# DESIGNING FOR A SMALL HOLIDAY COMMUNITY

***David Wilson [1] and Derrick Railton[2] [1]CPG New Zealand Limited, Wellington, New Zealand, [2]CPG New Zealand Limited, Dunedin, New Zealand***

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## ABSTRACT

Riversdale is a small coastal holiday community on the Wairarapa coast. The community is to be provided with a new sewerage scheme. Designing the scheme presented particular challenges due to a very low permanent population, extreme population increases during summer holiday period and a high groundwater table in sandy soils. Land application of the treated wastewater to a limited area required design flows to be developed with a high degree of confidence.

A daily population model was developed for Riversdale Beach by undertaking an occupancy survey over the summer holiday period and combining this with census data.

Infiltration inflow rates were assessed by first reviewing operational data from several Wastewater Treatment Plants (WWTPs) around New Zealand and typical design allowances for inflow and infiltration (I&I). This information was then assessed in the context of a significant portion of a possible gravity collection system being permanently submerged below groundwater levels.

The design flows analysis shows that groundwater inflow rates and volumes are critical factors in the design of the proposed sewerage scheme. As a result of the analysis, a pressurised wastewater collection system that effective eliminates infiltration inflow was recommended for consideration for the proposed scheme.

The design flows established were then put through an in-depth water balance modelling exercise as part of the land application design, which is the subject of another paper being presented by Hamish Lowe at this conference.



## KEYWORDS

**Wastewater flows, occupancy models, holiday communities, Infiltration inflows.**

# 1 INTRODUCTION

Riversdale Beach is a low-lying coastal township on the southeast coast of the North Island of New Zealand. CPG New Zealand Ltd (CPG) has been commissioned by Masterton District Council (MDC) to undertake the design and construction management of the Riversdale Beach Community Sewerage Scheme (RBCSS). RBCSS is to replace the existing conventional septic tank and on-site effluent disposal systems. Riversdale has no sources of industrial wastewater; therefore the proposed scheme only has to cater for domestic wastewater and I&I. Two key design parameters for the RBCSS were daily volumes and peak flows. The daily volumes were critical for the design of the irrigation buffer storage for land application, while peak flows were critical for the hydraulic design of the reticulation, pumping stations, rising mains and treatment plant.


*Figure 1: Extent of Proposed Riversdale Community Sewerage Scheme*

Monitoring of groundwater, carried out by Greater Wellington Regional Council (GWRC) at five locations between July 2006 and July 2008, indicates the groundwater levels vary from around 0.84 m below ground level (bgl) to 2.93 m bgl; with a median level typically around 2 m bgl. It should be noted that at the southern end of the community, water levels are closer to the surface year round, and in many cases are not expected to be much lower than 1 m bgl even in summer.

The Riversdale Beach community is characterised by a normally low resident population with large increases during weekend and holiday periods, particularly during the summer holidays. This very low permanent population combined with the high groundwater table means that there is a significant risk that a low but constant infiltration inflow could cause a significant contribution to the annual wastewater volume.

# 2 REVIEW OF DOMESTIC WASTEWATER FLOWS

## 2.1 AVERAGE FLOW PER PERSON

The assessment of an appropriate per capita domestic wastewater generation flow was developed from CPG's extensive experience with on-site wastewater design and the related standard AS/NZS 1547:2000. The Standard's suggested rate of 150 L/p/d was adopted for the calculation of the domestic wastewater flows for the design of the RBCSS.

## 2.2 PEAK SUMMER POPULATION FLOW ESTIMATE

The approach taken to develop the estimated existing and future peak summer flows was to estimate the current peak wastewater flow generation based on a 2008/09 occupancy survey. The next step was to identify an appropriate growth rate to apply to this estimate to establish the future peak summer population design flow.

### 2.2.1 SUMMER 2008/09 OCCUPANCY SURVEY

CPG undertook an occupancy survey during the 2008/09 summer holidays to estimate a peak summer populations and develop a daily occupancy model for the summer period. The main findings of this survey were that the peak summer population on 31 December 2008 for the 207 surveyed occupied private dwellings was 1,266 (including 193 day visitors); and over the 2008/09 summer survey period the overnight population varied between a peak of 1,073 on the 31 December 2008 and low of 435 on 25 January 2009 (see Figure 2 below).

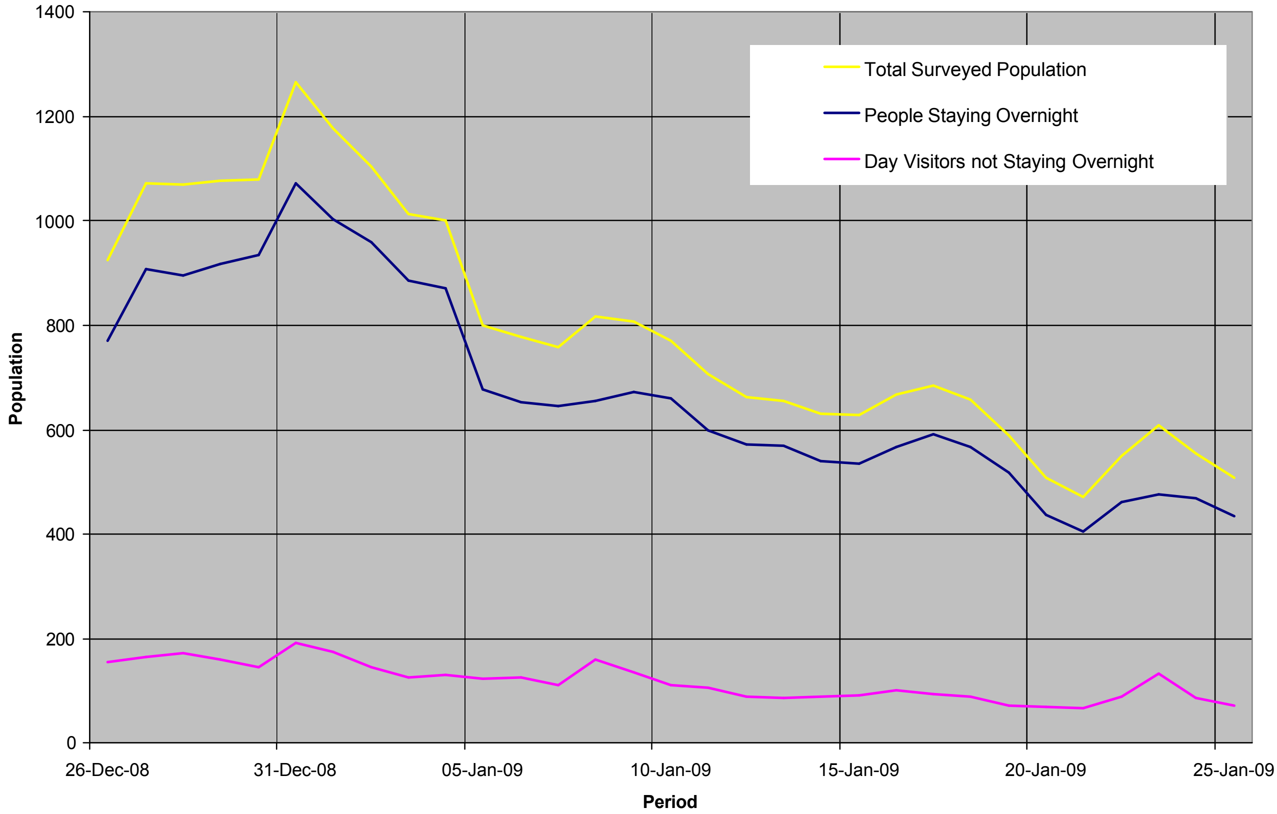


*Figure 2: Daily Occupancy figures for the Riversdale Beach Community from 26/12/08 to 26/01/09*

The peak average dwelling occupancy rate was 5.2 people per dwelling, excluding day visitors (i.e. 1,073 people staying overnight in the 207 occupied dwellings) by the same measure there was an average of 0.9 day visitors per dwelling. The peak occupancy rate was adopted as the design basis for estimating peak summer resident wastewater flows.

The 207 occupied dwellings compare to a total 257 dwellings, giving an 81% occupancy rate. Therefore the 2008/09 summer season did not represent the maximum possible summer occupancy conditions. It was considered appropriate and conservative for design purposes, to apply the 5.2 occupancy factor to the total number of residences in order to establish the likely maximum dwelling occupancy. Using the same logic, it was also appropriate to apply the 0.9 day visitor rate to the total number of residences to establish the likely maximum number of day visitors.

### 2.2.2 CURRENT PEAK SUMMER FLOW ESTIMATE

The 2008/09 occupancy survey provided a reasonable basis for estimating the current design peak resident population. For "other" sites, such as the campgrounds, surf club and other public facilities, the occupancy figures recommended in a MWH report titled "Estimation of Occupancy for Dwelling Units, and Public and Private Facilities", was adopted. This report established an existing peak population equivalent (PE) of 722 persons.

The current peak summer wastewater flow estimate was therefore calculated as follows:

| | | | | |
|---|---|---|---|---|
| Resident Population Flow | 257 dwellings @ 5.2 = | 1,336 people | @ 150 L/p/d | = 200 $m^3$/d |
| Day Visitors (from survey) | 257 dwellings @ 0.9 = | 231 people | @ 60 L/p/d | = 14 $m^3$/d |
| Campgrounds & Public Facilities | | 722 PE | @ 150 L/p/d | = 108 $m^3$/d |
| Total Estimated Current Peak Summer Daily Flow | | | | = 322 $m^3$/d |
| Overall Population Equivalent (assessed @ 150 L/p/d) | | | | = 2,146 PE |

### 2.2.3 DESIGN FUTURE PEAK SUMMER FLOW PROJECTION

A review of the development since 1954 indicated that during the first 20 - 30 years, Riversdale Beach quickly developed to a community of just over 300 lots. However, in more recent years, the community has developed at a much slower rate. Two sources were used to assess a probable future growth rates for Riversdale:

1. New dwelling consents issued by MDC from 1999 to present; and

2. Census data for the Wellington Region,

Over the last 10 years 30 building consents have been issued for new dwellings in Riversdale, equating to roughly 3 per year. There are currently an estimated 310 existing dwellings within the residential zone (the extent of the MDC data search), made up of 251 existing dwellings and 59 dwellings on "other" sites, ex Campgrounds, Surf Club, etc. The dwelling growth rate has been slightly more than 1% pa, based on the new dwelling building consent data.

A review of the census 'normally resident population' data from 1991 to 2006 for the Wellington Region, which is the catchment for people who are likely to buy and build in Riversdale, provided an annual growth rate of 0.75% pa.

A review of the development potential identified the areas and consented developments that are able to cater for future growth. This review indicated that Riversdale Beach has a lot of development potential and that this potential was unlikely to limit the future design peak population. Therefore the dwelling growth rate is likely to dictate the population in 20 - 30 years time.

Therefore a dwelling growth rate of 1% pa was considered to be conservative for estimating the long-term development in Riversdale. Some of this growth will be in Riversdale Terraces Stage 1, which has its own wastewater treatment system, and can accommodate 70 dwellings alone, the growth rate within the proposed RBCSS catchment has been adopted as 0.5% pa. This growth rate was applied to the current peak population estimate to establish the future peak design population in 30 years time, as follows:

| | | | | |
|---|---|---|---|---|
| Resident Population Flow | 1,336 PE @ 0.5% | = 1552 PE | @150 L/p/d | = 233 $m^3$/d |
| Day Visitors (from survey) | 231 people @ 0.5% | = 261 people | @ 60 L/p/d | = 15 $m^3$/d |
| Campgrounds & Public Facilities | 722 PE @ 1.0% | = 973 PE | @ 150 L/p/d | = 146 $m^3$/d |
| Total Estimated 2038/39 Peak Summer Daily Flow | | | | = 394 $m^3$/d |
| Overall Population Equivalent (assessed @ 150 L/p/d) | | | | = 2,626 PE |

## 2.3 OFF-PEAK TRENDS DURING THE YEAR

### 2.3.1 NON-RESIDENT POPULATION VARIATION

Data from several WWTPs around New Zealand was sourced to assess both population profiles over the year and the extent of I&I issues for New Zealand holiday communities. Typical examples are shown in Figures 3 and 4 below.

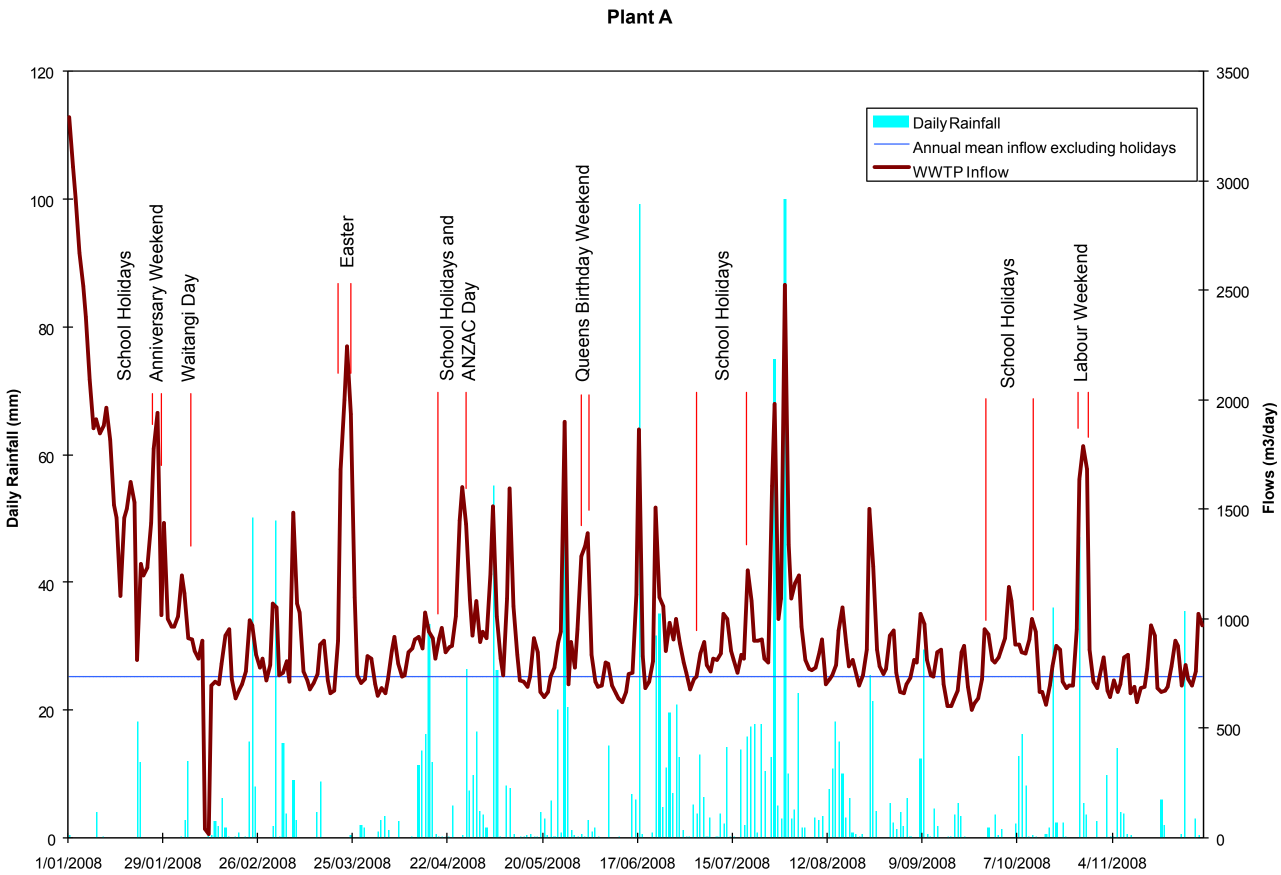


*Figure 3: Daily Inflow data at a beach holiday community WWTP*

Based on the inflow data this community has a normally resident population roughly 23% of the peak summer population. The inflow data clearly shows the importance of the summer holidays and other statutory holidays, Easter is the best example as it has little rainfall but a significant increase in inflows. The inflow data also shows the influence of I&I which causes peaks that are almost as significant as summer holiday peak.

The data for Waihi Beach, shown below in Figure 4, also shows the importance of the summer holidays and other statutory holidays. The Waihi Beach data clearly indicates the how of I&I related flows can generate significant volumes, this is especially evident in May and June 2008.

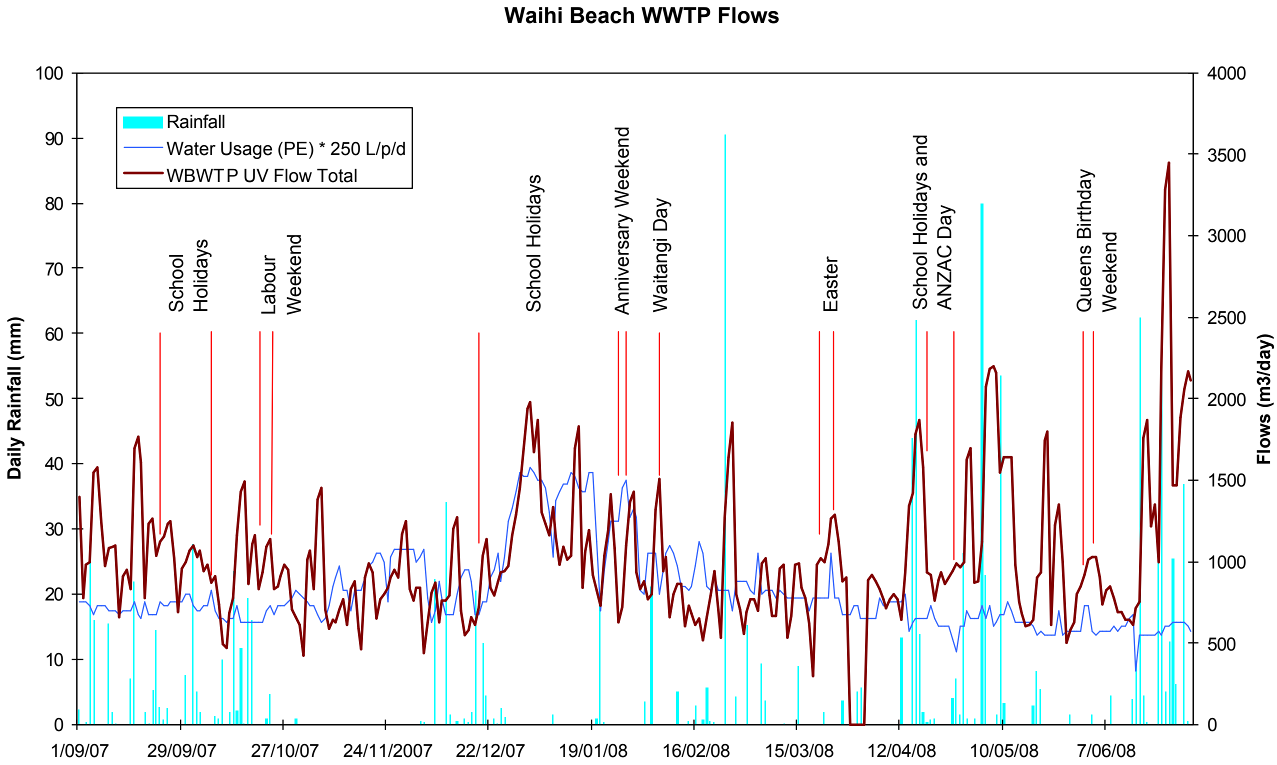


Figure 4: Daily Outflow Data at Waihi Beach WWTP UV plant

This review showed that these flows are very site specific and that they could not be used to easily generate daily design flows for the RBCSS. However the following only generic observation can be drawn from reviewing this data;

1. The summer holiday period results in the most significant peak population, followed by long weekends, while other school holidays have a less significant effect; and

2. The effects of I&I are at least, if not more, significant as population variation.

### 2.3.2 NORMALLY RESIDENT POPULATION

Based on the census data from 1991 through to 2006, the usually resident population in Riversdale Beach has remained at less than 65 people, roughly 3% of the assessed peak summer resident population. Typically holiday communities have a permanent resident population anywhere from 20% up to 50% of their peak summer population. The extremely low permanent population makes it necessary to investigate all possible population variations including weekend, and school holidays as well as the summer and statutory holiday peaks that were appear in the WWTP data review. Typical non-summer occupancy data was collected as part of the 2008/09 summer occupancy survey. A winter occupancy rate of 3.5 people per dwelling was adopted for long weekends, weekends and school holidays. Based on the 2008/09 Occupancy Survey, the following percentages of peak summer resident population were developed.

| Situation | Occupancy from Survey Data | Ratio of Winter and Summer Occupancy Rates (3.5/5.2 = 0.67) | Occupancy as Percentage of Peak Summer Resident Population |
|---|---|---|---|
| Long Weekends | 59% | 0.67 | 39% |
| Other Weekends | 32% | 0.67 | 21% |
| School Holidays | 28% | 0.67 | 19% |

*Table 2: Off-peak Occupancy Rates*

This information is summarised in Figure 5, which shows the estimated daily occupancy rate in Riversdale over a year.

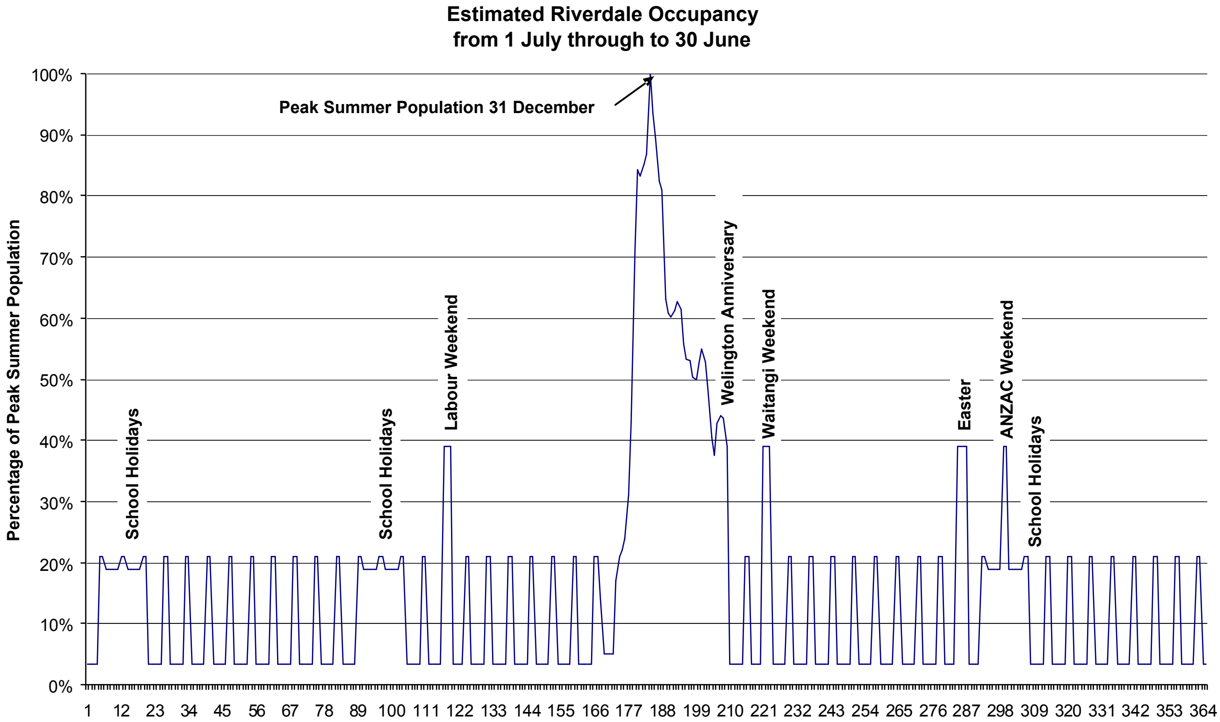


*Figure 5: Daily Occupancy as a percentage of Peak Summer Population*

Applying the estimated peak summer populations for 2008/09 and 2038/39 to the daily occupancy model indicates that Riversdale Beach Community would produce an annual domestic wastewater volume of 18,000 $m^3$ in 2008/09 increasing to 22,100 $m^3$ in 2038/39.

# 3 REVIEW OF I&I FLOWS

I&I is the result of stormwater and groundwater entering the sewerage system. Stormwater enters though illegal connections (such as gutter downpipes and private drains) to the sewerage system, inundation of gully traps and leaking manhole lids. As the Riversdale Beach Community relies on on-site roof water tank supply, there is a low risk of inflow from illegal stormwater connections. Groundwater enters through poorly constructed lateral connections, sewer pipe joints and manholes. If the water table is above the pipes, as it will be for the majority of any gravity reticulation in Riversdale, such leakage points could result in a constant water flow into the sewerage system.

Approaches for assessing potential I&I that were considered for Riversdale Beach are discussed in the following sections.

## 3.1 AS/NZS 3500.2:2003 PLUMBING AND DRAINAGE - PART 2 SANITARY PLUMBING AND DRAINAGE STANDARDS

Under AS/NZS 3500.2:2003, below ground drains are to be either water or air tested. For all materials, other than vitrified clay, a pass is achieved if the volume of water lost from the pipeline is zero after a period of five minutes. This implies in theory that a new PVC or PE reticulation pipeline should not leak. The test for vitrified clay allows a top up of 1.5 litres over 10 minutes per 30 m length. Using this pass rate as an assumed infiltration rate for the Riversdale Scheme would result in 0.323 L/s for the 3.6 km of reticulation that would be below the groundwater level. This could potentially result in 9,592 $m^3$/year of infiltration inflow.

Typical data from WWTPs around New Zealand shows that even new PVC and PE based systems do eventually leak. For example, the WWTP inflow data for the St Arnaud community scheme, which was installed using PVC pipes in 1999, shows that I&I occurred at significant rates. Therefore the AS/NZS 3500.2:2003 test for PVC and PE pipes was not considered appropriate and was not used to estimate possible I&I flows as it only tests the pipeline and not manholes or other significant sources of leakage.

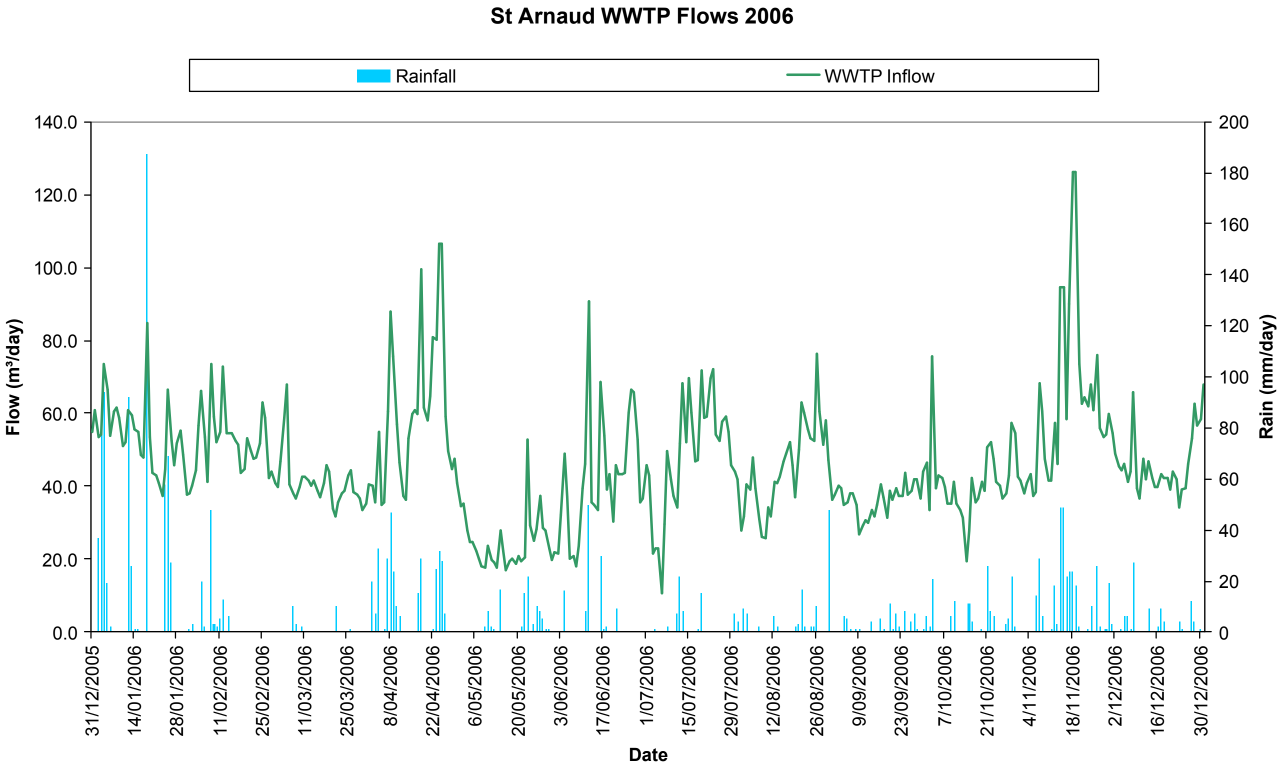


*Figure 6: Daily Inflow Data at St Arnaud WWTP*

## 3.2 REVIEW OF WAIKANAE WASTEWATER FLOWS

The sewer reticulation for Waikanae was installed from the late 1970's and was chosen for analysis as it provides an indication as to the likely performance of the Riversdale Scheme in 30 years time. It has the advantage over other holiday communities in that it has a fairly constant permanent population, removing one of variables from the equation allowing a simpler assessment of the influence of I&I. Data from two catchments that were of similar catchment sizes and populations to the estimated peak summer population for Riversdale were examined. These catchments were reviewed in terms of annual I&I volume per millimetre of rainfall per hectare of catchment from 1986 to 1998. The key figures are summarised in the table below.

| Catchment | Average ($m^3$/mm/ha) | Maximum ($m^3$/mm/ha) | Minimum ($m^3$/mm/ha) |
|---|---|---|---|
| A | 0.24 | 0.26 | 0.22 |
| B | 0.14 | 0.17 | 0.12 |

*Table 3: Annual I&I Volume (m3 per mm of rainfall per hectare of catchment)*

The catchment of the proposed RBCSS is roughly 40 ha and given an average annual rainfall of 1,072 mm, could be expected to produce an annual I&I volume of up to 11,500 $m^3$ (average of 0.36 L/s at 0.26 $m^3$/mm/ha) into the sewerage system. Upon review this "leakiness" approach is not valid for Riversdale Beach because infiltration inflows is the most significant source of I&I flows, not surface water inflows, and therefore a rainfall based approach was not considered appropriate to assess a likely volume.

### 3.3 TYPICAL NEW ZEALAND ANNUAL INFILTRATION AND INFLOW RATES

From available data the weighted average level of I&I as a percentage of total flow within New Zealand is 23%, ranging from 11% to 33%. Based on discussions with AWT, who undertake numerous I&I studies, it was suggested that a figure of 15% could be expected from a modern wastewater reticulation network and that 20% would be a conservative figure.

To be able to use these figures to make a prediction of I&I flows for Riversdale, it is necessary to assume a permanently resident community comprising 505 dwellings (the future peak summer occupancy of 2,626 PE/5.2 people per dwelling). From NZS 4404:2004 "Land Development and Subdivision Engineering", typical design figures would be 2.5 people per dwelling and an average dry weather flow of 250 L/p/d. This would equate to a total volume of 115,203 $m^3$/year; 15 - 20% of which would result in an I&I volume of 17,280 - 23,040 $m^3$/year (equivalent to an average flow of 0.55 - 0.73 L/s). This approach is quite generic and while useful flows produced from average figures needs to be used with caution.

### 3.4 SITE SPECIFIC I&I FLOWS SOURCE ASSESSMENT

As Riversdale will have a low permanent resident population, a small number of leaks could potentially result in a significant percentage increase in the total annual wastewater flow, for example 5 leaks at 0.1 L/s would produce 0.5 L/s or a total volume 15,768 $m^3$ per year. The potential for infiltration inflow into the sewer system through poorly made lateral connections (many of which will need to be made under water), and other leaks in the sewer network is very high. Just one poorly made connection or joint beneath the watertable can produce a significant and constant leakage flow rate.

## 4 DISCUSSION

The development of the occupancy model showed that Riversdale has a very low permanent resident population. The reviewed holiday community WWTP data highlights the significant influence of I&I flows. All of the data reviewed showed that I&I can produce flows as significant as the summer peak domestic flows.

Given its small size and the land application limitations, the RBCSS is very sensitive to I&I rates, which based on the above review could range from 0.3 - 0.75 L/s as an average over the year. The use of average figures to establish I&I flow rates was a useful approach for establishing likely values, however it needs to be undertaken with caution. The groundwater table is very high at Riversdale and for a conventional gravity scheme many laterals and sewer lengths will be permanently under water.

From the foregoing considerations it was determined that 0.5 L/s was an absolute minimum average I&I flow for design. However, given the uncertainty involved, design options for the Riversdale Sewerage Scheme need to be assessed against an I&I rate of both 0.5 L/s and 1.0 L/s to identify the risk posed to the viability of the scheme with higher infiltration rates.

It was considered likely that the average rate of 0.5 L/s could be reached within 1 - 2 years, especially if drainlayers are undertaking connections to the gravity network below groundwater. It was further indentified that over a longer period of time a figure nearer 1.0 L/s was possible. The elimination of infiltration inflows was therefore established as a crucial design consideration. This led to a recommendation that a pressurised wastewater collection system that effective eliminates infiltration inflow be considered for the proposed scheme.

## 5 CONCLUSIONS

Holiday communities with low permanent resident populations produce low annual domestic wastewater volumes. Their wastewater systems are therefore particularly sensitive to I&I flows. They are also sensitive to reasonable accurate assessment of weekend and holiday population trends during the year. The Riversdale occupancy study identified an average peak dwelling occupancy of 5.2 persons. This only occurred for a few days over the Christmas New Years holiday period. This study also identified an average 0.9 day visitors per dwelling. During the year the 3% (in terms of peak summer population) normally resident population increased to around 20% on weekends and school holidays and towards 40% on long weekends.

In regard to potential infiltrations inflow effects, I&I flows need to be considered in detail to enable the impact they might have on a scheme to be assessed accurately. In the case of the RBCSS it was estimated that infiltration inflow volume could generate 60 % or more of the total annual wastewater flow generated. This led to the recommendation that a pressurised wastewater collection system be considered for the proposed scheme.

## ACKNOWLEDGEMENTS

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Gareth Hall of CPG and Western Bay of Plenty District Council for the Waihi Beach Flow data; and

Peter Stephens of AWT.

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