POKENO WASTEWATER SCHEME – AN INNOVATIVE SOLUTION TO COMPLEX HYDRAULICS

Tony Miller
GHD Ltd, New Zealand

Daniel Thompson
Waikato District Council

ABSTRACT

Pokeno is situated on the south side of Bombay Hills complete with shallow basalt, undulating topography, 1,200 population on septic tanks, and an approved 800 lot subdivision due to come on stream this year.

Currently serviced only by septic tanks, GHD were tasked by Waikato District Council (WDC) with design of a wastewater scheme for a target population of 7,500 people in 2040, which needed to work within the constraints of limited budget, significantly increasing flows over time and sewage age, odour and septicity caused by the need for a 8.4km rising main to Tuakau.

The adopted solution involves staged implementation of the scheme to meet budget and operational constraints with a small diameter rising main to meet initial peak dry weather flow (PDWF) conditions, before the subsequent installation of a second stage larger rising main to meet projected 2040 flows. Innovative use of DWF / WWF storage has also been incorporated so as to give the optimum net present value outcome.

This paper describes the solution that was developed to meet these challenges – including scheme staging options, cash flow, funding strategies and innovation in the design process e.g. Esflow Storage and low pressure reticulation systems.

KEYWORDS

Innovation; slime shearing; odour; septicity; detention storage.

1 INTRODUCTION

1.1 LOCATION AND SETTING

Pokeno is now within Waikato District. The transition from being part of Franklin District Council was completed only recently during the Auckland Council amalgamation in 2010.

Pokeno is situated on the south side and foot of the Bombay Hills adjacent to State Highway 1. The township is set within the Waikato River catchment and spans over two small tributaries of that river being the Helenslee and Tanitewhiroa Streams. The township is situated over gently rolling topography and on the lower slopes of the Bombay Hills.

The geological setting is characterised by being underlain by South Auckland Volcanic Field deposits and recent alluvium/colluvium (Figure 2) in Appendix B. Extensive basalt occurs over much of the township with varying levels of cover to the hard rock beneath.

Data from 1996 to 2001 to 2006 Census shows an increasing population from the Pokeno Mesh Block increases from 1200 to 1500 to 1800. The mesh block covers a greater area than the town itself. For design the township has a population 1,200 serviced by septic tanks. Stage 1 of an eventual 800 lot subdivision is due to come on stream this year (2012).

2 WASTE WATER STRATEGY

2.1 WASTE WATER TREATMENT

Prior to GHD being involved with the project, a decision of the former Franklin District Council had determined that a separate onsite treatment plant was not desirable and had elected to reject the construction of a standalone plant. WDC adopted this decision and proceeded with the servicing of Pokeno by way of a collection and transfer system to the Tuakau wastewater treatment plant.

This could be achieved by an 8.4 km rising main and discharge into an existing 600 mmø concrete sewer interceptor.

2.2 POKENO SEWER RETICULATION

2.2.1 EXISTING

The existing sewage treatment for the existing 1200 population consists of septic tanks and a limited number of individual package plants but with no public sewer reticulation.

Part of the GHD brief was to ascertain the viability of a reticulation system to discharge to the proposed pump stations and rising main. Two types of reticulation were considered.

2.2.2 CONVENTIONAL GRAVITY

There is no existing public gravity sewer reticulation within the existing township.

A new 800 lot of the Helenslee subdivision is set out in Waikato Regional Plan Change 24. Stage 1 incorporates 80 lots and is due to come on stream this year. The development requirements have been completed and the first titles for stage 1 of the Helenslee Block are now available. Three new show homes are under construction with new residential dwellings in stage 1 expected to begin in earnest soon.

GHD undertook a scheme design of the existing township and determined that a gravity solution would be able to service approximately 90% of the existing township, existing commercial area and existing school to either of the two new proposed pump stations.

In addition to the Helenslee Block, there is an additional block of up to 400 new lots within the proposed Hitchen Residential Block to the immediate west of Pokeno. These can be serviced by gravity to proposed Pump Station B (PSB).

A 50 ha industrial subdivision has also been incorporated into Plan Change 24. This catchment can also be serviced to the proposed PSB by gravity.

2.2.3 PRESSURE SEWER

In parallel with the analysis of a gravity solution, a pressure sewer system to service the existing township was also analysed. All of the existing township could be serviced. However, because of the proposed gravity Helenslee Block to PSA, and new industrial catchment to PSB, there could be no saving in the potential deletion of either of the proposed pump stations.

2.2.4 CRITERIA FOR FINAL DECISION ON SERVICING.

The old commercial area of Pokeno and approximately 25% of the township can be easily serviced by relatively shallow gravity reticulation. The balance of the site would require deeper reticulation up to 6 m deep.

The cost for a new gravity connection is in the order of $5,000 per lot plus any premium towards the network reticulation. The costs of a pressure sewer connection would require each applicant to pay approximately $8000 per connection for the private works plus any network contribution.

A Council owned network for a pressure sewer is significantly less with smaller diameter collection network and potentially lower inflows and associated lower storage costs as the individual households would be required to store up to 24 hours on site.

The additional costs of the pressure sewer on existing households will make the uptake of new connections to the pressure network slower unless there is some compulsion from Council through regulation or rate surcharge.

Council is currently in consultation with the existing township's community regarding the design of reticulation for this area, and the outcome of this process and uptake of the resulting scheme will determine the final design and connection costs for this section of the network.

The decision on pressure or gravity sewer has had little impact on the choice selection for the trunk pump and rising main design. For the pressure sewer scenario, the uptake rates are likely to be slower and have lower rates of infiltration.

3 LOCAL CONSTRAINTS

Add photo

3.1 TOPOGRAPHY AND GEOLOGY

The existing township topography is rolling land falling to two tributaries of the Waikato River. The Helenslee Stream is closest to the southern motorway. A shallow ridge between both streams divides the township. Old State Highway 1 traverses up this ridgeline.

Beneath both valleys are fields of extensive basalt occurring at varying depths. One of the big challenges during the design phase was to infer where the basalt depth was, with a limited budget available for a geotechnical investigation.

The rising main choice was largely dictated by the access to public land. The rail corridor was ruled out early in the design sequence. This option had advantages from an operational perspective as it would reduce total head and decrease sewage age due to its reduced rising main length.

The road alignment from Pokeno has two localised high points before a significant rise to the high point approximately half way to Tuakau. The Pokeno Road passes through a public reserve where a near solid basalt road cutting can be observed. The geological map shows additional areas of basalt along Pokeno Road.

After the high point approximate half way, the proposed pipeline route along the road corridor undulates before dropping in elevation down to Tuakau along Bollard Road.

3.2 EXISTING RETICULATION AND FUTURE AREA TO BE SERVICED

The Franklin District Plan became operative in February 2000. Plan Change 24 (PC 24) was sought and is now operative (in part and subject to one outstanding appeal).

The proposed structure plan allows for significant development within the greater area. The target sewer design was for 7500 people by 2040. Once the development allowed for by PC 24 has been carried out there is a potential for larger flows. No work has been undertaken in the design to specifically allow for the peak discharge in addition to that allowed for by a 7500 population.

3.3 GROWING POPULATION

Current sewer disposal rates to a public system is zero. Once the stage 1 of Helenslee Block is underway, it is expected up to 80 additional houses per annum are to be connected. (i.e. initial annual population increase of 250 persons/year plus that resulting from the reticulation of the existing township.

The expected 2040 population is 7500 plus an ability to service new commercial and industrial areas.

3.4 HIGH HEAD AND HIGH FRICTION LOSSES

The static head for a rising main from the PSA site in Market Street is 50 m.

The friction head at minimum flushing velocities of 0.9 m/s resulted in friction losses of an additional 75 m head for a 125 mm OD PE pipe and 35 m for a 225 mm OD PE line. Thus the initial target head was between 125 m and 85 m total pump head.

In addition to total pump head is an allowance for de-rating the pipe for fatigue. The effects of water transients (water hammer) in case of emergency shutdown were considered.

In order to reduce head and improve sewer management (total head loss, sewage age and septicity in early years of operation when flows are less) the last 1.4 km of the pipeline was changed from downhill pressure main to gravity sewer that can drain between pump cycles.

There is a significant reduction in internal pipe diameter when increasing from PN 12 to PN 16. As a result of the design process, a target maximum PN 12 was considered desirable from a strategy to reduce cost and reduced friction head, and associated pump head and operating cost.

3.5 SEPTICITY AND ODOUR MANAGEMENT

The empirical value for sewage residence time prior to discharge without significant problems should be less than 8 hours at average day weather flow. During the initial connection and initial development phases the expected sewage age could be days old prior to discharge to the Tuakau Interceptor.

With old sewage comes associated problems of decomposing sewage in anaerobic conditions combined with highly turbulent flow in the energy dissipation within the receiving Tuakau Interceptor. Associated air release with line emptying at the end of each pump cycle would also therefore be an issue.

Similar potential issues were identified within the Pokeno pump stations and their associated storage chambers.

Within the wetwell and with the emptying of each pump cycle, there is displacement of air of volume equivalent to the volume of the sewage pumped. Our design philosophy was to limit the rise and fall of pump operation levels at Pump Station A due to it being located adjacent to residential properties. In time, full odour control has been allowed for as part of an upgrade strategy.

3.6 STORAGE

The target storage for consent purposes needed to be addressed as follows:

- Target 6 hour dry weather flow storage prior to discharge to the adjacent watercourse during a power failure or mains outage scenario;

- The design needed to address events in excess of the standard storage requirements and be cognisant of the associated odour management issues and

- Pump Station A (PSA) site was adjacent to an existing residential area. Pump Station B was adjacent to a proposed industrial area.

4 PUMP STATION AND RISING MAIN SYSTEM DESIGN

The principal challenge for the design team was to develop a system that addressed low initial flows of almost zero but are projected to increase to almost 2000 m^3/day by 2040. With low initial flows comes long periods between pump cycles and sewage aging.

A single 8.4 km rising main to meet the ultimate design has the lowest friction losses but has significant challenges to meet minimum cleansing velocities. Also, a single rising main (250 mm OD and 8.4 km) has a large volume to fill during the initial stages of operation with only a few litres per day during start up. Thus sewage age and sewer septicity would be a significant problem in the downstream Tuakau Interceptor.

4.1 RISING MAIN OPTIONS

A range of pipe and pump options was developed to meet these critical design constraints.

- A single pipe rising main was rejected because of the large fill volume and the inability to achieve acceptable cleansing velocities in the early years of operation.

- Twin equal sized rising mains and the associated pumps were analysed. Likewise, during the early years of operation the sewage age was significantly old, prior to discharge to the Tuakau Interceptor. The ultimate main pump configuration involved two 70 kW pumps operating is series to achieve the required self-cleansing velocity and an additional two pumps configured in series as standby.

Two identical pipes still had significant expected operation problems during early years of operation. Of concern was the age and velocity of sewage entering the Tuakau 600 mmø concrete interceptor. This sewage would be old, anoxic and potential to cause corrosion problems to the concrete pipe wall during the period when there are lower flows in the Tuakau Interceptor.

A solution was sought whereby the last downhill section (1.4 km) would be made into a larger downhill rising main that would drain between pipe cycles. Thus the velocity and age of sewer arriving at the Tuakau Interceptor would be significantly more tranquil, have less odour issues and have less impact upon the initial low flows in that pipe.

- The chosen ultimate solution involved twin rising mains of different diameters. The initial 160 mmø OD pipe would be thrust for a significant length of its journey. The initial pump size could be reduced to 4 of 24 kw pumps in series and backup configuration. The initial pipe fatigue criteria could be relaxed to being in service for a significantly shorter period.

- The initial pipe would be temporarily decommissioned when the upgrade was commissioned and would be brought back into service when the larger pipe was nearing design capacity and operated in parallel to further reduce friction head.

- The final pipe size installation could be delayed for a number of years. At the same time that the subsequent new 225 mmø pipe would be required, the initial 24 kW pumps would need to be upgraded to 70 kW. The pump station has been designed to allow for upgrade with minimal changes to structure and pipework.

- The final 1.4 km downhill section was a 355 mm OD main.

4.2 PUMP STATION OPTIONS

The total head from the Pump Station B site was an additional 10 – 15 m made up of additional static and additional friction losses because of the additional rising main length. This would involve design of PN 16 pipe for the first few kilometres of pipeline.

The adopted strategy involved:

- Pump Station A (PSA) on Market Street as the main pump station. (Reduced total head compared with PSB). PSA would service the Helenslee Block by gravity and also be able to service more than 60% of the existing township by gravity.

The operational strategy was to operate PSA within minimal use of storage and utilise storage in PSB until PSA had sufficient capacity to allow transfer from PSB. The benefits of this strategy would be to minimise odour generation and minimise storage at PSA

- PSB (within the industrial Block) would be used as a transfer pump station to PSA. This would only pump when the operational level in PSA was below the normal on level in that station.

The initial flows to PSB will be very small and initially only from the adjacent industrial area. As such the sewage age is expected to be significant before pumping to PSA without intervention. There is only a limited water public supply and as such top up from the public water supply was not an option.

Control odour and sewage age was proposed by injection of water into PSB at a rate that will allow 6-8 pump starts per day, until the catchment discharge on its own can progressively displace the injection rate. As town water was not available in sufficient quantities, a ground water source has been identified.

By adopting this policy, the dilution and addition of ground water at PSA will also transfer and cause a similar number of pump starts in PSA. Each pump cycle in PSA will move a slug of 340 m in the rising main and although the sewage will be some 60 hours old by discharge, the concentration will be significant reduced as compared with undiluted sewage. Odour risk is considered acceptable under this operation.

4.3 PUMPING RATE AND WORKING STORAGE.

Pump design relies of the pump station meeting peak PWWF inflow rate. The previous FDC design guide relies on PWWF being 5 times PDWF rate. WDC standards rely on Hamilton City standards which require a similar factor of 5.

The Pokeno design has modified this design criteria to meet three times PDWF but supplement the design by making active storage available. Pumping to the Tuakau Interceptor from PSA will have a priority over transfer from PSB. Working storage would be utilised at PSB to handle any shortfall in transfer capacity from PSB to PSA.

Working storage is in addition to emergency storage. Emergency storage is calculated at six hours ADWF.

At Pump station A the working storage is held in the wetwell and upstream manhole and pipe capacity. Following an outage, pumping will occur from this pump station until level is below normal on level.

In Pump Station B, storage will initially be held within the wetwell and upstream pipe capacity. However once this storage is exceeded an Esflow system has been designed for installation at a subsequent upgrade stage.

4.3.1 ESFLOW™ SYSTEM

The Esflow principle is to allow working storage of sewage by off line storage. An Esflow consists of multiple chambers. Sewage is drawn off from just below surface level in the wetwell and pumped to the first storage chamber. Settling of solids occurs and when full, overflows to chamber two in a similar manner. Similarly to a third chamber. Up-flow screening takes place before overflow to outside storage.

In this manner sewage is progressively cleaned of floatables and solids before overflow.

Once the emergency is passed, stored effluent is fed back to main wetwell by gravity as system capacity allows. In parallel a flush system is operated to ensure the chambers remain clean at end of the storage cycle.

Where overflows occur to an outside storage basin, the effluent has been partially treated, contains no floatables and almost no solids. As such, once the emergency has passed, treatment of the open basin will generally consist of spraying with a disinfectant. Thus the external storage basin remains in a fenced area and generally excluded from public access.

The Esflow for the Pokeno scheme has been design adjacent to PSB within the industrial area where odour control is less critical than in a residential area.

4.3.2 EMERGENCY STORAGE PSA

Six hours ADWF has been designed for PSA. This consists of four 12.5 m long fiberglass tanks and 2.5 m in diameter. This will be in the Helenslee flood plain and as such the design includes for hold-down to counter the effects of buoyancy. Return flow to the wetwell will be controlled by remote operated valves with manual override.

The construction of PSA storage will involve excavation to basalt layer and placing storage immediately above.

The order of priority of draining of system following an outage of emergency will be:

- PSA working storage;
- PSB wetwell;
- Emergency storage at A;
- Emergency storage at B;

- Esflow storage at B.

5 FUNDING MECHANISMS

5.1 FINAL COST ESTIMATE

The initial cost estimate for the ultimate scheme to include for the trunk gravity sewer, pump stations and rising main was $13.5M.

5.2 INITIAL STAGED ESTIMATE

Once the final design to service the 2040 predicted population of 7500 was completed, the design was modified to extract sensible elements from the final design to allow for construction of the interim initial build. The cost estimate for this initial phase of work was $9M for initial budget purposes.

It is noted that this initial estimate included for duplicate rising mains (200 mmOD and 250 mmOD pipes) using open cut methodology. An alternative methodology including single initial rising main by drilling was considered.

The FDC Long Term Plan (LTP) had identified funding for the upgrade of the Tuakau sewage scheme but no funds had been allocated for the Pokeno scheme. A reallocation of WDC funding was arranged to allow for the development and construction of the scheme. This LTP funding transfer was capped at $5M, necessitating a review and amendment of the design solution to identify a cheaper initial build solution.

In addition, the Helenslee Block developer will be funding contributions as each successive block is released.

5.3 REVIEW

A net present value analysis (NPV) was carried out on a range of initial rising main pipe size to meet servicing of the initial stages of development but to a lower standard and to consider the concept of potentially stranded assets in the long term plant. This design also considered alternative pumping strategies.

A redesign was carried out to assess minimum requirements to get the scheme operational without any of the usual nice to have features that would usually accompany a scheme.

These design options considered a range of smaller lines that would allow the scheme to be operational. However these sizes (90mm and 125mm OD) would all have to be abandoned at the subsequent scheme upgrade in 3-5 years' time. The 140 and 160 mm OD lines could be constructed and remain part of the final solution however the ultimate transfer capacity would be compromised or a larger second main would be required.

Based upon the NPV analysis the lowest NPV was the scheme with the original 200 mmOD sized rising main.

Council adopted the 160 mmOD rising main scheme as this scheme had a lower initial capital cost albeit was not the lowest NPV.

The engineers estimate for the 160 mm option was $3.6M and this scheme was re-designed, and tendered.

The tendered price was $3.151M and the contract has been awarded to Spartan Construction and the project is currently under construction.

6 CONCLUSIONS

1. The design for the ultimate scheme was developed completed with consideration of multiple competing criteria. Based upon the final design a staged implementation plan was developed with minimal subsequent stranding of assets in the ultimate scheme.

2. The site is geotechnically challenging. Shallow basalt has been identified across the wider area. The budget for ground investigation was constrained and assumptions were made to where basalt may be found. In order to limit project cost over runs during construction, effort was applied to "risk of basalt" encounters and consequential potentials for design modifications during construction.

3. The operation of the Pokeno wastewater collection and pumping scheme has to cater for no existing flows up to the design ADDWF of 2000 m³/day in 2040. The adopted solution uses a range of special features to limit initial capital cost, and innovative use of working storage to limit pumping peak flows down a long rising main whilst maintaining sewage in a condition to limit odour and septicity. These include:

    - Large wetwell diameters to increase local storage but limiting height between off and on limits to control volume and hence control sewage age;
    - Using ground water injection to limit water take from the limited public supply and to dilute the sewage to a level where risk of septicity is unlikely to cause significant problems during the startup phases; and
    - Limit rise and fall of water levels in wetwells to limit odour production.

ACKNOWLEDGEMENTS

Help from Daniel Thompson of Waikato DC in the preparation of this paper.

REFERENCES

- Hamilton City Standard Technical Specifications Manual, October 2010
- Waikato District Council's *Report for Pokeno Wastewater Scheme, Interceptor Detailed Design Report, October 2011 (GHD Ltd)*
- Pokeno Landowners Consortium's Pokeno Village: *Wastewater Issues and Options Report* , *October 2007 (Harrison Grierson)*