INNOVATIONS ON THE HIMATANGI BEACH COMMUNITY SEWERAGE SCHEME

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ABSTRACT

Himatangi Beach is a small settlement on the Manawatu coast, with a mix of permanent residents and holiday homes. The Himatangi Beach Community Sewerage Scheme (HBCSS) is a project to provide a low pressure sewerage reticulation and centralised wastewater treatment plant to replace on-lot private septic tanks with ground discharge. Like other low pressure sewerage schemes, capital and operating cost were vital to the project being accepted by the community.

Recognising this, the client incentivised connection to the voluntary scheme for residents, and sought innovation through the tender process. The project was awarded as a Design and Build contract, with several key innovations which delivered approximately 15% in capital cost savings. These innovations included sharing a single pump station unit (PSU) between two properties where possible, and to provide the electrical connection from overhead power lines in the street frontage, instead of connecting to the house switchboard.

This paper details the collaborative design approach undertaken for the HBCSS pressure sewerage system, including constructability and operability reviews. It also discusses including the innovative use of dynamic modeling to develop the design.

KEYWORDS

Community Sewerage Schemes, Design and Build, Low Pressure Sewerage

1 INTRODUCTION

1.1 THE HIMATANGI BEACH COMMUNITY

Himatangi Beach is located 35km to west of Palmerston North in the Manawatu region and lies on the Manawatu District Council (MDC) southern boundary. The Himatangi Beach community comprises around 460 permanent residents. During the peak holiday period the resident population can increase to 2500 of which 370 will stay at the Holiday Park. In addition there can be a similar number of day visitors as Himatangi Beach is the nearest beach to Palmerston North.

There are 400 residential dwellings (250 of which are permanently occupied) together with the Community facilities including the Holiday Park, the Surf Club, the Community Centre, the Volunteer Fire Station, the Bowls Club, the Cosmopolitan Club, the local store and the public toilet block.

The dwellings are mainly older bach style properties constructed over the last 50 years and range in size from one bedroom units to six bedroom houses. Section sizes are typically around 800m^2. The first two stages of the residential Sandown subdivision comprising 34 lots were constructed in 2008, of which six have currently been developed. There are a further ten undeveloped sections within the current urban area.

The township and surrounding area is characterised by undulating coastal sand dunes up to 10m above mean sea level. The ground water level is typically between one and two metres below ground level (except where the ground level is locally elevated) and is tidally influenced.

Figure 1: Himatangi Beach Community Sewerage Scheme Layout Plan

1.2 KEY DRIVERS

The existing residential properties, except for the Sandown subdivision, are served by on site wastewater systems, most of which are undersized by current standards. Most have single chamber concrete septic tanks. The size of disposal fields typically ranges between 3m^2 and 15m^2 but some properties have soak pits discharging direct to the groundwater. Over half of the properties have grey water systems which discharge directly into the ground. The Sandown subdivision is served by a privately owned pressure sewer system with the wastewater being pumped by on lot grinder pumps to a holding tank.

Twenty eight dwellings hold wastewater discharge consents while the remainder of the systems are covered by permitted development. The Holiday Park has a septic tank which also receives wastewater flows from the nearby Surf Club, Community Centre and Public Toilets. It was consented to discharge up to 60m^3/day of primary treated effluent on to a dune area to the north of the Holiday Park.

1.2.1 GROWTH

In 2004 the Community Committee asked the Council to investigate the feasibility of installing a community wastewater system. This was in part driven by significant growth in the permanent resident population in the period 1991 to 2001, and in part by the projected growth arising from the two planned major subdivisions which would potentially more than double the size of the community.

1.2.2 ENVIRONMENTAL

Other scheme drivers centred around environmental and public health concerns. Monitoring of 9 shallow bores indicated some low levels of contamination at some sites. Although this could not be directly attributed to the existing on site wastewater systems it was considered that there would be an increased risk of contamination and public health issues arising as a result of the cumulative effects of the existing on site wastewater systems and wastewater arising from the planned developments.

There was also anecdotal evidence of ponding and associated odour issues occurring in low lying areas where the ground water is closest to the surface. This was most evident during the peak holiday periods. A number of residents also reported problems with their septic tanks backing up. This was mainly due either to overloading of drainage fields or high ground water levels or in some instances root intrusions.

1.2.3 REGULATORY

Another driver which has arisen during the development of the scheme is the set of rules for on-site wastewater systems set out in Horizons Regional Council's One Plan regulatory framework. These require new on site wastewater systems for sections less than 10 hectares to provide secondary treatment and a 300m^2 disposal field for a three bedroom house with a 50% reserve area located in areas with free draining soils. Existing systems can be retained providing they are regularly maintained and do not impact on ground water or cause ponding or odour issues. However Horizons were concerned about the cumulative effects of the 400 existing systems in a relatively small area and were thus supportive of a community wastewater scheme which would allow the existing systems to be decommissioned.

1.2.4 AVAILABILITY OF FUNDING

The final driver for the scheme was the availability of a subsidy from the Ministry of Health's Sanitary Works Subsidy Scheme. The Himatangi Beach community had a Deprivation Index of 10 in the 2001 Census, meaning that it is ranked as one of the 10% most deprived areas in New Zealand in socio-economic terms. However even with the subsidy confirmed there was concern within parts of the community regarding the affordability of the scheme. Following a referendum in April 2011, Council decided to proceed with a community sewerage scheme but made joining the scheme voluntary.

Given that connecting to the scheme is on a voluntary basis and that the subsidy was only available for works completed by mid 2013 Council decided to incentivise property owners to sign up to the scheme by offering a $10,000 plus GST subsidy to all property owners who signed up by 31 December 2012. As a result the capital contribution payable by the 290 property owners who signed up to the scheme was reduced from $18,500 to $8,500 plus GST.

2 PROCUREMENT METHOD

One of the conditions of the aforementioned subsidy was that the scheme should be commissioned by May 2013. This meant Council had just over two years to obtain the required consents, purchase sites for the treatment plant and land treatment area, design, procure, construct and commission the whole scheme. This timescale drove the decision to select a design and construct procurement approach for the main elements of the scheme.

Following an earlier evaluation in 2006 by Good Earth Matters (ref 1) it had already been decided to utilise a pressure sewer system for conveying the wastewater to the treatment plant. This would reduce construction cost from expensive dewatering when constructing gravity sewers in sandy ground below groundwater level, and also greatly reduces the risk of infiltration into the system.

2.1 EXPRESSIONS OF INTEREST

After an Expression of Interest process, five consortia were invited to tender for the design and construct contract, with tenders received from three consortia. The scope of the contract included the design and construction of all works from the on lot pump stations to the new treatment plant, and also the construction of modifications to the existing on lot drainage. The client was responsible for the design of the modifications to the existing on lot drainage. The irrigation system required for the consented land treatment application was let as a separate design and build contract.

Because of the voluntary nature of the scheme the number of properties connecting to the scheme from the outset was unknown. However based on the feedback from earlier consultation it was assumed that half of the existing 400 properties plus all the community facilities would be connected from the outset and the other half would be connected over the following five years. The contract was therefore structured into separable portions to facilitate this.

2.2 TENDER STAGE

Following a review of the tenders by the client, it was apparent that significant savings would be needed to keep the subsidised capital contribution per property to below $10,000. This was considered by MDC to be the limit of affordability for many of the property owners to connect to the scheme. Tenderers were therefore requested to submit revised tenders based on cost-savings proposals outlined in their original tenders.

Two areas were identified by the client where significant savings could be achieved. These were the on lot pump stations, and the treatment plant. As a result, the client decided to take over responsibility for the design of the treatment plant, and opted for a pond based system. A non-notified resource consent had already been obtained by the clients technical advisors for a land based discharge.

During the tender phase, in parallel with a conforming submission, the contractor led consortium developed several key innovations with the potential to save $1m from the capital cost. These innovations were:

- Sharing pump station units between two properties.
- Providing electrical connections from the pump units directly to the electrical network, as opposed to connecting to private residential switchboards.

2.3 CONTRACT AWARD

Based on the anticipated cost savings from the innovations proposed above, a circa $5m contract was let to the contractor-led consortium in July 2012. The revised contract scope included:

- Detailed design of all works between the inlet to the pump station units and the inlet to treatment pond
- The installation of 200 Mono Eco 1-60 900 litre volume pump station units and associated pressure laterals and electrical works
- The diversion of 400 existing drains and decommissioning of 400 septic tanks
- Approximately 9km of pressure pipeline up to 140mm OD and 1 km of 180mm OD rising main between the township and the new treatment plant.
- The civil construction of a 1.8ha wastewater pond. The mechanical, electrical, irrigation and process equipment were procured directly by the client.

Together with the removal of the requirement to prove the performance of the treatment over a 5 year operational period, this resulted in significant Capex savings of approximately 15%.

3 DESIGN INNOVATIONS

3.1 SHARING OF PUMP STATION UNITS

As previously discussed, one of the key cost savings proposed was to share pump station units (PSUs) between two properties wherever possible, with the potential to generate a saving of up to $1m. The number of pump stations required could be reduced to around 230 if all the 400 existing dwellings were to connect to the scheme. The savings are as a result of:

- Reduced material costs from fewer PSUs and associated boundary kits

- Reduced material costs from fewer pressure laterals from the PSUs to the mains

- Reduced construction costs from PSU installation and commissioning
- Reduced construction costs from fewer electrical connections

This section details the preliminary work completed by the client to determine which properties could utilize the shared PSU system, as well as analysis of the design flow parameters and PSU characteristics to determine the suitability of the proposal.

3.1.1 ON LOT WORKS DESIGN

The client undertook a drainage inspection of around 350 properties whose owners had expressed an interest in joining the scheme. It was necessary to work out which adjoining properties could most readily be connected, while at the same time trying to minimise the number of pump stations serving only one property. This was dependent on:

- The number of properties in a street i.e. if there were an odd number of properties.
- The location of the existing drainage did not configure well with neighbours.
- The topography of the adjoining properties.
- Access requirements for constructing the pump stations and pipelines.
- Spatial requirements such as minimum distances between the pump stations and buildings, windows and boundaries.
- Property owner preferences where this could be accommodated without entailing extra cost.
- Minimising the reinstatement of paved areas and disturbance of landscaped areas and gardens.
- Some properties shared boundaries with vacant lots, community facilities or public reserves.
- Some properties opting out of the system, and/or already had compliant waste systems
- Community facilities would require their own PSU.

3.1.2 DESIGN CRITERIA

Prior to commencing design, the client commissioned a Flow Model Report (Ref 2), to provide baseline flow data for current and future populations, as well as baseline and peak flows due to summer, school and public holidays and weekends. The model used was similar to that developed for the Riversdale and Mahia sewerage schemes which were considered to have similar seasonal population characteristics.

As discussed previously, the demographics of the Himatangi Beach community showed an approximate ratio of 40% holiday homes to 60% permanent residents. The average resident occupancy per dwelling of Himatangi Beach was assumed to be 2.3 increasing to 5 on the peak day. Like other beachside communities around New Zealand, the population of Himatangi Beach increases at weekends, Public Holidays and the summer school holidays, with a substantial peak at Christmas/ New Year.

To estimate the variances in peak flows over the course of a year due to these seasonal fluctuations, assumptions were made to calculate the peak flows versus typical weekday flows, and the duration of these peaks. This is summarised in the table below:

Type	%age of Peak flow	No. Days/year	%age of year
Christmas Holidays	31%-100%	30	8%
Other Long Weekends	50%	13	4%
Other Typical Weekend	34%	86	24%
School Holiday Weekdays	33%	30	8%
Normal Weekday	23%	206	56%
TOTAL		365	100%

Table 1: Summary of Peak Flow Estimates and Duration

From this information, it is clear that for 206 days of the year the flows were at the minimum (only 23% of peak flow), and that for 322 days per year (which represents 88% of the year) the flows were less than 50% of the summer peak.

This together with the sewerage scheme being designed for the 2041 peak day, demonstrates that for the majority of the time, the scheme will have a great deal of extra capacity. The range of flows is expected to vary between 60m^3/d (current normal weekday flow) to 800m^3/d (2041 peak day).

3.1.3 TYPICAL PUMP STATION UNIT OPERATION

The pump station unit selected by the consortium was the Mono EMS1-60 unit. This is a purpose built positive displacement pump with macerator. A diagram of the EMS1-60 unit is shown below:

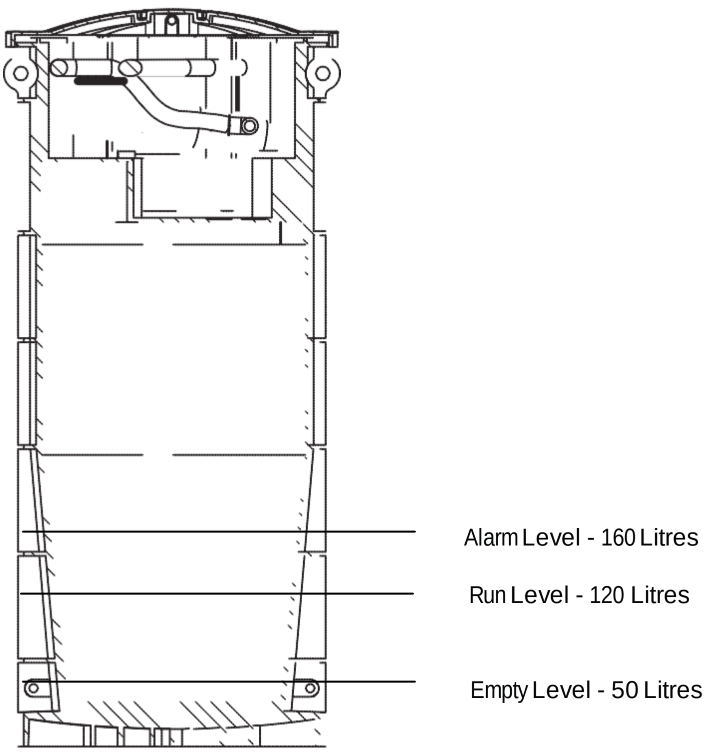

Figure 2: Mono EMS 1-60 Pump Unit

The EMS 1-60 has the following key characteristics:

Parameter	Value
Pressure limit	60m
Duty Flow	1 l/s
Tank Capacity	900 litres
Pump start level	170 litres
Pump stop level	50 litres
High level alarm	330 litres
Emergency capacity	570 litres

Table 2: EMS 1-60 pump unit characteristics

Wastewater enters the tank from the domestic plumbing. Once the water level reaches the pump on level (representing a volume of 170 litres), the pump starts and runs until the water level reaches the stop level (representing a volume of 50 litres). Therefore, the operating range is 120 litres.

At an average daily wastewater production of 200 litres per person per day, with a typical occupancy of 2.3 people per dwelling, the pump will run on average 3.8 times per day. With a discharge flowrate of 1.0 l/s, the pump will run for 120 seconds per cycle, or an average of 7.6 minutes per day.

Therefore, if a PSU was installed at every property, then many of these PSUs would not be utilised often at all, and those that were in use, have sufficient capacity to accept significantly more flows. Together with the peak versus non-peak flow comparisons discussed above, this presented the potential for most properties to share one PSU between two dwellings.

Two other important factors ensured that this option could be viable. The first was that the topography of Himatangi Beach is very flat, therefore there would be few problems in draining two houses domestic systems by gravity to a centrally placed PSU. The second was that the PSUs would remain as Council-owned assets, therefore any issue associated with sharing of the PSU owned by a neighbour were avoided.

Not all properties could share PSUs however, and this is discussed further in section 3.1.1 above. Therefore, the total number of PSUs to be installed if all existing properties were connected would be 230, which represented a reduction of 170 PSUs supplied and installed. This represented a nearly 15% saving in the overall project capital cost.

Another advantage of this approach is the reduction in the number of pump station units which need to be maintained, hence reducing the OPEX costs.

3.2 ELECTRICAL CONNECTIONS

One disadvantage of sharing PSUs was the electrical connection. On similar low pressure sewer schemes, the PSUs are electrically wired into the domestic switchboard of the house. However, this presented several problems.

Firstly, if the shared PSU was wired to a domestic switchboard, and that owner went away and switched off their power supply at the mains, this would isolate the shared PSU and affect the other party. Secondly, the cost of the power to run the PSU would be borne by the resident whose switchboard this was connected to.

The solution therefore, was to connect the shared PSU directly to the overhead electrical network, “upstream” of the switchboard meter. This eliminated the problems described above, and in the process reduced another potentially significant risk.

Due to the average age of the properties at Himatangi Beach, as with many other similar communities, electrical connection to the domestic switchboard may necessitate further upgrades to the electrical switchboards to bring this up to the latest electrical Code. This had the potential to add significant unforeseen cost onto the homeowner. Whilst single PSU connections still have been connected to the residential switchboard, connecting the majority of PSUs to the overhead lines ha greatly reduced this risk to the community.

4 DESIGN APPROACH

The project, being a design and build project, required a significant amount of collaboration between the client, designer and contractor to be a success. For this to work well however, a structure was required which outlined key elements including scope, design inputs and design deliverables. These key elements were all addressed in a Design Quality Plan, prepared by the contractor, and agreed by all parties involved in the design.

4.1 SCOPE

The scope of the contractors design was split into two parts. The first was the design of the on-lot works, including PSUs, boundary kits, gravity and rising mains, from the gully trap to property boundary. The second was the design of the community reticulation, from boundary kits to the wastewater treatment plant. Critical to the success of the scheme was interfacing with elements of the design that was being undertaken by the client i.e. on-lot works and the wastewater treatment plant.

The table below outlines the key responsibilities for various phases and elements of the overall project.

Project Phase	On-lot Works	Interface	Reticulation	Interface	WWTP	Interface	Irrigation
Design	Client - gravity drainage, PSU and pressure laterals locations	Upstream of boundary kits	🟧	Upstream of screen	🟩	Wet Well	🟩
	Contractor (Designer/ Pump Supplier) - Hydraulic, civil, structural		Contractor (Designer)		Client (Process and Treatment Pond)		Client
Construction	Contractor		Contractor		Contractor (Civils)		Client
					Client (M&E and Floating Treatment Media)		
Commissioning	Contractor		Contractor		Client		Client

Table 3: Identifying scope and interfaces during contract phases

There were two stages of design development for the reticulation scheme required under the Contract, with a third minor stage to allow for production of final construction issue documents:

- Preliminary design
- Detailed design
- Final (Completion) design

4.2 DESIGN DEVELOPMENT

The Preliminary design stage updated the tendered design to incorporate agreed changes resulting from post tender amendments. Further detail such as aerial photography, topographical survey and utility information were also added to the drawings.

One of the key advantages of design and build contracts is the ability for the contractor who is to build the scheme, is able to have input and drive the design to suit constructability aspects. During the design development stages outlined above, the contracting team reviewed the design stages and provided formal feedback on the design back to the designers. In this way, the design was shaped best to suit the intended construction methods, to optimize cost and time as much as possible. Conversely, this interaction provided the opportunity for designers to discuss aspects of their design with contractors.

It was also vital that the design was agreed between all parties, and therefore “frozen” before proceeding with the next stage of design.

4.2.1 COMMUNITY FACILITIES

The client also undertook the design of the pump stations serving all the community facilities. The Holiday Park pump station was designed to serve the 370 visitors who stay there during the peak week. Two duty/standby macerator pumps were installed together with an emergency storage tank capable of providing 12 hours storage in the event of a power outage or equipment failure.

A combined pump station was provided to serve the Public Toilets, Community Hall and Surf Club. This required a 2200 litre Duplex pump station unit with additional storage. Other community facilities where the volume of wastewater generated could significantly exceed that produced by a dwelling such as the Bowls Club have been supplied with 2200 litre pump station units.

4.2.2 INFLOW AND INFILTRATION

It was decided to make no allowance for infiltration and inflow. The rationale behind this was twofold. Firstly, the chances of peak rainfall coinciding with peak sewer flow would be say 1 week in the year (i.e. 1 in 52) and at a time when there are unlikely to be drainage problems during the summer given the sandy ground conditions. Secondly, as many of the visitors come from nearby Palmerston North they would be likely to go home if peak rainfall occurred. Therefore there was no need to provide additional capacity

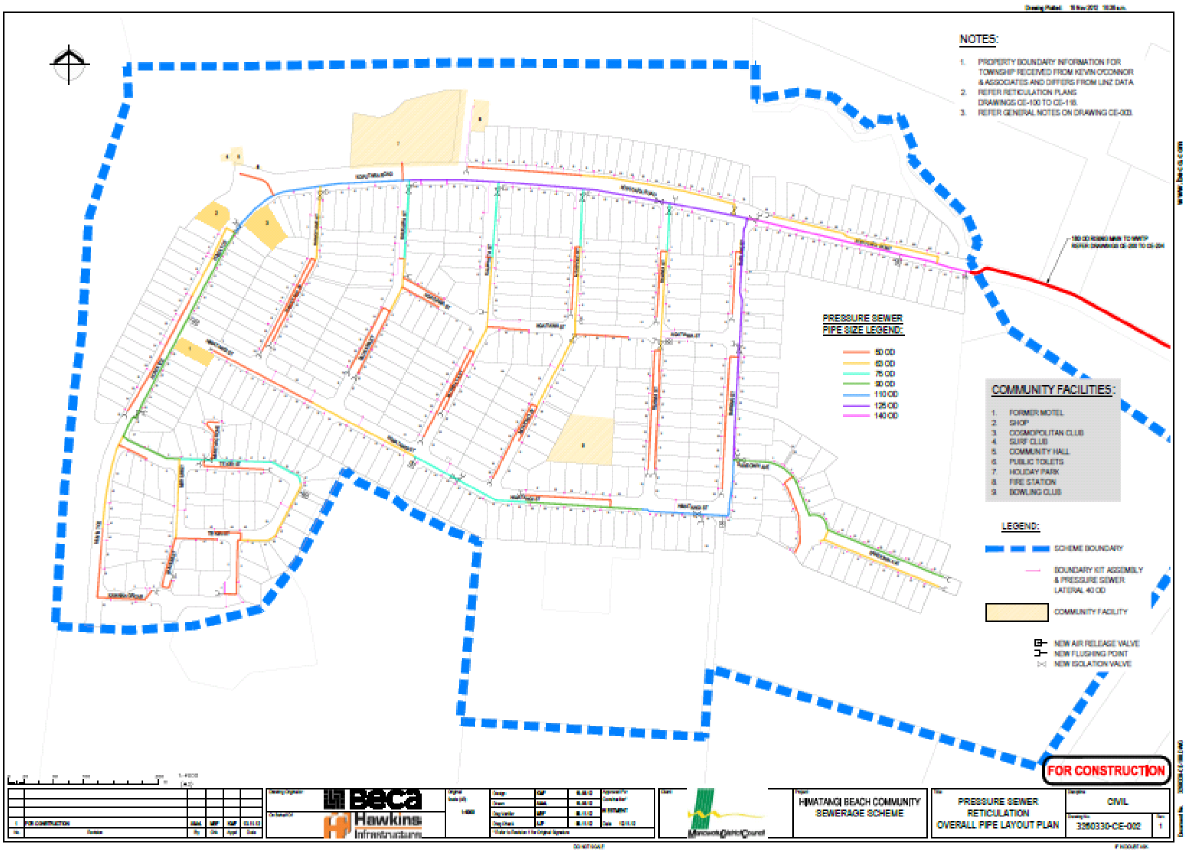

Figure 3: Himatangi Beach Community Sewerage Scheme Reticulation Layout

4.2.3 TREATMENT PLANT DESIGN

The treatment plant which comprises a 1.8 Ha pond with Floating Treatment Media (FTM) has been designed to handle the peak week average flow arising in 2026. However with the addition of further FTM it will be capable of treating peak week flows arising out to 2041. The FTM enables the pond to buffer the shock loading which occurs during the peak holiday period and also will facilitate the future installation of UV should this be necessary. The expected effluent quality is:

BOD5	< 10 mg/l
TSS	< 10 mg/l
Total Nitrogen	< 10 mg/l
Total Phosphorous	< 3 mg/l

- E Coli < 1000 cfu/l00 ml

4.2.4 DYNAMIC MODELLING

The three methods for designing low pressure sewerage systems in accordance with the Pressure Sewerage Code of Australia WSA 07-2007 are the Probability Method, Rational Method and Dynamic modelling. Preliminary design for the HBCSS was completed using the Probability method to provide a relatively quick design layout with pipe sizes. A dynamic model, using specialist software, was then developed to optimise the reticulation network, including pipe sizes.

As stated in the 'Himatangi Beach Community Sewerage Scheme: Design Report' (Ref 3), using a dynamic model to design low pressure sewers has the following advantages:

- Considers pump performance allowing different types of pumps to be assessed together
- Increased system optimisation
- Modelling of the system spatially
- Allows system operation to be assessed allowing further optimisation

The model was set up so that each dwelling had a typical diurnal flow profile. Where PSUs were shared between two properties, the flowrate was doubled. Each PSU was given a random water level, and then run for the Peak Day flow for the year 2040/41, which represented the maximum flow rate the system was to be hydraulically designed for. Growth was allowed for in the eastern part of township around the Sandown subdivision area and some infill development.

Several iterations of the model were run during the design development. The model outputs were focussed on the following key areas:

Benefit Area	**Reason**
Identifying sections of network where pressure in the reticulation was over 60m, and for how long.	60m represents the cut-out pressure for the EMS1-60 PSU. To ensure each PSU was able to be drained effectively, the system was optimised so that pressures would not be greater than 60m for more than 5 minutes at a time.
Identifying particular PSUs which may not be able to empty due to sustained system pressures	If high pressures mean a particular PSU cannot operate, water levels will rise from normal domestic usage. The modelling showed that for the 2041 Peak Day scenario, whilst 10 PSUs where shown to exceed the pump on volume (170l), none exceeded the high level alarm volume (330l), thus maintaining the emergency storage volume and causing no high level alarms.
Pipe velocities	Ensure the pipe velocities are greater than 0.75 m/s to provide self cleansing properties.
Retention times	Understand average retention times in the network to move sewerage through to the treatment plant, to reduce the risks of septicity.

Table 4: Summary of key areas interrogated by dynamic model during design development

The reticulation was sized to handle a daily average flow of 800m^3/day which is the 2041 peak daily flow. However the sizing of the pressure mains also needed to consider the operating pressure of the pumps and the operation of the network under a range of flow conditions. The current daily weekday flow will typically be between 60 and 75m^3/day which will lead to a build up of solids and septicity if the velocities are too low. The hydraulic model indicated the average retention times in the network on peak days to be 2.3 hours currently and 1.5 hours in 2041. For minimum flow days the retention will be 10.2 hours currently and 5.6 hours in 2041.

Hydraulic modelling of the network undertaken by the consortiums designers indicated that the peak flow in the network would be 28 l/s if the maximum pressure of 6 bar is not to be exceeded. This is the maximum pressure at which the selected pumps operate.

Therefore it was necessary to balance the operational aspects of the system against the hydraulic requirements. Given the difference in winter and summer peak day flows it may be necessary to carry out a flushing program.

4.2.5 CONSTRUCTABILITY

The design development from a constructability aspect focused on optimizing the overall pipe lengths, depths and locations, whilst adequately still servicing all lots in the scheme, meeting the specific requirements of the client and the Pressure Sewer Code.

As a general principle, road crossings were avoided due to minimize road reinstatement and traffic management costs.

4.2.6 OPERABILITY

The main operational aspects that were optimized during the design stage included location and number of flushing points, and locations of air and line valves.

In accordance with the Pressure Sewerage Code (ref 5), the flushing points were included at all branch dead-ends with more than five connections, downstream of line valves, where there was more than one upstream connecting line and at intervals not exceeding 500m.

Because the locations of residences identified as ‘permanent’ residents of Himatangi Beach as opposed to those used primarily as holiday homes, an assessment was made with baseline flow assumptions (occupancy of 2.3 people per residence) to determine sections of the reticulation network that may be susceptible to longer retention times or lower velocities. According to the Himatangi Beach Community Sewerage Scheme: Design Report’ (ref 3), these were identified typically at the furthest extents of the network and where capacity had been made for future development. These sections of the network can then be targeted for monitoring during operation of the scheme.

4.2.7 SAFETY IN DESIGN

At end of the Preliminary design phase, the designers completed a Safety in Design workshop on the design. The purpose of this was to identify and “design out” any potential design aspects that may pose safety risks in construction, commissioning or operation, for example ensuring all valves were off the carriageway wherever possible, and that the reticulation network was located sufficiently away from existing underground services and power poles.

5 CONCLUSIONS

The collaborative approach adopted by the client resulted in several key innovations for the Himatangi Beach Community Sewerage Scheme. These innovations included:

- Incentivising early connection to the voluntary scheme.
- Reducing capital and construction costs by sharing on-lot pump station units between two properties wherever possible.
- Connecting the shared pump station units electrically directly to the overhead electrical network, which reduced the risk of costly upgrades to residential switchboards.

By using direct feedback from the design and build process, enabled by the clearly defined scope and interfaces between the team, the project team were able to optimise the design for pipe diameter and pipe lengths, without compromising serviceability of the scheme. This was demonstrated by the use of dynamic modelling as a tool to develop the design to ensure serviceability for future peak flow conditions. The model also enabled testing of the system under future scenarios to demonstrate the ability of the system to meet the clients design objectives.

The benefits of these innovations resulted in a 15% saving on capital cost, and projected cost per property before subsidy of $18,500 excl GST at current prices and exchange rates. This assumes that over the period 2012-22 all the existing 400 dwellings will be connected together with all the community facilities plus a further 50 new dwellings.

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