Attachments Ngā Tāpirihanga

There are no attachments to this memo.

0. Draft Plan Change 14: Technical Report on Vacuum Sewer Systems as Qualifying Matter

Reference / Te Tohutoro:	22/660715
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1. Purpose of this Memo

1.1 The draft Housing and Business Choice Plan Change (PC14) process requires technical input from Council business units to inform viable planning provisions.

1.2 The purpose of this memo is for the Water & Wastewater Asset Planning Team to provide technical input on the vacuum sewer systems for the report required under section 32 of the Resource Management Act.

1.3 It describes the Shirley, Aranui and Prestons vacuum sewer systems and outlines why vacuum systems should be included as a Qualifying Matter in the draft PC14.

2. Executive Summary

2.1 Vacuum sewer systems were installed in Shirley and Aranui, by the Stronger Christchurch Infrastructure Rebuild Team (SCIRT) as part of the earthquake rebuild, and in Prestons, by Ngai Tahu, when the greenfield subdivision was developed.

2.2 The systems were designed based on wastewater flows from existing dwellings and from future development using the land zoning and density requirements of the then operative Christchurch City Plan (Living 1 zone: one dwelling per 450 m^2 land parcel).

2.3 The land zoning and density requirements were changed, when the Christchurch District Plan was introduced in 2016, and the vacuum sewer systems are not capable of accommodating further intensification.

2.4 The systems also experience inflow and infiltration during wet weather which is thought to be related largely to faulty private drainage pipes.

2.5 Vacuum sewer systems are complex and are not easily upgraded to provide more capacity. There is no funding in Council's Long Term Plan 2021-31 to resolve the capacity issue.

2.6 It is proposed that vacuum systems be included as a Qualifying Matter in the draft PC14.

3. Background

SCIRT Decision Process

3.1 The wastewater gravity networks in Shirley and Aranui were significantly damaged in the 2010/11 Canterbury earthquakes and the SCIRT was tasked:

3.1.1 To return the infrastructure networks to a condition to meet the levels of service prior to the 4 September 2010 earthquake, within the timing constraints of the rebuild.

3.1.2 Where restoration work was undertaken, and where reasonably possible and economically viable, greater resilience was to be incorporated into the network.

3.2 Only 'like for like' restoration was funded. Betterment, if economically favourable and required for the rebuild, had to be funded by Council.

3.3 SCIRT considered the following options for Shirley and Aranui: gravity system replacement, enhanced gravity system, vacuum sewer system and pressure sewer system.

3.4 These options were evaluated in terms of constructability, resilience, planning / communication, estimated lifecycle costs (capital and operational costs, inflow and infiltration savings, further seismic damage costs).

3.5 In both cases the vacuum sewer system option achieved the highest multi-criteria score and was approved by the SCIRT Scope & Standards Committee.

Vacuum Sewer System Description

3.6 In a conventional gravity wastewater system, private sewer laterals are connected to deep gravity wastewater mains which convey wastewater to the wastewater treatment plant.

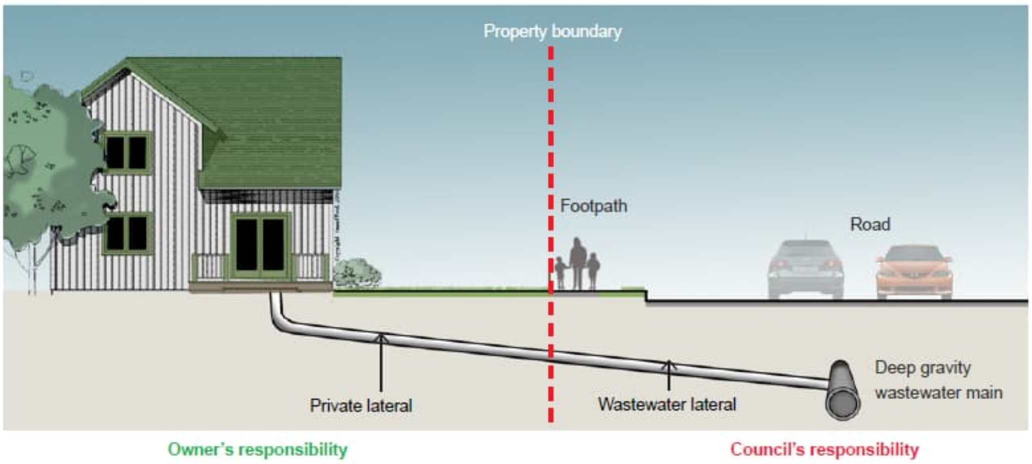


Figure 1: Conventional Gravity Wastewater System

3.7 In a vacuum system, four to six private gravity sewer laterals are connected to a vacuum valve/collection chamber. The vacuum pump station creates a vacuum on the wastewater mains and when a vacuum valve/collection chamber is full, wastewater is sucked out of the chamber and propelled towards the vacuum pump station – illustrated in Figure 3 and Figure 4.

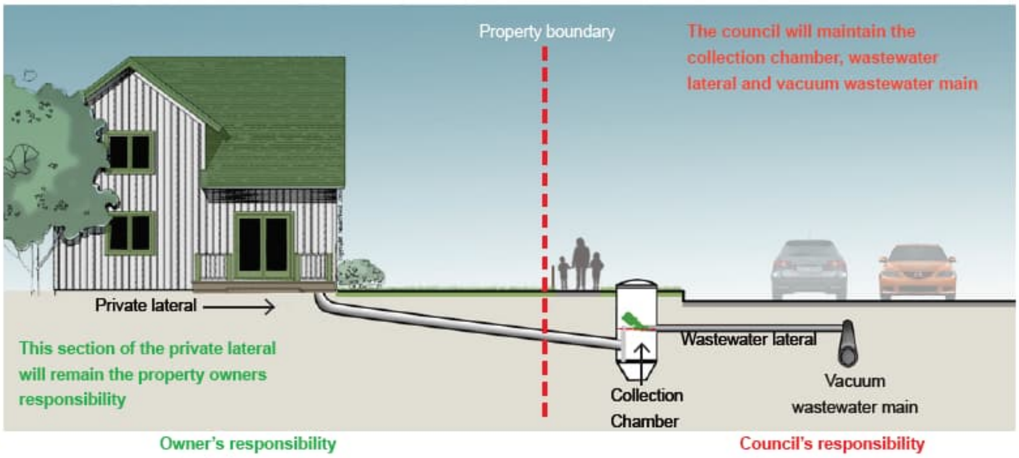


Figure 2: Vacuum Wastewater System

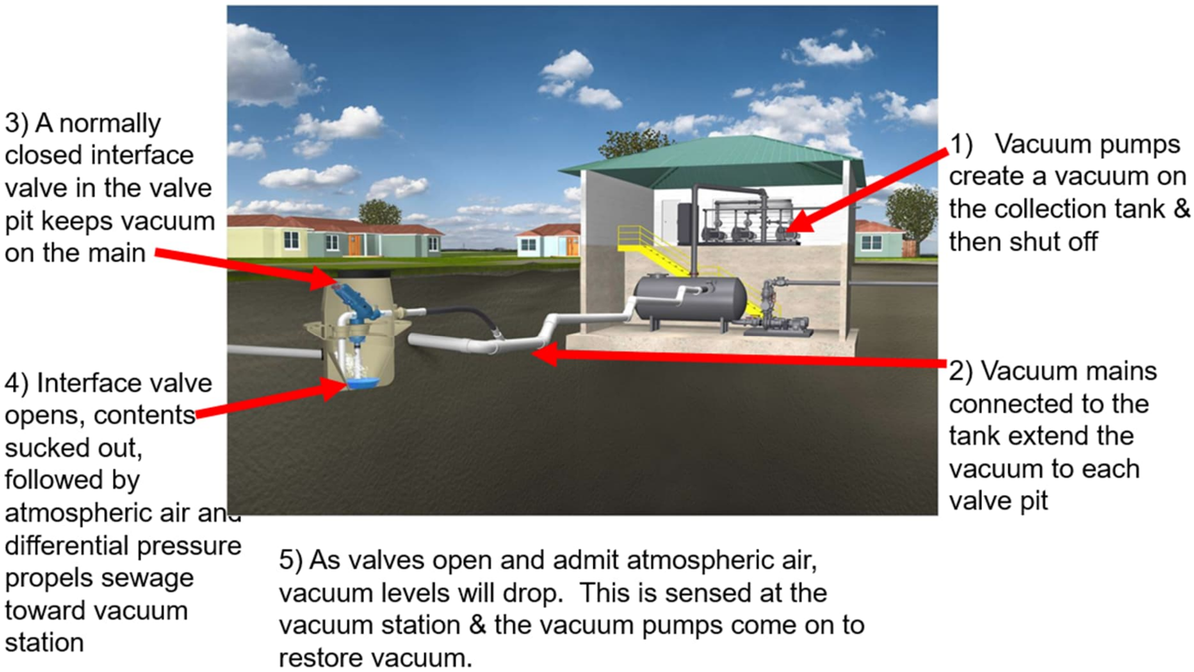


Figure 3: Vacuum Wastewater System Components

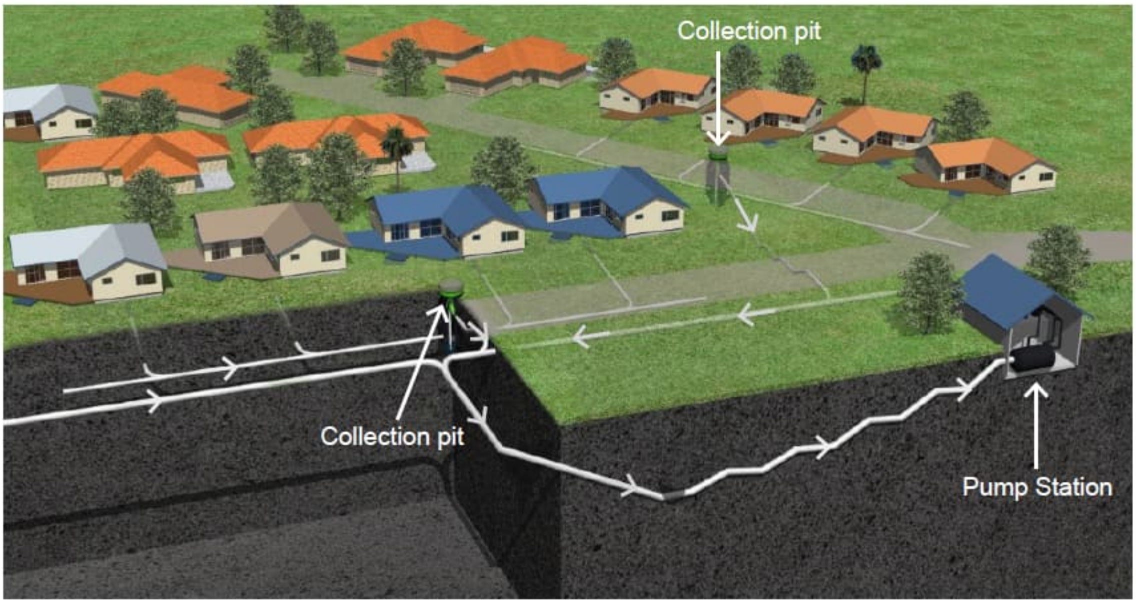


Figure 4: Vacuum Wastewater Network

3.8 The Shirley vacuum system has three vacuum arms (branch systems) and three vacuum mains enter the vacuum station. A single pipe creates the vacuum in all arms. There are 862 properties in the catchment.

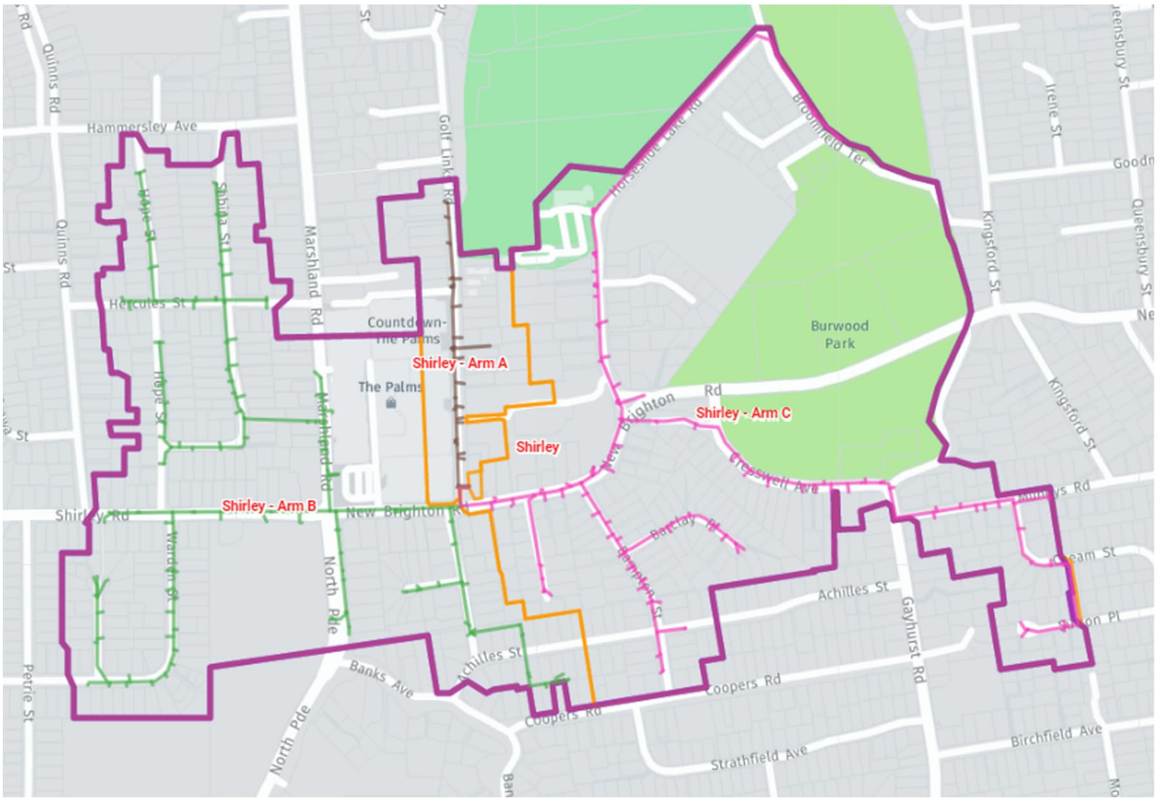


Figure 5: Shirley Vacuum Catchment

3.9 The Aranui and Prestons vacuum systems have six vacuum arms (branch systems) each and six vacuum mains enter the respective vacuum station. A single pipe creates vacuum in each system. There are 2,807 properties in the Aranui catchment and 1,685 (so far) properties in the Prestons catchment.

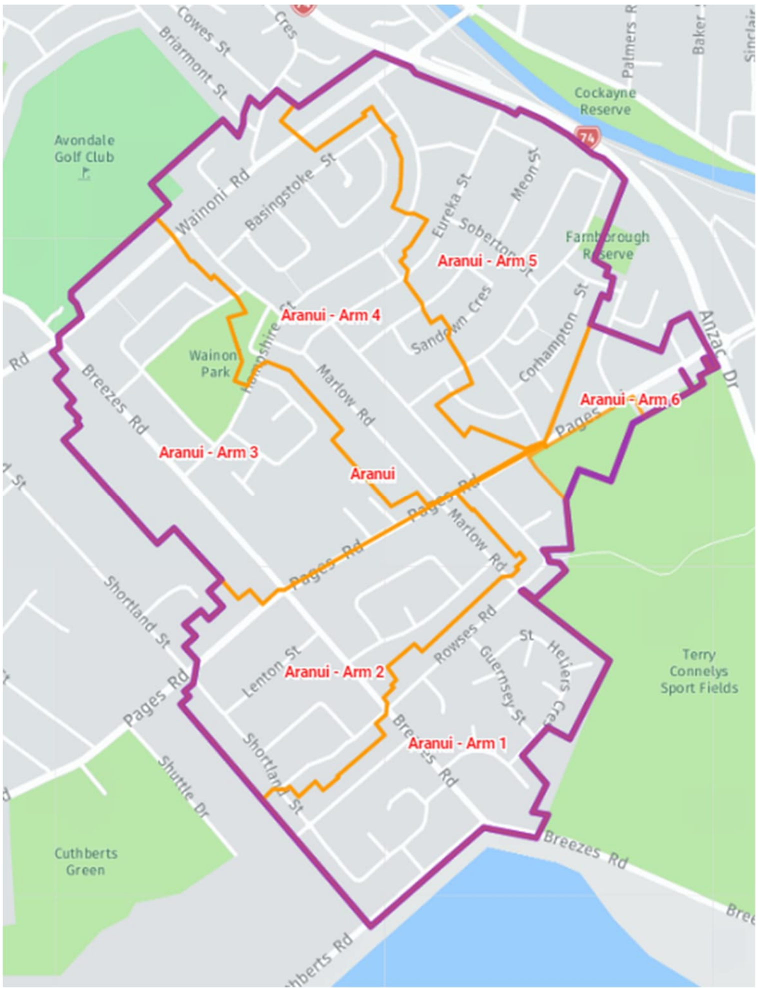


Figure 6: Aranui Vacuum Catchment

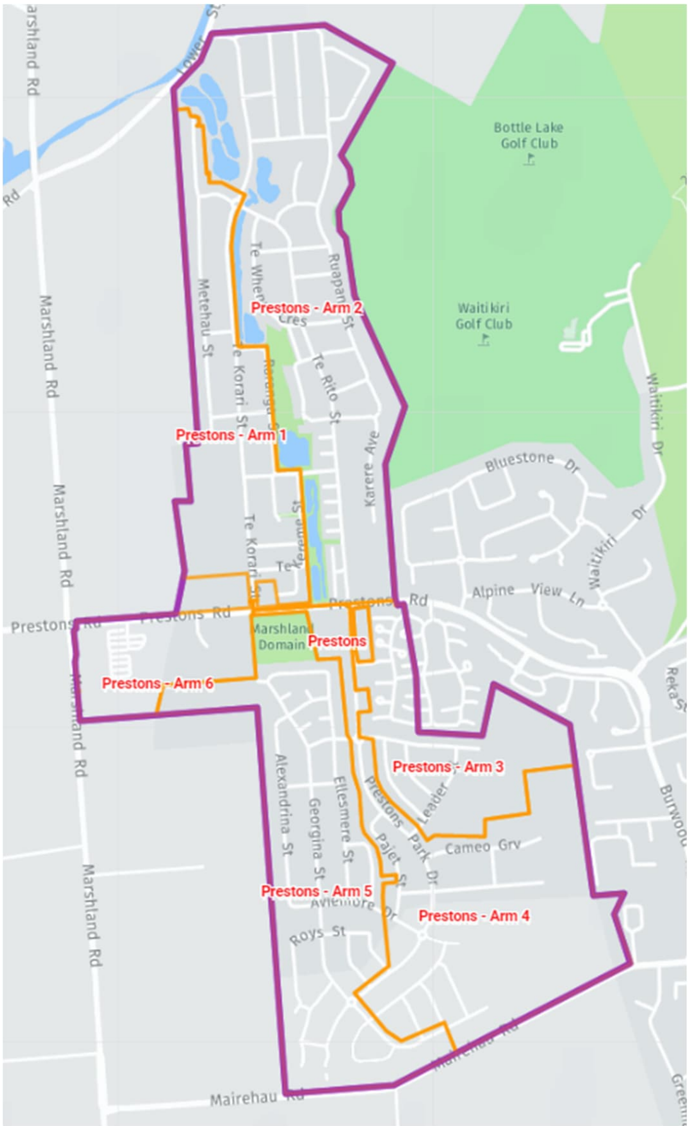


Figure 7: Prestons Vacuum Catchment

4. Vacuum Sewer System Design Capacity

4.1 In the Shirley and Aranui vacuum systems, SCIRT designed the sizes of the vacuum sewer mains and the vacuum pump stations to accommodate flow from existing dwellings and from future development using the land zoning and density requirements of the Christchurch City Plan (Living 1 zone: one dwelling per 450 m^2 land parcel).

4.2 Inflow and infiltration is the process of water, other than wastewater, entering the wastewater system and increasing wet weather flows:

4.2.1 Inflow refers to stormwater entering the wastewater network and occurs mainly through low gully traps and incorrectly connected private stormwater drains.

4.2.2 Infiltration describes the entry of groundwater, including sea-water, into the networks, mainly through faults such as cracked and broken private pipes.

4.3 The design made allowance for a Peak Wet Weather Flow (PWWF) Factor of 2.78. The design PWWF is the factor used to multiply the peak dry weather design flow with to allow for inflow and infiltration. A factor of 2.78 means that 64% of the peak design flow represents inflow and infiltration.

4.4 The Prestons vacuum system is based on similar design parameters with the exception of the storm inflow and infiltration peak factor which was set at 75% of the Shirley and Aranui PWWF factor. It was argued that all private infrastructure would be newly constructed and it was likely that inflow and infiltration would be lower.

4.5 The release of the Land Use Recovery Plan (LURP) resulted in the Christchurch City Plan being replaced by the Christchurch District Plan in 2016. Following information provided in a SCIRT memo in September 2014, approximately 30% of the Shirley vacuum catchment was rezoned from ‘Living 1’ to ‘Residential Medium Density’. Infill development has been occurring over the last few years under the updated density rules, however, the capacity of the vacuum sewer system has not changed. Vacuum sewer systems are not as easily upgraded as a gravity sewer system as all components of the system – including the vacuum pump station – would need to be upgraded at the same time to increase capacity; or an alternative option such as splitting an existing vacuum sewer system or the creation of satellite wastewater storage and pump stations, would need to be implemented.

4.6 The Christchurch District Plan allows for significantly denser infill development than the Christchurch City Plan. For instance in areas zoned ‘Residential Medium Density’, the District Plan specifies a minimum density of 30 dwellings per hectare (one dwelling per 333 m^2 land parcel). Based on consents processed in the previous 12 months, consented densities have ranged between 40 and 135 dwellings per hectare, with the average being 71 dwellings per hectare (average of one dwelling per 141 m^2 land parcel).

4.7 For comparison, the design densities for the vacuum sewer systems range from 11 to 29 dwellings per hectare in Aranui and 10 to 16 dwellings per hectare in Shirley.

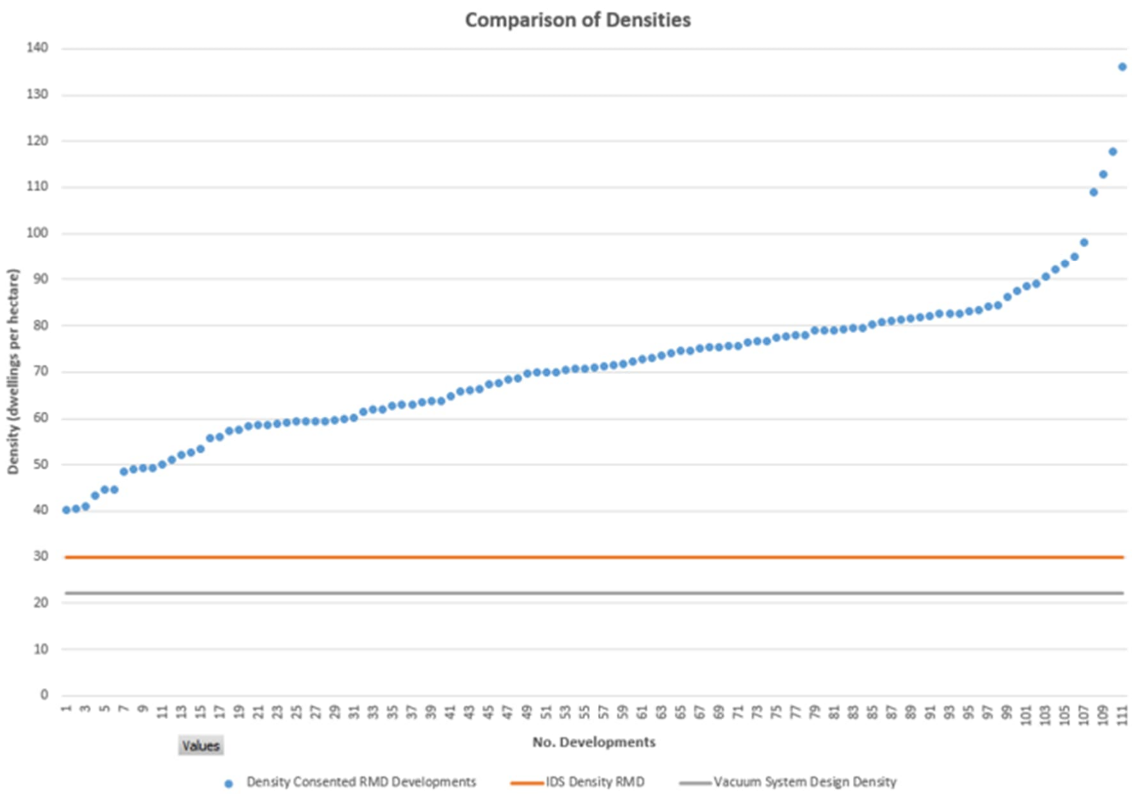


Figure 8: Comparison of consented RMD Developments vs IDS RMD Design Density and Vacuum System Design Density

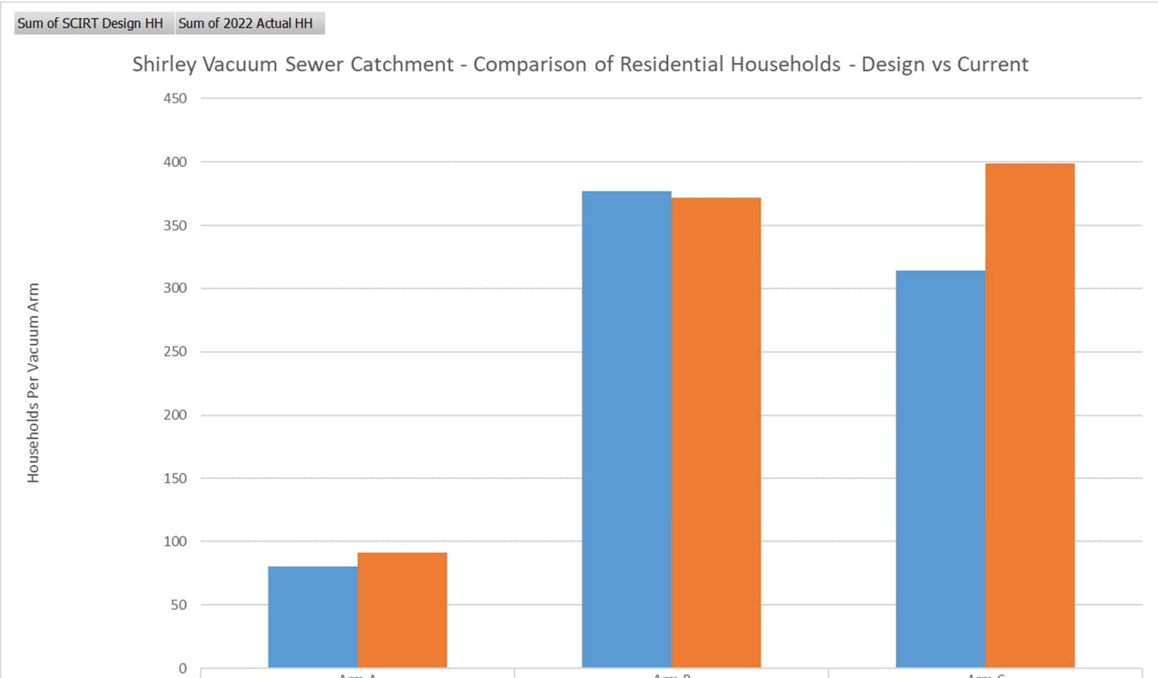
5. Vacuum System Design Capacity and Performance Issues

Current Households Exceed the Design Households

5.1 As outlined in Section 4, SCIRT designed the vacuum sewer catchments to accommodate flow from existing households and from future development using the land zoning and density requirements of the Christchurch City Plan (Living 1 zone: one dwelling per 450 m^2 land parcel).

5.2 Since the current Christchurch District Plan allows for denser infill development than the Christchurch City Plan, consented densities have been significantly higher than the catchments were designed for and therefore the number of households now exceeds the SCIRT design.

5.3 A comparison between the number of households considered in the SCIRT design and the actual number of households shows that in Shirley, two vacuum arms exceed the design and one arm is close to the design, with households ranging between 99% and 127%. In Aranui, the six arms are between 78% and 104% of the SCIRT design.



	Arm A	Arm B	Arm C
Sum of SCIRT Design HH	80	377	314
Sum of 2022 Actual HH	91	372	399

Figure 9: Shirley – Design vs Current Residential Households

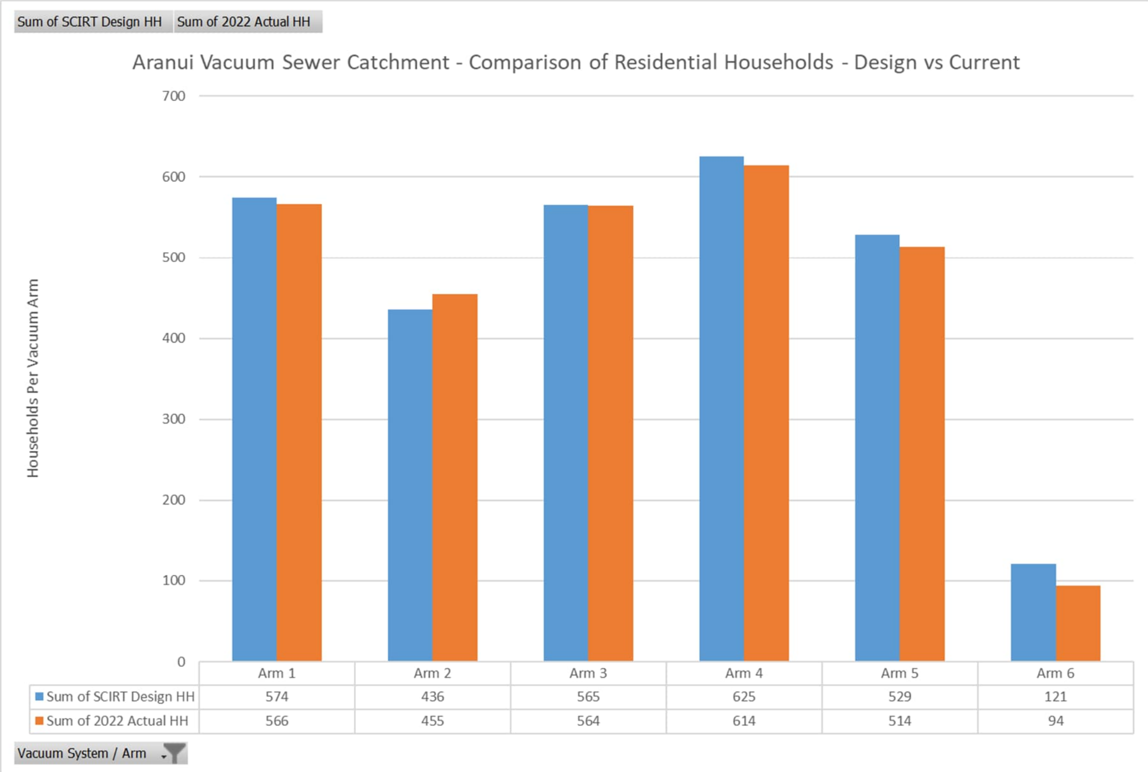


Figure 10: Aranui – Design vs Current Residential Households

Inflow and Infiltration Exceeds the Design Allowance

5.4 The risk of high inflow and infiltration from damaged private property laterals was highlighted in the Shirley and Aranui design phase.

5.5 Staff recommended that only properties that could demonstrate that the private laterals were in good condition should be allowed to connect to the vacuum sewer system. This approach was not supported by Council as it would have left several properties without service.

5.6 Vacuum system performance is dependent on maintaining the balance between air and liquid in the pipes (air-to-liquid ratio). This requires regular checking and setting of individual valve controls and ensuring that the vacuum mains do not become waterlogged.

5.7 Both the Shirley and Aranui vacuum sewer systems experience significant operational issues during wet weather which is an indicator that inflow and infiltration from private property laterals exceeds the design allowance.

5.8 Where flows exceed the design allowance into the collection chamber and through the vacuum valves, the system responds as follows:

5.8.1 The air to liquid ratio in the vacuum main decreases and eventually the mains become waterlogged

5.8.2 The vacuum pressure in the network decreases while the vacuum pumps try to respond by increased pumping times

5.8.3 The entire system performance becomes sluggish and leads to a reduced service or total loss of service in parts of the catchment

5.8.4 This has been experienced in both the Shirley and Aranui catchments and results in entire vacuum branches being closed down on a regular basis.

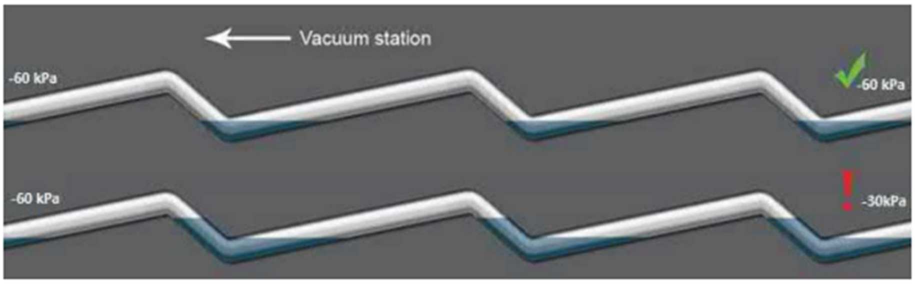


Figure 11: Vacuum Pressure in Pipes Affected by Waterlogging

5.9 Performance issues create a high operational staff presence onsite and it takes many days and sometimes weeks for the systems to recover after a significant wet weather event

5.10 An analysis of recent wet weather performance data has shown that compared to the design PWWF Factor of 2.78, in the Aranui catchment the actual PWWF Factor varied between 1.73 and 6.69 whereas in the Shirley catchment the actual PWWF Factor varied between 3.83 and 6.84. The analysis was carried out on the number of vacuum chamber valve opening events which are an indirect indicator of flow through the chamber. The PWWF data is illustrated in Figures 12 to 14.

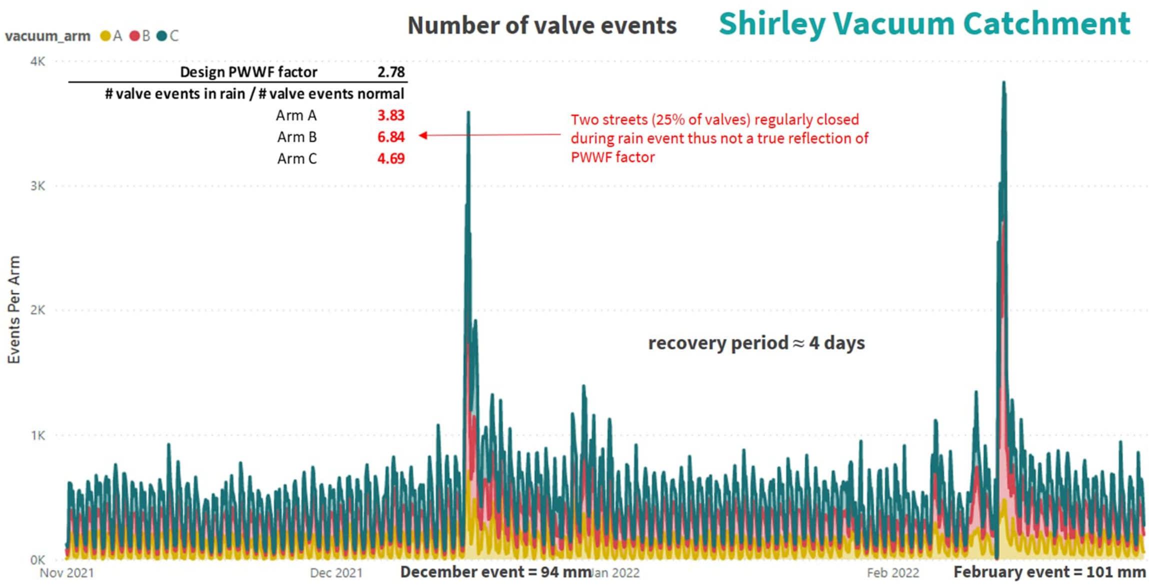


Figure 12: Shirley Vacuum System Wet Weather Performance

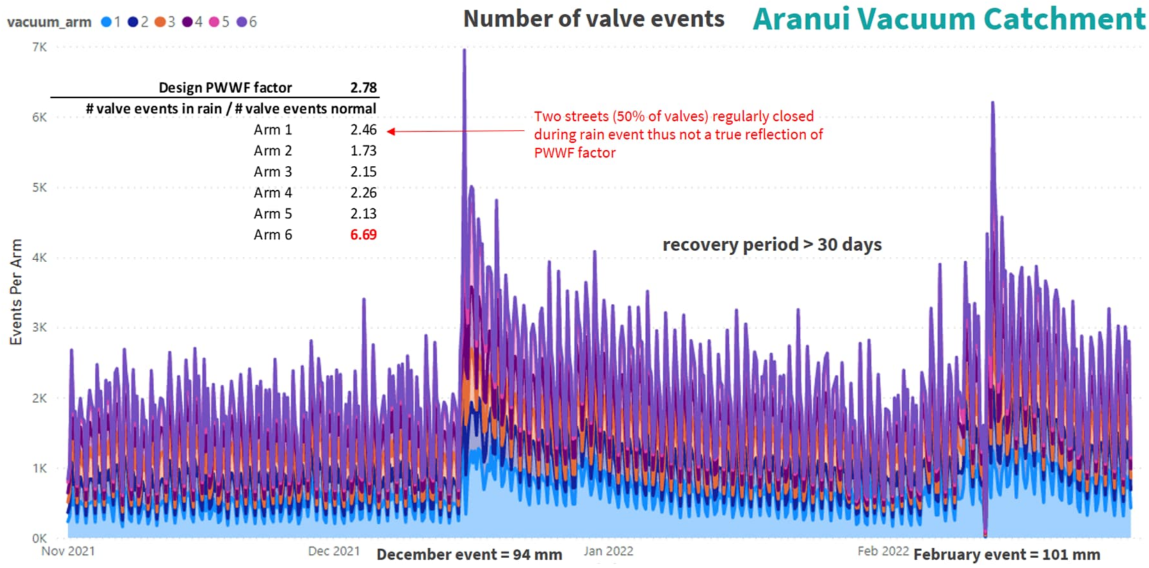


Figure 13: Aranui Vacuum System Wet Weather Performance

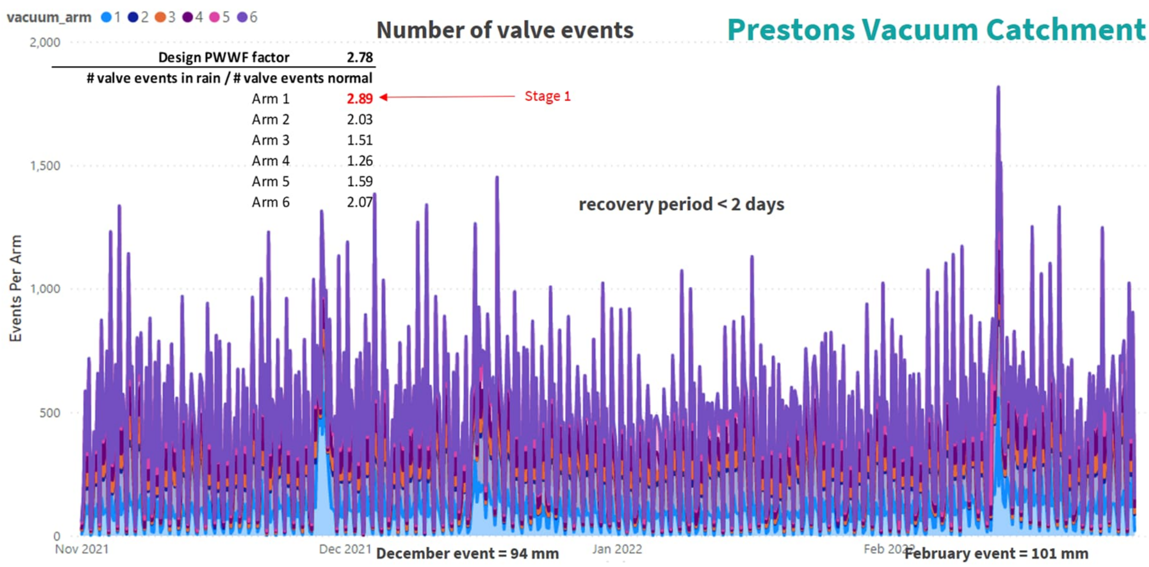


Figure 14: Prestons Vacuum System Wet Weather Performance

5.11 The true PWWF Factors are likely to be even higher since in both catchments some of the worst performing vacuum valve chambers had to be closed down.

Implications of Design Capacity and Performance Issues

5.12 The compounding effect of vacuum arms in the Shirley and Aranui vacuum sewer catchments either exceeding or being close to the SCIRT design capacity as well as significant inflow and infiltration issues have resulted in vacuum sewer pipes in some parts of the branched vacuum networks running at full capacity; while there are people who are still applying or enquiring to develop under current residential zoning provisions of the District Plan.

5.13 Capacity issues and associated drops in vacuum pressure affect the entire vacuum system, and allowing additional development would further exacerbate the issue.

6. Draft Plan Change 14: Housing and Business Choice Plan Change

6.1 The draft PC14 proposes significantly higher development densities across the city.

6.2 Since intensification in line with the existing District Plan provisions is unable to be accommodated due to the existing vacuum sewer capacity constraints, the draft Housing and Business Choice District Plan Change (PC14) has the potential to place an even greater operational burden on the vacuum sewer systems.

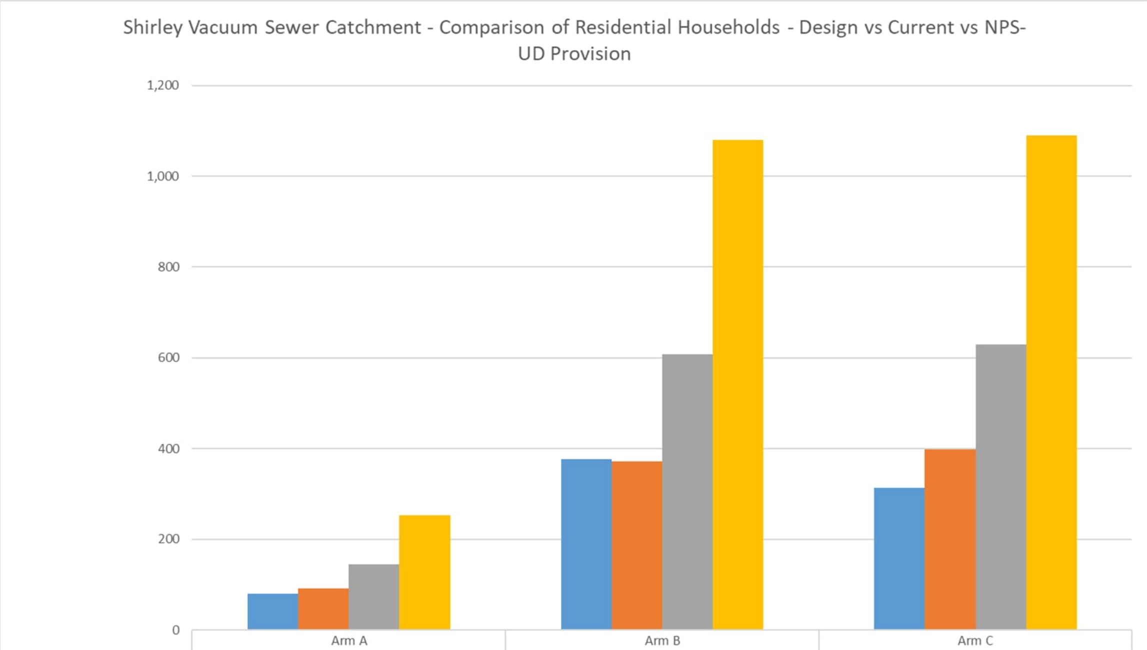
Draft Plan Change 14 Provisions

6.3 Under the Resource Management (Enabling Housing Supply and Other Matters) Amendment Act 2021 (the "Enabling Housing Act"), in most residential areas of the city resource consent will no longer be required to build up to three homes, up to 12 metres high (three storeys, depending on building design), from August 2022. These new rules are called Medium Density Residential Standards (MDRS).

6.4 The National Policy Statement on Urban Development 2020 (NPS-UD) requires even greater building development – both residential and commercial – to be allowed within and around the central city, suburban commercial centres and planned high frequency and capacity public transport.

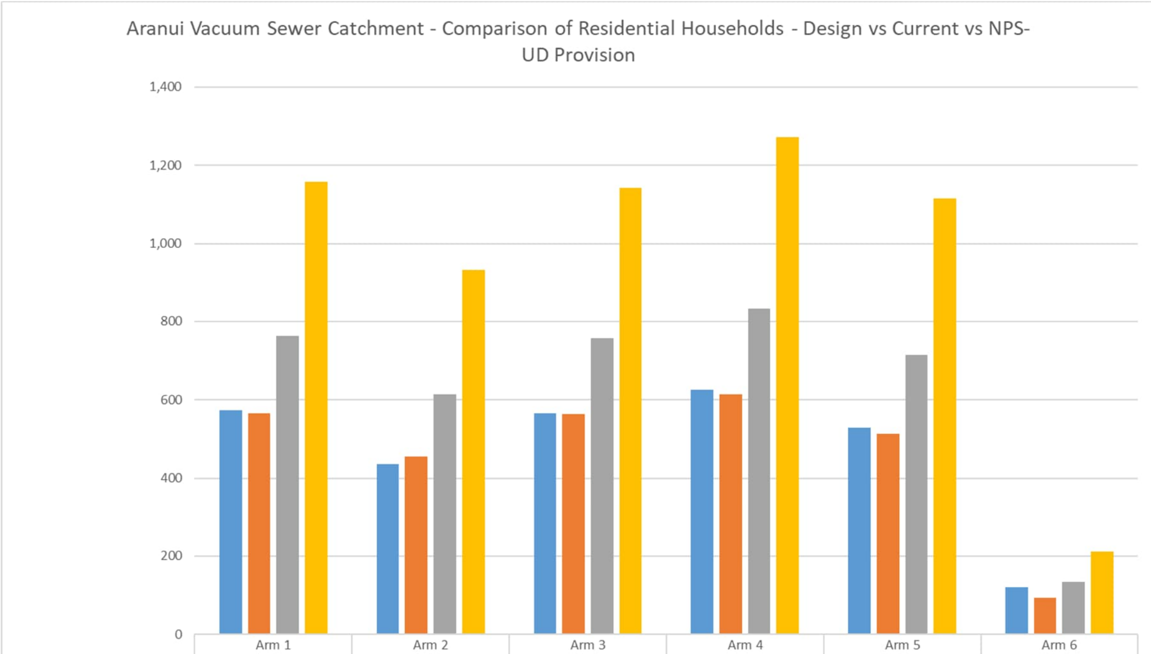
6.5 Council City Planners expect that intensification would allow up to 100 dwellings per hectare in the proposed 'Medium Density Residential' zone and up to 200 dwellings per hectare in the proposed 'High Density Residential' zone.

6.6 Enabling NPS-UD intensification in the vacuum sewer catchments would place additional significant demand on a system that is already at or near its design capacity. The effects on household numbers based on 10% or 30% uptake of the NPS-UD intensification is illustrated in the two figures below.



	Arm A	Arm B	Arm C
SCIRT Design HH	80	377	314
2022 Actual HH	91	372	399
NPS-UD HH - 10% Uptake	145	608	629
NPS-UD HH - 30% Uptake	252	1,080	1,090

Figure 15: Shirley – Design vs Current vs NPS-UD Households



	Arm 1	Arm 2	Arm 3	Arm 4	Arm 5	Arm 6
SCIRT Design HH	574	436	565	625	529	121
2022 Actual HH	566	455	564	614	514	94
NPS-UD HH - 10% Uptake	764	614	757	833	714	133
NPS-UD HH - 30% Uptake	1,159	932	1,142	1,272	1,115	212

Figure 16: Aranui – Design vs Current vs NPS-UD Households

Vacuum Sewer Systems as Qualifying Matter

6.7 Vacuum sewer system catchments are not suitable for the level of increased development that is enabled by the Enabling Housing Act and need to be excluded from the rules enabling increased development.

6.8 While some improvements can be implemented to enhance vacuum system performance and provide some extra capacity, the vacuum systems are constrained by the size and number of vacuum mains and the pump capacities of the vacuum pump stations.

6.9 Due to the existing wastewater system constraints in the Shirley, Aranui and Prestons vacuum sewer catchments the draft PC14 proposes that these areas be listed as Qualifying Matters and be exempt with reduced densities of housing.

6.10 Draft PC14 recommends that these areas should not be targeted for Medium Density Residential Zone or High Density Residential Zone (around The Palms Town Centre) intensification and proposes the following development instead:

6.10.1 Development within the Shirley and Aranui vacuum catchments would need to retain current density and be restricted to ‘like for like’ development.

6.10.2 Development within the Prestons vacuum catchment would need to be aligned with the existing Prestons vacuum sewer masterplan.

7. Improving Vacuum Sewer System Capacity and Performance

Improvements Already Implemented

7.1 The Council has already implemented several improvements that enhance the operation of the vacuum sewer networks.

7.2 Vacuum sewer system monitoring: installation of 1,494 vacuum monitoring devices plus dashboard (cost $1.7 million) which allow for the identification of vacuum chambers with unusually high numbers of valve events, and are therefore susceptible to inflow and infiltration or other operational issues, and targeted remedial actions.

7.3 Automatic air inlet systems (AAIS): installation of 13 automatic air inlet systems (cost $0.91 million) at the upstream end of vacuum arms that are prone to waterlogging. The AAIS detect low vacuum within a vacuum main and allow additional air to be introduced into the system to reduce the risk of vacuum loss. However, while the AAIS will reduce the risk of waterlogging during wet weather, the introduction of additional air may reduce the vacuum pumps' ability to handle the maximum flow.

7.4 Draft Water Supply and Wastewater 2022 Bylaw: Clause 32 strengthens the Council's rights in terms of the Local Government Act 1974 which will greatly improve the process of getting cooperation from property owners to repair faulty and leaky private drainage pipes.

32 MAINTENANCE OF PRIVATE WASTEWATER DRAINS

(1) The customer owns the private wastewater drains within the customer's property and on the customer's side of the point of discharge, and is responsible for all repairs and associated costs.

Explanatory note: *The Council owns and is responsible for maintenance of the public wastewater system including the pipe and the fittings from the point of discharge.*

(2) Private wastewater drains must be maintained in a state which is free from cracks and other defects which may allow infiltration, leakage, or cause blockages.

(3) If the Council believes that wastewater drains on private property are deficient, damaged, blocked, receiving excessive inflow and infiltration, are leaking, or are otherwise not in a satisfactory operating state; the Council may require the property owner to investigate the drain and rectify any issues, at the owner's cost.

Explanatory note: *Wastewater leaching from substandard drains can cause public health or environmental health issues (such as contaminating groundwater, producing a foul odour or attracting flies). Stormwater, groundwater, tree roots, sediment and other contaminants can enter the public wastewater system from cracks and damage in private wastewater drains, and overload or block the public wastewater system, or cause damage to the system or its machinery.*

(4) Where the Council requires a property owner to investigate and rectify any issues, a property owner must:

(a) Engage a suitably qualified person to undertake a camera investigation (or other agreed method of investigation) of the drain, and prepare a report on the findings; and
(b) Submit the report to the Council on the condition of the drains, prepared by a registered drainlayer, that includes either an appropriate repair strategy, or confirmation that the drain is in a satisfactory operating state (ie: contains no cracks, substandard joins, tree roots or other signs of blockage); and
(c) If repairs or replacements are necessary to fulfil the repair strategy, the property owner must demonstrate, to the Council's satisfaction that the repairs or replacements have occurred.

(5) Where the Council requires a property owner to investigate and rectify a drain under subclauses (3) and (4), the investigation and any repairs or replacements must be completed within timeframes as specified or agreed by the Council.

Explanatory note: *The requirements of this bylaw do not limit the Council from taking action under section 459 of the Local Government Act 1974.*

Figure 17: Draft Water Supply and Wastewater 2022 Bylaw, Clause 32

Potential Future Improvements

7.5 Use the Water Supply and Wastewater 2022 Bylaw to require properties identified as high inflow and infiltration contributors to inspect their drains and repair if found faulty (additional resources required to manage).

7.6 Expand the Vacuum Sewer Monitoring System functionality (in progress) to:

- Monitor pressure at ends of vacuum mains and integrate into vacuum monitoring dashboard
- Enable remote control of the AAIS and integration into the vacuum monitoring dashboard.

7.7 Seal vacuum chambers to reduce inflow and infiltration into the chambers (surface flooding, etc.) – additional funding required.

7.8 Large-scale upgrade of the vacuum systems which could comprise options such as providing large wastewater storage facilities from which wastewater would be pumped directly into neighbouring catchments, or dividing existing catchments and building new vacuum pump stations.

7.9 Potential upgrade options include: large-scale duplication of vacuum mains together with vacuum pump upgrades; splitting of existing vacuum sewer catchments and constructing new vacuum pump stations; creating satellite vacuum wastewater collection and storage facilities with alternative wastewater outfalls into neighbouring wastewater catchments.

7.10 Detailed cost estimates are not yet available as they will vary markedly between the different upgrade options and the expected household densities and associated wastewater flows.

7.11 Non-engineered, rough cost estimates for different capacity scenarios and expected household densities in development areas are as follows:

I&I Strategy	50% private I&I reduction		No private I&I reduction	
Development Density	70 HH/ha	100 HH/ha	70 HH/ha	100 HH/ha
Required Capacity	Capacity x3	Capacity x4	Capacity x5	Capacity x8
Rough Cost	≈ $35 million	≈ $50 million	≈ $60 million	≈ $100 million

Figure 18: Shirley: Non-engineered Cost Estimates

I&I Strategy	50% private I&I reduction		No private I&I reduction	
Development Density	70 HH/ha	100 HH/ha	70 HH/ha	100 HH/ha
Required Capacity	Capacity x2	Capacity x3	Capacity x5	Capacity x7
Rough Cost	≈ $75 million	≈ $115 million	≈ $200 million	≈ $280 million

Figure 19: Aranui: Non-engineered Cost Estimates

7.12 It needs to be borne in mind that the expected PC14 densities in MRZ and HRZ areas are likely to be much higher than the 70 households/hectare and 100 households/hectare used in the non-engineered cost estimates and therefore the actual costs much higher as well.

8. Alternative Options and Controls to Manage the Constraints

8.1 This section discusses whether there are viable alternative options and controls to manage the infrastructure constraints in the Shirley, Aranui and Prestons catchments.

8.2 On-site wastewater systems: the introduction of on-site wastewater systems that are commonly used in rural areas would not be a permitted activity in an urban environment as they would not meet the Canterbury Land and Water Regional Plan with respect to the following conditions contained within Rule 5.8:

- The discharge is not located within an area where residential density exceeds 1.5 dwellings per hectare and the total population is greater than 1000 persons;
- The discharge is not onto or into land where there is an available sewerage network.

8.3 Conventional local pressure sewer systems with tanks located on private property: the following factors make local pressure sewer systems unsuitable for a large scale rollout or as a full vacuum sewer system replacement.

- A local pressure sewer system cannot directly connect into a vacuum sewer system.
- While a local pressure sewer system might be a viable option for diverting a discrete area of the vacuum sewer catchment into the neighbouring gravity catchment under special circumstances (e.g. to divert a commercial area) there is insufficient capacity in neighbouring catchments for pressure sewer systems to divert the full proposed additional MRZ and HRZ development flows.
- Local pressure sewer systems have a higher initial capital costs and a higher life cycle cost. There can be issues with accessing Council infrastructure on private property for ongoing maintenance (as observed in greenfield local pressure sewer systems) and Council infrastructure located on private property is susceptible to abuse or misuse.
- Works on private property require property owner consent and obtaining property owner agreement on the location of the pump chamber and implementing the necessary legal arrangements for the vesting of the local pressure sewer infrastructure on private property is a complex administrative task.
- Property owners have concerns regarding the aesthetic nature of the pressure sewer tanks on private property.
- Construction on private property with existing houses is a complex undertaking with many constraints.

8.4 Local pressure sewer systems with tanks located on Council land (footpath or berm): while this option would eliminate the issue of obtaining property owner agreement and legal arrangements, it is not a viable option as there is no space available in an existing urban environment to install a tank in the footpath or berm outside each house; as the tanks would have to compete with other services such as water supply, power and telecommunications.

8.5 Install wastewater gravity networks: this option was also considered by SCIRT but was assessed as being too expensive and not providing sufficient resilience for future earthquakes.

9. Lost Development in Vacuum Sewer Catchments

9.1 In order to assess the impacts of including vacuum sewer systems as a Qualifying Matter in PC14, an assessment of current versus PC14 medium or high density development must be undertaken, using a location specific approach. Assuming a development uptake between 10% and 30%, lost development is assumed to be between 520 and 1,561 households in Shirley and 1,008 and 3,024 households in Aranui, as shown in Figure 20 and Figure 21.

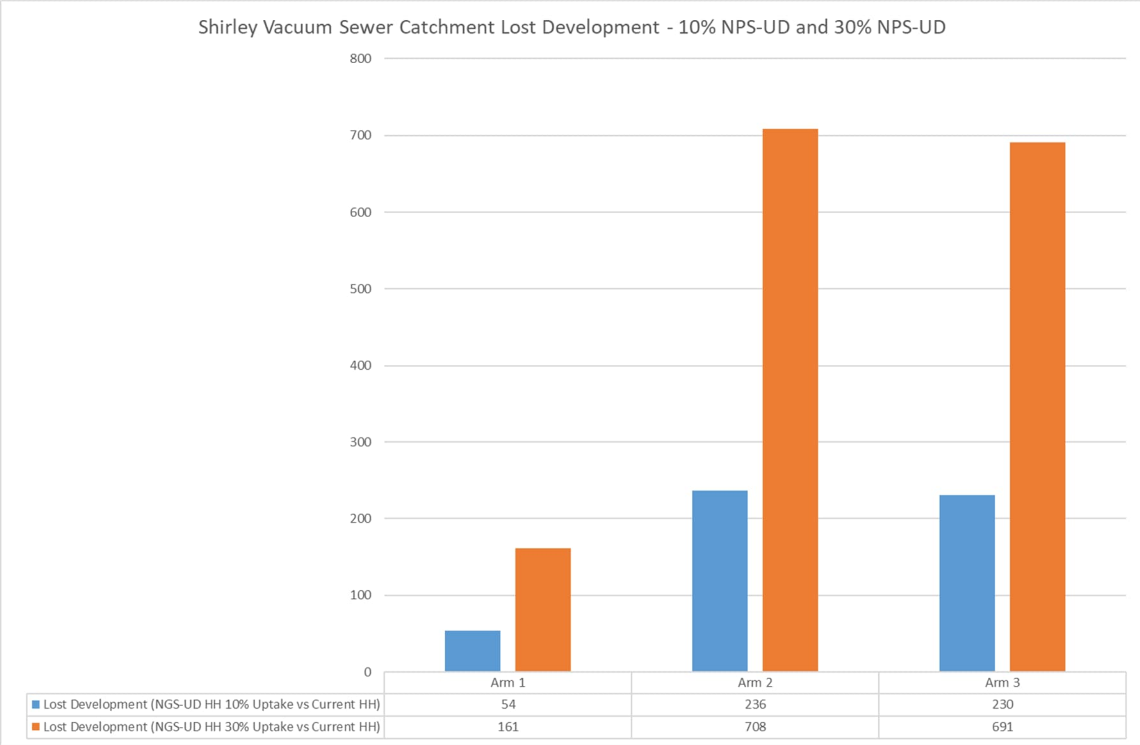


Figure 20: Shirley – Lost Development

Figure 21: Aranui – Lost Development

10. Conclusion

10.1 Due to the vacuum sewer design capacity constraints and associated negative environmental outcomes outlined in this report, vacuum sewer catchments should be included as a Qualifying Matter in the draft PC14.

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Signatories / Ngā Kaiwaitohu

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