HUAPAI WASTEWATER NETWORK: RENEWAL OF A GRAVITY WASTEWATER NETWORK WITH A PRESSURE WASTE COLLECTION SYSTEM

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ABSTRACT

The township of Huapai, northwest of Auckland in Rodney District, has had an existing gravity wastewater system replaced with a Pressure Waste Collection (PWC) system. This paper considers the driving factors in the selection of PWC as a solution for Huapai, making it the first gravity wastewater network replaced with a PWC system in New Zealand.

Application of PWC systems are typically confined to flat areas, low lying areas with a high water table or steep and rocky terrain. The use of PWC in Huapai is an example of attributes of the system being utilised to provide additional benefits, primarily in the immediate removal of inflow and infiltration from the existing catchment.

The potential advantages of PWC systems are discussed including the utilisation of operational storage to assist with network capacity issues and deferment of capital expenditure on trunk transfer mains, pump stations and other points of capacity restriction.

KEYWORDS

Huapai, Wastewater, Inflow and Infiltration, Pressure Waste Collection, Low Pressure Sewer.

1 INTRODUCTION

The existing Huapai Gravity Wastewater Network consisted of 140 residential and 17 commercial connections discharging to a small local Wastewater Treatment Plant (WWTP). The catchment consisted of two sub-catchments. The north-eastern sub-catchment, “Pinotage”, is entirely residential and is pumped to the WWTP by the Pinotage Pump Station. The second sub-catchment, “Merlot”, is residential to the west and commercial to the south. Refer Figure 1. The network consists of traditional gravity sewer, with significant proportions on private property. The catchment is gently undulating.

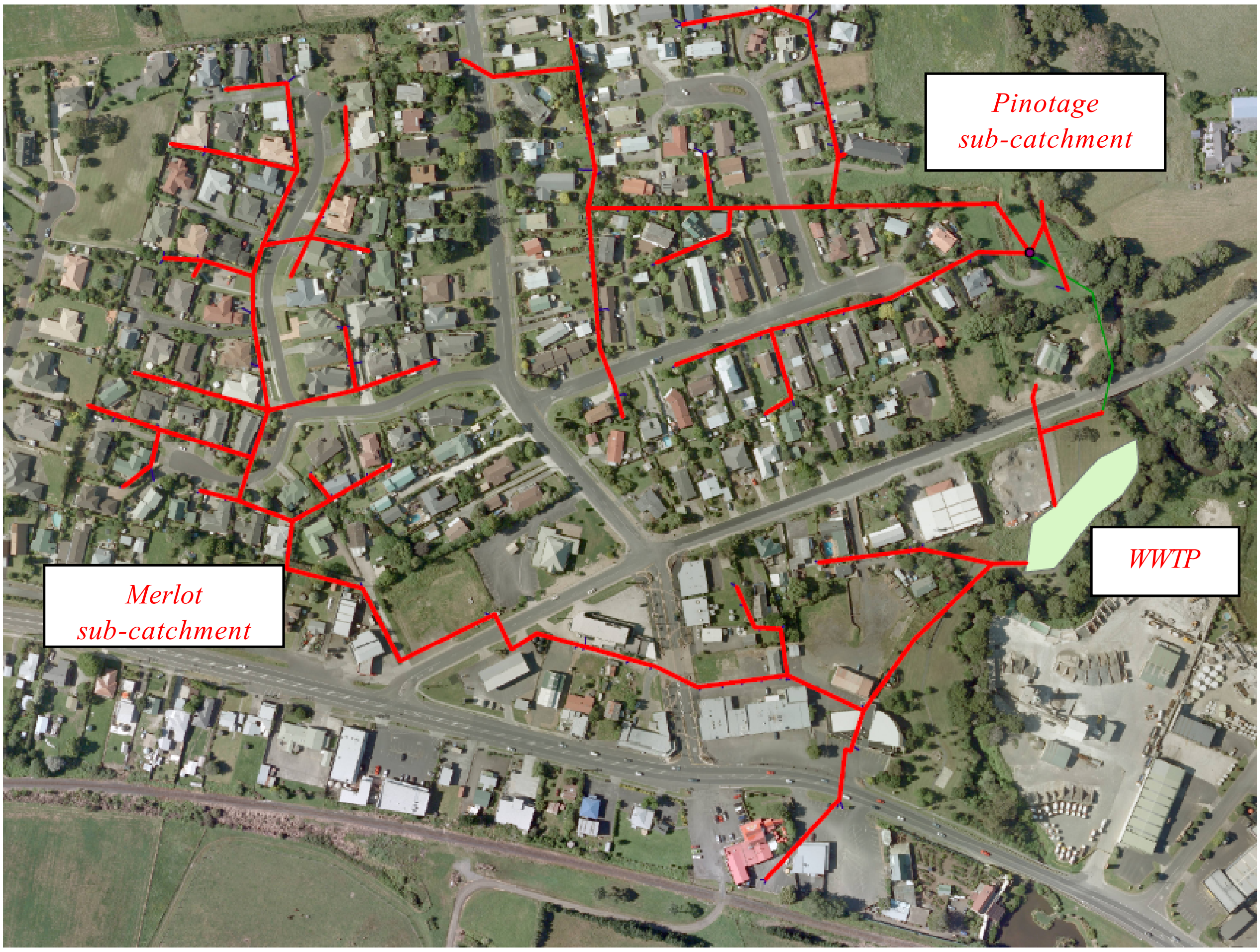
Both sub-catchments discharge to the Huapai WWTP which is a conventional activated sludge process, followed by an up-flow pebble filter, UV disinfection and stone filter. Treated effluent is then discharged to the Kumeu River. The Treatment Plant has a long history of overflows due to Peak Wet Weather Flows from the gravity wastewater network inundating the plant.

Efforts have been expended to control and reduce infiltration in the catchment. While these efforts were partially successful in controlling Inflow & Infiltration (I&I), it was not possible to reduce flows to a point where the WWTP would comply with Discharge Consent Requirements.

At the same time Rodney District Council (RDC) and the surrounding community had been investigating and refining options for wastewater reticulation of the surrounding area of Huapai, including Kumeu and Riverhead, a process originally spanning a 20 year timeframe. Following significant investigation, consultation and review, RDC resolved to reticulate the Kumeu, Huapai and Riverhead (KHR) areas using a PWC system, discharging to a

WaterCare bulk connection point near Whenuapai Airbase. The primary restriction to the WaterCare connection option was a maximum allowable flow rate of 75 l/s.

Figure 1: Plan View of Huapai Gravity Wastewater Network

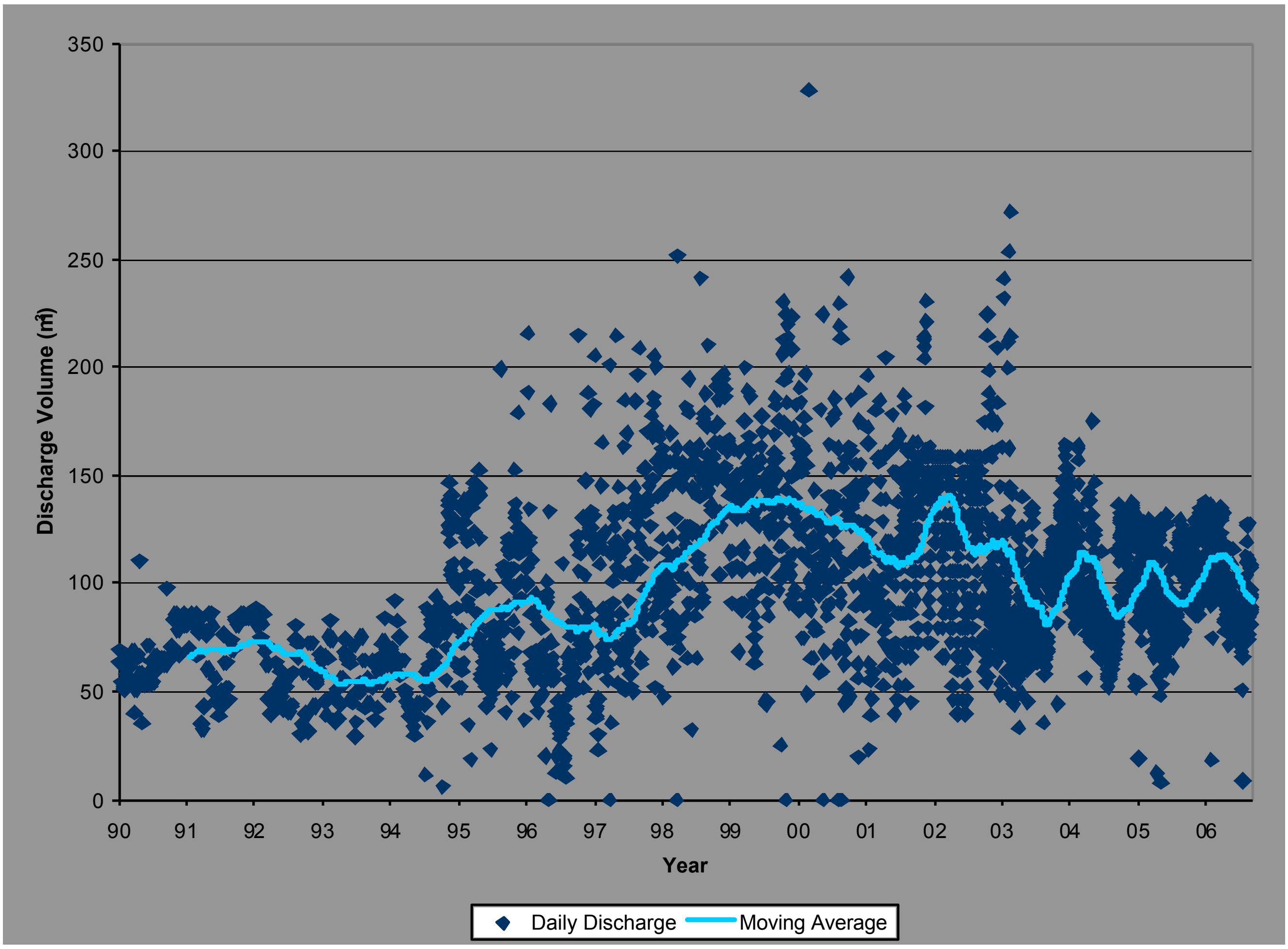


In order for the Huapai WWTP to comply with the Discharge Consent Requirements in the shortest practical time and to integrate the existing gravity catchment into the wider KHR wastewater reticulation, it was decided to retrofit the existing Huapai gravity network with a PWC system without delay.

2 HUAPAI GRAVITY NETWORK & HISTORICAL PERFORMANCE

The Huapai WWTP was constructed in 1985 as a small community based system. The plant was upgraded in 1995 to cater for a new 50 lot sub-division. Today the WWTP caters for 140 residential properties and 17 commercial connections (approximately 26 commercial properties). From around 1995 daily discharge volumes from the WWTP increased and began to exceed the Discharge Consent limits on a regular basis. Refer Figure 2. The Discharge Consent limits are currently a monthly average of 180m^3/day and a daily maximum of 206m^3.

Figure 2: Huapai Wastewater Treatment Plant Daily Discharge Volume 1990 to 2007



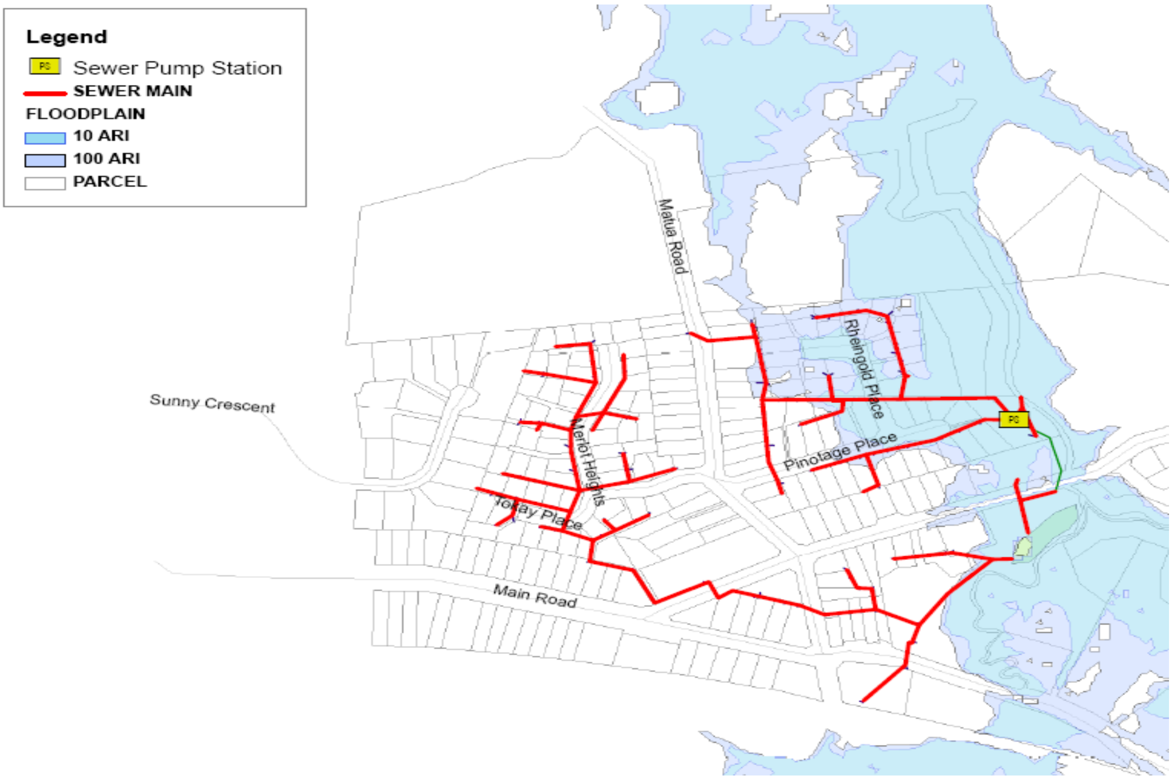
2.1 I&I PROGRAMME

Due to increasing occurrence and duration of overflows from the Huapai Treatment Plant to the Kumeu River, a programme of I&I investigation was initiated. This included all aspects of traditional I&I investigation, including CCTV inspections, dry and wet weather manhole inspections, raising and sealing of manholes, flow monitoring, gulley trap inspections and smoke and dye testing.

Moderate successes were achieved but it was quickly evident significant expenditure would be required to bring the Treatment Plant back into consistent compliance with the Discharge Consent requirements. Even with such expenditure there was a significant risk that an I&I reduction programme would not deliver the required results.

A fundamental underlying factor to this is the high water table due to the proximity of the Kumeu River Flood Plain. A significant proportion of the Pinotage sub-catchment lies under the inundation zone of the Kumeu Flood Plain (refer Figure 3).

Figure 3 – Flood Plain Inundation Zone



2.2 GRAVITY FLOW CHARACTERISTICS PRIOR TO RENEWAL

The gravity network does not contain a flow monitoring point prior to discharge into the TP, therefore instantaneous Peak Wet Weather Flow has not been determined. Daily plant discharge and overflow information is available and paints a clear picture of the performance of the network.

Daily Treatment Plant discharge volumes have been monitored since plant commissioning with records available dating back to 1990. In November 2008 a flow meter was installed on the constructed overflow line of the plant, allowing overflow volumes to be recorded and total discharge volumes to be derived. Prior to the flow meter being installed on the overflow line, overflow events were monitored by a float level on an inflow storage attenuation tank.

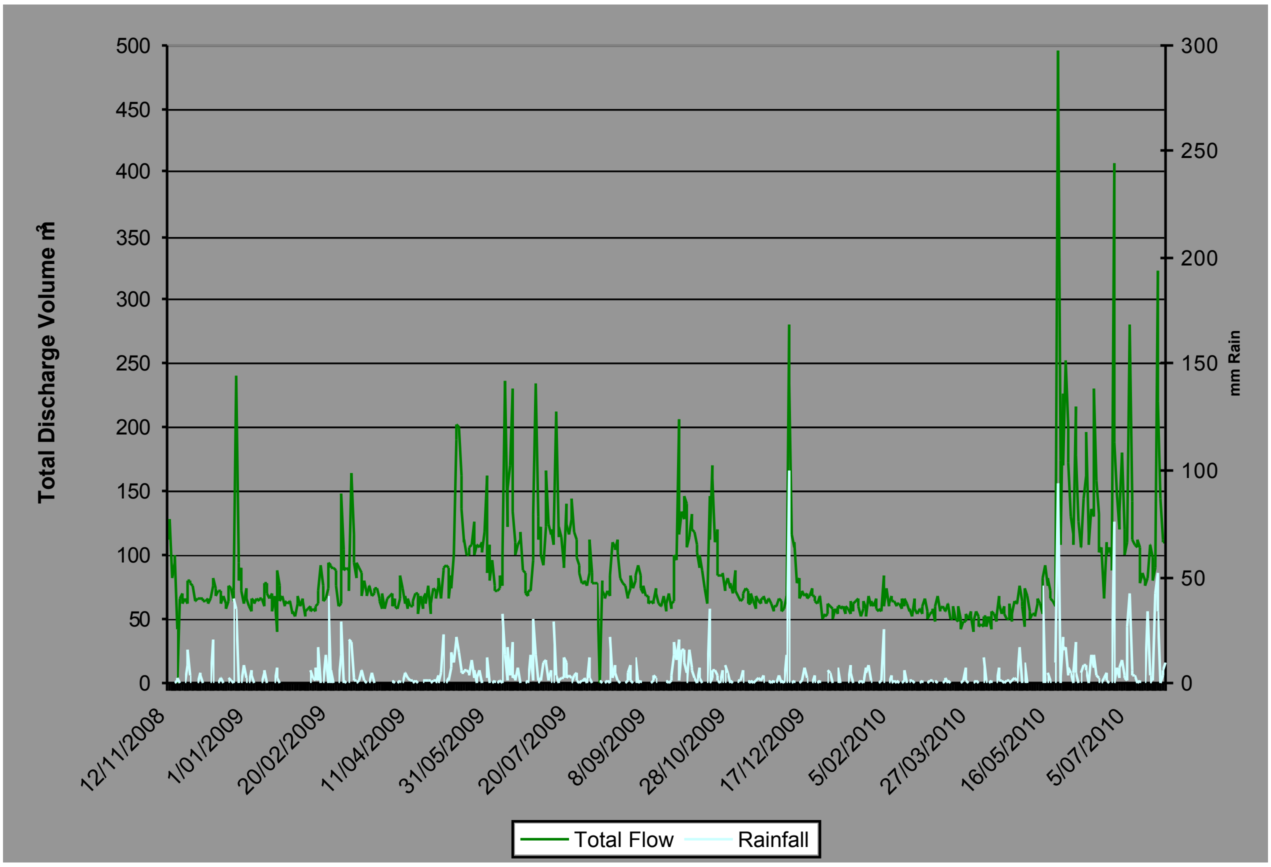
Figure 4 (below) shows total flows exiting the treatment plant since the overflow meter was installed. This is the combined volume of plant effluent discharge and overflow volumes. Average Dry Weather Flows of 60m3/d are typical for the treatment plant. During winter 2009, following saturation of the ground, total daily discharge volumes (including overflow) where in the order of 3.3 to 4 times ADWF daily volumes. Over this period three events occurred with a daily total discharge of 235m3, one event of 212m3 and one event of 200m3. A number of isolated events occurred at various times. These events were triggered by notable rain events.

The long dry summer of 2009/10 is clearly evident in the flow and rainfall data with a sustained six month period from December 2009 until May 2010 without an overflow event and with minimal rainfall. During this period pronounced ground shrinkage movement was observed in Huapai and the surrounding districts. Marked settlement was observed at several houses in Huapai, most notably in properties with shallow concrete slab foundations.

Following this dry period and instigated by a significant rain event, the WWTP total daily discharge volumes peaked at 496m^3, or 8 times daily ADWF. Preceding rain events have resulted in peak daily flows of 406m^3, 322m^3, 280m^3 and several lesser events, or 6.7 to 4.7 times daily ADWF.

It is hypothesised that the long dry summer and resultant observed ground movement has resulted in a deterioration of the existing gravity network, most likely through displaced joints and cracked pipes. This will be addressed with the imminent decommissioning of the gravity wastewater network and conversion to and integration with the stormwater network.

Figure 4 – Total Volume of Wastewater Existing Treatment Plant Including Discharge and Overflow



3 PRESSURE WASTE COLLECTION IMPLEMENTATION IN HUAPAI

3.1 OVERVIEW OF DESIGN

The PWC network comprises a total of 3,210m of public network (700m of 50mm, 1,250m of 63mm and 1,260m of 90mm OD PE100 PN 16 pipe). Boundary kits were installed for all lots in the catchment whether or not they were currently connected or developed.

Sewage flow rates were calculated at: PDWF 7.4 l/s. ADWF 1.6 l/s, Power outage flows (maximum predicted flow after a power outage) = 14 l/s. A Wet Weather Peaking Factor of 1.2 was used. Modelling indicated a sewage retention time of under 6 hours. The system does not contain any air valves.

The catchment is designed to discharge to the existing WWTP. The design also caters for the future decommissioning of the WWTP and eventual connection of the local reticulation to the KHR trunk transfer main, yet to be constructed.

Construction was facilitated via two contracts, one for the public network up to and including the boundary kits, the second for supply, installation and connection of onsite PWC units. The remaining gravity wastewater network is intended to be adopted and integrated into the existing stormwater network.

3.2 EXTENT OF ON PROPERTY WORKS

The fundamental driver of the project is to reduce I&I to a point where the Huapai WWTP can comply with the discharge consent conditions. It is expected that a portion of inflow will occur on private properties. Poor condition laterals, low gulley traps, illegal stormwater connections and rain water tank overflows are all likely causes of on property inflow. This is a common issue on PWC projects where existing septic tanks are decommissioned and transferred to new PWC reticulation. Experience has shown at Point Wells in Rodney District that the identification and rectification of properties contributing to inflow can be identified and rectified quickly with PWC systems.

House laterals were assessed for condition by CCTV prior to construction. Properties with poor condition laterals had the lateral replaced from the gulley trap to the PWC tank. Inspections were made of the existing plumbing and faults rectified where identified. Approximately 1,000m of new lateral were laid as part of the project, including replacement of poor condition lateral, and new lateral connecting to the PWC tank.

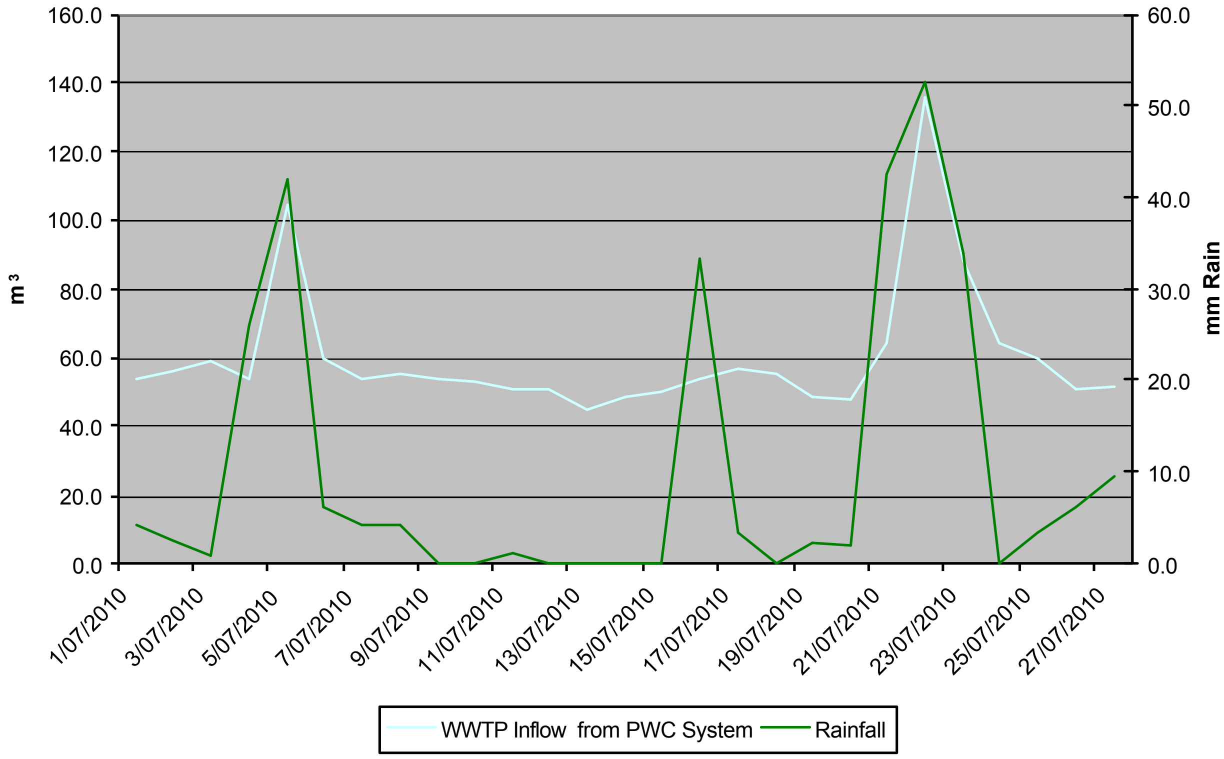
3.3 INITIAL PERFORMANCE INDICATIONS OF PWC SYSTEM

At the time of writing, all properties in the catchment have been transferred to the PWC network, excluding approximately 6 commercial connections. Representative flow data is limited. Daily ADWF's are in the range of $50m^3/d$ to $55m^3/d$. This is consistent with, or slightly below daily ADWF's observed from the gravity network of $60m^3/d$.

Rain responses have been observed in the PWC network. On the 5th July 2010, $104m^3$ was recorded discharging from the PWC system in response to 26mm of rain on the 4th July, followed by 42mm of rain on the 5th July. On the 22nd July flows peaked at 136 m^3 following rain on the 21st of 43mm and 53mm on the 22nd. Of interest is a rain event on the 16th July that did not trigger an increase in discharge volumes from the PWC system. This was 33mm of rain on the 16th but was preceded by dry weather (refer to Figure 5 below).

With discharge consent limits of 180 m^3/day monthly average and 206 m^3/day peak, the flow volumes from the PWC system are comfortably within the discharge consent requirements, even with the rain response from on property inflow. For this reason, it can be stated that the replacement of the gravity sewer with the PWC system has been a success.

Figure 5 – WWTP Inflow from PWC System for July 2010



While all residential properties have been connected, investigation and rectification of on property inflow has not yet taken place. Rain events have been used to identify a number of properties as having stormwater inflow and are in the process of being rectified. During the rain event of the 22nd July one property was recorded as contributing 3.4m^3 and a second contributing 1.8m^3. A combination of pump run hours and inspection of the PWC tank during rain events have resulted in the rapid identification of properties contributing to inflow. Based on past experience at Point Wells in Rodney District, it is expected that all properties contributing inflow will be rapidly identified and rectified. It is expected that a rain response will not be apparent in the PWC network in a short period of time.

4 KUMEU HUAPAI RIVERHEAD SCHEME DEVELOPMENT

Parallel to the ongoing I&I and WWTP issues within the Huapai Gravity Network, a solution was being sought to provide wastewater reticulation to the wider community in the KHR area. A contributory factor to PWC being selected as the solution for the Huapai Gravity Network was the decision to provide wastewater reticulation to the wider area also utilising a PWC System.

4.1 OVERVIEW OF SCHEME

The townships of Kumeu, Riverhead and Huapai outside of the gravity reticulated area, currently rely on onsite systems for wastewater treatment disposal. KHR were identified as requiring upgrade to a public reticulation system to protect public health and the environment. One of the principal reasons is the unsuitability of soil types in these townships to adequately dispose of the treated effluent on small urban properties, particularly over the wet portion of the year. A public reticulation system is required primarily to address the risks and issues from the existing developed areas, but also to service growth levels proposed through the Auckland Regional Growth Strategy (ARC, 1999).

Substantial investigations and consultation has been undertaken extending over a 20 year period. Three options were arrived at:

- Gravity reticulation discharging to a WaterCare Bulk Connection point at the border with Waitakere District;

- PWC system with a purpose built local WWTP; or,

- PWC system discharging to a WaterCare Bulk Connection point at the boundary with Waitakere District.

For comparison purposes of the three options, capital costs were determined. Gravity reticulation discharging to a WaterCare bulk connection point would cost $35.6M, PWC with local treatment and disposal would cost $31.29M, while a PWC system discharging to a WaterCare bulk connection point would cost $26.3M (prices at 2007 costs).

4.2 MAXIMUM FLOW RATE RESTRICTION

Due to existing and future capacity restraints the WaterCare bulk connection point has a maximum flow rate of 75 l/s. This limitation all but rules out a gravity network and capitalises on one of PWC's fundamental attributes of minimal diurnal peaking of flows.

The ultimate predicted wastewater flows (using ADWF) for both gravity and PWC schemes were predicted to be 4,225m^3/d and 4,972m^3/d respectively. However, ultimate predicted peak flows were forecast to be substantially different for the two schemes. Predicted Peak Flows were 244 l/s for gravity and 58 l/s for PWC.

Consequently, it was confirmed reticulation of KHR would proceed utilising a PWC System. Replacement of the Huapai gravity network dovetailed nicely into the regional reticulation system. PWC network design for Huapai has incorporated future flows in pipe sizing for surrounding areas, and incorporates future connection points to the KHR trunk transfer network.

5 POTENTIAL OPERATIONAL BENEFITS OF PWC

Traditional applications of PWC are for flat areas, low lying catchments with a high water table or steep and rocky terrain where laying of pipe to grade is difficult and expensive. The primary issue at Huapai was high I&I. This can partly be attributed to a high water table, although it has been demonstrated that significant I&I is generated from the western and southern "Merlot" catchment which is clear of the flood inundation zone.

Construction of PWC network reticulation is significantly cheaper than the equivalent gravity network. Pipe sizes are significantly smaller and are not required to be laid to grade. This eases constructability and simplifies avoidance of existing services in the service corridor. Pipe installation can be carried out primarily by directional drilling reducing disruption to the community and the environment.

While construction of the reticulation network is comparatively low cost, a significant cost is incurred with the installation of the onsite PWC tank and grinder pump unit at each property. For staged developments and areas of moderate or slow build out, this favours a financial model of making wastewater reticulation available with minimal capital outlay, while the bulk of the cost is incurred as properties connect to the network over time.

5.1 CONTROL OF I&I

PWC has a number of advantages over gravity systems in PWC's inherent ability to control I&I. Firstly the reticulation network is sealed preventing infiltration. The same can be said for modern construction of gravity networks, constructed of PE with sealed manholes and strict engineering standards. PWC has an advantage in that control of private property inflow is inherent in the PWC unit. Excessive inflow results in a high level alarm in the PWC unit, attracting immediate attention and investigation. Moderate to low inflow can be readily identified by pump run time information.

While monitoring of pump run time is required to identify properties with inflow, it is a relatively quick and efficient process of data collection to carry this out. Conversely, monitoring of individual property flows in a gravity network is very difficult, if not impossible. Various technical options are available for more efficient and more detailed monitoring of pump run times which is discussed further below. This inherent control of I&I is expected to be significant over the lifecycle of a PWC system where I&I performance is expected to be consistent into the future.

5.2 BUILT-IN SYSTEM STORAGE

PWC systems incorporate 24 hours onsite storage. For a standard domestic property installation this is approximately 650l storage as total tank volume. This storage gives redundancy in the event of power failure, pump malfunction or downstream network maintenance. Duplex units and other units catering for commercial properties are designed to cater for 24 hours storage in the event of network or power interruption.

The storage capacity gives a suitable buffer for unplanned events such as widespread power failure and gives a good degree of flexibility for planned work such as network maintenance and making of new connections etc.

5.3 REMOTE CONTROL BY TELEMETRY

Technological advances are reducing the cost and increasing the functionality of telemetry control systems for PWC networks. Industry estimates for onsite pump unit telemetry are currently in the order of $1,000 per property depending on the degree of functionality required. Advances in technology and the adoption of these systems by network operators opens up the possibility of a number of advantages in the management of PWC networks.

5.3.1 REMOTE ALARM MONITORING

Disruption to the property owner can be avoided by remote monitoring of the PWC Control Panel alarms. This may be a service offered by the pump supplier or service agent in the case where the property owner owns and is responsible for the PWC unit. In the case where the Local Authority retains ownership of the PWC unit, remote alarm monitoring removes the need to interact with property owners, reducing inconvenience to them and improving operational efficiency to the network operator. Rather than dispatching an operator to investigate an initial alarm, the system can be monitored remotely. In the case of planned network shutdown the network operator can proceed with work without residents needing to be notified or otherwise aware the network is shutdown for short periods of time.

5.3.2 OPERATIONAL UTILISATION OF ONSITE STORAGE AND MANAGEMENT OF OPERATIONAL EVENTS

Advances in the functionality of telemetry systems opens up the potential for a step change in wastewater network management.

The utilisation of onsite storage for operational reasons has not yet been implemented in a PWC network in New Zealand, but offers significant potential to the Local Authority and Network Operator. In the same way roading networks now manage peak traffic flows by remote control of traffic signals, the PWC wastewater system could be utilised to manage peak wastewater flows.

A common dilemma for Local Authorities is the facilitation of growth and property development surrounding urban centers and small settlements that have existing wastewater reticulation that is old and under pressure. It would be a common example to have an existing gravity catchment suffering high I&I and a local WWTP being put under pressure due to excessive peak flows, preventing the possibility of significant new connections. Telemetry control could be used to restrict flows from new developments at peak times, avoiding pressure on the existing network at times of peak flows. Additionally, on-site storage in new developments could be utilised by telemetry during network events such as heavy rain or downstream plant failure to better manage flow and spill volumes.

Installation of appropriate telemetry onto a PWC network opens up the opportunity of fully integrated control of the network and wastewater flows. Benefits may range from increased operational efficiency to deferment of capital expenditure in downstream assets, or the installation of smaller and less costly downstream assets.

6 CONCLUSIONS

The Huapai gravity wastewater catchment suffered significant inflow and infiltration, impacting on the ability of the Huapai WWTP to comply with Discharge Consent conditions.

A PWC system was selected to replace the gravity wastewater network due to its inherent ability to manage I&I.

At commissioning, the Huapai PWC system is delivering daily flows to the WWTP within the Treatment Plant Discharge Consent limits. A rain response is occurring in the PWC system. This is due to inflow from existing properties.

Pump run hour meters on the PWC units are allowing the efficient identification of properties contributing inflow to the PWC network.

REFERENCES

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