COMPARISON OF RISKS, COSTS AND ENVIRONMENTAL IMPACTS ASSOCIATED WITH WASTEWATER COLLECTION SYSTEMS

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ABSTRACT

Local authorities are continually faced with the challenges of providing the most cost effective solution for reticulated sewerage infrastructure. The days of automatically providing a gravity sewer system and limiting the decision making process to the depth of sewers and the number of pump stations are long gone. Local authorities can now choose from gravity, vacuum and pressure systems or a combination of these systems.

The challenge for Local authorities is to bring the options for sewerage reticulation into line with the reliability and longevity of gravity sewer systems, which we are all well familiar. It has long been acknowledged that inflow and infiltration is the most significant issue affecting gravity systems. Both vacuum and pressure systems eliminate most of these extraneous flows, benefiting both the wastewater treatment plant and ultimately the disposal system.

This paper will outline the installation costs and maintenance costs as well as the social implications (health, inconvenience) and importantly the environmental drivers (infiltration, exfiltration, overflows) that should be considered in any decision. The installation of any reticulated sewerage system will have a social impact of some sort, be it disruption during construction or the stimulation of growth in the community. Environmental impacts are usually separated into two groups being, impacts during construction and impacts during operation.

This paper shall discuss these issues in more detail and provide local authorities with a comprehensive overview of current issues associated with wastewater collection systems in the 21st Century.

KEYWORDS

Wastewater reticulation, vacuum sewer, low pressure sewer

1 INTRODUCTION

Today we are faced with numerous choices to solve what would normally be a straight forward problem. Local Council's are continually faced with the challenges of providing the most economical solution for reticulated sewerage infrastructure. The days of automatically providing a gravity sewer system and limiting the decision making process to how deep and how many pumping stations are required are long gone. We are now faced with many areas that are being developed, where the use of gravity-flow sewers may not be economically feasible for reasons of topography, high groundwater, structurally unstable soils and rocky conditions. Furthermore, in small un-serviced communities, the cost of installing gravity-flow sewer systems is prohibitive, especially if the density of development is low. To overcome these difficulties, pressure, vacuum and effluent sewer systems have been developed as alternatives. Local Council's can now choose from gravity, vacuum and pressure systems or a combination of these systems.

This paper outlines the options available to Local Council's for consideration. The paper will look at the risks, costs and environmental impacts associated with wastewater collection systems.

2 WASTEWATER COLLECTION SYSTEMS

2.1 GRAVITY BASED SYSTEMS

The use of gravity-flow sewers for the collection and transport of wastewater from residential and commercial properties has been, and continues to be, the accepted norm for sewerage collection systems in New Zealand and overseas. The use of gravity –flow sewers is accepted because (1) the performance of gravity-flow sewers is well established and documented and (2) a well developed body of knowledge is also available for their design, construction and operation.

Gravity-flow sewers are the system most widely used in New Zealand and Australia. The planning, design, construction and operation has been documented recently in Australia through the WSAA code for sewerage. Whilst this sets down guidelines for this type of system there are still variations from Council to Council around even within Australia where the code is commonly used.

It is long been acknowledged that inflow and infiltration is the most significant issue affecting gravity-flow sewer systems. There have also been recent moves to reduce the cost and the Inflow/Infiltration component into gravity-flow sewer systems. These developments have been achieved via:

1. Reduction of the number of manholes which reduces cost and potential I/I points;

2. Use of continuous welded PE pipes and wider spacing between manholes;

3. Reduction of peak flows which reduces power consumption and increases efficiency at pumping stations.

Gravity systems are marked by deep pipes laid on grade which can be difficult and expensive to construct in ground with hard soils or high water tables. Gravity sewer reticulation is also difficult to construct in areas that have already been developed.

2.2 VACUUM BASED SYSTEMS

The use of vacuum systems can be difficult to comprehend to many Councils as there appears to be a different set of rules. However, the wastewater flow from the dwelling to the vacuum collection manhole is by gravity and is no different from any gravity-flow system. The manhole normally collects up to four individual dwellings depending on topography. The vacuum collection manhole is based on a standard pre-cast concrete manhole but can also be constructed in PE or GRP. The collection manhole houses the vacuum interface valve, which is connected to the vacuum main and a formed sump at the bottom of the manhole enables an air sensor pipe to be installed.

There is no requirement for power at the vacuum manhole as the vacuum interface valve is operated pneumatically. Vacuum mains are laid in a saw-tooth profile and are buried in shallow trenches. As the pipes are under vacuum, flow in the vacuum mains can be uphill. This means that pipe depths are governed not by grade but by cover requirements and therefore can be kept shallow. The vacuum for the system is generated by a vacuum pumping station. The vacuum pumping station collects the wastewater from the network and pumps it into the downstream gravity sewer network or onto the wastewater treatment plant.

Vacuum sewer systems are widely accepted overseas with approximately 100 systems in Australia the oldest of which is almost 30 years old. There are over 2000 systems operational worldwide. Recently the Water Services Association of Australia (WSAA) developed a design code for vacuum sewerage systems and this is now used as a minimum standard of practice.

2.3 PRESSURE BASED SYSTEMS

There has been a lot of interest in recent times in New Zealand regarding the low pressure sewer systems concept. A pressure sewer system consists of small grinder pumps which serve a single house or in some cases a small group of houses. The grinder pump is a semi-positive displacement pump capable of pumping between 0.6l/s to 1.0l/s up to 60 metres head. Because the pump grinds the household wastewater into a liquid slurry, the outlet pipe from each of the pumping units is small, typically 32mm NB.

The pumping chamber is usually sized to provide storage of one day's flow for a typical household. This prevents the risk of a sewer overflow in the event of a power failure. Audible and visual alarms are also provided to enable the property owners to detect system failures or faults and contact the system operation and maintenance personnel. The power required to operate the pumping units is sourced from the domestic power supply of each dwelling.

Low pressure sewer systems have been implemented under several different ownership/maintenance models to date in NZ and this may impact on the true cost of operating such systems. Low pressure sewer systems have been around for almost 40 years in Australia. Sydney Water and South East Water have installed thousands of these units over the last ten years.

2.4 EFFLUENT BASED SYSTEMS

In some parts of Australia and New Zealand, the effluent only system is used in various guises. These systems require the property to be fitted with a septic tank and the effluent only is collected and pumped through a system very similar to a low pressure sewer system. However, the main difference is that the septic tank is kept to pre-treat the sewage prior to transport to the treatment plant. This enables the components of the conveyance system such as the pumps, pipes and treatment system to be designed for lower flows/loads with corresponding cost savings.

Obviously the septic tank will need to be maintained at a cost to ensure no solids carry over will occur as this is likely to affect the downstream network as it will not have been designed to cater for solids within the effluent. Effluent only systems will reduce the biological load on the downstream treatment plant but not the hydraulic load.

3 ENVIRONMENTAL IMPACTS

In terms of environmental impacts there are two main groups that engineers are concerned with being impacts during construction and impacts during operation.

3.1 IMPACTS DURING CONSTRUCTION

The main impact during construction is the impact on water tables aside from the impact of construction on residents. If the topography dictates the gravity sewers to be deep, in most cases dewatering will be required. Dewatering has the potential to affect the water table, particularly in coastal areas. The effect of dewatering for deep sewers can manifest in the following ways.

- In Australia, there is a risk of damage to vegetation due to the shock from lack of water during construction;
- Silt control requirements;
- Ingress of salt water in fresh water tables;
- Potential to affect buildings and create a risk associated with settlement in built up areas.

Another potential issue that may not be readily obvious is that deep gravity sewers may act as a subsoil drainage system. Generally gravity sewers follow the topography and are laid on grade to the lowest point where a pumping station is traditionally constructed. In order to construct gravity sewers accurately in clayey soils, granular material is used for supporting and surrounding the pipe and in some cases to backfill the entire trench if compaction of clay backfill is not possible.

If the topography of the area is flat and the designer has maximized the depth of the sewers to minimize the number of pumping stations required to service the area, then this network of deep sewers can effectively provide a network of subsoil drains to the area, effectively reducing the ground water table in the process. There are ways to minimize these effects and this involves constructing a series of clay plugs or anti seepage collars at regular intervals along the gravity sewer pipe. This is rarely done and would simply add additional costs to a project without any visible benefits.

Both vacuum and low pressure sewer networks utilize smaller diameter pipework and trenching for vacuum sewers is very shallow whereas pressure sewers are commonly installed via directional drilling. These alternative systems have the ability to minimize short and long term damage to the environment.

3.2 IMPACTS DURING OPERATION

Exfiltration and Infiltration are the two major operational concerns associated with wastewater collection systems in environmentally sensitive areas.

Gravity and Vacuum sewer collection systems are usually operated by the Councils and therefore a certain amount of control is available. However, overflows from a pressure sewer system to some extent rely on the customers to notify the Council, unless every low pressure pump in the system is fitted with a telemetry based alarm. The gravity and vacuum sewer systems are equipped with telemetry alarms and in some cases back up generators to minimize the risk of overflows into the environment.

Telemetry based alarm systems are available for pressure systems however, due to the number of pumping units per development, the cost of installing and maintaining this number of alarm panels means they are seldom specified or installed.

In a gravity sewer system, when ground movement occurs or intentional/accidental damage is caused to the sewer, infiltration, exfiltration or overflows may occur and can go on for long periods of time before the Council is notified (only if it is visible) and repairs are implemented. The recent use of welded PE pipes in gravity sewer systems will have reduced this risk, however the majority of gravity sewers are constructed using other materials with more joints between manholes. Root intrusion into gravity sewer joints are a common sight in CCTV footage.

Pressure sewer systems are considered as sealed systems. The pressure class used in pressure sewer applications is greater than gravity sewers but when a leak occurs it is under pressure and the discharge will tend to be greater as the flow rate is higher. The nature of the pressure sewer system means that all of the pumping units in the system will continue to pump when they are required to until the Council is alerted to the pipe break. If the pipe break and resulting discharge is not visible, there is a risk that the problem may not be identified for some time.

Vacuum sewer systems do not suffer from this issue as the vacuum mains are under a negative pressure so any breakage or leaks occurring in the pipeline will cause infiltration into the pipe not exfiltration into the environment. In addition, the vacuum pumping station will monitor the vacuum in the system and when a constant negative pressure cannot be maintained without the vacuum pumps operating, an alarm is raised for the operator to locate the leak and repair the fault. Vacuum systems are operated differently to pressure sewer systems and gravity systems and operators needs to be appropriately trained.

4 SOCIAL IMPACTS

The installation of any reticulated sewerage system will have a social impact of some sort, be it disruption during construction or the stimulation of growth in the community.

Vacuum and gravity sewerage systems will essentially have the same social impact. The customer will pay a plumber to connect their property to the system and then adopt a flush and forget approach. The real behind the scenes management of the sewerage system will be looked after by the local council.

Low pressure sewer systems on the other hand require a more active involvement on the part of the customer. Typically they will have an input as to where the pump unit is to be installed on the property. The customer will need to provide the power to run the pump unit and they also have a part to play in emergency failures. They may even be advised to “try not to use the system” in the event of an extended power failure.

The social impacts of pressure sewer systems must be factored into consideration when deciding on any reticulation option. A larger amount of consultation and education would be required to ensure that customers are fully aware of their roles in maintaining the systems.

5 RELIABILITY, RISKS AND COSTS

Gravity systems are seen by Councils as easy to maintain and very little preventative maintenance ever takes place. There are however a lot of long term cost issues when dealing with either multiple pumping stations, particularly when they require major upgrades, or when catchments are subject to infill development and the original storage or gravity sewer capacity is exceeded. Long term costs can create significant headaches especially when gravity pipework needs to be enlarged, relined or replaced.

Low pressure sewer systems have been around for approximately 40 years, predominantly in the United States and some US suppliers have claimed the pumps have lasted up to 30 years. The pressure sewer systems installed within Australia are still relatively new with the oldest only 10 years old. So documented long term operational costs and maintenance in Australia are not known.

Vacuum systems have also been around for more than 30 years. In Australia, maintenance frequency and operational costs have been monitored by Sydney Water since 1986. This data has allowed Australian authorities to understand that the long term operational costs of a vacuum system are in fact lower than in gravity systems. The cost of a vacuum sewer systems will vary depending on the location and whether experienced contractors familiar with the technology is available. As there are strict requirements for the construction of the vacuum lines as levels and vacuum losses are critical for the success of any vacuum system.

6 ISSUES FOR SPECIFIC SYSTEMS

As we are all aware there are no ideal reticulation systems out there to solve all our reticulation problems. However, what we do have are a range of solutions which can be utilized or tailored to suit a specific site or situation. Despite all of this there are number of specific issues that need to be addressed with each of the alternative systems mentioned above.

Gravity

- The effectiveness of design modifications such as plastic manholes and continuous welded gravity sewers needs to be documented.
- Other cost and risk reduction incentives must continue to be developed.

Vacuum

- Greater acceptance is required for this technology.
- Strict construction tolerances are required.

Pressure

- Ownership and maintenance of the assets needs to be clear.
- Systems to prevent overflow risk is required.

7 CONCLUSION

All of the abovementioned collection systems have a place as reticulated sewerage systems. It is important to compare like systems in terms of standards of service when comparing capital costs. There is widespread experience with vacuum sewerage and pressure sewer systems available now to enable local network operators to consider alternative collection systems with confidence.