RESTORING THE HEALTH OF KAWAKAWA BAY

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ABSTRACT

Kawakawa Bay is a small coastal settlement on the south eastern coast line of the Auckland Region, 35kms east of the Manukau CBD. The Bay contains approximately 270 dwellings and has a population in the order of 600 predominantly permanent residents, although the population increases significantly during the summer period. Until 2012 wastewater treatment and disposal was by on site systems, mainly septic tank and soakage trench.

Since 1997 and until recently, numerous water quality investigations in local streams and along the Kawakawa Bay foreshore indicated that the existing septic tank systems were causing contamination of stormwater, groundwater and in the Bay.

In 2002, as public health concerns were increasing, the then Manukau City Council implemented short term health protection measures for the community, which included erecting signs in the area warning people of the risks associated with bathing and shell fish gathering and offering hepatitis inoculation to residents as well as regular pumping out of septic tanks. A moratorium on further residential development within the Bay was also put in place until the sewage disposal issue was resolved.

In December 2004, Council called for design-build-operate (DBO) tenders for the implementation of a wastewater scheme. Following the evaluation of tenders Council awarded (2005) the DBO contract to Fulton Hogan whose designer for the project was Harrison Grierson. The contract period was extended by nearly 3 years largely due to issues relating to the granting of some resource consents for the project. The sewerage scheme was handed over to the client, Watercare Services Limited following the successful completion of the 3 month proving period followed by the 18 month operations period, in March 2013.

The offer was based on a vacuum collection system and a 4 stage Bardenpho (nitrogen removal) wastewater treatment plant with the final aeration tank converted into a membrane bioreactor (MBR) that provides improved treatment efficiencies and disinfection of the treated effluent.

This paper will describe the how the implementation of the sewerage scheme at Kawakawa Bay has conserved, improved and is now preserving the local environment and has removed the public health risk from the community that enjoys the intrinsic value of the coastal ecosystem.

KEYWORDS

Vacuum sewerage systems, biological nutrient removal, membrane bioreactors

1 INTRODUCTION

1.1 THE LOCATION OF KAWAKAWA BAY

Kawakawa Bay is located 35 kms east of the Manukau CBD and is the next significant community along the scenic coastal drive from Beachlands/Maraetai. The bay is shown in the photograph below.

Photograph 1: The 4km coastline of Kawakawa Bay

1.2 THE PROBLEM AT KAWAKAWA BAY

The permanent population of approximately 600 residents rely on rainwater tanks for water supply and until recently on septic tank systems for the treatment and disposal of wastewater. The summer population can significantly increase as the baches fill to capacity, tents are erected on sections and day trippers come to the bay to use the popular boat ramp, swim and collect shell fish.

Basic baches started being erected in the Bay in the 1950's, by the 1970's a number of subdivisions had been completed and by the 1990's the population had reached 600. The septic tank systems installed for the baches built through to the 1970's would not meet current design standards and by the 1990's would have exceeded asset life expectations.

Average lot size is approximately 800m2 many of which have been subdivided. It is likely that septic tank systems would have suffered from a lack of maintenance and also a number would have had inappropriate stormwater connections from yard and roof areas.

Development in the low lying, flat topography of Kawakawa Bay has been accompanied by the formation of numerous water table drains which combine with natural overland flow paths connecting to local streams. The stormwater flows out to the Bay. Pathogen indicator organisms have been detected in water samples collected from local watercourses and the foreshore area, as part of numerous water quality surveys.

The composite photograph below combines an aerial of the main part of Kawakawa Bay with the overland flowpath overlay from Auckland Council's GIS system. This composite illustrates how break out from the failing septic tank systems would have led to contamination reaching watercourses and then on to the Bay itself.

Photograph 2: The central part of Kawakawa Bay showing overland flowpaths

2 COUNCIL'S RESPONSE

By 2002, as public health concerns were increasing the then Manukau City Council implemented short term public health measures which included,

- Erect warning signs prohibiting swimming and shellfish gathering along the 4km of coastline
- Set up a programme of regular septic tank maintenance
- Offer the population inoculation against Hepatitis
- Establish a moratorium on further residential development
- Initiate a community consultation programme on wastewater issues
- Investigate options for implementing a community sewerage scheme

2.1 THE FIRST TIME SEWERAGE SCHEME

In December 2004, Council called for design-build tenders for the implementation of a wastewater scheme. Following the evaluation of tenders Council awarded (2005) the design-build contract to Fulton Hogan whose designer for the project was Harrison Grierson.

The offer was based on a vacuum collection system where the private drainage from the households was by gravity to a vacuum pit at the lot boundary. At this point wastewater is drawn into the collection network when the wastewater level in the vacuum pit reaches the level controller that actuates the vacuum interface valve. The wastewater is conveyed by pressure differential along the network to a collection tank at the vacuum pump station and then pumped to the wastewater treatment plant. At the treatment plant wastewater is screened and then flows to two tanks that balances peak flows through the plant. The plant is a four stage biological nutrient removal process and the final solids liquid separation phase is by membranes submerged in the final aerobic tank. The permeate from the membranes is stored in lagoons prior to irrigation to forestry areas.

3 WHY A VACUUM SYSTEM?

Vacuum sewer systems have been used widely overseas for over 35 years. Advances in system design means that a modern vacuum system provides an economical and reliable method for the conveyance of wastewater for small and medium sized communities to a point of connection to a gravity sewer network or a treatment plant.

The advantages of a vacuum sewer system are the use of small diameter pipe, layout flexibility and shallow burial depths. This provided particular advantages at Kawakawa Bay where the topography of the area serviced is low lying combined with the high water table and sandy subsoil conditions. The cost of installing a conventional gravity system would have been significantly greater.

The Vacuum Sewer System was designed in accordance with the WSAA Vacuum Sewerage code of Australia. In detail, each vacuum pit is fitted with a vacuum /atmospheric interface valve which is opened and closed automatically by a pneumatic level controller when the sewage level in the pit reaches a preset level. When the valve opens sewage is sucked into the main under vacuum. The valve closes at a pre-set time after the controller senses that the sump is empty, this is typically 3-6 seconds. While open, air is rapidly drawn into the pipe, and the sewage is conveyed along the collection pipeline as a foaming mass of sewage and air towards the vacuum pump station by differential pressure.

The pipelines have been laid in a vertical saw-tooth configuration and when a pressure equilibrium is established in the pipeline the sewage comes to rest in the low points of the pipeline and occupies the full pipe cross sectional area. This makes it easy to remobilise the sewage the next time a vacuum interface valve is opened.

Photograph 3: The vacuum interface valve

Photograph 4:   No trenches exceeded 1.8m depth along the 4km of shoreline

At the end of the vacuum line, the sewer discharges into the closed vacuum vessel within the vacuum pumping station building. The rotary vane vacuum pumps regulate the vacuum in the system between negative 70 and negative 50Kpa. Air exhausted from the collection network is filtered through a bark filter to scrub any odours from the discharge. Positive displacement sewage pumps, activated by a level controller draw sewage from the bottom of the vacuum vessel and convey the wastewater through the pressure rising main to the wastewater treatment plant.

Photograph 5:   Access building for the completed vacuum pumping station and biofilter

Photograph 6: The vacuum pumping station substructure, 200 m^3 of concrete and 21 tonnes of steel

The comparative advantages of gravity, vacuum and pressure sewer systems, as they relate to Kawakawa Bay have been listed below. The vacuum system was assessed as providing the best overall option based on cost, speed of installation, risk mitigation and best opportunity for environmental enhancement and selected to be included in the scheme design.

Table 1:Comparative Advantages of Gravity, Vacuum and Pressure Sewers for Kawakawa Bay

Feature	Conventional Sewer System	Vacuum Sewer System	Low Pressure Sewer System
Pipe sizes	150NB or greater	90NB or greater	50NB or greater
Pipe gradients	Falling to strict grades	Generally following the contour but to specific grades as required by the system	Grade variable to suit contours
Trench depths	Deep trenches required to avoid [additional pump stations	Pipes able to be laid in shallow trenches all leading to a single pump station	Pipes able to be laid in shallow trenches as no need for a community pumps station
Number of pumps stations required	Numerous, one for each gravity catchment	One only that serves the whole Kawakawa Bay area	One grinder pump for each property
Inflow and Infiltration	Can be serve in older systems	Minimal due to sealed system	Minimal due to sealed system
Maintenance costs	High, associated with sewer and numerous pump stations maintenance	Low sewer maintenance costs, medium for vacuum pump station maintenance	High, associated with maintaining many grinder pumps
Operational costs	High, numerous pump stations	Low, single pump station	High, power cost for numerous pump stations
Septicity of wastewater at treatment plant	Can be septic with low flows and numerous	Aerobic, short residence time in sewer and large	Septic, long residence times in the sewer

	pump stations	air inflows	
Cost of future population growth	High due to more pump stations and pipework	Low, only pipework required to extend area of scheme	High, due to grinder pump and pipework needed for each new connection
Leak in communal pipeline	Exfiltration, contamination of groundwater or watercourses	Loss of vacuum, alarm condition triggering a maintenance call out	Exfiltration under pressure, contamination of groundwater or watercourses
Extended power outage	Numerous portable generators required to bring system on line	Single generator required at the vacuum pump station brings whole system on line	System unable to operate

4 TREATMENT PLANT DESIGN

4.1 PROCESS DESCRIPTION

A consideration in the treatment process selection was the features of the collection network. The vacuum sewer system is well suited to a process using MBR technology as the network is sealed and minimises infiltration into the system and keeps the ratio of average to wet weather flows close to one. This innovation minimised the amount of flow balancing required at the plant inlet and the number of membranes used in the process. In addition, the large amounts of air that are regularly drawn into the vacuum sewers keeps the sewage "fresh" and avoids a common problem with long pressure sewers where septic sewage is delivered to the treatment plant.

The process design was based on the 4 stage Bardenpho nitrogen removal process incorporating MBR for solids/liquid separation. The key features of the design are the split feed configuration of the influent and the use of submerged membranes to separate the mixed liquor from the treated wastewater. This method of solids/liquid separation eliminates the issues associated with poor solids settling in a conventional activated sludge system and also enables the process to run long sludge ages, reducing the sludge production over that of a conventional activated sludge system.

Wastewater arriving at the plant passes through an inlet works consisting of a mechanical screen and grit removal system. The screened sewage passes through to flow balancing tanks to smooth out pumped flows from the network.

The balanced flow is pumped at a fixed rate to a splitter box which distributes the wastewater to the 2 anoxic zones to which already nitrified (nitrate rich) mixed liquor is recycled from the downstream aerobic zones. The carbon present in the screened wastewater is used to denitrify the recycled nitrate which is then released as nitrogen gas.

The ammonia present in the screened wastewater passes through the anoxic zones to be nitrified in the aerobic zones and then that nitrified mixed liquor is recycled back to the anoxic zones.

The mixed liquor is pumped from the second anoxic tank to the membrane tank. The membranes retain the activated sludge, bacteria and viruses in the reactor but allow treated wastewater to pass under gravity head to the permeate tank. The membranes have been installed with supplemental coarse bubble aeration that continuously scours the membrane surface to prevent fouling. An overflow weir is located inside the membrane tank for for returning the activated sludge to the aerobic tank.

WAS is wasted from the MBR tank to the WAS tanks. The amount of sludge produced from the MBR with its higher mixed liquor concentration and longer sludge age is significantly less than conventional activated sludge systems. The MBR has been designed to operate in the range 10 to 12 g/l and the WAS wasted occupies one half to one third of the volume typical of WAS wasted from a conventional activated sludge or SBR process.

Photograph 7: Inlet Works area

Photograph 8: Secondary Process Treatment area

5 PLANT DESIGN

Flow data was based on winter and summer average dry weather per capita flow of 180l/p/d and 130l/p/d, respectively, as provided in the contract.

Table 2: Kawakawa Bay Treatment Plant Flow Data

	Population Equivalents	**Design Peak Flow m^3/d**	**Actual Flow m^3/d (03/11 to 05/12)***	
			Average	**Peak**
Current	600	154	60	110
Future to 2021	1500	256	-	-
Future to 2051	3000	Upgrade	-	-

*Data derived from the operations monitoring period as part of the DBO contract requirements

The process design requirements were driven by the effluent quality targets specified in the contract. Plant influent characteristics were also derived from information provided by the Client for the Beachlands/Maraetai Scheme and interpolations of differences between the two schemes. The BOD and TKN concentrations were significantly higher than typical values for municipal wastewater and due to low per capita water usage at Kawakawa Bay as a consequence of water supply from raintanks.

The membrane units selected for the solids/liquid separation phase were two, 200 sheet Kubota membrane modules with an average capacity of 192m^3/d and a peak flow capacity of 256m^3/d. This flow matched the contract requirements of winter peak flow at 2021. Flow balancing to smooth the diurnal peaks was provided at the plant inlet and some storage is available between the high and low levels in the reactor tanks which gave a plant flow capacity in excess of 260m^3/d.

Table 3: Kawakawa Bay Treatment Plant Performance Data

Kawakawa Bay Treatment Plant Performance Data *				
Parameter	**Influent quality (90%ile)**		**Effluent Quality (90%ile)**	
	Plant Design	**Plant Data (03/11 to 05/12)**	**Contract Requirements**	**Plant Data (03/11 to 05/12)**
CBOD5 (mg/l	384	565	<15	2
TSS mg/l	377	795	<15	6
TKN mg/l	77	145	-	5
AmmN mg/l	55	94	<5	2
NO^3N mg/l	-	-	<15	10
E Coli cfu/100ml	-	-	<50	1.6
FC cfu/100ml	-	-	<50	1.6

*Data derived from the operations monitoring period as part of the DBO contract requirements

6 TREATMENT PLANT PERFORMANCE

A comparison of actual performance data with data provided in the tender documents shows considerable variation. Actual wastewater characteristics were significantly stronger than that used in the design, for example TKN was nearly 90% stronger whereas flow data was lower was approximately 30% less volume per day.

While this caused some initial concern with the plant commissioning the process flexibility, especially with the MBR, allowed the commissioning engineers to successful bring the plant online and meet the contract obligations with respect to the 3 month proving period before the contract could move to the 18 month operations phase and subsequent handover to the Client.

7 SUMMARY

The successful design, construction and operations of the Kawakawa Bay Sewerage Scheme has removed the source of pollution from Kawakawa Bay. Monitoring of water quality around the Auckland Region is undertaken by the Auckland Council in accordance with Ministry of Health and the Ministry of the Environment guidelines and based on four criteria, full contact use, partial contact use, risk of contamination and cultural significance. These guidelines determine if a beach is safe, unsafe or where retesting is required.

Kawakawa Bay has been declared safe since November 2012, the signs have come down and the population enjoys full contact recreation and locals collect and consume shellfish from the foreshore area.

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