautiously as the standard deviation (margin of error) is large (see Table 35, Appendix D for details).

Fifty-three permanent residents and 86 holiday homeowners supplied information on their refuse management practices (Table 24). Although these data may reflect intent and not actual practices, they show good support by both groups for recycling. There appears to be more rubbish produced per person per day at the holiday homes than at a permanent residence (Table 38) and the holiday home data appear to be more variable. The data were based on estimates provided by the occupants and it is likely that these data reflected intentions and not what occurs in practice. However, it does show their support of recycling initiatives.

Table 24
Refuse Management Practices of Permanent Residents and Holiday Homeowners in Akaroa

	Holiday Homeowners	Permanent Residents
Sample size	53	86
Recycle all	62%	87%
Recycle part	13%	4%
Don't recycle	25%	9%
Compost	25%	55%
Take home rubbish	28%	NA

3.7 Discussion

The objectives of this section of the research were to gather data on solid waste volumes in Akaroa, to analyse the data and determine if relationships with visitor numbers could be established, and to investigate solid waste management practices by businesses and residents.

From the data collected a model that satisfactorily explains total tourist demands on waste disposal systems in Akaroa could not be determined. However strong relationships between visitor numbers and street waste volumes were established.

In some areas solid waste management practices in Akaroa are unsatisfactory.

3.7.1 Modelling of Solid Waste

The research could not establish significant correlations between business refuse and the visitor counts and therefore cannot be used to predict any future demands on waste systems. A number of factors could account for this result. These relate to business and B&B accommodation use of refuse services, to data unavailability and other factors including:

- Small sample size (n = 12)
- The study days (Thursday to Sunday) did not correspond with all the refuse collection days for business: Monday (wheelie bins, rubbish bags), Tuesday (recycling), Wednesday, (wheelie bins), Friday (wheelie bins), Sunday (wheelie bins).
- The proportion to which each business was servicing residents and visitor was not accounted for.
- Visitors do not throw waste directly into the business bins. The business operators control the waste they send to landfill and how they send it. It was observed that one operator placed a bag of business waste into a green street bin.
- Is it likely that more rubbish is produced earlier in the week in the 'stocking up/preparation days'. For example, if an Akaroa business gets a once-a-week delivery of stock on Wednesdays before the anticipated weekend rush, then the waste will be in their bin on Wednesdays.
- Many of the retail businesses offered a postal service whereby packaging waste that would otherwise be thrown out was used to package and protect purchases for posting.
- Eighty-six per cent of the businesses participated in recycling and 24 per cent collected food for pig scraps. This means that much of the waste is diverted from landfill. Much of the waste produced in businesses as a result of services to visitors is recyclable (i.e., cardboard, wine bottles) and diversion rates may be a better indication of visitor flows.
- Some parts of the waste stream were not measured and we were not able to determine if there is a correlation between visitor numbers and total waste (including waste to landfill, recycling, pig scraps, composting, reuse).

None of the 16 Bed and Breakfast accommodation providers filled out the waste section of the survey form supplied. It could be assumed that Bed and Breakfast accommodation waste volumes would be similar to those data supplied by holiday homes. However, the waste sent to landfill is controlled by the operators of the business and is largely independent of the tourists. For example, operators choose if they want to recycle and if they compost. Waste may also be dependent on how long the visitors stay and which day they leave. For example, if there is no daily room service, the waste from the room would not be removed until the visitor leaves and would represent the waste from the total stay. A better indicator may be the total volume for a week compared to total weekly visitor bednights.

There are strong correlations between street waste volumes and 13 out of the 17 visitor counts. Therefore, the street bins and reserve refuse present a good indication of refuse sent to landfill by tourists. These data could be used to project future street-bin volumes based on known tourist-rate increases and the information used to plan for optimum bin numbers. The current bin system is adequate for winter but in summer they are frequently overflowing and need to be collected twice daily.

The recycling depot volumes do not account for any recycling collected by the contractor or any kerbside recycling, and the proportion of recyclables at the depot from permanent residents and businesses is not known. Data from this study show that both residents and businesses are willing to recycle and it is common for recyclables to be stockpiled before being dropped off at the recycling depot.

3.7.2 Potential Improvements in Environmental Performance by Businesses

Adoption of programmes such as Green Globe 21 would help businesses to improve their environmental performance. The extent to which a business could reduce its refuse to landfill, water use, and wastewater production is influenced by the motivation of the business and the facilities available to them. Only eight per cent of the businesses in this study had heard of programmes such as Green Globe 21 and only four per cent (one business) was beginning to implement such a system.

It would be difficult for businesses in Akaroa to increase paper recycling, as there is limited paper recycling collection facilities (only cardboard and newspaper). There is also no option for businesses to participate in an organic refuse collection.

In this study, the objective was to obtain volume data rather than data on individual waste types. However, it was observed that although high recycling rates exist amongst the businesses (86%) surveyed, recyclable items – particularly office paper, magazines, and envelopes as well as compostable materials such as food and garden refuse – were in the refuse bins.

Christchurch City Council has data from an audit conducted on the composition of business 'black-bag' refuse in 1997. This audit showed that rubbish in these bags comprised 48.5 per cent paper and 33.7 per cent kitchen refuse. If similar proportions existed in the Akaroa waste stream then there would be good scope for reduction of these wastes going to landfill either by increasing recycling and composting options or introducing other means such as environmental purchasing policies.

3.7.3 Future Demands on Waste Systems

It could not be demonstrated that the environmental performance of businesses in Akaroa is related to visitor demands. Instead environmental performance is more a factor of awareness, motivation, and facilities within the community. Providing these facilities may also increase the demand on infrastructure as it is likely that although waste to landfill may decrease, waste to recycling and composting would increase.

3.7.4 Applicability of Solid Waste Data to Other Tourism Towns

Caution should be used when applying these data to other tourism towns as this represents a snapshot of 12 days taken over three different periods. However, inferences could be made about the data used to establish correlation of visitor counts to the street bin and reserve volumes, and business participation rates in recycling, particularly if the town was isolated like Akaroa and had similar facilities. These facilities include:

- Kerbside recycling of cardboard, tin, aluminium, HDPE, PET, glass, and newspaper for residents and businesses
- Recycling depot where both businesses and residents can drop off their recyclables in close proximity to their site (less than 2 km away)
- Similar mix of tourism business types (note Table 19)
- Landfill facilities out of town (greater than 15 km)
- Availability of the services of a refuse contractor to collect refuse and recycling
- No access to commercial composting facilities.

3.7.5 Improved Data Collection

Better insights into relationships between tourist numbers and solid waste could be obtained if more and better data is available. Recommendations on data collection include:

- An increased sample size, which includes a full seven days' data to account for all the collection and disposal days and more sample periods (i.e., weekly and monthly data for waste volume and visitor counts).
- Measurement of all waste to landfill, reuse, and recycling for all samples.
- Weekly waste volumes for businesses compared to weekly visitor counts would be more appropriate and may show a correlation.
- Measurement of volumes from a sample of bed and breakfast accommodation, permanent residents and holiday homes (no surveying and estimation by occupants).
- Total waste including landfilling, reuse and recycling may be a better indication of tourist demands as this would eliminate the influence of the operator over any one waste management practice.

3.8 Conclusions

Obtaining both micro data and aggregate data on solid wastes in small towns requires careful planning and co-operation from many people including solid waste collection operators. Unavailability of some data limited the ability of this research to determine the relationship between visitor numbers to Akaroa and total solid wastes from the township. No relationship could be found, given the data limitations, between visitor numbers and business solid waste, or between visitor numbers and recycling volumes.

However strong relationships were found between several measures of daily visitor numbers and street bin solid waste volumes. These relationships could be used to project future street waste volumes and aid planning by BPDC.

Solid waste management practices in Akaroa are of variable quality and improvement is possible in several areas. Eighty six percent of businesses participate in recycling schemes, but most only participate on a partial basis. Only one Akaroa business participates in an environmental management scheme and adoption of a scheme such as Green Globe 21 would contribute to improved business solid waste management, as well as water and wastewater management. Improvements in solid waste management are also more likely to occur if services such as organic refuse collection were available in Akaroa.

Chapter 4
Funding Systems for Water, Wastewater and Solid Waste

4.1 Introduction

This chapter examines the ways in which Akaroa's water supply, wastewater and solid waste systems are funded. Revenue must be collected to meet the capital and the operating costs of these systems. Users and beneficiaries of these systems pay a variety of rates and charges to meet these costs. The types of rates and charges used influence demand for these services, in the short run affecting operating costs, and in the long run influencing the amounts of investment needed.

Banks Peninsula District Council has responsibility for provision of infrastructure to cater for ratepayers' needs and to set policy regarding infrastructure required to deal with resource use and disposal for Akaroa.

4.2 The Services Provided

4.2.1 Water

Water is used for a variety of purposes – drinking, personal washing, watering gardens, filling swimming pools, by businesses, to wash boats and cars, for public toilets, for firefighting. Water use in Akaroa township in some years has reached 2,400m^3 per day during December – January. Water is required to meet New Zealand drinking water standards. Provision of potable quality water to large numbers of households and businesses can be separated into several components including water collection, storage, treatment, reticulation, metering, and delivery. BPDC has made major investments in water collection, storage, treatment facilities and reticulation in Akaroa. During 2002 it invested $270,000 in water meters for Akaroa properties.

4.2.2 Sewage

Sewage is collected from over 1000 properties in Akaroa including from residences, motels, motels, holiday homes and public toilets. Households and businesses connect their wastewater pipes to the community sewage system and the wastewater is piped to treatment site at the southern town boundary. Following treatment the water is disposed of into the harbour. Ministry of Health quality standards must be met before wastewater can be piped into the sea. BPDC has major investments of capital in sewage collection, and treatment facilities in Akaroa.

4.2.3 Solid Wastes

Households, tourists, and businesses produce solid waste that requires disposal. Packaging, old newspapers, used household and business items are collected in Akaroa township and transported for disposal at the Christchurch landfill. BPDC vehicles collect the solid wastes from residences, some commercial properties, street and reserve bins, and deliver it to the landfill site. Landfill sites are scarce, costly to develop and operate. BPDC also operate a weekly kerbside recycling bin collection service and an Akaroa recycling centre.

4.3 BPDC Funding Systems

New Zealand local government funding policies are constrained by several pieces of legislation including the Rating Powers Act 1988, and the Local Government Amendment Act (No. 3) 1996. The Local Government Act 2002, and the Local Government (Rating) Act 2002 come into force at midyear 2003. Some key features of the current legislation include the following points:

- Territorial Local Authorities (TLA) may levy rates and charges based upon Land Values, Annual Rental Values and Capital Values of rateable properties
- Differential rates are permitted
- Uniform annual charges are permitted
- Water, sewerage and solid waste systems must be fully funded by charges levied on users of those systems
- Where an identifiable group of ratepayers benefits from a Council action, that group should meet the costs of the service provided (Rating Powers Act 1988, section 122 F).

Note there has been an impediment to the ability of Councils to levy volumetric charges for sewage, and this only disappeared when the Local Government Act 2002 came into force in July 2003. Any new charging system should be designed with respect to the Local Government Act 2002 and the Local Government (Rating) Act 2002.

Territorial Local Authorities (TLAs) have reacted to the guidelines and constraints imposed by the relevant legislation, and have chosen in some cases to introduce a large number of different rates and charges. Banks Peninsula District Council developed a Draft Funding Policy, effective 1 July 2002 (BPDC, 2002b). This document spells out the Council's funding policy decisions with respect particularly to the provisions of the Local Government Amendment Act (No. 3) 1996.

The objective of the Act is to promote consistent, prudent, effective and sustainable financial management in local government. The Act prescribes the processes that local authorities should follow to arrive at the funding policies for each activity. It consists of a three-step process. These steps involve considering (BPDC, 2002b):

- Who benefits from a Council's service or activity? Can the benefit be divided between different groups of users?
- Should those who pay for this service be the same as those who benefit or should adjustments be made in the interests of fairness or efficiency?
- What funding mechanism(s) should the Council choose to recoup the cost of an activity?

BPDC have considered these points when selecting funding policies for each of the services the Council provides. Their decisions are reflected in the current BPDC funding policies. The major components of the current funding systems for water, wastewater, and solid wastes are listed below (see Table 25).

Table 25
BPDC Funding Mix 2002/03 For Selected Activities

Activity	Sub-Activity	General Rate %	Separate Rates %	Fees and Charges %
Water		5	70	25
Wastewater	Sewerage		100	
Refuse Management	Public Refuse bins	100		
	Recycling and waste minimisation		100	
	Refuse Collection		100	
	Refuse tip rehabilitation	10	90	
	Waste disposal		100	

Source: Banks Peninsula District Council, Annual Plan 2002/03. Page 23.

The Banks Peninsula District Council applies differentials before collecting general rates based upon Capital Value. The BPDC rationale for the differentials is the services funded by way of general rates provide greater benefits to other sectors than they benefit the residential sector. Rural fire protection, environmental health, provision of public conveniences, provision and maintenance of roads are cited as examples of these services (BPDC, 2002b, p.24). The differentials were reviewed and set at the following levels for 2002/03: Residential 1.00; Rural 1.25; Commercial 1.60; Industrial 2.25. However these differentials do not play any role in calculation of separate rates.

These funding principles are then applied by BPDC and rates and charges struck to recoup the costs of the various services provided. The monetary amounts charged for the various water, wastewater and solid waste services provided in Akaroa township are listed below. Many of the amounts charged by BPDC are standard amounts throughout the district, others are Akaroa specific figures. The listed figures are the same for residential and commercial ratepayers, unless specifically stated otherwise.

Water

- Uniform annual rate is $240.50 per annum. Undeveloped sections pay a half charge per annum.
- Water in excess of 300m^3 per year is charged at $0.89 per m^3 in.
- Private Work. Water infrastructure contributions are $2,832 per property.

Wastewater

- A wastewater infrastructure rate is payable with a uniform annual rate of $207.40 per annum on all properties within the sewage reticulation area.
- Pan charge is $80.10 per pan. Households are charged for one pan only. Commercial and industrial properties are charged for numbers of pans.
- Wastewater infrastructure contributions are $0.0000952 per dollar of rateable Capital Value.
- Private Work. Sewer infrastructure contributions are $2,438 per property.

Solid Waste

- Refuse collection rate is payable with a uniform annual charge of $47.30 per rateable property. Large commercial firms do not pay this charge as they hire a private firm to collect their solid waste.
- Refuse disposal rate is payable with a uniform annual charge of $133.60 per rateable property.

The total amounts of revenue obtained by BPDC from these charges in Akaroa are listed below in Table 26.

Table 26
Revenue for Akaroa, 2001/02

	$ per unit/factor	Unit or factor	Amount
Water			
Uniform annual rate	240.50	rateable property (1010 total)	$242,905.00
Excess water use	0.89	cubic metre	$11,950.00
Wastewater			
Infrastructure uniform annual rate	207.40	rateable property (1007 total)	$208,851.80
Pan charges, commercial sector	80.10	pan	$5,607.00
Pan charges, total	80.10	pan	$84,230.00
Wastewater infrastructure contributions	0.0000952	$CV	$29,861.00
Solid waste			
Collection uniform annual charges	47.30	rateable property (955 total)	$45,171.50
Disposal uniform annual charges	133.60	rateable property (1010 total)	$134,936.00
Total revenue			**$757,905.30**

4.4 Budgeted Costs of Services for Akaroa

The total budgeted costs of providing these services in Akaroa are listed below in Table 27. The data source for these items is BPDC management accounts 2002/03. The estimated shares are the respective average shares of Akaroa's total operation costs with respect to BPDC's total operation costs over two budgeted years. Since such a calculation was not possible for the public refuse bins, a share of 80 per cent has been assumed due to the high percentage of visitors to Akaroa.

Table 27
Budgeted Costs of Services

Water Supply	2002-2003	2001-2002
Operation and maintenance	$177,510.00	$188,843.00
21.6% share of operation overheads	$49,419.29	$43,433.93
Total operational costs, water	**$226,929.29**	**$232,276.93**
Capital projects	$350,000.00	$240,000.00
Loan costs	$61,795.00	$18,497.00
Total capital costs, water	**$411,795.00**	**$258,497.00**
Wastewater		
Operation and maintenance	$193,793.00	$164,203.00
20.4% share of operation overheads	$43,649.27	$38,302.22
Total operational costs, wastewater	**$237,442.27**	**$202,505.22**
Capital projects	$10,210.00	$20,000.00
Loan costs	$144,244.00	$129,335.00
Total capital costs, wastewater	**$154,454.00**	**$149,335.00**
Waste Disposal		
Operation and maintenance	$212,325.00	$197,077.00
70.7% share of operation overheads	$15,882.05	$10,584.50
Total operational costs, waste disposal	**$228,207.05**	**$207,661.50**
Capital projects	$0.00	$2,000.00
Loan costs	$13,987.00	$10,804.00
Total capital costs, waste disposal	**$13,987.00**	**$12,804.00**

Water Supply	2002-2003	2001-2002
Refuse Management		
Public refuse bins, share of 80%	$34,016.00	$70,877.60
Recycling and waste minimisation	$30,146.00	$29,036.00
32.4% share of operation overheads	$8,845.52	$6,300.83
Urban collection LS	$21,000.00	$31,180.00
Rubbish bag purchase	$8,470.00	$8,296.00
32.88% share of operation overheads	$10,742.22	$7,503.54
Total operational costs, refuse management	**$102,478.00**	**$153,193.97**
Grand Total Operational Costs	**$795,056.61**	**$795,634.62**
Grand Total Capital Costs	**$580,236.00**	**$420,636.00**

4.5 Cost Allocation

To examine the allocation of costs of water, wastewater and solid waste disposal we calculate the rates and charges for four illustrative Akaroa properties. The four properties are a bach, a residential home, a small commercial business and a 20 room motel. Calculation of rates and charges requires capital values (CV) and we use current averages for the property types in Akaroa. The CV for the tourism business is indicative for a 20 room motel in Akaroa. The excess water use charges are based upon volumes estimated in earlier sections of this report.

Table 28
Illustrative Rates For Water, Sewage, Refuse in Akaroa

	$ Per Unit or Factor	Unit or factor	Amount
For an Akaroa bach			
Water uniform annual rate	$240.50	1	$240.50
Wastewater uniform annual rate	$207.40	1	$207.40
Wastewater infrastructure	$0.0000952	$200,000	$19.04
Pan charge	$80.10	1	$80.10
Refuse collection rate, uniform annual charge	$47.30	1	$47.30
Refuse disposal rate, uniform annual charge	$133.60	1	$133.60
Total Annual			**$727.94**
For an Akaroa permanent residential home			
Water uniform annual rate	$240.50	1	$240.50
Wastewater uniform annual rate	$207.40	1	$207.40
Wastewater infrastructure	$0.0000952	$200,000	$19.04
Pan charge	$80.10	1	$80.10
Refuse collection rate, uniform annual charge	$47.30	1	$47.30
Refuse disposal rate, uniform annual charge	$133.60	1	$133.60
Total Annual			**$727.94**
For an Akaroa commercial business			
Water uniform annual rate	$240.50	1	$240.50
Wastewater uniform annual rate	$207.40	1	$207.40
Wastewater infrastructure	$0.0000952	$300,000	$28.56
Pan charge	$80.10	1	$80.10
Refuse collection rate, uniform annual charge	$47.30	1	$47.30
Refuse disposal rate, uniform annual charge	$133.60	1	$133.60
Total Annual			**$737.46**

Table 28 continued

	$ Per Unit or Factor	Unit or factor	Amount
For an Akaroa tourist business			
Water uniform annual rate	$240.50	1	$240.50
Excess water charges	$0.89	850	$756.50
Wastewater uniform annual rate	$207.40	1	$207.40
Wastewater infrastructure	$0.0000952	$2,000,000	$190.40
Pan charge	$80.10	20	$1,602.00
Refuse collection rate, uniform annual charge	$47.30	0	0
Refuse disposal rate, uniform annual charge	$133.60	1	$133.60
Total Annual			**$3,130.40**

4.6 Comparison of Funding by Four Illustrative Properties

A bach with occupancy during the year of four weeks plus five two day weekends plus five days at Easter total 43 days which is 11.78 per cent of time occupied. If we assume four persons per visit the total equals 172 person days at Akaroa. Peak period occupancy is assumed to be 100 per cent. Four weeks for four persons equals 112 person days.

A residential home with two adults and one child resident during the entire year has 1,092 person days at Akaroa. Peak period occupancy is assumed to be 28 days and with three occupants this totals 84 person days.

A commercial property, which has three staff and one toilet pan, may sell products or services to thousands of customers per year. Their water use, sewage and solid waste volumes may be similar to a residential property.

A tourism business with 20 pans may have only 50 per cent average occupancy throughout the year. Assuming 2.8 persons per pan, this implies 365 x 20 x 2.8 x 0.5 = 10,220 person days per year at Akaroa.

Peak period occupancy of 80 per cent implies 28 x 20 x 2.8 x 0.80 = 1254 person days.

We can compare the relative magnitudes of person days, peak period person days, services rates paid and water usage for the four illustrative properties. The magnitudes are expressed below as ratios of the relevant figure for a bach, and for a permanent resident home.

Ratios compared with bach values	**Bach**	**PR**	**CB**	**TB**
The ratios of person days at Akaroa	1.00	6.36	6.36	59.41
The ratios of peak period person days at Akaroa	1.00	0.75	0.75	14.9
The ratios of annual water, sewage, refuse rates paid	1.00	1.00	1.01	4.30
The ratios of annual water usage[1]	1.00	5.7	3.7	32.5

1 Based on survey data collected during 2002/2003

Ratios compared with permanent resident values	PR	CB	TB
The ratios of person days at Akaroa	1.00	1.00	9.34
The ratios of peak period person days at Akaroa	1.00	1.00	19.87
The ratios of annual water, sewage, refuse rates paid	1.00	1.01	4.30
The ratios of annual water usage	1.00	0.65	5.70

These ratios illustrate that the current BPDC funding systems for water, wastewater and solid wastes, do not balance water use with rates paid for the four property types. The illustrative tourism business uses 32.5 times as much water annually as an illustrative bach does but the ratio of services rates paid by the two properties is only 4.30 : 1.00. There are likely to be similar imbalances between the wastewater produced and rates paid for the four property types.

4.7 Criteria For Evaluating Funding Systems

Hanemann (1998) provides three main criteria for designing water rates, namely revenue generation, cost allocation and provision of incentives. These three main criteria themselves encompass several subsidiary components. Revenue generation should be sufficient to cover all of the costs that the water utility encounters when providing this service. Therefore, revenue generation should be sufficient, stable over time and the benefits of a more complex funding scheme should be traded off against higher administrative costs.

Cost allocation should apportion the costs of the service among the different customers in a non-arbitrary manner. It should avoid cross subsidies and it should allocate the full private and social costs to users. In this case, social costs should include environmental damage caused by supply of water including reduced in stream flows during periods of peak demand.

Further, funding systems should provide incentives for efficient water use. Statically efficient water use internalises the full costs of water supply at any point in time, meaning direct as well as environmental costs. In this sense the quantity and time of water usage are chosen optimally. Dynamically efficient water use accounts for the development of water usage over time. To this extent water charges should incorporate future costs as well to ensure an efficient growth of water demand.

Finally, the incentives should encourage water conservation and the charging rate scheme should be transparent to users to ensure the correct interpretation occurs of incentives set by the water utility (Hanemann, 1998). These criteria for evaluating water funding systems can readily be adapted and applied to wastewater and solid waste funding systems.

Charging policies in use at present, and proposed charging polices, can be tested against those criteria. The breadth of questions posed by the criteria indicates that it will be very difficult for any one charging system to score highly against all criteria. Selection of preferred charging policy is likely to require trading off performance on one criterion against performance on one or more other criteria.

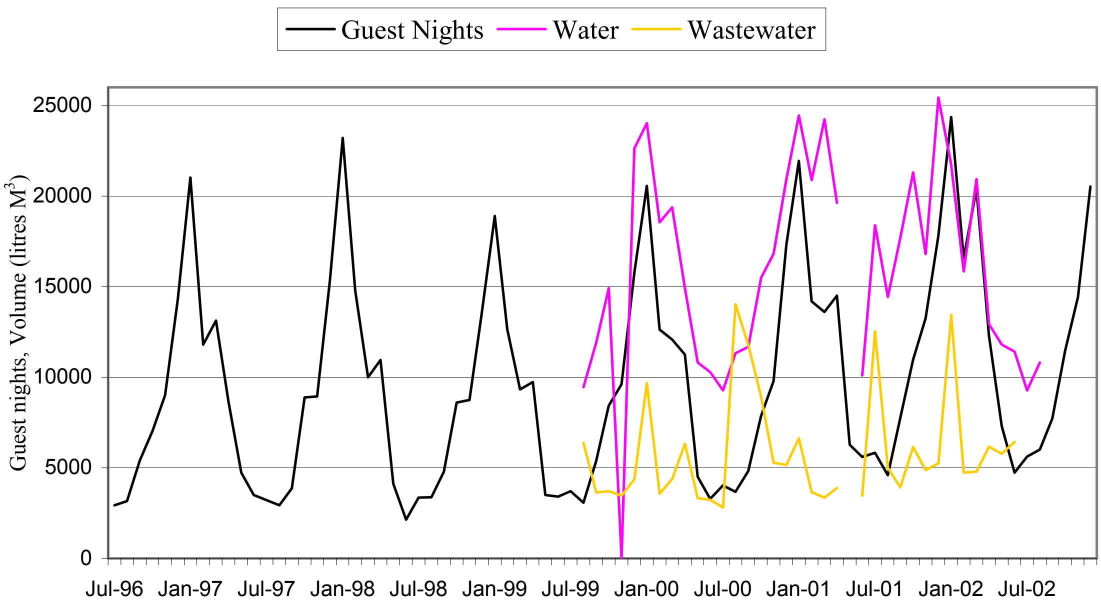
4.8 Water Rating: Critique And Suggestions For Improvements

In the following section we compare the current charging system for water used in Akaroa to the criteria advocated by Hanemann (1998) and advocate an improved method of charging for water and wastewater.

4.8.1 Evaluation Against Hanemann's Funding Criteria

As Figure 10 shows, tourism is a major driver of water demand, especially during summer months. However, the calculated ratios of water use and rates for the four illustrative properties above show the illustrative tourism business is not paying for its share of water and wastewater under the present rates and charges system. Except during the peak period, holiday homeowners are subsidising all other customer groups. Commercial customers and permanent residents pay roughly the same rates for similar utilisation of services. If holiday homeowners are taken out of the calculation, the level of subsidisation of tourism businesses by permanent residents and other commercial businesses becomes clear. Hence, the current system does not comply with the user pays principle. The primary virtues of the current system are transparency and revenue security.

Figure 10
Tourism and Water/Wastewater Usage



Sources: Statistics New Zealand, Accommodation Survey December 2002; water and wastewater data from BPDC records

Hanemann's (1998) criteria for the design of water services funding systems as previously described are summarised and the water rating system used in Akaroa is judged against these criteria (see Table 29).

Table 29
Evaluation of Akaroa's Charging System Against Funding Criteria

Criteria		Compliance	Justification
Revenue generation			
	Sufficient	Yes	The collected rates cover all costs.
	Stable over time	Yes	Revenue is predictable and does not significantly change with water use.
	Administration costs and complexity	Costs only	Equivalent of a flat rate for most residents and little differentiation between users.
Cost allocation			
	Non-arbitrary	No	High users pay the same as low users.
	No cross subsidisation	No	High water users are subsidised as well as certain groups of users.
Incentive provision			
	Static efficiency	No	Since the first block of water allowance is great and there are no seasonal peak charges the water rating system does not encourage efficient water use.
	Dynamic efficiency	No	The high water allowance imposes hardly any restrictions on water usage and therefore no incentives to change long-run behaviour.
	Encourage conservation	No	The lack of differentiated water charges sets no incentive to engage in water conservation.
	Correct interpretation	Partially	It is a very transparent system, but it does not lead to recognising the right incentives.

4.8.2 A Proposal for a Better Water and Wastewater Charging System

Introduction and Background Information to Proposed Charging Scheme

Because Akaroa has water meters installed for each rateable property, it is well positioned to introduce an improved water pricing system. The proposed tariff system is applicable to the whole community with no special consideration of different sectors or industries. This will simplify its administration, as only the water use data is needed for billing purposes. However, the water usage of different customer groups is needed to set up an efficient water and wastewater pricing system. The proposed water charging system is a form of a two-part tariff. The proposed scheme for Akaroa consists of three blocks of water demand with increasing volumetric charges for each block, a relatively high first fixed charge and increasing fixed charges for the second and third block, starting with a low amount for the second block.

The implementation of the system, which will be detailed below, requires the collection of data on the costs structure of the water supply and the distribution of water consumption for different consumer groups. This data should be collected over the course of a few years before the implementation of a differentiated water-charging scheme and updated regularly after its implementation to accomplish best possible compliance with the criteria outlined in preceding paragraphs.

Most importantly, a two-part tariff with increasing block charges will reflect the user pays principle. High water users will pay relatively more, reflecting the increased direct and environmental costs they inflict on the water and wastewater services. A well thought through charging system, respecting the user pays principle, will make any industry-specific charges unnecessary. In Akaroa's case, the tourism industry would pay for increased water demands arising from increases in their visitor numbers. In addition, an increasing block system serves the purpose of granting low-income groups access to a basic amount of water at an affordable rate (Bailey, 2002; OECD, 1999).

Metered pricing sets an incentive for users to engage in water conservation behaviour, since they gain personal benefits from lower water usage. Under a flat rate there is no penalty for wasting water. There is substantial evidence from numerous studies showing a marked and sustained reduction of peak demand and annual usage of water on an international and national level (Bailey, 2002; OECD, 1999). Most studies also show a higher reduction in peak demand than in annual demand, due to a higher percentage of discretionary water use at peak periods with savings ranging from 15 per cent to 50 per cent (for example see Jordan, 1999; Foxon *et al*., 2000). Auckland City Council reports 35 per cent higher use of water for non-metered customers, Wellington Regional Council estimates a 20 per cent reduction of water use through metering, Rotorua reports 35 per cent lower water use annually and 50 per cent lower use during summer for metered customers. (PCE, 2000; MED, 1999)

The effects of price changes on water demand are significant as well. Price elasticity for households range from –0.2 to –0.4, with considerably higher values during summer and for industrial and agricultural sectors (OECD, 1999). Whereas there are no studies about elasticities for the New Zealand market, a response of consumption patterns to a change of price and/or a change of the charging system can be assumed. Beyond possible short-term water conservation through a change in behaviour, we could expect substitution effects away from water intensive plants and products. If significant reductions of water use are achieved, the construction of increased water supply capacity might be circumvented which will add to saved monetary and environmental costs.

Environmental costs, which could be avoided or mitigated, are likely to be greatest during summer. Abstraction of water from streams will reduce in-stream flows, potentially threatening stream ecology. Excessive draw down of underground aquifers can have a major impact on the sustainability of the resource, and can result in salt-water intrusion and can damage the structure of the aquifer. Inefficient water pricing in industrial applications can lead to excessive use of water to dilute effluent. Prices set below costs for effluent disposal may lead to pollution of waterways (NZBRT, 1995). Environmental costs are difficult or even impossible to quantify in dollars. Nevertheless, the inclusion of an estimated small magnitude for these costs might be superior to no inclusion at all. The return from any inclusion of environmental costs could be used to fund projects to mitigate water supply impacts, to implement protection methods, to subsidise water saving behaviour (for example a below cost sale of low flush toilets and advanced shower heads), to fund educational campaigns and the like.

Wastewater volumes from properties are not metered, but a close correlation between water demand and wastewater discharge allows a reasonable estimation of the amount of wastewater produced per property. Hunter Water Corporation (Australia) estimates an approximate 50 per cent of water use as wastewater, Anglian Water International (UK) estimates 90 per cent, and Metrowater for Auckland estimates 77 to 79 per cent but for the calculation of wastewater rates it uses 75 per cent for residents and 100 per cent for businesses (NZBRT 1995; Metrowater, 2003). Limited time series data on water and wastewater demand for Akaroa suggests a fairly stable pattern between water and wastewater usage occurs during the course of a year, as shown earlier in Figure 10. Wastewater flow does not fluctuate wildly and it has biannual peaks. Study of daily rainfall records suggests the larger peak is due to the Spring rainfalls around August and the smaller peak due to increased water usage during January, linked with much greater tourist numbers in Akaroa. As discussed below, the calculation of seasonal water to wastewater ratios is proposed, because water demand is more seasonally dependent than is wastewater volume.

Cost Allocation to Fixed and Volumetric Parts of the Tariff

A relatively high first fixed charge is based on the fact that most of the fixed cost can be assigned to the supply of the first unit of water. Nevertheless, additional fixed charges for subsequent blocks of water demand can be justified on the basis of increasing capacity needs with the associated direct and environmental costs. Increased capacity needs are especially severe during peak periods as emphasised by the data collection of this research. The amount charged for the first block of water should reflect the great share of fixed costs in the first unit of water supply. Therefore, it should include administrative costs, basic capacity costs and basic infrastructure costs. The resulting first block of fixed charges will be relatively large compared to the fixed charges for the subsequent blocks.

The size of the first block of fixed charges determines the trade off of revenue security, meaning the coverage of costs and revenue stability, with social and environmental aspects, meaning equity and incentive structures. Greater revenue security would be achieved with a larger first block of fixed charges, but this would counteract equity and water conservation goals.

The additional fixed charges for the subsequent blocks of water delivery should start at a low value and then increase. The main reason for such a structure is the stress inflicted on the capacity, after the first unit of water has been accounted for. Higher water users create a greater pressure on the current system and a greater likelihood of the need for additional capacity.

The volumetric part of the water charge should include the operational and environmental costs of water abstraction, water treatment, water delivery, wastewater collection, wastewater treatment and waste disposal. It is assumed that direct variable costs are relatively constant across different levels of water demand. Information about the cost structure of water supply is needed to confirm this. The environmental costs are most likely to increase with increased water demand.

Increased volumetric charges are also justifiable on equity considerations. Rising block tariffs serve the purpose of granting low-income groups access to an amount of water sufficient for normal living at an affordable rate. (Bailey, 2002; OECD, 1999) A property value-based system assumes a direct relationship between wealth and relative water use. This is not necessarily correct, for example see Bailey (2002, p 403). Businesses with the same rateable value might have different water usage, for example through the need of cooling and washing, and a pensioner who has paid off their house during a life-time might not otherwise be wealthy.

Setting the Block Limits

The choice of the number of blocks is a trade-off between complexity and transparency of true costs. True costs include direct and environmental costs associated with increased water usage. Within one block the customer will be charged a constant per cubic metre price for the volumetric charges plus the respective fixed charges when entering a new block. The size of the blocks should be determined by considering the water demand distribution of different customer groups.

The change towards a three blocks scheme is not a major one, given that the community in Akaroa is now effectively confronted with a two block system. The suggested three blocks system will not perfectly reflect true costs. However, it will improve the reflection compared to a two blocks system for which the first block of water use is large, its charge fixed and only the excess water use charged at a volumetric rate. A three blocks scheme will achieve water conserving and equity goals reasonably well. Its simplicity will ease its acceptance and understanding by customers, which will support the achievement of the goals set.

The first block should be set with respect to water demand from residents (permanent and holiday homeowners) and businesses with low water demand. This group will be labelled in short as residential users for the following discussion. The upper limit of water delivery for the first block should be just above the average residential water demand, for example being exceeded by the upper 20 to 30 per cent of residential users.

More than one block of water charges tailored for the residential customers could be introduced based on the income distribution of the community. Studies suggest income elasticity for water demand ranges from 0.5 to 1.0 (OECD, 1999). Lower income groups are expected to consume less water or substitute towards a less water intense life-style more quickly. Thus, if the council wanted to support lower income groups it could decide on introducing a low water usage block with lower fixed and volumetric charges. A general argument against such a low water demand block is that even with three blocks, low water users will still pay less than they do now with a uniform annual water charge. If Akaroa has a relatively even income distribution this is a further reason in favour of a simpler water charging system.

Water conservation incentives are set for every customer with the introduction of volumetric charges for every cubic metre demanded. A switch to the second block will cause additional fixed charges, though not as high as the first tranche, and higher volumetric charges for the additional water used above the first limit. This will set even stronger conservation incentives for customers using more than the average residential customer, here the top 20 to 30 per cent of all residential customers.

Every customer demanding water from the public water supply will have to pay the first tranche of fixed charges covering most fixed costs as detailed above and the low volumetric charges. This will secure a great part of the revenue needed for the operation of the water utility. The first part of the revenue generation should not overpower the subsequent charges in order to maintain an overall incentive structure. Therefore, there should still be a significant increase in volumetric charges for blocks two and three.

The upper limit of the second block could be chosen with respect to the average water demand of the small or medium sized commercial customers, aside from those which have a very low water demand, for the same reasons as the choice of the upper limit of the first block. This group is likely to incorporate bed and breakfast accommodation, backpackers and food providers, and will be labelled as small tourism service enterprises (STSE).

The group of the remaining commercial customers, that is likely to consist of hotels, motels and the camping ground and can be labelled large tourism service enterprises (LTSE), should be pooled in the third block. The higher level of volumetric charges in this block provide additional incentive to conserve water for these users. However, the wide range of absolute water demand over a relatively small number of businesses makes any further differentiation, and more blocks, infeasible.

Aside from the first block of fixed charges the fixed charges for the blocks should be set with regards to the effects of water demand on the capacity requirements. This will in turn go in line with increased stress on the environment. Considerations for the size of the first block were given above. The second block of fixed charges can be relatively low compared to the first tranche of fixed charges. The existence of additional fixed charges will emphasise the additional capacity costs inflicted on the water supply system. Given that a significant jump in water demand between the STSEs and the LTSEs was observed, the fixed and volumetric charges for the third block should be significantly higher than those of the second block.

Seasonality

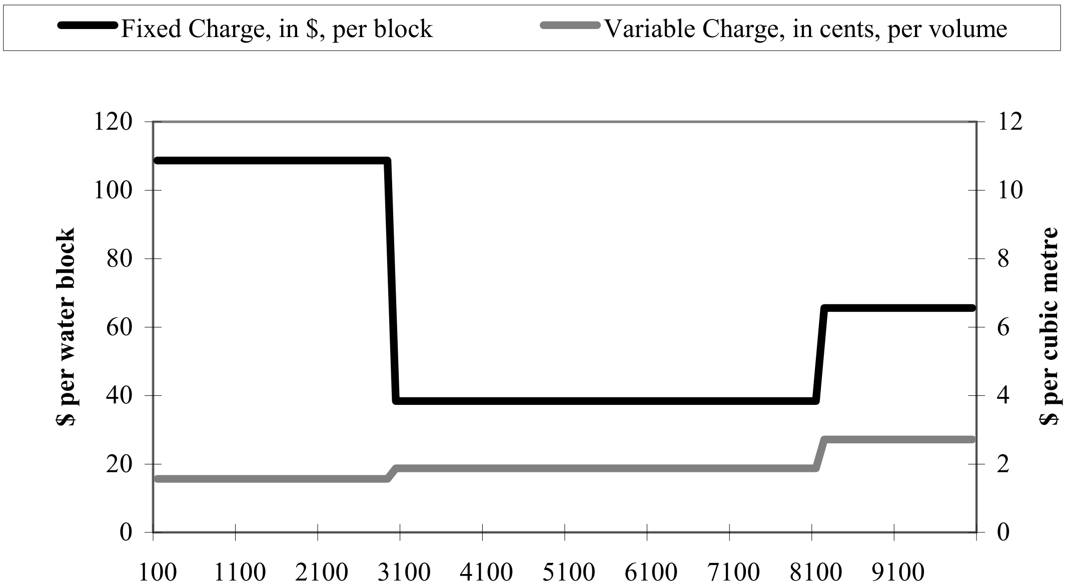
The proposed charging system should be further enhanced by the introduction of seasonal rates. The time series data available supports different rates during the course of a year due to varying water demand patterns. Seasonal water charges ensure in particular that permanent residents will not overly carry the burden of increased water usage by visitors during the peak-visiting season.

An increased summer rate for all charges will reflect the increased capacity constraints and environmental burden during summer time. Due to the relatively small fluctuations of wastewater volumes, different ratios of water to wastewater usage could be applied for different seasons, but that adds complexity. While seasonal water to wastewater ratios are desirable to signal correct costs, they might not be recommended on the grounds of excessive complication of the charging system.

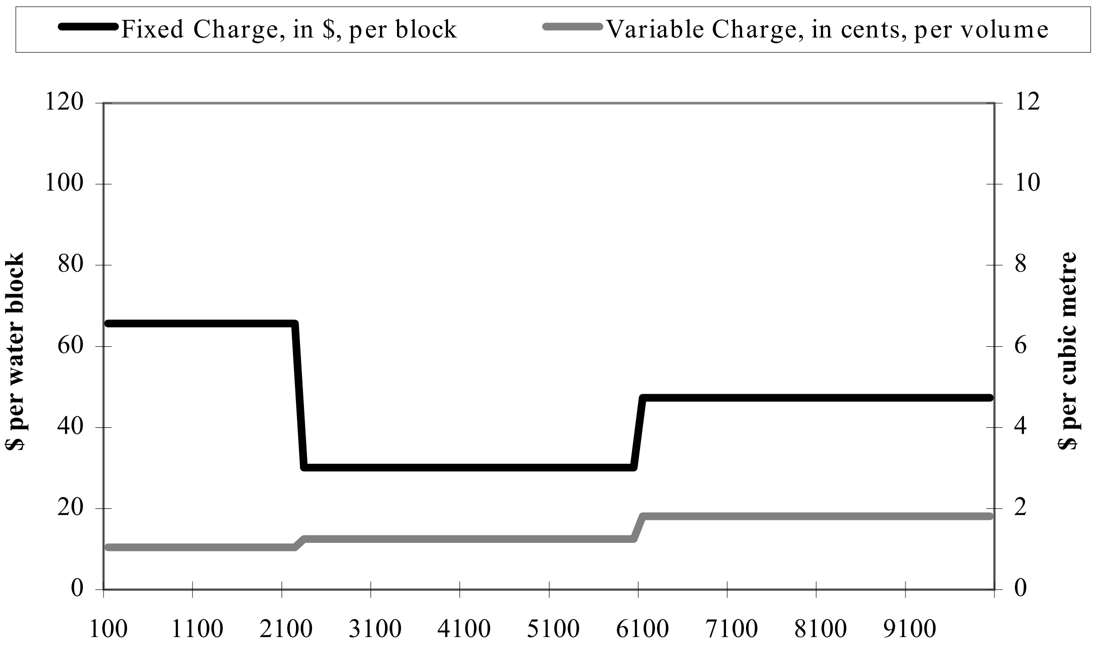
Given that seasonal pricing is chosen, the number and length of seasons has to be decided. Four seasons of varying durations and three different price levels are proposed for greater efficiency of water use. A short time series has been available to assess the seasonality of Akaroa's water demand. This suggests the following seasons: Jun/Jul/Aug/Sep – lowest price, Oct/Nov – medium price, Dec/Jan/Feb/Mar – highest price, and Apr/May – medium price. Block limits will need to be set to the right level for each season to be sure they work as planned.

If it is perceived that a four seasons/three prices scheme is not feasible, for example because of greater educational demands, an alternative two season/two prices scheme could be used. In such a case water demanded from December through to April could be charged at a high volumetric price and the remainder of the year would have a lower charge. Customers would not have to learn as many seasonal cut-off points and the different prices, but the incentives for efficient water use during the course of the year are reduced. However, it could also be the case that customers would be more inclined to support a more efficient system, than a compromise solution, given that seasonal pricing is introduced. Figure 11 illustrates hypothetical water charges for two seasons. The high season volumetric charge has been arbitrarily set at 150 per cent of the low season volumetric charge to illustrate peak season pricing. The peak season volumetric charges per metre are not large.

Figure 11
Illustration of Possible Water Charges for Two Seasons.



High season water charges



Low season water charges

Implementation

Meters will need to be read at the end of each season and the seasonal bill sent to each customer. A continued practice of data collection and use of computer support will make it possible to reassess block limits. Solid computer support will make the choice of the more efficient four-seasons/three prices seasonal model more feasible. In a seasonal context, the block limits should be set with respect to the seasonal average of residential, STSE and LTSE water demand. Continued reassessment will ensure efficient water use at any point in time and across time.

Optimally, a system to calculate charges will only need the current meter reading per customer to deliver the necessary seasonal limits and prices for the following seasons. This requires having not only detailed metered readings, but also data on different cost components. Once such a computer programme to calculate charges is in place the administration costs will be reduced to meter reading, data entry and mailing out the bills. Christchurch City Council employs four to five full time meter readers for 100000 readings per year (pers comm van Toor, 2003). In a first approximation for Akaroa this would equate to just over four per cent of these costs (1010 x 4 = 4040 readings per year). If a yearly wage of $31,000 were assumed meter reading would amount to $4.96 to $6.20 per year per customer plus some office costs.

In a number of OECD countries some form of increasing block structure for water tariffs is used nationwide or in parts of the country. Mainly two or three blocks are used, for example in Australia, Belgium, Canada, Luxembourg, Netherlands, Spain, Switzerland and Turkey. Countries with many blocks are Greece (five), Japan (two to seven), Korea (six to ten) and Portugal (two to five). For Mexico the number of blocks are unspecified. Most increasing block schedules have a fixed charge; Canada, Greece, Korea, Mexico, Spain and Turkey also have a minimum allowance. The water tariffs are geared towards social and water conservation concerns, and achieve these goals (OECD, 1999).

Achieving understanding and support by the water utility's customers of a more complex system, such as the one proposed, should be a high priority goal. The Banks Peninsula District Council has set a positive example by fostering the acceptance of water metering in general (Foote *et al*., 2002). The success of that campaign provides grounds for believing it will be possible to achieve understanding and acceptance of the proposed charging scheme and its merits. Table 30 provides a summary of the proposed water and sewage charging system.

Table 30
Evaluation of the Proposed Charging System Against Funding Criteria

Criteria		Compliance	Justification
Revenue generation			
	Sufficient	Yes	Computer support will ensure that the collected rates cover all costs.
	Stable over time	Yes	Preceding and continued water demand monitoring will ensure stability.
	Administration costs and complexity	Yes	Slightly higher complexity, but communication skills and computer support will assist.
Cost allocation			
	Non-arbitrary	Yes	User pays principle
	No cross subsidisation	Yes	User pays principle
Incentive provision			
	Static efficiency	Yes	The continued practice of reassessing the block limits will ensure efficient water use at any point in time.
	Dynamic efficiency	Yes	The continued practice of reassessing the block limits will ensure efficient water use across time.
	Encourage conservation	Yes	The design of the block limits will encourage water conservation.
	Correct interpretation	Partially	It is a transparent but more complicated system. In combination the continued communication practice and the incentive structures will become clear.

4.9 Solid Waste Charges: Critique And Suggestions For Improvements

This section compares the current charging system used in Akaroa for solid waste disposal against Hanemann's (1998) criteria and proposes an improved charging system.

4.9.1 Evaluation Against Hanemann's Funding Criteria

Akaroa households pay an annual flat rate for waste collection and disposal at present. Businesses pay the same disposal rate for the provision of a landfill, but no collection rate. Most businesses are part of a separate collection service which charges per pick up of different sized rubbish units. The collecting contractor then pays disposal costs for the collected truckloads at the dump. Hence, for businesses a type of volumetric charge is in place. While this commercial charging system can be proposed for revision because of price efficiency and environmental reasons, the following is written with respect to the charges faced by residents (see Table 31).

Uniform annual charges for solid waste collection and disposal sets no incentive to reduce waste. Any incentive will only become effective for very high waste producers who produce more waste than the yearly allowance of 52 bags at 50 litres each. These would mainly be commercial enterprises. Households, which do not fill a whole bag every week, and property owners who do not utilise the waste collection, for example holiday homeowners taking their rubbish back with them, are relatively overcharged under the current system, as well as lacking an incentive to reduce waste.

Table 31
Evaluation Akaroa's Solid Waste Charging System Against Funding Criteria

Criteria		Compliance	Justification
Revenue generation			
	Sufficient	Yes	The collected rates cover all costs.
	Stable over time	Yes	Revenue is predictable.
	Administration costs and complexity	Costs only	Small administration costs, but no differentiation.
Cost allocation			
	Non-arbitrary	No	High users pay the same as low users.
	No cross subsidisation	No	High users are subsidised.
Incentive provision			
	Static efficiency	No	Waste reduction incentives only for very high users.
	Dynamic efficiency	No	The high waste allowance imposes hardly any restrictions on waste production and therefore no incentives to change long-run behaviour.
	Encourage conservation	No	The lack of differentiated waste charges sets no incentive to engage in waste reduction.
	Correct interpretation	Partially	It is a very transparent system, but it does not lead to recognising the alleged incentives.

4.9.2 A Proposal for a Better Solid Waste Charging System

An improved system would take different volumes of waste per household into account. One way to achieve this is to take the refuse rates out of the rating system and to distribute different sized bags through the retail market. The prices of the bags could increase proportionally or over-proportionally with the size of the bags. The advantages of such a system are the acknowledgement of the user-pays-principle and the introduction of waste reduction incentives.

The costs of recycling are currently included in the waste collection charges. This practice should continue under a new system. It is acknowledged that this does not reflect true costs and recycling might be perceived as free. Nevertheless, further complication of the charging systems and environmental reasons weigh in favour of continuation of that policy. Under the new system higher waste producers would also pay more for recycling, such that recycled waste reduction incentives are effective all the same. Table 32 outlines the proposed charging system for solid wastes.

Such a system could be introduced relatively easily. It would require the estimation of refuse costs per volume. Current data on waste volume and costs could be used to design a system with proportional costs per volume for the introduction of the new system. Monitoring of refuse costs and waste behaviour as well as feedback from the community, will allow for future enhancement of the refuse-charging scheme. These further improvements could be due to better cost estimations, refined information on actual waste volumes, meaning the choice of the different sizes of bags, or the introduction of waste reduction incentives through pricing. Especially the size of the bags could best be evaluated through community questionnaires.

Table 32
Evaluation of the Proposed Charging System Against Funding Criteria

Criteria		Compliance	Justification
Revenue generation			
	Sufficient	Yes	Through estimation of volumetric costs and refuse disposal usage.
	Stable over time	Yes	Continued cost and waste monitoring will ensure stability.
	Administration costs and complexity	Yes	Utilisation of retail market and straight forward charges.
Cost allocation			
	Non-arbitrary	Yes	User pays principle
	No cross subsidisation	Yes	User pays principle
Incentive provision			
	Static efficiency	Yes	Different sized bags will ensure efficient waste production at any point in time.
	Dynamic efficiency	Yes	Different sized bags will ensure efficient waste production across time.
	Encourage conservation	Yes	Different sized bags will encourage waste reduction.
	Correct interpretation	Partially	It is transparent and sets environmentally sensible incentives.

4.10 Summary of Findings

Water and Wastewater

- Charging system
  - Payments are mostly independent of service usage
  - Incorporation in annual rates makes payments less obvious
- Financial contribution versus water and wastewater usage
  - Holiday homeowners pay too much per annum, but too little for peak usage
  - Permanent residents and commercial customers with little use subsidise large users
- Long term effects
  - No incentives for efficient water demand are set

    - Capacity constraints approached due to waste of water
    - Environmental degradation

Solid waste

- Charging system
    - Payments are mostly independent of service usage
    - Incorporation in annual rates makes payments less obvious
- Financial contribution versus waste production
    - Low users subsidise medium to high users
- Long term effects
    - No incentives for waste reduction are set
    - Environmental degradation

4.11 Summary of the Proposals

Water and Wastewater

- Increasing fixed charges
    - Large first block of charges
    - Second additional charge lower than first, third increasing again
- Increasing volumetric block charges
    - Limits dependent on grouped water demand
    - At least three blocks
- Data required before and after implementation
    - Costs components
    - Water usage with respect to
        - Customer groups
        - Seasons
- Likely outcomes
    - Reduced water and wastewater flows, especially during peak season
    - Lower operating costs
    - Delayed need for new capacity
    - Implementation of user pays principle
    - Lower annual cost of water and wastewater for most customers

Solid Waste

- Volumetric charges
    - Include recycling in refuse charges
    - Retail market based system
    - Different sized bags
    - (Over-) proportional price increase

- Data required before and after implementation
    - Costs components
    - Refuse monitoring
- Likely outcomes
    - Reduced waste
    - Implementation of user pays principle

Chapter 5
Summary

Non-commercial accommodation such as holiday homes is a very significant provider of guest-nights in Akaroa. The official District Council list of holiday homes underestimated the number of holiday homes by about 200 or over 70 per cent.

Monitoring of daily water consumption to individual properties during three four-day study periods enabled the research to estimate normalised water demand (litres/guest night) and demand by small tourist businesses. These values were used in water demand models.

Total water and wastewater volumes in Akaroa are highly variable and somewhat unpredictable due to high demand external water uses and rainfall infiltration into the sewers. The internal water use is correlated with dry weather wastewater flow, although the water volume is consistently higher. Dry weather wastewater flows are predictable, however infiltration from rainfall events can increase wastewater flows by up to 23 fold.

External water use was highly variable and is likely to be largely due to garden and lawn watering. High external water demand corresponded to periods of hot dry weather. Car and boat washing placed a small but significant demand on the town's water resource.

A model has been developed that can be used to anticipate, for the different sector users, peak water demand and dry-weather wastewater flows as well average monthly flows based on CAM tourist data. The model is specific to Akaroa, but it is likely that a similar model could be developed for other small towns so long as sufficient data is available on visitor numbers, and normalised water use rates for each major sector.

Applying the monthly water use model, the tourism sector's share of water use during August 99 to Dec 2002 was 14.7 per cent on average, but ranged from five per cent to 41 per cent of a month's actual water use. The tourism sector's water demand during summer could be as high as 60 per cent of the total peak water demand in Akaroa.

The research demonstrates there are indicators that correlate well with guest-nights and dry weather wastewater flows. Road count, grocery store door count and Information Centre doors count showed high levels of correlation. Similar indicators are likely to be available in other townships and might be tested to determine how well correlated they are with guest nights and water and wastewater flows.

Strong relationships were found between several measures of daily visitor numbers and street bin solid waste volumes. These relationships could be used to project future street waste volumes and aid planning by BPDC.

Solid waste management practices in Akaroa are of variable quality and improvement is possible in several areas. Eighty six percent of businesses participate in recycling schemes, but most only participate on a partial basis. Only one Akaroa business participates in an environmental management scheme and adoption of a scheme such as Green Globe 21 would contribute to improved business solid waste management, as well as water and wastewater management. Improvements in solid waste management are also more likely to occur if services such as organic refuse collection were available in Akaroa.

The BPDC charging systems used for these services were compared to ten criteria and the charging systems used in Akaroa were found to be deficient in several respects. The charging systems for water and wastewater do not accurately allocate costs to users, and provide weak or zero incentive to users to conserve water including during periods of peak demand.

Improved charging systems for water and wastewater are proposed which if carefully implemented have the potential to overcome most of the existing defects in the current charging system. The proposed charging system incorporates volumetric charges which can be readily estimated as all Akaroa properties have water meters installed.

Careful implementation of the proposed charging system is expected to lead to moderation of water demands, particularly during the peak demand period, lower annual costs for BPDC, and avoid the need for costly new water sources for Akaroa in the foreseeable future.

The current solid waste charging system does not accurately allocate costs to ratepayers. An improved charging system is proposed requiring distribution of bags for solid waste disposal through retail outlets.

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Appendix A
Survey Forms for Commercial Accommodation Providers

Akaroa Tourism Survey:Jan /2003 -Lincoln University, Tourism Recreation Research and Education Centre
Motels

Business name	
No of permanent residents	

Contact for survey;

Andrew Dakers
Registered Engineer
Ph 021 533386
Email: Dakers@paradise.net.nz
Fax: 03 942 9954

		Number of overnight guests for the night of:			
	Number of bednights available	Thursday 16th Jan	Friday 17th Jan	Saturday 18th Jan	Sunday 19th Jan
Motel units					
Other accommodation. Specify					
Note any significant water usage – e.g. irrigation, car or boat washing. Specify					

Note any special measures taken to use town water efficiently and reduce solid waste output	

Akaroa Tourism Survey:Jan/2003 -Lincoln University, Tourism Recreation Research and Education Centre
Hotels

Business name	
No. of permanent residents	

Contact for survey;

Andrew Dakers
Registered Engineer
Ph 021 533386
Email: Dakers@paradise.net.nz
Fax: 03 942 9954

		Number of overnight guests for the night of:			
	Number of bednights available	Thursday 16th Jan	Friday 17th Jan	Saturday 18th Jan	Sunday 19th Jan
Hotel Rooms					
Other accommodation. Specify					
Note any significant water usage – e.g. irrigation, car or boat washing. Specify					

Note any special measures taken to use town water efficiently and reduce solid waste output	

Akaroa Tourism Survey: Jan/2003 -Lincoln University, Tourism Recreation Research and Education Centre
Camping Ground

Business name	
No. of permanent residents	

Contact for survey;

Andrew Dakers
Registered Engineer
Ph 021 533386
Email: Dakers@paradise.net.nz
Fax: 03 942 9954

Number of overnight guests for the night of:			
Thursday 16th Jan	Friday 17th Jan	Saturday 18th Jan	Sunday 19th Jan

Note any special measures taken to use town water efficiently and reduce solid waste output	

Akaroa Tourism Survey: Jan/2003 -Lincoln University, Tourism Recreation Research and Education Centre
Bed and Breakfast

Business name	
No. of permanent residents	

Contact for survey;

Andrew Dakers
Registered Engineer
Ph 021 533386
Email: Dakers@paradise.net.nz
Fax: 03 942 9954

		Number of overnight guests for the night of:			
	Number of bednights available	Thursday 16th Jan	Friday 17th Jan	Saturday 18th Jan	Sunday 19th Jan
B and B rooms					
Note any significant water usage – e.g. irrigation, car or boat washing. Specify					

Do you recycle:	Paper, cardboard - Y / N ?	Glass – Y / N ?	Cans - Y / N ?	Plastics - Y / N ?

Do you compost kitchen and other green wastes **Y / N ?**	**Do you collect rainwater?** **Y / N ?**	Other comments

Akaroa Tourism Survey: Jan/2003 -Lincoln University, Tourism Recreation Research and Education Centre
Back Packers

Business name	
No. of permanent residents	

Contact for survey;

Andrew Dakers
Registered Engineer
Ph 021 533386
Email: Dakers@paradise.net.nz
Fax: 03 942 9954

		Number of overnight guests for the night of:			
	Number of bednights available	Thursday 16th Jan	Friday 17th Jan	Saturday 18th Jan	Sunday 19th Jan
Rooms					
Note any significant water usage – e.g. irrigation, car or boat washing. Specify					

Note any special measures taken to use town water efficiently and reduce solid waste output	

Appendix B
Survey Forms for Holiday Home and Permanent Resident Street Survey

Akaroa Tourism Survey: Jan/2003 -Lincoln University, Tourism Recreation Research and Education Centre
Holiday Home Survey

Street address	
Date of visit	
Time of visit	am or pm

If somebody is home – complete the following details:

Occupants arrival date			**Occupants departure date**	
	Thursday 16th Jan	Friday 17th Jan	Saturday 18th Jan	Sunday 19th Jan
Number of occupants				
External water use				
Outside water use – irrigation, car or boat washing				
Number of rubbish bags				

Do they:

Recycle paper/cardboard	- Y / N	Recycle glass	- Y / N
Recycle plastic	- Y / N	Recycle cans, metals	- Y / N
Compost kitchen and green wastes	- Y / N	Collect rainwater	- Y / N

Akaroa Tourism Survey: Jan/2003 -Lincoln University, Tourism Recreation Research and Education Centre
Permanent Home Survey

Street address	
Date of visit	
Time of visit	am or pm

If somebody is home – complete the following details:

Occupants arrival date			**Occupants departure date**	
	Thursday 16th Jan	Friday 17th Jan	Saturday 18th Jan	Sunday 19th Jan
Number of permanent occupants				
Number of visitors				
5.1.1 External water use				
Outside water use – irrigation, car or boat washing				
No of rubbish bags				

Do they:

Recycle paper/cardboard	- Y / N	Recycle glass	- Y / N
Recycle plastic	- Y / N	Recycle cans, metals	- Y / N
Compost kitchen and green wastes	- Y / N	Collect rainwater	- Y / N

Appendix C
Survey Forms for Town Centre Street Survey

Street Survey- Akaroa 3

For day-trippers survey people in the street.

Name of surveyor		Location	South end North end	Date	

Ask if tourist or on holiday in Akaroa. If yes proceed with Visitor questions below. If not establish if

Permanent local resident	Y/N
On business in Akaroa	Y/N
Banks Peninsula resident shopping or on business trip	Y/N
Other	Y/N

No. of people in party?

Visitor Questions

1. Is this a daytrip to Akaroa?	Y/N

YES ← → NO

Where have you come from today?	
What commercial tourist activities have you done or you plan to do in Akaroa today?	

How many days have stayed and will be staying in Akaoroa?	
What commercial tourist activities have you done or you plan to do in Akaroa today?	
Type of accommodation	Hotel, Motel, Backpackers, Camp. Ground, Campervan, Holiday home, friends, other

Appendix D
Tables 33-38

Table 33
Business Waste Volumes Codes

Season	1	10/10/02 to 13/10/02
	2	5/12/02 to 8/12/02
	3	16/01/03 to 19/01/03
Day	1	Thursday
	2	Friday
	3	Saturday
	4	Sunday
Code	H	Hotels
	M	Motels
	BP	Backpackers
	CG	Camping Ground
	BB	B&B
	B	Bakery
	R	Restaurant/Café
	B	Butchery
	F	Fish and Chips
	RC	Retail/Crafts
	D	Dairy/Store
	S	Supermarket
	SB	Small Boat
	LB	Large Boat

Table 34
Business Solid Waste to Landfill

Volume m3	Day	Date	Code
0.0336	1	10/10/2	LB
0.0336	2	11/10/2	LB
0.0336	3	12/10/2	LB
0.0336	4	13/10/2	LB
0.06	1	5/12/2	LB
0.24	2	6/12/2	LB
0	3	7/12/2	LB
0	4	8/12/2	LB
0.07	1	16/1/3	LB
0.11	2	17/1/3	LB
0.02	3	18/1/3	LB

Volume m3	Day	Date	Code
0.05	4	19/1/3	LB
0.01	1	10/10/2	SB
0.01	2	11/10/2	SB
0.01	3	12/10/2	SB
0.01	4	13/10/2	SB
0.07	1	5/12/2	RC
0.07	2	6/12/2	RC
0.07	3	7/12/2	RC
0.07	4	8/12/2	RC
0.07	1	16/1/3	RC
0.07	2	17/1/3	RC
0.07	3	18/1/3	RC
0.07	4	19/1/3	RC
0.1	1	10/10/2	RC
0.1	2	11/10/2	RC
0.1	3	12/10/2	RC
0.1	4	13/10/2	RC
0.02	1	5/12/2	RC
0.02	2	6/12/2	RC
0	3	7/12/2	RC
0.02	4	8/12/2	RC
0.01	1	16/1/3	RC
0.01	2	17/1/3	RC
0	3	18/1/3	RC
0.002	4	19/1/3	RC
0.02	1	10/10/2	RC
0.015	2	11/10/2	RC
0	3	12/10/2	RC
0.02	4	13/10/2	RC
0.1	1	5/12/2	H
0.1	2	6/12/2	H
0.12	3	7/12/2	H
0.37	4	8/12/2	H
0.29	1	16/1/3	H
0.05	2	17/1/3	H
0.11	3	18/1/3	H
0.37	4	19/1/3	H
0.15	1	10/10/2	H
0.21	2	11/10/2	H
0	3	12/10/2	H
0.3	4	13/10/2	H
0.18	1	5/12/2	H
0.36	2	6/12/2	H
0.24	3	7/12/2	H

Volume m3	Day	Date	Code
0.24	4	8/12/2	H
0.24	1	16/1/3	H
0.31	2	17/1/3	H
0.17	3	18/1/3	H
0.18	4	19/1/3	H
0.04	1	10/10/2	H
0.28	2	11/10/2	H
0.05	3	12/10/2	H
0.24	4	13/10/2	H
0.12	1	5/12/2	H
0.24	2	6/12/2	H
0.24	3	7/12/2	H
0.24	4	8/12/2	H
0.25	1	16/1/3	H
0.17	2	17/1/3	H
0.02	3	18/1/3	H
0.12	4	19/1/3	H
0.09	1	10/10/2	H
0.28	2	11/10/2	H
0.13	3	12/10/2	H
0.28	4	13/10/2	H
0.03	1	5/12/2	M
0.03	2	6/12/2	M
0.03	3	7/12/2	M
0.03	4	8/12/2	M
0.06	1	16/1/3	M
0.08	2	17/1/3	M
0.07	3	18/1/3	M
0.08	4	19/1/3	M
0.01	1	10/10/2	M
0.04	2	11/10/2	M
0.06	3	12/10/2	M
0	4	13/10/2	M
0.22	1	5/12/2	M
0.17	2	6/12/2	M
0.13	3	7/12/2	M
0.48	4	8/12/2	M
0.5	1	16/1/3	M
0.24	2	17/1/3	M
0.27	3	18/1/3	M
0.24	4	19/1/3	M
0.25	1	10/10/2	M
0.35	2	11/10/2	M
0.35	3	12/10/2	M
0.47	4	13/10/2	M

Volume m3	Day	Date	Code
0.24	1	5/12/2	M
0.24	2	6/12/2	M
0.24	3	7/12/2	M
0.24	4	8/12/2	M
0.56	1	16/1/3	M
0.03	2	17/1/3	M
0.02	3	18/1/3	M
0.13	4	19/1/3	M
0.24	1	10/10/2	M
0.51	2	11/10/2	M
0.13	3	12/10/2	M
0.37	4	13/10/2	M
0.1	1	5/12/2	M
0.08	2	6/12/2	M
0.04	3	7/12/2	M
0.12	4	8/12/2	M
0.06	1	16/1/3	M
0.13	2	17/1/3	M
0.07	3	18/1/3	M
0.04	4	19/1/3	M
0.19	1	10/10/2	M
0.21	2	11/10/2	M
0.09	3	12/10/2	M
0.16	4	13/10/2	M
0.14	1	5/12/2	CG
0.14	2	6/12/2	CG
0.14	3	7/12/2	CG
0.14	4	8/12/2	CG
1.02	1	16/1/3	CG
0.3	2	17/1/3	CG
0.24	3	18/1/3	CG
0.8	4	19/1/3	CG
0.66	1	10/10/2	CG
1.27	2	11/10/2	CG
0.25	3	12/10/2	CG
0.93	4	13/10/2	CG
0.05	1	5/12/2	BP
0.05	2	6/12/2	BP
0.05	3	7/12/2	BP
0.05	4	8/12/2	BP
0	1	16/1/3	BP
0.24	2	17/1/3	BP
0	3	18/1/3	BP
0	4	19/1/3	BP
0.01	1	10/10/2	BP

Volume m3	Day	Date	Code
0.24	2	11/10/2	BP
0	3	12/10/2	BP
0	4	13/10/2	BP
0.24	1	5/12/2	B
0.24	2	6/12/2	B
0.24	3	7/12/2	B
0.1584	4	8/12/2	B
0.24	1	16/1/3	B
0.24	2	17/1/3	B
0.24	3	18/1/3	B
0.24	4	19/1/3	B
0.24	1	10/10/2	B
0.24	2	11/10/2	B
0.24	3	12/10/2	B
0.24	4	13/10/2	B
0.15	1	5/12/2	F
0.2	2	6/12/2	F
0.2	3	7/12/2	F
0.2	4	8/12/2	F
0.2	1	16/1/3	F
0.3	2	17/1/3	F
0.2	3	18/1/3	F
0.25	4	19/1/3	F
0.5	1	10/10/2	F
0.45	2	11/10/2	F
0.4	3	12/10/2	F
0.45	4	13/10/2	F
0.1	1	5/12/2	R
0.05	2	6/12/2	R
0.08	3	7/12/2	R
0.08	4	8/12/2	R
0.12	1	16/1/3	R
0.26	2	17/1/3	R
0.22	3	18/1/3	R
0.31	4	19/1/3	R
0.025	1	10/10/2	R
0.0375	2	11/10/2	R
0.05	3	12/10/2	R
0.05	4	13/10/2	R
0.24	1	5/12/2	R
0.18	2	6/12/2	R
0.07	3	7/12/2	R
0.11	4	8/12/2	R
0.04	1	16/1/3	R
0.32	2	17/1/3	R

Volume m3	Day	Date	Code
0.11	3	18/1/3	R
0.23	4	19/1/3	R
0.1032	1	10/10/2	S
0.1032	2	11/10/2	S
0.1032	3	12/10/2	S
0.1032	4	13/10/2	S
0.07	1	5/12/2	D
0.05	2	6/12/2	D
0.06	3	7/12/2	D
0.06	4	8/12/2	D
0.02	1	16/1/3	D
0.16	2	17/1/3	D
0.04	3	18/1/3	D
0.01	4	19/1/3	D

Table 35
Street Bin and Reserve Refuse Volumes

Volume	Day	Season	Date
0.95	1	1	10/10/2
0.80	2	1	11/10/2
1.05	3	1	12/10/2
0.75	4	1	13/10/2
0.75	1	2	5/12/2
1.35	2	2	6/12/2
0.70	3	2	7/12/2
0.80	4	2	8/12/2
2.15	1	3	16/1/3
1.70	2	3	17/1/3
1.95	3	3	18/1/3
1.80	4	3	19/1/3

Table 36
Recycling Deport Volumes (m^3)

Day	Date	Al	HDPE	PET	B glass	W glass	G glass	C/board stacked	C/board whole	N/paper stacked
1	10/10/2	0.05	0.10	0.05	0.05	0.00	0.13	0.09	0.13	0.13
2	11/10/2	0.00	0.10	0.00	0.00	0.05	0.05	0.08	0.00	0.00
3	12/10/2	0.00	0.00	0.00	0.03	0.00	0.16	0.00	0.00	0.00
4	13/10/2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	5/12/2	0.05	0.00	0.00	0.03	0.03	0.07	0.12	0.00	0.05
2	6/12/2	0.00	0.00	0.00	0.07	0.02	0.07	0.08	0.00	0.03
3	7/12/2	0.10	0.44	0.25	0.07	0.05	0.13	0.16	0.00	0.00
4	8/12/2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	16/1/3	0.03	0	0.06	0.09	0.05	0.14	0	0	0
2	17/1/3	0.03	0	0.13	0.2	0.1	0.07	0	0	0
3	18/1/3	0.07	0.11	0.16	0.11	0.06	0.26	0.77	0	2.2
4	19/1/3	0.1	0.59	0.09	0.09	0.24	0.54	0.05	0	0

Table 37
Correlation of Recycling Centre Volumes and Visitor Counts

n	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**11**	**12**	**12**	**12**	**12**	**12**
Tins	Bednights	Overpr	Totnoncom	HBN	MBN	BB	BP	CG	Totcom	NS	IC	SS	JRT	BRT	RGT	TOTT	Road
Correlations With Volume	0.4595	-0.2459	0.4527	0.0641	0.1226	-0.0154	0.0973	-0.0917	0.0535	-0.0007	-0.1156	-0.5877	-0.3645	-0.174	0.2515	-0.2476	0.0001
p	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	< 0.05	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1
Aluminium	Bednights	Overpr	Totnoncom	HBN	MBN	BB	BP	CG	Totcom	NS	IC	SS	JRT	BRT	RGT	TOTT	road
Correlations With Volume	0.3172	0.3364	0.3252	0.3273	0.3563	0.5474	0.4572	0.448	0.3192	0.6631	0.557	0.06	0.3451	0.5472	0.4915	0.3767	0.6393
p	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	<0.1	> 0.1	> 0.1	> 0.1	< 0.05	<0.1	> 0.1	> 0.1	<0.1	> 0.1	> 0.1	< 0.05
HDPE	Bednights	Overpr	Totnoncom	HBN	MBN	BB	BP	CG	Totcom	NS	IC	SS	JRT	BRT	RGT	TOTT	Road
Correlations With Volume	0.1664	0.2445	0.1723	0.175	0.2374	0.3864	0.3157	0.1961	0.0501	0.5216	0.3394	-0.154	0.1885	0.3723	0.4909	0.3147	0.5352
p	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	<0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	<0.1
PET	Bednights	Overpr	Totnoncom	HBN	MBN	BB	BP	CG	Totcom	NS	IC	SS	JRT	BRT	RGT	TOTT	Road
Correlations With Volume	0.7086	0.2218	0.7131	0.4404	0.6128	0.6782	0.4359	0.5897	0.6222	0.5627	0.4722	0.0487	0.368	0.4359	0.6131	0.3192	0.5998
p	< 0.01	> 0.1	< 0.01	> 0.1	< 0.05	< 0.05	> 0.1	< 0.05	< 0.05	<0.1	> 0.1	> 0.1	> 0.1	> 0.1	< 0.05	> 0.1	< 0.05
Brown Glass	Bednights	Overpr	Totnoncom	HBN	MBN	BB	BP	CG	Totcom	NS	IC	SS	JRT	BRT	RGT	TOTT	Road
Correlations With Volume	0.6886	0.3542	0.6965	0.4492	0.7327	0.7762	0.5228	0.8546	0.7951	0.7311	0.7731	0.701	0.6294	0.5839	0.2891	0.445	0.7332
p	< 0.05	> 0.1	< 0.05	> 0.1	< 0.01	< 0.01	<0.1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05	< 0.05	< 0.05	> 0.1	> 0.1	< 0.01
White Glass	Bednights	Overpr	Totnoncom	HBN	MBN	BB	BP	CG	Totcom	NS	IC	SS	JRT	BRT	RGT	TOTT	Road
Correlations With Volume	0.1702	0.4372	0.1809	0.2902	0.4423	0.6382	0.521	0.5472	0.3095	0.7751	0.7133	0.443	0.5953	0.6615	0.3755	0.5455	0.7845
p	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	< 0.05	<0.1	<0.1	> 0.1	< 0.01	< 0.01	> 0.1	< 0.05	< 0.05	> 0.1	<0.1	< 0.01

n	12	12	12	12	12	12	12	12	12	12	12	11	12	12	12	12	12
Green Glass	Bednights	Overpr	Totnoncom	HBN	MBN	BB	BP	CG	Totcom	NS	IC	SS	JRT	BRT	RGT	TOTT	Road
Correlations With Volume	0.0844	0.5976	0.0992	0.3936	0.3419	0.5846	0.3454	0.4626	0.2245	0.7645	0.5945	0.386	0.5214	0.6878	0.446	0.7009	0.7355
p	> 0.1	< 0.05	> 0.1	> 0.1	> 0.1	< 0.05	> 0.1	> 0.1	> 0.1	< 0.01	< 0.05	> 0.1	<0.1	< 0.05	> 0.1	< 0.05	< 0.01
Cardboard Flattened	Bednights	Overpr	Totnoncom	HBN	MBN	BB	BP	CG	Totcom	NS	IC	SS	JRT	BRT	RGT	TOTT	Road
Correlations With Volume	0.3019	0.1509	0.3052	0.3568	0.4077	0.3962	0.2588	0.4556	0.483	0.3471	0.333	0.2963	0.2478	0.3057	0.1985	0.2264	0.4193
P	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1
Cardboard Whole	Bednights	Overpr	Totnoncom	HBN	MBN	BB	BP	CG	Totcom	NS	IC	SS	JRT	BRT	RGT	TOTT	Road
Correlations With Volume	-0.3381	0.13	-0.3344	-0.3149	-0.5078	-0.3331	-0.5842	-0.3253	-0.4232	-0.3078	-0.2361	-0.239	-0.3967	-0.2528	-0.4756	-0.122	-0.3772
P	> 0.1	> 0.1	> 0.1	> 0.1	<0.1	> 0.1	< 0.05	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1
Newspaper	Bednights	Overpr	Totnoncom	HBN	MBN	BB	BP	CG	Totcom	NS	IC	SS	JRT	BRT	RGT	TOTT	Road
Correlations With Volume	0.2473	0.2652	0.2536	0.3549	0.371	0.438	0.1852	0.4967	0.4901	0.3163	0.3331	0.4094	0.3602	0.3481	0.2036	0.3078	0.4071
P	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1	> 0.1

Table 38
Descriptive Statistics for Holiday Homes and Permanent Residents

	Descriptive Statistics for:	
	Holiday Home	**Resident**
	n = 21	*n = 84*
Mean	6.021E-03	3.759E-03
SD	7.0658E-03	2.71E-03
SE Mean	1.671E-03	2.959E-04
Minimum	6.000E-04	5.555E-04
Maximum	0.0375	0.0125

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