HOW MUCH MUNICIPAL WASTEWATER PASSES THROUGH LAND IN NEW ZEALAND?

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ABSTRACT

There are approximately 330 council operated wastewater treatment plants throughout New Zealand. Each has a unique set of criteria that requires specific decisions to optimise the treatment processes and discharge. The smallest plant identified caters for only 7 households and the larger city treatment plants are catering for over 100,000 households plus industrial waste. Although the large variation between plants makes it unrealistic to compare them; the type of discharge systems with in each region is often common.

Lowe Environmental Impact LEI undertook a survey that focused on the type of wastewater discharge system used for each treatment plant, with a focus on the plants that used land based discharge options. The discharges were categorised into three main groups: land, water and combined land and water. These categories were further divided into ocean, in-stream and bank discharges to surface water; and trees, dairy, cut and carry, grazed and high rate discharges to land.

Survey results indicated that 43 % of treatment plants nationally discharge to land in some way. This percentage is reduced when expressed on a population basis with only 11 % of the national wastewater flow being discharged only to land. Of the total number of treatment plants utilising a land discharge system, 50 % utilise in-stream and bank discharges and 23 % adopt a high rate discharge to land system. Of the systems that utilise an irrigation approach, 11 % irrigate trees, 0 % dairy pasture, 11 % cut and carry, 6 % grazed pasture. It is noted that some systems discharge to both water and land, and in some cases use multiple forms of land application are used.

The data collected has enabled the following areas to be explored:

- The uptake of land treatment in New Zealand;
- Types of land treatment adopted;
- The proportion of land based versus water discharge systems per region; and
- The types of discharges taken up considering the populations serviced.

This paper explores national and regional trends with the use of land treatment. A comparison between the number of systems and a population equivalent basis is also provided to allow consider the impact of the larger municipal discharges.

KEY WORDS

Land Treatment, Community, Trends, Wastewater Discharge

INTRODUCTION

There is drive in New Zealand to improve water quality and water management. This has been exemplified by the establishment of the Land and Water Forum that is pulling together as many

directions and ideas as possible to drive a way forward. One component of this is the waste stream. This paper profiles the discharge of municipal wastewater in New Zealand and its contribution to the water management scene. However, the data presented here creates more questions than answers, including:

- What are the environmental effects from different types of WWTP discharges? Does it require attention now or later?
- Is land application appropriate for all or only appropriate for smaller populations?
- What is the value from the current land applications? Do these councils consider it the best approach and why?
- Is additional wastewater treatment the best approach?
- Should there be more recycling of water at the source, in each home?
- Are households the most relevant focus today or should industry and commercial plants be a greater focus?

Land application of wastewater removes the traditional discharges from waterways. This is beneficial socially, culturally, recreationally, environmentally and economically. Wastewater can become an asset for land production by providing irrigation and nutrients instead of a contaminant to waterways, especially during low flow conditions. Removal of contaminants by shifting the wastewater from rivers to the land allows the waterways to redevelop their natural ecology and become an asset for recreation. Culturally building the health of waterways is an important development for replenishing the mauri and becoming a resource for both Maori and the whole population.

Irrigation of wastewater to land can be designed as deficit, non-deficit or high rate applications. This equates to no drainage to groundwater, minimal drainage to groundwater or significant drainage to groundwater. These options use the soil and plants as contaminant filters while benefiting them with a supply of water and nutrients.

A preliminary survey was carried out by LEI that identified which WWTPs around New Zealand use what type of discharge system. This survey distinguished between discharges to land or water or a combined system using both. Further classification of the three systems was undertaken as, grazed pasture and high rate discharges to land. The data was developed to include the populations that were serviced by the WWTPs and estimates of the volumes discharged calculated.

A combined land and water discharge system does not take water out of waterways completely, but provides most of the benefits that are offered by a land based system. One difficulty with land application is that most of the wastewater is available in the winter when soil moisture levels are high and irrigation is not needed. The consequence is that a large amount of storage is required if 100% land application chosen. A compromise is to have some wastewater discharged to waterways at high flows, mostly occurring in winter. The effects from these discharges are often minimal on the environment. Conversely, irrigation mostly in summer, during low flow periods in waterways, has the potential for the greatest positive effects on the environment.

The number of WWTPs, the volumes from the plants and the type of discharges are identified and described in this paper.

MATERIALS AND METHODS

Identification of WWTPs and descriptions of the type of discharges used were collected by direct contact with councils and from the most up to date data from council websites. Reference to the Water NZ spreadsheet (WNZ 2012) of similar data was also referenced.

The data for each includes:

- Number of WWTPs;
- Populations serviced by WWTPs;
- Volume of discharges; and
- Type of discharges.

It is noted that the data must be interpreted in general terms because of the following assumptions:

- The 'urban population' (Statistics NZ estimated 2015) are the contributing number of people to a WWTP;
- 300 L of water used/person/day; and
- 50 persons contributing to plants where a population was not identified.

The urban populations in a given locality were often added together on the assumption they represented the combined population contributing to each WWTP.

A flow of 300 L/person/day has been allocated to calculate the wastewater discharge from each WWTP. The amount is based on approximately 200 L/person per day from household use. The additional 100 L allocates a nominal value to account for infiltration and inflow (I & I) through the reticulation network and possible industrial or commercial inputs that may enter a municipal plant. The reality is that in many communities the flows are much greater as a result of I & I and industrial discharges.

There were over 100 WWTPs where the population was not easily identified. It was assumed that these plants service populations below 100. This assumption was based on the remaining population in New Zealand not accounted for from the urban statistics, which implies that 7 % population are serviced by individual on-site systems. It is known that some WWTPs have very low populations served, such as the Waiotira plant in Northland that services 7 only households. A nominal figure of 50 persons contributing to these WWTPs was given to complete the data set.

This data was categorised as follows:

- Nationally;
- Regionally;
- Per district;
- Per discharge type.

General categories for the type of discharge used were created to compare the data. The following categories were used to distinguish the different approaches used for discharges:

- Water Discharges
    - Ocean
    - River in-stream
    - River bank
- Land Discharges

    - Irrigated to trees
    - Irrigated to dairy
    - Irrigated for cut and carry
    - Irrigated to grazed pasture
    - High Rate
    - Unknown land discharges
- Unknown Discharges

RESULTS AND DISCUSSION

National - Number of WWTPS

There are 330 WWTPS in New Zealand that were identified in this investigation. These service a population of approximately 4.4 M with the remaining 7 % of the population using individual on-site systems.

The majority of discharge comes from 18 WWTPs that service populations above 35,000 people. Mangere being the largest plant, services 1.2 M people with a volume of 1.3×10^8 m^3/year. Of the 18 plants, 8 have populations above 100,000. Figure 1 represents the number of plants that service the populations.

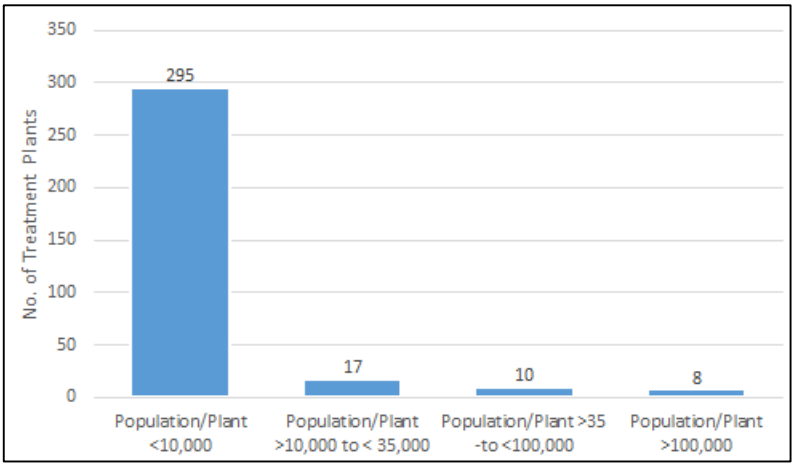

Fig. 1: Number of WWTPs servicing populations

National - Volume of wastewater from WWTPs

Approximately 83% of the wastewater produced is from the 18 plants servicing populations above 35,000 people. This is nearly 400 M m^3 per year by comparison to 79 M m^3/year from the 312 plants servicing small populations below 35,000. These numbers are based on 0.3 m^3/person/day, as described above. The actual volume is represented in Figure 2 below. This graph can be compared to the number of plants presented in Figure 1 above to recognise the small number of WWTPs with large volumes.

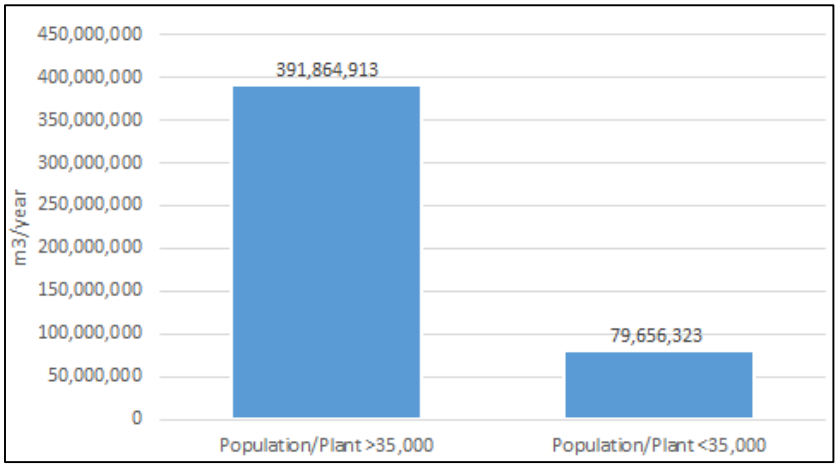

Fig. 2: Volume from WWTPs above and below 35,000

National - Water use Options

To enable some understanding of what these figures may represent in terms of beneficial re-use of the nutrients in the wastewater, they can be equated to irrigation and nitrogen fertiliser. At 400 mm/year of irrigation, 117,000 ha could be irrigated. At 150 kgN/ha/year, 78,000 ha could be fertilised.

This production of resources primarily comes from the 18 large WWTPs. Table 1 shows the proportion of irrigation and nitrogen fertiliser from WWTPs servicing above and below 35,000 people, therefore 18 WWTPs versus 312 WWTPs respectively.

Table 1: Potential irrigated and fertilised hectares from WWTPs

Population	Wastewater Volume	Irrigated at 400 mm/year	Nitrogen Fertiliser at 150 kgN/ha/year
Units	m^3/year	hectares	hectares
From WWTPs > 35,000	391,864,913	97,966	65,311
From WWTPs < 35,000	79,656,323	19,914	13,276
Total	471,521,236	117,880	78,587

National - Land, Water or a Combined Discharge System - Number of WWTPS

The 18 WWTPs that service populations above 35,000 people predominantly discharge to water. There are 3 plants that discharge to land as follows:

- Whangarei 47,500 discharging to land and water
- Taupo 23,700 people discharged to land
- Rotorua 68,000 people discharging to land

Figure 3 represents the total 330 WWTPs and the type of discharges.

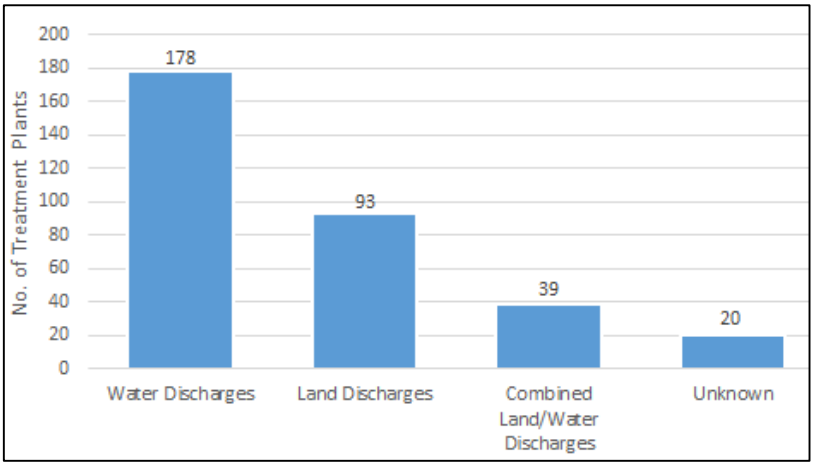

Fig. 3: Type of discharge from WWTPs

Land, Water or a Combined Discharge System - Volume of wastewater from WWTPs

From the 330 WWTP, 11% (54M m^3) of the volume is discharged to land; 13% (59M m^3) is used in a combined land and water system. 75% (352M m^3) of the volume is discharged direct to surface water with an ocean or river outfall. This is depicted in Figure 4.

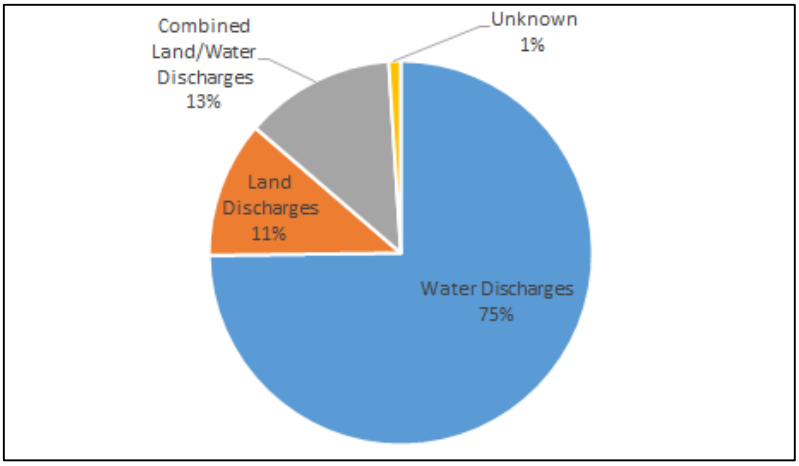

Fig. 4: NZ Wide Treatment Plant Discharges

The discharges to land are mostly allocated as high rate discharges as presented in Figure 5. High rate discharges include a variety of approaches but mostly wetland systems or soakage trenches. Eleven constructed wetland discharge systems were identified in the Northland region.

The 'unknown' category in Figure 5 includes applications to land but the method of land use was not identified, although it does include discharges to one amenity park from the Denehirst WWTP and one golf course from Omaha WWTP. This highlights the need for an additional category of recreational use in the survey. The remaining categories are self-explanatory. There are no discharges applied to pasture used for dairy production. This is likely to be a result of a rule set by Fonterra that requests wastewater must be treated to California Health Law Title 22 standards before it can be used.

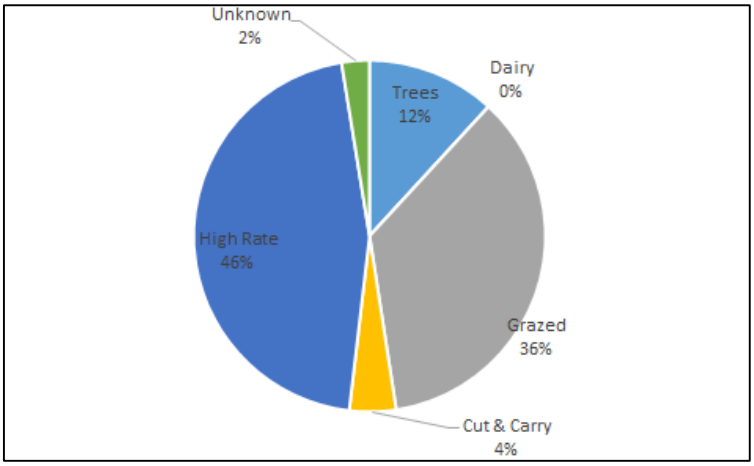

Fig. 5: NZ Wide Land Discharge Methods

Regional - Number of WWTPS

Figure 6 identifies the number of WWTPs in each region. Waikato has the most with 53 plants compared to 8 WWTPs in the Taranaki region and Gisborne has 2 WWTPs.

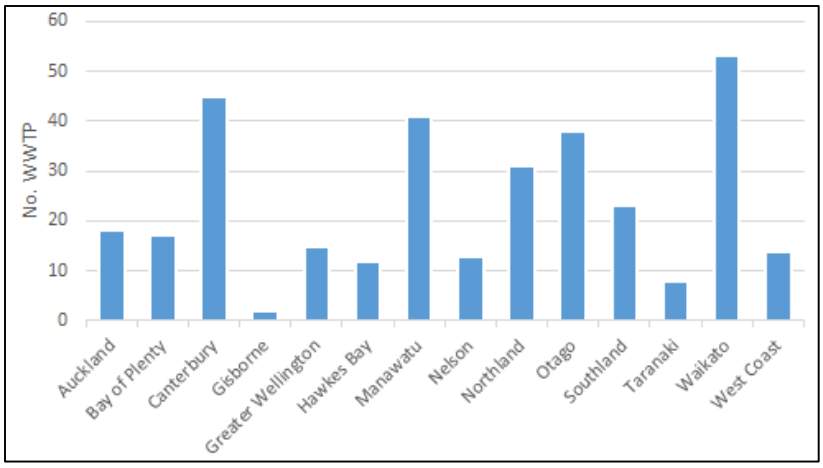

Fig. 6: Number of WWTPs per region

Regional - Volume of wastewater from WWTPs

By comparison to the number of WWTPs in Figure 6, Figure 7 depicts the greater volume discharged from the Auckland region (35%). Waikato, Northland and Canterbury each have between 11 to 14% of the national volume and the other regions each have 5% or less.

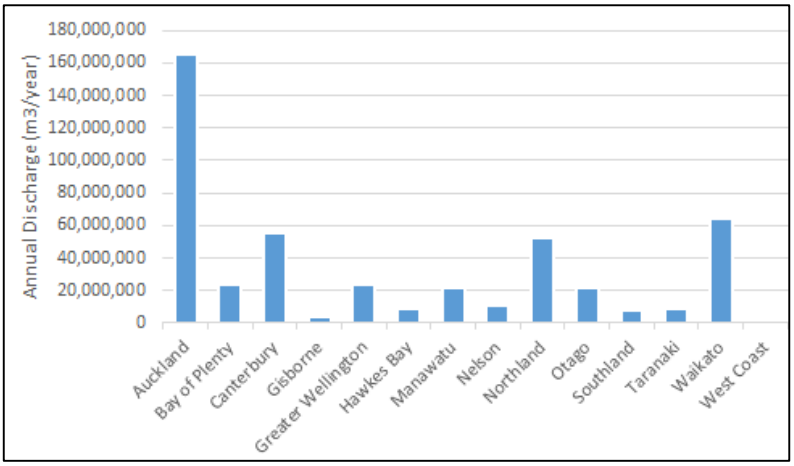

Fig. 7: Volume of wastewater from each NZ region

Regional – Land, Water or Combined Discharge

With reference to the above data, some plants with higher populations sway the statistics to result in a high percentage of discharge from a particular type. The large plant at Mangere and the large populations in the Auckland Region result in 75% of NZ's discharge to water. The volume to wastewater discharged to land is predominantly from Waikato with 55% of the land applications likely to be contributed to by the Taupo WWTP. The combined land and water discharge is dominated by Northland that represents 87% of this type of discharge that is dominated by the Whangarei plant. Figure 8 represents the regional discharge volumes for each discharge type.

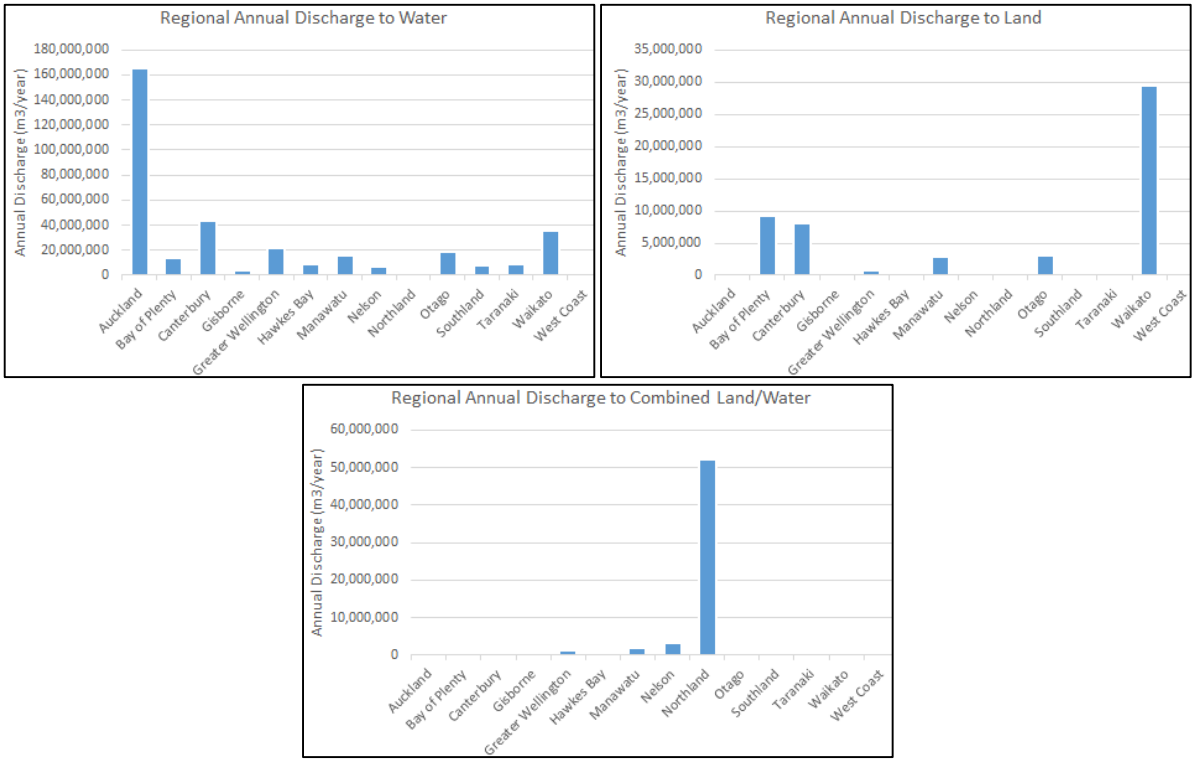

Fig. 8: Percentage of discharge to water, land or combined land and water per region

CONCLUSIONS

There are 330 WWTPs in New Zealand, most servicing populations below 35,000. By far the largest volumes of wastewater pass through18 WWTPs that service above 35,000 people. Currently approximately 54M m^3 of wastewater are applied to land, 59M m^3 applied through a combined land and water discharge system and 352M m^3 is discharged to water. Land treatment includes irrigation of grazed pasture, trees and for cut and carry. The majority of land treatment goes via a high rate land passage such as soakage trenches and wetlands. Water discharges are to rivers and the ocean.

With the current push to remove wastewater from waterways for environmental health, for recreational purpose and for the support of Maori; these statistics provide a basis from which to start discussions on the possible/probable contribution of wastewater discharges to water quality in NZ. The data identifies that some WWTPs have opted for land application of wastewater which suggests that wastewater discharges could shift from being a pollutant to a resource for farm productivity.

Each WWTP have chosen unique solutions to their circumstances that could provide answers that are useful for other locations. 132 WWTPs have chosen land or combined land and water discharge systems compared to 178 discharging to water alone. It could be assumed that larger plants are best to choose water discharges for practical reasons yet Rotorua[1] is discharging to land with 68,00 people contributing to its WWTP. However, the logistics of utilising the large volume of water on to land from an urban based plant such as Mangere may not be realistic. Approximately 87% of the wastewater volume from combined land and water discharge systems is situated in the Northland region. Waikato, Bay of Plenty and Canterbury together occupy 87% of the of the wastewater volume from land discharge.

This discussion focusses on municipal wastewater and only represents part of the bigger picture of New Zealand's waste stream. WWTPs include both wastewater and biosolids. There are separate industrial and commercial WWTPs, plus individual on-site systems and farm dairy effluent. These additional waste streams require further investigation to represent the resources that could be available for production and improved environmental benefits.

Further work to be carried out:

- Identify actual contributing populations to WWTPs;
- Identify actual discharges from each WWTP;
- Update discharge type with upgrades made to each WWTP;
- Identify the practical suitability of land versus water discharge system; and
- The effect on the environment from each WWTP.

REFERENCES

Water New Zealand (2012) NZ Wastewater Treatment Plant Inventory. Source: https://www.waternz.org.nz/Category?Action=View&Category_id=260 Retrieved November 2015.

[1] The Rotorua WWTP currently discharges a portion to land. In future the majority, and possibly all, will be discharged to water.