BEFORE THE HEARING PANEL
I MUA NGĀ KAIKŌMIHANA WHAKAWĀ MOTUHAKE WAIKATO

IN THE MATTER	**of the Resource Management Act 1991**
AND	
IN THE MATTER	**of Proposed Plan Change 12 to the Operative Hamilton District Plan**

STATEMENT OF PRIMARY EVIDENCE OF PHILIP THOMAS JAGGARD ON BEHALF OF KĀINGA ORA – HOMES AND COMMUNITIES

(THREE WATERS)

26 JULY 2024

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1. EXECUTIVE SUMMARY

1.1 My full name is Philip Thomas Jaggard. I am a Director/Infrastructure Specialist consultant at MPS Limited providing expert and technical advice, and direction on three waters infrastructure and effects. I have been engaged by Kāinga Ora-Homes and Communities (**"Kāinga Ora"**) to provide evidence addressing infrastructure capacity in support of its submissions to Plan Change 12 to the Hamilton District Plan (**"PC12"**).

1.2 In summary, my evidence concludes that:

1.3 Focusing development into an existing and compact urban form has several benefits and can generally be viewed as positive as reduces the overall area required to be serviced.

1.4 I see no requirement for a density limit control and consider that the Infrastructure Capacity Overlay could be removed. This is because:

i. There is already a trigger for assessment, with three or more dwellings requiring consent within the General Residential Zone, or four more dwellings requiring consent within the Medium Density Residential Zone. Assessment criteria for infrastructure assessment could be included where the permitted number of dwellings in a residential zone are exceeded (i.e., 3 or more in GRZ and 4 or more in the MDRZ).

~~ii.~~ PC12 proposes amendments which make clear in the Plan that a development wanting to connect to the city's water, wastewater and stormwater networks will be required to obtain an additional approval through the Three Waters Connection Policy, which sits outside of the conventional resource management planning process.

iii. Further, under the existing Bylaws, LGA and Building consent process, Council has an ability to decline connections to infrastructure, if no capacity is available.

1.5 I do not consider that the Infrastructure Capacity Overlay and density trigger is justified on stormwater terms because:

i. the redevelopment of a site under either the two or three dwellings per lot scenario can and will likely result in the same or similar stormwater discharges and effects, as the building coverage and impervious surface controls are based on percentages and are the same irrespective of whether two or three dwellings are proposed.

ii. Therefore, it can be concluded that redevelopment of sites into either two or three dwellings will more than likely have the same stormwater flows and contaminant loads in terms of environmental effects on the Waikato River.

1.6 Through PC12, Hamilton City Council is proposing to require all new residential dwellings to install rainwater reuse tanks for non-potable use. I disagree that rainwater reuse tanks should be the only tool available to developer to manage stormwater effects because:

i. As our analysis in the report appended as **Attachment A** shows, a typical rainfall reuse system designed in accordance with HCC Practice Note will run dry frequently throughout the year and not relieve any design pressure on the public water supply system.

ii. The high costs, frequent maintenance tasks and public health risks, raises serious questions around the ongoing affordability and sustainability of the reuse schemes. The benefits of the reuse systems are limited to reduced water demand and management of stream erosion. These can all be achieved by other means using alternative stormwater devices and water supply efficiency measures at a lower whole of life cost.

1.7 In my opinion the additional prescriptive rules for tree canopy and deep soil areas are not required from a stormwater management perspective. A sufficient range of methods and tools are already available to developers to manage the effects of stormwater runoff.

1.8 Flood hazards and risks is proposed to be addressed through a further Plan Change 14. HCC has provided an interim guidance on processing applications for managing flood risk. This will not be addressed in my evidence.

2. INTRODUCTION

2.1 My full name is Philip Thomas Jaggard, and I am a Director/Infrastructure Specialist consultant at MPS Limited providing expert and technical advice, and direction on three waters infrastructure and effects. My experience includes providing infrastructure advice, support and expert witness evidence on water, wastewater and stormwater servicing for brownfield and greenfield development proposals for both public and private entities across Auckland.

2.2 I hold a Bachelor of Science from the University of Auckland and have over 20 years' experience in the water sector, with the past nearly eight years as a consultant at MPS Limited.

2.3 Prior to MPS Limited, I have been intimately involved in the strategy, planning and delivery of three waters infrastructure to improve levels of service and service growth in Auckland. I was the Wastewater Planning Manager at Watercare and more recently the Strategy and Resilience Manger, Healthy Waters, Auckland Council. During my time at both organisations, I provided input, and contributed to, the development of Auckland Unitary Plan, Auckland Council's Infrastructure Strategy and Land Release Programme.

2.4 My experience working for both public and private entities, gives me insight into how regulatory systems operate and the issues that arise when those systems don't function well.

2.5 Kāinga Ora has requested my expert technical advice and opinion on the PC12 provisions relating to infrastructure and development, with my scope of work including:

i. Reviewing the PC12 provisions.

ii. Reviewing Council evidence/documents.

iii. Reviewing submission points relating to infrastructure.

iv. Reviewing high level strategic evidence; particularly planning and economics.

a) Participating in expert conferencing where required.

b) Preparing expert three waters infrastructure evidence.

Code of Conduct

2.6 Although this is a Council hearing, I have read the Environment Court's Code of Conduct for Expert Witnesses in its Practice Note 2023 and agree to comply with it. My qualifications as an expert are set out above. I confirm that the issues addressed in this statement of evidence are within my area of expertise and experience.

Scope of Evidence

2.7 The focus of my evidence will be on impact of development on infrastructure, particularly in brownfield areas, controls on connections and the level of intensification.

2.8 The aspects of the Kāinga Ora submissions on PC12 of greatest relevance to infrastructural issues are:

i. Opposition to Council's proposal to the proposed Infrastructure Constraints Overlay, to the extent that it is applied through a density control.

ii. The concern of Kāinga Ora is that Council has not justified its proposed requirements in the Three Waters Chapter 25. In particular, the requirement to install rainwater reuse tanks for non-potable use of rainwater in residential zones, given the potential health and safety risks and lack of sustainability of reuse tanks in the long-term.

2.9 I have been asked to provide evidence in relation to:

i. Infrastructure Capacity Overlay

ii. Rainwater tanks – non potable use

iii. Tree Canopy and Deep Soil Areas

2.10 My evidence will address the following topics in order:

i. Background

ii. Benefits of redevelopment

iii. Infrastructure Planning

iv. Managing Infrastructure Constraints

v. Rainwater Reuse Tanks

vi. 10mm Retention Requirement

vii. Stormwater Quality and Quantity Discussion

viii. Waikato River Flows

ix. Tree Canopy and Deep Soil Areas

x. Conclusion

2.11 Where appropriate and relevant, my evidence will reference and rely on the evidence by Michael Campbell (planning) and Brendon Liggett (corporate).

3. BACKGROUND

3.1 A key outcome of the National Policy Statement on Urban Development is to minimise barriers that constrain the ability to deliver housing development across public housing, affordable housing, affordable rental, and market housing.

3.2 PC12 proposes an extensive Infrastructure Capacity Overlay which requires a Three Waters Infrastructure Capacity Assessment to be undertaken where:

i. Three or more residential units are proposed within the General Residential Zone

ii. Four or more residential units/lots are proposed

iii. Net site area per residential unit is less than 200m^2 in the General Residential Zone

iv. Net site area per residential unit is less than 150m^2 in the Medium Density Zone

3.3 The capacity assessment and limit on density per lot is required based on the Hamilton City Council ("**HCC**") assessment showing that the future stormwater, water and wastewater networks will have significant issues unless additional infrastructure is planned.

3.4 As detailed through the evidence of Mr Brendon Liggett, Kāinga Ora has submitted that the Overlay be removed as it unnecessarily complicates the planning framework by having to consider infrastructure capacity.

3.5 I acknowledge the statutory status and content of Te Ture Whaimana but, for reasons set out below, consider that it can be complied with and given effect to (insofar as it relates to infrastructure capacity and effects) through alternative controls than those proposed by HCC.

4. BENEFITS OF REDEVELOPMENT

4.1 The impact of a compact urban form and redevelopment on infrastructure requirements can be generally viewed as positive. By concentrating growth within existing serviced areas, a compact urban form and associated infrastructure investments can have positive effects such as the following:

i. It allows authorities to capitalise on and optimise investment decisions relating to renewal and growth programmes, (i.e.: it provides an opportunity to benefit from programmes relating to the replacement of aging or failing assets).

ii. By minimising the extent of urban form beyond existing limits, it can reduce adverse impacts on the environment.

iii. It minimises the total area to be serviced.

iv. It minimises the total linear length of infrastructure required.

v. It reduces the carbon footprint of development.

vi. Redevelopment can reduce water demand through water efficient appliances and plumbing fittings.

vii. Redevelopment can progressively reduce inflow and infiltration to the wastewater system from private drainage by replacing older earthenware pipes with PVC, freeing up capacity for growth.

viii. It can provide greater security of supply for water infrastructure through duplication and pipe upgrades to service growth.

ix. It can reduce existing wastewater overflows.

x. It can reduce flooding hazards and risks in existing developed areas.

xi. It can reduce contaminants in runoff from existing serviced areas with improved water quality outcomes.

xii. It can result in more efficient use of existing infrastructure as some local infrastructure components have spare capacity due to the specification of minimum-sized pipelines. For example, public wastewater pipes typically have a minimum diameter of 150mm. A pipe this size may service only a dozen or so houses but has the potential capacity for up to approximately 250 dwellings.

4.2 By permitting and allowing for redevelopment in the GRZ and MRZ zones, it is likely that the benefits of redevelopment and growth listed above in **Error! Reference source not found.** will be realised.

4.3 However, without sufficient growth and redevelopment alongside appropriate enabling provisions in the District Plan, the ability to

redevelop in accordance with the zone outcomes will be difficult, and there will be pressure to release more Greenfield land for development that overall will have a greater effect on the Waikato River and its tributaries.

5. INFRASTRUCTURE PLANNING

5.1 Infrastructure planning is the process whereby detailed planning work assesses existing capacity, predicts further demands and issues and undertake assessments in investigations to develop an optimised investment plan for implementation.

5.2 While I agree that the PC12 reports show infrastructure capacity issues, this is not an uncommon occurrence when changes are made through planning documents or when undertaking assessments for future growth.

5.3 In fact, it is nearly always the case that the planning for growth will generally allow for more development than the existing infrastructure can currently service. This is especially relevant to greenfield areas, where no infrastructure usually exists when plans are approved.

5.4 Councils and infrastructure providers undertake planning, design and constructing of three water infrastructure using long time frames e.g. 100 years or more, given the expected life of an infrastructure asset.

5.5 Following changes to planning documents, review of growth (actual and planned) it is common for infrastructure providers to review and update infrastructure plans taking into consideration the ultimate population predictions.

5.6 Overall, and the ability to redevelop and grow within the existing urban environment, enables a variety of housing typologies to be developed to meet demand across Hamilton.

5.7 However, there is no certainty as to where and how development within a city or township will occur under any development scenario, as it is market driven.

5.8 The impact of growth on infrastructure capacity will always be difficult to predict. However, prioritising trunk and bulk upgrades over localised upgrades allows infrastructure providers to provide capacity and enable growth to occur over the largest possible service area. In addition, it can remove local network constraints due to backwater conditions from the trunk/bulk networks.

5.9 Infrastructure planning takes into consideration that not all land will develop to the full potential of the plan. Providing planning provisions that enable development, is not the same as that development occurring.

5.10 Infrastructure planning and upgrades will generally account for the fact that there is uncertainty to growth and development forecast and not all lots will develop to their full potential, as the release of land for more intensive development does not always result in that land being developed. For example, a development in Point Chevalier, Auckland, immediately adjacent to the town centre and zoned "Terrace Housing and Apartment Buildings Zone" with a permitted building height of 16m is constructing over 15 townhouses of only two storeys.

5.11 Infrastructure planning considers a wide range of factors, not limited to growth uncertainties, funding, costs, benefits and expected life of an assets to determine an optimal investment profile for implementation.

6. MANAGING INFRASTRUCTURE CONSTRAINTS

6.1 HCC propose to add an Infrastructure Capacity Overlay to require a restricted discretionary consent for residential development, based on a density control. This adds complexity and cost to small scale development proposals, which I understand have less of an ability to absorb the costs and time delays of resource consent. I consider this density control to be unnecessary for the reasons that follow.

6.2 Firstly, there are several alternative mechanisms available to Council/Infrastructure providers to manage connections to the network and effects. These include the relevant local Bylaws, Asset Owner rights, Local Government Act and the Building Act. Under the existing Bylaws, LGA and Building consent process, Council has an ability to decline connections to infrastructure, if no capacity is available.

6.3 Secondly, in my opinion there is insufficient justification or need for the Infrastructure Capacity Overlay and the density limits proposed under the General Residential Zone (GRZ) and Medium Density Zone (MRZ) given the effect of the provisions as set out below:

i. Changes to 4.1.1 Residential Zones – Purpose;

ii. Changes to Table 1.2.2.5b Information required for each type of Three Waters Infrastructure Capacity Assessment;

iii. Changes to Three Waters Infrastructure Capacity Assessment (Chapter 25);

iv. Reduction of the permitted dwellings numbers from three to two in the GRZ; and

6.4 I address each of these in turn, including identifying where I think further changes are required:

6.5 **4.1.1 Residential Zones - Purpose**: The Residential Zones purpose statement now includes additional text which states that a development wanting to connect to the city's water, wastewater and stormwater networks may require additional approval through the Three Waters Connection Policy and that this process sits outside of the conventional resource management planning process. This inclusion makes it clear to people wishing to develop (including "permitted" activities) that developments wishing to connect to the public three waters networks will a require an additional approval outside the District Plan.

6.6 Further, under the existing Bylaws, LGA and Building consent process, Council has an ability to decline connections to infrastructure, if insufficient capacity is available.

6.7 **Table 1.2.2.5b Information required for each type of Three Waters Infrastructure Capacity Assessment**: There is no difference in the information required by Table 1.2.2.5b for sites inside or outside the Three Waters Infrastructure Capacity Overlay.

6.8 **Changes to Three Waters Infrastructure Capacity Assessment (Chapter 25):** A three Water capacity Assessment is required for any development involving four or more dwellings, irrespective of whether or not it is located in the Infrastructure Capacity Overlay. The only difference for site in the Infrastructure Capacity Overlay is that an infringement to the density trigger or three residential units on a site located in the GRZ would trigger a Three Waters Infrastructure Capacity Assessment. I explain below I do not consider there to be material difference in effects generated in either of these scenarios.

6.9 **Reduction of the permitted dwelling numbers**: The reduction in the number of permitted dwellings in the GRZ and MDRZ provides an opportunity to use exceedance of the permitted dwelling numbers rather than exceedance of the density standard as the threshold for an infrastructure capacity assessment, as in my view there is unlikely to be any practical difference in infrastructure capacity terms between utilising a density trigger of 1:200m^2 / 1:150m^2 or a dwelling trigger of 3 + / 4+..

6.10 That is, in my view a simpler approach would be to remove the density controls and include assessment criteria for 'Infrastructure Capacity' to the Restricted Discretionary Rule associated with developments where the permitted number of dwellings is exceeded. This would ensure that Council are able to consider this at resource consent stage, where the number of permitted dwellings are exceeded without complicating the provisions with defacto density controls, as

discussed through the evidence of Messrs Michael Campbell and Brendon Liggett.

6.11 For example, a two-lot development exceeding the proposed density controls of 200m^2 in GRZ, is unlikely to be declined unless there are already restrictions on connections within an area. It is extremely improbable that one or even two additional dwellings will be the tipping point to halt all new connections in a catchment regarding water and wastewater supply.

6.12 Any water or wastewater modelling or calculation assessment of the public network is not sufficiently accurate to assess the effects of one or two additional houses and are well within the margins of error of a calibrated model.

6.13 For example, the table below summarises the insignificant difference in wastewater flows for a two- or three-unit development from the PC12, assuming they infringe the density limit. For simplicity purposes 400m^2 and 450m^2 sites have been used for GRZ and MRZ respectively.

Development/Coverage	Pre-Redevelopment One Dwelling Site less than 4Post 00m2	Post-Redevelopment Two Residential Units in GRZ site less than 400m2	Pre-Redevelopment Dwelling Site less than 450m2	Post Redevelopment Three Residential Units in MRZ site less than 400m2
Peak Daily Flow (L/s)	0.089	0.176	0.089	0.264
Peak Wet Weather Flows (L/s)	0.096	0.184	0.097	0.272

6.14 The difference in flows is negligible and it would not be possible to assess the effects of the additional demands on the network. Therefore, either the connections need to be approved or the area will already be embargoed due to a capacity constraint, and this would apply to all new connections, irrespective of activity status.

6.15 In addition, as the density per lot decreases, this increases the likelihood that a smaller dwelling will be built, e.g., one- or two-bedroom houses, further reducing the likely difference between pre and post development flows.

6.16 I do not consider the density control is warranted in stormwater terms either. This is because in relation to stormwater runoff, it is not the density that is relevant, but the impervious coverage of a site.

6.17 For example, the redevelopment of a site on a lot scenario will likely result in the same or similar stormwater discharges and effects as building and impervious coverage controls are based on percentages. These controls are the same irrespective of whether one, two or three dwellings are proposed and does not support the application of a density limit.

6.18 In addition, developments under the Regional Infrastructure Technical Standards (**RITS**) are required to match pre-development flow rates for the 2- and 10-year Average Recurrence Interval (ARI) storm events through controlled attenuation and multistage outlets or devices that reduce the runoff flow. Additional storage is required to limit the post development 100-year ARI event flow rates to 80% of the pre-development 100-year ARI event flow rates, where downstream flooding is identified.

6.19 Therefore, it can be concluded that redevelopment of sites into either two or three dwellings will more than likely have the same stormwater flows and contaminant loads in terms of environmental effects on the Waikato River, irrespective of density controls.

6.20 Over the years I have been involved in the management of several development restriction “red zones” in my role at Watercare, and North Shore City Council. At both organisations, we did not use or seek rules in the District or Unitary Plan to control connections, as it was considered to be cumbersome and duplicates existing processes.

6.21 Overall, it is my opinion that the Infrastructure Constraint Overlay and proposed density limits are not the most efficient method for

managing infrastructure capacity constraints and I support the request of Kāinga Ora for the removal of this overlay and the associated density controls in the GRZ and MRZ.

7. STORMWATER MANAGEMENT AND WATER CONSERVATION

7.1 Through PC12, Hamilton City Council is proposing to require all new residential dwellings to install rainwater reuse tanks for non-potable use. In addition, Rule ***25.13.4.2A Stormwater – Residential zones***, specifies onsite retention requirements including 10mm of runoff depth and retention of rainwater through a combination of rainwater capture appropriately connected to the building for non-potable reuse. These are being imposed to manage effects of stormwater runoff and water conservation. I disagree with the proposal to rainwater reuse tanks and with the retention requirements for the reasons set out below.

Rainwater Reuse Tanks

7.2 As set out above, Hamilton City Council is proposing to require all new residential dwellings to install rainwater reuse tanks for non-potable use. Refer to:

i. **25.13.4.2A f) C.** states: "*The retention is to be provided through a combination of rainwater capture appropriately connected to the building for non-potable reuse, and infiltration via targeted soakage within the lot boundary.*"; and

ii. ***25.13.4.5 Water Conservation Measures*** - *The following water sensitive technique for water conservation measures shall be incorporated, connected to, achieved, or maintained as part of any new development as identified below*. The requirements include *Rainwater tank of minimum size of 3,000 litres for non-potable* use (e.g., garden watering, toilet, or laundry).

7.3 HCC has removed the ability to use "other equivalent features" instead reuse tanks, such as detention tanks, for managing stormwater effects from residential roofs. However, within non-

residential zones, a rainwater tank for non-potable use is an optional solution for managing the stormwater effects. That is, a rainwater tank must be provided within the residential zones, but non-residential zones have a range of solutions available to them.

7.4 Kāinga Ora submitted in opposition to the amendments to the on-site stormwater rules made under 25.13.4.2A Stormwater – Residential zones from PC12. I understand that Kāinga Ora is not opposed to stormwater controls and water conservation measures where they are appropriate, but opposes limiting the tools available to developers to manage effects and conserve water that achieve the overall desired outcome. I agree.

7.5 Kāinga Ora commissioned MPS to undertake a case study alongside a redevelopment example, to demonstrate the difference in providing a detention versus a reuse tank within a residential development. The conclusion of the study was that the on-going maintenance and costs associated with a reuse tank were far greater than that of a detention tank, with very little to no additional benefits on the public infrastructure networks. A copy of the study is attached to this evidence as **Attachment A**.

7.6 The analysis undertaken on behalf of Kāinga Ora for proposed developments in Hamilton suggests that a typical rainfall reuse system designed to accordance with HCC Practice Note:

i. Will run dry frequently throughout the year;

ii. Will not reduce peak demand during dry weather on the public water supply system;

iii. Is expensive and costly to operate and maintain;

iv. Will be significantly more expensive to operate per m^3 of water than the public water supply;

v. Presents potential public health risks to tenants;

7.7 Noting that public water supply systems are designed, consented, and constructed for peak demand. A water utility operator will need to assume no reduction from the implementation of reuse tanks due to the frequency that they run dry during dry weather conditions.

7.8 Other concerns identified in that report included that:

i. Reuse tanks are less resilient to power outages and failures;

ii. Disinfection treatment of the non-potable reuse is recommended by overseas studies and authorities. Disinfection would add additional operation and maintenance requirements, including costs;

7.9 Overall, the report concluded that the benefits of the reuse systems are limited, and any benefits can all be achieved by other means e.g.: by using alternative stormwater devices and water supply efficiency measures which have a lower whole of life cost.

Detention tanks - Stormwater Water Quality and Quantity Discussion

As indicated above, HCC has removed the ability to use "other equivalent features" instead of reuse tanks, such as detention tanks, for managing stormwater effects from residential roofs. Detention tanks are a more than adequate solution to manage and control stormwater runoff from impervious surfaces.

7.10 The Waikato Regional Council ("**WRC**") Stormwater Guidelines (refer page 91-92) states the following: "*As can be seen from the table above* (Table 6-9*), concrete tiles, colour steel and gravel have low contaminant discharge potential and hence it is considered that runoff from these surfaces does not require water quality treatment.*"

7.11 The above shows that water quality treatment is not required for all impervious surfaces, as there is limited if any benefit to do so. This is also consistent with the HCC Practice Note for rainfall reuse tanks to divert first flush stormwater away from the tank.

7.12 Stormwater detention tanks designed to attenuate flows help manage peak stormwater discharges to the environment effectively. These systems are less complex, more reliable, and cost-effective compared to rainwater reuse systems.

7.13 Detention tanks used in conjunction with infiltration devices (where practical) can manage the effects of impervious surfaces in urban areas by reducing peak flows and volumes to local water bodies, which is crucial for protecting downstream environments from erosive forces.

7.14 Detention tanks are a more than adequate solution to manage and control stormwater runoff from impervious surfaces and is one of the tools in the toolbox outlined in the WRC Stormwater Guidelines.

Rainwater reuse - 10mm Retention Requirement

7.15 As indicated above, HCC has introduced at least 10mm runoff depth to be retained onsite as Stormwater management measure. In my view Council have not done the necessary analysis to introduce this control.

7.16 The PC12 first Section 32 report states the following:

"*It was determined that retaining 10mm of runoff depth onsite and would mimic natural catchment conditions and meet required technical parameters. It was also determined that a combination of rainwater capture/reuse and infiltration is optimal to achieve this and can support retention of 60-70% of the mean annual rainfall volume, with the reuse of 20-30% of mean annual volume mimicking natural levels of water loss through evapotranspiration*."

7.17 However, the technical reports prepared for Council provides no references to support the claim of 60-70% natural inception rates stated or provide any modelling results (based on calibrated flows) to demonstrate these figures are accurate for Hamilton. In addition, it appears that the modelling undertaken has not included the first flush diversion as set out in the Rainwater Reuse Practice Note HCC02, and therefore may overestimate the reduction in runoff volume etc

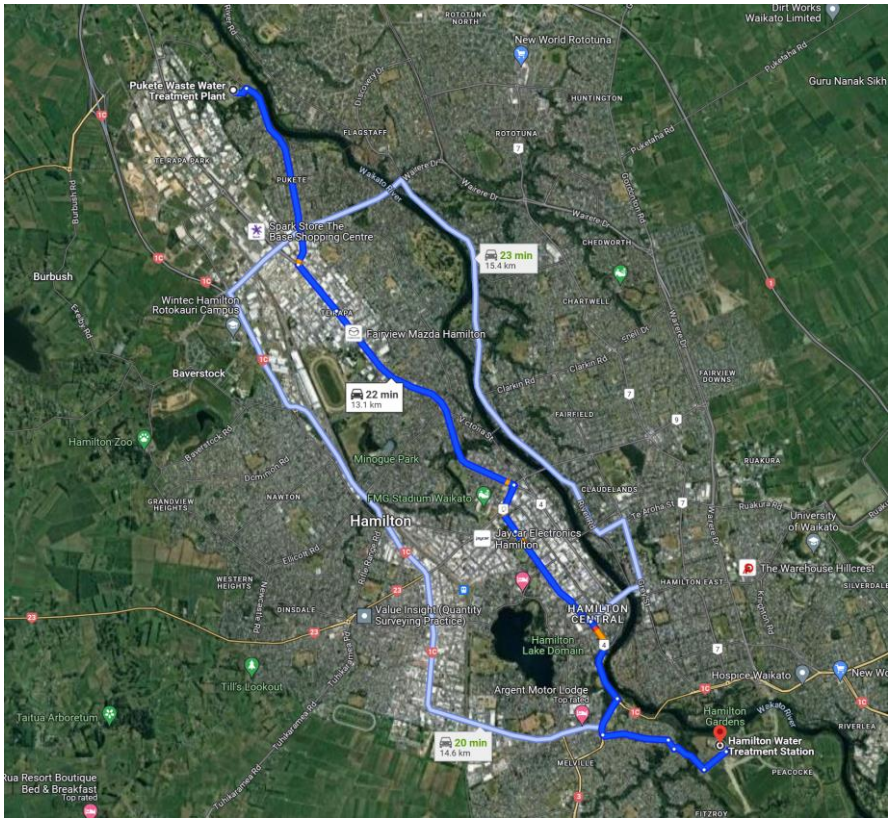
7.18 In my opinion, the technical reports do not provide sufficient analysis or assessment to support the 10mm retention depth proposed and the 60-70% natural inception rates or adequately consider the risks, and sustainability of the proposed approach against alternative stormwater management approaches.

7.19 It is important to note that Auckland Council's proposal for 10mm retention in the Proposed Auckland Unitary Plan ("**PAUP**") was reduced to 5mm through detailed modelling analysis undertaken for the PAUP hearings process.

7.20 In addition, Auckland Council through the PAUP only applies retention or detention requirements in limited brownfield stormwater catchments, due to the level of imperviousness that had already occurred and expected level of effects from redevelopment.

8. WAIKATO RIVER FLOWS

8.1 The following maps shows the location of the Water Treatment Plant and the Wastewater (Pukete) Treatment Plant that services Hamilton.



8.2 The distance between the two points is approximately 15 kilometres along the Waikato River.

8.3 Rainfall reuse is unlikely to have any measurable effect on flow rates on the Waikato River because:

i. Any water extracted from the Waikato River for water supply is returned via the wastewater treatment plant discharge. It is assumed (as is typical) that the Wastewater Treatment Plant (WWTP) discharges more water to the Waikato River than the corresponding water take extracts. This is because the wastewater system receives and transports water from wet weather events and groundwater base flows.

ii. Any rainwater reuse water collected for indoor use reduces the stormwater runoff flow that would increase the Waikato River flows. Any reuse used indoors will be returned to the River via the WWTP discharge.

iii. Any reduction in water demand from the Waikato River by the public water system due to rainwater reuse will be offset by a reduction in stormwater runoff to the Waikato River due to the diversions to rainwater reuse tanks.

iv. The mean flows of the Waikato River - Hamilton Traffic Br[1] is 257.16 m^3/s. The highest recorded flow (m^3/s) is 790.72 m^3/s. on 15/07/1998, with the lowest recorded flow 137.84 m^3/s on 28/12/2016.

v. The Hamilton City Council water take consent provides for increases in maximum daily take volumes to meet demand, starting from 105,000 cubic metres per day in 2009 to 146,315 cubic metres per day from December 2038. This equates to an average water take of 1.22m3/s and 1.69m3/s respectively, noting that this may fluctuate throughout the day to meet demand and top up reservoirs.

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[1] https://www.waikatoregion.govt.nz/environment/envirohub/environmental-maps-and-data/station/43308/FL?dt=Flow

vi. This equates to

A. 2009 - 0.47% of the medium flow and 0.88% of the lowest recorded ever flows.

B. 2038 – 0.66% of the medium flow and 1.23% of the lowest ever recorded flow.

vii. Ms Colliar[2] states in her evidence for the Strategic Hearings that "*the Water Treatment Plant has a current peak production capacity of 106,000 m^3 per day, which results in a maximum daily abstraction capacity of 111,000 m^3 per day*". This equates to an average abstraction rate of 1.28m^3/s, or 0.5% of the mean flows of the Waikato River.

viii. Based on the above numbers, rainfall reuse is unlikely to have any measurable effect on flow rates on the Waikato River, and marginally changes the locations of where water is taken in or out of the Waikato River system. The figures are likely to be well below the margin of error of any flow measuring device on the Waikato River.

9. TREE CANOPY AND DEEP SOIL AREAS

9.1 The Council has sought to include 'tree canopy" and 'deep soil areas' within the modified PC12 provisions, as outlined in Mr Campbell's evidence.

9.2 As Mr Campbell's evidence states in paragraph 10.1, *"these amendments appear to be in response to submissions concerning the reduction and fragmentation of permeable areas as a consequence of residential development intensification, and the resultant loss of adequate contiguous soil volume for specimen tree planting and stormwater infiltration."*

9.3 Redevelopment of sites may use a variety of stormwater tools to manage the effects of impervious coverage. In my opinion, the prescriptive rules for tree canopy and deep soil areas are not required

[2] vii. The Statement of Evidence of Jacquelin Maree Collair dated 20 December 2022

from a stormwater management perspective. A sufficient range of methods and tools are already available to developers to manage the effects of stormwater on receiving environments.

9.4 These methods may include options such as permeable paving, as it is included in the definition of permeable surfaces as they can pass water to the ground below. Permeable paving can serve an important function, allowing water to recharge streams and groundwater systems below.

9.5 In addition, there are a range of unintended consequences whereby the placement of trees and deep soil zones (uncompacted) impact others (e.g., shade, building/foundation damage, leaf litter etc…) and/or underground infrastructure. For example, trees planted above or near underground infrastructure, can cause network blockages and a significant amount of damage to pipes as the trees and root systems grow. The root system of trees can extend beyond the width of the overhead canopy.

9.6 The addition of tree canopy and deep soil areas merely adds complexity and compliance costs to an expanding list of permitted standards in residential zones.

9.7 I support Mr Campbell's recommendation that:

i. the urban tree canopy rules and associated references within the objectives, and policies of the residential zones, be retained as per the notified provisions; and

ii. The requirements for deep soil areas within 4.2.5.3 and 4.3.5.3 are removed, along with the associated definition and reference within objectives and policies.

10. CONCLUSION

10.1 It is now clear in PC12 that a development wanting to connect to the city's water, wastewater and stormwater networks will be required to obtain an additional approval through the Three Waters Connection

Policy, which sits outside of the conventional resource management planning process.

10.2 Further, under the existing Bylaws, LGA and Building consent process, Council has an ability to decline connections to infrastructure, if no capacity is available.

10.3 Therefore in my view Infrastructure Capacity Overlay and density limits can be removed via proposed amendments made to the Three Waters Infrastructure Capacity Assessments. The difference in flows is negligible and it would not be possible to assess the effects of the additional demands on the network.

10.4 I do not consider the Infrastructure Capacity Overlay is justified on stormwater terms either. This is because the redevelopment of a site under either the two or three dwellings per lot scenario can and will likely result in the same or similar stormwater discharges and effects, as the building coverage and impervious surface controls are based on percentages and are the same irrespective of whether two or three dwellings are proposed.

10.5 Through PC12, Hamilton City Council is proposing to require all new residential dwellings to install rainwater reuse tanks for non-potable use. I do not agree with this requirement for the following reasons:

i. A typical rainfall reuse system designed to accordance with HCC Practice Note, will run dry frequently during dry periods throughout the year and does not relieve any design pressure on the ultimate capacity of public water supply system.

ii. The high costs, maintenance tasks, and public health risks, raises serious questions around the ongoing affordability and sustainability of the reuse schemes against alternatives, including using the public supply and the use of detention tanks.

iii. The benefits of the reuse systems are limited, but these can all be achieved by other means using alternative stormwater devices and water supply efficiency measures at a lower whole of life cost.

iv. HCC has not demonstrated rainwater reuse systems are an appropriate long term sustainable solution.

Philip Jaggard
26 July 2024

- **Attachments (Attachment A: Stormwater Reuse Assessment)**

Kāinga Ora Hamilton Redevelopment Projects

Stormwater Reuse Assessment Report

Draft

24 July 2024

Stormwater Reuse Assessment Report

Prepared for:

Kāinga Ora

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Revision	1
Status	Draft
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EXECUTIVE SUMMARY

This Stormwater Reuse Assessment has been prepared for Kāinga Ora in relation to Hamilton City Council (HCC) proposed requirements to install rainwater reuse systems on all new developments through the proposed Plan Change 12 (PC12) District Plan provisions, and the Regional Infrastructure Technical Specifications (RITS) document.

Rainwater reuse systems are commonly promoted as being a green sustainable solution for stormwater management and for reducing water demand on public supplies and sources. However, as our analysis shows, a typical rainfall reuse system designed in accordance with HCC Practice Note, will run dry frequently throughout the year and not relieve any design pressure on the public water supply system. Public water supply systems are designed, consented, and constructed for peak demand and drought conditions. A utility operator does not typically assume any reduction in demand from the implementation of reuse tanks due the frequency that they run dry, especially during drought conditions.

Our analysis shows that the cost per m^3 water harvested from a well-maintained rainwater reuse system is high ranging from 5.5 to 18.1 times more expensive than water supplied from a public water supplier if volumetric charging was applied.

As Hamilton does not charge for water volumetrically, there is no saving to the property owner from reduced water charges. Therefore, the high costs associated with implementing reuse systems raises serious questions around the ongoing affordability and sustainability of the schemes against alternatives, including using detention tanks and public supply system.

Research shows that rainfall reuse systems are typically not well maintained and if they are – then they are expensive to operate. Rainfall collected for reuse is likely to contain harmful contaminants, such as bacteria and viruses which can cause illnesses or infections. Public health risks around the use of rainwater purely for toilet flushing and irrigation are now being studied overseas, with some authors and authorities recommending the use of disinfection treatment processes.

Many of the claimed benefits of reuse systems can all be achieved by other means using alternative stormwater management devices (e.g. detention tanks) and water supply efficiency measures (low flow devices) at a lower whole of life cost.

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CONTENTS

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1. INTRODUCTION

1.1 Background

Kāinga Ora aims to optimize land use by upgrading older state houses with newer, well-insulated homes in areas of high demand, including Hamilton. To achieve this goal, Kāinga Ora is undertaking redevelopment projects of existing housing stock to provide more housing for those most at need.

Kāinga Ora is a provider of tenancy services to about 200,000 tenants, maintaining 69,000 homes and delivering 1,100 new additional homes each year, with an aim to improve environmental wellbeing through their construction and urban development activities, and to catalyse positive change across the broader New Zealand industry.

Kāinga Ora wish to ensure sustainable practices[1] are integrated into the way they plan urban development areas, build homes and do business. The six key priority areas as follows:

- support a transition to low-carbon construction,
- improve biodiversity and urban ngahere (forest) outcomes in our communities,
- protect and restore waterways surrounding development areas,
- support low-carbon transport,
- reduce construction and demolition waste,
- ensure homes and communities are resilient to future climate change impacts.

Hamilton City Council (HCC) is proposing to require the use of rainwater reuse tanks to be installed on all new developments through the proposed Plan Change 12 (PC12) District Plan provisions and the Regional Infrastructure Technical Specifications (RITS). (refer to Section 1.2 for further details)

Kāinga Ora is concerned about the effects and sustainability of this requirement in relation to its operational activities and costs. PC12 as drafted, essentially does not facilitate alternative methods for managing roof runoff (e.g. detention tanks) outlined in the Waikato Regional Council Stormwater Guidelines or the Regional Infrastructure Technical Standards (RITS) documents.

1.2 Plan Change 12

Kāinga Ora has commissioned MPS to undertake a detailed assessment of rainwater reuse systems in line with the proposed HCC Rainwater Reuse guidance document prepared for PC12. Kāinga Ora wish to understand if rainwater tanks are a sustainable and cost-effective long-term solution for managing the effects of stormwater on the receiving environment.

Rainwater reuse systems are commonly claimed as being a sustainable solution for stormwater management as they reduce the volume of stormwater runoff, while reducing demand on the public potable water supply.

[1] https://kaingaora.govt.nz/en_NZ/about-us/sustainability-at-kainga-ora/

Through PC12 HCC is proposing to require all new residential dwellings to install rainwater reuse tanks for non-potable use. The updated HCC 02: Rainwater reuse tank (rain tank) Practice Notes for PC12 states the reuse tank is to be connected via a pump (or gravity) to all toilets, irrigation and ideally to the laundry, and may be connected to the outside taps.

25.13.4.5 Water Conservation Measure

a. The following water conservation measures shall be incorporated, connected to, achieved or maintained as part of new development for as identified below:

Where required	***Water sensitive techniques***
i. New residential units in a residential zone. *ii. Other new buildings in a residential zone containing a kitchen, laundry, toilet or bathroom*	• *Provisions for future installation of water metering infrastructure.* • *Use of low flow fixtures in kitchen, laundry, toilets and bathrooms.* • *Rainwater tank of minimum size of 3,000 litres for non-potable use (e.g., garden watering, toilet, or laundry)*

In addition, rule ***25.13.4.2A Stormwater – Residential zones*** *(see below)*, requires retention of rainwater through a combination of rainwater capture appropriately connected to the building for non-potable reuse, and infiltration via targeted soakage within the lot boundary. An exception is permitted where there are poor infiltration rates.

25.13.4.2A Stormwater – Residential zones

Development of all new impermeable surfaces and redevelopment of existing impermeable surfaces greater than 20m2 in area must implement one of the following two stormwater management measures:

i. On-site retention as follows:
  A. Provide retention (volume reduction) of at least 10mm runoff depth on the new and redeveloped impermeable surfaces; and
  B. Where redeveloped impermeable surfaces comprise over half of the total existing impermeable surfaces on the site, redevelopment must also provide retention of 10mm of runoff depth on at least 20% of the remainder of existing impermeable surfaces; and
  C. The retention is to be provided through a combination of rainwater capture appropriately connected to the building for non-potable reuse, and infiltration via targeted soakage within the lot boundary.

ii. Where infiltration is not achievable due to poor infiltration rates, groundwater levels or site conditions, this component of the required retention volume can be replaced by on-site stormwater quality treatment as follows:
  A. *Provide quality treatment for runoff from the 90th percentile 24 hour storm event (25mm) from new and redeveloped impermeable surfaces prior to discharge.*

1.3 Scope of this Report

Kāinga Ora has concerns that the requirement in PC12 to install rainwater reuse systems will create an ongoing costly liability to the organisation and that the solutions are not a long-term sustainable solution. Sustainability consists of fulfilling the needs of current generations without compromising the needs of future generations, while ensuring a balance between economic growth, environmental care, and social well-being.

The Resource Management Act 1991 purpose is to promote the sustainable management of natural and physical resources. Under the Act, "*sustainable management means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while—*

(a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and
(b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and
(c) avoiding, remedying, or mitigating any adverse effects of activities on the environment.

Kāinga Ora concerns in relation to rainwater reuse tanks include:

1. Is the solution the best practical option?
2. Will the desired outcomes be achieved?
3. How does reuse compare to alternatives?
4. What is the long-term likely success of stormwater reuse schemes in developments?
5. What is the whole of life costs (capital and operational) of reuse schemes?
6. What effects and impacts on occupiers will reuse provide?
7. Are there any public health risks or concerns?
8. What are environmental impacts from reuse?

The scope of this report focuses on the proposed HCC requirements for stormwater reuse on residential developments and assesses the benefits, issues, impacts, and costs (Capex and Opex) for installing stormwater reuse schemes for Kāinga Ora as follows:

- Develop individual conceptual reuse schemes based on proposed developments layouts in line with HCC's proposed updated Rainwater Reuse Practice Note HCC02.
- Model and assess the effects of reuse on water supply demand for each development.
- Model and assess the effects of reuse on stormwater discharges for each development.
- Summarise the benefits, issues, and risks of stormwater reuse in a residential development.
- Summarise alternative water efficiency techniques for reducing demand on water supply networks.
- Prepare a multi criteria assessment of rainwater reuse system vs detention tanks.
- Prepare the estimated capital and annual operational costs for the reuse vs an alternative detention tank system. Operational costs will be based on HCC's recommended maintenance obligations.
- Prepare a NPV assessment of a reuse scheme to determine a potential payback period.
- Summary of the above assessment on reuse schemes and recommendations.

Exclusions:

- Design of the reuse scheme.
- Assessment of infiltration for at grade impervious surfaces – it is assumed that one of the following methodologies would be applied from the toolbox of solutions to manage runoff from at grade impervious surfaces and this is subject to detailed site investigations
    - Infiltration devices.
    - Detention tanks.
    - Pervious paving.
    - Others.

It is assumed for the purposes of this report that either of the above solutions can be applied to at grade impervious surfaces to meet the required standards.

2. PROPOSED DEVELOPMENT

3. RAINWATER REUSE CONCEPT DESIGN

To assess the advantages and disadvantages of a reusing stormwater for a range of development types, rainwater reuse concepts were developed in-line with the proposed HCC 02: Rainwater reuse tank (rain tank) Practice Note developed for PC12.

Rainwater reuse concepts have been evaluated for the following development types (based on actual designs):

- six one-bedroom modern apartments (a single three storey building);
- four terrace two bedroom houses, all with a single bathroom/toilet.
- six modern two-bedroom duplexes each with a single bathroom/toilet.

3.1 Standard Rainwater Reuse System

If a rainwater reuse system was to be installed based on the HCC 02: Rainwater reuse tank Practice Note document, the following concept would be installed for each of the building types (refer to Figure 1):

- Reuse scenarios tank volumes:
    - Apartment Building: 5m^3
    - Terrace House (per unit): 3m^3
    - Duplex Roof: 3m^3 (above ground).
- The following pre-treatment would be provided for all scenarios:
    - Leaf guards on gutters.
    - Insect screens.
    - A first flush diverter which diverts the most ‘contaminated’ roof runoff away from the tank.
    - A tank vacuum type overflow which helps to remove sediment build up from the bottom of the tank.
    - A filter at the pump.
    - An inlet system which prevents sediment from being stirred up when the tank is nearly empty.
- Water pump with pressure activated switch connected to:
    - Apartment Building: Each of the six one-bedroom apartments within the building would be connected to a single rainwater reuse system for the building.

    - Terrace House: each dwelling in the block of four would be connected to an individual single rainwater reuse system.
    - Duplex: each individual dwelling in the block of two would be connected to an individual single rainwater reuse system.
- 25mm registered air gap to the mains water supply top up.
- Float valve to top up the tank with mains water supply during dry periods.
- Air vent with insect screen.
- Stormwater overflow to public stormwater system.
- All pipes and taps supplying rainwater reuse water will be colour coded (lilac) and clearly marked.
- All taps connected to the non-potable water source will be clearly marked as not for drinking.

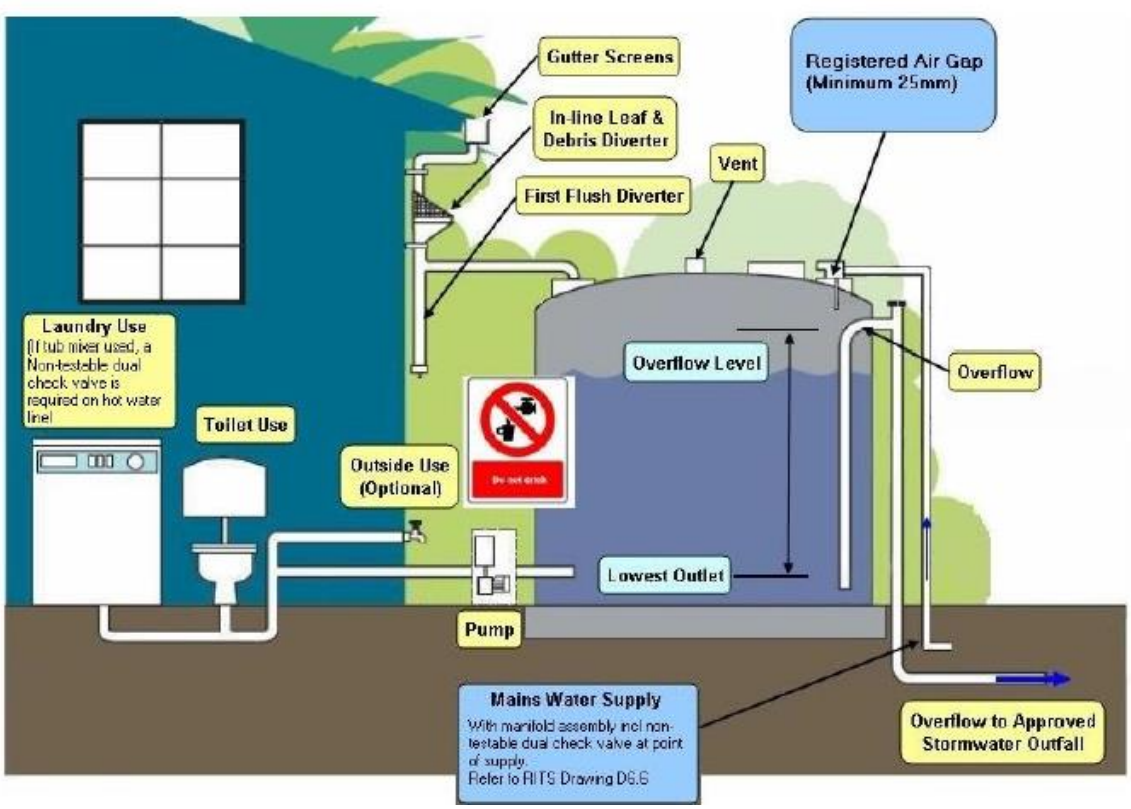


Figure 1: Rainwater reuse tank schematic (above ground)

An above ground tank would be selected for all options to eliminate the more onerous maintenance, access, costs, and confined space requirements of a below ground tank.

4. WATER BALANCE MODEL

4.1 Water Balance Model Concept

A water balance model has been developed using hourly rainfall data to assess the impact of the above rainwater reuse concept on stormwater flows and water supply usage. The following diagram shows a schematic of the water balance model used to model the stormwater discharges and water supply usage of the reuse concept.

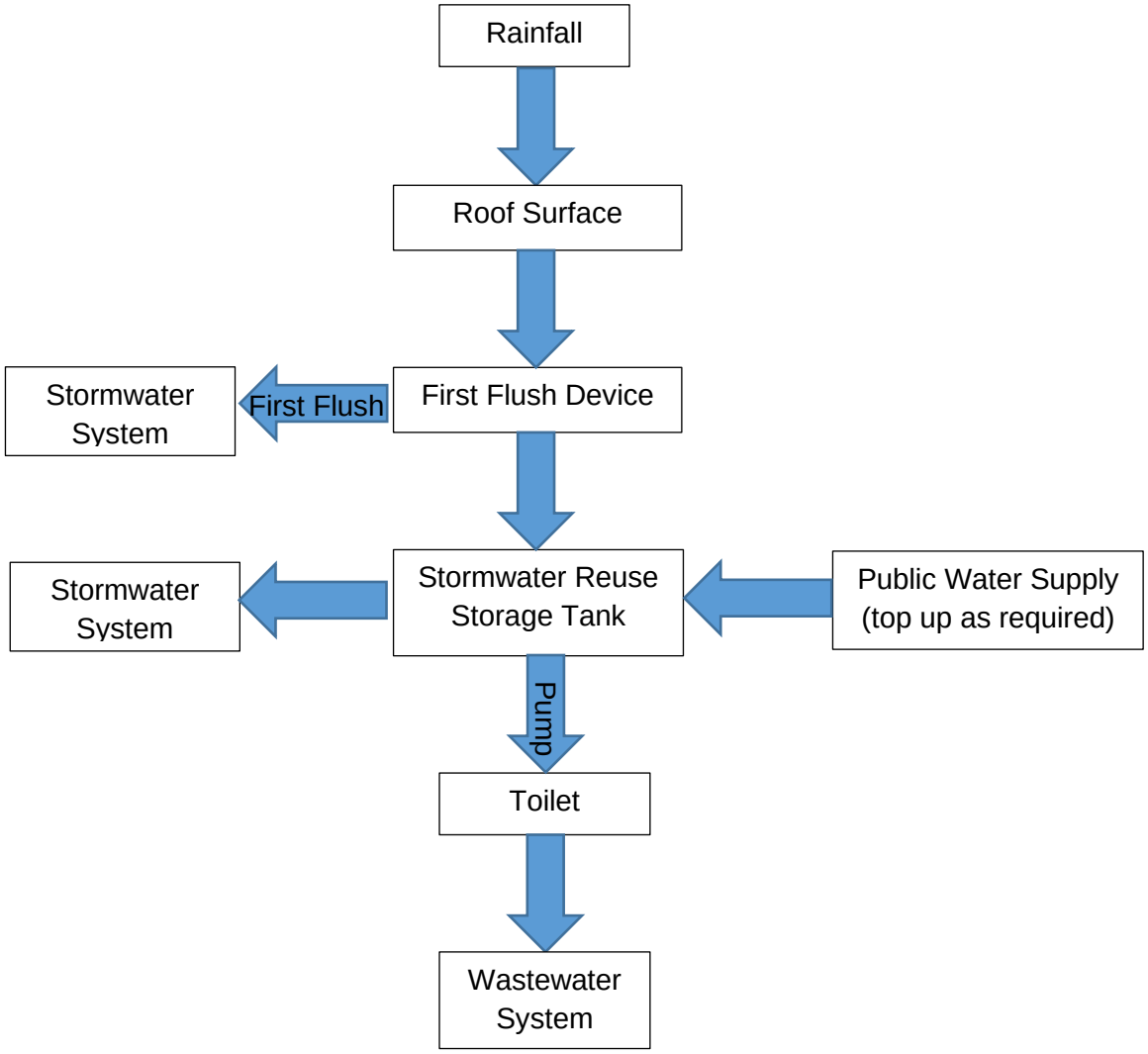


Figure 2: Stormwater Water Balance Model Schematic

It is important to note that first flush stormwater and overflows should not be allowed to pool or to run onto either the property or neighbouring properties or allowed to pool underneath buildings or around foundations (Gaw, 2004).

In addition, the Building Act 2004 E1.3.1 states "*Except as otherwise required under the Resource Management Act 1991 for the protection of other property, surface water, resulting from an event having a 10% probability of occurring annually and which is collected or concentrated by buildings or sitework, shall be disposed of in a way that avoids the likelihood of damage or nuisance to other property*". Therefore, the first flush stormwater and overflow is required to be connected to the stormwater system on site.

4.2 Model Operation and Scenarios

The water balance model operates on an hourly timestep. The model calculates the amount of rainfall collected, stored, discharged to the stormwater system and rainwater used for toilet flushing. In addition, it calculates the volume of mains water required to flush the toilet when the tank is empty. Two scenarios have been modelled as follows:

- Toilet use only.
- Toilet and laundry use.

Outdoor use has not been modelled due to the highly variable nature of use, seasonal fluctuations and risks associated with children who may drink (ignoring any signs) from outdoor taps/hoses.

If the volume within the tank equals 0m^3, then potable water from the public supply is used to flush the toilet. The model is considered conservative as:

- It underestimates mains water supply use by not adding water to the storage tank when empty. In practice, once a tank is nearly empty, the float control valve would open and fill the tank to a specified volume (e.g., 0.5 to 1m^3) lowering the available storage in the tank for rainfall collected water.
- Assumes any rainfall collected is first used for indoor use.
- Excludes outdoor use.

4.3 Model Inputs and Assumptions

Average daily water use per person has been applied at 260 L/person/day, based on HCC RITS document. Information gathered from HCC Long Term Plan (LTP) indicates that the current water supply consumption per person in 2022/2023 was 305 L/person/day. The LTP target for the following ten years is for water supply consumption to be less than 400L/person/day.

Several studies on the percentage of water used in the household for toilet flushing and laundry use in New Zealand ranges from 17% and 21% and 14% to 24%, respectively. A midpoint of 19% for toilet use was selected for modelling purposes. A midpoint of 38% was selected for toilet and laundry use.

As the apartment building consists of one-bedroom dwellings, a reduced occupancy level of two people per unit was applied from the standard 2.7 in the RITS document. Indoor use was calculated as follows:

Apartment Building (total six one-bedroom apartments)

- Toilet use only = 19% of the average number of people (12.0) x 260 L/p/day = 593L/day.
- Toilet and laundry (cold only) use = 38% of the average number of people (12.0) x 260L/p/day = 1,186L/day.

Terrace House (per unit – two bedrooms)

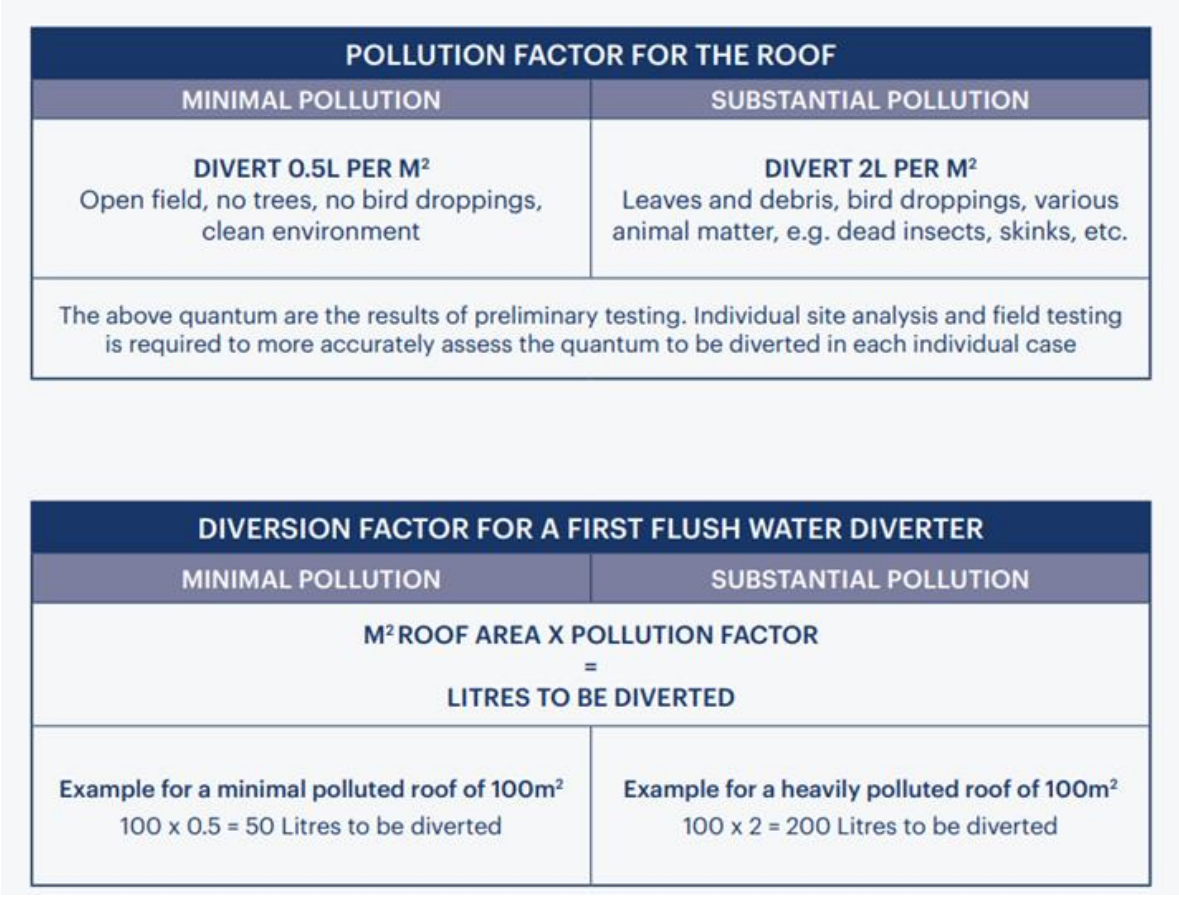
- Toilet use only = 19% of the average number of people (2.7) x 260 L/p/day = 133L/unit/day.
- Toilet and laundry use = 38% of the average number of people (2.7) x 260 L/p/day = 266L/unit/day.

Duplex (per unit – two bedrooms)

- Toilet use only = 19% of the average number of people (2.7) x 260 L/p/day = 133L/unit/day.
- Toilet and laundry use = 38% of the average number of people (2.7) x 260 L/p/day = 266L/unit/day.

Internal water demand (representing toilet flushing and laundry) was modelled as a constant demand applied split evenly throughout the day.

ProMax (a supplier of first flush devices) recommends the following pollution factors (refer Figure 3) for First Flush devices.



POLLUTION FACTOR FOR THE ROOF	
MINIMAL POLLUTION	SUBSTANTIAL POLLUTION
DIVERT 0.5L PER M² Open field, no trees, no bird droppings, clean environment	**DIVERT 2L PER M²** Leaves and debris, bird droppings, various animal matter, e.g. dead insects, skinks, etc.
The above quantum are the results of preliminary testing. Individual site analysis and field testing is required to more accurately assess the quantum to be diverted in each individual case	

DIVERSION FACTOR FOR A FIRST FLUSH WATER DIVERTER	
MINIMAL POLLUTION	SUBSTANTIAL POLLUTION
M² ROOF AREA X POLLUTION FACTOR = LITRES TO BE DIVERTED	
Example for a minimal polluted roof of 100m² 100 x 0.5 = 50 Litres to be diverted	**Example for a heavily polluted roof of 100m²** 100 x 2 = 200 Litres to be diverted

Figure 3: First Flush Calculation (ProMax Website)

As the rainwater reuse scheme is not used for drinking purposes, applying the minimum ProMax pollution factor of 0.5L/m^2, equates to a first flush diversion volume of:

- Apartment Building: 64.5L
- Terrace House (per unit): 21.5L
- Duplex Roof (per unit): 27.5L.

However, a first flush device was trialled and measured to determine the expected volume discharged over an hour for inputting into the model. Testing confirmed that the flow rate in a first flush device varies by the head in the pipe, but on average could empty at an average rate

of approximately 25L/hour. This is similar to the minimum diversion volume recommended for the Duplex and the Terrace House. For simplicity purposes a first flush flow rate of 25L/hour was applied to the model for all dwellings. This will underestimate the amount of runoff that will be diverted directly to the stormwater system from the apartment building.

The following provides a summary of the modelling inputs and assumptions:

1. Hourly rainfall data has been taken from the CliFlow NIWA database for the nearest rainfall gauge Ruakura, Hamilton (Agent ID: 26117), for the period 09/11/2005 15:00 to 08/03/2023 00:00.
2. Missing rainfall data was identified between 01/03/2016 10:00 and 29/03/2016 10:00 and was populated by substituted from the previous year.
3. Model simulation duration = approximately 17.3 years.
4. Roof (catchment) area:
    a. Apartment building = 129m^2
    b. Terrace house = 43m^2;
    c. Single unit in Duplex = 55m^2
5. A roof runoff coefficient of 100% has been applied, however, some loses from roof splatter could be expected to occur.
6. Storage Tank Volumes:
    a. Apartment Building = 5m^3
    b. Terrace House – each unit = 3m^3
    c. Duplex – each unit = 3m^3
7. Initial storage tank volume = 1.5m^3
8. Daily water consumption per person = 265L/p/day
9. Apartments - Average number of people per one-bedroom apartment = 2.0
10. Apartment Building - Total number of people = 12.0
11. Terrace House and Duplex Units - Average number of people per dwelling = 2.7
12. Apartment Building Total Internal non-potable toilet use = 593L/day/building
13. Apartment Building Total Internal non-potable Toilet and laundry use = 1,186L/day/building
14. Terrace House and Duplex Internal non-potable toilet use = 133L/day/dwelling
15. Terrace House and Duplex Internal non-potable Toilet and laundry use = 266L/day/dwelling
16. First flush diversion per hour = 25L/hour when raining
17. If the storage = 0m^3, the toilet and laundry is supplied from the public water supply system.

4.4 Results Apartment Building

Table 1 and Table 2 provides a summary of the results of the water balance model (calculating averages over the 17.3-year period) for the proposed Apartment Building rainwater reuse concept.

Table 1: Water Balance Model Results – Toilet Use only

Parameter	Average (m^3/year)	Runoff Breakdown	Toilet Use Breakdown
Indoor Use Demand	216.5		100%
Roof Runoff	145.7	100%	
First Flush Diverted	25.8	18%	
Rainfall water used indoors	119.7	82%	55%
Storage tank overflow volume	0.2	<0.2%	
Potable Supply	96.8	N/A	45%

Table 1 shows that approximately 55% of the total demand of toilet flushing can be met by the storage tank, with the remainder being met by the potable supply, suggesting the tank will be empty for nearly one half of the year. Approximately one fifth of rainfall collected on the roof will be discharged via the first flush device and the tank will rarely ever overflow to the stormwater system.

Table 2: Water Balance Model Results – Toilet and Laundry Use

Parameter	Average (m^3/year)	Runoff Breakdown	Toilet and Laundry Use Breakdown
Indoor Use Demand	433.0	N/A	100%
Roof Runoff	145.7	100%	
First Flush Diverted	25.8	18%	
Rainfall water used indoors	119.7	82%	28%
Storage tank overflow volume	0.2	<0.2%	
Potable Supply	313.3	N/A	72%

Table 2 shows that approximately 28% of the total demand of toilet flushing and laundry use can be met by the storage tank, with the remainder being met by the potable supply, suggesting the tank will be empty for nearly three quarters of the year. The tank will rarely overflow to the stormwater system.

4.5 Results Terrace House Unit

Table 3 and Table 4 provides a summary of the results of the water balance model (calculating averages over the 17.3-year period) for the proposed Terrace House rainwater reuse concept:

Table 3: Water Balance Model Results – Toilet Use only

Parameter	Average (m^3/year)	Runoff Breakdown	Toilet Use Breakdown
Indoor Use Demand	48.7	N/A	100%
Roof Runoff	48.6	100%	
First Flush Diverted	18.4	38%	
Rainfall water used indoors	28.6	59%	59%
Storage tank overflow volume	1.6	3%	
Potable Supply	20.2	N/A	41%

Table 3 shows that approximately 59% of the total demand of toilet flushing can be met by the storage tank, with the remainder being met by the potable supply, suggesting the tank will be empty for nearly half the year. Over one third of the rainfall collected on the roof will be discharged via the first flush device and 3% of the volume collected will overflow from the tank to the stormwater system.

Table 4: Water Balance Model Results – Toilet and Laundry Use

Parameter	Average (m^3/year)	Runoff Breakdown	Toilet and Laundry Use Breakdown
Indoor Use Demand	97.4	N/A	100%
Roof Runoff	48.6	100%	
First Flush Diverted	18.4	38%	
Rainfall water used indoors	29.7	61%	31%
Storage tank spill volume	0.4	<1%	
Potable Supply	67.7	N/A	69%

Table 4 shows that approximately 31% of the total demand of toilet flushing and laundry use can be met by the storage tank, with the remainder being met by the potable supply, suggesting the tank will be empty for over two thirds of the year. The tank will very rarely overflow to the stormwater system.

4.6 Results Duplex Unit

Table 5 and Table 6 provides a summary of the results of the water balance model (calculating averages over the 17.3-year period) for the proposed rainwater reuse concept:

Table 5: Water Balance Model Results – Toilet Use only

Parameter	Average (m^3/year)	Runoff Breakdown	Toilet Use Breakdown
Indoor Use Demand	48.7	N/A	100%
Roof Runoff	62.1	100%	
First Flush Diverted	20.1	32%	
Rainfall water used indoors	35.8	58%	74%
Storage tank overflow volume	6.2	10%	
Potable Supply	12.9	N/A	26%

Table 5 shows that approximately 74% of the total demand of toilet flushing can be met by the storage tank, with the remainder being met by the potable supply, suggesting the tank will be empty for nearly one third of the year. Approximately one third of rainfall collected on the roof will be discharged via the first flush device and 8% of the volume collected will overflow from the tank to the stormwater system.

Table 6: Water Balance Model Results – Toilet and Laundry Use

Parameter	Average (m^3/year)	Runoff Breakdown	Toilet and Laundry Use Breakdown
Indoor Use Demand	97.4	N/A	100%
Roof Runoff	62.1	100%	
First Flush Diverted	20.1	32%	
Rainfall water used indoors	40.3	65%	41%
Storage tank overflow volume	1.7	3%	
Potable Supply	57.1	N/A	59%

Table 6 shows that approximately 41% of the total demand of toilet flushing and laundry use can be met by the storage tank, with the remainder being met by the potable supply, suggesting the tank will be empty for nearly two thirds of the year. Approximately 3% of the volume collected will overflow from the tank to the stormwater system.

4.7 Summary

Overall, the results show that there is limited benefit in reducing water demand during periods of dry weather from the public system, as the storage tanks are empty during these periods. A water utility operator will need to assume no reduction from the implementation of reuse tanks due the frequency that they run dry throughout the year, particularly during drought periods, as the drought standard for public water supplies is much larger than for non-potable supplies.

5. OPERATION AND MAINTENANCE

5.1 Maintenance Requirements

Rainwater reuse systems need to be maintained regularly by the property owner/occupier to ensure that the system is operating as it is intended, that water quality is satisfactory, and to prevent premature failure of the system. Figure 4 on the next page sets out HCC "best practice" expectations for maintenance of rainwater reuse tanks. Property owners will need to be comply with the following requirements under PC12:

5.13.4.2A Stormwater – Residential zones

c. Stormwater management measures must be maintained and operated in perpetuity in accordance with best practice by the relevant property owner(s).

d. Where stormwater management devices serve more than 1 site or residential unit, then an operations and maintenance plan must be established and implemented to ensure compliance with relevant standards. The operations and maintenance plan must be provided to the Council within three months of practical completion of works.

Table 3: Summary of rainwater reuse tank maintenance requirements

Maintenance action	Frequency
Inspect and clean pre-screening devices and filters.	3 months or less
Inspect and clean gutters, overflows, and small diameter orifice.	6 months or less
Inspect tank for sludge/sediment build up, inspect, and clean gutters and clear surrounding vegetation and overhanging trees from roof areas. Air gap and /or testable backflow preventer inspected and tested by certified inspector and results provided to Council.	Yearly or less
Inspect tank structural integrity, pipework, electrical and pump by qualified professionals.	5 yearly or less

Figure 4: HCC Rainwater Reuse Tank Maintenance expectations

5.2 Operation and Maintenance Discussion

5.2.1 Operational Issues

In general, across the region, the majority of properties subject to PC12 rules will be in private ownership. The following section highlights the potential issues that may eventuate for properties in private ownership.

Good maintenance is crucial to keeping the operation of the rainwater reuse system trouble free. Research and surveys (Abbott et al, 2007) show that few owners maintain their rainwater collection systems adequately or in line with recommendations, leading to issues and failures. As the occupiers are unlikely to be the property owner, this can add additional challenges in ensuring operational tasks are completed routinely in line with HCC recommendations.

There is limited research on rainwater reuse tanks for non-potable use in New Zealand. However, Hunter Water and Hunter Research Foundation (Australia) carried out a study of rainwater tank functionality to gather information about current and potential future failure rates of rainwater tanks. Qualified plumbers provided a free rainwater tank check at each property and participating households gave a brief interview, followed by completing a post audit online survey. The data indicated an overall failure rate of 18% of tanks, based on the following conditions:

i. tank not watertight
ii. gutter to tank plumbing not operational
iii. switching device not operating
iv. pump not operational (whether switched on or off).

The failure rate increased to 34% when the definition was broadened to include systems in which the switching device and/or pump had been replaced, indicating a previous failure. The most common source of failure was the pump, followed by the switching device.

Of most concern was that half of households with a failed system thought it was working. The research indicates a low level of consumer knowledge and awareness of the operation and maintenance requirements of rainwater reuse tanks.

Age of the tank was significantly associated with under performance, suggesting that failures will increase over time in line with other assets. This, and associated failures, are likely to become a long-term issue if the stock of rainwater tanks increases.

Anecdotal evidence on grey water and rainwater systems that do fail but have access to a public mains supply, is that the owner will take the least cost option and disconnect the system due to high remedial costs and desire to avoid ongoing issues. The PC12 s32 report also noted that rain tanks installed by the owner's choice are likely to have better maintenance and upkeep. This raises questions around the long-term sustainability of getting property owners to maintain these systems over the long term, particularly as the expertise will be outside the knowledge and capability of a typical homeowner.

In addition, as the size of the roof area and tank is relatively small (3-5m^3), the tank will run near empty for long periods of time. This increases the disturbance of any sediment collected within the bottom of the tank that would likely cause operation and maintenance issues with an increased risk of blocked filters and pump damage requiring service call outs.

During my time at the former North Shore City Council (NSCC), several issues came to my attention regarding reuse systems, whereby households were issued extremely large water bills (thousands of dollars), which were six monthly at the time.

Investigations found that the top up system from the public supply would jam open, filling the tank with potable water overflowing into the stormwater system, wasting a significant amount of potable water. As no charging system exists in Hamilton, when this issue arises, it is likely to go unnoticed for long periods of time without the incentive for homeowners to fix the issue due to a lack of volumetric charging. These types of issues reduce the likelihood that the tanks will reduce overall demand from the public water supply.

5.2.2 Power Outages

During power outages the pumped non-potable water supply from the rainwater reuse tanks to the household will not operate and residents will not be able to flush the toilet without manually filling the cistern. This lowers the resilience of the water supply system to the household and creates a weak link in supplying adequate sanitary services to households.

As demonstrated by the recent storm events across the North Island during January and February 2023 and the recent Northland Transpower incident, power outages following storm events or failures of the network can extend for long periods (even days), even in built up urban areas such as Auckland.

5.2.3 Frequency of Maintenance

Kāinga Ora is concerned about the frequency of maintenance tasks will have on it tenants and their right to quiet enjoyment of the property. Property inspections are required to give a minimum of 48 hours' notice before an inspection/maintenance tasks, and at the most, two weeks' notice. This requirement raises several issues whereby the organising of professionals to undertake the required maintenance schedule adds to the number of visits and contacts Kāinga Ora staff and/or contractors will need to make to undertake.

Kāinga Ora generally undertake general tenant inspections at least once per year. The additional operation and maintenance requirements of a rainwater reuse system will add a minimum of 4 additional visits per year (for a total minimum of five) and this may result in the future issues.

5.2.4 Compliance

The HCC operation and maintenance schedule indicates that a backflow testing/inspection is to be undertaken annually and provided to Council. This will not only add cost to the property owner but increase Council's internal compliance costs in maintaining and reviewing records. Experience in Auckland is that there is insufficient funding and resources to drive an effective compliance monitoring and testing programme of such schemes (s32 Report, Morphum, 2022).

It is not clear on what basis (regulations/law) Council can request annual inspections on single dwellings, as there is no provision under Section 100 (2) of the Building Act for single dwellings to provide a compliance schedule. However, requests for compliance schedules can be required for buildings with multiple dwellings, such as apartment buildings.

In addition, any issues with future cross contamination of the reuse scheme with the public supply and resulting associated public health issues will need to be investigated by both Kāinga Ora as property owner and HCC as the water supplier authority to ensure they comply with the New Zealand Drinking Water Standards (DWSNZ). The risk for cross connections is considered to be higher in a multi-unit apartment building due to the layout and complexity of the building services.

In addition, it is possible that non-potable reuse supplies to multi-unit apartments could be included in future water regulations.

5.3 Summary

Ownership, operation, and the maintenance responsibility of the rainwater reuse system will be either managed by Kāinga Ora or if the property is on-sold, by the property purchaser. Research shows that few private owners maintain their rainwater collection systems adequately or in line with recommendations and future issues are more than likely to occur resulting in systems failing or being disconnected from the house.

In addition, experience tells us that the management and operation of potentially hundreds to thousands of small non-potable systems will be difficult and expensive to operate. It is important to note that private landowners may not have the capability, physical ability or skills set to undertake the required tasks themselves and will need to hire many of the same professionals that Kainga Ora use to undertake maintenance tasks.

6. CAPITAL AND OPERATIONAL COSTS

An NPV analysis has been undertaken to determine the long-term costs of rainfall reuse systems assuming the operation and maintenance requirements recommended by HCC. In addition, indicative costs for an alternative detention tank solution have been prepared for comparison purposes.

It is noted that the costs on the supply of storage tanks, water pumps and operational and maintenance tasks can vary between suppliers/providers. However, cost estimates were obtained from variety of sources and were reviewed against other previously published cost estimates prepared by Auckland Council in 2013. The following provides a summary of the NPV model inputs and assumptions:

- Apartment Building Reuse Tank Design, Supply, Fittings, Pump, Installation, and plumbing = $13,500.
- Terrace House and Duplex Reuse Tank Design, Supply, Fittings, Pump, Installation, and plumbing = $10,500.
- Detention Tank = Design, Supply, Fittings, Pump, Installation, and plumbing =$5,000
- Detention Tank operational costs – $130 per annum
- Pump Replacement – Supply, installation, replace fittings etc… every 10 years = $1,500.
- Plumber callout fee $70, plus $30 per quarter hour.
- Inspect clean and replace filters - $130 per visit by plumber three times/year
- Apartment Building Inspect and clean gutters per year - $700 per visit by gutter cleaning specialist – three storey buildings will likely require additional health and safety requirements e.g. scaffolding or scissor lifts could increase this cost estimate.
- Terrace House and Duplex Inspect and clean gutters per year - $300 per visit by gutter cleaning specialist.
- Apartment Building Pump power $100/per year.
- Terrace House Pump power $50/per year.
- Council backflow preventer inspection and report - $250 per year by plumber. Includes inspect filters and tank clean.
- Every 5 years pump inspection, test, and maintenance etc… $250 per 5 years by plumber.

- Real discount Rate – 5%
- NPV Period 20 years

Table 7: NPV Assessment

Parameter	Apartment Building Rainwater Reuse Costs	Terrace House/ Duplex Unit Rainwater Reuse Costs	Detention Tank Costs
Design, Supply and Install	$13,500	$10,500	$5,000
Average Annual Operation Cost	$1,410	$1,110	$130
NPV 25 years	**$31,003**	**$24,265**	**$6,685**

Based on the Apartment Building reuse system providing a volume of 119.7m^3 per year for toilet use and an average annual maintenance cost of $1,410, equates to a cost of $11.78/m^3 of water. Based on the Terrace house reuse system providing a volume of 28.6m^3 per year for toilet use and an average annual maintenance cost of $1,110, equates to a cost of $38.81/m^3 of water. For comparative purposes, the cost per m^3 for treated potable water in Auckland is $2.142. The reuse systems operational costs range from 5.5 to 18.1 times more expensive than water charged on a volumetric basis from Watercare.

Therefore, the costs associated with operating reuse systems raises serious questions around affordability and sustainability of the schemes against alternatives, including using the public supply. Particularity, given the fact that the public water supply system will need to be consented, designed, and constructed on the basis that the tanks are dry during dry periods.

Previous studies (Leonard et al) have shown that where the cost of water is not linked to usage (i.e., Hamilton) there are no potential savings and consequently no direct financial benefit to the homeowner to install water reuse or recycling devices. In addition, these studies have shown that the schemes do not pay back the costs to the property owner (over twenty years) in areas with water and wastewater volumetric charges, and the owners will never recover their investment.

Given the high costs of reuse systems, and the duplication of infrastructure and resource requirements it is not sustainable or economic to install rainwater reuse systems to reduce demand on the public.

7. OPTION EVALUATION

The reuse concepts and an alternative detention tank solution have been input into a simple multicriteria analysis (MCA) tool to assess the advantages and disadvantages of each option and the results are provided in Table 8 below. Each area is given a score between 1 and 5. The results show that detention tanks are ranked higher and is the best practical option for stormwater management long term due to the issues with rainwater reuse systems.

Stormwater detention tanks designed to attenuate flows help manage peak stormwater discharges to the environment effectively. These systems are less complex, more reliable, and cost-effective compared to rainwater reuse systems.

Table 8: MCA

AREA	Notes	Weighting	Reuse Concept	Detention Tank	Comments
ENVIRONMENTAL SUSTAINABILITY					
Stormwater discharges	Manage stream erosion and water quality	10%	5	5	All solutions achieve similar water quality outcomes as contaminates from roofing materials are negligible
Environmental	Contributes positively to the natural environment and net zero carbon emissions	15%	3	4	The reuse concept has a higher carbon footprint, as the tanks are larger, uses more power and resources and requires more operation and maintenance tasks.
CUSTOMERS/USERS					
Community Acceptance / Satisfaction that solution addresses issue	Does the solution address stormwater issues	5%	5	5	All options are considered to be similar in terms of acceptance.
Ease of Maintenance	Ease of access to implement solution	15%	2	4	The reuse concept requires more frequent maintenance to ensure trouble free operations.
HEALTH AND SAFE PEOPLE					
Ability to Manage Hazards to Staff, Contractors and Public	Minimises H&S risks	5%	4	5	The Reuse concept requires, working at height more frequently to clean and inspect gutters, increasing the risk of an incident.
Public Health	Impact on household occupiers	20%	3	5	The reuse concept has a higher public health risk by increasing the risk to occupants and the public water supply. Issues and illnesses may occur and go unreported.
ASSET MANAGEMENT					
Constructability	Ease of Implementation & Commissioning	20%	3	4	Reuse tanks are slightly more complicated to install due to the number of fittings
RESILIENCE AND SECURITY					
Resilience - Climate Change, Natural Hazards, Asset Failure etc...	Contributes positively to resilience	5%	3	5	Reuse systems are more prone to failure and frequently run dry and will not operate in power outages.
ECONOMIC PROSPERITY					
Whole of Life Costs	Contributes positively to efficient use of funds and resources	5%	2	4	Reuse tanks are more expensive to install and maintain
TOTAL SCORE		100%	30	41	
RANK			2	1	
WEIGHTED SCORE			3.15	4.45	
RANK			2	1	

Detention tanks used in conjunction with infiltration devices (where practical) can manage the effects of impervious surfaces in urban areas by reducing peak flows and volumes to local water bodies, protecting downstream environments from erosive forces. They are a more than adequate solution to manage and control stormwater runoff from impervious surfaces and is one of the tools in the toolbox outlined in the WRC Stormwater Guidelines.

8. ALTERNATIVES TO REDUCE WATER SUPPLY DEMAND

As well as ensuring the building occupiers are aware of the impact of their behaviour on water supply, water consumption can be minimised through a variety of water efficiency techniques. Water efficiency techniques that can help reduce demand on water supply sources and networks can be achieved through the following:

1. Metering and volumetric charging of water supply and wastewater services. Evidence in New Zealand indicates that volumetric charging assists in the management of water demand by reducing household use and the volume of wastewater requiring transportation and treatment. Thus, minimising the demand on water sources ensures the conservation of financial resources leading to improved efficiency. For example, Tauranga City Council and Kāpiti District Council have both recently rolled out

residential metering, achieving reductions in residential water use of 25% and 26% respectively.

2. Educating and promoting water efficiency to the public to moderate demand and usage can help reduce pressure on our water supply networks, conserve water resources, and save money. For example, many of us have the habit of leaving our bathroom tap running while shaving or brushing our teeth. This uses over five litres of water, every time. By simply turning the tap off while brushing our teeth or shaving, we can reduce this water use to just one litre (source:https://www.waterforlife.org.nz/water-saving-tips#In_the_bathroom).
3. Installing low-flow fixtures: Replacing high-flow showerheads, faucets, washing machines, dishwashers and toilets with low-flow and water efficient fixtures can significantly reduce water consumption.
4. Stop leaks: Leaks in pipes and fixtures can waste significant amounts of water. Regular maintenance and prompt repair can prevent this wastage in both the public and private systems. For example, a leaking toilet can waste about 80 litres of water per day. Without volumetric charging, there is little incentive for households to fix leaks.
5. Using drought-tolerant plants: Planting species that require less water can reduce the amount of water needed for landscaping. If maintained properly, climate-appropriate landscaping can use less than one-half the water of a traditional landscape (Source: Saving Water Helps Protect Our Nation's Water Supplies | ENERGY STAR)

The www.waterforlife.org.nz website has numerous tips on how to save water from changing behaviours or appliances (refer: https://www.waterforlife.org.nz/water-saving-tips).

Leonard et al, concluded "*Installation of water saving fixtures in a house can provide immediate benefit to the homeowner and save significant amounts of water without the expense of water reuse and recycling. As attitude and personal beliefs are major factors in water conservation overseas, research should not ignore the barriers and drivers which change behaviours. Recycling does not reduce water use. It is not therefore the most cost-effective means of managing water. Understanding water end use and controlling excessive use of water should be the first step in water management, before water reuse or recycling."*

9. INFRASTRUCTURE AND ENVIRONMENTAL IMPACTS

9.1 Public Water Supply System

HCC identifies in the PC12 documents that it provides Hamilton's residents and businesses with a safe, high-quality, reliable, and sustainable service, through treatment, distribution, and management of Hamilton's water supply. Raw water is drawn from the Waikato River into the water treatment plant (WTP), where it is treated to provide a high standard of drinking water. The water supply system is made up of a single treatment plant, nine reservoirs and over 1,250km of associated pipe network.

As the raw water is taken directly from the Waikato River, there is no reliance on reservoir capacity to consider as there can be in other supply systems. Modelling of the reuse system indicates that they will frequently run dry throughout the year and not be able to provide continuous water for indoor use. Therefore, water from the public system is required to be provided during dry periods.

As the storage tanks will frequently run dry, a water supply operator would not make any reduced allowance in demand when planning, designing, constructing, and consenting for the supply of water to residents, as the public system is required to provide peak demands. In addition, water supply piped networks are designed to meet demand including fire flow requirements. Therefore, there is limited benefit to the HCC water supply system, other than an unquantified saving in operational costs.

No costs are available from HCC to compare the marginal cost of supplying households with water for toilet flushing from the public system. However, given the scale of economies of the public system and sunk costs, the marginal cost is expected to be significantly less than the costs prepared in Section 6.

For example, water supplied by Watercare on 1 July 2023 will be $\$2.412m^3$, while the operational cost per year for the reuse system of the Apartment Building and Terrace House equates to $\$12.50/m^3$ and $\$41.11/m^3$ of water supplied or 6.85 and 22.5 times more expensive, respectively. It is important to note that the Watercare cost is not the marginal cost to supply water, which is required to allow detailed financial modelling to be undertaken. This clearly shows that reuse is not a sustainable solution on resources and funds as it duplicates infrastructure requirements to supply safe water to households.

9.2 Public Wastewater System

HCC identifies in the PC12 documents that it provides Hamilton's residents and businesses with a sustainable, reliable, and cost-effective service which includes collection, conveyance and treatment of wastewater and trade wastes discharges.

The City's wastewater system is comprised of a single centralised wastewater treatment plant (WWTP), over 130 pump stations and over 800 km of connecting pipework. The system services over 50,000 households and provides trade waste services to over 5,000 commercial and industrial premises. No measurable or quantifiable effects are expected to occur on the wastewater system from the implementation of rainwater reuse systems, as no change to wastewater flows is predicted.

9.3 Public Stormwater System

HCC identifies in the PC12 documents that it provides services to Hamilton's residents and businesses that protects the health of people and to prevent habitable building inundation from flooding and minimises the pollution of the city's streams, lakes, and the Waikato River.

The stormwater system collects, diverts, conveys, treats, and discharges rainwater to land or surface water. It comprises the piped network, including inlets and outfalls, artificial drains, stormwater treatment devices such as ground soakage, raingardens and constructed wetlands, and natural features such as gullies and streams, the Waikato River, or lakes to which the stormwater is discharged.

The stormwater system also includes overland flow paths, which may lie anywhere - on roads, parks, or private property. The system drains an urban catchment of approximately 9,000 ha however the total catchment area draining to the city reach of the Waikato River is much larger at approximately 30,000 ha.

9.3.1 Stormwater Discharges - Volume

Public stormwater systems and pipes are generally designed for large storm events (e.g. 10-year ARI or larger) to manage stormwater and flooding within urban environments. As the proposed developments will be connected to the existing stormwater system, there is a toolbox of options to designers to ensure discharges to the stormwater system can be appropriately managed. These generally include rainwater reuse tanks, detention tanks, pervious paving, and infiltration devices with either of these solutions able to achieve the required peak flow management of discharges to the public system.

The retention of water for reuse is generally required to protect the downstream streams from erosive forces/shear stresses. The proposed implementation of rainwater reuse systems is expected to lower peak flows and volumes to local water ways during small storm events. However, the effect on the Waikato River flows and volume is expected to be negligible given the relative size of the stormwater catchments and flows.

The effects of flows and volume reduction on the local waterway is not possible to be assessed accurately without additional information investigation, but some general comments can be made.

Alternative solutions such as the controlled release of stormwater using detention tanks or infiltration can achieve similar or improved stormwater outcomes, if erosion is an area of concern. TR2013/035 page 57 states "*Runoff volume increases should therefore be minimised as far as technically feasible; implicit in this statement is a concession that matching pre-development volume may be unachievable in some cases."* This statement recognises that matching stormwater flows to natural flow patterns is practically impossible across the entire flow regime, as presented in the Figure 5 below

For example, detention tanks and rain gardens designed appropriately can reduce the chance of stream erosion occurring during storms events by reducing peak flows from urban runoff as shown in Figure 5. The figure also shows that Extended Detention may have higher flows for very small storms than a natural catchment, but these are unlikely to be highly erosive in nature and provide a source of water to streams, particularly the upper headwaters where the streams may be ephemeral or intermittent. However, once flows exceed 1L/s/ha, runoff from detention tanks drops below that expected from a natural catchment, lowering the potential erosive capacity of the flows.

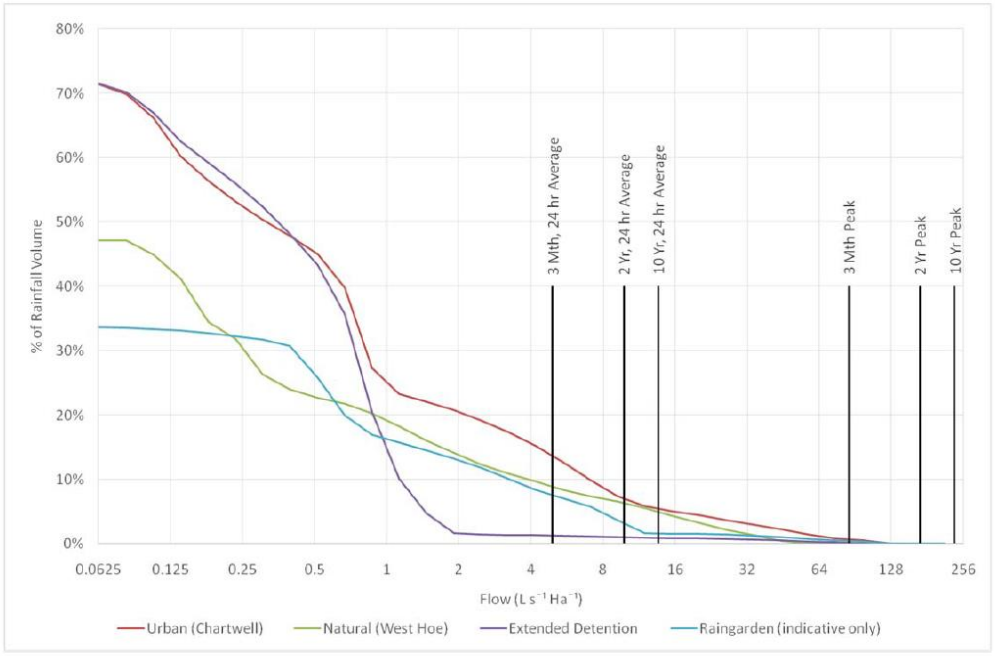


Figure 16. Flow exceedance curves comparing extended detention with raingardens (note the curves are flat below 0.0625 L s^{-1} Ha^{-1}, the data has been clipped for readability)

Figure 5: Flow Exceedance Curves Comparing Flows (Source: Auckland Council TR2013/035)

9.3.2 Stormwater Discharges - Water Quality

In existing brownfield areas, any reduction/removal of existing stormwater flows is likely to result in the public stormwater discharges containing higher concentrations of contaminates. This may also have a negative impact on the existing environment and ecology, because the percentage to the overall discharge will be from higher contaminating generating surfaces such as roads.

Claims of improved water quality from the implementation of reuse or detention tanks are based on anecdotal evidence that sediment and contaminants, organic material collect in the filters (if fitted) and tanks, and in the case of reuse tanks will pass through to the wastewater treatment plant. However, as a first flush devices are connected to the downstream stormwater system and that, most zinc found in roof runoff is in the dissolved phase (Kimberly), it will pass right through to the stormwater system. It is also noted that in Auckland Regional Council's (ARC) TP10 document, "*Airborne sediments deposited on roofs are extremely small, and will not settle out in the tank*" (ARC, 2003).

We are not aware of any research or assessment that has quantified the reduction in stormwater contaminant loads, removal rates, or performance metrics that a rainwater reuse system or detention tank may provide in New Zealand conditions. This is supported by Peyroux (2022) whereby they state, "*Our expert opinion is that there is not sufficient evidence to support the premise that reuse or detention tanks are effective stormwater treatment devices as no measurements exist on the load reductions."*. The primary purpose of tanks is for flow management.

This is further supported by ARC's study (Kingett Mitchell Ltd, 2004) into roof runoff quality, whereby it is noted that many new roofing materials were found to contribute little contamination and were relatively unreactive. The shift to roofing materials with improved durability such as coloursteel have made a substantial difference to the quality of roof run-off, and hence reduced contribution to stormwater contaminant loads. This led to the generally accepted position in the stormwater industry that treatment of stormwater runoff from coloursteel type roofing does not require treatment prior to disposal, due to the extremely low levels of sediment and heavy metals, and the fact that the known removal performance of stormwater treatment devices.

This is further supported by the Waikato Stormwater Management Guideline (WSMG) (Updated version May 2020) that states: "*As can be seen from the table above [Table 6-9], concrete tiles, colour steel and gravel have low contaminant discharge potential and hence it is considered that runoff from these surfaces does not require water quality treatment*."

10. PUBLIC HEALTH DISCUSSION

In providing water to be used within households, the first consideration is the building occupier's health and safety and ensuring they are not exposed to unnecessary hazards or contaminants. A water supply system is not sustainable if it does not meet the basic needs of the occupiers and/or requires substantial operation and maintenance obligations that result in ongoing issues and/or places the health of the occupiers at risk. Therefore, it is good practice (safety in design) to design systems that support efficient and sustainable use of water, energy, and materials.

Rainwater reuse systems are well known to have several potential health issues, with microbiological and pathogens being an area of particular concern to household occupiers. Many of the roof water supplies surveyed in New Zealand revealed deficiencies in the use of rainwater catchment systems and components. In a significant number of supplies where they found heavy faecal contamination there was evidence of lack of maintenance; inadequate treatment of the water; poorly designed delivery systems and storage tanks; and failure to adopt even simple physical measures to safeguard the water against microbiological contamination.

Research on rainwater reuse systems used for non-potable uses such as toilet flushing is still in its early days, with limited research having been undertaken to date. However, as more systems are being implemented, issues have begun surfacing and concerns are now being raised on the long-term sustainability and public health risks of such systems. We are not aware of HCC or any other Council in New Zealand undertaking research into the potential public health risks that may occur due to the implementation of the proposed water conservation scenarios.

Recent research in Australia (Murphy 2017) to estimate the health risks associated with the exposure to pathogen Campylobacter when harvesting urban stormwater for toilet flushing and irrigation activities, identified that only two treatment scenarios could supply water of sufficient quality for toilet flushing and irrigation end-uses: (1) using stormwater biofilters coupled with Ultra-Violet (UV) treatment and (2) a more conventional coagulation, filtration, UV, and chlorination treatment plant. Importantly, the studies modelling results suggest that the current

guidelines in place for stormwater reuse in Australia are not adequate for protecting against exposure. Given New Zealand has no guidelines, the exposure to risk is likely to be similar.

Furthermore, authorities in the United States are becoming acutely aware of the public health risks with non-potable reuse systems. For example, California's onsite non-potable reuse specifications requires that the rainwater is disinfected or other treatment or both, to ensure that the required water quality is delivered at the point of use. For toilet flushing this equates to:

i. Escherichia coli: <100 CFU/100mL
ii. Turbidity: < 10NTU
iii. Water quality sampling should occur every 12 months or after system repair or refurbishment.

If disinfection is required either through legislative changes, Building Consent, or a Health and Safety risk assessment, then the costs to operate a reuse system would significantly increase due to ongoing maintenance and expertise to run the disinfection system, including possible water quality testing.

It is only a matter of time before an incident occurs and the associated regulatory response occurs whereby all owners will be required to retrofit disinfection. This is supported by the recent article in the April/March 2023 Water NZ magazine Titled: Water tanks: We must do Better by Jim McGibbon (Water New Zealand Backflow Group member and former chair). McGibbon raises several concerns over the risks associated with rain tanks and notes "*Like with all installs, there is a health and safety component, and the installer is ultimately the one who will be prosecuted if tragedy occurs*".

The use of rainwater reuse systems also requires the installation of a dual plumbing systems that introduces a risk of cross connection between the rainwater system and the clean drinking water system. Cross connection cases have been reported in Australia, Netherlands, and Finland. Australia is likely to have similar design standards to New Zealand, suggesting that cross connections are more of an eventuality than not. It is understood that though multiple cross-connection events overseas have been reported, the matter has not been studied in much detail.

While relatively few disease outbreaks linked to contaminated roof-collected rainwater have been reported in New Zealand, indications are that there could be under-reporting of illnesses. Residents experiencing sporadic gastrointestinal illnesses are less likely to seek medical attention unless the illnesses are severe and/or life-threatening.

An illness complaint from a compromised tank connected to a household will likely require both the water supplier and Kāinga Ora to investigate the cause. It is possible that an air gap could be compromised in the future by tank settlement issues, modified plumbing/downpipes, or extreme storm events, whereby the tank is unable to overflow to maintain the required 25mm air gap

Therefore, the mandatory requirement for reuse systems raises questions on whether the systems will comply with PC12 rules **25.13.4.2A Stormwater – Residential zones** that

stormwater system safeguard people from illness and under rule **25.13.4.4 Water,** an adequate, reliable, safe, and efficient supply of potable water shall be provided

25.13.4.2A Stormwater – Residential zones
A stormwater reticulation and disposal system must be provided that is adequate to safeguard people from injury or illness and protect property upstream or downstream from damage caused by surface water.

25.13.4.4 Water
a. An adequate, reliable, safe and efficient supply of potable water shall be provided.

11. BENEFITS OF PUBLIC WATER SUPPLIES

In the mid-19th century modern public water supplies were established in Western countries, such as London and New York City and established in all modern cities since. Water supply systems use advanced technologies like filtration and chlorination to provide safe water to households and growing populations. Public water supplies are a vital service that is essential to the health and wellbeing of communities around the world.

Access to clean and safe water in households is essential for maintaining good health as it helps to prevent the spread of waterborne diseases caused by contaminated water sources. Public water supplies provide a reliable source of water that is treated and tested regularly to ensure it meets safety standards. and are an efficient and effective service providing scale of economies in supply suitable safe and clean water to households.

Without public water supplies, people would be forced to rely on unsafe and potentially contaminated water sources, which pose a serious threat to their health. Moreover, access to clean water for hygiene is essential in preventing the spread of infectious diseases, particularly in areas with poor sanitation.

Water supply systems are commonly run by public entities such as Councils or Water Entities, as they provide economies of scale, are regulated, and hold the right level of expertise in the delivery of water services. Several small water supply schemes struggle to be run efficiently, effective and to the required standards due to a lack of expertise and the high cost due to a lack of economies of scale. This is one of the reasons for the proposed current Three Waters reform.

Relying on individual households to operate and maintain water supply systems for toilet flushing (and laundry use) is a significant diversion from the provision of providing publicly available safe water to households and raises several questions on the overall sustainability claims, costs, and implications of using stormwater runoff in households.

Roof collections systems are known sources of microbial contamination, as water authorities and suppliers across New Zealand do not allow roof water systems to be plumbed into houses connected to a mains water supply without the use of backflow prevention devices. This is to stop the roof collected rainwater (that does not meet DWSNZ guidelines) from domestic tanks entering the reticulated potable water supply.

It is not unreasonable to assume that new viruses and diseases could arrive in New Zealand in the foreseeable future and be associated with issues around reuse tanks. In addition, overseas experience tells us that cross connections are likely to occur placing households at unnecessary risk. It is likely issues and illnesses will be underreported.

Rainwater reuse systems may help to reduce peak demand (when available) on the public system but are expensive (more expensive than using public supplies) and will frequently run dry. As there are no water and wastewater charges in Hamilton, there is not even a small financial offset to households for the additional high running costs. Even considering future water supply charges, the marginal cost in supplying safer water from the public system is substantially cheaper and safer solution.

Reuse systems could add over $1,110 to individual household budgets. Comparatively this is more than one third of the average household rates bill in Hamilton.

If all Kāinga Ora properties in Hamilton ultimately ended up with a reuse system, this would add potentially over $3.3 million Kāinga Ora's operational expenses per annum. Extending this New Zealand wide would add $75.9 million per annum to be funded by the taxpayer.

The costs of running these tanks in line with HCC operational guidance exceed the financial benefit of water charges using Watercare's current charges, on a purely operational basis.

12. STONEFIELDS STORMWATER REUSE

The Stonefield's stormwater reuse scheme in Auckland, where the developer was required to install a large-scale residential reuse scheme using the water from the stormwater pond is an example where poor decisions and insufficient planning and risk assessments were undertaken.

The dual water plan for the Stonefields development in Auckland shows that the costs and public health risks associated with reuse should not be underestimated. Post integration in 2010, in my role at Auckland Council, I was aware of numerous internal discussions being held between Auckland Council and Watercare on who would own and operate the Stonefields stormwater reuse scheme. Serious concerns were raised by Watercare and Auckland Council staff on the viability and safety of the scheme.

Eventually it was decided the reuse piped network would be supplied with treated potable water from the Watercare water supply network due to the following:

i. High cost of running the system (understood to be more than 10 times the cost of potable water).
ii. Public health risks from lower quality water and plumbing connection errors.
iii. Costs required to bring the scheme up to an acceptable water quality standard to manage public health risks.

13. SUMMARY

Rainfall collected for toilet flushing (with optional laundry use) is claimed to be a sustainable way of conserving water resources as it reduces the demand on mains water supplies and

sources. However, as our analysis shows, a typical rainfall reuse system designed to accordance with HCC Practice Note, will run dry frequently throughout the year and not relieve any design pressure on the public water supply system. As public water supply systems are designed, consented, and constructed for peak demand, a water utility operator will need to assume no reduction from the implementation of reuse tanks as they will be empty during dry periods and peak demand.

Our analysis shows that the cost per m^3 water harvested from a well-maintained rainwater reuse system is substantially higher than water supplied from a public water supplier if volumetric charging applied. The high costs associated maintenance tasks and public health risks, raises serious questions around the ongoing affordability and sustainability of the schemes against alternatives, including using the public supply.

Research shows that rainfall reuse systems are typically not well maintained and if they are – then they are expensive to operate. Overseas, cross connections either within the household or to the public supply have occurred and given the potentially high number of systems that could be constructed in Hamilton under PC12, it is just a matter of time before a cross-connection incident occurs.

Rainfall collected for reuse is likely to contain harmful contaminants, such as bacteria, viruses, which can cause illnesses or infections. Public health risks around the use of rainwater purely for toilet flushing and irrigation are now being studied overseas, with some authors and authorities recommending additional disinfection treatment processes.

The benefits of the reuse systems are limited, but these can all be achieved by other means using alternative stormwater devices and water supply efficiency measures at a lower whole of life cost.

Therefore, the use of detention tanks and the water efficiency (low flow) plumbing fixtures for managing the effects of development in Hamilton is the best practical option for managing stormwater effects and conserving water.

Therefore, it is questionable that the rainwater reuse systems required under PC12 safeguards people from illness and that the supply of non-potable water is adequate, reliable, resilient, safe, and efficient.

14. REFERENCES

Abbott S[1], Caughley B[1] and Douwes J[2], (No date), *The microbiological quality of roof-collected rainwater of private dwellings in New Zealand*, [1]Institute of Food Nutrition and Human Health, Massey University, [2]Centre for Public Health Research, Massey University.

ARC (2003), *Design Guideline Manual: Stormwater Treatment Devices, First Edition, Technical Publication No.10 (TP10)*, ARC, Environment and Planning Division.

Auckland Council (2013), *Auckland Unitary Plan stormwater management provisions: Technical basis of contaminant and volume management requirements Technical Report 2013/026* (TR2013/035), Auckland Council.

Babbage (2023), *Infrastructure Assessment Report No.116 & No.118 Hukanui Road, Hamilton*, for Kainga Ora - Homes and Communities.

California's Non-potable Reuse Specifications as set out in 2019 California Plumbing Code Title 24, Part 5 (2020).

DCA Architects of Transformation Limited (2023), *Tranche 16 – No.116 & No.118 Hukanui Road, Hamilton, Resource Consent Drawings*, Resource consent issue drawings for Kāinga Ora.

Gaw S, Auckland Regional Public Health (2004), *Roof Water in Urban Areas*, Planning Quarterly 2004.

Heinrich M, (1 February 2009), *Getting a handle on water use in Auckland homes*, BRANZ Build 110 magazine.

Kennedy P, Sutherland S (2008). *Urban Sources of Copper, Lead and Zinc*. Auckland Regional Council Technical Report 2008/023.

Kingett Mitchell Ltd, Diffuse Sources Ltd (2004a), *A study of roof runoff quality in Auckland, NZ: Implications for Stormwater Managemen*t. Auckland Regional Council Technical Publication No.213.

Kusumawardhana A, Zlatanovic L, Bosch A and Peter van der Hoek P, (2021) *Microbiological Health Risk Assessment of Water Conservation Strategies: A Case Study in Amsterdam*, Int J Environ Res Public Health. Published online doi: 10.3390/ijerph18052595

Leonard M, Wood D, Skinner A (Date unknown), Institute of Environmental Science and Research Ltd, *How Efficient is On-site Water Reuse as a Water Management Option*, Water NZ Ltd, https://www.waternz.org.nz/Attachment?Action=Download&Attachment_id=1263

McGibbon J (2023), *Water tanks: We must do Better*, Water NZ April/March 2023 Magazine Water NZ Ltd.

Murphy H.M, Meng Z, Henry R, Deletic A and McCarthy D.T (2017), *Current Stormwater Harvesting Guidelines Are Inadequate for Mitigating Risk from Campylobacter During Nonpotable Reuse Activities,* Environ Sci Technology 51(21):12498-12507. doi: 10.1021/acs.est.7b03089. Epub 2017 Oct 30.

Peyroux, C and Fisher, T (Tonkin + Taylor) (2022), *Drury Centre Fast Track Consent -Water quality of runoff from roof surfaces, Technical memo prepared to support the Fast Track Resource Consent.*

Pollard, A (2022), *Residential water use in New Zealand*, BRANZ Study Report SR469

Seyb R (PDP Partners) and Shaver, E (Auckland Council) (2000), *Developing Stormwater Source Control Policy: Exposed Metal Roofing in Auckland*.

Tonkin & Taylor (2004), *Roof runoff study, Results and interpretation*. NZ Metal Roofing Manufacturers Inc. Report, Job No.60560.

Van Metre P.C., Mahler B.J. (2003). *The contribution of particles washed from rooftops to contaminant loading to urban streams.* Chemosphere 52 1727–1741

van Zyl K, Whittaker C and Scott T, (August 2022), Residential *Water Use in New Zealand – End Use Disaggregation 2.0,* Department of Civil and Environmental Engineering, The University of Auckland.

Water NZ Ltd (January 2019), *Water Metering and Volumetric Charging on Domestic Dwellings*, Water NNZ Ltd, https://www.waternz.org.nz/Article?Action=View&Article_id=2069.

Waikato Regional Council (Updated version May 2020), Waikato Stormwater Management Guideline (WSMG).