Proposed Plan Change C: Kakatangiata

Stage 1: Kikiwhenua Residential Area

Stormwater Servicing Assessment

AUG 2018
This document was prepared by Palmerston North City Council, City Networks, Water and Waste Services Division.

<table>
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<th>Date</th>
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1 Introduction

This report summarises the assessment of the stormwater servicing requirements for Proposed Plan Change C. Specifically, this assessment involved hydraulic modelling of the proposed subdivision to determine its impact on the surrounding environment and the measures required to mitigate any adverse impacts from the development. The assessment has been undertaken using the preliminary development plan information provided by the developer in the context of the Palmerston North City Council's proposed Kakatangiata Residential Growth Area.

The proposed Plan Change area is roughly a 24 hectare block bounded by Te Wanaka Road, the Mangaone Stream and State Highway 56. The Kikiwhenua Residential Area is Stage One of the wider proposed Kikiwhenua Residential Area Residential Growth Area. It is situated at the top of the catchment, adjacent to the Mangaone Stream. Figure 1 below provides an overview of the Te Wanaka Road subdivision extents. The specific area covered by this assessment is outlined in blue.

Figure 1: Kikiwhenua Residential Area
2 Stormwater Services Assessment

2.1 Existing Stormwater Services

The catchment is bounded by the Mangaone Stream to the east, and falls in a south westerly direction towards Pioneer Highway. The catchment topography is illustrated below in Figure 2, based on LiDAR data flown in 2006.

![Figure 2: Site Topography](image)

The existing Council reticulated stormwater network in the vicinity of Te Wanaka Road is detailed in Figure 3 below. A survey of the area was carried out to identify any culverts in the area that control overland flow of stormwater within the wider catchment. Open drains border the Te Wanaka rezone area, with a 300mm diameter stormwater main conveying road and localised stormwater runoff in a northerly direction along Pioneer Highway to the Mangaone Stream prior to its entry to the Manawatu River. The remainder of the flow is conveyed via an open drain along Pioneer Highway west towards Longburn before again eventually entering the Manawatu River.
The majority of stormwater runoff is conveyed via open channels and natural, ephemeral streams that traverse private properties. As such, it is imperative that the development does not increase flood frequency and flood risk for properties downstream of the rezone area. In addition, an increase in frequency of specific high flow events and increases in stormwater discharges flows has the potential to adversely impact on downstream watercourse morphology. Therefore hydrologic neutrality must be achieved to minimise the effects of changes in both peak flow and the frequency of stormwater runoff events.

### 2.2 Stormwater Runoff Assessment

Tonkin and Taylor were engaged to carry out a hydrological assessment to determine the effects of development in the Kikiwhenua Residential Area on stormwater runoff. The assessment included determination of the extent of mitigation in the form of stormwater detention to limit the peak discharge to pre-development flows.
The preliminary assessment has been completed by modelling the proposed rezoning area using HEC-HMS software to determine an estimated storage volume. The assessment is attached as Appendix A. A further detailed assessment using 2D stormwater modelling software is yet to be completed, but will be used to confirm and refine the conclusions and findings.

Key findings from the preliminary assessment are as follows:

- The critical storm duration for detention storage was assumed to be 24 hours.
- The primary outlet was sized to restrict the flows to 10 year ARI pre-development flows.
- The emergency spillway was sized to restrict the flows to 100 year ARI pre-development flows.
- A working storage volume of 10,500m$^3$ is required$^1$.

If a single stormwater detention pond were proposed, the preferred location would be the northwest corner of the development at the intersection of Pioneer Highway and Te Wanaka Road, as this is the lowest point of the catchment. Alternatively, multiple detention ponds could be located through the development. In a distributed scenario each pond would need to be sized according to the catchment area served.

A preferred location for a single stormwater detention pond has been identified by the landowners to the south of the site, however it is assessed that this cannot provide effective stormwater management without extensive re-leveling of the entire development and reliance on a dedicated stormwater pumping system.

A Stormwater Management Plan (SMP) will be required for any development which results in a change of land cover affecting stormwater runoff characteristics (i.e., peak flows, volumes, and frequency of runoff).

The SMP must identify any changes in runoff characteristics generated from the development or change in land use and propose measures to mitigate the effects. The SMP must be prepared by a suitably qualified stormwater design consultant, preferably with experience in Water Sensitive Design (WSD) concepts and elements.

The SMP must address the following:

a) a site specific assessment of the likely changes in stormwater quantities created by this development/land use changes for the 2 year, 5 year, 10 year, 20 year and 50 year (including climate change) ARI events using the HIRDS database;

b) scoping of all internal stormwater infrastructure and how it will interact with the existing drainage system;

c) outline how the development will hydraulically relate to its surrounding environs, including assessment of overland flow paths and potential flood impacts;

d) outline how the stormwater management system will ensure that any changes in runoff from the site will be addressed.

The potential changes in runoff will be addressed through the use of WSD components focused on the following parameters:

- Reduction in peak flow discharges by flow attenuation
- Reduction in discharge volumes by infiltration, soakage or other means appropriate for the site (i.e., the first 5 or 10mm of daily rainfall runoff from impervious areas may need to be retained on site in certain circumstances)
- The ability to use WSD to address stormwater runoff quality aspects

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$^1$ This volume is subject to change following completion of the 2D modelling by Tonkin and Taylor.
Landowners will need to complete a comprehensive Stormwater Management Plan which includes modelling of stormwater discharge and mitigation options to confirm the gravity option to be constructed that effectively manages stormwater runoff effects and does not result in flooding risk for the new and existing properties. A pumping solution will not be an acceptable alternative to a gravity system.

A large grassed swale has been proposed along Pioneer Highway. This could be used for detention, however additional storage will still be required to provide the estimated total volume of detention storage.

### 2.3 Stormwater Management

#### 2.3.1 Overview

Council stormwater activities are governed by a range of statutory planning instruments which define our performance standards. These include the Resource Management Act, National Policy Statements and Regional Plans such as Horizons Regional Council One Plan. Council is required to manage the effects of any development on stormwater, so the effects of development are less than minor on the environment and do not exacerbate existing flood and quality effects. Historically, Councils Levels of Service for Stormwater management have been less controlled in the absence of strict standards in the Manawatu Region. Horizons Regional Council has signalled its intention to require resource consents for all future urban stormwater runoff, so it is incumbent on Council to ensure stormwater effects from any development are effectively managed in anticipation of future qualitative and quantitative standards being applied.

Land development increases stormwater runoff volumes due to the increases in impervious area, particularly during the early period of a rain event, but also increases contaminant discharges due to the residential and roading activities which take place. The additional runoff volumes, flows and contaminant discharges can have significant negative impacts on receiving environments. In order to avoid potential adverse effects, Council will require implementation of stormwater management solutions. The application of stormwater volume and quality mitigation practices is typically referred to as water sensitive design (WSD).

The mitigation devices are designed to mitigate effects through retarding initial rainfall loss by promoting pervious surfaces, increasing the time of concentration to reduce peak runoff and velocity through provision of storage and providing treatment to remove some contaminants at source or prior to discharge. Council will require design to incorporate a treatment train (series of treatment stages between the source and outfall) to remove gross pollutants as well as sediments, metals and hydrocarbons.

#### 2.3.2 Stormwater Quantity Management

In order to ensure that stormwater discharge volume increases are minimised and runoff peak flows and velocities are managed to no more than pre-development levels, Council has determined the following requirements as a minimum requirement for upstream lot and road reserve areas within the re-zone area:

- permeable area shall be at least 30% of the net lot area excluding road reserve.
- road corridors shall be designed to provide areas for pervious pavements and/or grassed / planted swales to reduce total runoff and peak flows

Examples of typical solutions for road corridor treatments are provided in figures 4, 5 and 6 below. In addition to reducing stormwater runoff volume through soakage and evapotranspiration, road swales, rain gardens and tree pits will also provide treatment of stormwater runoff.
Figure 4: Schematic of Street with WSD elements (Auckland Design Manual, Long Bay)
Figure 5: Schematic of Street with WSD elements (Auckland Design Manual, Long Bay)

Figure 6: Schematic of residential street with WSD elements (Auckland Design Manual, Long Bay)
Prior to discharge of stormwater from the development, additional stormwater detention can be achieved using detention pond(s) sized to limit the total post-development flow peak to pre-development levels. Ponds shall be designed to provide for both stormwater attenuation and treatment and shall include:

- amenity features through appropriate planting
- treatment through the provision of treatment wetlands and forebays

For the Kikiwhenua Residential Area the total storage volume required has been identified in the Tonkin and Taylor report (refer Section 2.2 above). The ponds can be in the form of dry ponds, wet ponds, or wetland design.

Further guidance on the design of these ponds can be found in the following documents:


It is important that the detention ponds are integrated into the development and designed to be an integrated feature of the development. This will contribute to the visual amenity but also simplify upkeep and maintenance of the detention area.

### 2.3.3 Stormwater Quality Management

In order to ensure that discharge of contaminants from the stormwater is minimised as to ensure any discharge does not impact significantly on the receiving environment, Council has determined the following requirements as a minimum requirement for upstream lot and road reserve areas within the re-zone area:

- Each lot must incorporate rain gardens or other biofiltration devices to treat road runoff prior to discharge to the stormwater network.
- The surface runoff resulting from the first 10mm of any rain event from the road carriageway and property hardstand areas draining to the road shall be treated prior to entering the piped stormwater network which will require the road corridor to be designed to enable the majority of runoff to be treated. Examples of road corridor layouts and treatment options are presented in Section 2.3.2.

Bioretention devices filter stormwater through a vegetated filter bed made of natural soil or engineered media. Depending on its design, bioretention may also perform a hydrological detention function by reducing runoff volumes and detaining runoff flows. Specific devices include rain gardens, tree pits, stormwater planters and bioretention swales.

Design guidelines for bioretention devices can be found in Auckland Council Guideline Document GD2017/001, Stormwater Management Devices, Section C3. Examples of specific treatment devices are illustrated in Figure 7 (stormwater planter box to treat roof water) and Figure 8 (typical swale design) as follows.
Figure 7: Schematic of planter box (North Shore City Council “Bioretention Devices”, 2008)

Figure 8: Schematic of typical treatment swale (Auckland Council Guideline Document GD2017/001)
3 Summary

Land development increases the volume, velocity and peak flow of stormwater runoff, and also has the potential to degrade stormwater water quality by generating additional contaminants. Stormwater management is required to mitigate the effects of the proposed development within the Te Wanaka rezone area and ensure the development does not increase the flood risk for surrounding and downstream areas, and does not adversely impact the receiving system.

Tonkin and Taylor were engaged to complete a hydrological assessment of stormwater runoff from the Te Wanaka rezone area and evaluate both the effects of development and determine appropriate mitigation for stormwater quantity and quality effects. In order to address the increase in stormwater runoff and the additional contaminants from the development, Council has determined the following is required:

- A minimum detention storage volume of 10,500m³ either in one or more ponds with appropriately sized outlets to limit the post-development peak flow to pre-development levels².

- The detention pond(s) must be designed such that the outlet reduces the peak flow to pre-development flow rates for the 10 year ARI rainfall event, and the spillway passes the 100 year ARI rainfall event at pre-development flow rates.

- Water sensitive design elements must be incorporated in the development of each lot and the road corridor to deliver both stormwater quantity and quality requirements.

- A stormwater treatment train comprising multiple treatment steps from source to outlet must be provided to treat all stormwater runoff

- Each lot must limit total imperviousness area to no more than 70% of the gross area.

² Total storage volume may be adjusted following the final stormwater assessment currently being undertaken by Tonkin and Taylor.
Appendix A

Te Wanaka Road Development Stormwater Runoff Assessment and Preliminary Pond Sizing (Tonkin and Taylor, 1 August 2018)
Palmerston North City Council
Private Bag 11034

Attention: Robert van Bentum

Dear Robert

Te Wanaka Road Development Stormwater Runoff Assessment and Preliminary Pond Sizing

Introduction

Tonkin + Taylor (T+T) were appointed by Palmerston North City Council (PNCC) to carry out preliminary analysis for a proposed development area bounded by the Mangaone Stream to the east, Te Wanaka Road to the west and Pioneer Highway (SH56) to the north (Figure 1). This is referred to as Stage 1 in our Letter of Engagement dated 29 June 2018.

Figure 1: Location of proposed development area
Details provided to us (which we understand are still preliminary) indicate that the proposed development might result in impermeable surfaces (paved areas and roofs) covering up to 70% of the development area, with negligible change in land use over the rest of the catchment. Currently the catchment drains to the northwest of the property where there is a culvert under Te Wanaka Road. Proposed development will increase runoff from the site and it is proposed that a detention pond in the vicinity of the existing culvert under Te Wanaka Road be built to limit future peak discharge to no more than the current peak discharge in response to a 100 year ARI design storm.

This letter presents the hydrological analysis to determine current and projected future runoff from the catchment during the 10 year and 100 year ARI design events.

**Storm rainfall**

Storm rainfall was downloaded from NIWA’s HIRDS V3 database for present day and with allowance for a projected 2.1°C increase in temperature to 2090. The 10 year and 100 year ARI storm depths, used to generate hydrographs are listed in Table 1.

### Table 1: HIRDS V3 storm rainfall for Te Wanaka Road Catchment

<table>
<thead>
<tr>
<th>Storm duration</th>
<th>Present day 10 year ARI</th>
<th>Present day 100 year ARI</th>
<th>Climate change projected to 2090 10 year ARI</th>
<th>Climate change projected to 2090 100 year ARI</th>
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<tbody>
<tr>
<td>5 minutes</td>
<td>7.6</td>
<td>13.4</td>
<td>8.9</td>
<td>15.7</td>
</tr>
<tr>
<td>15 minutes</td>
<td>13.0</td>
<td>22.9</td>
<td>15.1</td>
<td>26.7</td>
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<tr>
<td>1 hour</td>
<td>25.4</td>
<td>44.9</td>
<td>29.4</td>
<td>52.5</td>
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<tr>
<td>2 hour</td>
<td>32.8</td>
<td>56.0</td>
<td>37.7</td>
<td>65.4</td>
</tr>
<tr>
<td>3 hour</td>
<td>38.1</td>
<td>63.7</td>
<td>43.6</td>
<td>74.4</td>
</tr>
<tr>
<td>6 hour</td>
<td>49.1</td>
<td>79.4</td>
<td>56.1</td>
<td>92.8</td>
</tr>
<tr>
<td>12 hour</td>
<td>63.3</td>
<td>99.0</td>
<td>72.0</td>
<td>115.6</td>
</tr>
<tr>
<td>24 hour</td>
<td>81.7</td>
<td>123.4</td>
<td>92.5</td>
<td>144.1</td>
</tr>
<tr>
<td>48 hour</td>
<td>97.1</td>
<td>146.7</td>
<td>109.5</td>
<td>171.4</td>
</tr>
</tbody>
</table>

**NOTE:** The 5 minute, 15 minute and 3 hour storm depths, required for input to HEC-HMS, were calculated using the equations in the HIRDS V3 documentation.

Rainfall-runoff analysis was undertaken using HEC-HMS software. Meteorology files were created in HEC-HMS for storm durations of 1, 2, 3, 6, 12, 24 and 48 hours with the peak rainfall intensity limited to 3 to 4 times the average rainfall intensity. This is a conservative ratio of peak to average intensity for storms in New Zealand. This was achieved using the frequency storm method and only entering the cumulative rainfall depths from Table 1 in the MET file for the selected storm duration and the three immediately shorter durations.

**Runoff analysis**

Simulations were carried out using the SCS Unit Hydrograph Method, to generate flood hydrographs for 10 year and 100 year ARI design rainfall. This was done for scenarios with and without allowance for climate change, for both current development and proposed future development in the catchment. This enabled quantification of the likely impact that the proposed development would have on runoff and also the projected impact of climate change on runoff. The SCS method allows both peak discharges and volumes of runoff to be estimated while taking into account soil structure and changes to land use.
The Rational Method was used to provide a sensibility check on the hydrograph peaks generated for present day development and storm rainfall.

**Catchment characteristics**

A single catchment was used to model runoff for present day development because the extent of impermeable surface is small relative to the size of the catchment. The catchment was divided into impermeable and permeable sub-catchments for the future development scenarios.

Catchment permeability was assessed based on the Landcare Research Soil Permeability map for the area shown in Figure 2. This shows the proposed development area to be underlain by two different soil types.

![Figure 2: Landcare Research Permeability with the catchment and proposed development area – Group A and B indicate the hydrologic soil group used to estimate the SCS Curve Numbers](image)

SCS Curve numbers (CN) were estimated based on the soil group and tables from the SCS publication.
The catchment characteristics used in the HEC-HMS model are summarised in Table 2.

### Table 2: Catchment characteristics

<table>
<thead>
<tr>
<th>Catchment characteristic</th>
<th>Current development</th>
<th>Proposed future development</th>
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<tr>
<td></td>
<td>Impervious area</td>
<td>Pervious area</td>
</tr>
<tr>
<td>Catchment area (ha)</td>
<td>24.2</td>
<td>12.9</td>
</tr>
<tr>
<td>SCS Curve number</td>
<td>60</td>
<td>98</td>
</tr>
<tr>
<td>Time of concentration (minutes)</td>
<td>60</td>
<td>37</td>
</tr>
<tr>
<td>Catchment Lag (minutes)</td>
<td>40</td>
<td>25</td>
</tr>
<tr>
<td>Initial abstraction (mm)</td>
<td>34</td>
<td>1</td>
</tr>
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</table>

### Runoff model results

The simulated peak discharge at the northwest corner of the catchment for 10 year and 100 year ARI design storms are summarised in Table 3. Numbers shown in red indicate critical duration runoff rates.

### Table 3: Simulated 10 year and 100 year ARI peak discharge for present and proposed future development

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Storm duration (hours)</th>
<th>Peak discharge (m³/s) and volume (10³ m³)</th>
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<tr>
<td></td>
<td></td>
<td>Present development</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Discharge (m³/s)</td>
</tr>
<tr>
<td>10 year</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>ARI no change</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.01</td>
</tr>
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<td></td>
<td>6</td>
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<td></td>
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<td></td>
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<td>0.15</td>
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<td></td>
<td>48</td>
<td>0.17</td>
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<tr>
<td>10 year</td>
<td>1</td>
<td>-</td>
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<tr>
<td>ARI with change</td>
<td>2</td>
<td>0.01</td>
</tr>
<tr>
<td>(2090)</td>
<td>3</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>0.23</td>
</tr>
<tr>
<td>Scenario</td>
<td>Storm duration (hours)</td>
<td>Peak discharge (m$^3$/s) and volume (10$^3$ m$^3$)</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Discharge (m$^3$/s)</td>
</tr>
<tr>
<td>100 year ARI no climate change</td>
<td>48</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0.05</td>
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<td></td>
<td>48</td>
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<tr>
<td>100 year ARI with climate change (2090)</td>
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<td>0.13</td>
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<td></td>
<td>2</td>
<td>0.27</td>
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<td></td>
<td>3</td>
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<td></td>
<td>24</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>0.58</td>
</tr>
</tbody>
</table>

The results show that with the present low level of development the critical storm duration generating the highest peak discharge of 0.5 m$^3$/s is 24 or 48 hours and with the proposed development the peak discharge increases to 2.0 m$^3$/s in a 3 hour design storm.

**Proposed mitigation**

PNCC tasked T+T with sizing a stormwater detention pond for the purposes of peak discharge control. Ponds can also be used for treatment and stream erosion reduction purposes by incorporating specific detention and outlet controls for smaller magnitude events, however these elements are not included as part of the project scope.

For this project PNCC have requested that T+T determine a pond volume and size to reduce peak discharges in a post development case to pre development peaks in 10 year and 100 year return period events, both with and without climate change adjustments. No consideration of total runoff volume was required. We understand these are the key requirements required for effects mitigation at this stage of the project. If erosion control or treatment requirements are required, additional pond volume and area would likely be required, as well as a different outlet arrangement.

To further describe the pond performance requirements:

- For 10 year ARI current climate storm, the pond will require sufficient storage volume, and an outlet arrangement suitable to limit peak discharge to 0.17m$^3$/s (the critical discharge for this return period) and 0.53m$^3$/s for the 100 year.

- Similarly for the 10 year ARI with climate change, discharge will be limited to 0.23m$^3$/s, and for the 100 year with climate change case to 0.73m$^3$/s.
In this assessment, we have assumed that there are no constraints downstream of the pond that would limit the peak discharge. We have also limited the maximum depth of the pond required to 3m to prevent the pond from being classified as a large dam. The site is relatively flat, so this depth is very likely a practical upper limit for which there is sufficient drop to drain the site into the pond.

An estimate of required pond storage volume can be found by looking at the difference in storm volume between critical events. For the 100y ARI with climate change event, the difference between runoff volumes between pre and post development cases is 11,800m³. This volume provides a useful starting point for pond volume estimation.

The pond has been sized from the following approach:

1. Assuming a rectangular pond base with a frustrum shape, a pond volume is determined (using the volume mentioned above as a guide)

2. For the present day climate, 10 year ARI event, the critical duration discharge is 0.165m³/s. An orifice outlet is sized to convey the discharge, and using a routing model a maximum pond water level is determined for the critical duration 10 year ARI events. If the water level is too high, a larger pond volume is chosen.

3. A secondary higher level spillway (which we assume will take the form of a rectangular weir with its crest limited to a certain width) is placed at the limit of the 10 year ARI flood level, and sized to take the 100y ARI flood discharge in the pre development case (0.53m³/s). If the water level is too high, a larger pond volume is chosen.

4. Steps 1 to 3 are iterated until a reasonable pond arrangement is found.

Figure 3 shows the pond routing output from HEC HMS for the 100y including climate change, 24 hour storm scenario, which is the critical case in terms of storage volume required. The figure shows the inflow and outflow over time, as well as the increasing storage and water level in the pond.
We have assumed a dry pond arrangement with the working volume and approximate outlet arrangements below:

- A 40m by 80m rectangular base, with 3h to 1v side slopes
- A 225mm diameter primary outlet (sized to restrict flows to 10 year ARI current climate) at 21m RL – lowest pond level
- A 0.8m width weir upper outlet (sized to restrict flows to 100 year ARI current climate) at 23.0m RL
- An emergency spillway (probably as an extension of upper outlet) at 23.5m RL
- A working volume to emergency spill level of approximately 10,500m$^3$
- For the proposed rectangular shape, this volume results in a working depth range of approximately 2.5m, and pond surface area of 5,225m$^2$

There is flexibility in pond arrangement in terms of shape and layout. Further design work will probably require a smaller depth which will require larger area to accommodate the required storage.
volume. We recommend the pond is constructed using a best practice layout with guidance from an up to date technical document such as Auckland Council’s TR2013/18\textsuperscript{1}.

The increased peak discharges which occur as a result of development can be mitigated to pre development by sizing outlets that restrict the peak outflows.

**Applicability**

This report has been prepared for the exclusive use of our client Palmerston North City Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We trust this meets your requirements. Please contact the undersigned if you have any questions.

Yours Sincerely

Hamish Smith  
Water Resources Engineer

Hugh Cherrill  
Project Director

1-Aug-18

\textsuperscript{1}https://static1.squarespace.com/static/58291be26a49634bd85ae0bf/t/582ceee893fc023f9cca60f/1479339813573/tr2013018hydraulicenergymanagementinletoutletdesignfortreatmentdevices.pdf