BEFORE INDEPENDENT HEARING COMMISSIONERS
IN CHRISTCHURCH

TE MAHERE Ā-ROHE I TŪTOHUA MŌ TE TĀONE O ŌTAUTAHI

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of the hearing of submissions on Plan Change 14 (Housing and Business Choice) to the Christchurch District Plan

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STATEMENT OF PRIMARY EVIDENCE OF MICHELE ANN MCDONALD ON BEHALF OF CHRISTCHURCH CITY COUNCIL

WATER AND WASTEWATER, INCLUDING LOW PUBLIC TRANSPORT ACCESSABILITY

Dated: 11 August 2023

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EXECUTIVE SUMMARY

1. My full name is **Michele Ann McDonald**. I am employed as team leader – asset planning water and wastewater at Christchurch City Council (the **Council**).

2. I have prepared this statement of evidence on behalf of the Council in respect of my input into, and matters arising from the submissions and further submissions on Plan Change 14 to the Christchurch District Plan (the **District Plan**; **PC14**).

3. My evidence is specific to the expected impact of PC14 on the future demand planning for water and wastewater infrastructure and the low public transport accessibility qualifying matter that will focus intensification in areas that will also enable the delivery of cost-effective infrastructure.

4. It is my opinion that:

   (a) The rightsizing of infrastructure will become extremely difficult when Medium Density Residential Standards (**MDRS**) design standards are enabled throughout the city. This may result in the oversizing of infrastructure in some parts of the city and the need for reactive upgrades in other parts. My evidence outlines why both these outcomes will have a negative impact on the cost-effectiveness of water and wastewater infrastructure.

   (b) The capacity of vacuum sewer systems must be managed with more care than other wastewater systems. This is because of the integrated and interdependent nature of these systems, where wastewater from up to 6 residential units flows into a communal vacuum valve chamber to be transported via suction along a network of vacuum pipes to a central pump station. Due to the absolute reliance on maintaining a positive air to liquid ratio to move wastewater through the system, flow that exceeds the design capacity has a direct impact on the operation of the vacuum sewer system and, if left unattended, will cause a system collapse.

   (c) No capacity provision was made to accommodate MDRS intensification in the Council's vacuum sewer catchments. The vacuum sewer systems in Aranui, Shirley and Prestons will not be able to support the MDRS density standard and the implementation of MDRS density standards in certain parts of the vacuum sewer catchments will result in the loss of service and will create a critical risk to public health.

(d) To enable MDRS design standards in the vacuum sewer catchments will require enough capacity to have been created to allow all properties to develop at MDRS density standards. This would mean that the existing vacuum sewer systems will have to be duplicated or replaced because the upgrade of some components only will not alleviate the capacity constraints nor provide the capacity to serve MDRS design standards in any part of the system.

(e) Significant infrastructure planning and funding will be needed to provide capacity in the vacuum sewer catchments to enable development at MDRS design standards. By considering the additional capacity that would be needed and by applying cost in relation to the replacement value of the existing systems, a capital investment of up to $240 million may be needed to service 25,000 additional residential units (or $10,000 per new unit). This estimate does not include the additional capital that would be needed to upgrade capacity in the downstream catchments and which is not quantifiable until engineering designs have been completed.

(f) Because of this and considering the existing capacity constraints that have a direct impact on the performance of the vacuum sewer systems, vacuum sewer capacity constraints should be included as a Qualifying Matter in PC14.

(g) The objectives of the low public transport accessibility areas qualifying matter (to focus development to specific areas near high frequency bus routes) aligns well with the principles of efficient and cost-effective infrastructure development, but I also consider that additional, focused spatial development will further enable this.

INTRODUCTION

5. My full name is **Michele Ann McDonald.** I am employed by the Council in the role of Team Leader: Asset Planning – Water and Wastewater and have held this position since March 2019 (seconded up to September 2020 and permanent as of February 2021). I am responsible to provide leadership and technical expertise to Council's water and wastewater infrastructure growth and development planning processes. Part of my responsibility is to

inform Council's long-term plan with respect to the funding required for new infrastructure to accommodate growth.

6. As part of my role at the Council, I have been asked to provide technical advice on the capacity of Council's water and wastewater infrastructure considering PC14. In March 2022, I briefed Council on Vacuum Sewer System Capacity Constraints. I also contributed to the development of the Technical Report on Vacuum Sewer Systems as Qualifying Matters[1] (Appendix 33 to Part 2 of the section 32 report) and co-wrote the Three Waters Memo[2] (Appendix 46 to Part 2 of the section 32 report) on the merits of the low public transport accessibility qualifying matter in the context of water and wastewater infrastructure.

7. In preparing this evidence I have:

   (a) Read the parts of Council's s32 Qualifying Matters Evaluation Report that dealt with the vacuum sewer constraint and low public transport accessibility areas.

   (b) Drawn on my involvement in compiling the Technical Report on Vacuum Sewer Systems as Qualifying Matters (Part 2, Appendix 33) and the Memo on the Three Waters perspective on proposed qualifying matter to focus intensification within 800 metres of public transport routes.

   (c) Reviewed a summary of key themes of submissions.

8. I am authorised to provide this evidence on behalf of the Council.

QUALIFICATIONS AND EXPERIENCE

9. I hold a Bachelor of Science degree in Civil Engineering and an additional Bachelor of Science Honours degree in Urban Engineering, both attained from the University of Pretoria, South Africa.

10. I have over 30 years' experience as a civil engineer specialising in water and wastewater planning and delivery. I started working at the Council in January 2017 in the role of Senior Planning Engineer for the Asset Planning: Water and Wastewater team. Over the course of my career, I

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[1] https://www.ccc.govt.nz/assets/Documents/The-Council/Plans-Strategies-Policies-Bylaws/Plans/district-plan/Proposed-changes/2023/PC14/Section-32-Appendices-1/PC14-Qualifying-Matters-Technical-Memo-on-Vacuum-Sewer-Systems-as-Qualifying-Matter.PDF.

[2] https://www.ccc.govt.nz/assets/Documents/The-Council/Plans-Strategies-Policies-Bylaws/Plans/district-plan/Proposed-changes/2023/PC14/Section-32-Appendices-1/PC14-QM-s32-Low-Public-Transport-Accessibility-Areas-Three-Waters-Memo-s32-Appendix-46.PDF.

have been responsible for several water and wastewater infrastructure development plans for cities and large metropolitan areas.

11. I am a registered professional engineer in South Africa and a Chartered Member of Engineering New Zealand.

CODE OF CONDUCT

12. While this is a Council hearing, I have read the Code of Conduct for Expert Witnesses (contained in the 2023 Practice Note) and agree to comply with it. Except where I state I rely on the evidence of another person, I confirm that the issues addressed in this statement of evidence are within my area of expertise, and I have not omitted to consider material facts known to me that might alter or detract from my expressed opinions.

13. I confirm that, while I am employed by the Council, the Council has agreed to me providing this evidence in accordance with the Code of Conduct.

SCOPE OF EVIDENCE

14. My statement of evidence addresses the following matters:

    (a) Water and wastewater planning considerations; and

    (b) Vacuum Sewer Capacity Constraints Qualifying Matter and responses to submissions on this matter; and

    (c) Low Public Transport Accessibility Area Qualifying Matter and responses to submissions on this matter.

15. I address each of these points in my evidence below.

WATER AND WASTEWATER PLANNING CONSIDERATIONS

Introduction

16. The Council operates diverse types of wastewater systems that respond differently when capacity is exceeded, as explained below:

    (a) <u>Gravity systems:</u> Council's Infrastructure Design Standards (**IDS**) specify that gravity pipes must be designed with enough capacity so that the maximum flow expected from a development will not exceed 70% of the capacity of the pipe. This is to make provision for some future intensification and the deterioration of the sewer system that causes increased inflow and infiltration over time. If intensification causes the full flow capacity of a gravity pipe to be exceeded, surcharge of the pipe occurs and this will eventually result in wastewater overflows from manholes onto streets and can also cause wastewater spillages onto private properties. Council owns and operates more than 1,600 kilometres of gravity wastewater pipes including about 29,000 manholes that collects wastewater from more than 1,000 kilometres of wastewater laterals (the gravity pipes from each property to the main).

(b) Pump systems: Council pump stations have been sized to service the maximum expected future flow from its catchment area at the developed density. Pressure mains are sized to match the capacity of the pump station. If the flow into a pump station exceeds the capacity of the pump station, then wastewater overflows at constructed sewer outfalls (as built in accordance with the IDS and Council's Wet Weather Overflow Discharge Consent) into stormwater channels and rivers. If due to intensification, a pump station must be upgraded to deliver a higher demand, then it can also mean that the size of the pressurised main pipeline would need to be upgraded. Council operates over 150 sewer pump stations with their associated pressurised pipeline networks.

(c) Vacuum sewer systems: The Shirley and Aranui vacuum systems were sized to service the properties that were present prior to the earthquake with limited provision for larger sites to be subdivided. The Prestons vacuum sewer system was sized to service the number of properties enabled by the development. If due to intensification, capacity is exceeded in any part of a vacuum sewer system, the entire system and all properties connected to the system, will be impacted by a reduced ability to convey wastewater and which could lead to a total system failure. This will cause wastewater to accumulate in vacuum chambers and upstream sewer laterals and can lead to the eventual spillage of wastewater onto private property. For a vacuum sewer system, this means that the capacity of each vacuum chamber, vacuum pipe and the vacuum pump station must be managed both independently and collectively. Council owns and operates three vacuums sewer systems comprising approximately 4,400 vacuum chambers, 64 kilometres of vacuum pipes and 3 separate vacuum stations.

(d) Local pressure pumping systems: Individual properties are serviced by on-site pressure pumps and chambers that are sized to provide a 24-hour storage capacity to avoid spillages in the case of power failures. Intensification would trigger the need for increased storage as well as additional pumps. Full deployment of MDRS design standards may not leave enough space to provide the additional storage that would be needed. Local pressure pipes that convey wastewater from the properties are sized to align with the number of pumps in the service area. If the number of pumps increases due to intensification, then at a certain point, the size of the local pressure pipe will also have to be increased. However, for greenfield areas, Council has implemented smart local pressure sewer systems, which mean that some intensification can be accommodated because Council will have the ability to control when the pumps operate, to reduce the peak flow. This will only be possible up to a certain point and full MDRS enablement may require pressure pipe upgrades. Council owns and operates more than 2,000 smart local pressure sewer pumps.

17. Water and wastewater infrastructure have a minimum life period of 50 years. For pipes, buildings and reservoirs, the life period must be 100 years. The rightsizing of infrastructure is therefore especially important to ensure the best utilisation of infrastructure over its life period.

18. Infrastructure capacity becomes constrained when growth exceeds the allowance made or due to other reasons such as higher inflow and infiltration. Whereas gravity systems or local pressure sewer systems, by virtue of its design, has some inherent provision for intensification, this is not the case for vacuum sewer systems. As also outlined above, different systems react differently when capacity is exceeded. In the case of gravity systems serviced by pump stations, when capacity is exceeded, wastewater will still be conveyed, and the excess wastewater will be spilled at manholes or at constructed sewer outfalls. For vacuum sewer systems, when the capacity is exceeded and vacuum is lost, then no wastewater will be conveyed and there is no alternative route for wastewater to be discharged away from the system. For local pressure sewer systems, if the capacity of a pressure sewer main is exceeded, some pumps may 'cut out' i.e., fail to operate. Pumps will automatically re-start until after 10 failed

attempts, the pump will be locked out and an alarm raised. A spillage onto private property will only occur if storage has been breached.

19. When a pipe (gravity or pressure and water or wastewater) reaches capacity, it must be replaced with a bigger pipe. It is not always feasible to duplicate pipes to increase capacity, because of space constraints and to avoid duplicate operations and maintenance costs (example, a duplicate pipe will lead to duplicate valves needing to be maintained). If a pipe is replaced but has not reached its end-of-life period, the remaining book value of the pipe is written off, effectively resulting in a capital loss.

20. In my experience and setting aside the cost of installing significantly greater infrastructure when potential use is uncertain, not all infrastructure can be successfully sized to service a future demand that far exceeds the existing demand (for example to make provision for the maximum intensification that could potentially occur in the service area). This is because water and wastewater infrastructure must be operated at a minimum flow demand to remain functional. The engineering design of infrastructure must comply with minimum demand criteria, that if not achieved, will result in non-functional infrastructure. An example is that the wastewater flow down a gravity pipe may be less than the minimum flow needed to enable a continuous and self-cleansing gravity flow and would result in high retention times, causing both blockages and extreme odour issues.

Water and wastewater infrastructure planning processes

21. Water and wastewater infrastructure plans are based on a minimum 50-year planning horizon. Due to the large capital investment and long lead times needed to construct water and wastewater infrastructure, infrastructure plans aim to achieve the right sizing of infrastructure that is meant to last for up to 100 years.

22. The infrastructure plans are used to inform Council's long-term plan. Although the sizing of infrastructure is reviewed on a project-by-project basis, funding decisions are aligned with the 10-year long-term planning period. Once infrastructure is designed and constructed, it is expected to have sufficient capacity to service the demand over its life period.

23. Developer constructed water and wastewater infrastructure is sized for the number of properties created by the developer. Developers do not build in provision for future intensification, but Council enables some intensification

by specifying (through the IDS) the minimum size of the sewer pipes and water mains that service individual developments.

24. Collective infrastructure that service more than one development is sized as part of the infrastructure planning process, by applying the prevailing and expected 50-year growth profile to the service area. If intensification is more than expected and results in a higher demand than what the infrastructure has been planned and designed for, the subsequent infrastructure plan will highlight a capacity constraint and the need for an upgrade.

25. The Council aims to review its infrastructure plans to align with the long-term planning process. However, due to the complexity involved in infrastructure development planning, and the fact that growth models are developed only at the end of the 3-year long-term planning cycle i.e. just in time for long-term plan adoption, there is inevitably a lag between infrastructure plans and adopted long-term plans. In this respect, Council has not yet adopted a revised growth plan that is based on the MDRS intensification estimates, and this will possibly be adopted as part of the next long-term plan only. This means that Council's next long-term plan (2025 to 2035 to be adopted pre-July 2024) does not provide all the funding that will be needed to enable MDRS design standards throughout the city as capital growth programmes are based on previous growth plans.

26. A key objective of infrastructure planning is to develop cost-effective infrastructure, meaning that infrastructure must be provided at the right time and to the right size.

Impact of Intensification on Water and Wastewater Infrastructure

27. Water and wastewater infrastructure systems evolve over time to become an interconnected and collective network. At a suburb level, infrastructure is sized to service a group of properties, whilst at zone, catchment and city-wide level, infrastructure is sized to service several sub-zones or sub-catchments. Intensification in some parts of the system will therefore have a cumulative impact on catchment and city-wide infrastructure.

28. **Appendix A** to my evidence contains a map of Council's trunk wastewater infrastructure and that illustrates the collective nature of wastewater infrastructure, whilst highlighting the several individual connections to peripheral catchments.

29. **Appendix B** to my evidence contains a map of Council's water infrastructure and illustrates the interconnected nature in some parts of the system, whilst highlighting the individual connections to peripheral zones.

30. In my opinion ad-hoc and sporadic intensification impacts the cost-effectiveness of water and wastewater infrastructure in the following ways:

    (a) Reactive upgrades can result in capital write-offs: As noted above, infrastructure is sized to deliver the future demand over its life period. If a pipe (or any other infrastructure component) must be upgraded because of additional and unplanned demand, but still has not reached its end-of-life period, it will result in the remaining book value of the pipe to be written off.

    (b) Over-sized infrastructure: Because of the long life-period of infrastructure, combined with the severe consequences if capacity is exceeded, I foresee that infrastructure planners will want to future proof infrastructure by providing sufficient capacity so that all or most properties can develop to MDRS design standards. As there is a direct relation between the cost of infrastructure and the size of infrastructure, over-sized infrastructure, will result in a higher initial investment for infrastructure capacity that may not be realised.

    (c) Non-functional infrastructure: Infrastructure that is over-sized could create functionality issues (as explained above). Minimum infrastructure design criteria will, in my opinion, be what will limit the sizing of future infrastructure. Therefore, even if MDRS design standards dictate a higher demand, it may not be possible to create enough capacity to meet that demand. If the demand does occur, an infrastructure upgrade would be triggered before the end of life of the infrastructure has been reached (resulting in capital write offs).

    (d) Potential loss of development contributions: The Council Development Contributions Policy 2021, dictates that development contributions may not be collected beyond 30 years (this aligns with the longest period of a loan used to fund capital expenditure). Therefore, if additional capacity is provided for intensification, but actual development does not occur within the 30 years, then development contributions would not be collected, and the debt incurred would have to be carried by rates. I conservatively estimate that Council's water and wastewater growth investment would need to be at least $50 million over the next 10 years (aligned to the existing growth profile) or $5 million per year. This amount would be expected to be funded by Development Contributions over a 30-year term. If only 50% of the development occurs over the 30 years, then an additional $25 million or $1.7 million per year, would have to be funded from rates for growth provided but not used.

31. From my experience, beyond a certain point that aligns with reasonable growth expectations, it will not be cost-effective to oversize infrastructure to provide for intensification that may not eventuate within the life period of the infrastructure. Conversely, there is a risk that reactive upgrades would be required to provide capacity for intensification that has been enabled but not planned when the infrastructure was initially sized.

32. Infrastructure planning that aligns with a focused growth plan provides the best opportunity to develop infrastructure at the right time and to the right size.

33. Much of the impacts and risks outlined above can be adequately mitigated by pursuing a structured water and wastewater planning process. Except for the vacuum sewer capacity constraint areas and the peripheral areas included in the low public transport accessibility qualifying matter (as further discussed below), the increased demand that would be placed on water and wastewater infrastructure as a result of intensification, does not justify additional development restrictions. This is further corroborated by the fact that some water and wastewater infrastructure have been provided with inherent capacity to accommodate growth through intensification.

VACUUM SEWER CAPACITY CONSTRAINTS QUALIFYING MATTER

Background to Christchurch Vacuum Sewer Catchments

34. The wastewater gravity networks in Shirley and Aranui were significantly damaged in the 2010/11 Canterbury earthquakes. The Stronger Christchurch Infrastructure Rebuild Team (the **SCIRT**) was tasked to return the infrastructure networks to a condition that would meet the level of service in place prior to the 4 September 2010 earthquake.

35. The Infrastructure Rebuild Technical Standards and Guidelines provided for restoration work to enable greater resilience but otherwise, only ‘Like for Like’ restoration was funded.

36. In researching the matter, I found that several wastewater system options (gravity, pressure and vacuum) were considered before the decision was made to service parts of Shirley and Aranui with a vacuum sewer system. Options were evaluated in terms of constructability, resilience, planning, customer communication and life cycle costs.

37. The above decision was also supported by an independent decision to provide a vacuum sewer system to service Prestons (Living G) Outline Development Plan area. This servicing decision was made by the Developer and approved by Council in terms of the Resource Consent.

38. Christchurch City Council now owns and operates three vacuum sewer systems at Shirley, Aranui and Prestons and as illustrated in **Figure 1** below.

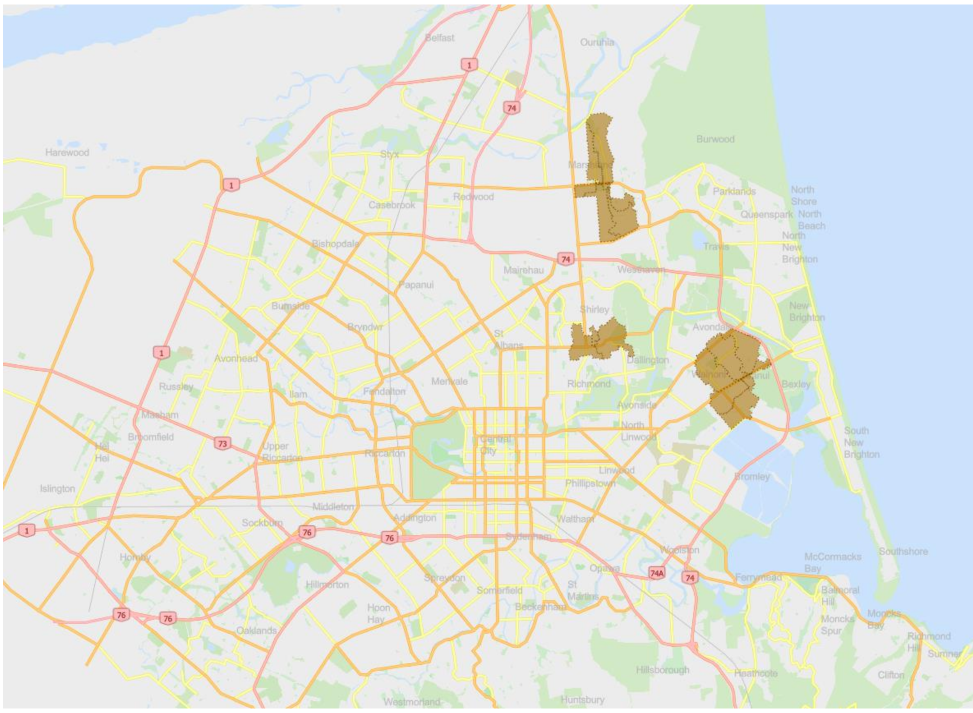


Figure 1 – Christchurch Vacuum Sewer Catchments including all Vacuum Arms

Vacuum Sewer System Design Considerations

39. In a vacuum sewer system and when applying the design criteria, a maximum of six private properties can be connected to a shared vacuum valve/collection chamber. The vacuum chambers are connected by welded polyethylene vacuum pipes to a central vacuum pump station (as shown in

Figure 2).

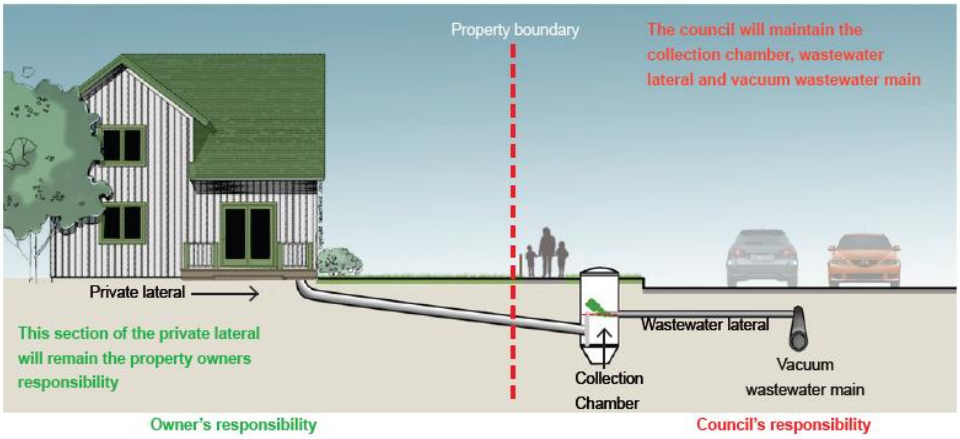


Figure 2 – Vacuum Wastewater System Representation

40. The vacuum pumps that are located at the central vacuum pump station extract air from the vacuum pipes to create negative pressure. The negative pressure allows vacuum valves to open pneumatically when a certain amount of wastewater has collected in the chamber. When the vacuum valve opens, wastewater is sucked out of the chamber, through the vacuum pipes and into a central collection tank located in the vacuum pump station (as shown in **Figure 3**).

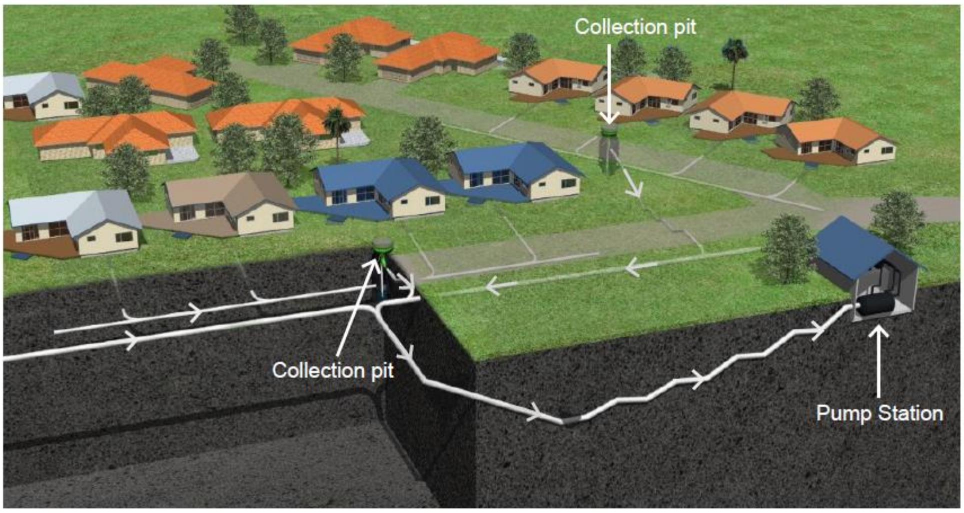


Figure 3 – Vacuum Wastewater System Components

41. A vacuum sewer system is centrally operated but can contain several vacuum arms (or sub-catchments). The different vacuum pipes that service the several vacuum arms are combined at the vacuum pump station and a single pipe creates the vacuum in all the arms (as shown in **Figure 4**). It is for this reason that a performance issue in one arm (the loss of vacuum) will also impact the performance of other arms.

42. Wastewater that has been sucked into the central collection tank, located at the vacuum pump station is pumped to a downstream gravity catchment or in the case of Aranui, direct to the wastewater treatment plant.

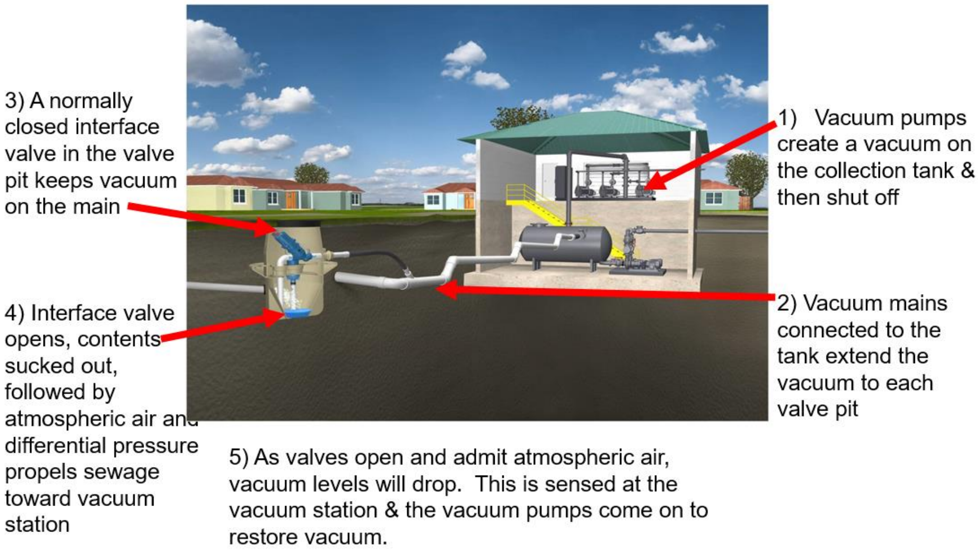


Figure 4 – Vacuum Sewer System Components

43. The Christchurch vacuum sewer systems were designed in accordance with the Vacuum Sewerage Code of Australia WSA 06-2008 (**Code**) which specifies the maximum flow that can be serviced by each pipe. The Code states that because polyethylene welded pipes are used for the vacuum pipes, that inflow and infiltration need to be recognised for the gravity part of the system only. The Christchurch Infrastructure Design Standard requires that a peak wet weather factor of 2.78 should be used when sizing a vacuum sewer system. This factor was applied for the Shirley and Aranui vacuum sewer systems, but a reduced wet weather peak factor (2.35) was used to design the Prestons vacuum sewer system.

44. 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 to ensure that not too much air is introduced and that the vacuum mains are able to maintain the required vacuum to allow the wastewater to be moved through the system.

45. When flows exceed the design allowance of the vacuum pipes, the system becomes waterlogged. This means that the air-to-liquid ratio in the vacuum pipe decreases which results in sluggish system performance and increased vacuum pump runtimes needed to maintain negative pressure (as shown in **Figure 5**). Eventually, waterlogging will cause the loss of service to parts or all of the catchment.

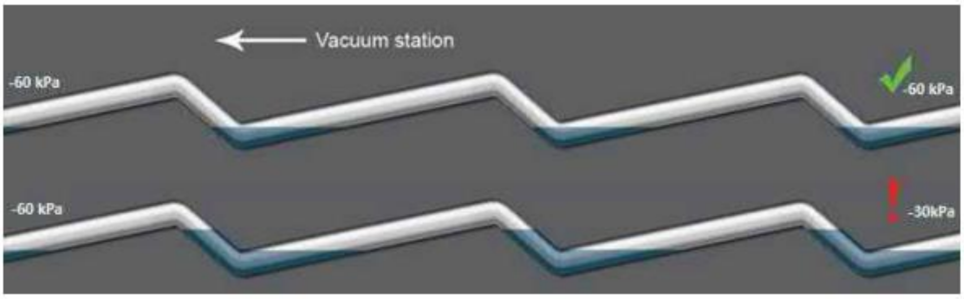


Figure 5 – Vacuum Pressure in Pipes Affected by Waterlogging

Vacuum Sewer Capacity Constraints and Performance Issues

46. The Shirley and Aranui vacuum sewer systems were sized to service the properties that were present before the earthquake with limited provision for low density development of some larger sites.

47. The Prestons vacuum sewer system was designed to service the Prestons (Living G) Outline Development Plan which provided for the establishment of up to 2,200 residential properties at a combined density of approximately 15 households per hectare.

48. During the 2016 district plan change discussions, SCIRT stated that additional capacity could be available in the vacuum sewer systems if the amount of inflow and infiltration that enters the system from private properties can be reduced or minimized. This statement resulted in the adoption of the plan change to rezone parts of the Shirley vacuum sewer catchment as residential medium density.

49. In my opinion, the reduction of inflow and infiltration from private property is not an appropriate strategy for enabling additional development. This is because of the reliance on private property owners to perform ongoing inspection and maintenance of their stormwater and sewer systems. In my experience that frequently does not occur, and enforcement of the Bylaw (despite requiring extensive resources) are not always successful.

50. As further demonstrated below, I have determined that even if inflow and infiltration from private properties can be reduced by 50%, there will still not be adequate capacity to enable development at MDRS design standards throughout the vacuum sewer catchments. To achieve a 50% reduction in inflow and infiltration, Council will have to enforce its Bylaw on all property owners, requiring that sewers be inspected and repaired at the cost of the property owner and that confirmation of said inspections and repairs be provided to Council. It is considered by many that enforcement of the Bylaw

in low-income areas may not have the desired effect, despite the many resources and extended timeframes that will be involved.

Shirley vacuum sewer catchment

51. The Shirley vacuum sewer catchment (**Figure 6**) has three vacuum arms that are serviced by a vacuum sewer pump station with a maximum capacity of 41 Litres per second. The combined flow capacity of the three vacuum arms is less than the capacity of the pump station and limits the capacity of the Shirley vacuum sewer system to 39 Litres per second.

52. Each vacuum arm was sized to service different residential household densities. The system also provides a wastewater service to several businesses, schools, and retirement villages.

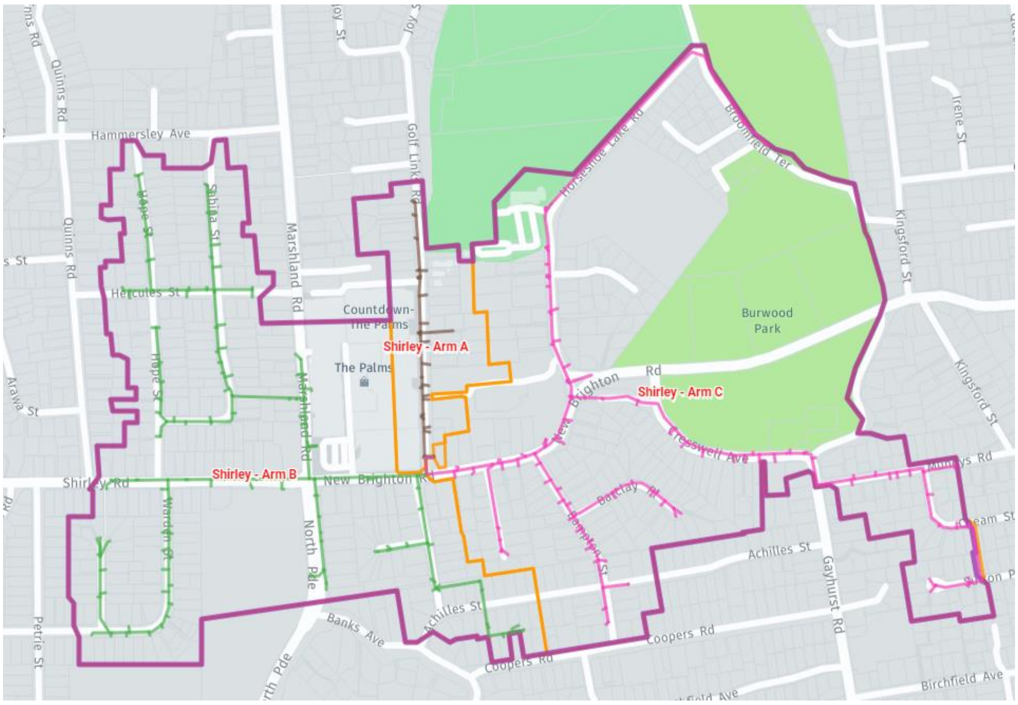
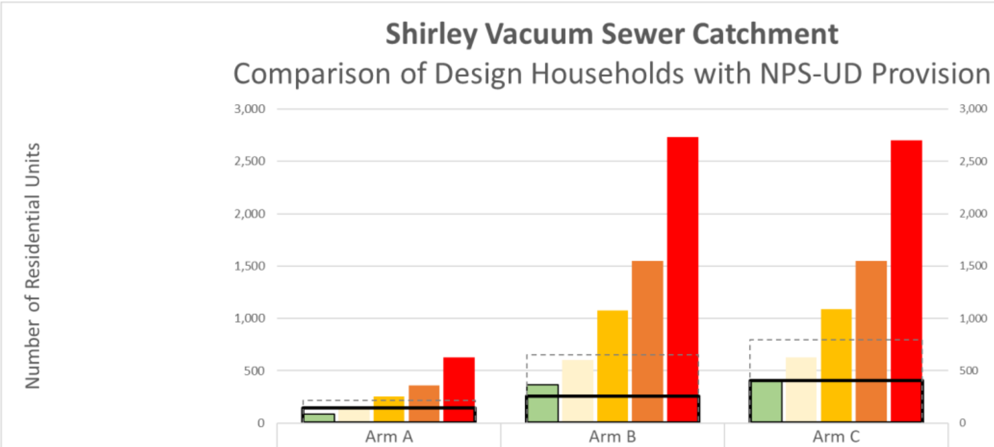


Figure 6 – Shirley Vacuum Sewer Catchment Layout

53. The Shirley vacuum sewer system will not be able to provide a wastewater service for development to MDRS density standards. This is illustrated in **Figure 7** below by comparing the maximum number of residential units that can be serviced by each vacuum arm with the potential MDRS development in that arm.

54. I calculated the number of residential units that can be serviced by the Shirley vacuum sewer system by applying the Christchurch unit flow parameters to the peak design flow for each vacuum arm. I assumed that new residential units will not contribute to additional inflow and infiltration. I

also developed a scenario to determine the impact of reducing private property inflow and infiltration by 50%. Even if private property inflow and infiltration can be halved, the Shirley vacuum sewer system will still not have enough capacity to enable MDRS design standards, at any uptake level, to be implemented within the catchment.



	Arm A	Arm B	Arm C
Actual HH's	88	367	395
NPS-UD HHs - 10% Uptake	142	604	626
NPS-UD HHs - 30% Uptake	250	1,077	1,087
NPS-UD HHs - 50% Uptake	359	1,550	1,549
NPS-UD HHs - 100% Uptake	629	2,733	2,702
Max Design HHs	146	254	406
Max Design HHs with 50% I&I	217	653	798

Figure 7 – Shirley Household Capacity vs MDRS development

55. In 2016, the Christchurch City Plan was replaced by the Christchurch District Plan, providing for approximately 30% of the Shirley vacuum catchment to be rezoned from 'Living 1' to 'Residential Medium Density'. This enabled infill development at a higher density than what was provided for in the vacuum sewer system design and is the reason why the capacity of Vacuum Arm B has now been exceeded. This has a clear impact on the performance of the system as demonstrated in **Figure 8** below. The Shirley vacuum pump station design flow capacity is exceeded, and vacuum loss is experienced during rain events. Due to intensification that exceeds the design allowance, the Shirley vacuum sewer system regularly fails to operate in wet weather, requiring Council to dispatch sucker trucks to stop private property spillages.

56. The options, costs, and time of enabling this system to accommodate MDRS levels of growth are addressed in the following section.

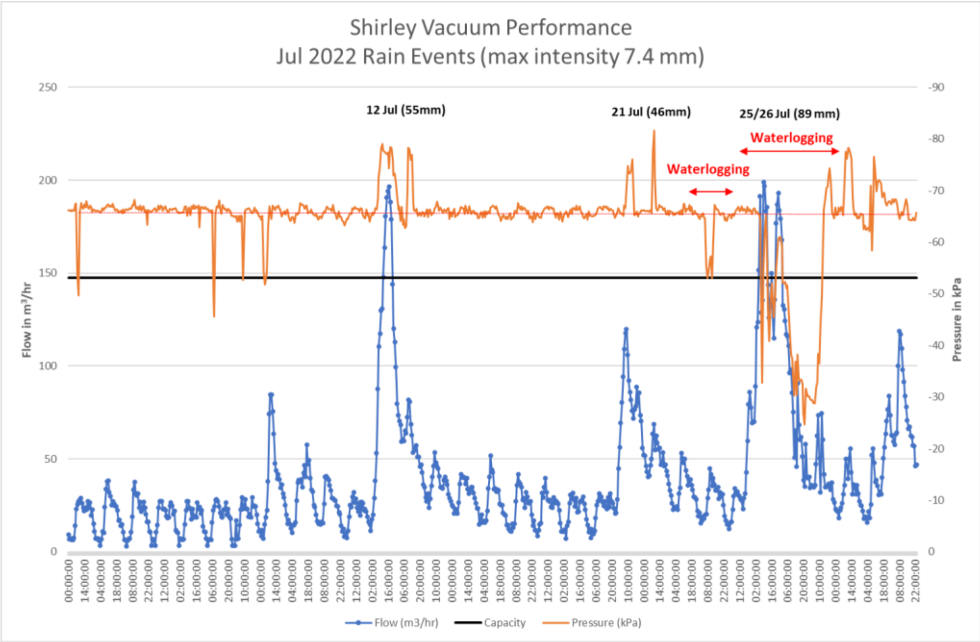


Figure 8 – Shirley Performance Failures

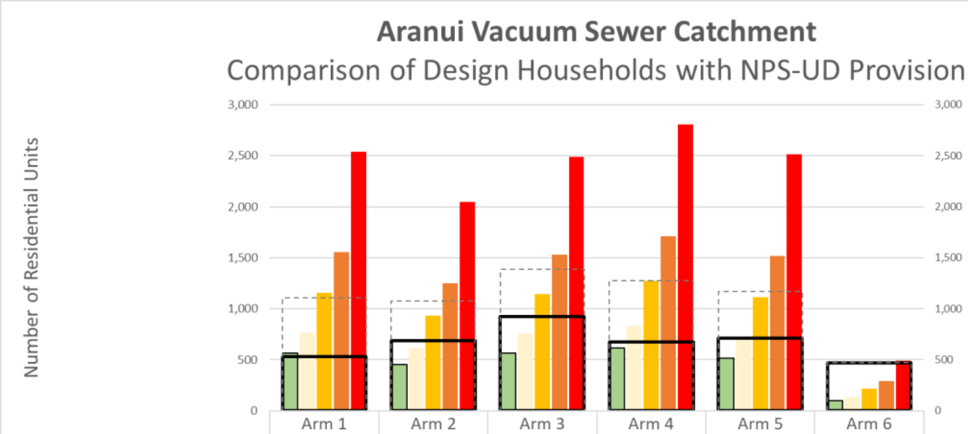
Aranui vacuum sewer catchment

57. The Aranui vacuum sewer catchment (see **Figure 9**) has six vacuum arms that are serviced by a vacuum sewer pump station with a maximum capacity of 119 Litres per second. The combined design flow capacity of the vacuum arms is higher than the design capacity of the pump station and means that the capacity of each vacuum arm must be managed in relation to the pump station capacity.

58. Each vacuum arm was sized to service different residential household densities. The system also provides a wastewater service to several businesses and schools.

Figure 9 – Aranui Vacuum Sewer Catchment Layout

59. The Aranui vacuum sewer system will not be able to provide a wastewater service for development to MDRS density standards. This is illustrated in **Figure 10** below by comparing the maximum number of residential units that can be serviced by each vacuum arm with the potential MDRS development in that arm.



	Arm 1	Arm 2	Arm 3	Arm 4	Arm 5	Arm 6
Actual HH's	566	455	564	614	514	95
NPS-UD HHs - 10% Uptake	764	614	757	833	714	134
NPS-UD HHs - 30% Uptake	1,159	932	1,142	1,272	1,115	213
NPS-UD HHs - 50% Uptake	1,554	1,250	1,527	1,711	1,516	292
NPS-UD HHs - 100% Uptake	2,541	2,045	2,490	2,807	2,517	488
Max Design HHs	529	687	926	677	713	469
Max Design HHs with 50% I&I	1,106	1,077	1,388	1,273	1,171	469

Figure 10 – Aranui Household Capacity vs MDRS development

60. I calculated the number of residential units that can be serviced by the Aranui vacuum sewer system by applying the Christchurch unit flow parameters to the peak design flow for each vacuum arm. I assumed that new residential units will not contribute to additional inflow and infiltration. I also developed a scenario to determine the impact of reducing private property inflow and infiltration by 50%. Even if private property inflow and infiltration can be halved, the Aranui vacuum sewer system will still not have enough capacity to enable MDRS design standards, at any uptake level, to be implemented within the catchment.

61. Aranui Vacuum Arm 1 has exceeded its design capacity and is one of the reasons for the deficient performance of the Aranui vacuum sewer system as demonstrated in **Figure 11**. Due to waterlogging in upstream parts of the system, the pump station cannot operate at its design capacity. Total systems vacuum loss is also experienced in some rain events. To avoid spillage of wastewater onto private property, Council dispatches sucker trucks to clear wastewater from the failed system. Several residents have already complained about the constant deployment of sucker trucks during rain events.

62. The options, costs, and time of enabling this system to accommodate MDRS levels of growth are addressed in the following section.

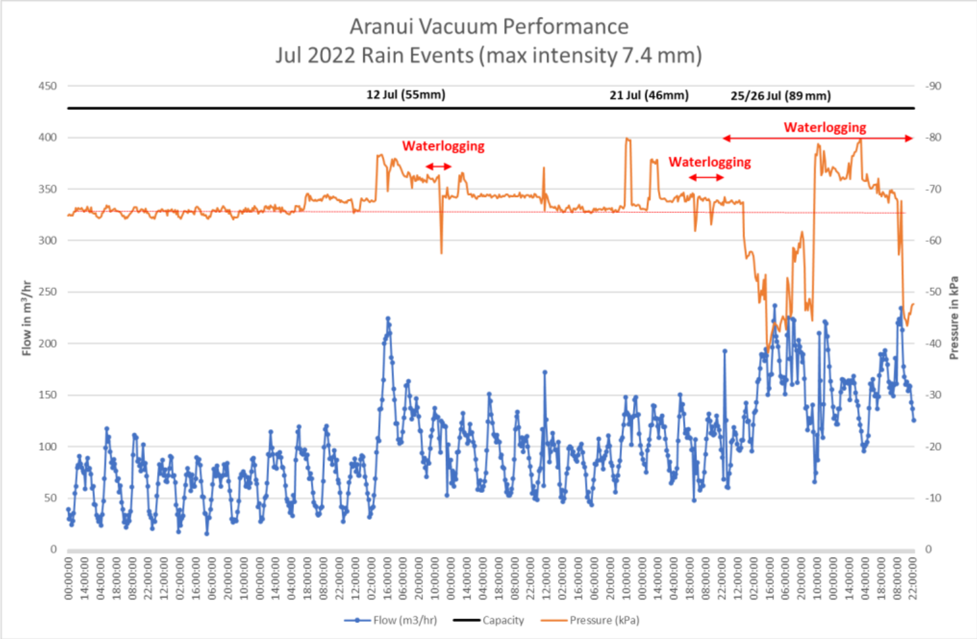


Figure 11 – Aranui Performance Failures

Prestons vacuum sewer catchment

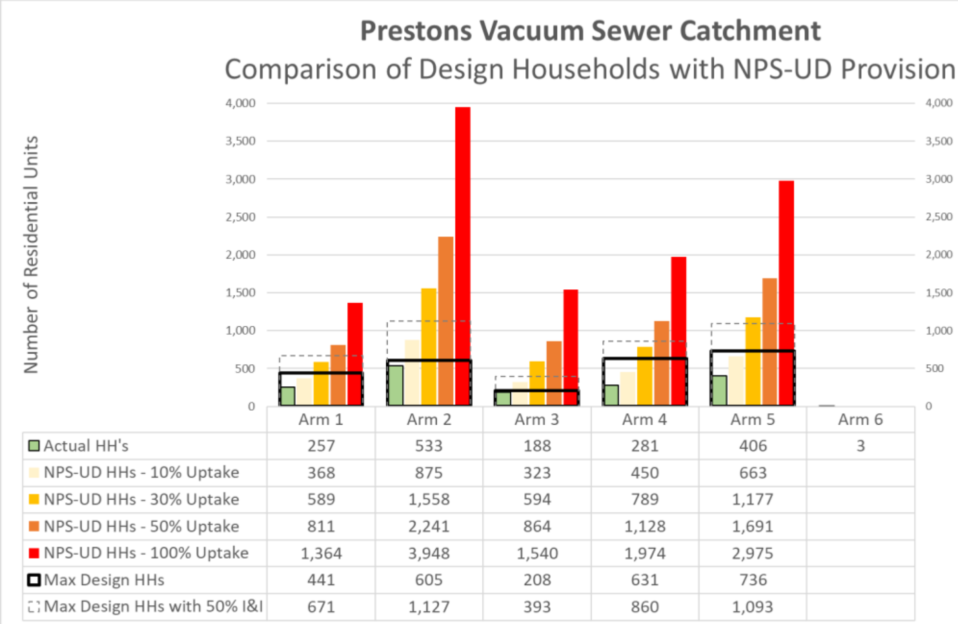
63. The Prestons vacuum sewer catchment (see **Figure 12**) has six vacuum arms that are serviced by a vacuum sewer pump station with a maximum capacity of 72.5 Litres per second. The combined design flow capacity of the vacuum arms is higher than the design capacity of the pump station and means that the capacity of each vacuum arm must be managed in relation to the pump station capacity.

64. The Prestons vacuum sewer system was designed to service a residential household density of less than 15 households per hectare. The system also provides a wastewater service to several businesses and schools.

Figure 12 – Prestons Vacuum Sewer Catchment Layout

65. The Prestons vacuum sewer system will not be able to provide a wastewater service for development to MDRS density standards. This is illustrated in **Figure 13** below by comparing the maximum number of

residential units that can be serviced by each vacuum arm with the potential MDRS development in that arm.



	Arm 1	Arm 2	Arm 3	Arm 4	Arm 5	Arm 6
Actual HH's	257	533	188	281	406	3
NPS-UD HHs - 10% Uptake	368	875	323	450	663	
NPS-UD HHs - 30% Uptake	589	1,558	594	789	1,177	
NPS-UD HHs - 50% Uptake	811	2,241	864	1,128	1,691	
NPS-UD HHs - 100% Uptake	1,364	3,948	1,540	1,974	2,975	
Max Design HHs	441	605	208	631	736	
Max Design HHs with 50% I&I	671	1,127	393	860	1,093	

Figure 13 – Prestons Household Capacity vs MDRS development

66. I calculated the number of residential units that can be serviced by the Prestons vacuum sewer system by applying the Christchurch unit flow parameters to the peak design flow for each vacuum arm, whilst recognising the lower capacity. The design of the Prestons vacuum sewer system was based on a reduced inflow and infiltration factor, and I used this lower factor to determine that a maximum of 2,250 residential units can be serviced by the Prestons vacuum sewer system pump station. I assumed that new residential units will not contribute to increased inflow and infiltration. I also developed a scenario to determine the impact of reducing private property inflow and infiltration by 50%. Even if private property inflow and infiltration can be halved, there would be a risk that the Prestons vacuum sewer system will still not have enough capacity to enable MDRS design standards to be implemented throughout the catchment.

67. I do however realise, that because the capacity of the vacuum arms in Prestons is significantly higher than the vacuum station capacity, that an increased vacuum station capacity, could service more development, but still not at a density envisioned by the MDRS design standards.

68. Even though the Prestons vacuum sewer catchment is still being developed and maximum capacity has not yet been reached, the performance of the system shows that waterlogging already occurs during certain rain events

(**Figure 14**). This means that inflow and infiltration from private properties exceeded the capacity in some parts of the system.

69. The costs and time of enabling this system to accommodate MDRS levels of growth are addressed in the following section.

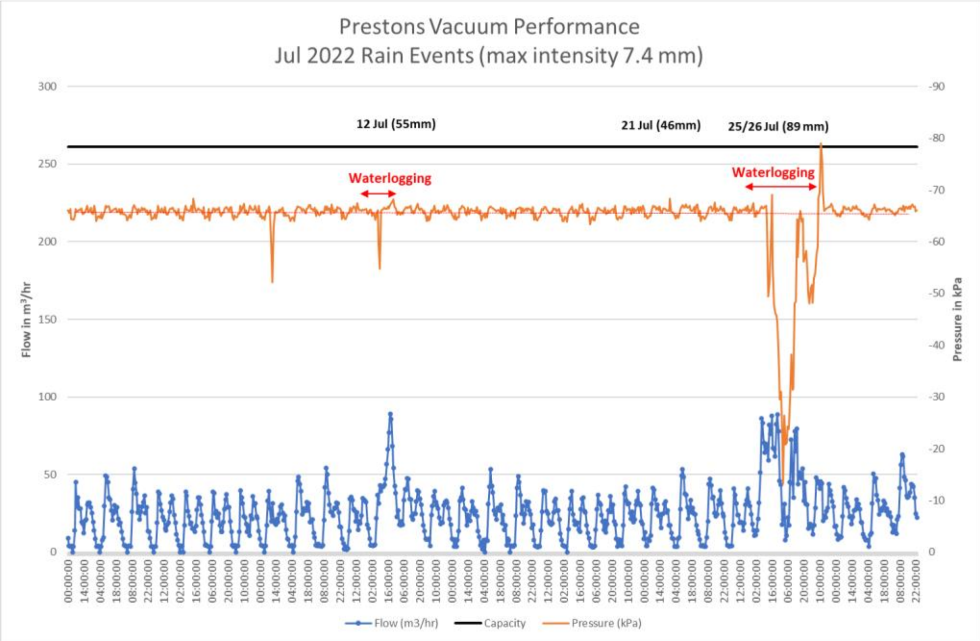


Figure 14 – Prestons Vacuum Sewer System Performance Failures

Comments on Infrastructure Planning and Funding Requirements to enable MDRS design standards in Vacuum Sewer Catchments

70. Due to the vacuum sewer system design considerations outlined above, component-based upgrades will not resolve the capacity constraints. For example, the upgrade of the Shirley vacuum pump station will not provide additional capacity to the vacuum arms to avoid waterlogging.

71. For the vacuum sewer systems to service development at MDRS design standards, the capacity of all the components of the system i.e., vacuum chambers, vacuum pipes and vacuum pump stations will have to be increased. This will effectively mean that the vacuum sewer systems will have to be duplicated or replaced. Methods of duplication can include:

(a) building new vacuum pump stations and splitting the vacuum sewer catchment into multiple catchments; or

(b) installing duplicate (satellite) wastewater storage and pump stations to defer flow from the vacuum arms to other catchments; or

(c) providing a duplicate local pressure sewer system to pump wastewater into other catchments.

72. Once capacity of the vacuum sewer system has been addressed through duplication or replacement, additional capacity will have to be created downstream of the vacuum sewer catchment to receive the increased flow from the vacuum sewer catchments. Such follow-on capacity may be required at several locations, depending on the infrastructure option that is selected.

73. Because of the complexity of the solutions needed to provide additional capacity, I do not consider it appropriate nor efficient, to progressively increase capacity over time as and when intensification occurs. The full capacity needed to allow a complete uptake of MDRS design standards will have to be provided upfront to avoid capacity being exceeded in some parts of the vacuum sewer system that could lead to performance issues and system failure.

74. It is therefore my opinion that to enable MDRS design standards within the vacuum sewer catchments, a wastewater system with enough capacity to service any or all properties at MDRS density standards will have to be provided.

75. Considerable engineering design will be needed to ascertain the infrastructure solutions and concomitant cost to enable MDRS intensification in the vacuum sewer catchments. These conceptual engineering designs will also have to consider the downstream upgrades needed for each of the potential solutions. If the vacuum sewer systems were sized to service development at MDRS design standards, then, by using the replacement value of the systems, the cost would have been:

(a) The 2023 replacement value for the 41 litres per second (**L/s**) Shirley vacuum sewer system that provides connections to 850 residential units is $12.6 million. If MDRS design standards are applied, an estimated capacity of 170 L/s would be needed for a total of 6,000 residential units. By applying the 2023 replacement value, the cost of a vacuum sewer system to service such a development, would be approximately $62 million.

(b) The 2023 replacement value for the 119 L/s Aranui vacuum sewer system that provides connections to 2,808 residential units is $56 million. If MDRS design standards are applied, an estimated capacity of 340 L/s would be needed for a total of 12,900 residential units. By applying the 2023 replacement value, the cost of a vacuum sewer system to service such a development, would be approximately $160 million.

(c) The 2023 replacement value of the 72.5 L/s Prestons vacuum sewer system that provides connections to 1,700 residential units is $30 million. If MDRS design standards are applied, an estimated capacity of 344 L/s would be needed for a total of 11,800 residential units. By applying the 2023 replacement value, the cost of a vacuum sewer system to service such a development, would be approximately $120 million.

76. The total current replacement value of the vacuum sewer systems is approximately $100 million. Allowing for the utilisation of existing vacuum sewer capacity ($100 million) and by using the replacement value of the systems, it is estimated that the capital cost to provide capacity to service an additional 25,000 residential units as triggered by the MDRS design standards, could be as high as $240 million. Additional upgrades downstream of the systems would likely increase the cost to more than $10,000 for each new unit.

77. The vacuum sewer systems were constructed over a 4-year period. New infrastructure solutions to duplicate the vacuum sewer systems and including provision for downstream upgrades would not be achievable in less than 5 years from the point that funding is made available.

Response on submissions

78. I have noted the support from Waka Kotahi for the vacuum sewer systems capacity constraint qualifying matter. The submitter (#805) also states that there is a potential pathway where alternatives to other adjoining wastewater systems can be obtained to allow for intensification of the site. I agree with this statement but advise that such an alternative will only be available if there is capacity in the adjoining wastewater systems.

79. There is limited capacity in the adjacent wastewater systems. It is for this reason that the wastewater from the vacuum sewer systems is pumped over long distances to the nearest trunk sewers (± 2.5 kilometres for Prestons, ± 1 kilometre for Shirley, ±1.6 kilometres for Aranui).

LOW PUBLIC TRANSPORT ACCESSIBILITY AREA QUALIFYING MATTER

Supporting Cost-Effective Infrastructure

80. The intention of the low public transport accessibility qualifying matter is to enable MDRS design standards near high frequency bus routes that connect large commercial centres. The objective of focusing development to specific areas aligns well with the principle of cost-effective infrastructure development.

81. In relation to water and wastewater infrastructure I do not consider that MDRS intensification in all areas will support cost-effective infrastructure development. Specifically, I consider that intensification in the following area categories will make it difficult to achieve cost-effective infrastructure development:

    (a) Serviced areas on the periphery of the water and wastewater service catchments. These areas such as South New Brighton, Mount Pleasant, Redcliffs, Clifton Hill, Sumner and Lyttelton Harbour are serviced by individual connections to the rest of the city. MDRS intensification within these areas could increase the demand beyond the existing capacity and require the upgrade of these individual connections. Due to the cost and complexity to upgrade large individual connections progressive upgrades are neither feasible nor cost-effective. For example, it would be both difficult (due to space constraints) and costly to upgrade or duplicate the recently installed water and wastewater mains through the Lyttelton road tunnel. As discussed in previous sections of my evidence, this could lead to functionality issues in the near term. This is different from areas within the city that are serviced by an integrated infrastructure system, where capacity can be shared to better accommodate intensification in a progressive manner.

    (b) Greenfield Areas that are serviced by infrastructure that was implemented within the past 10 years. Infrastructure servicing Halswell, Westmorland, Casebrook and Prestons were sized to support a residential household density of 15 households per hectare. MDRS design standards will increase the demand and will trigger the need for new infrastructure to be upgraded. In the case of pipes, this would mean that new pipes will have to be abandoned and replaced with bigger pipes. However, as noted above, where greenfield areas are serviced by smart local pressure sewer systems, some capacity is available for intensification.

(c) Hill land with service constraints and complexity. Water and wastewater servicing of areas such as Hillsborough, Huntsbury and Cashmere are extremely complex because of the vast elevation changes and limited space. Much of the infrastructure in these catchments runs through private properties (as opposed to roads) and numerous reservoirs are in place at different elevations to service small groups of properties. Intensification due to MDRS design standards in these areas will trigger build over pipe requests (that will be declined in accordance with the Council Bylaws that do not allow buildings over pipes) and will also require the upgrade of key water mains and reservoirs for which space may not be available.

Response on submissions

82. Several submissions raised issues with the choice of bus routes that had been included in the qualifying matter and this has prompted Council to consider excluding existing high frequency bus routes.

83. My evidence considers the potential impact of these proposed changes on the development of efficient and cost-effective water and wastewater infrastructure in the context of my discussion above.

84. I support the following changes:

(a) Recognising the low frequency extent of the Blue Line (#1) and thereby including the upper parts of Cashmere as at Dyers Pass Road and Hackthorne Road in the qualifying matter and therefore not allowing MDRS intensification to occur in these areas. I consider this area as ‘hill land’ per my categorisation above with substantial portions of Council’s water and wastewater infrastructure located on private land as opposed to roads. Because this area is also a wastewater capacity constraint area, any additional development will require the upgrade of pipes located on private property. The area is serviced by three reservoir sites, all at separate locations and elevations. Intensification will require upgrades to the water supply mains that service these reservoir sites and to the storage capacity. I support excluding this area, because of the impact that MDRS development would have on existing infrastructure located on private land and because intensification will require significant and costly upgrades to infrastructure located on private land.

(b) Removing the Orange Line (#7) core route beyond Shirley centre and therefore removing Burwood, Travis Wetland, Queenspark and Parklands from the qualifying matters. I do not consider these areas to be peripheral to the Council's water and wastewater service area and even though MDRS development may require infrastructure upgrades, the integrated network would support progressive, efficient, and cost-effective development.

85. I do not support the following changes:

(a) Removing Purple Line (#3) that services Mount Pleasant, Redcliffs, Clifton Hill and Sumner. These qualifying matters need to be retained. The areas on the #3 line east of Ferrymead are serviced by a series of infrastructure that culminates into a combined, individual connection to the rest of the city. I therefore consider these areas to be peripheral to the water and wastewater system. Due to the nature of the infrastructure, there is no ability to distribute additional demand to adjacent infrastructure with capacity. The area therefore suffers from a compounding loss of capacity as it is the tail of cascading catchments and zones, each with separate wastewater pump stations and reservoirs. The nature of the wastewater network here means that any upgrade of the pump station could also require the upgrade of the pressure main as well as a series of pump stations and pressure mains in wastewater catchments that the service flows into. The same applies to water supply, in that the servicing water mains, booster pump stations and reservoirs may need to be upgraded to provide sufficient capacity further on. The cost to upgrade infrastructure would therefore not be targeted to just this area (along the #3 line) but would be felt across the network. In my opinion, this is inefficient and represents a poor return on investment when compared to how responsive the network can be within the substantive suburban areas where MDRS is proposed to be enabled.

CONCLUSION

86. In my experience, efficient and cost-effective infrastructure is best achieved in the context of an agreed and formalized spatial growth plan. Ad-hoc and sporadic intensification may trigger infrastructure upgrades that are oversized or will cause continuous reactive upgrades. Even if upgrades are limited to meet the minimum functional design requirements, oversized infrastructure can cause untimely and increased capital expenditure on some infrastructure whilst other infrastructure may remain constrained because of funding and resource constraints.

87. In my opinion the containment of intensification to high frequency public transport routes will promote development in areas that are better suited to the progressive increase in demand and exclude areas where additional demand could trigger costly and ineffective infrastructure development.

88. I support consideration of the existing high frequency bus routes as part of the low public transport accessibility area qualifying matters. The objective of focusing development to specific areas aligns well with the principle of cost-effective infrastructure development. The exception is where this would lead to intensification in areas which, in my opinion, will not support cost-effective infrastructure development. I therefore do not recommend that areas in Mount Pleasant, Redcliffs and Sumner (Purple Line) should be included in the qualifying matter for the reasons outlined in my evidence above. As explained in my evidence above, the provision of costly infrastructure in peripheral and unsuitable (hills) areas, will also impact other consumers within the wider network, especially if intensification does not occur as expected.

89. I consider that the performance of vacuum sewer systems is severely impacted if capacity is reached (or exceeded) in certain components. In my opinion, the Christchurch vacuum sewer systems will have to be duplicated by alternative systems or completely replaced and additional downstream capacity will have to be provided to support MDRS design standards. These changes will be well beyond the typical growth funding provision of Council’s long-term plan, especially if considering a potential capital outlay in the order of $240 million, when the typical long-term plan wastewater allocation for growth is less than $50 million over 10 years.

90. Because an increase in demand due to MDRS intensification could render the vacuum sewer systems inoperable and because I do not consider that

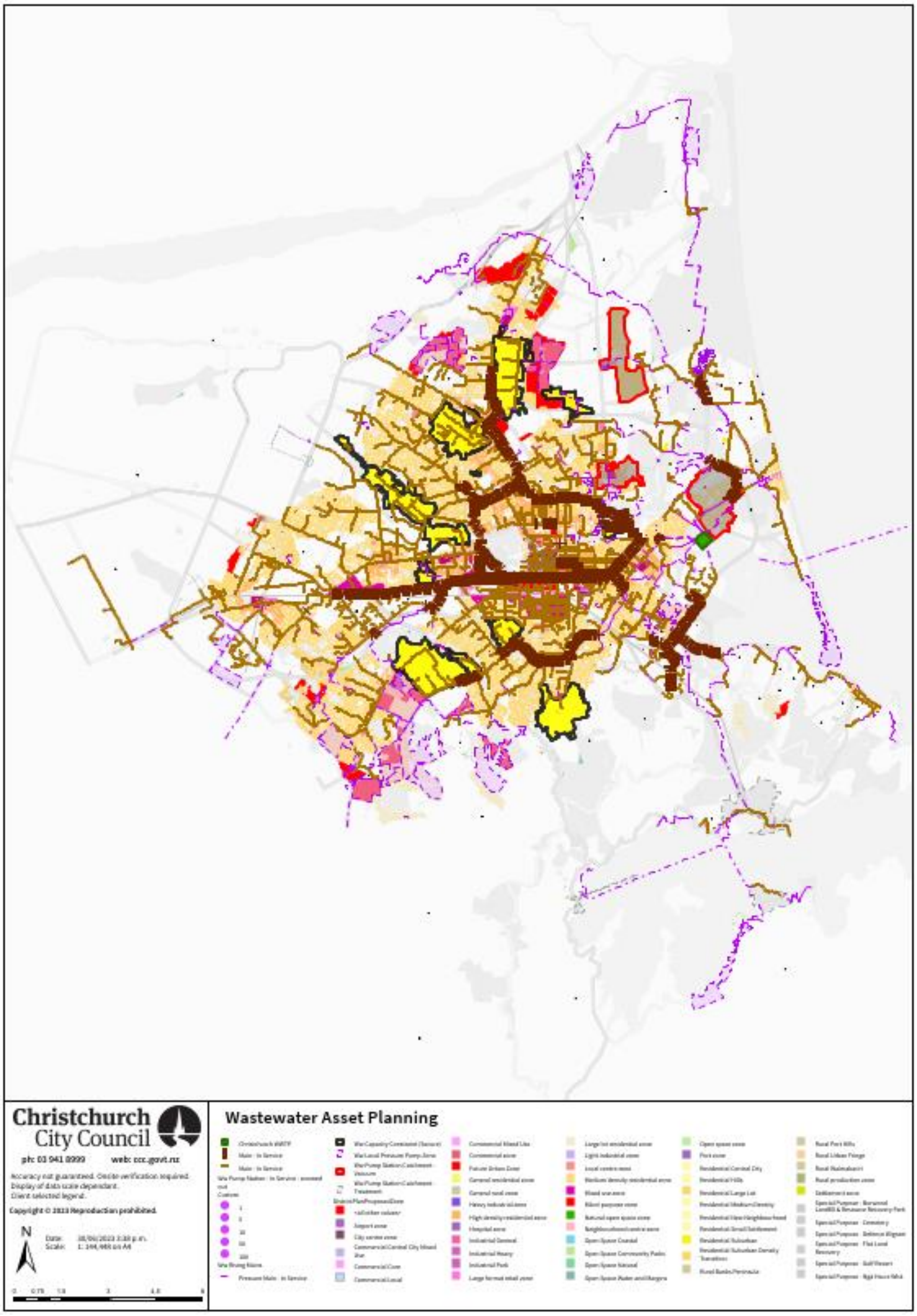
the replacement or duplication of the systems could be achieved in the medium to long term because of the cost and funding implications, I support vacuum sewer capacity constraints should being accepted as a Qualifying Matter in PC14.

91. Except for my support for the vacuum sewer capacity constraint and the low public transport accessibility qualifying matters and despite the risks that ad-hoc and staggered intensification may have on water and wastewater infrastructure, this does not warrant additional development restrictions for the sake of water and wastewater infrastructure capacity. It will, however, be important that water and wastewater infrastructure plans remain aligned with land development to avoid a reactive response to demand that exceeds capacity.

Dated: 11 August 2023

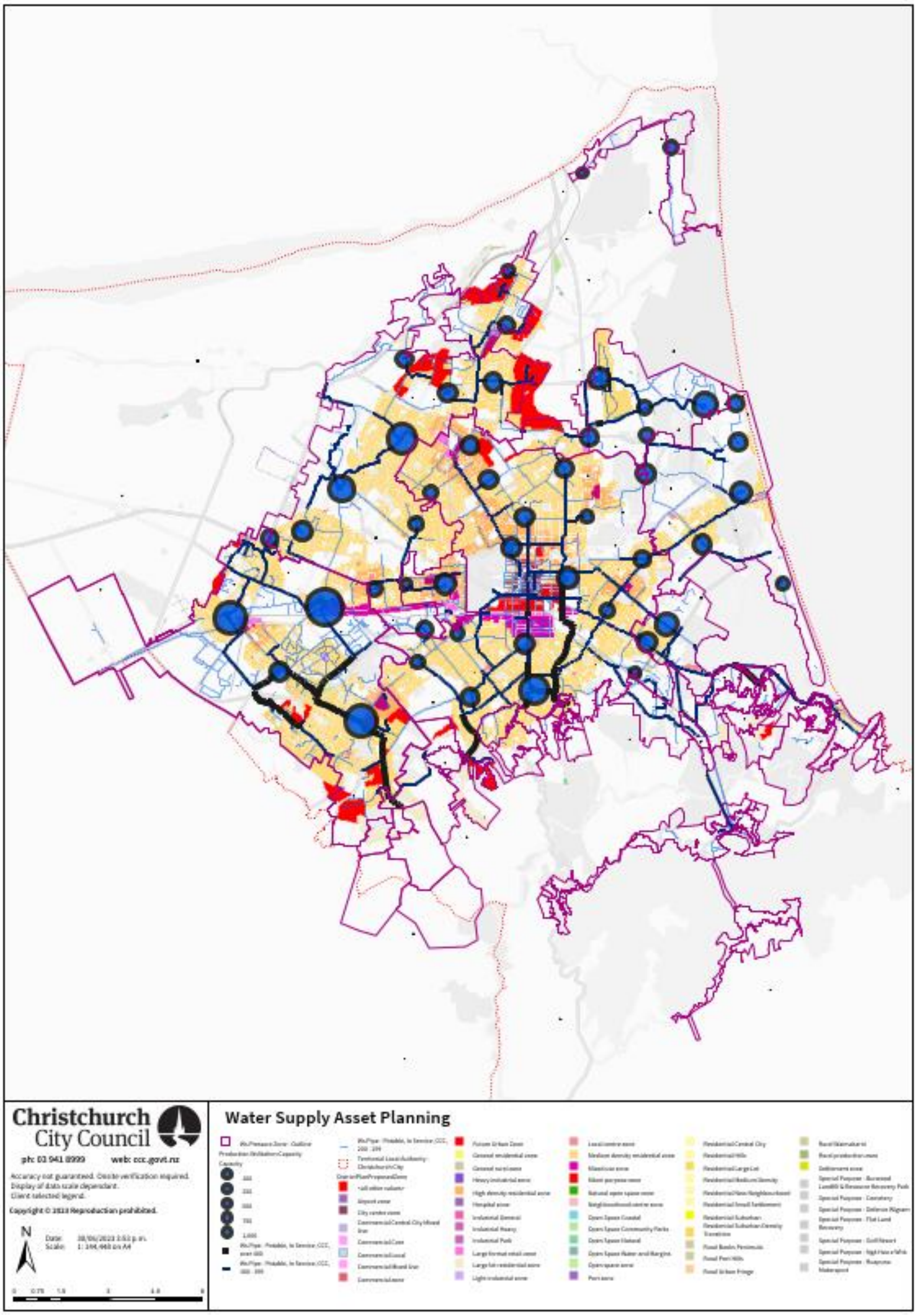
Michele Ann McDonald

APPENDIX A – WASTEWATER PLANNING MAP



Notes: The map highlights that most of the wastewater capacity is centred around the trunk mains (bold brown lines). Current wastewater planning is focused on resolving wastewater capacity constraints identified by the bright yellow areas. Greenfield developed local pressure sewer systems (purple areas overlaid on red future urban zone) also have some intrinsic capacity available because of smart technology that has been deployed. This is not the case in SCIRT developed local pressure sewer systems (such as Brooklands, Worsley, Southshore).

APPENDIX B – WATER PLANNING MAP



Notes: The map highlights the difficulty to create additional capacity in secondary water zones or hill zones because of the distance to the water source (blue dots).