Western
Bay of Plenty
District Council

Appendix 4 –

Infrastructure Assessment Reports

- o Report 12 – Te Puke Flood Modelling – Stage 7
- o Report 13- Te Puke Intensification – Water Supply Modelling
- o Report 14 - Te Puke Intensification – Wastewater Modelling
- o Report 15 - Te Puke Stormwater Management Guidelines
- o Report 16 – Te Puke Intensification Infrastructure Report (Wastewater, Stormwater, Water)
- o Report 20 – Te Puke Stormwater Modelling Report
- o Report 21 - Ōmokoroa Structure Plan Stage 3 – High-Level Slope Stability Hazard and Risk Assessment
- o Report 24 - Bay of Plenty Regional Active Fault Mapping for Growth Areas
- o Report 26 - Natural Hazard Risk Assessment for Seddon Street Development, Te Puke – S&L – 2022

Additional background information reports on Natural Hazards are available on Councils webpage https://www.westernbay.govt.nz/property-rates-and-building/natural-hazards

Western Bay of Plenty District Council

Te Puke Stormwater Modelling

Stage 7 Modelling Report

Western Bay of Plenty District Council

Te Puke Stormwater Modelling

Stage 7 Modelling Report

Prepared By	Louise Algeo Hydraulic Modeller	Opus International Consultants Ltd Tauranga Office Gartshore House, Level 3, 116 Cameron Road PO Box 646, Tauranga 3140 New Zealand	
Reviewed By	Franciscus Maas Senior Hydraulic Engineer	Telephone: Facsimile:	+64 7 578 2089 +64 7 578 2086
		Date: Reference: Status:	May 2015 3-53062.04 Draft for Comment
Approved for Release By	Mark Hunter Utilities Infrastructure Engineer		

Contents

1 Introduction

1.1 Background

In November 2012 Opus produced *Te Puke MIKE URBAN Stormwater Modelling, Stage 2 – Modelling Report* (Opus, 2012) which outlined the construction of a MIKE URBAN hydraulic model for the stormwater system of Te Puke.

This was followed by an update during Stage 4 in April 2014 in which changes were made to the Stage 2 MIKE URBAN model and scenarios for a 1 in 5 year and a 1 in 50 year Average Recurrence Interval (ARI) event were simulated. These changes were outlined in *Te Puke Stormwater Modelling, Stage 4 – Modelling Report and Network Upgrade Costings* (Opus, 2014a).

Opus produced *Western Bay of Plenty Stormwater Modelling guidelines (Opus, 2014b) as* part of Stage 5. An independent peer review in 2014 of the flood mapping identified that the flood extent in the vicinity of open channels and water courses in the catchment were not adequately shown. As a result, the open channels were moved from MIKE URBAN to the MIKE 21 surface as part of Stage 6.

1.2 Purpose

The purpose of this report is to outline the changes made to the Stage 4 MIKE FLOOD model as part of Stage 6, and to present the results of the new model "nested rainfall" scenarios that are based on these revisions (Stage 7). All modelling is for the existing degree of catchment development and the existing stormwater network.

1.3 Model Scenarios

The revised model serves as the basis of two scenarios; 50 year ARI and 10 year ARI, both of which use a 24-hour duration nested storm supplied by Western Bay of Plenty District Council (WBOP DC). Each scenario has been simulated using MIKE FLOOD (MIKE URBAN-MIKE 21 coupled) computational hydraulic model. The scenarios are:

- 50-year ARI, 24-hour duration nested storm
- 10-year ARI, 24-hour duration nested storm

The above scenarios are for existing infrastructure, existing catchment development only.

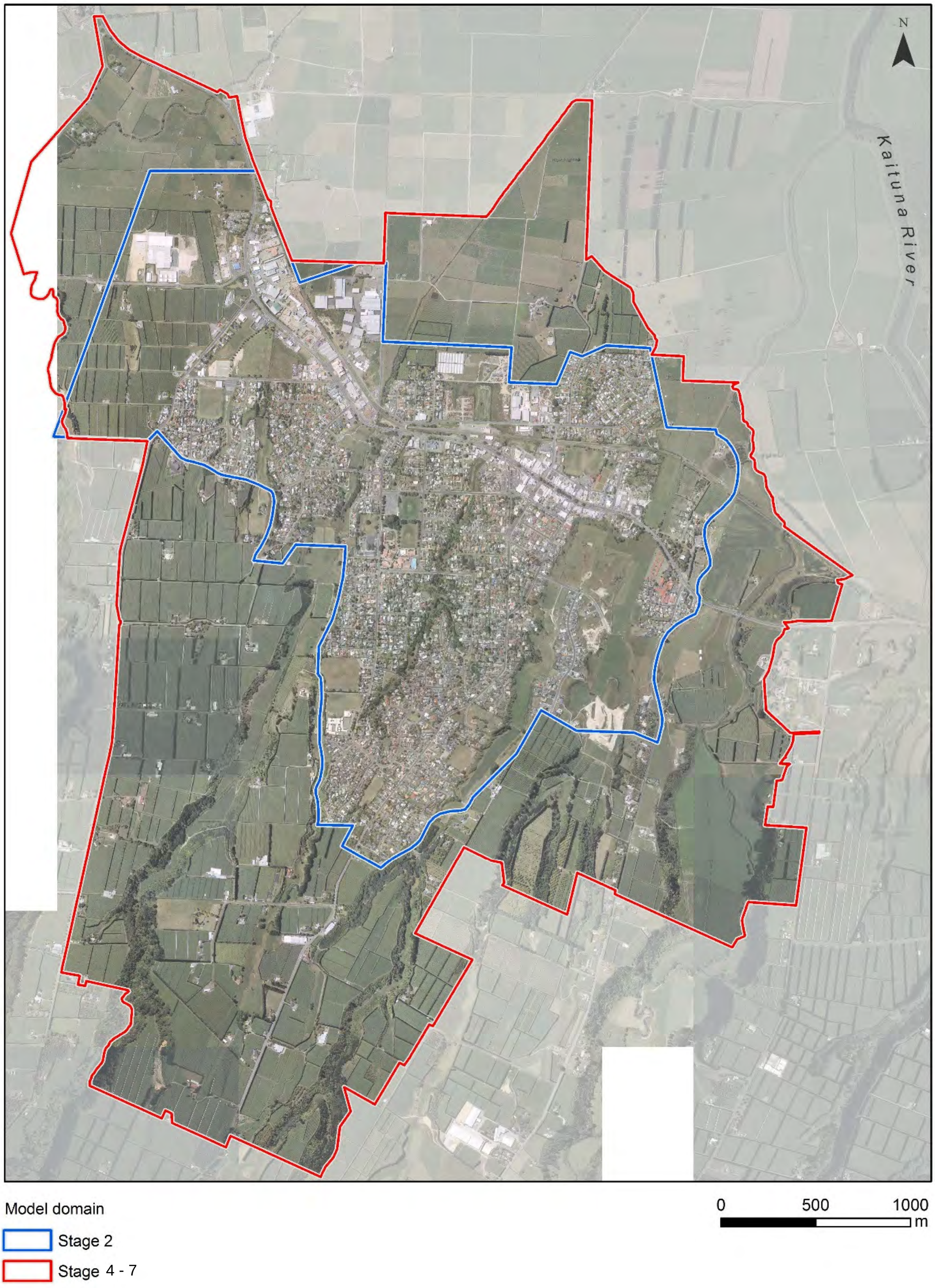


Figure 1 Comparison of model domains between Stages 2 and 4

2 Model Build

2.1 Introduction

The Stage 4 model was adapted during Stage 6 and 7. This section describes the changes made to the model.

2.2 Piped Network

There has been no change to the piped network since Stage 4 (Opus 2014a).

2.3 Open Channel Network

As part of Stage 6, existing open channels in MIKE URBAN have been removed and were transferred to the MIKE 21 surface (Figure 2).

The upstream inflows have also been transferred to MIKE 21. The downstream boundaries in MIKE URBAN were replaced by sumps with a constant water level in MIKE 21. This is detailed in Section 2.5 and 2.6.

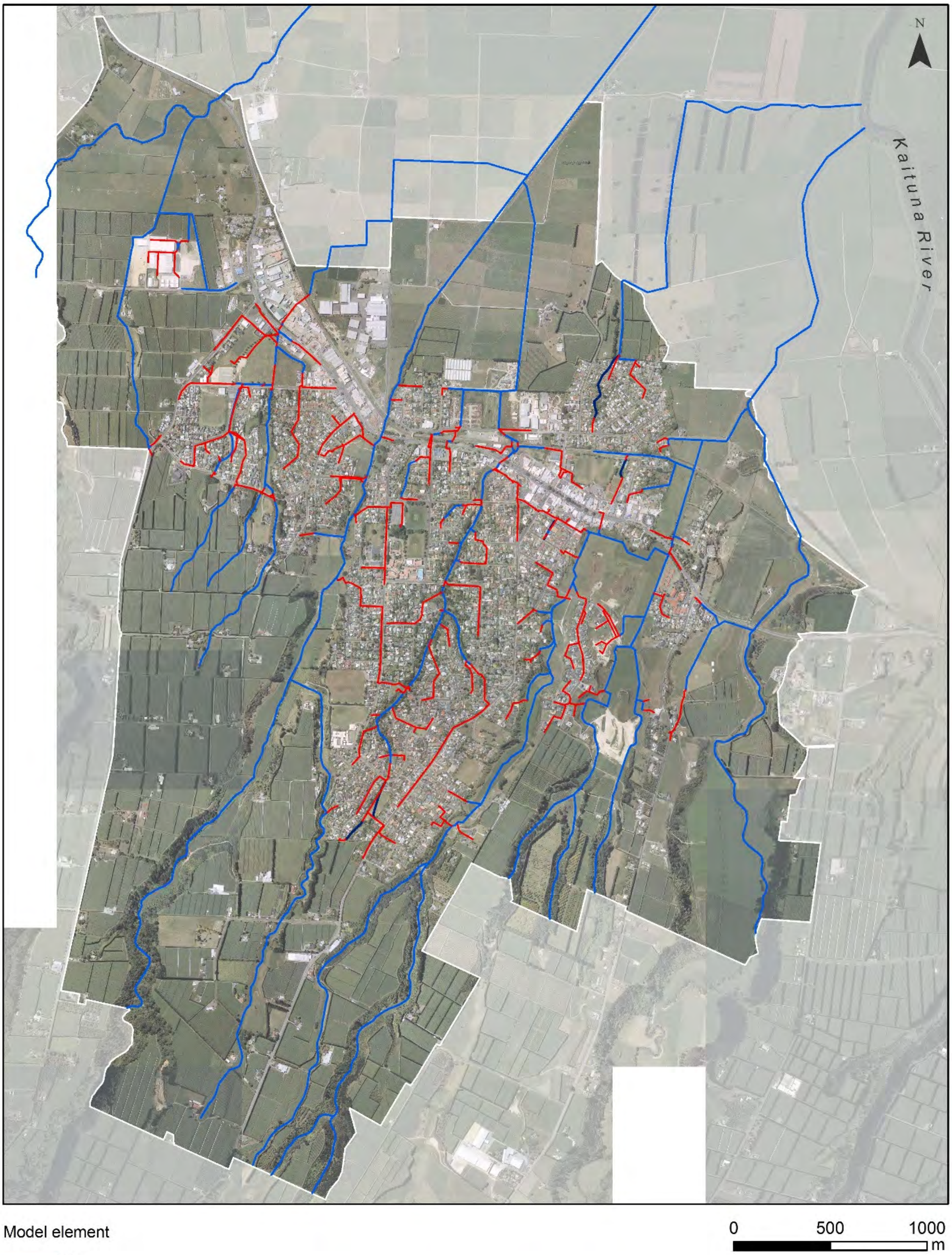


Figure 2 Te Puke stormwater drainage network in the Stage 7 MIKE FLOOD model

2.4 Catchments

The MIKE URBAN model uses two types of catchments. These are shown in Figure 3. The MIKE URBAN catchments are those used directly in the model for generating runoff. These cover the existing extent of stormwater infrastructure. The area and imperviousness values of these catchments are used to convert rainfall intensity to runoff volumes which are then assigned to model nodes during the network simulation. The catchments north of the model domain are included since the channels that run through them control the downstream water level boundaries and resultant backwater effects into the model domain.

The second catchment type – Inflow catchments – do not exist explicitly within MIKE URBAN but are instead used to calculate flows which are assigned as boundary conditions to the nodes at the upstream edge of the model domain (Figure 6). The calculated inflows therefore provide the runoff volumes in those parts of the model domain not covered by the MIKE URBAN catchments. Hence, the model considers the full upstream influence of these catchments rather than simply the portion that falls within the model domain. In Stage 4 these inflows were applied to the nodes in the 1-D component of the model whereas from Stage 6 onwards the inflows have been applied to the MIKE 21 surface.

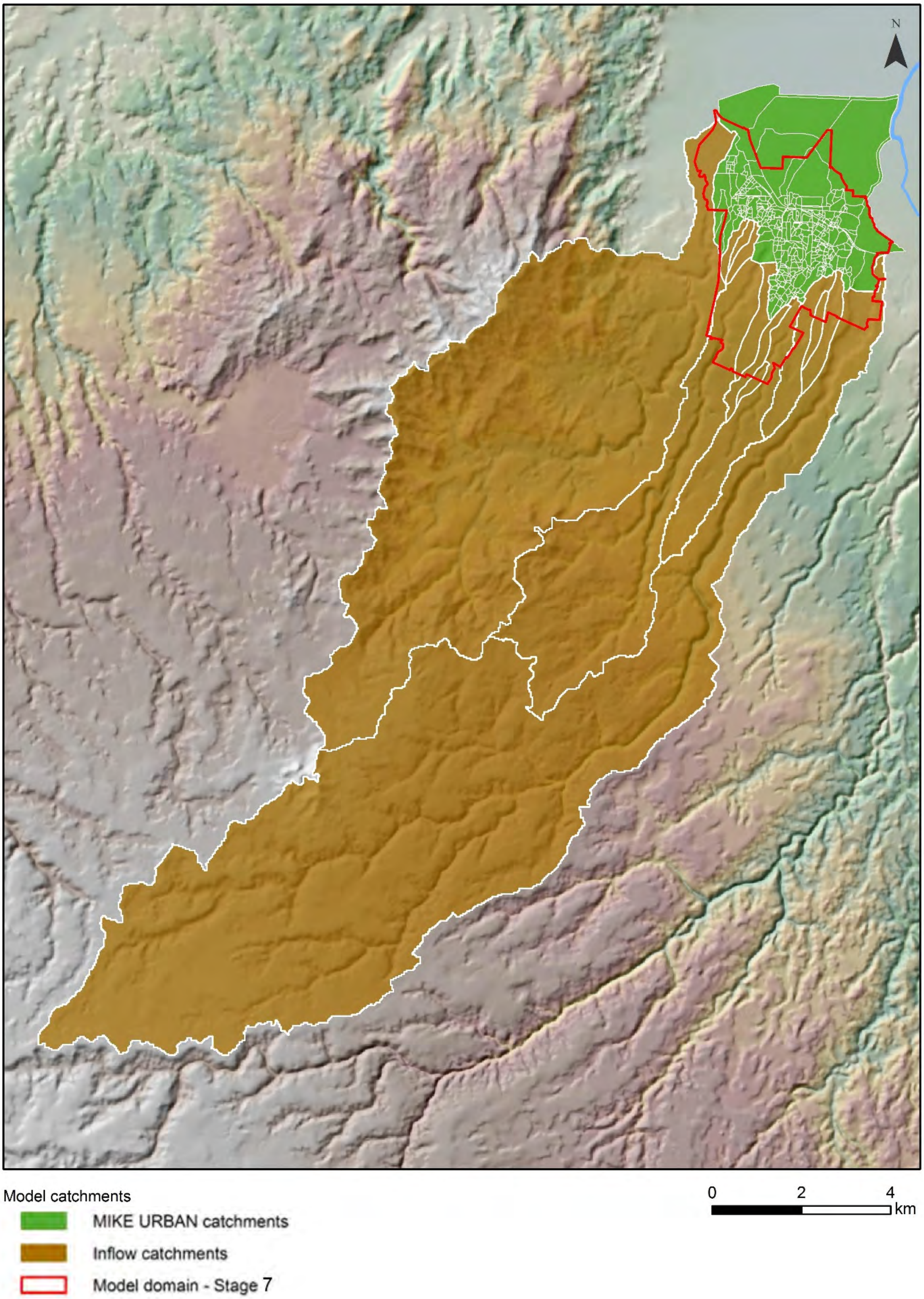


Figure 3 Te Puke catchments

2.5 Boundary Conditions

2.5.1 Rainfall

In Stage 4 the rain was temporally distributed in accordance with that used by Tauranga City Council (Opus, 2012). For Stage 7 this was replaced by a "nested storm" pattern supplied by WBOP DC. The design event intensity over the 24-hour duration is shown in Figure 4.

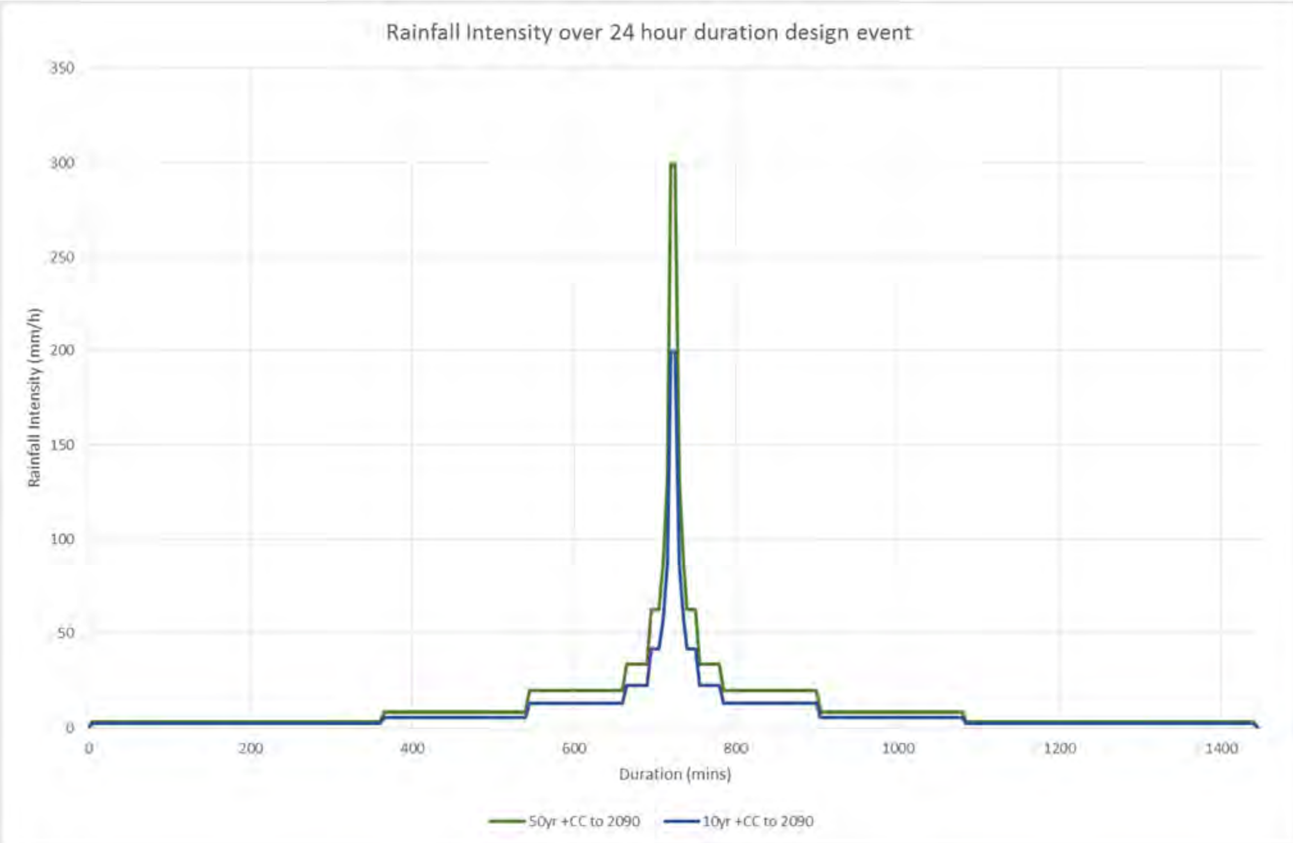


Figure 4 – "Nested storm" rainfall intensity over 24-hour duration

2.5.2 Inflows

Inflows for catchments upstream of the model domain used for the scenarios simulated in Stage 4 were retained for Stage 7. However these inflows were applied directly onto the MIKE 21 component of the MIKE FLOOD model in the location of the Stage 4 nodes (Figure 4). Discharges from the Stage 4 model were proportionally allocated on the basis of catchment areas and applied at the location of the node in Stage 4 (Figure 4). In accordance with the Bay of Plenty Regional Council guidelines (BOPRC, 2012) 2.33-year and 20-year ARI inflows were used for the 10-year and 50-year ARI overall model scenarios respectively. Table 1 details the magnitude of these flows as well as where they were applied to the MIKE 21 surface.

Table 1 Estimated peak discharges for the catchments upstream of Te Puke

Name	Stage 4 Node	Stage 7 MIKE 21 coordinate		Estimated Peak Discharge (m^3/s)	
		(j)	(k)	2.33-yr ARI	20-yr ARI
Raparapahoe River	FNJN0155	25	958	15.49	16.98
		26	958	15.49	16.98
		27	958	15.49	16.98
		28	958	15.49	16.98
		29	958	15.49	16.98
Raparapahoe Canal Tributary 1	FNJN0156	166	630	0.32	0.35
Raparapahoe Canal Tributary 2	FNJN0157	205	636	0.24	0.26
Raparapahoe Canal Tributary 3	FNJN0158	196	553	0.61	0.67
Ohineangaanga Stream	FNJN0159	130	220	8	8.78
		131	220	8	8.78
		132	220	8	8.78
Ohineangaanga Tributary	FNJN0160	199	84	1.48	1.63
Waiari Tributary 1a	FNJN0162	251	41	0.88	0.96
Waiari Tributary 1b	FNJN0164	273	27	0.3	0.33
Waiari Tributary 1c	FNJN0165	314	8	5.64	6.19
Waiari Tributary 2a	FNJN0167	518	334	2.59	2.85
Waiari Tributary 2b	FNJN0168	558	293	0.48	0.52
Waiari Tributary 3	FNJN0169	606	321	1.1	1.21
Waiari Stream	FNJN0170	776	295	35.87	39.24
		777	295	35.87	39.24
		778	295	35.87	39.24

2.5.3 Downstream Boundaries

The downstream boundaries were applied as ‘sumps’ directly into the MIKE 21 element of the model. Two types of sumps were used in the model. The first type of sump was introduced to allow water to leave the model domain without influencing the flood extent or depth. The second sump was introduced at the downstream end of the open channel watercourses to account for the backwater effect from the Kaituna River. Figure 5 shows the location of these sumps.

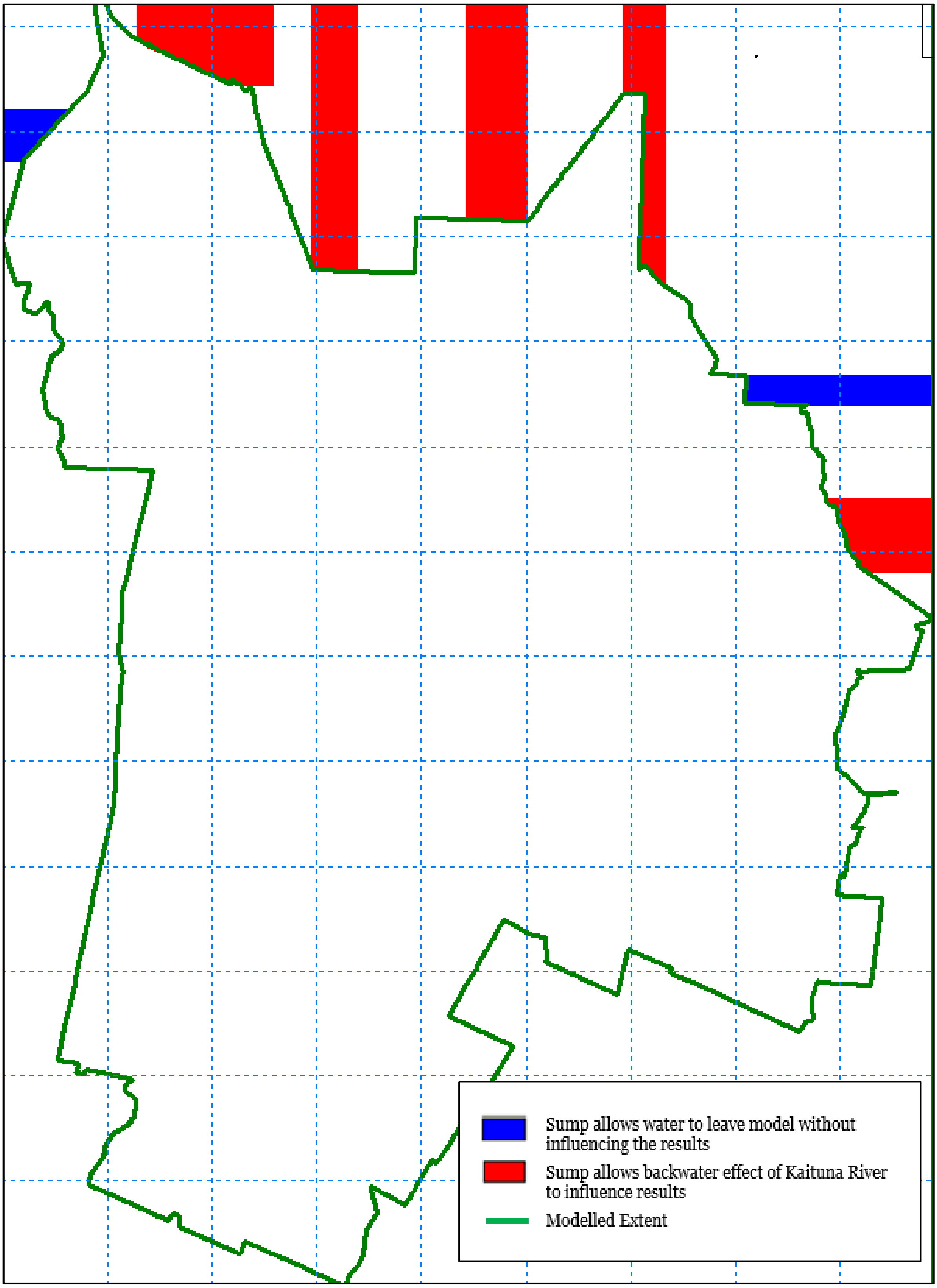


Figure 5 - Location of sumps

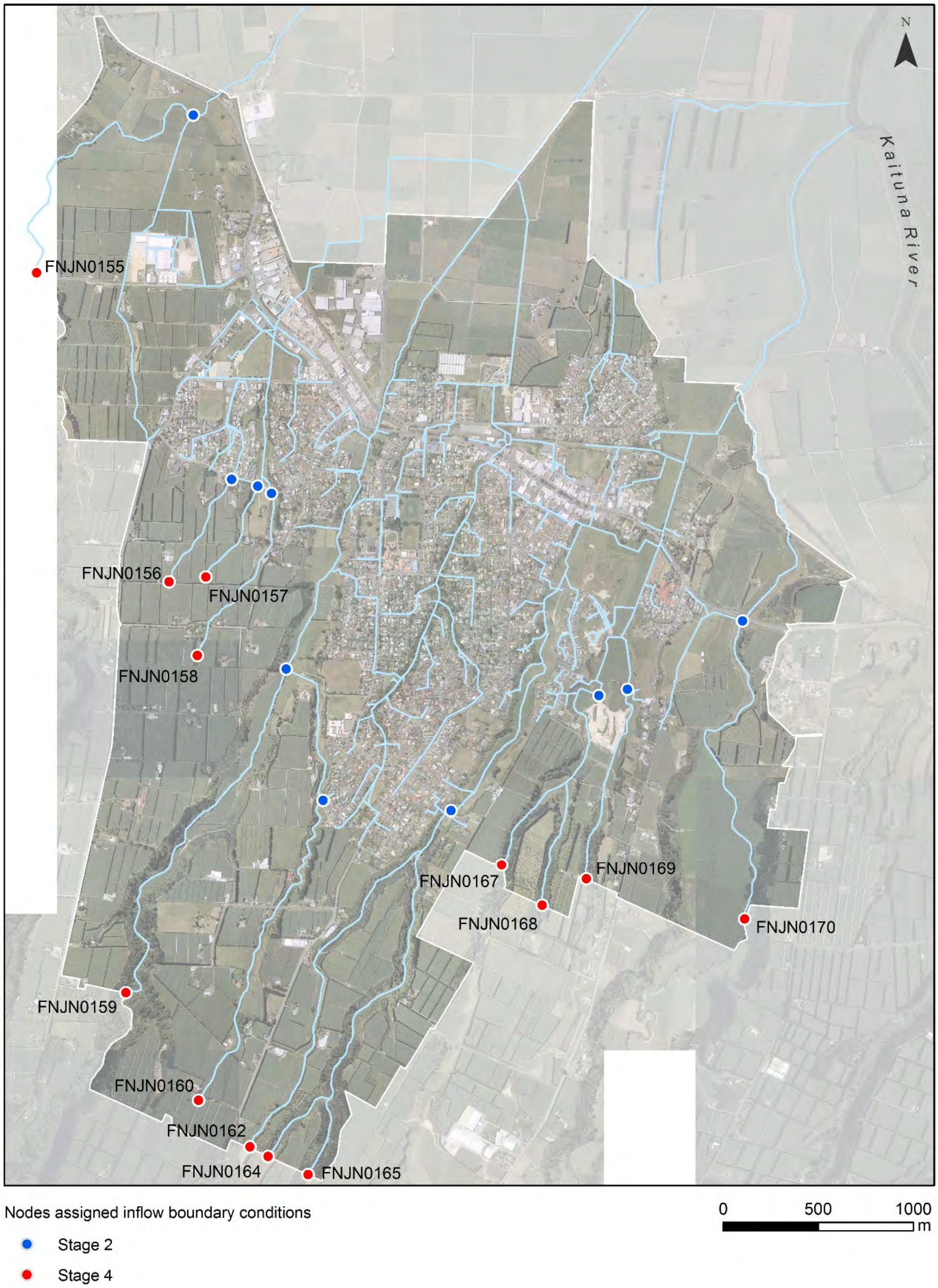


Figure 6 Location of inflow boundary conditions in the Stage 4 MIKE URBAN model

3 Model Results

3.1 Introduction

MIKE FLOOD was used to analyse two additional design events for the Te Puke stormwater model. These were:

- 10-year ARI event as a result of a 10-year ARI, 24-hour duration nested design rainfall event with 2.33-year inflows and downstream water levels.
- 50-year ARI event as a result of a 50-year ARI, 24-hour duration nested design rainfall event with 20-year inflows and downstream water levels.

3.2 Flood extent

A flood depth map was produced for the 50-year, 24-hour nested storm and the 10-year, 24-hour nested storm scenarios (existing infrastructure) using MIKE FLOOD. The output from MIKE FLOOD was a grid file of water depth. A water level grid was created from this by adding the depth values to the ground levels of the DEM. These flood maps are shown in the Appendix.

3.3 Comparison to Stage 2 results

Table 2 shows the water levels at the downstream end of the model predicted by the Stage 2 model compared to the water levels predicted by the developed Stage 7 model for the 50-year ARI event scenario.

Table 2 – Comparison of modelled downstream water levels

MIKE URBAN Link	MIKE 21 COORDINATE	WATER LEVELS (m)	
		MIKE URBAN Stage 2	MIKE 21 Stage 7
FLOD0122	(222, 1147)	7.64	7.12
FLOD0041	(328, 967)	6.79	5.98
FLOD0025	(501, 1014)	5.75	4.88
FLOD0056	(633, 952)	3.73	3.03
FLOD0092	(818, 685)	4.69	3.30

The differences between Stage 2 and Stage 7 are likely to be partly related to the way the channels have been represented in MIKE 21 in Stage 7 whereas they were represented in 1-D in MIKE URBAN in Stage 2. In Stage 2 the water would have been confined in the open channels in the MIKE URBAN model, whereas the Stage 7 model results show significant breakout from the channels. Another reason is that they are not a direct comparison due to the difference in the rainfall applied to the model between the two stages.

4 Conclusions

Flood mapping for the 50-year ARI, 24-hour duration nested rainfall event shows shallow surface flooding in the vicinity of residential areas, with deeper flooding largely confined to rural areas, park land and open channels.

5 References

Bay of Plenty Regional Council (2012), *"Hydrological and Hydraulic Guidelines"*, Bay of Plenty Regional Council, 2012.

Opus (2012), "*Te Puke MIKE URBAN Stormwater Modelling. Stage 2: Modelling Report*", a report prepared by Opus International Consultants for Western Bay of Plenty District Council, Reference 3-50909.00, November, 2012.

Opus (2014a), "*Te Puke Stormwater Modelling. Stage 4: Modelling Report and Network Upgrade Costings*", a report prepared by Opus International Consultants for Western Bay of Plenty District Council, Reference 3-53063.00, April 2014.

Opus (2014b), "*Western Bay of Plenty Stormwater Modelling guidelines*", a report prepared by Opus International Consultants for Western Bay of Plenty District Council, August 2014.

Appendix

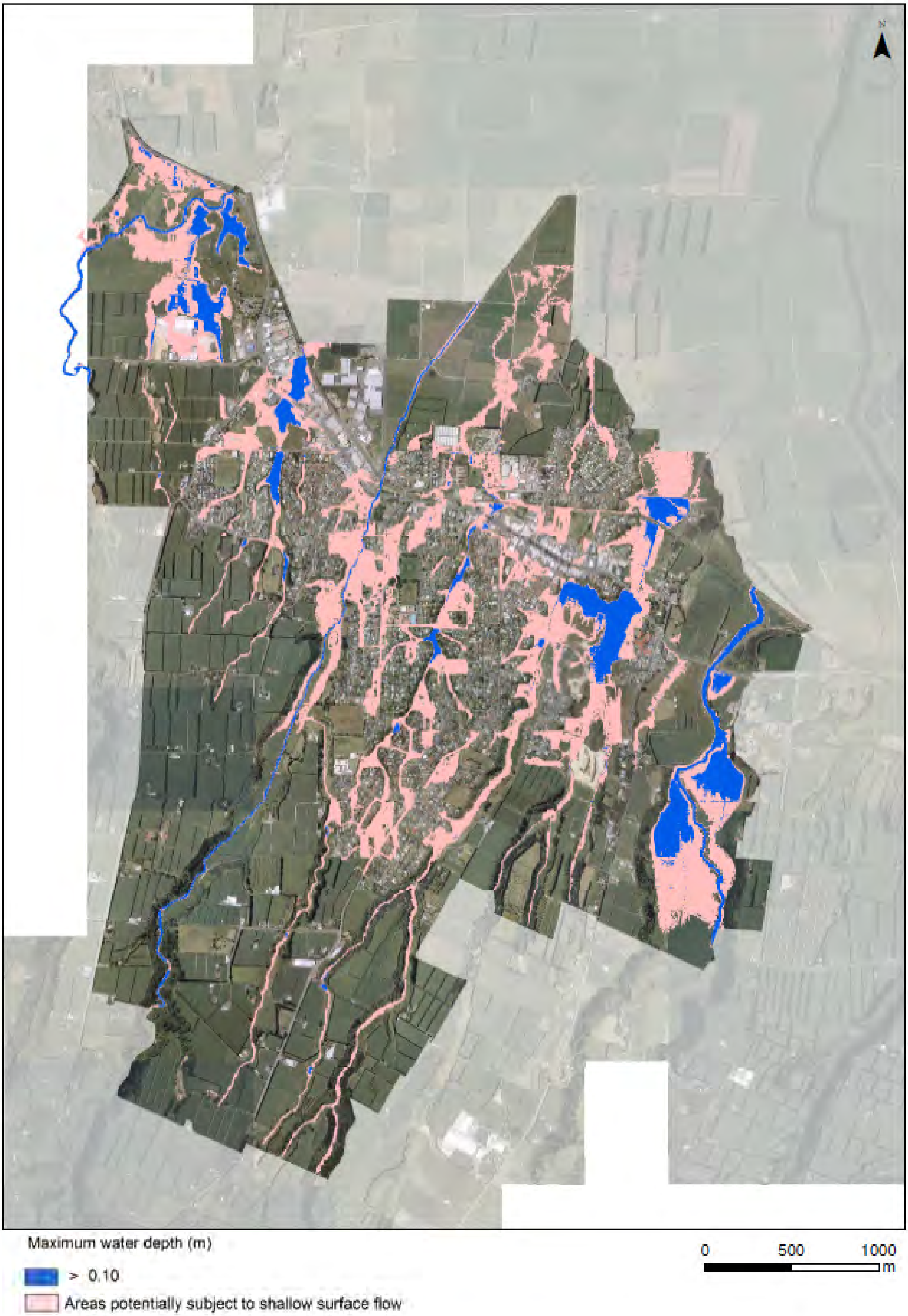


Figure 7 – Flood depth for the 10-year 24-hour duration design "nested storm" rainfall event

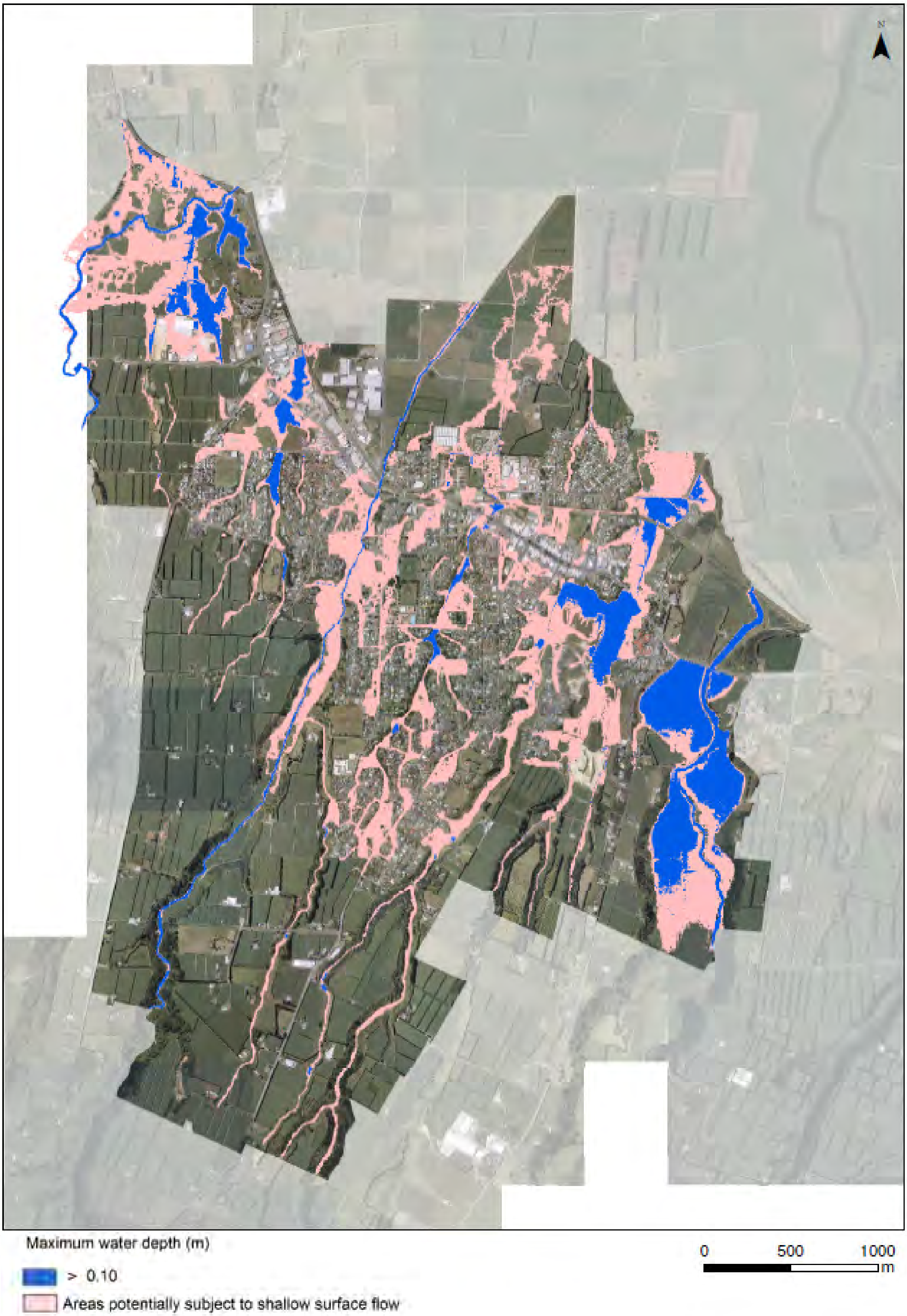


Figure 8 – Flood depth for the 50-year 24-hour duration design "nested storm" rainfall event

Opus International Consultants Ltd
Gartshore House, Level 3, 116 Cameron Road
PO Box 646, Tauranga 3140
New Zealand

t: +64 7 578 2089
f: +64 7 578 2086
w: www.opus.co.nz

Te Puke Intensification

Water Supply Modelling

Western Bay of Plenty District Council

Reference: 520742

Revision: 0

2022-06-13

Bringing ideas to life

Document control record

Document prepared by:

Aurecon New Zealand Limited
Ground Level 247 Cameron Road
Tauranga 3110
PO Box 2292
Tauranga 3140
New Zealand

T +64 7 578 6183
F +64 7 578 6143
E tauranga@aurecongroup.com
W aurecongroup.com

Document control						aurecon
Report title		Water Supply Modelling				
Document code		520742-0000-REP-CC-0000_Te Puke Water Supply Modelling	**Project number**		520742	
File path		Https://aurecongroup.sharepoint.com/sites/P520742/5 Deliver Design/502 Modelling/TePukeWaterIntensn/Report/520742-0000-REP-CC-0000_Te Puke Water Supply Modelling.docx				
Client		Western Bay of Plenty District Council				
Client contact			**Client reference**			
Rev	**Date**	**Revision details/status**	**Author**	**Reviewer**	**Verifier** (if required)	**Approver**
0	2022-06-13	Report	R Kelly	A Ho	A Ho	N Raynor
Current revision		**0**				

Approval			
Author signature		Approver signature	
Name	Robert Kelly	Name	Neill Raynor
Title	Associate	Title	Principal

Contents

Appendices

Figures

1 Background

Future growth is expected in Te Puke. This includes infill of existing areas; greenfield areas currently being developed and potential structure plan areas. There are also further future possible development areas, but these are not being considered for any Plan Change at this time and hence will not be considered as part of this package of work. The areas and number estimate of extra connections were provided by Paul Van den Berg - Infrastructure Engineer Water of Western Bay of Plenty District Council (WBOPDC) by email 28/03/2022. The infill areas include two estimates, these being a low projection and a high projection.

Council has asked Aurecon to undertake water supply modelling for Te Puke including these developments to determine what impacts the extra demand will have on the supply network and what upgrades may be required.

2 Scenarios Modelled

The following scenarios were modelled:

- Scenario 1 – Existing conditions
- Scenario 2 – Infill – low projection
- Scenario 3 - Infill – high projection
- Scenario 4 – Scenario 3 plus greenfield areas currently being developed
- Scenario 5 – Scenario 4 plus potential future structure plan areas.

Each scenario was modelled four times, once with average daily demand and once with maximum daily demand. Firefighting flows were also modelled twice for each scenario, one with a fire in the Te Puke CBD and once with a fire in the Hookey Drive area (20 runs in total).

3 Methodology

3.1 Base Model

The base model was taken from the existing case scenario for recent modelling undertaken for Rangiuru Business Park (RPB). Please refer to section 2.2 of report "Rangiuru Business Park Water Modelling" (Aurecon, December 2021) for details on the updates made to the base model.

It is noted that the base case model for RPB already included demands for the Zest and Te Mania developments. These were removed for the existing (current day) model for this study.

3.2 Average Day and Peak Day

Scada data supplied by Council shows the daily averaged flow out of No. 1 Road reservoir to be around 65 litres/s for a normal day, and 92 litres/s for a maximum demand day (e.g. a hot summers day in the middle of a dry period).

To model a peak summers' day, all demands in the model were multiplied by a factor of 1.4 (92/65, excluding all demands east of the shut valve that are supplied separately in the Maketu/Paengaroa/Pukehina zone).

3.3 Demand Growth Data

The locations and number estimate of extra connections were provided by Paul van den Berg - Infrastructure Engineer Water of Western Bay of Plenty District Council (WBOPDC) by email 28/03/2022. This is included as Appendix A.

These extra connections were represented in the model as additional demands. The size of the demand and location where the additional demands were added into the model are provided in detail in Appendix B.

A summary of the total demand for the Te Puke Zone supplied by the No. 1 Road reservoir (i.e. including Te Puke township and surrounding rural areas but excluding the Maketu/Pukehina Paengaroa Zone) is given in Table 1 below. This is the average daily flow out of No. 1 Road reservoir but does not include peaks and troughs due to diurnal patterns or demand from No. 3 Road reservoir refilling.

From Table 1 for an average day the daily demand rate increases from 65 litres/s for the existing conditions to 85 litres/s for the ultimate development scenario 5. For a peak summers' day, the daily demand rate increases from 92 litres/s for the existing conditions to 119 litres/s for the ultimate development scenario 5. This shows the demand in Te Puke increases from current day to the ultimate development scenario by about 30%.

Table 1 - Te Puke Zone - Daily Demand Rates (litres/s)

Scenario		a – Average Day	b - Peak Day
1	Existing	1a (65 litres/s)	1b (92 litres/s)
2	Brownfield infill – low projection	2a (67 litres/s)	2b (94 litres/s)
3	Brownfield infill – high projection	3a (70 litres/s)	3b (97 litres/s)
4	Scenario 3 plus current greenfield	4a (76 litres/s)	4b (106 litres/s)
5	Scenario 4 plus extra areas that may be rezoned	5a (85 litres/s)	5b (119 litres/s)

N.B: Peak diurnal flows will be higher than the values given in Table 1

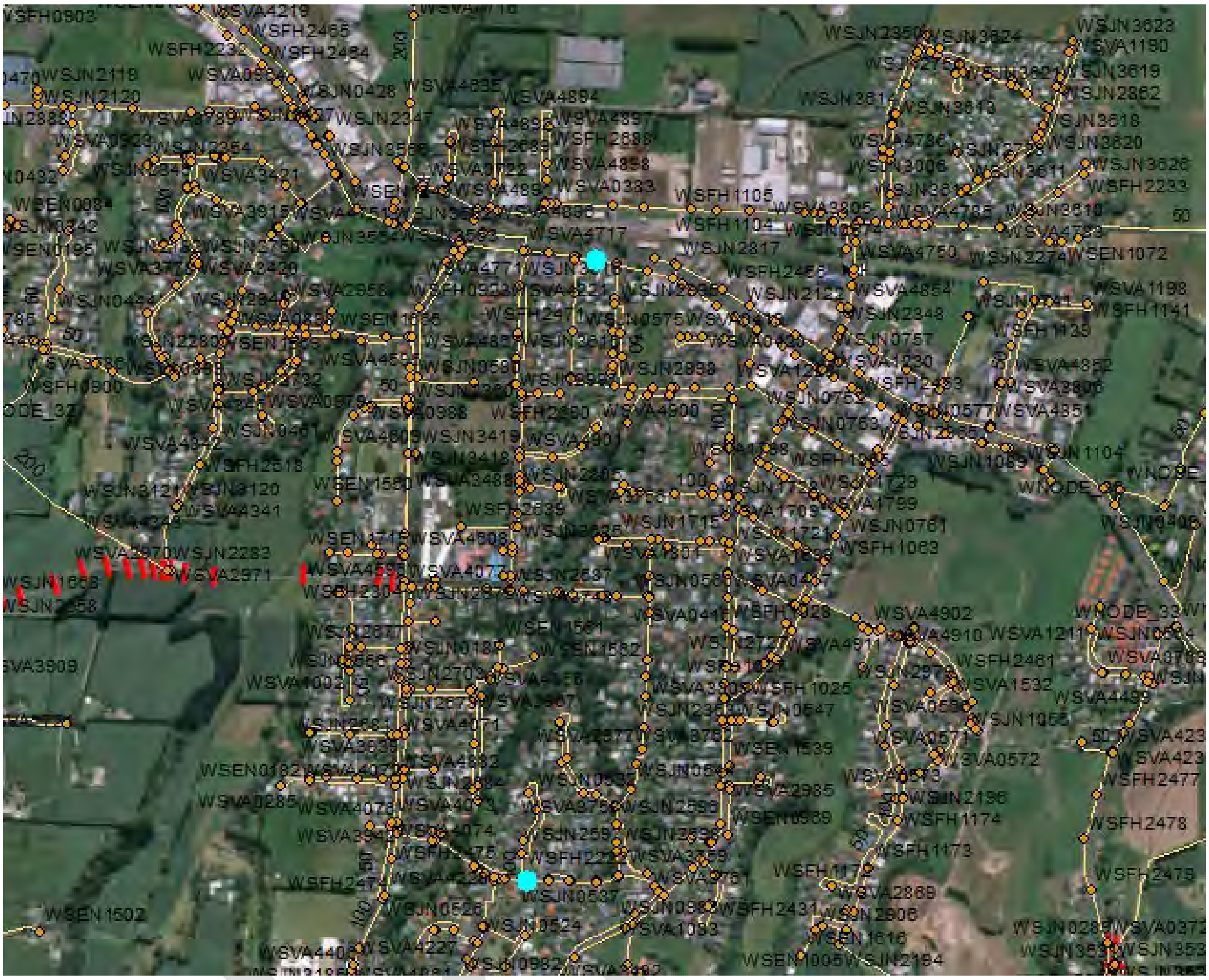
3.4 Fires

Fires were modelled in the low pressure Hookey Drive area (WSFH1003) and also in the CBD (WSFH1082) as shown in Figure 1 below.

Fires were modelled for the average day scenario. They were modelled to occur at 10am near but not at the diurnal peak. This is in approximate accordance with the Fire Code (NZ Standard 4509:2008) which specifies supply systems be designed to provide 60% of annual peak demand in addition to the fire flow.

Figure 1 - Location of Fire Tests

CBD - WSFH1082 (northern blue dot), Hookey Drive area WSFH1003 (southern blue dot)



4 Results

4.1 Pressure Maps

Figure 2 and Figure 3 below show the pressure at 8:15am (time of peak demand) for the existing development scenario and ultimate development scenario respectively for an average day. Figure 4 and Figure 5 show the pressure at 8:15am (time of peak demand) for the existing development scenario and ultimate development scenario respectively for a peak summers' day.

Comparing Figure 2 with Figure 3 or comparing Figure 4 with Figure 5 it can be seen that there is little difference between the existing development and the ultimate development scenarios. There is a low-pressure area (less than 30m) denoted by the blue and green dots around Hookey Drive. This low-pressure area expands northwards slightly for the ultimate scenario for both the average day and the peak summers' day comparisons. Inherently the minimum pressure in the existing low-pressure areas decrease by a magnitude of 1m compared with existing development during average day, and 2m for peak summers day (described in Section 4.2). Otherwise, the pressure maps generally show little difference between scenarios.

Figure 2 - Scenario 1a – Existing Development, Average Day – Pressure at Peak Demand Time

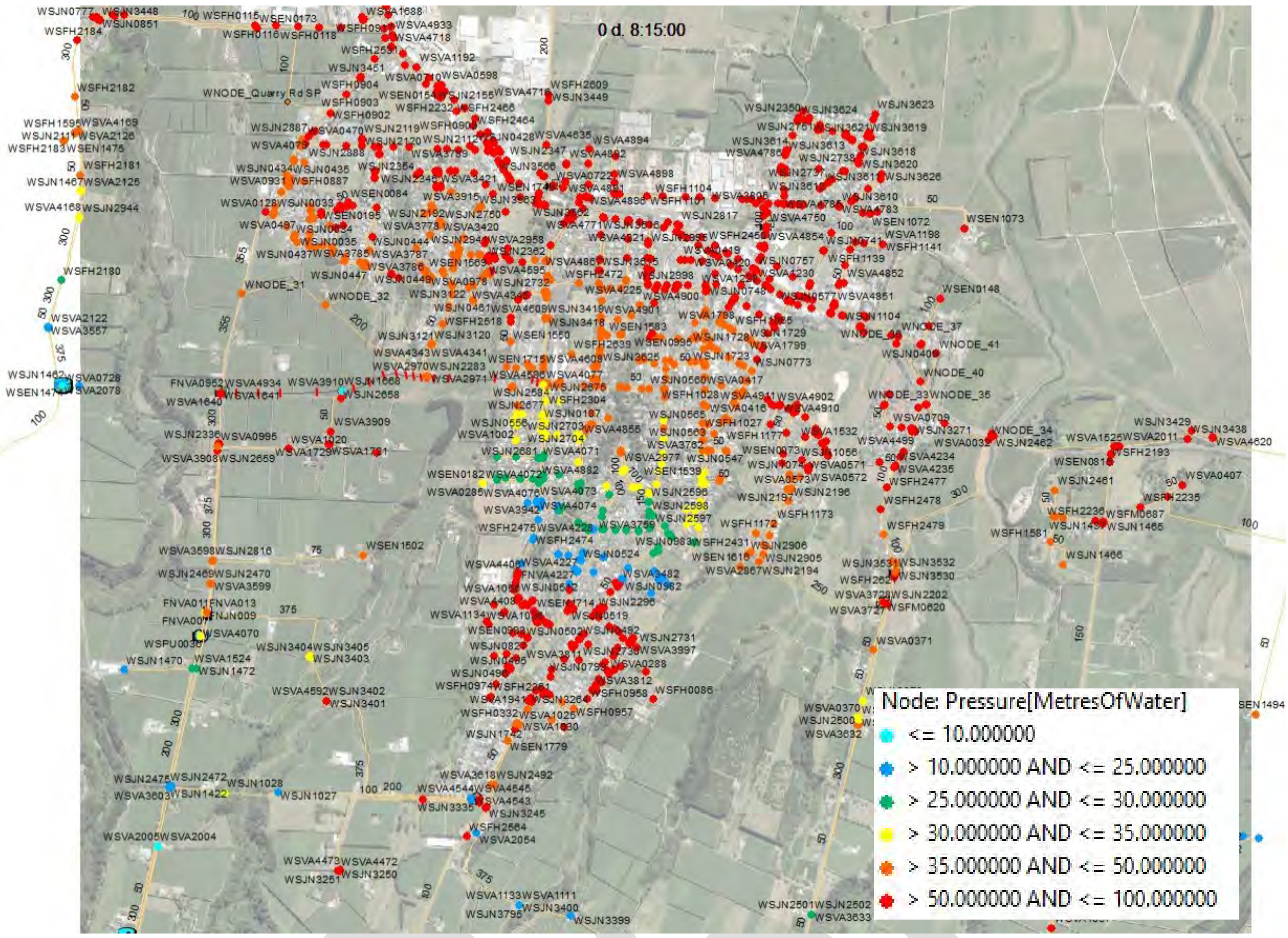


Figure 3 - Scenario 5a – Ultimate Development, Average Day – Pressure at Peak Demand Time

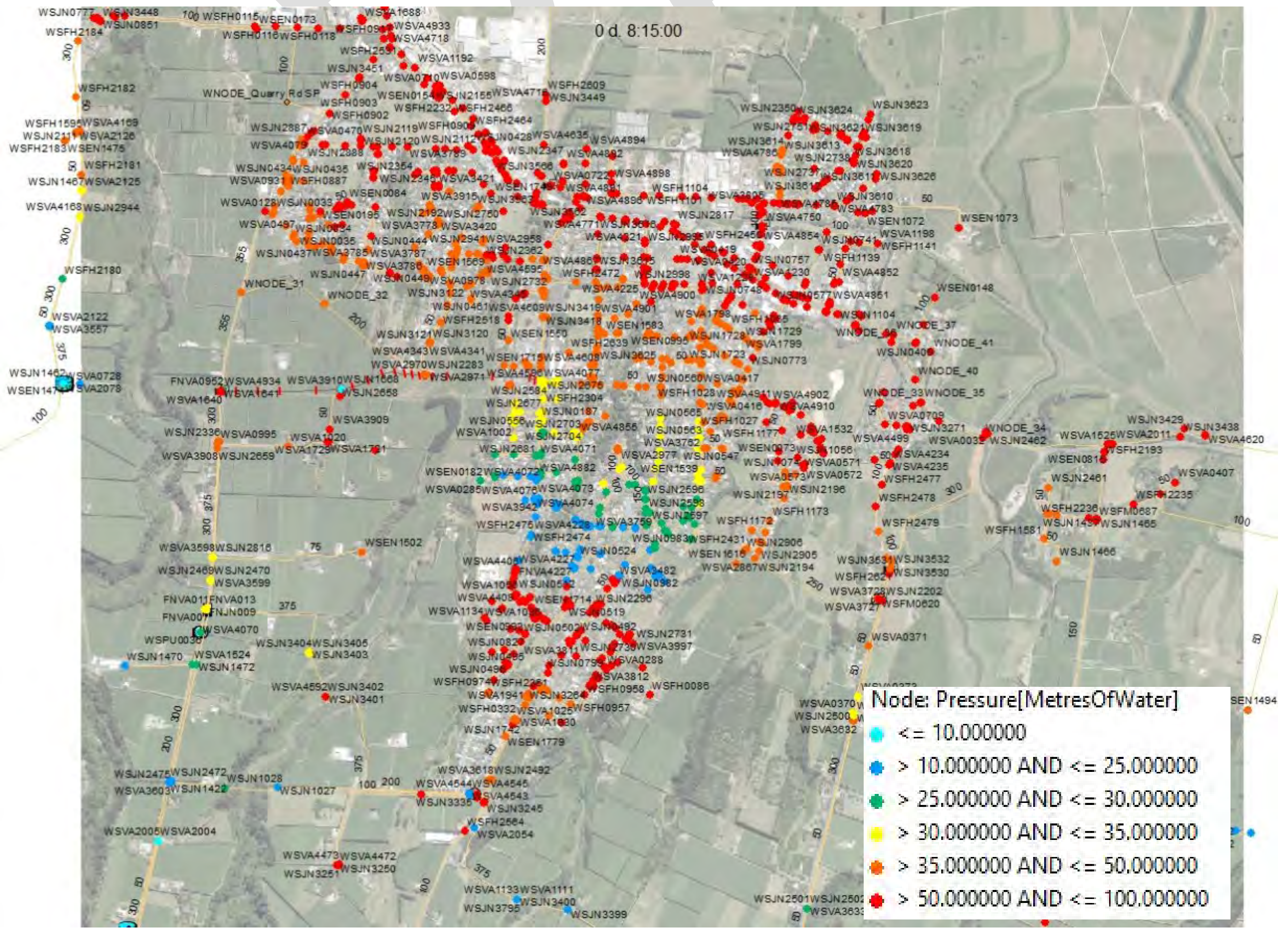


Figure 4 - Scenario 1b – Existing Development, Average Day – Pressure at Peak Demand Time

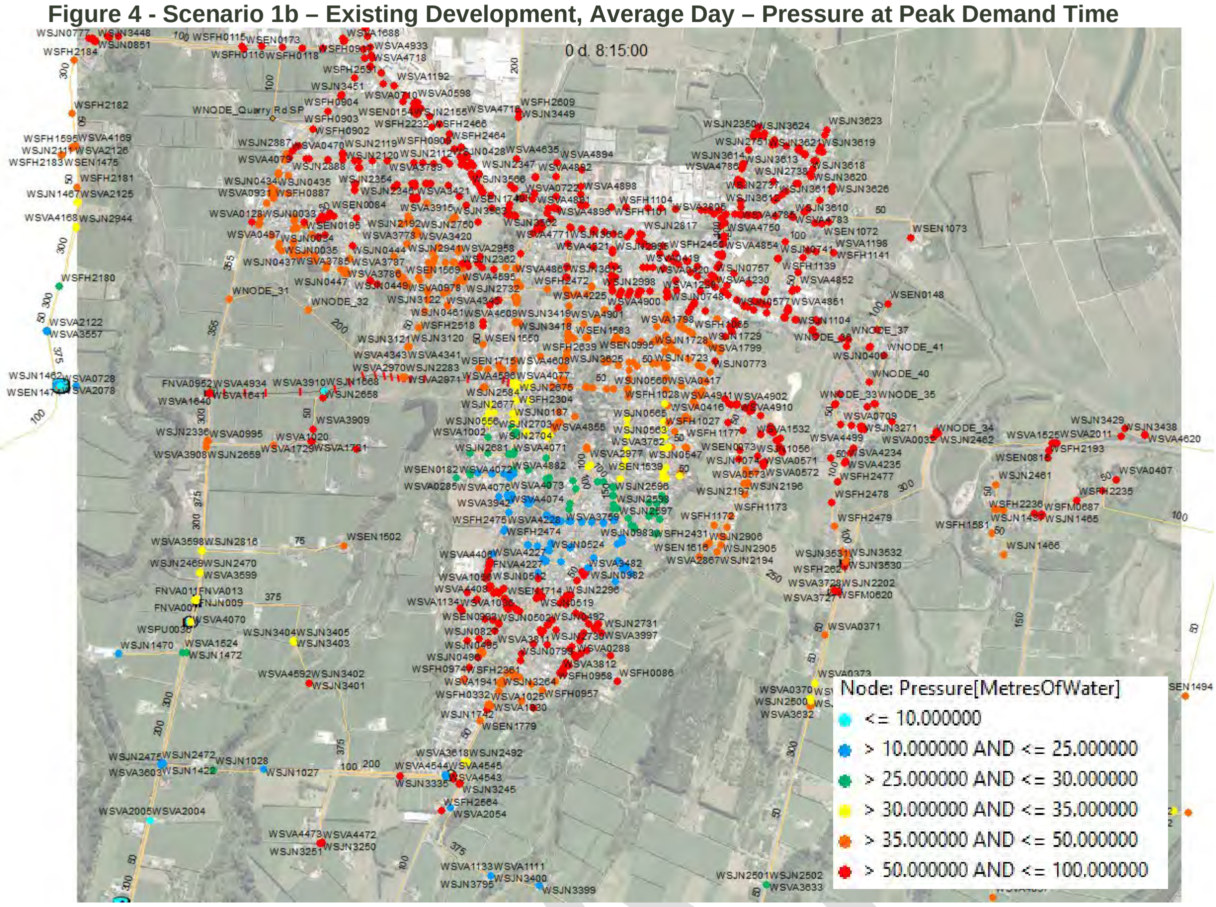
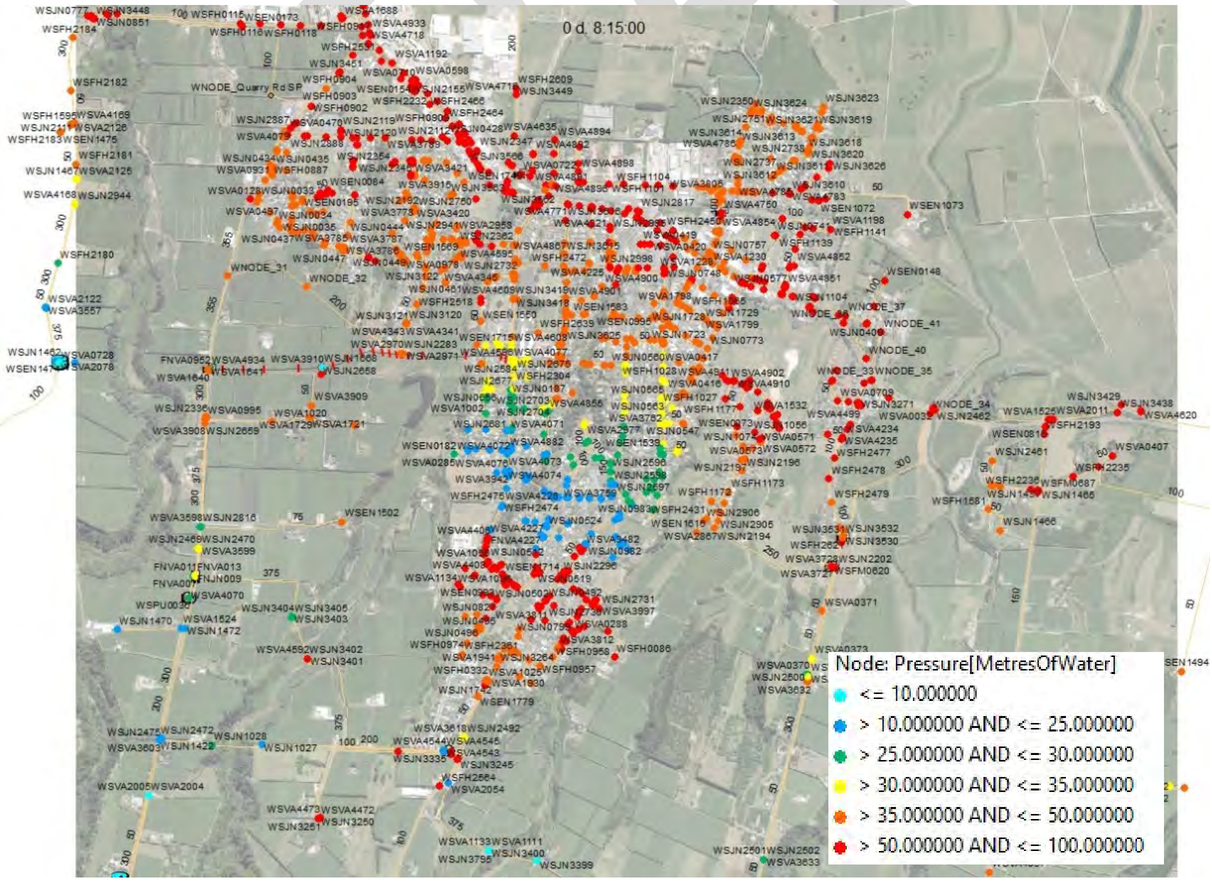


Figure 5 – Scenario 5b – Ultimate Development, Peak Summers' Day – Pressure at Peak Demand Time



4.2 Diurnal Pressure Patterns

Diurnal pressure patterns were extracted at the two locations shown in Figure 1, namely WSFH1082 (Jellicoe St in the CBD) and WSFH1003 (Hookey Drive area).

4.2.1 Scenario a – Average Day

Figure 6 below shows the diurnal pressure pattern at WSFH1082 (Jellicoe St in the CBD) for Scenario a - Average Day. This shows that the daily minimum pressure drops from 56m for scenario 1a (existing development) to 55m scenario 5a (ultimate development) i.e., a drop of about 1m.

Figure 6 - Scenario a - WSFH1082 (CBD)

(Black sc1a, blue sc2a, green sc3a, cyan sc4a, red sc5a)

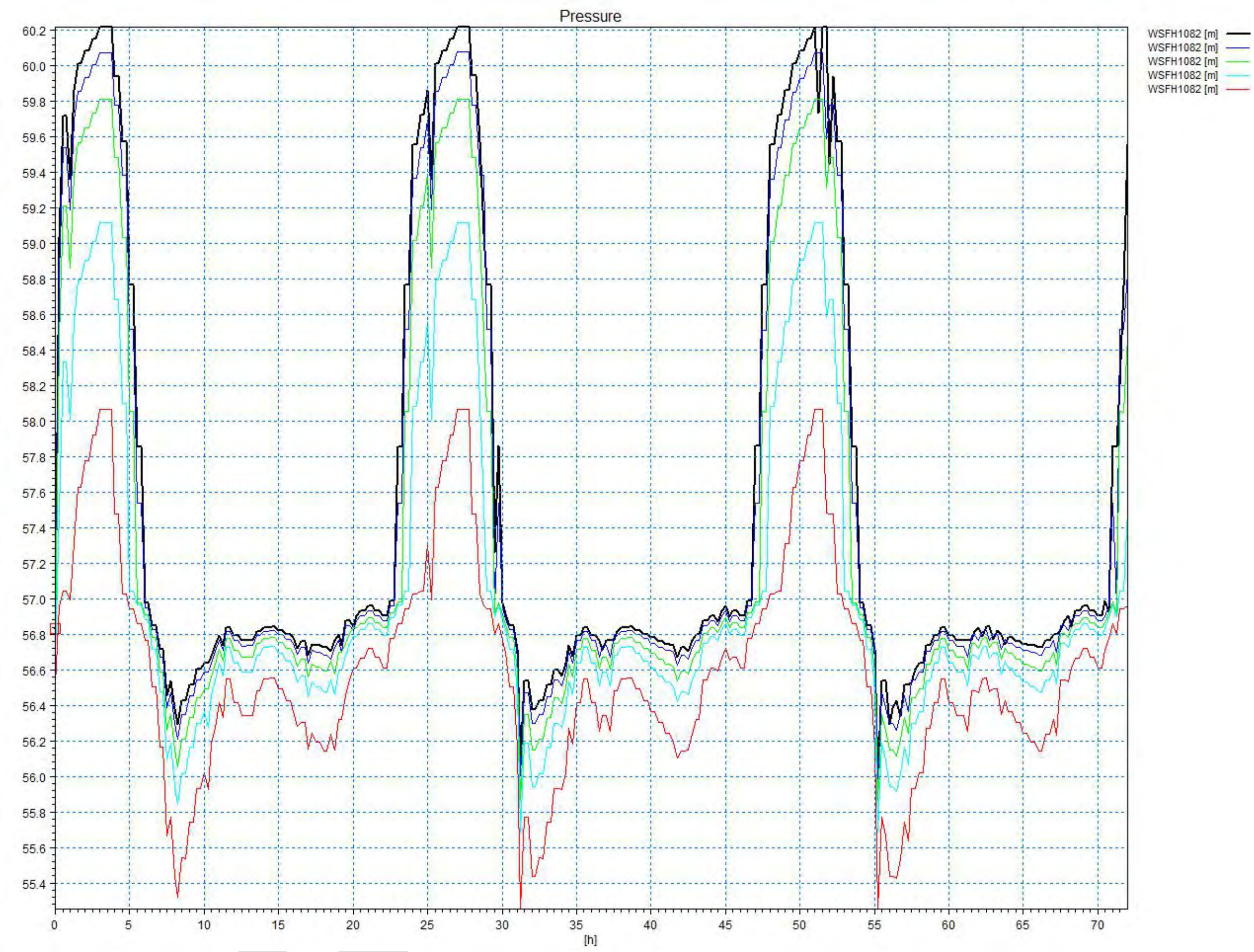
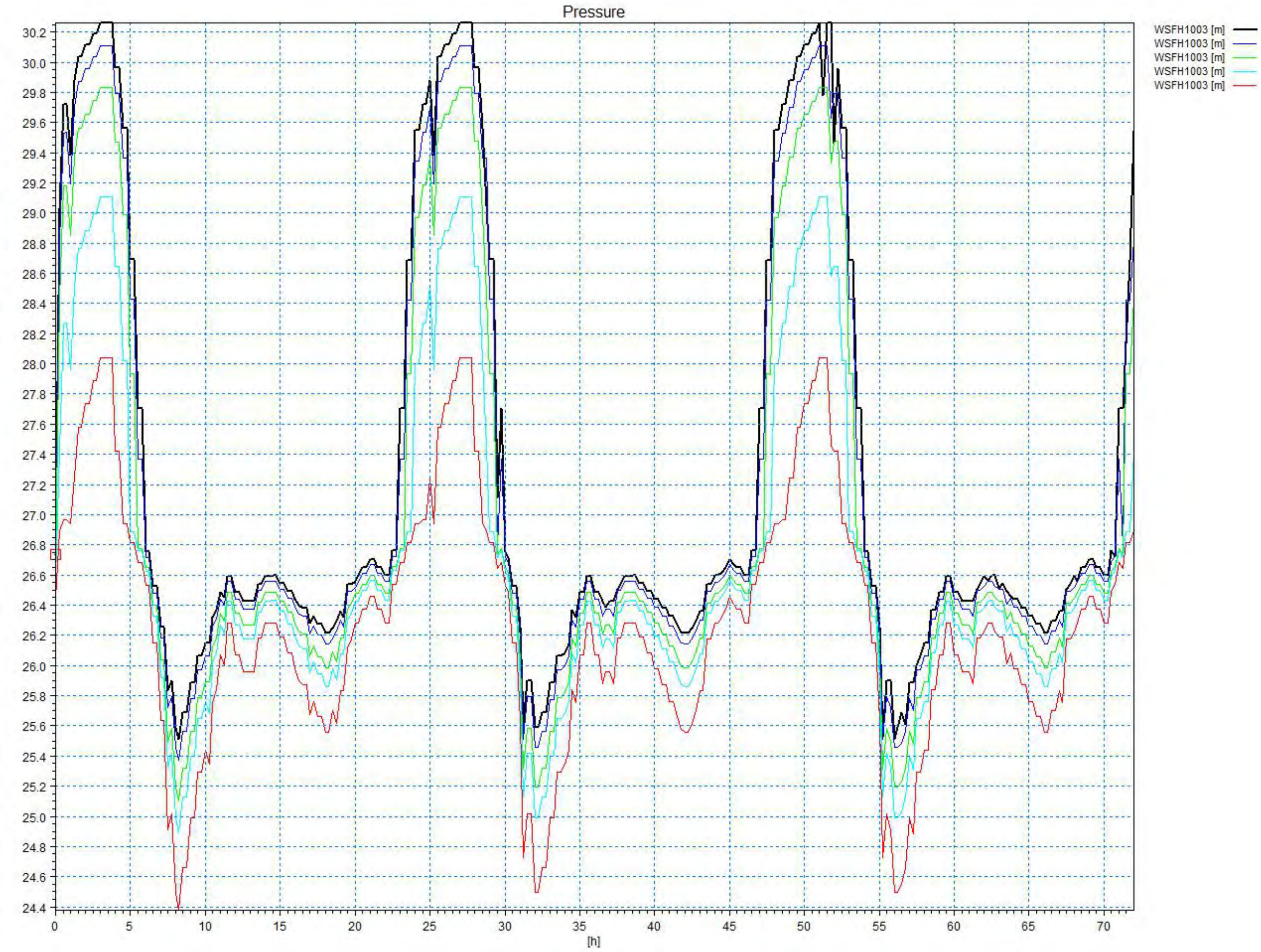


Figure 7 below shows the diurnal pressure pattern at WSFH1003 Hookey Drive) for Scenario a - Average Summers' Day. This shows that the daily minimum pressure drops from 25m for scenario 1a (existing development) to 24m scenario 5a (ultimate development) i.e. a drop of about 1m

Figure 7 - Scenario a - WSFH1003 (Hookey Drive)

(Black sc1a, blue sc2a, green sc3a, cyan sc4a, red sc5a)



4.2.2 Scenario b – Peak Summers' Day

Figure 8 below shows the diurnal pressure pattern at WSFH1082 (Jellicoe Street in the CBD) for Scenario b - Peak Summers' Day. This shows that the daily minimum pressure drops from 55m for scenario 1b existing development to 53m scenario 5b (ultimate development) i.e. a drop of about 2m.

Figure 8 - Scenario b - WSFH1082 (CBD)

(Black sc1b, blue sc2b, green sc3b, cyan sc4b, red sc5b)

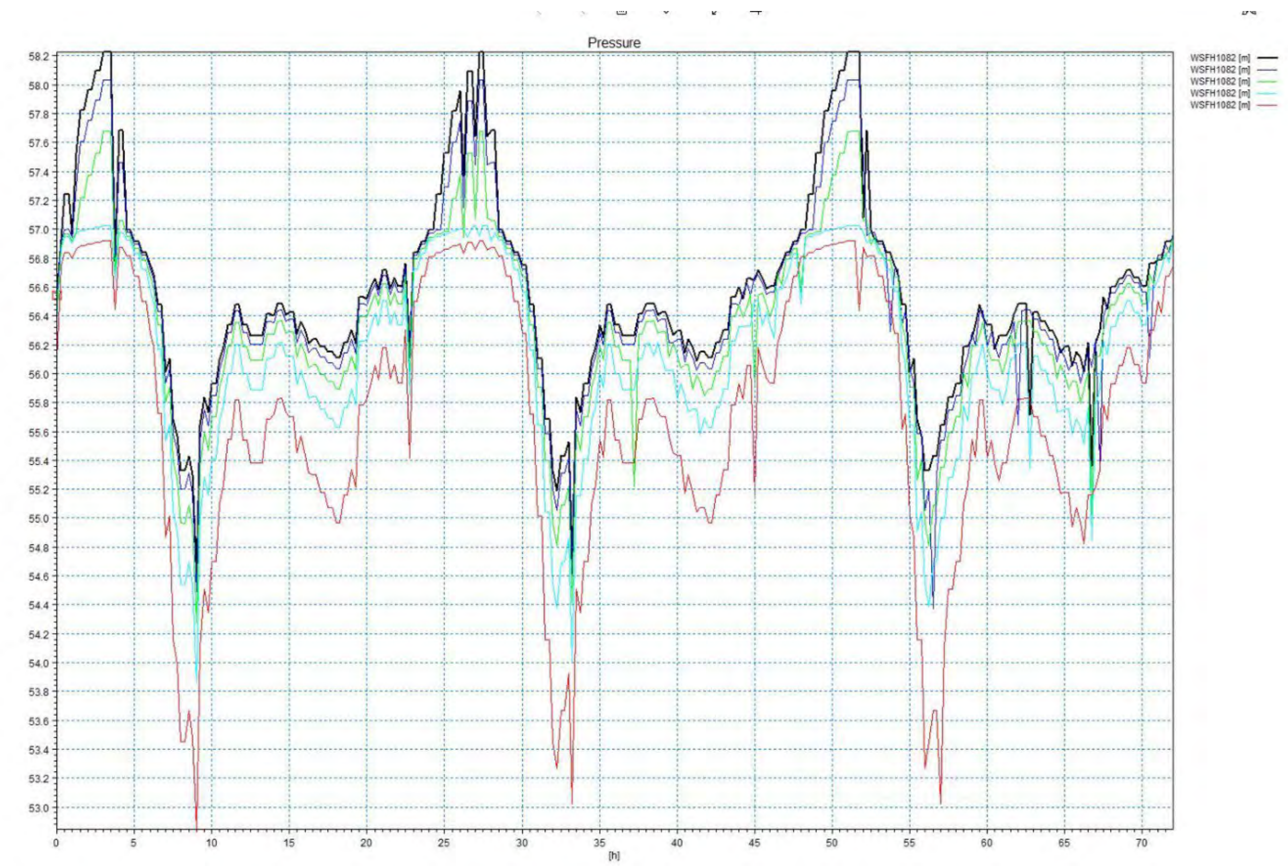
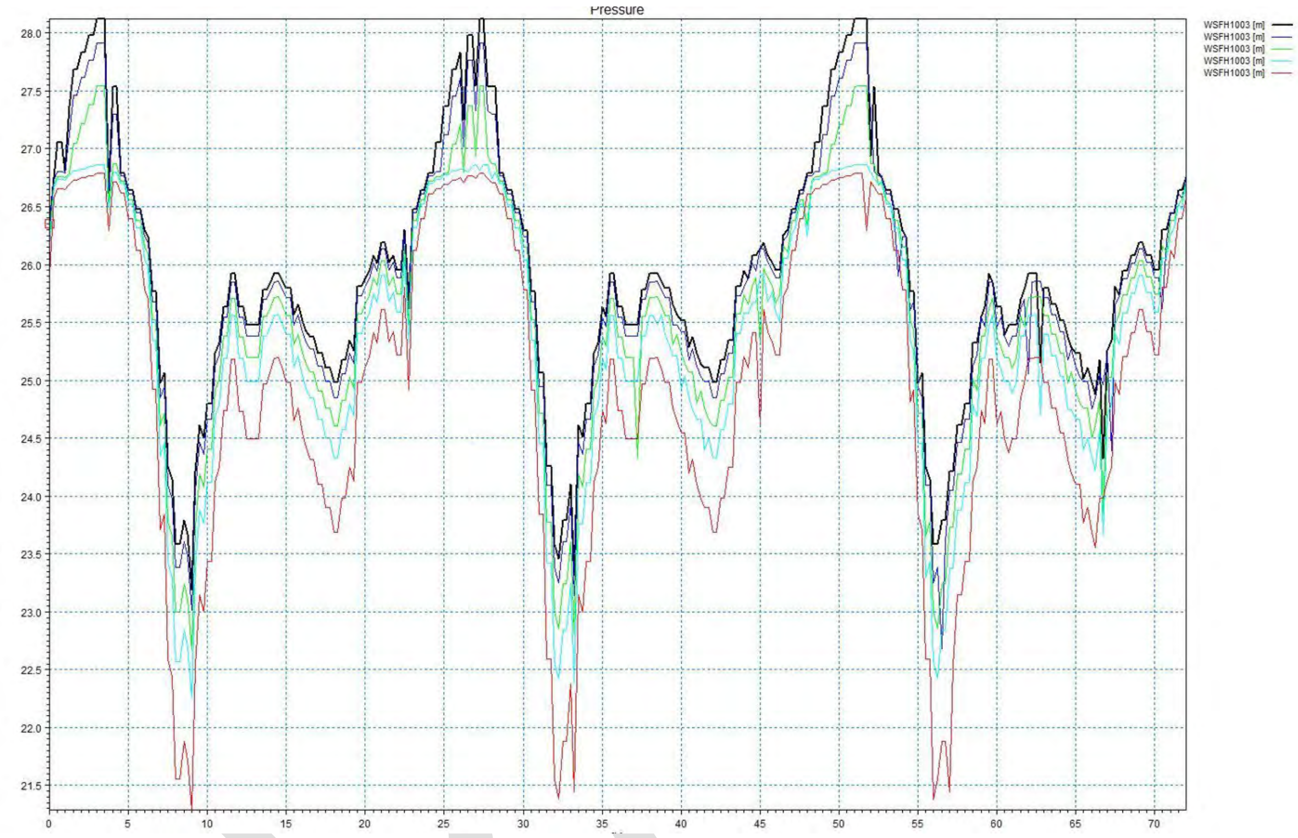


Figure 9 below shows the diurnal pressure pattern at WSFH1003 Hookey Drive) for Scenario b - Peak Summers' Day. This shows that the daily minimum pressure drops from 23m for scenario 1b (existing development) to 21m scenario 5b (ultimate development) i.e. a drop of about 2m

Figure 9 - Scenario b - WSFH1003 (Hookey Drive)

(Black sc1b, blue sc2b, green sc3b, cyan sc4b, red sc5b)



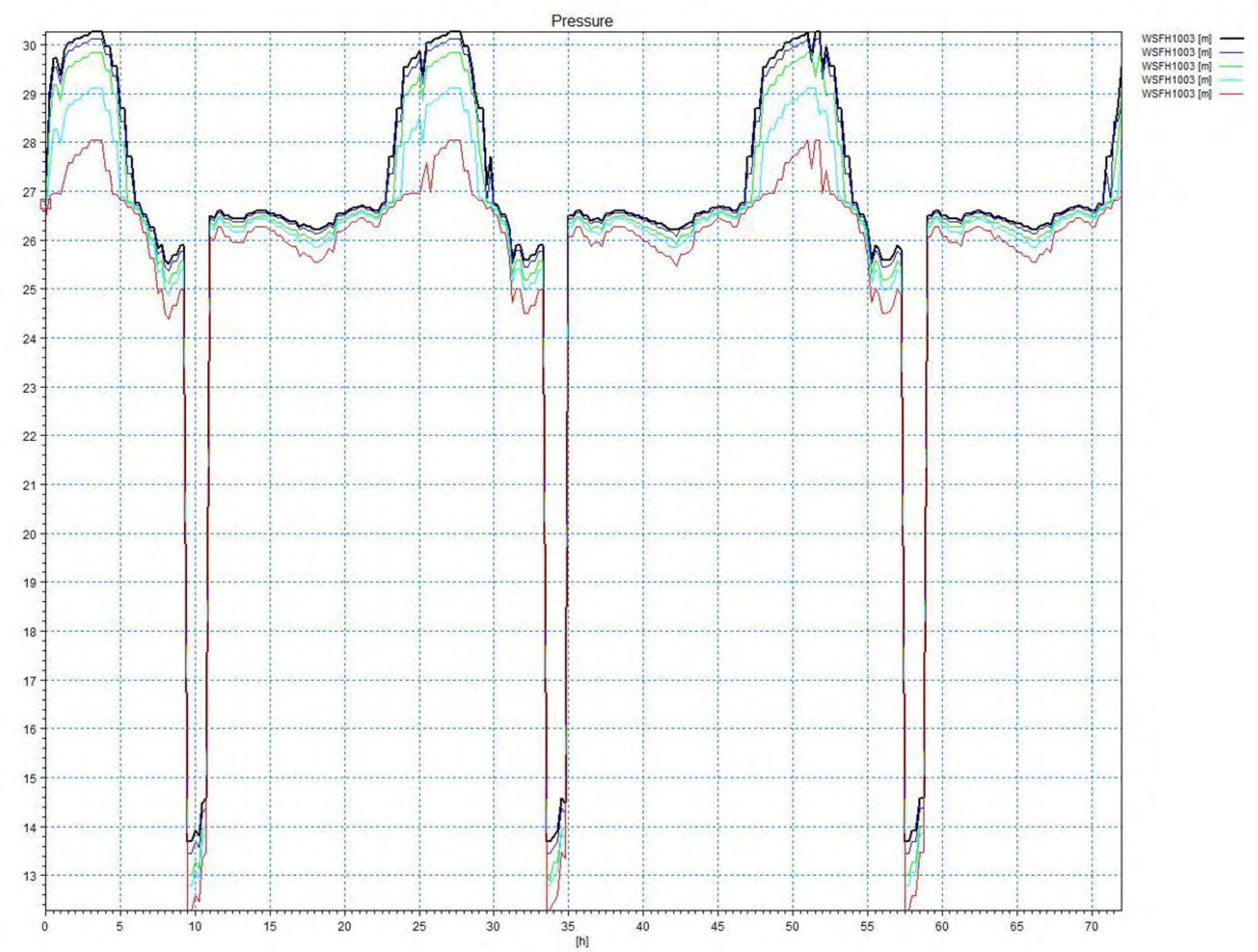
4.2.3 Scenario c – Fire at Hookey Drive (WSFH1003)

Figure 10 below shows the impact of a fire at Hookey Drive (based on a fire at 10am on an average day (not peak summers' day). With existing demand (scenario 1c black) the pressure falls to 14m.

For the ultimate development scenario with future infill and greenfield and Structure plan demands (scenario 5c red) the pressure falls to 12.5m. This is in compliance with the fire code which requires pressure not to fall below 10m.

Figure 10 - Scenario c - Fire at Hookey Drive (WSFH1003)

(Black sc1c, blue sc2c, green sc3c, cyan sc4c, red sc5c)

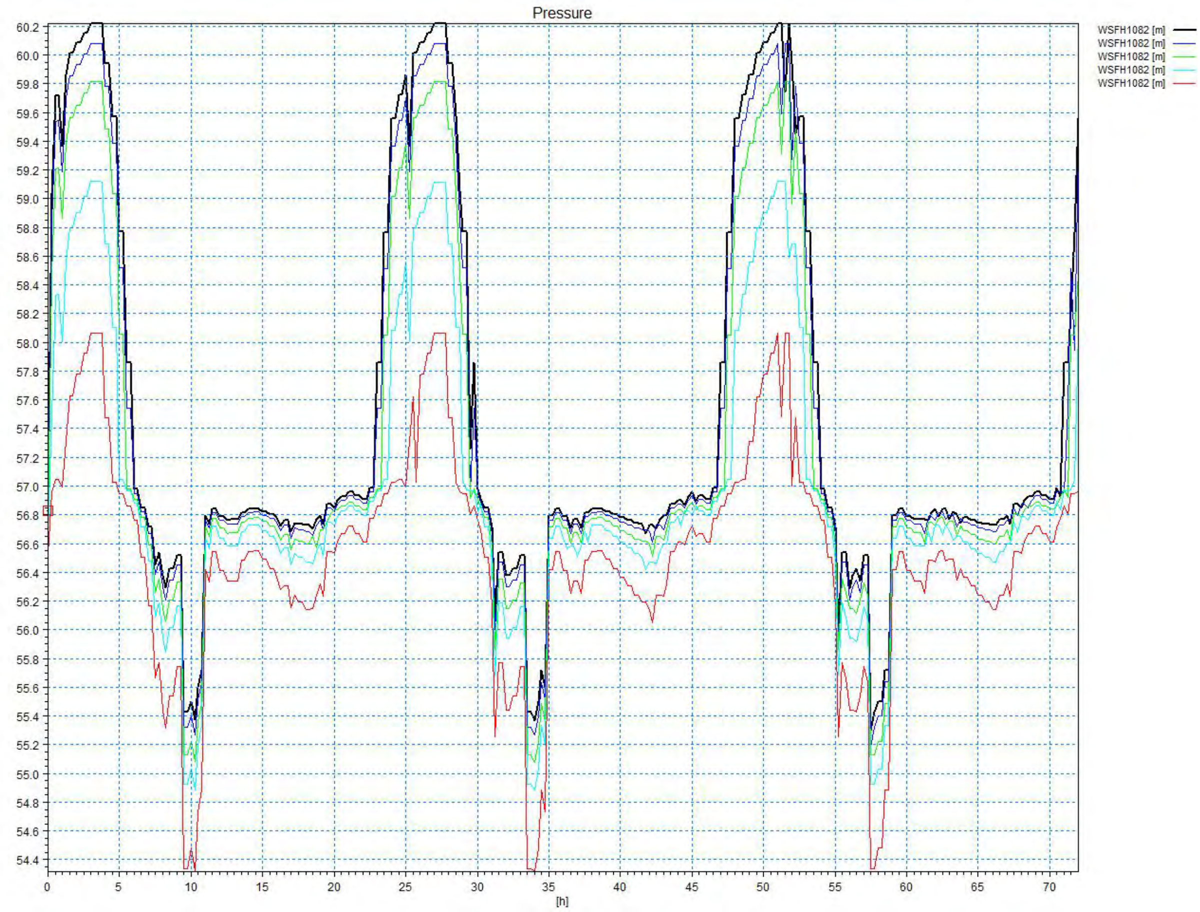


4.2.4 Scenario d – Fire in CBD (WSFH1082)

Figure 11 below shows the impact of a fire in the CBD (based on a fire at 10am on an average day (not peak summers' day). With existing demand (scenario 1d black) the pressure falls to 55m. For the ultimate development scenario with future infill and greenfield and structure plan demands (scenario 5d red) the pressure falls to 54m. This is in compliance with the fire code which requires pressure not to fall below 10m. (It should be noted that this is based on a fire-fighting flow of 25 litres/s which may not be adequate depending on the type of building in the CBD that is ablaze. However, Council have been consulted on this and they do not wish to investigate firefighting supply in more detail than this for this particular study.)

Figure 11 - Scenario d - Fire in CBD (WSFH1082)

(Black sc1d, blue sc2d, green sc3d, cyan sc4d, red sc5d)



4.3 Headloss in Pipes

Figure 12 and Figure 13 below show pipes with a maximum headloss of more than 3m per km of headloss in the peak summers' day. Figure 12 is of scenario 1b (existing development) while the second image Figure 13 is of scenario 5b (ultimate development).

It can be seen the ultimate development does put a little more strain on the network, notably in the Seddon Street area (refer blue rectangle on Figure 13) and the proposed No.3 Road / Te Puke Quarry Road Sport / Industrial area (refer yellow rectangle).

Figure 12 - Scenario 1b - Pipe Headloss – Peak Day – Existing Development

(Red pipes have maximum headloss >3m/km)

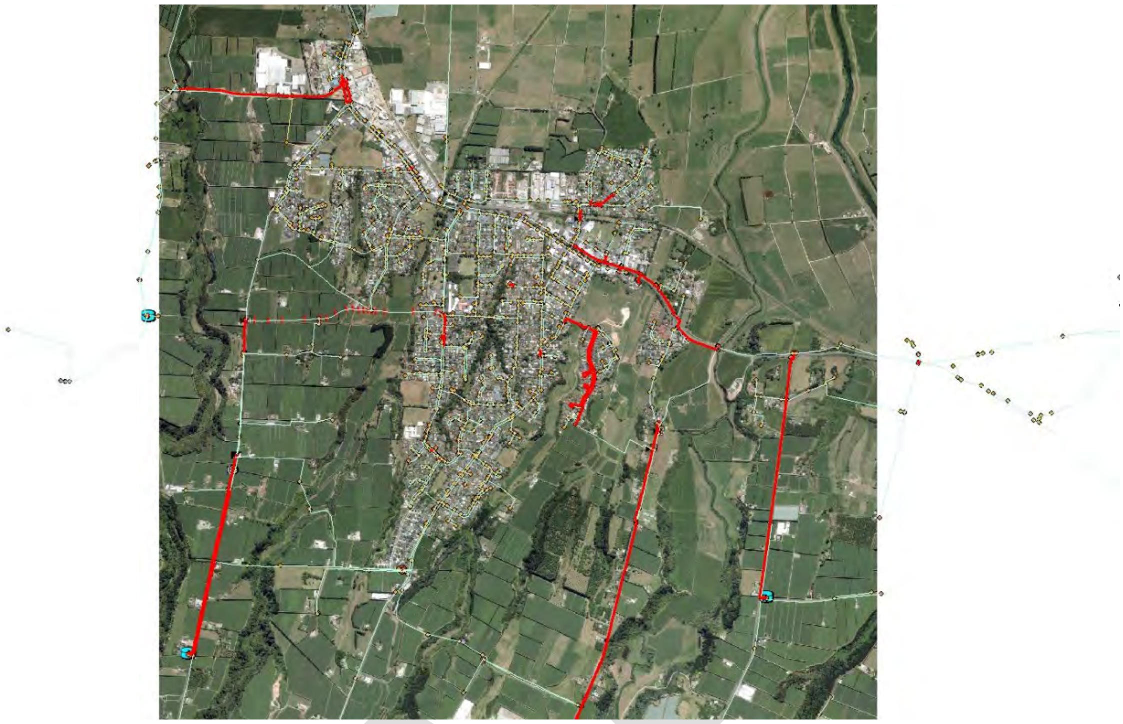
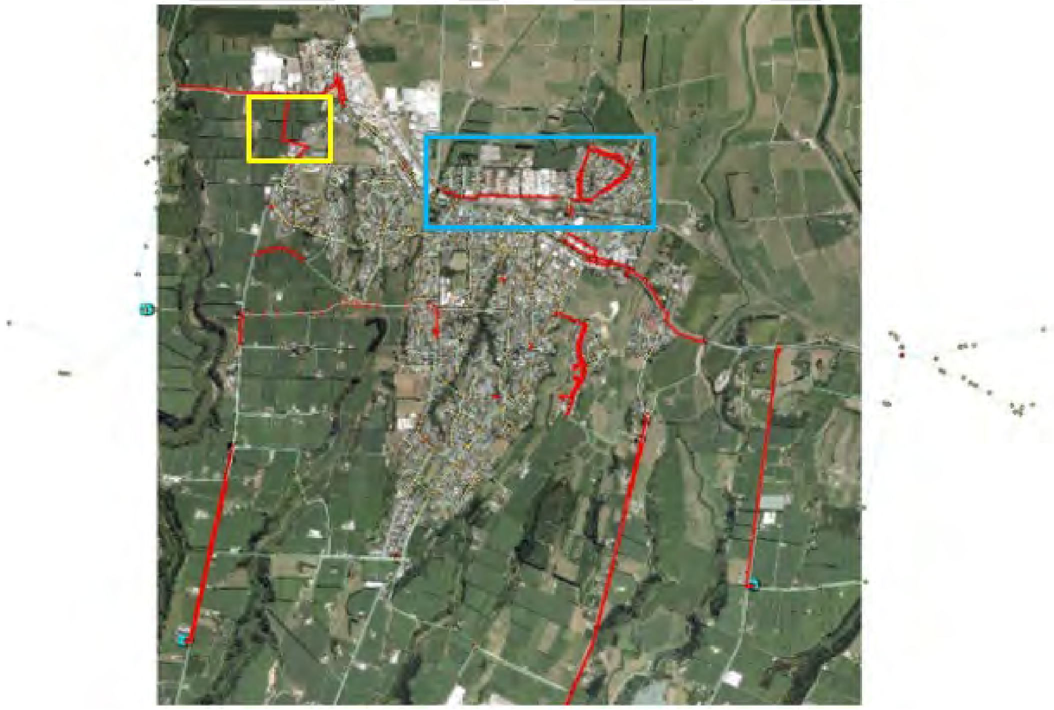


Figure 13 - Scenario 5b –Pipe Headloss – Peak Day – Ultimate Development

(Red pipes have maximum headloss >3m/km)



4.4 Ability to Fill No. 3 Road Reservoir

It is seen in Figure 14 that in scenario 5b (peak summers' day, ultimate development) the No. 3 Road reservoir fails to refill. It starts with a water level of about 5m but after 72 hours has less than 2.5m depth remaining.

Figure 14 - Scenario 5b - No 3 road Reservoir Water Level (m)

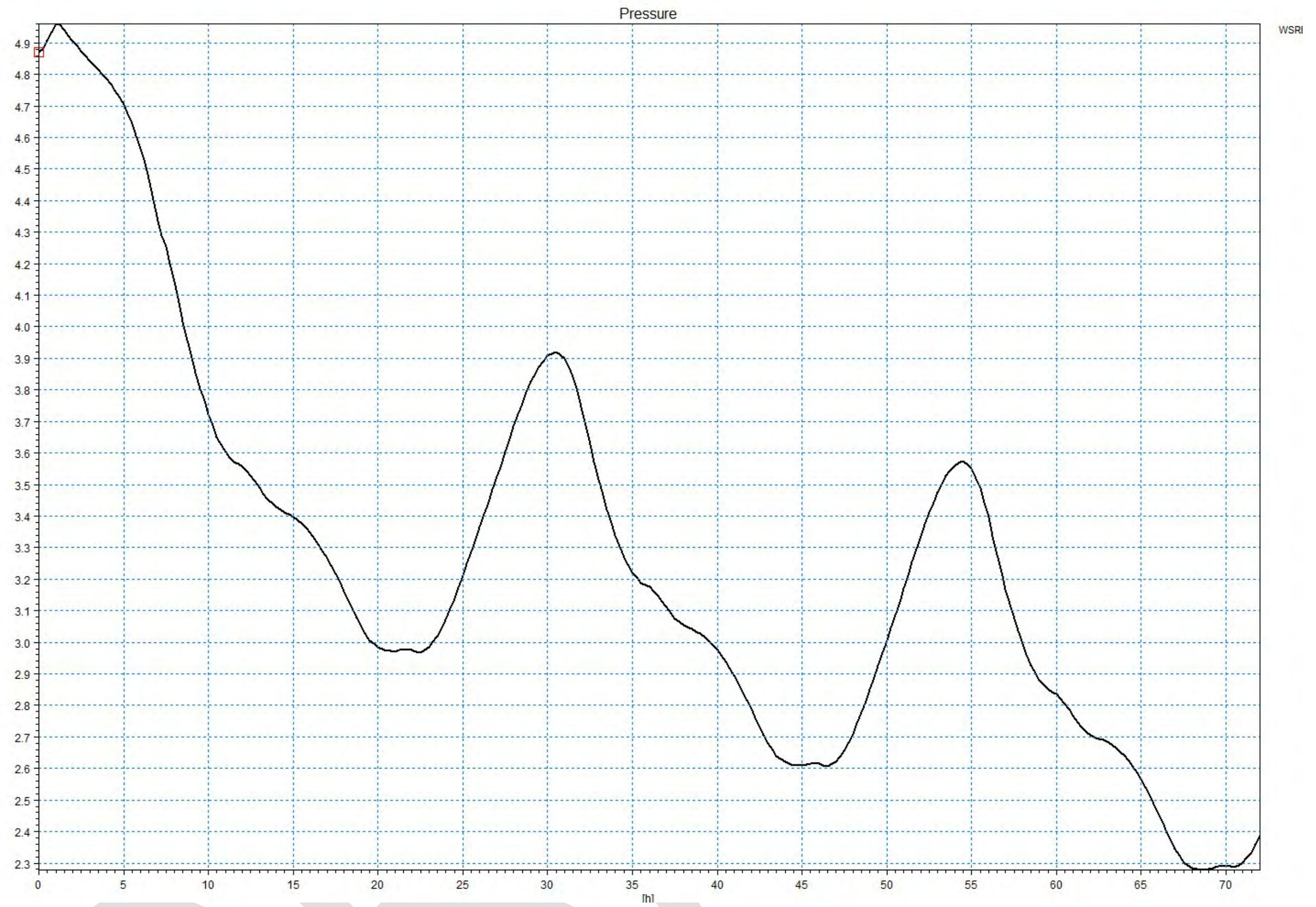
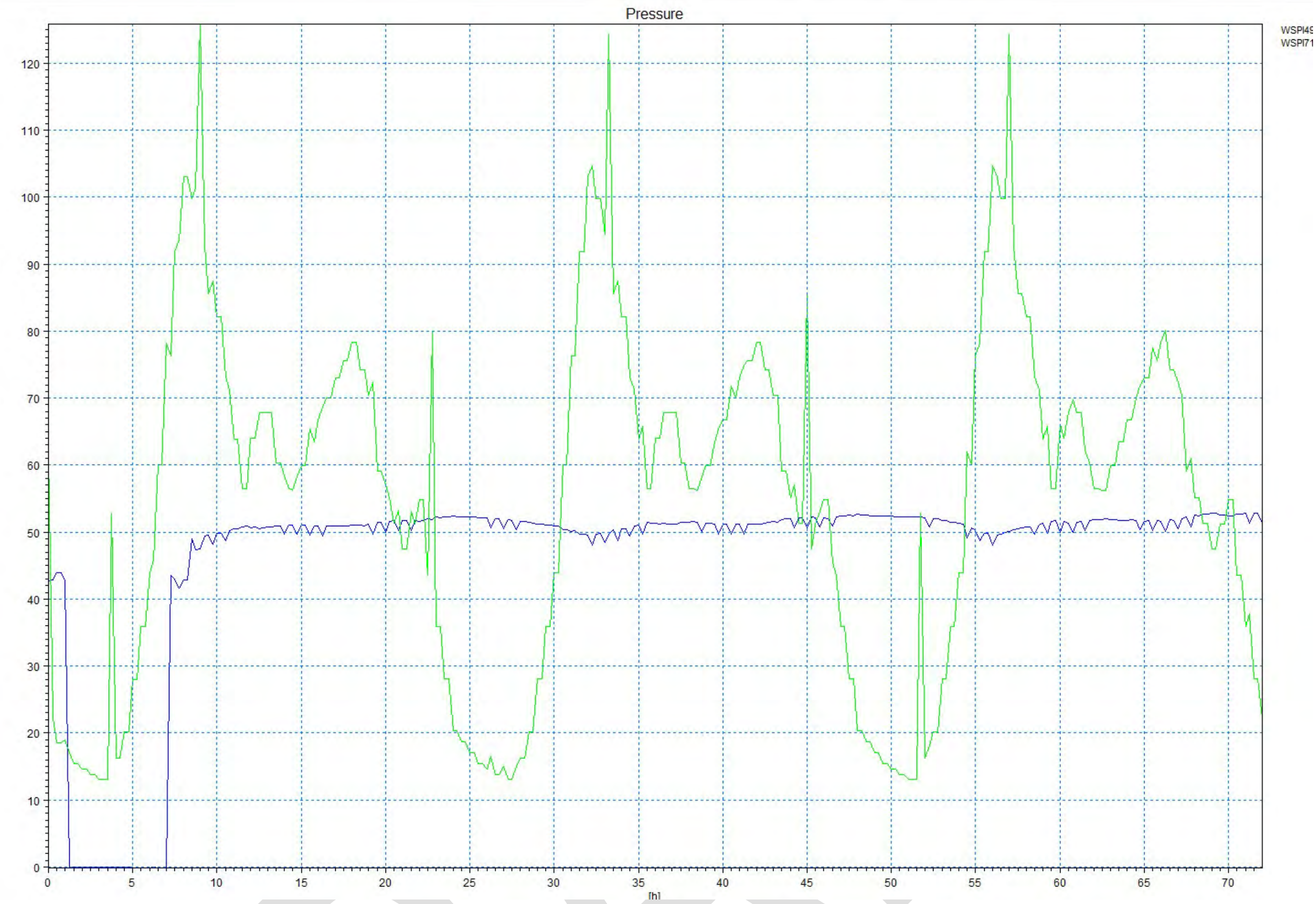


Figure 15 shows below the pumped inflow (blue) and the gravity outflow (green) from No. 3 Road reservoir.

The pumped inflow of 50 litres/s (40 litres/s main pump and 10 litres/s standby pump) is not sufficient for the demand in scenario 5b (peak day, ultimate development).

Figure 15 - No. 3 Road Reservoir Inflows and Outflows

(Green outflow, blue inflow)



5 Discussion

5.1 Minimum Pressures

Currently there is a low-pressure zone around Hookey Drive in the southern part of the Te Puke township. This can be seen by the blue and green dots in Figure 2 and Figure 4 where the minimum pressure falls below the level of service of 30m.

This low-pressure area expands northwards in the ultimate development scenario as seen on Figure 3 and Figure 5. This low-pressure zone is caused by closed PRVs immediately north of the zone.

This situation is fairly straightforward to rectify for both the existing and ultimate development scenarios by reopening the PRVs. The booster pump at Dudley Vercoe Drive could also assist.

5.2 Pressure Drops Caused by Development

Figure 6 to Figure 9 show diurnal pressures in the CBD and Hookey Drive. The ultimate development causes only 1 to 2m pressure drop for the ultimate development scenario compared to existing development. Apart from the Hookey Drive area discussed previously, pressures in the Te Puke township are all well above the minimum level of service of 30m.

5.3 Headloss in Pipes

Comparing Figure 12 and Figure 13 it can be seen that there are only a few pipes exceeding the recommended 3m/km for either the existing or ultimate development scenario even in a peak summers' day. The additional strain on the pipes in the Seddon Street area would be alleviated by network upgrades in that area as part of the structure plan and development process. Similarly, any development off Te Puke Quarry Road may require upgrades.

It is noted that headlosses greater than 3m/km occur along much of No. 1 Road for both scenarios. Major pipe upgrades are already planned along No. 1 Road which could help alleviate this strain, although it is noted there will also be additional strain not modelled due to Rangiuru Business Park development.

5.4 Filling of No. 3 Road Reservoir

It was noted that for Scenario 5b the No. 3 Road reservoir failed to refill adequately. It was noted that the No. 3 Road boost pumps have recently been reduced (refer Aurecon Dec 2021).

For the ultimate development of Te Puke this pump capacity reduction may need to be reversed. Alternatively, Council have noted that they are currently exploring new bore supplies on No. 3 Road that could supply the No. 3 Road reservoir directly rather than relying on No. 1 Road reservoir. This would increase resilience as it would not rely on the cross-county pipeline from No. 1 Road to No. 3 Road nor the No. 3 Road boost pump.

5.5 Total Bore Supply

Currently bores can supply about 135 l/s to the No. 1 Road reservoir. At present the daily averaged outflow from No. 1 Road reservoir is 65 l/s. This is predicted to increase to about 85/s in the ultimate scenario 5a (refer Table 1). Thus, the average demand would increase by about 30% from 65 l/s to 85 l/s.

It is also noted that while the average demand for the ultimate development is predicted to be 85 l/s; in hot dry conditions this is predicted to increase to around 120 litres/s (refer Scenario 5b in Table 1). At 120 litres/s this would require the bores total capacity 135 l/s to operate consistently at 90% during hot dry periods.

Currently the capacity of No. 1 Road reservoir is about 1500m^{3,} and No. 3 Road reservoir is 4500m^3 giving a total storage of 6000m^3. The current average demand of 65 l/s equates to 5600 m^3/day while the increased ultimate development demand of 85 l/s equates to 7300 m^3/day. Hence the storage available would reduce from over a day's supply (if failure occurs when the reservoirs are full) for existing development to under a day's supply with the ultimate development.

It is noted that the calculations above do not include the additional demand from the Rangiuru Business Park. An additional demand from the proposed Rangiuru Business Park of 148 hectares (net yield) at 30m^3/hectare/day (as suggested by David Napier of Inspiratus acting for the developers) would equate to an additional daily average flow of about 51 l/s which would add further pressure to both bore supply and reservoir storage.

6 Limitations and Applicability

- Although the model was calibrated in 2017, there were significant issues getting a good match in the No. 1 Road area. Some work has been carried out as part of the Rangiuru Business Park study (Aurecon, Dec 2021) to improve the confidence of the model in this area, but due to time constraints for this work, the current network model should not be considered fully calibrated.
- Demands in the 2017 calibrated model were based on customer data from 2014. While these have been scaled up for the base model as documented in the RPB study (Aurecon, Dec 2021) to match current flow data this was a fairly approximate process using global values and will not be entirely accurate.
- The modelling results therefore have an element of uncertainty to them, errors in the model assumptions will lead to errors in the results. However, a number of checks on flows and pressures were made (Aurecon, Dec 2021) and the modelling results provided in this report are the best available information we have at this time.

7 Recommendations

The recommendations below are based on the ultimate development of Te Puke but exclude both Te Puke West and Rangiuru Business Park commercial developments. Any upgrades required for either of the aforementioned developments would need to be over and above those listed below. While upgrades for these developments can be calculated separately, ideally holistic modelling would be undertaken to check for any unforeseen interactions.

- The low-pressure area in Hookey Drive should be rectified, this could be done using the existing PRVs and possibly the Dudley Vercoe boost pump. While this could initially be undertaken by operations / field investigations the model should be updated with the new operational configuration. Remodelling of the ultimate development scenario with the revised operational configuration is recommended.
- An increase to the capacity of the No. 3 Road boost pump will be required for the ultimate development to prevent the reservoir running dry in peak summer periods. Alternatively, a separate dedicated source to No. 3 Road reservoir may be required.
- There are significant head losses in the pipe along No. 1 Road. An upgrade of this pipe would reduce the potential strain on this pipe. (This is over and above upgrades required for Rangiuru Business Park development.)
- For resilience it is recommended reservoir capacity should be added for the future growth in demand. It is noted that for the ultimate development for an average day there will be less than a day's storage available (and even less if the system fails when the reservoirs are partially empty). For a peak day the storage ratio will be even worse.
- For the ultimate development for peak summer days the demand is predicted to be about 120 litres/s. This requires the current bores (capacity 135 litres/s) to run consistently at 90%. For resilience it is recommended bore capacity should be added for the future growth in demand.
- Figure 13 suggests localised pipe upgrades may be required for particular developments such as Seddon Street and No.3 Road / Te Puke Quarry Road (Sport/Industrial). It is recommended that modelling of options be undertaken as part of the process of developing structure plans development for these areas.

A

Demand Growth Data supplied by WBOPDC

Te Puke Yield

11/03/2022

1) Existing Te Puke population

As per the 2018 census, Te Puke had a population of 8,688 and 2,964 dwellings. It is estimated that the population has increased to 9,700 and the dwellings to 3,117 by June 2021 (see Table 1 below).

Table 1: Existing Te Puke population number of dwellings

	Population			Dwelling			Average persons per household:	
	2018 census	2021 (31 June) Estimate	Difference	2018 census	2021 (31 June) estimate	Difference	2018 census	2021 (31 June) estimate
Te Puke	8,688	9,700	1,012	2,964	3,117	153	2.93	3.11

2) Development Potential within existing built-up areas (Redevelopment potential/infill development)

The amendments to the Resource Management (Enabling housing supply and other matters) Act of December 2021 have enable significant redevelopment / infill subdivision in the existing built-up area zoned Residential. The table below and attached map provides both a low and high estimate of additional dwellings that can be constructed in Te Puke by means of redeveloping some existing lots or infill development.

The low projection is mainly based on infill development, either in the front or at the back of the existing dwelling. The low projection is based on the following assumptions:

- Adding a dwelling or two dwellings on a section without shifting the existing dwelling.
- Providing at leased 200m² land area for each dwelling.
- Additional dwellings will only be constructed on relatively flat sections.
- No existing shared driveways are used due to legal complexities.
- No additional dwellings within a floodable area.
- Land value and existing improvement value were not taken into consideration.
- Available area has a practical shape and dimensions for the construction of an additional dwelling.

The high projection is based on the redevelopment of an existing section with a relative low improvement value and infill development on sections with a higher improvement value. Therefore:

- Where the property has an improvement value below $200,000, either demolish the existing dwelling or shift it to a location on the section that will enable the construction of the maximum number of dwellings, based on a net density of around one dwelling per 200m².
- Infill residential development was still included on sections with an improvement value of more than $200,000
- Additional dwellings / redevelopment will only occur on relatively flat sections.
- Existing shared driveways are used.
- No additional dwellings within a floodable area.
- Available area has a practical shape and dimensions for the construction of additional dwellings.

Note:

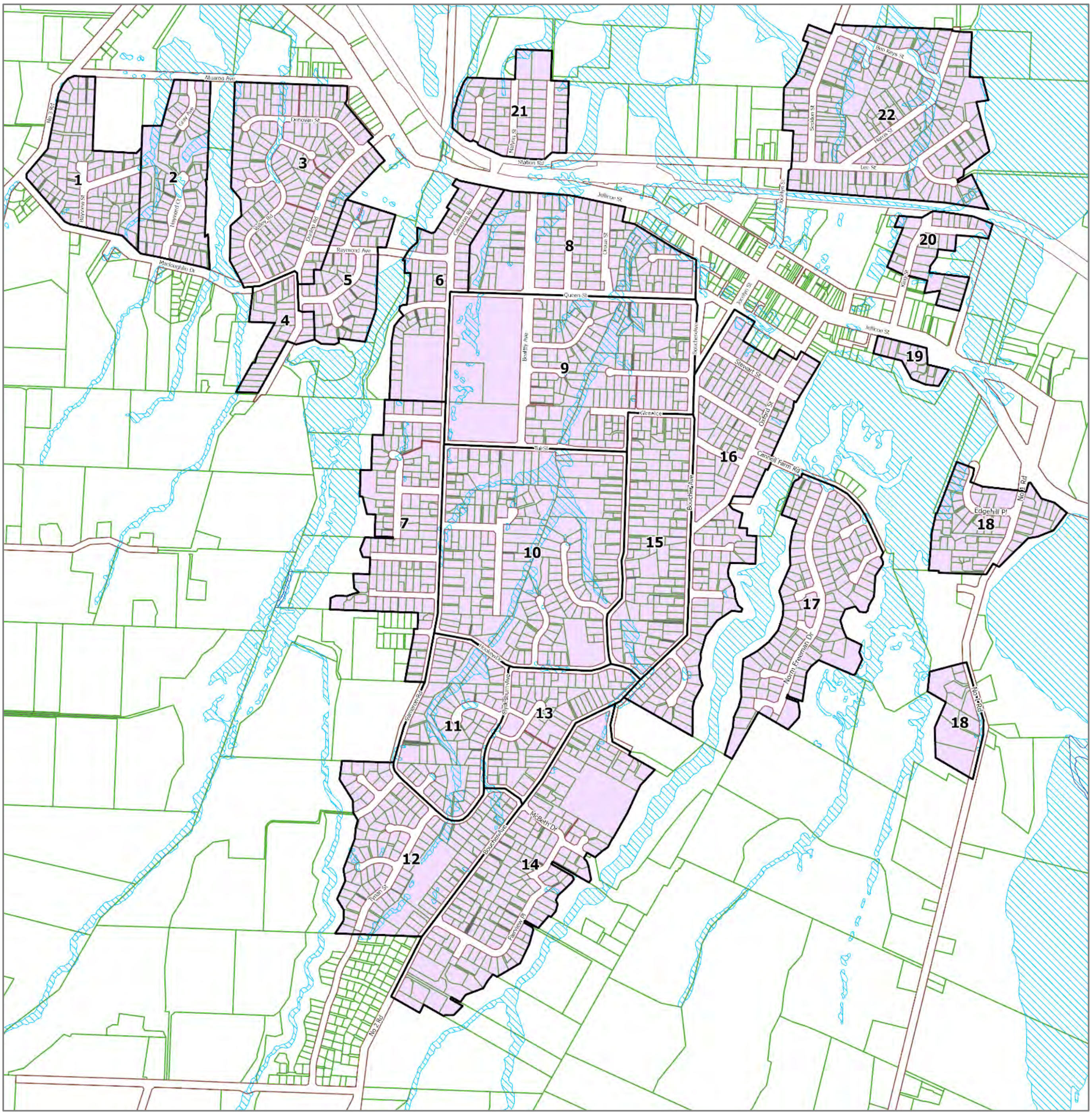
This excludes:

- The Landscape Road area, which will be included as a Structure Plan area as part of the next District Plan review and
- The relative new residential development between Dudley Vercoe Drive and Area 12 (along the Tynan Street and No 2 Road)

Table 2: Existing dwellings per area with low and high projection of additional dwellings (see Map 1 for the location of these areas)

Area	Street	From/To	Existing Lots	Low projection		High projection	
				Additional Dwellings:	Additional Population 2.7 people/dwelling	Additional Dwellings:	Additional Population 2.7 people/dwelling
Area 1	No 3 Road -Rimu Ln	Atuaroa to MacLoughlin Dr	98	3	8.1	12	32.4
Area 2	Hayward Crt + Gray Ave	Between Macloughlin Dr + Atuaroa Ave	70	5	13.5	14	37.8
Area 3	Between MacLoughlin + Atuaroa Ave	Along Valley Rd , Donovan St + Dunlop Rd	181	16	43.2	42	113.4
Area 4	Dunlop RD (southern portion)	From Maclaoughlin Dr - Southern end	32	3	8.1	10	27
Area 5	Portion of Raymond Ave	Inclu Bayly Pl, Bishop Cr + Nettingham Pl	66	1	2.7	7	18.9
Area 6	Mainly western side of Cameron Rd	North of Kowhai Ave + south of Jellicoe St.	64	2	5.4	12	32.4
Area 7	Western side of Cameron RD	From Kowhai Ave to Te Puke Intermediate	124	7	18.9	25	67.5
Area 8	Jellicoe - Queen	Beteen Cameron & Boucher Ave	109	14	37.8	34	91.8
Area 9	Queen - Tui & Glen Trc	Between Cameron & Boucher	90	10	27	29	78.3
Area 10	Tui - Hookey Dr	Between Moehau & Cameron	163	12	32.4	38	102.6
Area 11	South of Hookey Dr	Between Glydesburn + Cameron	78	4	10.8	18	48.6
Area 12	South of Cameron Dr	Western side of Boucher Ave	111	10	27	28	75.6
Area 13	South of Hookey Dr	Between Boucher + Clydesburn	72	7	18.9	13	35.1
Area 14	East of Boucher Ave	From Lenihan Dr to Ernies Way	164	15	40.5	37	99.9
Area 15	Glen Trc - Hookey Dr	Between Boucher & Moehau	135	6	16.2	18	48.6
Area 16	East of Boucher Ave	From Queen - Northern side of Lenihan Dr	171	15	40.5	29	78.3
Area 17	Norm Freemand & Cannell Farm Dr		140	0	0	0	0
Area 18	No 1 Rd		66	8	21.6	14	37.8
Area 19	Jellicoe Street - Eastern side		14	0	0	6	16.2
Area 20	King St & StockRd		33	10	27	32	86.4
Area 21	North of Station Rd	Conifer Pl - George St	44	3	8.1	10	27

Area 22	North of Station Rd	Seddon St, Harris St & Lee St	236	65	175.5	163	440.1
	Total		**2261**	**216**	**583**	**591**	**1,596**



Map 1: Location of different areas included in Table 2

3) Greenfield areas currently being developed

- This is land that is in the process of being developed. Therefore, pre-application meeting with council staff and bulk earthworks has started, or subdivision consent has been obtained.
- These areas are all located in existing Structure Plan Area 3, south of MacLoughlin Drive and Dunlop Road

Development	Gross Area (approximate)	Number of residential lots	Residents (Mid projection of 2.3 persons/HHE)	Residents (High projection of 2.6 persons/HHE)
Orchard Church subdivision	1.748ha	39	89	101
Te Mania	16.45ha	350	805	910
Zest Residential Development	20.31ha	384	883	998
79 Dunlop Rd	0.434ha	7	16	18
TOTAL	**38.94**	**780**	**1,793**	**2,027**

4) Potential Structure Plan Areas

Residential

Area name	Total Size	Developable Land	Minimum lots (20 lots/ha)	Min Residents (2.4/household)	Maximum lots (25 lots/ha)	Max Residents (2.4/household)	Comments
Seddon Street West	20.88	12.39	247	592	309	741	• Less than 1km from the town centre. • Effected by two gullies. • There is also an opportunity that the southern portion adjoining the industrial area be zoned Industrial if access can be obtained from Station Rd
Seddon Street East	13.68	11.64	232	556	291	698	• This includes area of possible Private Plan Change. Less than 1km from the town centre. • Effected by two gullies.
Landscape Road (zoned Residential)	11.34ha	6.68ha	133	319	167	400	• Is a combination of redevelopment and greenfield development • Partly zoned Residential. • Floodable on western side and steep bank down the middle (north to south). • Less than 1km from town centre. • Close to existing reserve. • Has an industrial activity on one of the sections. • Can be well integrated with future reserve/wetlands.
Main blocks of unconsented land North of Whitehead Ave (Future Urban Zone)	20.39ha	16.33ha	326	782	408	979	• Downstream stormwater issues. • Has to obtain connectivity with subdivisions on the northern side

Industrial

Area Name	Total Size	Developable Land	Household Equivalents (HHE)	Comments
No.3 Rd/Te Puke Quarry Rd **(Sport/Industrial)**	48.49ha	42.65ha	94.778HHE	• HHE are based on: o The assumption that the entire area is used for industrial purposes. o HHE for wastewater as that is the main constrain in Te Puke. One HHE is equal to a gross floor area of 1,800m². • It is assumed that the total floor area will be as follow: o All ground floor o Developable land X 0.8 (to exclude roads) X 0.5 (to exclude average lot area not covered by buildings) = 170,600m² covered with buildings. HHE are therefore 170,600 / 1,800m² = **94.778HHEs**

5) Areas that will not be considered as part of this Plan Change

Area name	Total Size	Developable Land	Minimum lots (20 lots/ha)	Maximum lots (25 lots/ha)	Comments
North of Cannel Farm Dr (zoned Residential)	17ha	5.4ha	108	162	• Zoned Residential. • Low lying and possible liquefaction damage. • Less than 1km from town centre. • Already part of current Structure Plan Area 5.
South of Cannel Farm Dr (zoned Residential)	16.4ha	8.6ha	172	258	• Zoned Residential. • Low lying and possible liquefaction damage. • Less than 1km from town centre. • Already part of current Structure Plan Area 5.
South of Cannel Farm	50ha	31ha	620	930	• Will be good to achieve better connectivity to

Dr (Zoned Rural but included in RPS)					Boucher Ave via Lenihan Dr and McBeth Dr, but topography is an issue. • Therefore, connectivity issues.
Dudley Vercoe Dr (zoned Rural but included in RPS)	49.5ha	40ha	800	1,200	• Connectivity issues. Can only connect to Dudley Vercoe Dr. • Connection to Williams Dr will be costly due to topography. • Furthest away from the town centre. • Possible downstream stormwater issues. • Water pressure issues.

B

Demands Applied to the Model

Scenarios 2 and 3 - Infill: Low and High Projection

		Low projection - Scenario 2				High projection - Scenario 3			
			220	20%			220	20%	
Area	Node applied to	Extra people	Extra flow 220 litres/person/day	Leakage	flow l/s	Extra people	Extra flow 220 litres/person/day	Leakage	flow l/s
1	WSVA0934	8.1	1782	2138	0.025	32.4	7128	8554	0.099
2	WSVA0943	13.5	2970	3564	0.041	37.8	8316	9979	0.116
3	WSJN0451	43.2	9504	11405	0.132	113.4	24948	29938	0.347
4	WSJN3120	8.1	1782	2138	0.025	27	5940	7128	0.083
5	WSFH2521	2.7	594	713	0.008	18.9	4158	4990	0.058
6	WSJN0470	5.4	1188	1426	0.017	32.4	7128	8554	0.099
7	WSJN0556	18.9	4158	4990	0.058	67.5	14850	17820	0.206
8	WSFH2471	37.8	8316	9979	0.116	91.8	20196	24235	0.281
9	WSJN0584	27	5940	7128	0.083	78.3	17226	20671	0.239
10	WSFH1009	32.4	7128	8554	0.099	102.6	22572	27086	0.314
11	WSVA1069	10.8	2376	2851	0.033	48.6	10692	12830	0.149
12	WSVA1046	27	5940	7128	0.083	75.6	16632	19958	0.231
13	WSVA1068	18.9	4158	4990	0.058	35.1	7722	9266	0.107
14	WSJN0798	40.5	8910	10692	0.124	99.9	21978	26374	0.305
15	WSVA3809	16.2	3564	4277	0.050	48.6	10692	12830	0.149
16	WSJN0760	40.5	8910	10692	0.124	78.3	17226	20671	0.239
17		0	0	0	0.000	0	0	0	0.000
18	WSJN0566	21.6	4752	5702	0.066	37.8	8316	9979	0.116
19	WSJN1104	0	0	0	0.000	16.2	3564	4277	0.050
20	WSJN3657	27	5940	7128	0.083	86.4	19008	22810	0.264
21	WSJN3684	8.1	1782	2138	0.025	27	5940	7128	0.083
22	WSJN0977	175.5	38610	46332	0.536	440.1	96822	116186	1.345
		583			**1.8**	**1596**			**4.9**

Scenario 3 - Greenfield Areas Currently Being Developed

Development	Gross Area (approximate)	Number of residential lots	Residents (Mid projection of 2.3 persons/HHE)	Residents (High projection of 2.6 persons/HHE)	220 Extra flow 220 litres/person/day	20% Leakage	Sc4a, 4c 4d average day flow litres/s	Sc4b max day flow litres/s	
Orchard Church subdivision	1.748ha	39	89	101	22220	26664	0.309	0.437	WSJN3758
Te Mania	16.45ha	350	805	910	200200	240240	2.781	3.936	WSJN2283
Zest Residential Development	20.31ha	384	883	998	219560	263472	3.049	4.316	WNODE_3
79 Dunlop Rd	0.434ha	7	16	18	3960	4752	0.055	0.078	WSJN3121
TOTAL	**38.94**	**780**	**1,793**	**2,027**	445940	535128	6.194	8.766	

Scenario 5 - Potential Extra Structure Plan Areas

Area name	Total Size	Developable Land	Minimum lots (20 lots/ha)	Min Residents (2.4/household)	Maximum lots (25 lots/ha)	Max Residents (2.4/household)
Seddon Street West	20.88	12.39	247	592	309	741
Seddon Street East	13.68	11.64	232	556	291	698
Landscape Road (zoned	11.34ha	6.68ha	133	319	167	400
North of Whitehead	20.39ha	16.33ha	326	782	408	979
Te Puke West Indutrial					95	228

65 average day Te Puke demand
92 max day Te Puke demand

220 Extra flow 220 litres/pers	20% Leakage	Sc4a, 4c 4d average day flow litres/s	Sc4b max day flow litres/s		
163020	195624	2.264	3.205	WSEN1491	Increase pipe WSPI7049
153560	184272	2.133	3.019	WSEN1491	
88000	105600	1.222	1.730	WSEN0148	Increase pipe WSPI2397
215380	258456	2.991	4.234	WNODE_32	
50160	60192	0.697	0.986	WNODE_Quarry Rd SF	Add in new 100mm pipes WLINK_77 and 78 joining Quarry Rd 200mm and No 3 Rd 100mm
		9.307	13.173		

Document prepared by

Aurecon New Zealand Limited
Ground Level 247 Cameron Road
Tauranga 3110
PO Box 2292
Tauranga 3140
New Zealand

T +64 7 578 6183
F +64 7 578 6143
E tauranga@aurecongroup.com
W aurecongroup.com

aurecon

Bringing ideas to life

Aurecon New Zealand Limited
Ground Level 247 Cameron Road
Tauranga 3110

PO Box 2292
Tauranga 3140
New Zealand

T +64 7 578 6183
F +64 7 578 6143
E tauranga@aurecongroup.com
W aurecongroup.com

Memorandum

To	**Coral-Lee Ertel**	From	**Jennyl Estil**
Copy	**Denzel Belbin**	Reference	**521303**
Date	**2022-06-03**	Pages (including this page)	**4**
Subject	**Te Puke Intensification Wastewater Modelling**		

1 Background

Te Puke is expecting significant growth in the future. Western Bay of Plenty District Council (WBOPDC) has performed a study to estimate the future yield considering infill and greenfield developments as well as potential structure plan changes. This is summarised in the 'Te Puke Yield – Existing and Potential Greenfield' document dated 3rd of March 2022.

WBOPDC commissioned Aurecon to undertake a wastewater modelling study to identify any potential issues in the existing wastewater network as a result of the intensification. An uncalibrated model (referred to as 'existing model' in this document) which was built by Mott MacDonald in September 2019 has been used in this study.

2 Scope of Work, Assumptions and Limitations

Outlined below is the scope of work and the assumptions applied in this study:

- The scope includes modelling the intensification scenario described in the document "Te Puke Yield - Existing and potential Greenfield- 11-03-2022", however this excludes item "5) Areas that will not be considered as part of this Plan Change"
- The modelling used the potential yield data based on high projection scenarios
- The wastewater modelling has been undertaken using Mike Urban version 2020
- The events used were based on the dry weather flow (DWF) and wet weather flow (WWF) scenarios defined in the existing model. No additional events have been modelled. The WWF peak flow was assumed to be five (5) times the average dry weather flow.
- A high-level review of the model has been undertaken to compare the population with that of the recent estimates. However, no detailed review has been performed to check the accuracy of the population distribution throughout the catchment in the existing model
- The model is uncalibrated. No checks have been made against recent asset or SCADA data. It is assumed the model correctly represents the pipe network and network operations such as pumping rates and regimes. It is however possible that either these were put into the original model incorrectly or that pump rates / pump operations etc have changed since the model was built.

3 Existing Model Update

According to the model build report (Mott MacDonald, 2019), the existing model population data were sourced from the 2013 census mesh block and were estimated to have a total population of 6902. A future growth projection of 4% according to Smart Growth data was applied resulting in an estimated total population of 7,175 for the year 2017. This modelled population is below the estimated total 2018 population of 8,688 as per the document "Te Puke Yield - Existing and potential Greenfield- 11-03-2022".

To better analyse the impact of intensification, the representation of the population in the existing model was updated. Ideally, the population requires update based on the more recent census data. Upon consultation with WBOPDC, it was agreed to adjust the current model population by estimating the new growth factor in accordance with the June 2021 estimate of 9,700 as per "Te Puke Yield - Existing and potential Greenfield- 11-03-2022".

4 Intensification Modelling

Table 1 provides a summary of the additional population that were incorporated into the model. The greenfield and potential structure plan areas were connected to the existing network based on engineering judgment on the most likely loading point location considering both the topography as well as the distance from the development site. These assumed discharge locations are shown in Figure A.

Table 1 Intensification Areas and Additional Population

Type of Development	Additional Population
Redevelopment potential/infill development	1,596
Greenfield areas currently being developed	2,027
Potential Structure Plan Areas	2,913
Total	6,536

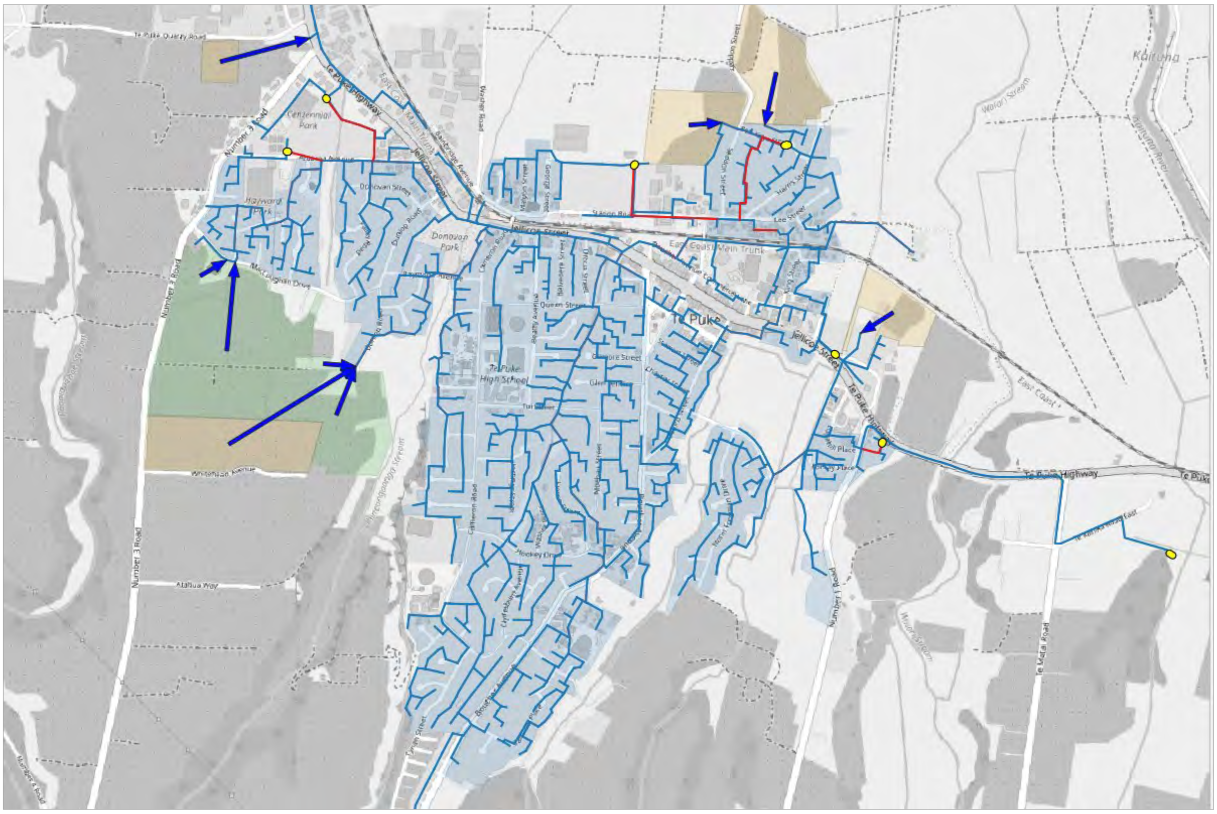


Figure A Discharge locations of the new developments

The scenarios assessed include both the existing and intensified development conditions under dry and wet weather flow events as presented in Table 2.

Table 2 Model Scenarios

Scenario Name	Network	Wastewater Loads	Events
Existing Development	Existing	Current	DWF and WWF
Intensified Development	Existing	Intensified	DWF and WWF

5 Results and Discussion

The performance of the network has been assessed using the following criteria:

- Pipe flow capacity – The comparison of the modelled peak flow to the theoretical pipe full capacity identifies pipes that are under stress in dry and wet weather flows conditions. The theoretical pipe full capacity is computed based on Manning's equation. Surcharged pipe conditions occur when the maximum pipe flow is greater than the pipe full capacity.
- Pipe filling capacity – The comparison of the modelled peak depth in relation to the pipe diameter identifies pipes that may surcharge due to backwater effects from downstream areas. In some instances, the peak flow of the pipe is less than its full capacity, however surcharging may still occur as a result of downstream constraints that pose hydraulic restriction on the local network.
- Manhole overflows – Uncontrolled overflows occur where pipes are surcharged (when the pipe capacity is exceeded) resulting in the hydraulic grade line to be above the manhole lid level.

Figures 1 to 8 show the location of surcharged pipes and manhole overflows for both existing and intensified conditions under DWF and WWF events.

The outcome of the modelling suggests that the intensification is likely to cause adverse impacts on the existing wastewater network with a number of surcharging pipes and manhole overflows occurring throughout the catchment.

It should be noted that under dry weather flows, several pipes are expected to be surcharged following the intensification. This is evident in the pipes south of Hayward Park as well as south and east of Donovan Park. These areas are likely to be impacted due to significant increase in wastewater discharge from the ongoing greenfield developments and future development on the main blocks north of Whitehead Ave. In addition to this, the infill developments around the area will also contribute to increased wastewater loads resulting in additional stress to the surcharged pipes.

Whilst the impact to manhole overflow is negligible for dry weather flow conditions, the intensification results in approximately three (3) times the overflows (both number of locations and total volume) compared to that of the existing development under wet weather events. The new overflow locations predominantly exist where the increase in population is notable such as the proposed developments around Seddon Street and north of Whitehead Ave.

Furthermore, the impact of infill developments is notable along the gravity main that runs northward along the reserve area from Noel Bowyer Park up to Jellicoe Street. It is noted that several pipes along this area are likely to experience surcharging already during wet weather flow events in the existing conditions; however, the intensification will result in increased volume of manhole overflows.

Table 3 Pipe Flow Capacity

Surcharged Due to Pipe Flow Capacity ($Q_{max} > Q_{cap}$)	Existing (2021)		Intensified Development	
	Number	%	Number	%
Peak Dry Weather Flow	2	0.2%	18	1.4%
Peak Wet Weather Flow	76	5.9%	105	8.1%

Table 4 Pipe Filling Capacity

Surcharged Due to Downstream Constraint ($D_{max} > D$)	Existing (2021)		Intensified Development	
	Number	%	Number	%
Peak Dry Weather Flow	20	1.5%	82	6.3%
Peak Wet Weather Flow	260	20.1%	373	28.8%

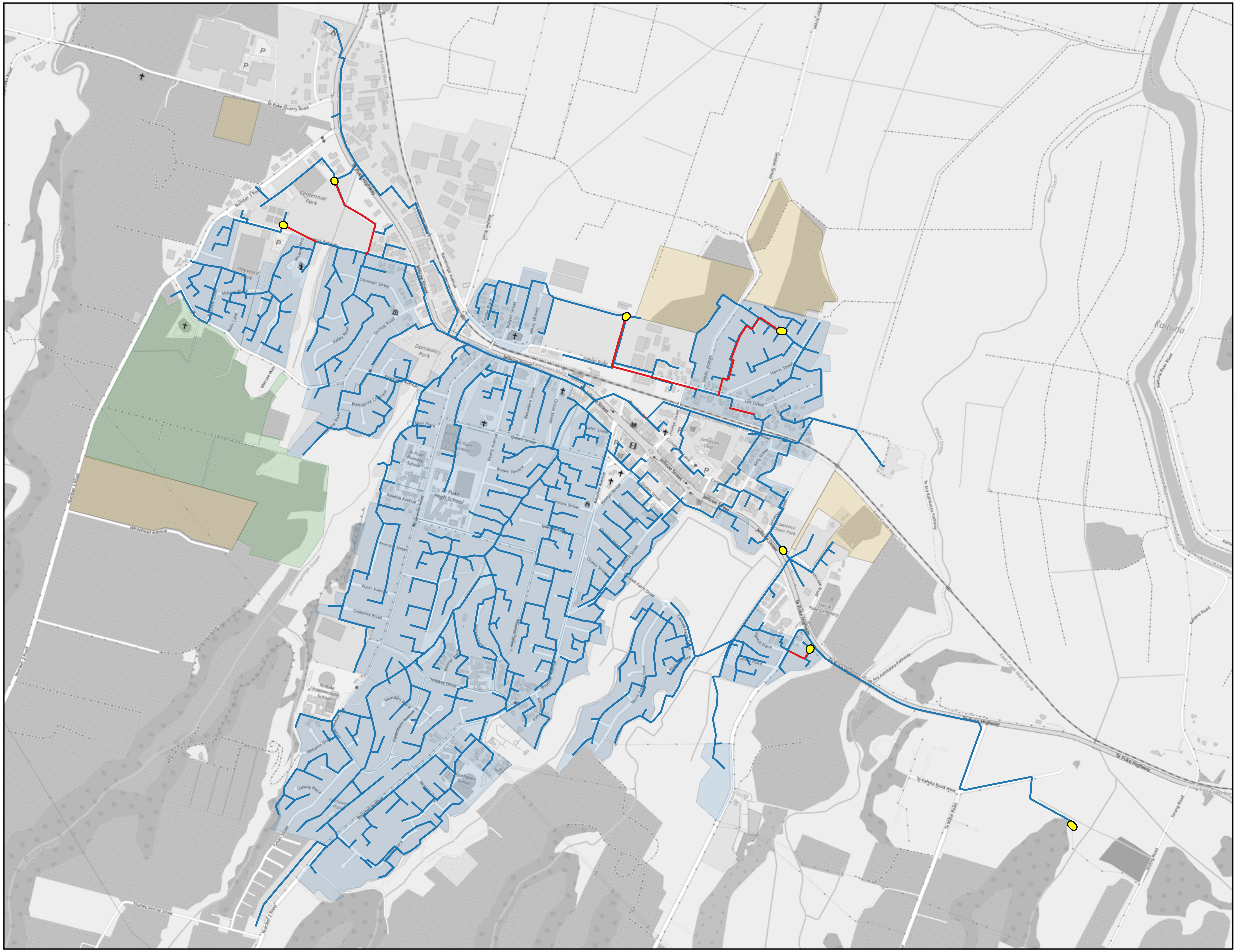
Table 5 Modelled Overflows

Scenario	Existing (2021)		Intensified Development	
	Number	Spill Volume (m^3)	Number	Spill Volume (m^3)
Peak Dry Weather Flow	0	0	2	12
Peak Wet Weather Flow	9	3,411	31	9,754

6 Summary / Recommendations

- Modelling has shown the planned intensification of Te Puke (via a combination of both infill and greenfield development) will place an increasing strain on the wastewater network. The number of manholes predicted to 'spill' in a wet weather event increases from 9 manholes with the existing population to 31 manholes for the intensified scenario.
- It is noted that the results above are based on an uncalibrated model
- Before Council invests in any upgrades to the network to mitigate the predicted spills, it is recommended that calibration of the model is undertaken. This will provide a more accurate representation of flows for both dry weather and wet weather events. It will also ensure pump operations etc. are correctly included in the model.
- The calibrated model can be used to re-assess the impact of intensification and used for options analysis.

C:\Users\jennyl.estil\Aurecon Group\521303 - Omokoroa Wastewater Options Modelling - TePuke\03 Working Files\02 GIS



Max. Link's absolute Discharge versus Qcap

- Unsurcharged (Qmax < Qcap)
- Surcharged (Qmax > Qcap)

Development Areas

- Infill Development Areas
- Greenfield Development Areas
- Potential Structure Plan Areas

Manhole Overflows (m3)

- 0.01 - 50
- 50 - 200
- 200-500
- >500

Pump Stations

Notes:

Rev A

Map by: Jennyl Estil

0 600 1,200 m

A3 Scale: 1:16,000

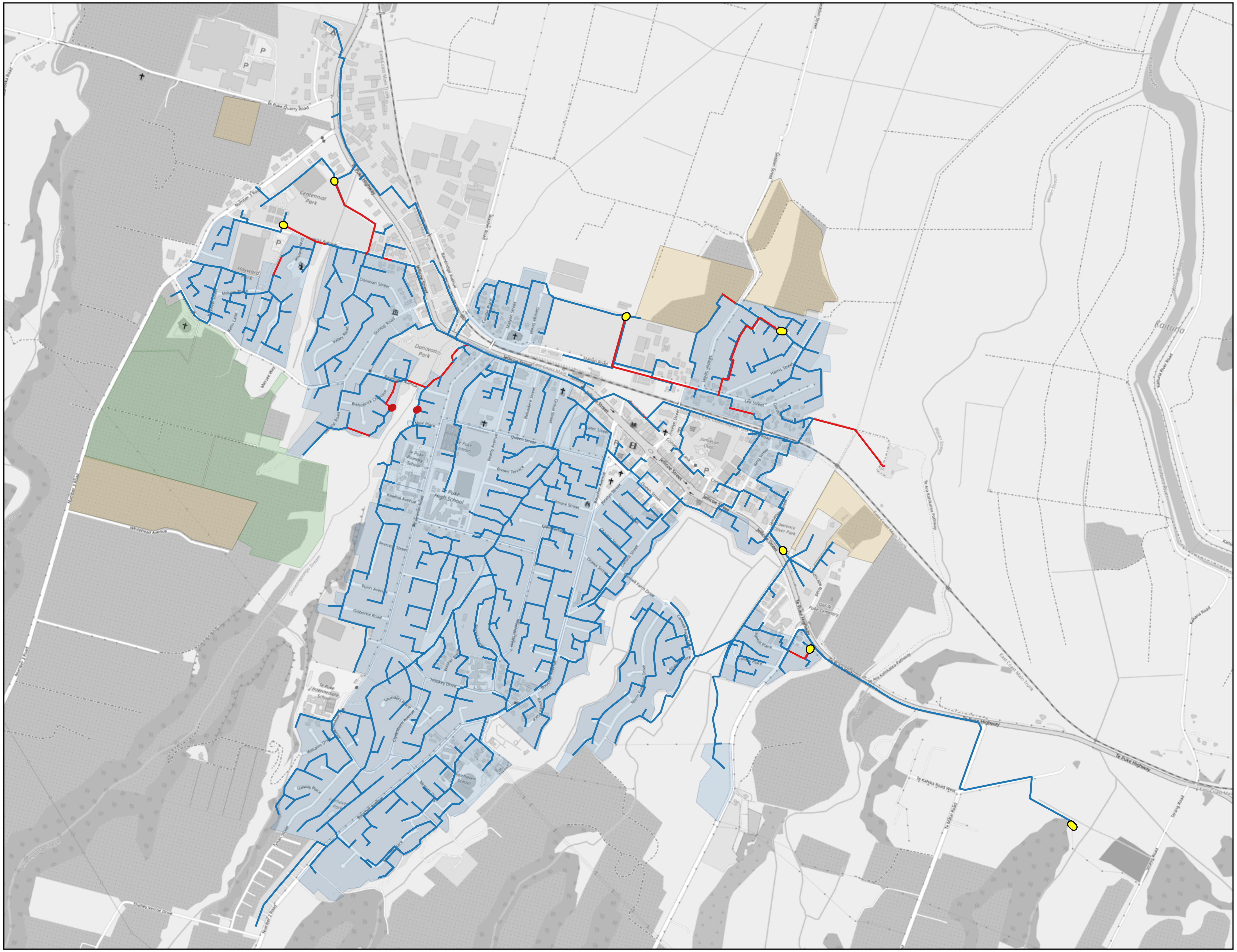
EPSG:2193

3/6/2022

Project Number: 521303

Te Puke Wastewater Intensification

Figure 1. Pipe Performance (Q versus Qcapacity)
Existing Conditions - Dry Weather Flow



C:\Users\jennyl.estil\Aurecon Group\521303 - Omokoroa Wastewater Options Modelling - TePuke\03 Working Files\02 GIS

Map by: Jennyl Estil

aurecon

Max. Link's absolute Discharge versus Qcap

- Unsurcharged (Qmax < Qcap)
- Surcharged (Qmax > Qcap)

Development Areas

- Infill Development Areas
- Greenfield Development Areas
- Potential Structure Plan Areas

Manhole Overflows (m3)

- 0.01 - 50
- 50 - 200
- 200-500
- >500

- Pump Stations

Notes:

Rev A

0 600 1,200 m

A3 Scale: 1:16,000

EPSG:2193

3/6/2022

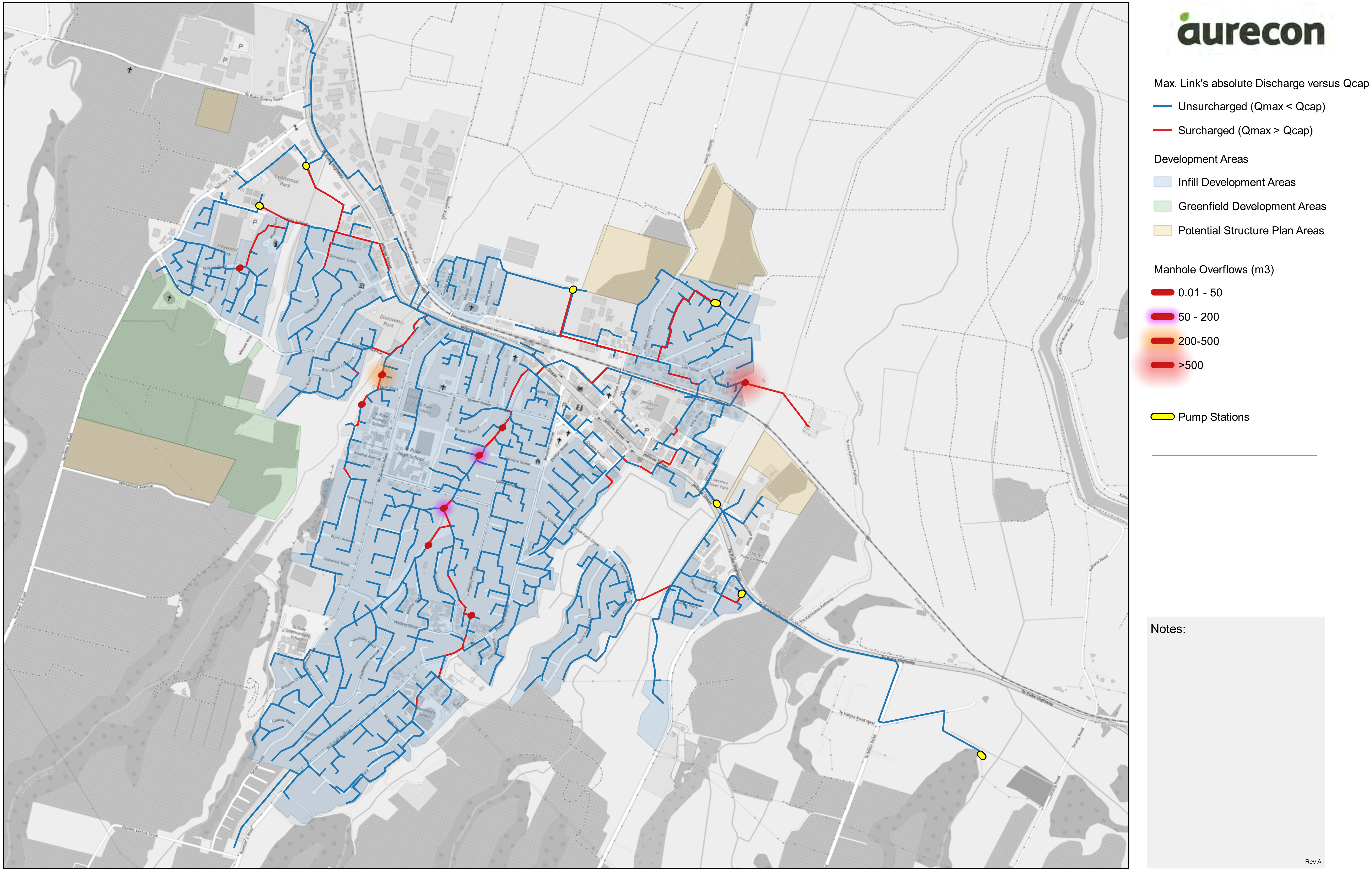
Project Number: 521303

Te Puke Wastewater Intensification

Figure 2. Pipe Performance (Q versus Qcapacity)
Intensified Conditions - Dry Weather Flow

C:\Users\jennyl.estil\Aurecon Group\521303 - Omokoroa Wastewater Options Modelling - TePuke\03 Working Files\02 GIS

Map by: Jennyl Estil



0 600 1,200 m

A3 Scale: 1:16,000

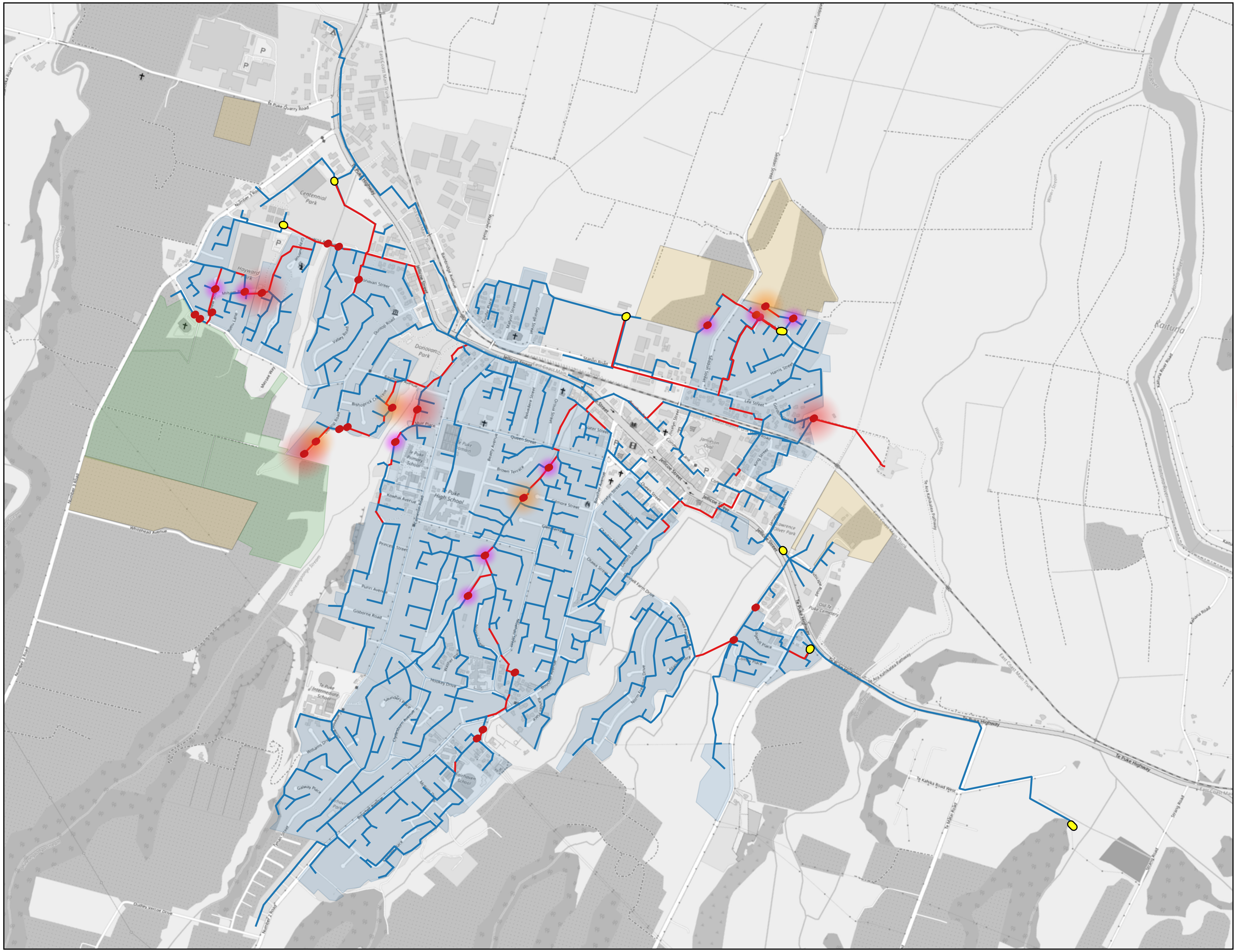
EPSG:2193

3/6/2022

Project Number: 521303

Te Puke Wastewater Intensification

Figure 3. Pipe Performance (Q versus Qcapacity) Existing Conditions - Wet Weather Flow



aurecon

Max. Link's absolute Discharge versus Qcap

Unsurcharged (Qmax < Qcap)

Surcharged (Qmax > Qcap)

Development Areas

Infill Development Areas

Greenfield Development Areas

Potential Structure Plan Areas

Manhole Overflows (m3)

0.01 - 50

50 - 200

200-500

>500

Pump Stations

Notes:

Rev A

C:\Users\jenny\estil\Aurecon Group\521303 - Omokoroa Wastewater Options Modelling - TePuke\03 Working Files\02 GIS

Map by: Jennyl Estil

0 600 1,200 m

A3 Scale: 1:16,000

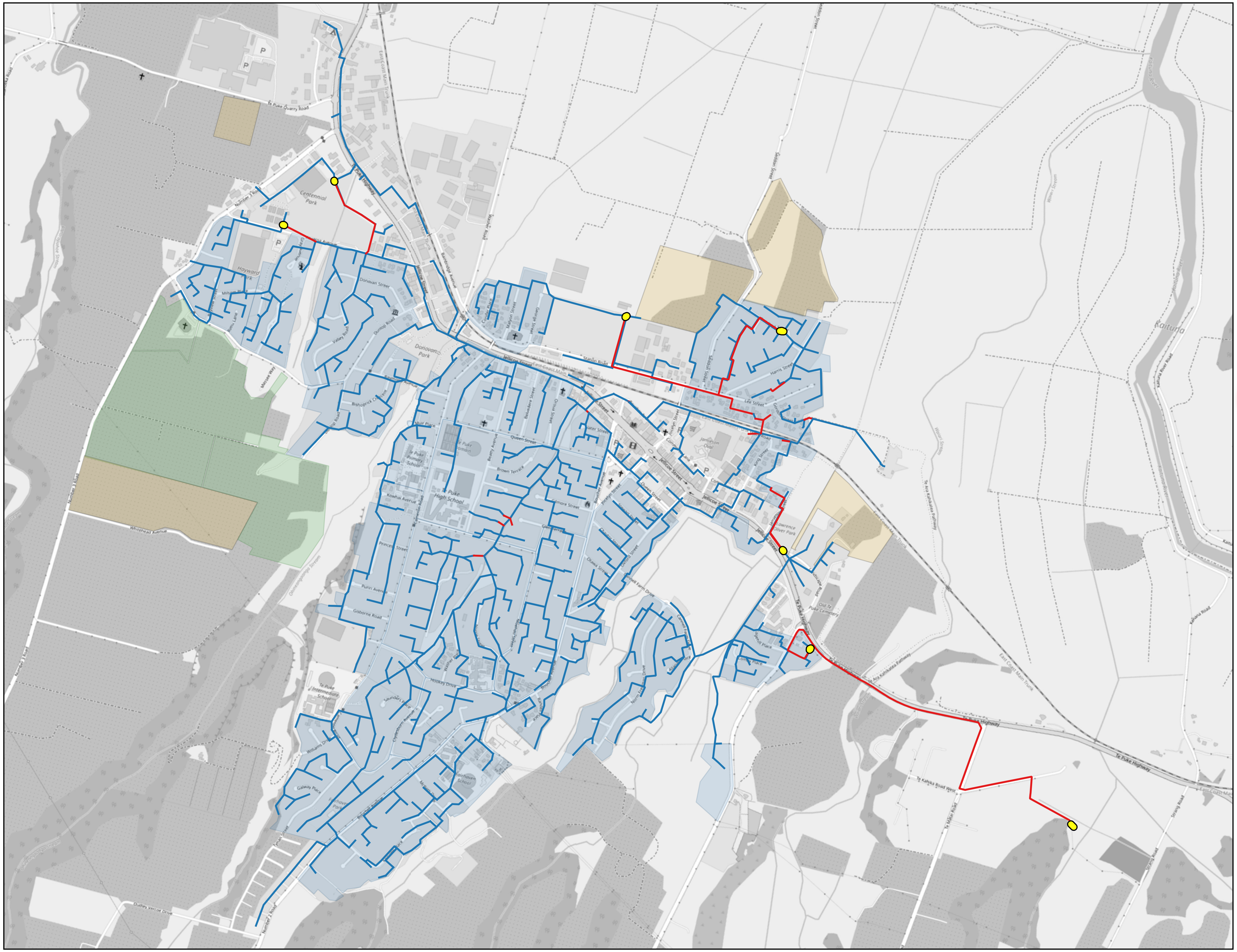
EPSG:2193

3/6/2022

Project Number: 521303

Te Puke Wastewater Intensification

Figure 4. Pipe Performance (Q versus Qcapacity) Intensified Conditions - Wet Weather Flow



aurecon

Maximum Pipe Filling

- Unsurcharged (Dmax < D)
- Surcharged (Dmax > D)

Development Areas

- Infill Development Areas
- Greenfield Development Areas
- Potential Structure Plan Areas

Manhole Overflows (m3)

- 0.01 - 50
- 50 - 200
- 200-500
- >500

- Pump Stations

Notes:

Rev A

C:\Users\jenny\.estil\Aurecon Group\521303 - Omokoroa Wastewater Options Modelling - TePuke\03 Working Files\02 GIS

Map by: Jenny Estil

0 | 600 | 1,200 m

A3 Scale: 1:16,000

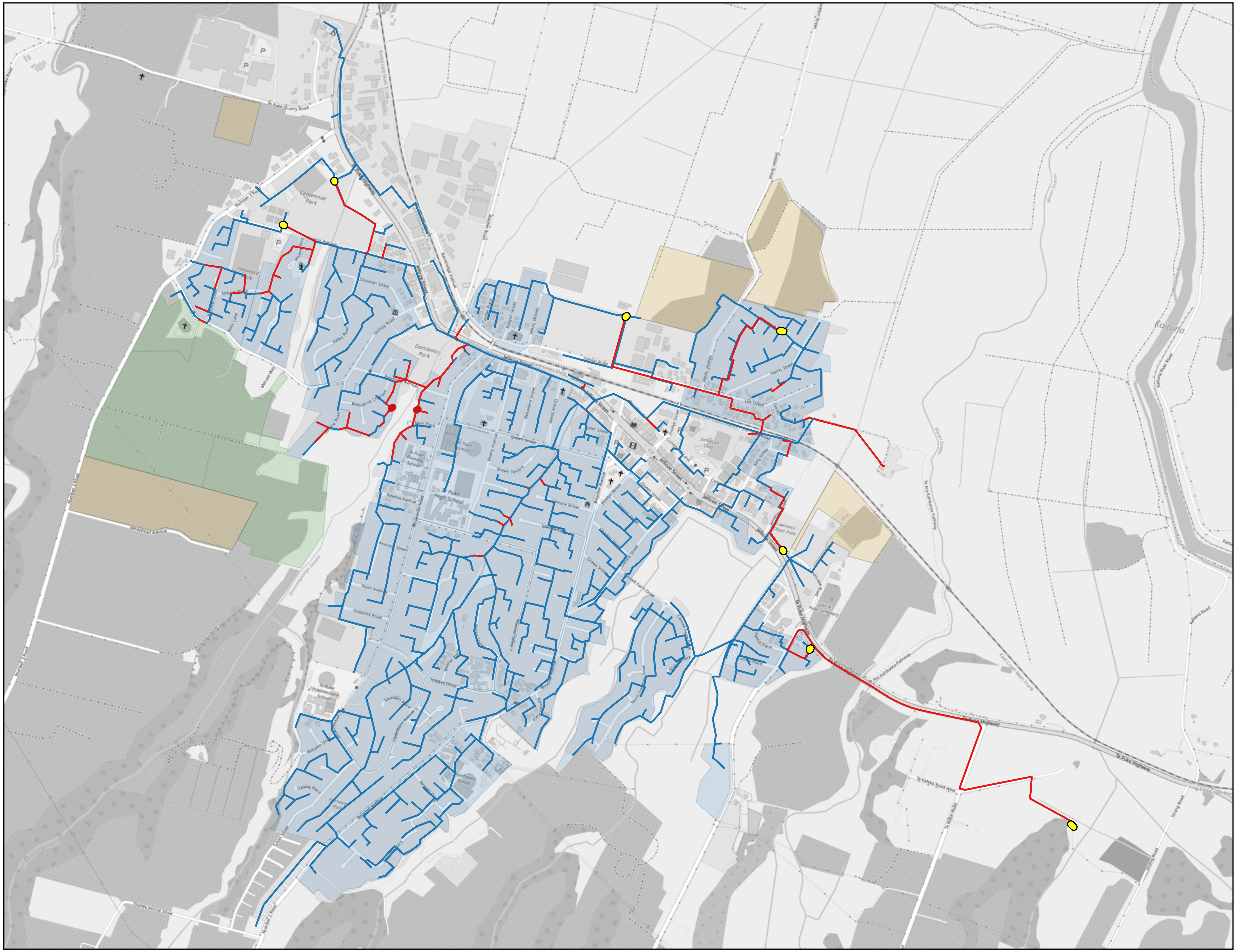
EPSG:2193

3/6/2022

Project Number: 521303

Te Puke Wastewater Intensification

Figure 5. Pipe Performance (Pipe Filling: Depth versus Pipe Diameter) Existing Conditions - Dry Weather Flow



aurecon

Maximum Pipe Filling

Unsurcharged (Dmax < D)

Surcharged (Dmax > D)

Development Areas

Infill Development Areas

Greenfield Development Areas

Potential Structure Plan Areas

Manhole Overflows (m3)

0.01 - 50

50 - 200

200-500

>500

Pump Stations

Notes:

Rev A

C:\Users\jennyl.estil\Aurecon Group\521303 - Omokoroa Wastewater Options Modelling - TePuke\03 Working Files\02 GIS

Map by: Jennyl Estil

0 600 1,200 m

A3 Scale: 1:16,000

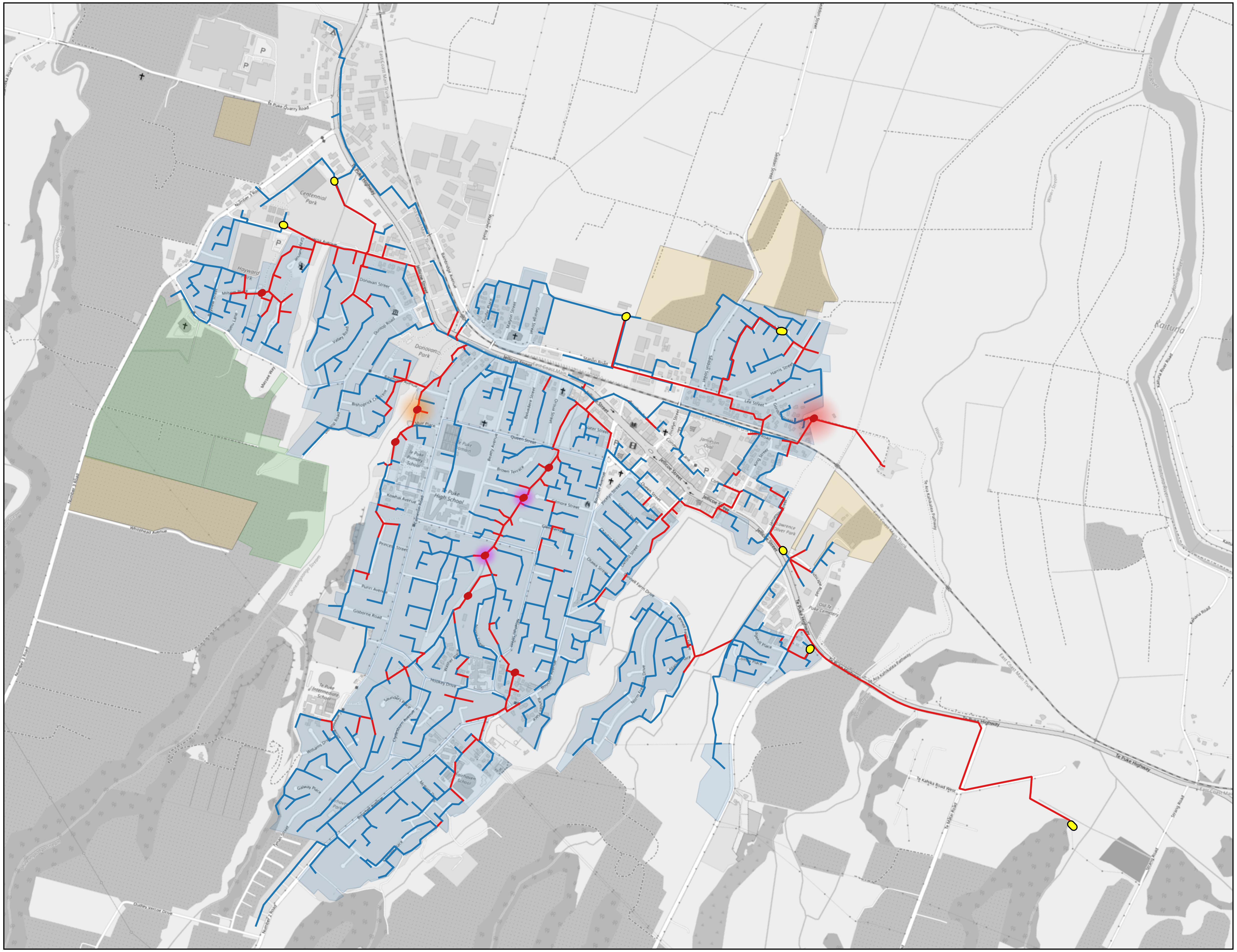
EPSG:2193

3/6/2022

Project Number: 521303

Te Puke Wastewater Intensification

Figure 6. Pipe Performance (Pipe Filling: Depth versus Pipe Diameter) Intensified Conditions - Dry Weather Flow



aurecon

Maximum Pipe Filling

- Unsurcharged (Dmax < D)
- Surcharged (Dmax > D)

Development Areas

- Infill Development Areas
- Greenfield Development Areas
- Potential Structure Plan Areas

Manhole Overflows (m3)

- 0.01 - 50
- 50 - 200
- 200-500
- >500

- Pump Stations

Notes:

Rev A

C:\Users\jennyl.estil\Aurecon Group\521303 - Omokoroa Wastewater Options Modelling - TePuke\03 Working Files\02 GIS

Map by: Jennyl Estil

0 | 600 | 1,200 m

A3 Scale: 1:16,000

EPSG:2193

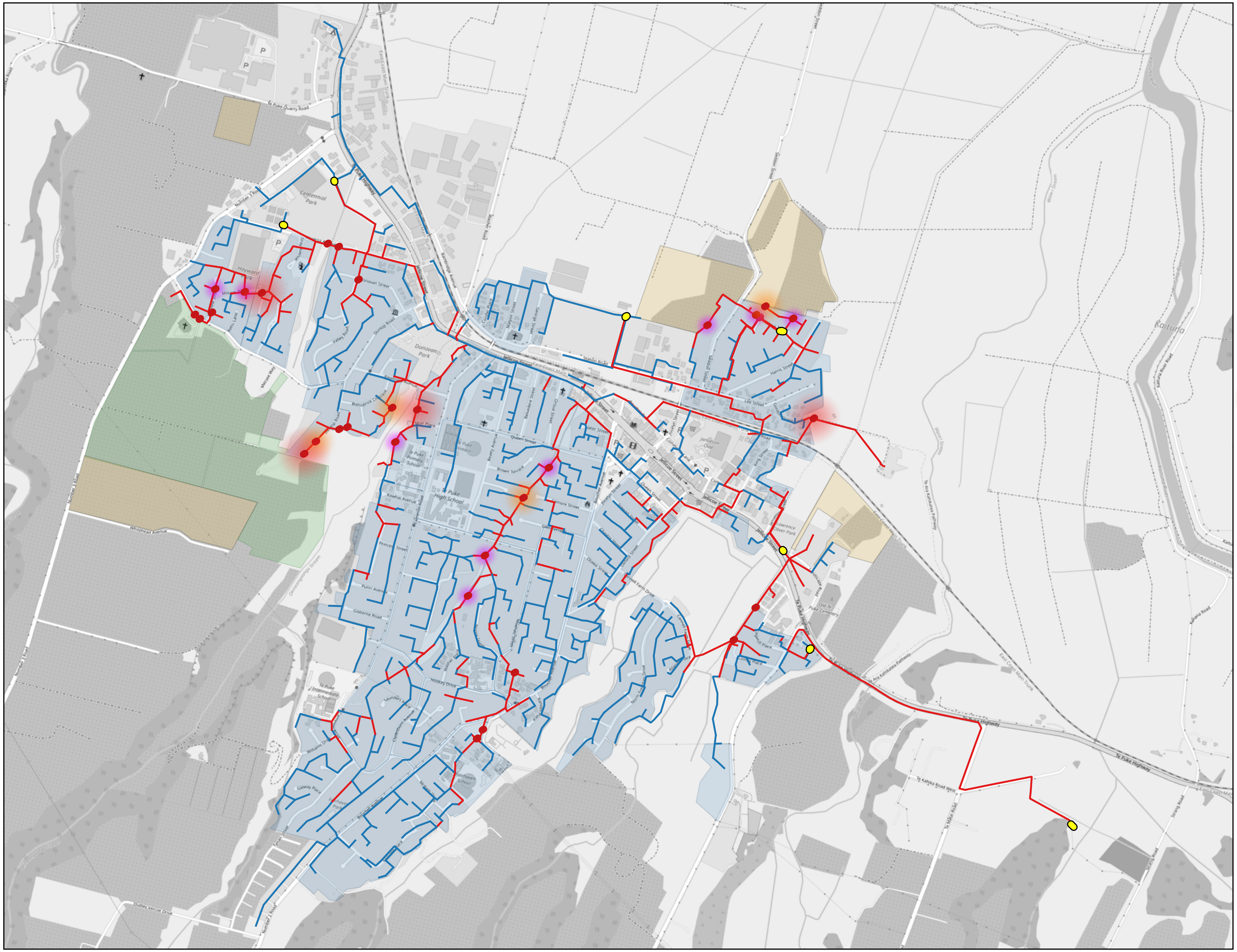
3/6/2022

Project Number: 521303

Te Puke Wastewater Intensification

Figure 7. Pipe Performance (Pipe Filling: Depth versus Pipe Diameter)
Existing Conditions - Wet Weather Flow

C:\Users\jennyl.estil\Aurecon Group\521303 - Omokoroa Wastewater Options Modelling - TePuke\03 Working Files\02 GIS



aurecon

Maximum Pipe Filling

- Unsurcharged (Dmax < D)
- Surcharged (Dmax > D)

Development Areas

- Infill Development Areas
- Greenfield Development Areas
- Potential Structure Plan Areas

Manhole Overflows (m3)

- 0.01 - 50
- 50 - 200
- 200-500
- >500

- Pump Stations

Notes:

Rev A

Map by: Jennyl Estil

0 600 1,200 m

A3 Scale: 1:16,000

EPSG:2193

3/6/2022

Project Number: 521303

Te Puke Wastewater Intensification

Figure 8. Pipe Performance (Pipe Filling: Depth versus Pipe Diameter) Intensified Conditions - Wet Weather Flow

Mā tātau ā raurangi
For our future

Stormwater Management Guidelines for Te Puke

Western Bay of Plenty District Council

Western Bay of Plenty District Council

Stormwater management Guidelines for Te Puke

Western Bay of Plenty District Council is experiencing growing pressure with developments occurring in greenfield (new residential development) & brownfield (existing residential development) areas. In December 2021, the Resource Management (Enabling Housing Supply and Other Matters) Amendment Act 2021 became law. This legislation enables higher density development in residential zones with some provisos. This includes the management of significant risks from additional stormwater due to the increase in hard surfaces.

Bay of Plenty Regional Councils Rivers and Drainage team (BOPRC-RAD), manage a drainage scheme directly downstream from Te Puke. A significant portion of Te Pukes stormwater network drains into this scheme. There is concern that increased intensification within Te Puke will result in increased flooding within the BOPRC-RAD area. Increased stormwater runoff from intensification within Te Puke will therefore need to be carefully managed to ensure no downstream properties are impacted.

To enable further development of Te Puke without having a negative impact on existing stormwater infrastructure or impact on downstream properties, Council is proposing to use several alternative stormwater management methods. These include:

- Limiting impervious surfaces within existing developed areas where intensification occurs to 50%. This will ensure existing issues are not made worse due to further development.
- Where the 50% imperviousness limit can not be achieved, require developments to manage increased stormwater volumes onsite using rain tanks, attenuation tanks, ground soakage etc.
- If attenuation tanks are proposed, the calculations supplied to Council shall be based on the particular tank (brand and model) that is specified to be used in the design. Tanks come in a variety of sizes and the height of the tank controls the maximum and average outflow velocities.
  Tanks shall be designed with a minimum of 100mm dead storage below the control orifice to allow for sedimentation. Tanks shall be located so that:
  a) There is no adverse effect on slopes, retaining walls or building foundations as a result of the weight of the water within the tank.
  b) They are supported by stable ground that is not affected by a building restriction line.
- Encourage on-site soakage where appropriate using the soakage maps/report provided in Appendix A.
  Note that site specific requirements apply in accordance with the New Zealand Building Code and WBOPDC DS5 that includes the soakage rate of soils which need to be determined with site-specific soakage testing.
  Groundwater influences the efficiency of soakage to a great extent.

Not only must the entire soakhole, soakpit or soakage mechanism be located above the static groundwater level in heavy rain conditions, but seasonal changes shall also be considered.

- Impermeable pavement will also be encouraged.
- Encourage developers to utilise inert exterior building materials to minimise the generation of contaminants (i.e. no unpainted zinc or copper products that would result in soluble metals becoming entrained in stormwater unless additional treatment is provided).
- Using swales where appropriate to help slow down the surface runoff as well as to provide stormwater treatment.
- Overland flow paths for large rainfall events (i.e. up to and an including a 1% AEP event) need to be identified and protected at a neighbourhood scale as part of development.
- Gross pollutant traps should be incorporated where possible as a form of pre-treatment for downstream devices. These traps could be incorporated into catchpits or at the end of pipes. There are a large range of traps available from numerous suppliers in New Zealand.
- Maximise the use of vegetation throughout the development. Trees should be used where possible in road corridors, stream corridors and other public reserve areas to reduce the temperature of stormwater runoff entering the receiving environment and provide shading of stream corridors to improve ecological habitat value.
- Using Sediment and Erosion Control guidelines by Tauranga City Council provided in Appendix B.

REPORT

Appendix A

Tonkin+Taylor

Te Puke Stormwater Ground Soakage Recommendations

High Level Slope Stability Considerations

Prepared for

Western Bay of Plenty District Council

Prepared by

Tonkin & Taylor Ltd

Date

July 2022

Job Number

1020515 v1.0

Together we create and sustain a better world

www.tonkintaylor.co.nz

Document control

Title: Te Puke Stormwater Ground Soakage Recommendations					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
22/07/2022	V1.0	For issue to client	Jesse Beetham	David Milner	Reuben Hansen

Distribution:

Western Bay of Plenty District Council 1 PDF copy

Tonkin & Taylor Ltd (FILE) 1 PDF copy

Table of contents

1 Introduction

Western Bay of Plenty District Council (WBOPDC) are currently undertaking a plan change to facilitate intensification of the existing Te Puke urban area (herein known as the Study Area) and propose to use ground soakage as one option for disposal of the additional runoff created by new dwellings and impervious areas.

Ground soakage discharge can be an economical and efficient way to manage and dispose of stormwater associated with hardstand areas (roofs and hardstand areas generally associated with buildings), where geological conditions are suitable. However, a key factor controlling the effectiveness of ground soakage discharge are soil properties and groundwater conditions. Most importantly, ground soakage discharge is most effective in areas where permeable soils are present (granular soils) and the ground water table is located at depth within the subsoil profile.

In some instances, ground soakage discharge can adversely impact the built and natural environment, such as causing slope instability. Increased ground soakage can affect localised groundwater conditions, which can then result in increased porewater pressures. In some cases, increased porewater pressures can affect the stability of sloping land. As a result of this, ground soakage discharge may not be appropriate in some areas of the Study Area where sloping land is present.

This report summarises a high-level desktop assessment of the ground soakage suitability in the Study Area in regards to slope instability. The main aim of this assessment was to differentiate the Study Area into two mapped ground soakage zones (Zone A and Zone B) to inform District Plan rules for the use of soakage. Definitions of these zones are:

- **Zone A:** Stormwater ground soakage discharge likely to be suitable in this zone and unlikely to affect slope stability (based on the desktop review of available information).
- **Zone B:** Stormwater ground soakage discharge may not be suitable in this zone due to possible adverse effects on adjacent slopes.

The purpose of this zoning was to define areas alongside steeply sloping land within the Study Area that could be adversely affected by some ground soakage devices (e.g., soakholes or soakpits).

The scope of this report is to provide a high-level overview of the suitability of the natural ground in the Study Area to receive, and dispose of, stormwater in relation to slope stability. There will still be a requirement at a site-specific level for other factors to be addressed to meet the additional requirements of Clause E1 of the NZ Building Code (Section 2.1) and WBOPDC Development Standard 5 (Section 2.2). This will likely be achieved at resource consent or building consent stages of a given development.

2 Relevant literature and information related to ground soakage and slope stability

2.1 New Zealand Building Code Clause E1 – Surface Water

The main objectives of Clause E1 – Surface Water (Ministry of Business, Innovation & Employment, 2002) are to *"(a) Safeguard people from injury or illness, and other property from damage, caused by surface water, and (b) Protect the outfalls of drainage systems*". Furthermore, Section 9.0 of this clause outlines the requirements for the disposal of surface water when using soak pits. In reference to this project, Section 9.0.1 of Clause E1 reads as follows:

"*Where the collected surface water is to be discharged to a soak pit, the suitability of the natural ground to receive and dispose of the water without causing damage or nuisance to neighbouring property, shall be demonstrated to the satisfaction of the territorial authority.*

Comment: Means of demonstrating the suitability of the ground are outside the scope of this Verification Method. Disposal of surface water to a soak pit may also require a resource management consent."

2.2 Western Bay of Plenty District Council (WBOPDC) Development Standard 5 (DS5)

Section 5.12 of the WBOPDC DS5 (2009) outlines the requirements for the disposal of stormwater by ground soakage in the Western Bay of Plenty Distrct. Information relevant to this study from Section 5.12 of DS5 is summarised as follows:

- The disposal of stormwater from building roofs, parking access and manoeuvring areas in the district has historically been successfully undertaken by discharging stormwater through ground soakage devices.
- In some areas of the district, ground soakage through the means of soakholes or soakpits has contributed to land instability and groundwater seepage in elevated areas.
- The permeability of the soils present in the district are highly variable however, the soils associated with the elevated ground in and around Te Puke are likely to be more permeable than the surrounding, lower lying areas (due to the likely presence of finer grained soils).
- Site specific investigations undertaken by an appropriately qualified and experience Chartered Professional Engineer are required to determine if ground soakage is appropriate for a site. This site-specific assessment shall:
  - Determine the soil conditions and groundwater conditions associated with the site of interest;
  - Determine the soakage rate of the underlying soils (at a known depth). A factor of safety (reduction factor) should be applied to this soakage rate;
  - Provide certification that ground soakage will not have an "*adverse effect on other land or property from land stability, seepage or overland flow perspective i.e. that adjoining slopes, basements, retained and unretained batters are identified and the possible effects on these features are quantified*"; and
  - Identify likely overland flowpaths that would result from overloaded soakage devices.
- Ground soakage devices shall be located above the static groundwater level.

2.3 Relationship between groundwater and slope stability

Groundwater is known to be one of the many factors that can influence the stability of sloping land. Without external influences, the weight of a slope in an unaltered environment generates stresses that can be altered by the presence and movement of groundwater. These changes in stresses can result in slope instability (Blyth & de Freitas, 1986). Discharging stormwater through inground soakage methods can be one of the ways that alters natural groundwater conditions, and in turn, effecting the stresses on nearby slopes which could result in slope instability.

As a result of the potential adverse relationship between slope stability and altered groundwater conditions, many territorial authorities in New Zealand have put procedures and guidelines in place to decrease the risk of ground soakage methods impacting slope stability. In most cases, these procedures and guidelines are associated with setback zones located alongside steeply sloping land.

3 Study Area characteristics

This section of the report collates and documents the available information used to determine the slope stability considerations associated with stormwater ground soakage in the Study Area.

3.1 Ground surface levels

The ground surface level of the Study Area is characterised by a high-resolution (1.0 – 2.0 m) LiDAR derived Digital Elevation Model (DEM). This LiDAR survey data was acquired by Aerial Surveys in 2020/2021 and extends from the Lower Kaimai area to Paengaroa (including the Te Puke urban area). As shown in Figure 3-1, the ground surface elevation within the Study Area is variable, varying from less than 5 m RL in the north to 95 m RL in the south (NZVD2016).

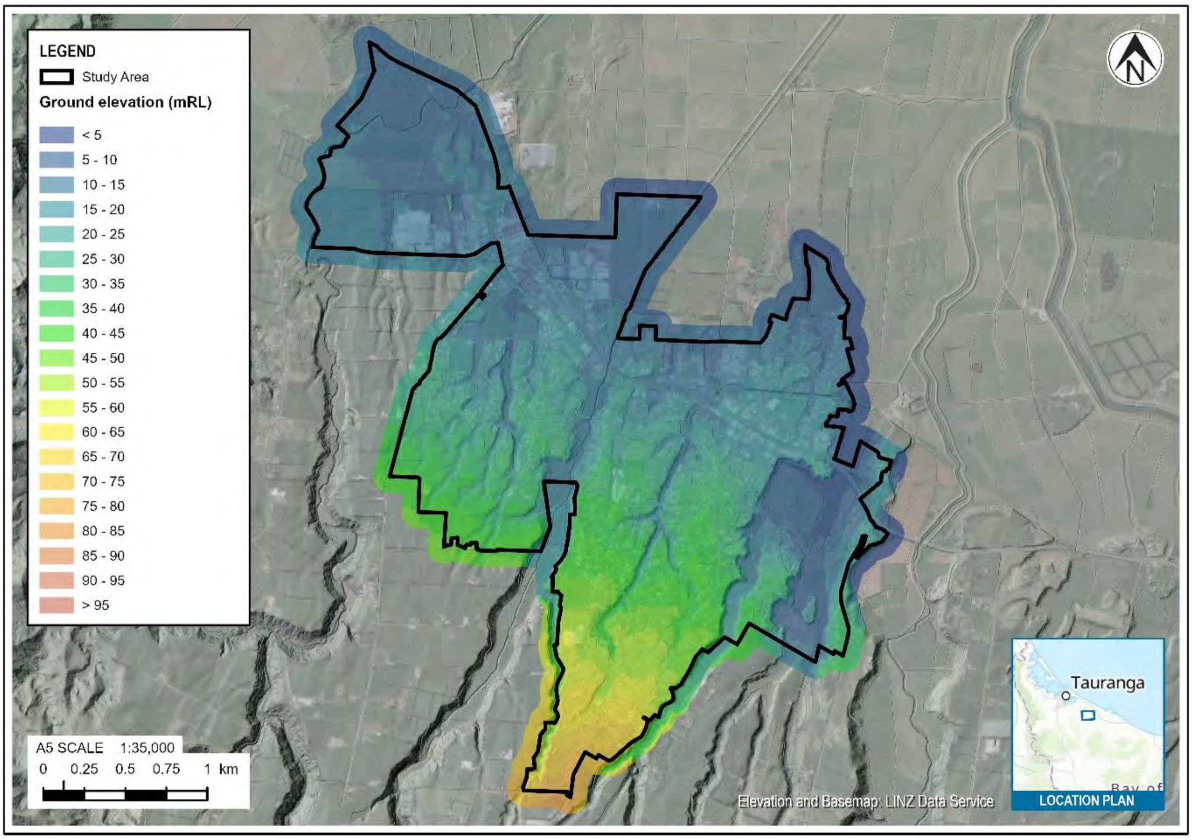


Figure 3-1: Ground surface elevations across the Study Area

A topographical screening tool was developed to quantitatively interpret ground surface levels across the Study Area from the high-resolution (1.0 – 2.0 m) LiDAR-derived DEM. The purpose of the screening tool was to provide a means of quantitatively identifying sloping land from the DEM dataset. The screening tool is based on the method proposed by Stepiniski and Jasiewicz (2011) and considers single elevation points from a DEM dataset in relation to adjacent elevation points at a set distance. The adjacent elevation points are interpreted to be above, below, or in-line with the initial elevation point and an algorithm is used to categorise these patterns into broad landform classifications, which are known as geomorphons. For the purposes of this assessment, three landform types were considered. These geomorphons were:

- Flat Land;
- Valley and Toe Slopes; and
- Sloping Land.

The geomorphons generated from this algorithm are shown in Figure 3-2.

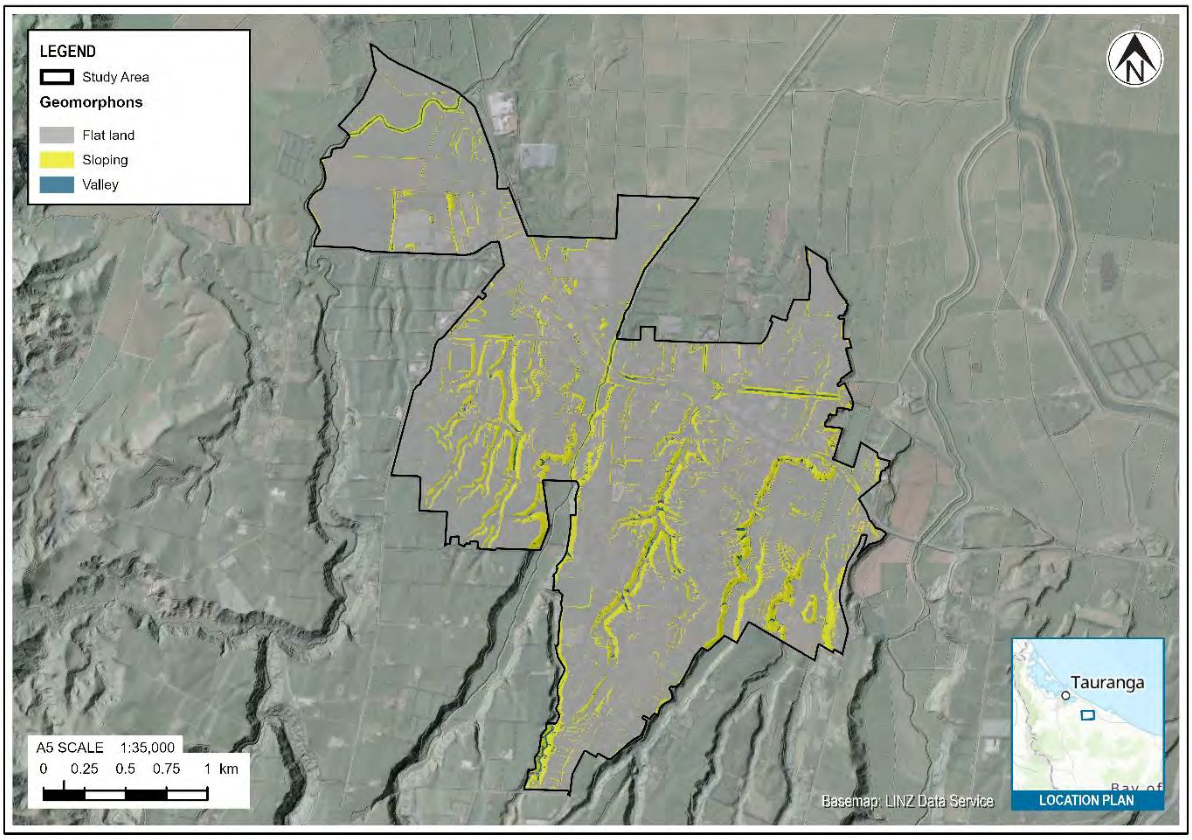


Figure 3-2: Geomorphons gernerated for the Study Area

The LiDAR derived DEM was also used to interpret slope heights and slope angles across the Study Area. ArcPro GIS software was used to interpret the sloping land across the Study Area and categorised this land into the following slope heights and angles (refer to Table 3-1).

Table 3-1: Slope height and angle categories for Study Area

Slope height categories (m)	Slope angle categories (°)
Less than 5	10 - 15
5 – 10	15 - 20
10 – 15	20 - 25
15 – 20	25 - 30
20 – 25	More than 30
25 – 30	
35 – 40	

These slope height and angle categories are shown in Figure 3-3, Figure 3-4 and in Figures A1 to A14 in Appendix A.

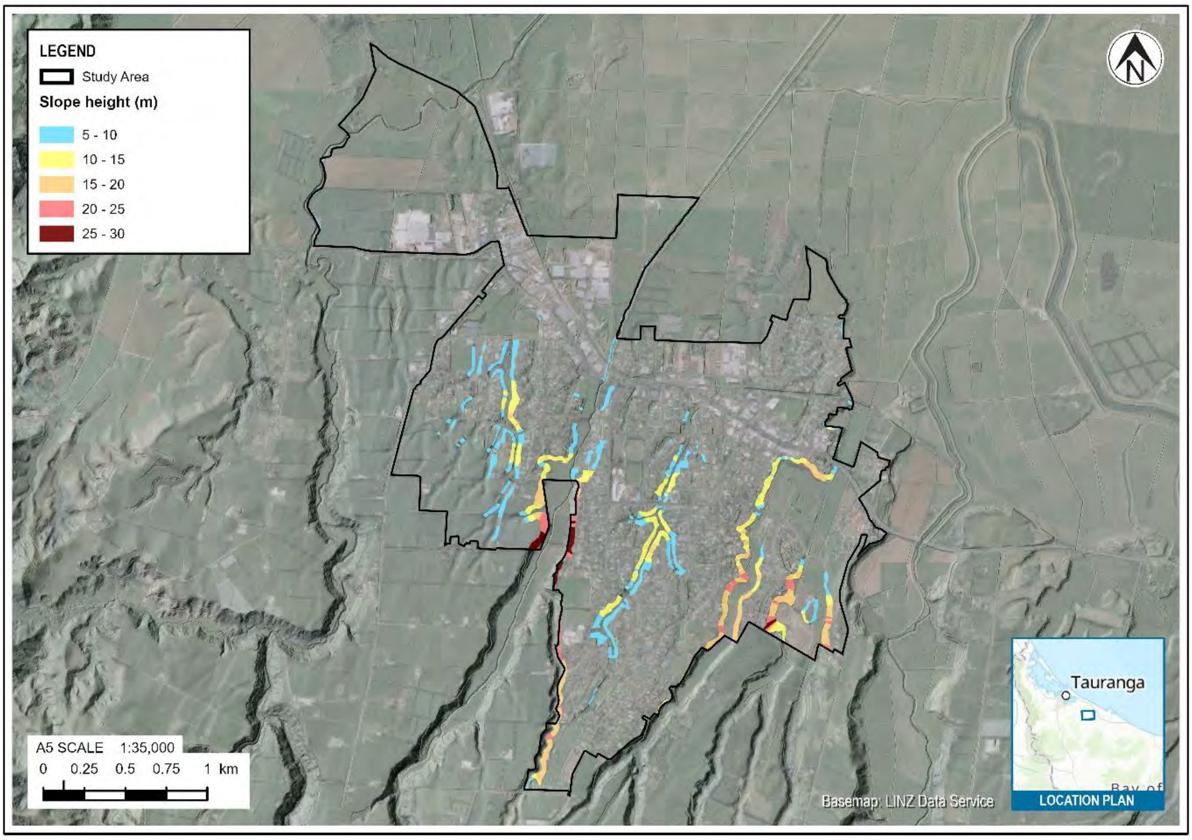


Figure 3-3: Slope heights across the Study Area

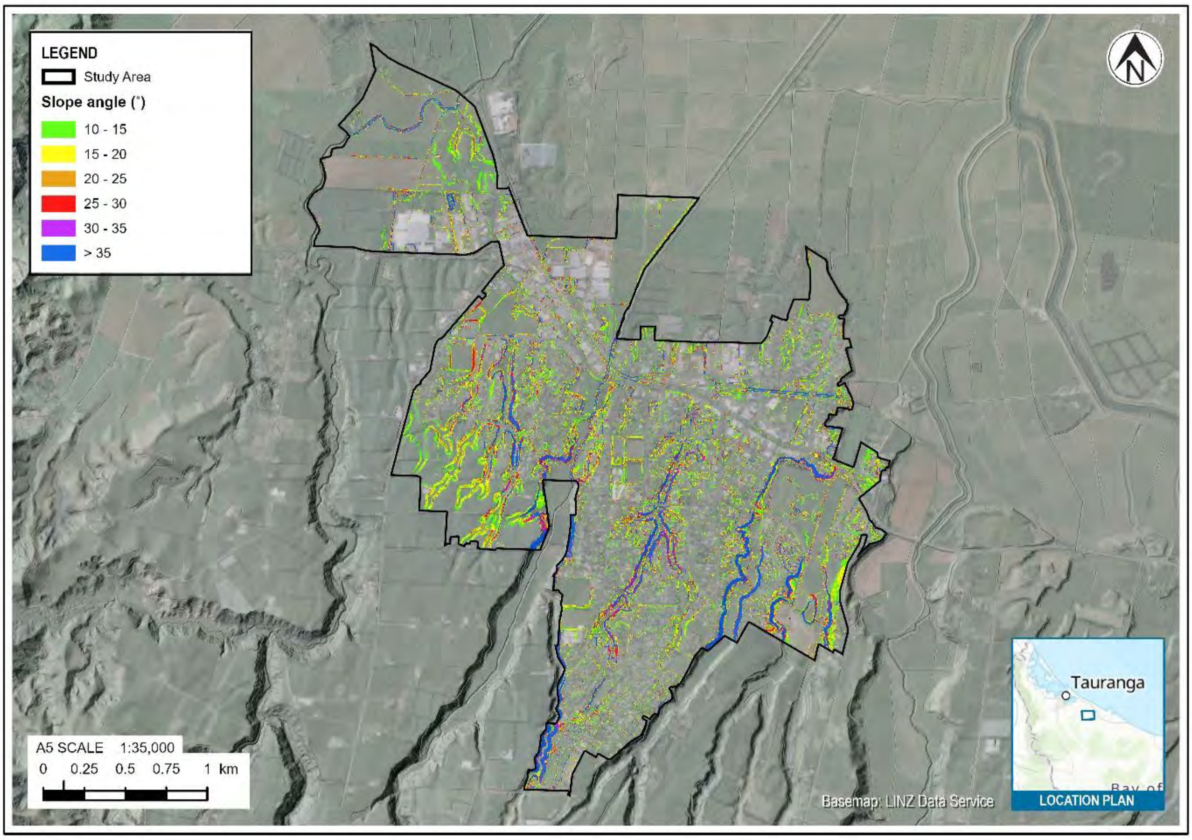


Figure 3-4: Slope angles across the Study Area

3.2 Geology, geomorphlogy and surficial soils

Published geology

The geology of the Study Area (Figure 3-5) is shown on a 1:250,000 scale geological map compiled by GNS (Leonard, Begg, & Wilson, 2010). The map shows three geological units comprise the Study Area which are: the Mamaku Plateau Formation, Pleistocene-aged Tauranga Group alluvium and Holocene-aged Tauranga Group alluvium. Descriptions of these units are as follows:

- **Mamaku Plateau Formation:** This formation is described as a welded, columnar jointed rhyolitic ignimbrite.
- **Pleistocene-aged Tauranga Group alluvium:** These sediments are described as being alluvium dominated by pumice lava fragments and felsic crystals of volcaniclastic provenance sourced from the Taupo Volcanic Zone.
- **Holocene-aged Tauranga Group alluvium:** Sediments comprising alluvial and colluvial gravel and sand dominated by pumice clasts, silt, and clay with localised peat deposits.

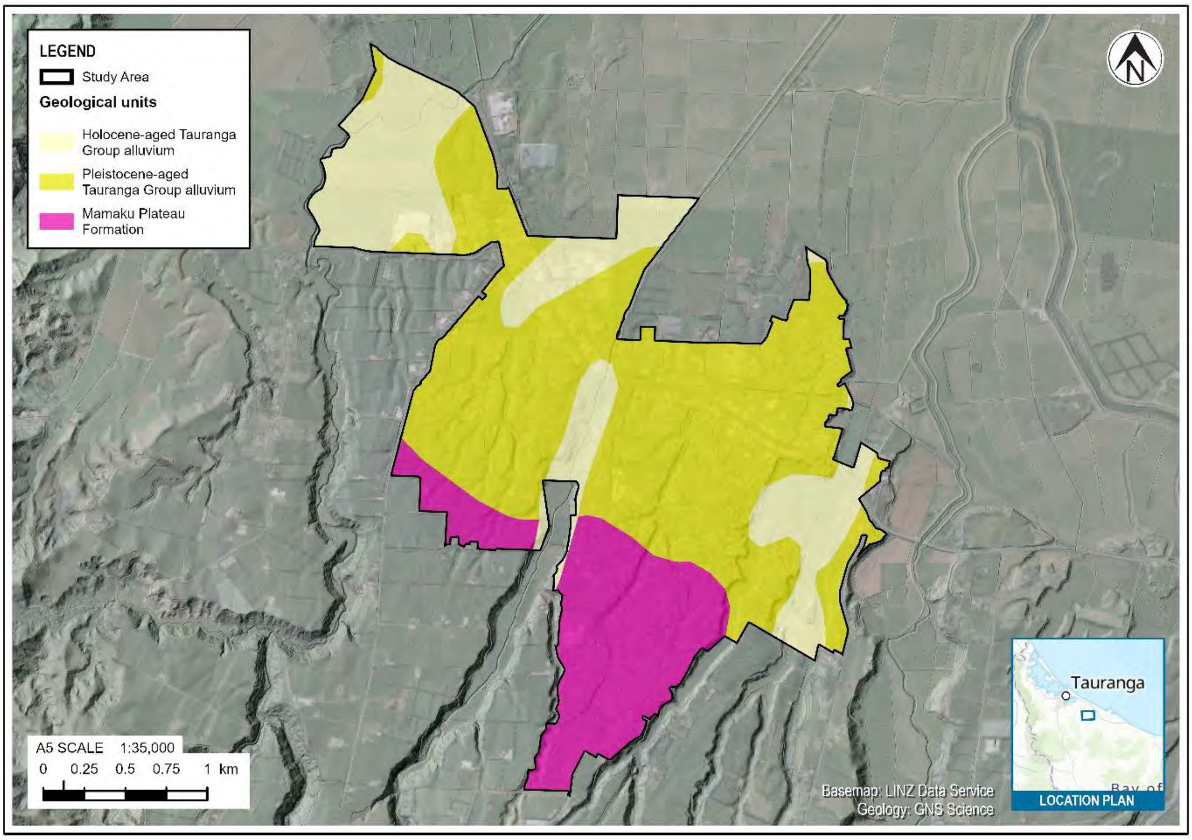


Figure 3-5: Main geological units associated with the Study Area (Leonard, Begg, & Wilson, 2010)

The geological units within the Study Area are also shown in Figure A in Appendix A.

Geomorphology

The geomorphology of the Study Area can also be subdivided into three main terrains and are closely associated with the mapped geological units detailed above. The geomorphic terrains comprising the Study Area are as follows:

- **Hills and Ranges:** The southern extent of the Study Area is typically associated with the mapped Mamaku Plateau Formation. This terrain is represented by the land within the Study Area that has the highest elevations.
- **Alluvial Terraces:** This terrain comprises the majority of the Study Area and represents the elevated Pleistocene-aged Tauranga Group alluvial deposits. These Alluvial Terraces are elevated above the present-day streams and valleys that dissect the Study Area.
- **Alluvial Channels:** The streams and gullies that dissect the Study Area represent the Alluvial Channels terrain. This terrain is generally positioned at a lower elevation compared to the Alluvial Terraces and Hills and Ranges terrains. These Alluvial Channels are likely to be contain the Holocene-aged Tauranga Group alluvium.

Mapped surficial soils

A geospatial map of the soils within the Bay of Plenty Region is available on the Bay of Plenty Regional Council open data portal (Bay of Plenty Regional Council, 2022). This map was created using information sourced from Landcare Research (S-MAP). This information was used to identify the types of soils present within the Study Area (Table 3-2) and the drainage classifications associated with these mapped soil types. It should be noted that these soils were mapped at a 1:50,000 scale and their locations and extents shown on these maps may not be accurate at higher resolution scales.

Table 3-2: Summary of soils mapped within the Study Area

New Zealand Soil Classification	Drainage classification	Mapped extent in Study Area
Allophanic Soil	Well drained	70%
Gley Soil	Poorly drained	20%
Recent Soil	Well drained	8%
Pumice Soil	Well drained	2%

3.3 Types of slope failures observed in Study Area

A report titled Geology of the Tauranga Area (Briggs, et al., 1996) provides the following information on slope instability in the Tauranga Area (including Te Puke):

"*Slope instability and mass failure may vary from deep-seated to superficial, and rotational slumps are common. Many of the pyroclastic rocks are strong, welded ignimbrites that are jointed and erode by rock fall, but others particularly in the central Tauranga Basin are very weak non-welded ignimbrites which lack any major discontinuities and may erode by large and small scale rotational slides. Slope failures can be catastrophic events associated with high intensity rainstorms, and superficial failures can be common that involve failure of the soil, tephra and sometimes weathered bedrock, especially on steeper slopes.*"

Furthermore, the report accompanying the geological map compiled by GNS (Leonard, Begg, & Wilson, 2010), also states the following for the Bay of Plenty Region in relation to slope stability hazards:

"*Underlying geology makes some areas particularly susceptible to landslides, notably some unconsolidated Quaternary ignimbrites and volcaniclastic sediments in the Tauranga area. These deposits are also reworked as soft sediment fans (as at Matata) and often contain sensitive clays. Both primary and reworked deposits are prone to shallow landslips, triggered by heavy rainfall.*"

Based on the literature above, the DEM dataset and hillshade of the Study Area was reviewed on ArcPro GIS to identify any obvious historic slope failures. No obvious large failures were identified in this high-level review, however, evidence of shallow surficial slope failures was common across the Study Area.

4 Methodology

The following methodology was used to differentiate the Study Area into the two pre-defined ground soakage zones (Zone A and Zone B):

i Using the base information outlined in Section 3, the sloping land within the Study Area was first differentiated into slopes that were greater than 5 m high, with gradients greater than 25 degrees and slopes that were less than 5 m high.

ii Once these slopes within the Study Area were identified, they were further subdivided into 5 – 10 m, 10 – 15 m, 15 – 20 m, 20 – 25 m, and 25 – 30 m slope height categories.

iii The toe of slope (TOS) and crest of slope (COS) features were then mapped for the slopes identified in steps i and ii. These features were based on the source information elements outlined in Section 3 of this report.

iv Setbacks were then applied to the TOS feature which were defined by slope height and gradient parameters. These setbacks were based on general engineering judgment and a 3H:1V (3 horizontal by 1 vertical) stable slope ratio (a minimum 15 m setback was applied to the COS features of slopes greater than 5 m height). Given the high-level, desk-based nature of this study, we are unable to provide site specific stable slope ratios at this time. Set-back ratios could be refined at a site-specific level with detailed slope stability assessments.

v The setback defined by Step iv was then used to differentiated between **Zone A** and **Zone B** areas within the Study Area.

The outputs of this methodology are presented in figure B1 to B7 in Appendix B.

5 Results and discussion

The methodology outlined in Section 4 categorised the Study Area into two slope stability related ground soakage zones, Zone A and Zone B. These two zones characterise, at a high-level, how the stability of the land within the Study Area is likely to be affected by disposal of stormwater to ground soakage.

Land within the Study Area that has been categorised as Zone A generally comprises flat land and sloping land less than 5 m in height (with gradients less than 25 degrees). Zone A land is associated with all three mapped geological units (Mamaku Plateau Formation, Pleistocene-aged Tauranga Group alluvium, and Holocene-aged Tauranga Group alluvium) and with all four of the mapped surficial soil units (Allophanic Soil, Gley Soil, Recent Soil and Pumice Soil).

Zone B land within the Study Area is associated with slopes greater than 5 m in height, with gradients greater than 25 degrees. Zone B is also associated with some gently sloping to flat areas of land located above and alongside steeply sloping land in the Study Area. The extent of Zone B in these areas is dependent on an 18-degree (1V:3H) slope setback from a manually mapped base of slope. Zone B land is typically associated with two of the mapped geological units (Mamaku Plateau Formation and Pleistocene-aged Tauranga Group alluvium) and two of the mapped surficial soil units (Allophanic Soil and Pumice Soil).

The main difference between Zone A and Zone B is the possibility of ground soakage discharge affecting slope stability. Ground soakage discharge is likely to influence groundwater conditions in both Zone A and Zone B. However, altering the groundwater conditions in Zone B could have adverse effects on the stability of adjacent sloping land. Conversely, ground soakage discharge in Zone A is not likely to have adverse effects on slope stability in the Study Area[1].

Ground soakage discharge may be appropriate in some areas of Zone B however, a suitably qualified and experienced person will need to undertake further investigations/assessments at a site-specific level to justify how and why ground soakage discharge will not affect slope stability of nearby slopes.

The ground soakage discharge suitability zones (Zone A and Zone B) of the Study Area are shown in Figures B1 to B7 in Appendix B.

[1] The influence of ground soakage discharge on slope stability may still need to be addressed in **Zone A** at a site-specific level if steep slopes less than 5 m in height are present (e.g., retaining structures, earthworks etc).

6 Conclusions

Ground soakage discharge of stormwater could have a detrimental effect on slope stability in the Study Area if undertaken within close proximity to sloping land. As a result, this study was initiated to determine where ground soakage discharge could be suitable in the Study Area in relation to slope stability to inform District Plan rules. This study reviewed ground surface levels, geological information, soil information and geomorphology to determine what slopes in the Study Area are more likely be susceptible to instability by elevated groundwater. A review of the available base information then allowed the slopes within the Study Area to be differentiated into different height and angle categories. Set-backs were then applied to these slope categories.

The Study Area was then differentiated into two ground soakage discharge suitability zones, Zone A and Zone B. The definitions of these two zones are as follows:

- **Zone A:** Stormwater ground soakage discharge likely to be suitable as it is unlikely to affect slope stability (based on the desktop review of available information).
- **Zone B:** Stormwater ground soakage discharge may not be suitable in this zone due to possible detrimental effects on slope stability (based on the desktop review of available information). Additional information will be required at a site-specific level by a suitably qualified and experienced person if ground soakage discharge is proposed for a site in this zone.

There may be some areas of Zone B that, at a site-specific level, could be recategorised if slope heights are found to be less than 5 m in height with slope angles less than 25 degrees. Recategorisation of Zone B areas at a site-specific level within the study area will require a suitably qualified and experienced person to provide evidence that shows:

1. Slope height is less than 5 m, and
2. Slope steepness is less than 25 degrees.

These stormwater ground soakage discharge zones were determined at a high level and not at a site-specific level. Furthermore, the mapped ground soakage zones only relate to ground soakage suitability with respect to slope stability, there are a variety of other factors that need to be assessed a site-specific level when designing stormwater soakage systems (requirements are outlined in New Zealand Building Code and WBOPDC DS5). This includes the soakage rate of soils which needs to be determined with site-specific soakage testing.

7 Future work recommendations

One of the other most influential factors that can determine whether or not ground soakage discharge is suitable on a site is the groundwater condition. Currently, the WBOPDC DS5 states that "*the entire soakhole, soakpit or soakage mechanism shall be located above the static groundwater level in heavy rain conditions*". Further to this recommendation, designers should also consider seasonal changes in groundwater conditions and changes related to climate change.

The depth from the ground surface to the groundwater table controls the size and efficiency of soakage devices. In some cases, where shallow groundwater conditions are present, ground soakage may not be an appropriate stormwater disposal method.

WBOPDC may wish to undertake a groundwater study for the Te Puke urban area to determine where areas of shallow groundwater are present and to quantify seasonal groundwater fluctuations. This information could then allow WBOPDC to determine where ground soakage discharge may not be suitable in the urban area (this groundwater information would be supplementary to the slope stability considerations outlined in this report).

8 Applicability

This report has been prepared for the exclusive use of our client Western Bay of Plenty District 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.

This assessment has been made at a broad scale across the defined Study Area and is intended to describe the ground soakage discharge suitability in the Study Area in relation to slope stability in an approximate way only. It is not intended to precisely describe the ground soakage discharge suitability at an individual property scale. This information is general in nature, and more detailed site-specific assessment may be required (e.g., for resource consent and building consent applications).

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

Report prepared by:

....

Jesse Beetham
Engineering Geologist

Authorised for Tonkin & Taylor Ltd by:

....

Reuben Hansen
Project Director

Technical review by:

....

David Milner
Senior Engineering Geologist

JMB
\\ttgroup.local\files\tgaprojects\1020515\issueddocuments\20220722 te puke ground soakage report\20220722.jmb.tepukegroundsoakagereport.v0.1.docx

9 Bibliography

Bay of Plenty Regional Council. (2022, June 6). *Maps and data*. Retrieved from Bay of Plenty Regional Council : https://maps.boprc.govt.nz/

Blyth, F. G., & de Freitas, M. H. (1986). *A Geology for Engineers.* Great Britain: Bulter & Tanner Ltd, Frome and London.

Briggs, R. M., Hall, G. J., Harmsworth, G. R., Hollis, A. G., Houghton, B. F., Hughes, G. R., . . . Whitbread-Edwards, A. R. (1996). *Geology of the Tauranga Area.* Hamilton, NZ: Department of Earth Sciences, University of Waikato.

Leonard, G. S., Begg, J. G., & Wilson, C. J. (2010). *Geology of the Rotorua area - 1:250 000 geological map 5.* Lower Hutt, New Zealand: Institute of Geological & Nuclear Sciences.

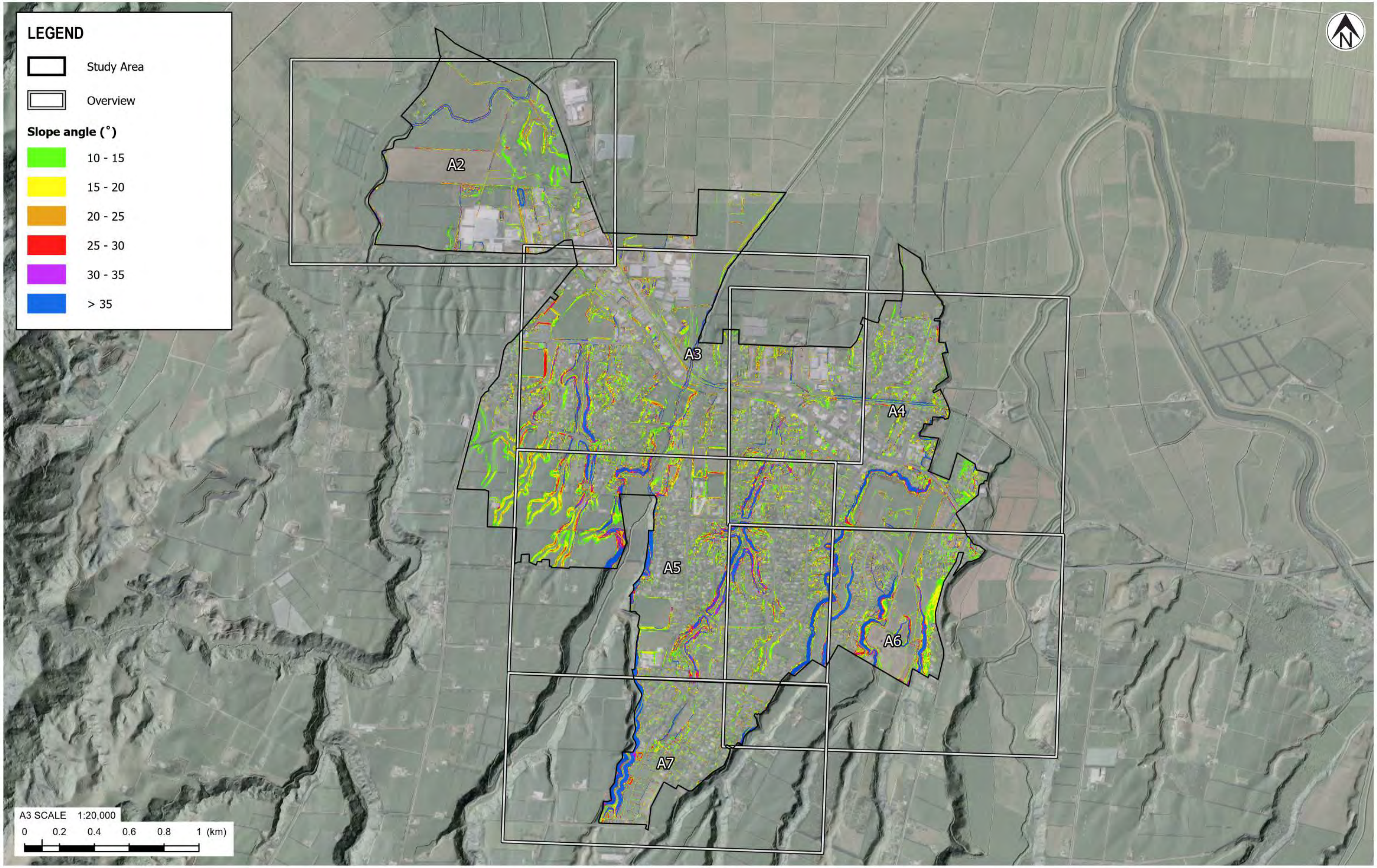
Ministry of Business, Innovation & Employment. (2002). *Acceptable Solutions and Verification Methods For New Zealand Building Code Clause E1 Surface Water.* Wellington: Ministry of Business, Innovation & Employment.

Stepinski, T. F., & Jasiewicz, J. (2011). Geomorphons - a new apporach to classification of landforms. *Geomorphometry*, 109-112.

Appendix A Study Area characteristics

- **Figure A1 to A7 – Slope angles within Study Area**
- **Figure A8 to A14 – Slope heights within Study Area**

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_SlopeAngle_Overview 2022-Jul-19 12:13 pm Drawn by MOLI



Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. World Topographic Map (Vector Tile): Esri, HERE, Garmin, FAO, NOAA, USGS

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN: Tauranga

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL

PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS

TITLE SLOPE ANGLE- OVERVIEW

SCALE (A3) 1:20,000 FIG No. FIGURE A1 REV 0

COPYRIGHT ON THIS FIGURE IS RESERVED   DO NOT SCALE FROM THIS FIGURE.

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_SlopeAngle 2022-Jul-19 11:39 am Drawn by MOLI

Tonkin+Taylor
Exceptional thinking together   www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN: Tauranga, Bay of P

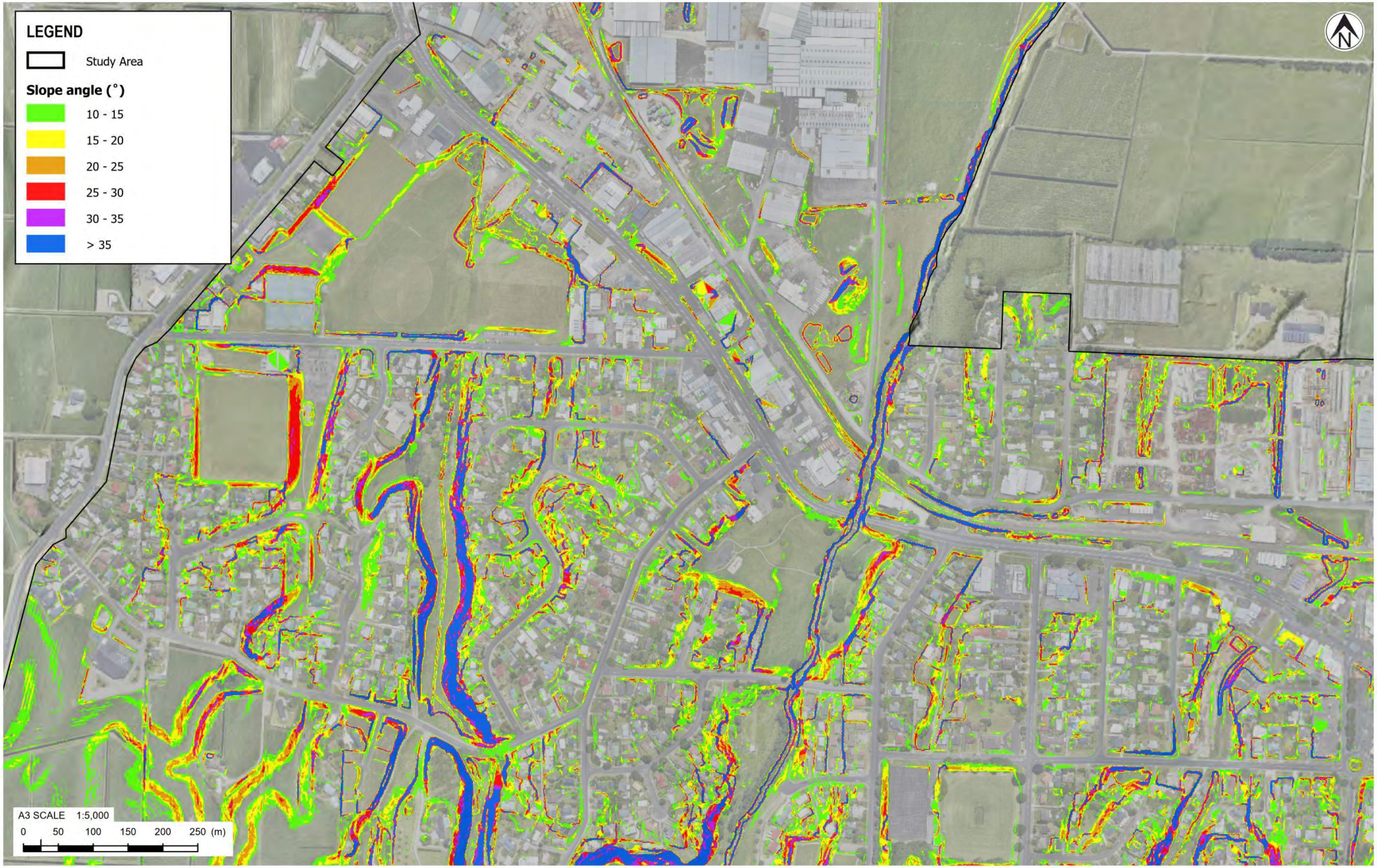
PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS
TITLE SLOPE ANGLE

SCALE (A3) 1:5,000   FIG No. FIGURE A2   REV 0

COPYRIGHT ON THIS FIGURE IS RESERVED   DO NOT SCALE FROM THIS FIGURE.

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_SlopeAngle 2022-Jul-19 11:39 am Drawn by MOLI

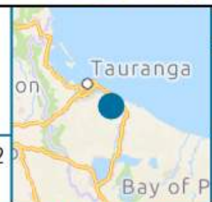


Tonkin+Taylor

Exceptional thinking together   www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22



LOCATION PLAN

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL

PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS

TITLE SLOPE ANGLE

SCALE (A3) 1:5,000   FIG No. FIGURE A3   REV 0

COPYRIGHT ON THIS FIGURE IS RESERVED   DO NOT SCALE FROM THIS FIGURE

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_SlopeAngle 2022-Jul-19 11:39 am Drawn by MOLI

Tonkin+Taylor
Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

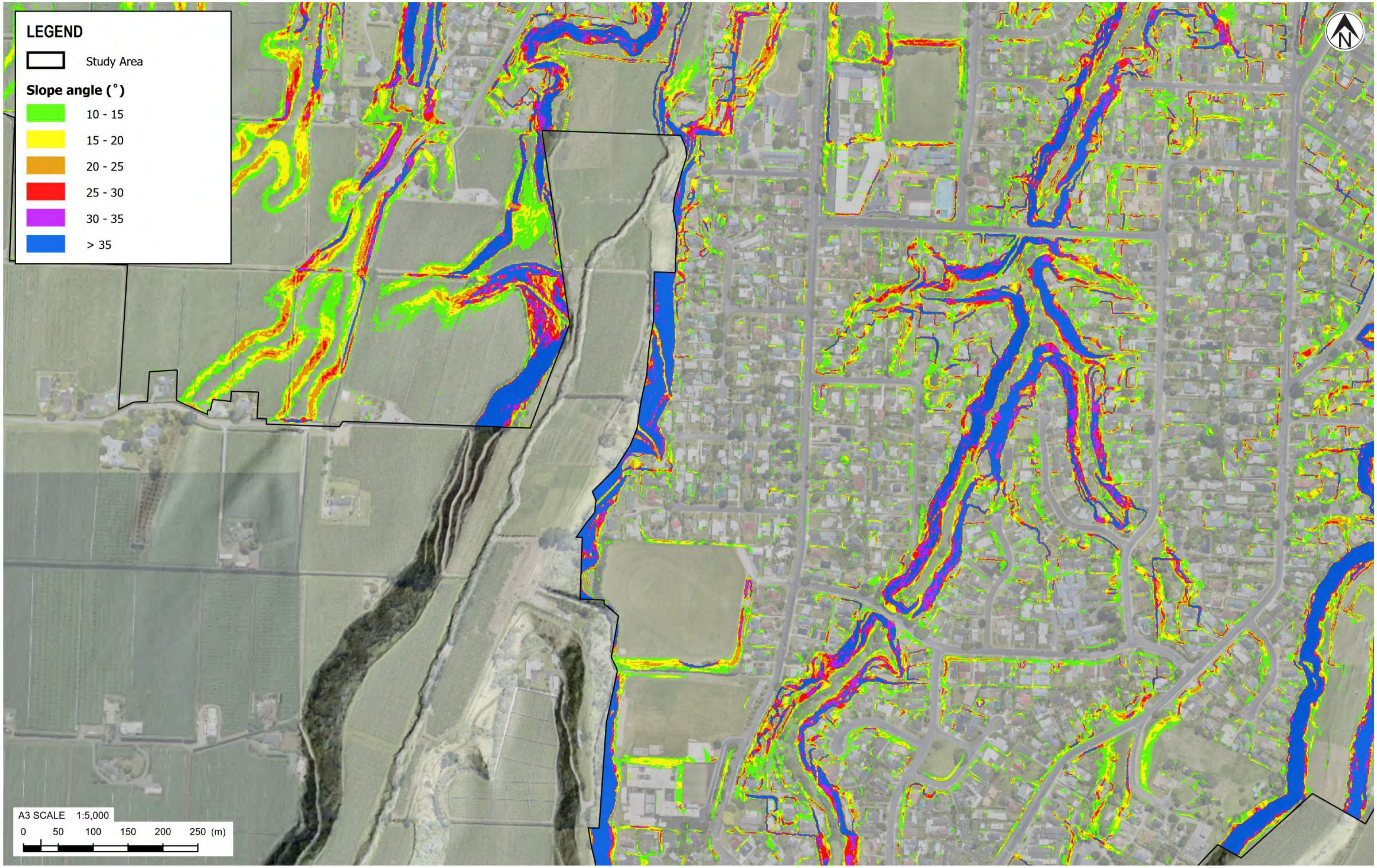
LOCATION PLAN: Tauranga, Bay of P

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT: WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT: TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS
TITLE: SLOPE ANGLE
SCALE (A3): 1:5,000 FIG No. FIGURE A4 REV 0

COPYRIGHT ON THIS FIGURE IS RESERVED DO NOT SCALE FROM THIS FIGURE.

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_SlopeAngle 2022-Jul-19 11:39 am Drawn by MOLI



Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

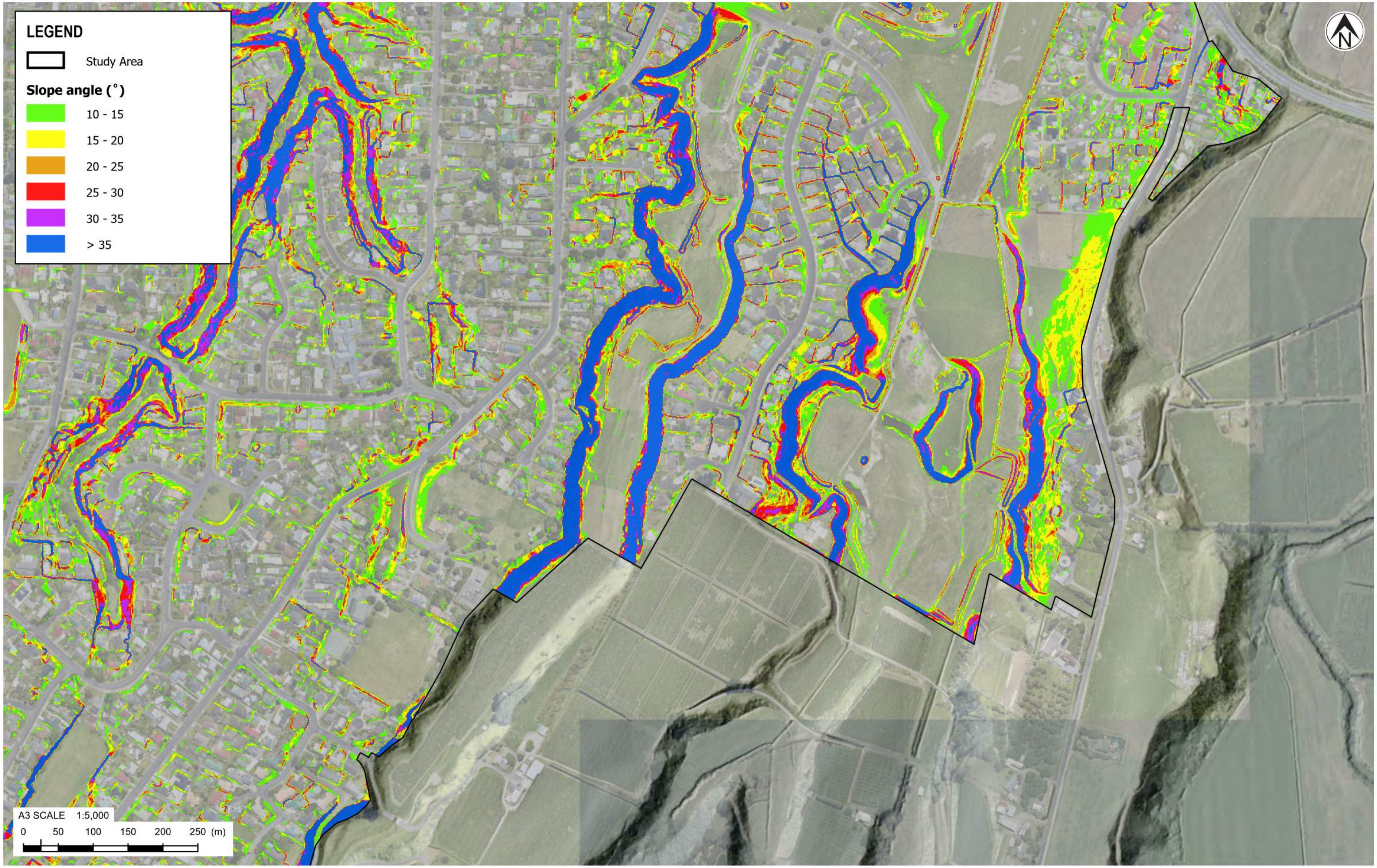
CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL

PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS

TITLE SLOPE ANGLE

SCALE (A3) 1:5,000 FIG No. FIGURE A5 REV 0

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_SlopeAngle 2022-Jul-19 11:39 am Drawn by MOLI



Tonkin+Taylor
Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

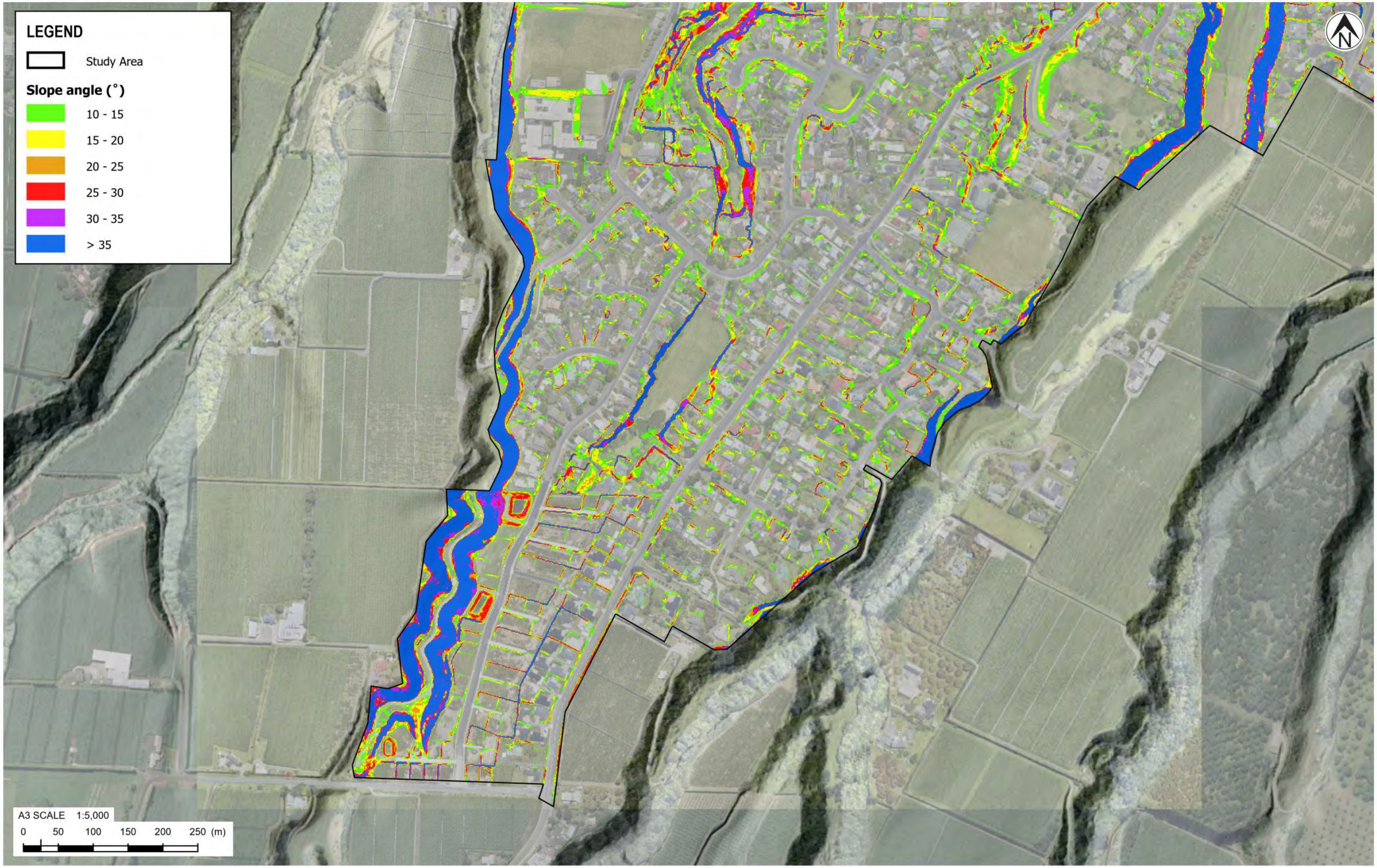
REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS
TITLE SLOPE ANGLE

SCALE (A3) 1:5,000 FIG No. FIGURE A6 REV 0



Tonkin+Taylor
Exceptional thinking together www.tonkintaylor.co.nz

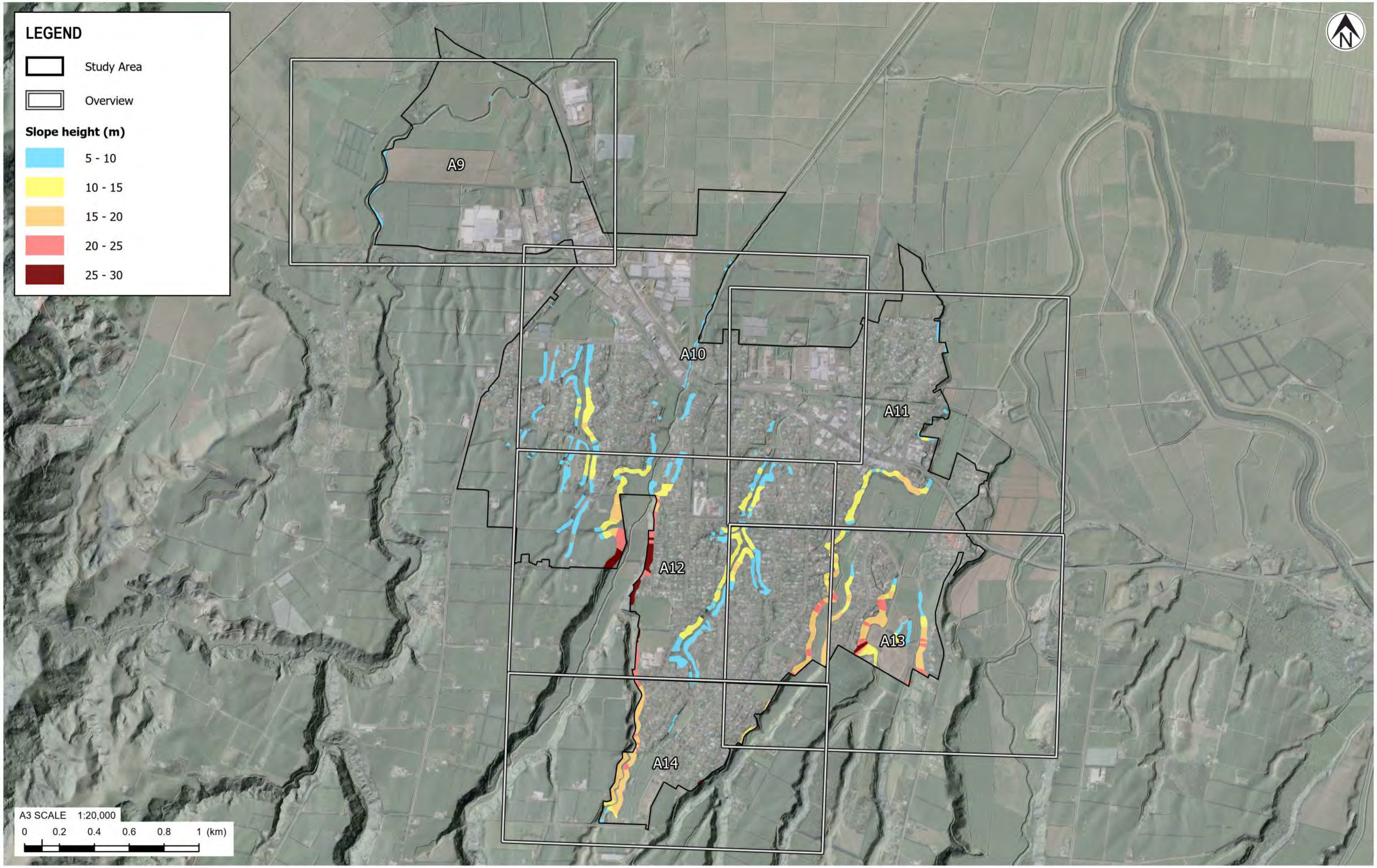
NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN: Tauranga, Bay of P

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS
TITLE SLOPE ANGLE
SCALE (A3) 1:5,000 FIG No. FIGURE A7 REV 0



Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. World Topographic Map (Vector Tile): Esri, HERE, Garmin, FAO, NOAA, USGS

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN: Tauranga

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS
TITLE SLOPE HEIGHT- OVERVIEW
SCALE (A3) 1:20,000 FIG No. FIGURE A8 REV 0

COPYRIGHT ON THIS FIGURE IS RESERVED   DO NOT SCALE FROM THIS FIGURE.

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_SlopeHeight 2022-Jul-20 2:22 pm Drawn by MOLI

Tonkin+Taylor
Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

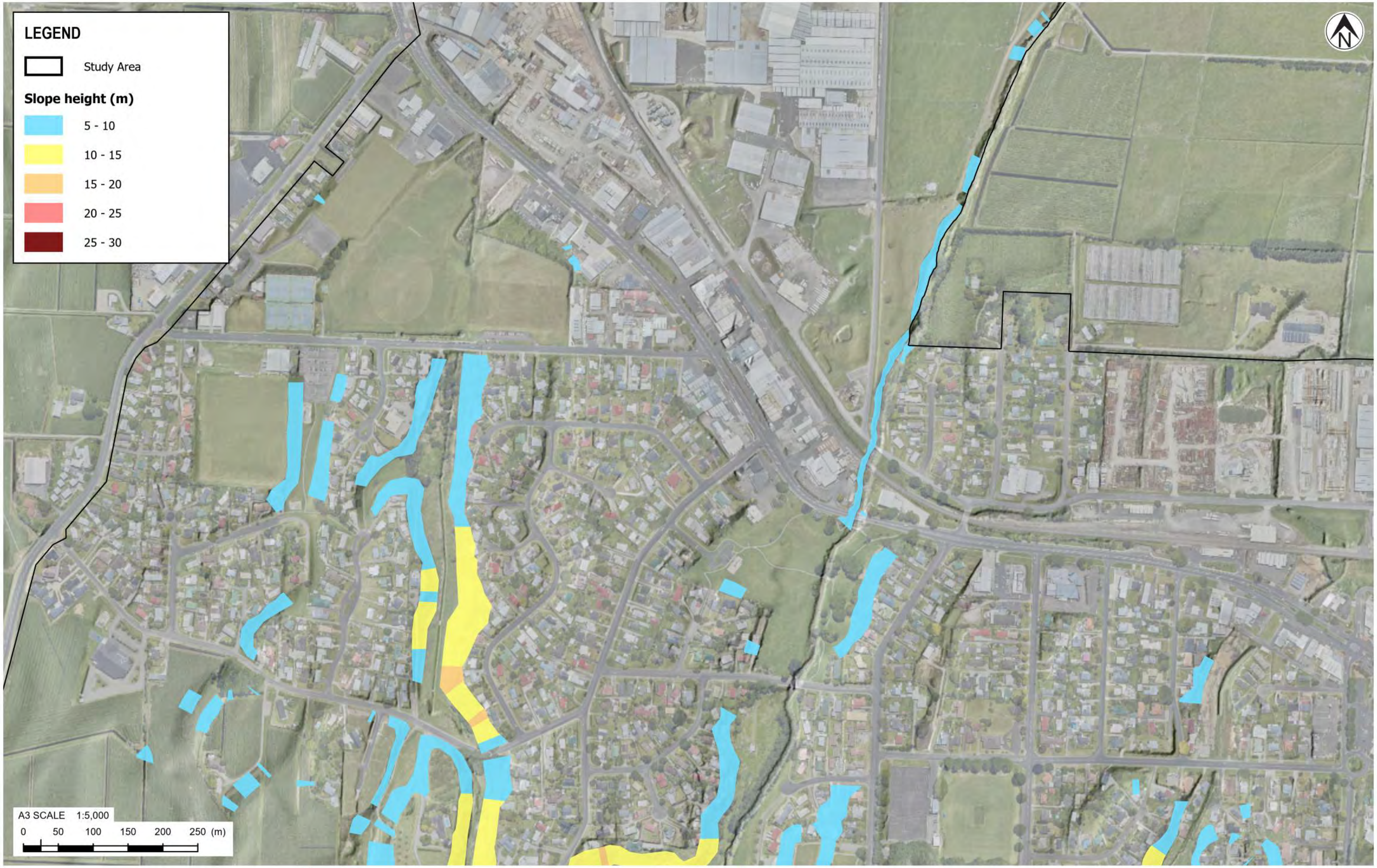
LOCATION PLAN: Tauranga, Bay of P

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT: WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT: TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS
TITLE: SLOPE HEIGHT

SCALE (A3) 1:5,000 FIG No. FIGURE A9 REV 0

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_SlopeHeight 2022-Jul-20 2:52 pm Drawn by MOLI



Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL

PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS

TITLE SLOPE HEIGHT

SCALE (A3) 1:5,000 FIG No. FIGURE A10 REV 0

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_SlopeHeight 2022-Jul-20 2:52 pm Drawn by MOLI

Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN: Tauranga, Bay of P

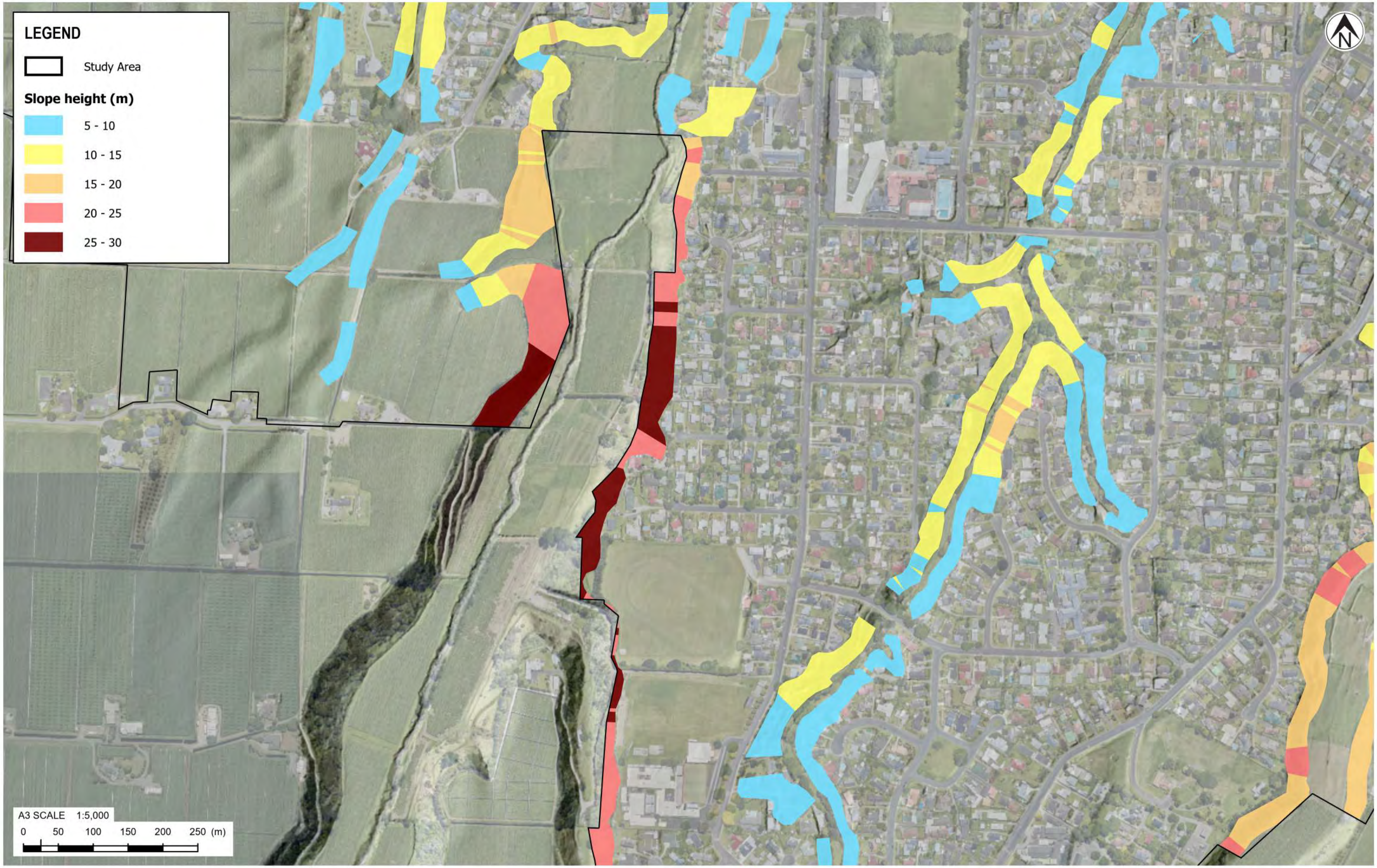
PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL

PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS

TITLE SLOPE HEIGHT

SCALE (A3) 1:5,000 FIG No. FIGURE A11 REV 0



Tonkin+Taylor
Exceptional thinking together   www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN: Tauranga, Bay of P

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT: WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT: TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS
TITLE: SLOPE HEIGHT

SCALE (A3) 1:5,000   FIG No. FIGURE A12   REV 0

COPYRIGHT ON THIS FIGURE IS RESERVED   DO NOT SCALE FROM THIS FIGURE.

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_SlopeHeight 2022-Jul-20 2:52 pm Drawn by MOLI

Tonkin+Taylor
Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

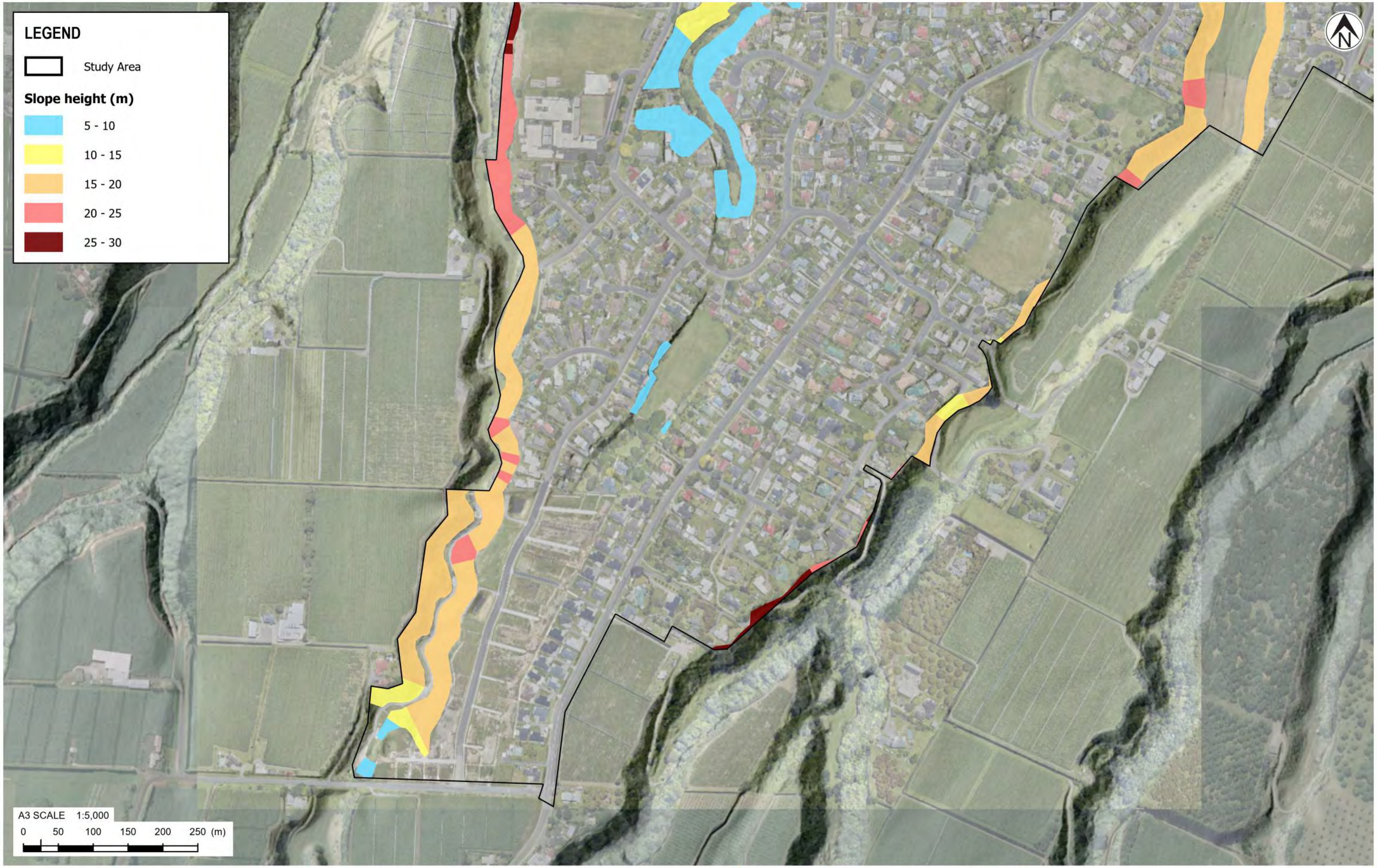
REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN: Tauranga, Bay of P

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS
TITLE SLOPE HEIGHT

SCALE (A3) 1:5,000 FIG No. FIGURE A13 REV 0



Tonkin+Taylor
Exceptional thinking together   www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN: Tauranga, Bay of P

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT: WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT: TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS
TITLE: SLOPE HEIGHT

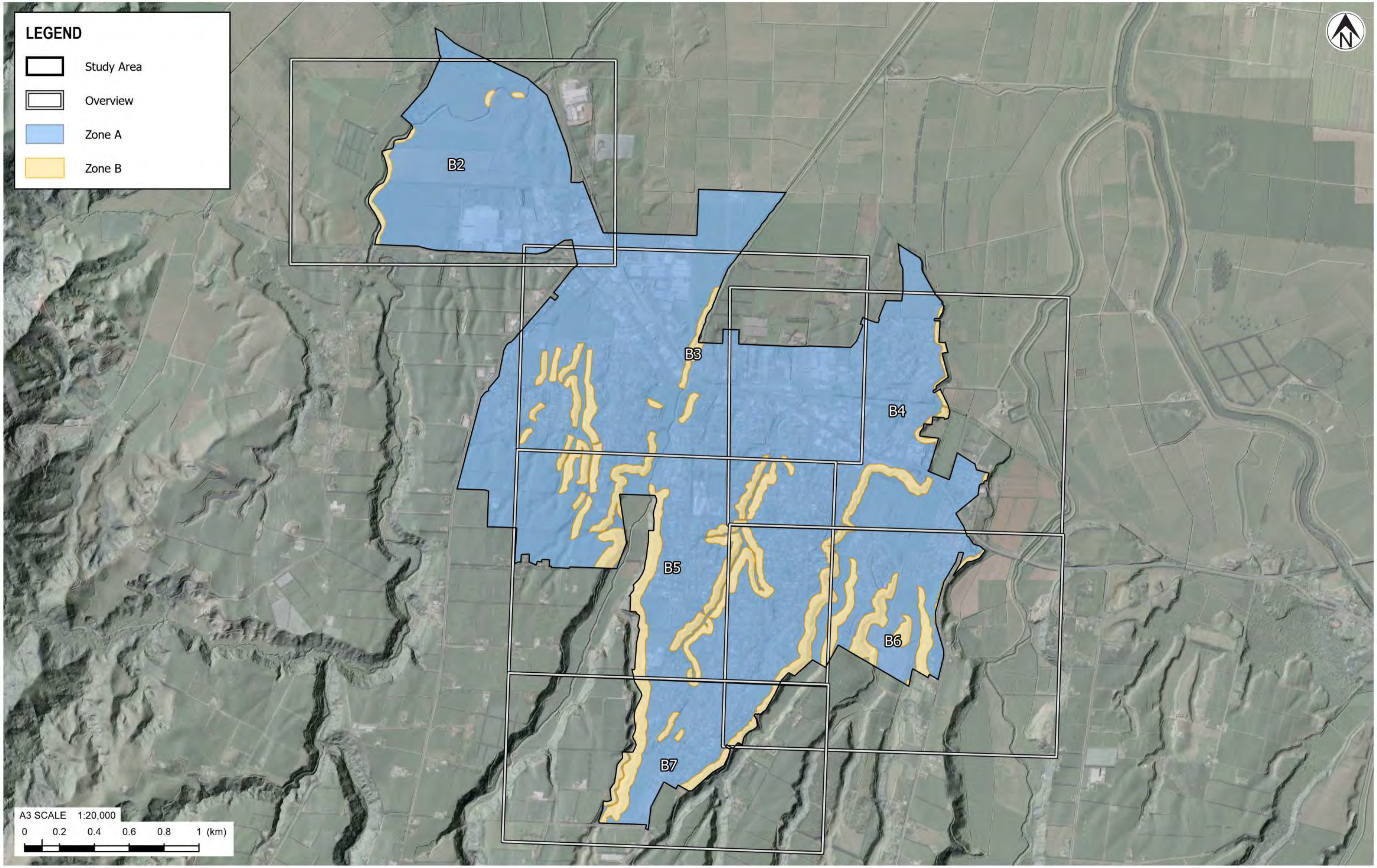
SCALE (A3): 1:5,000   FIG No. FIGURE A14   REV 0

Appendix B Assessment outputs

- **Figure B1 to B7 – Soakage zones within Study Area**

COPYRIGHT ON THIS FIGURE IS RESERVED DO NOT SCALE FROM THIS FIGURE.

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_Soakage_Overview 2022-Jul-21 8:20 am Drawn by MOLI



Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. World Topographic Map (Vector Tile): Esri, HERE, Garmin, FAO, NOAA, USGS

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN: Tauranga

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL

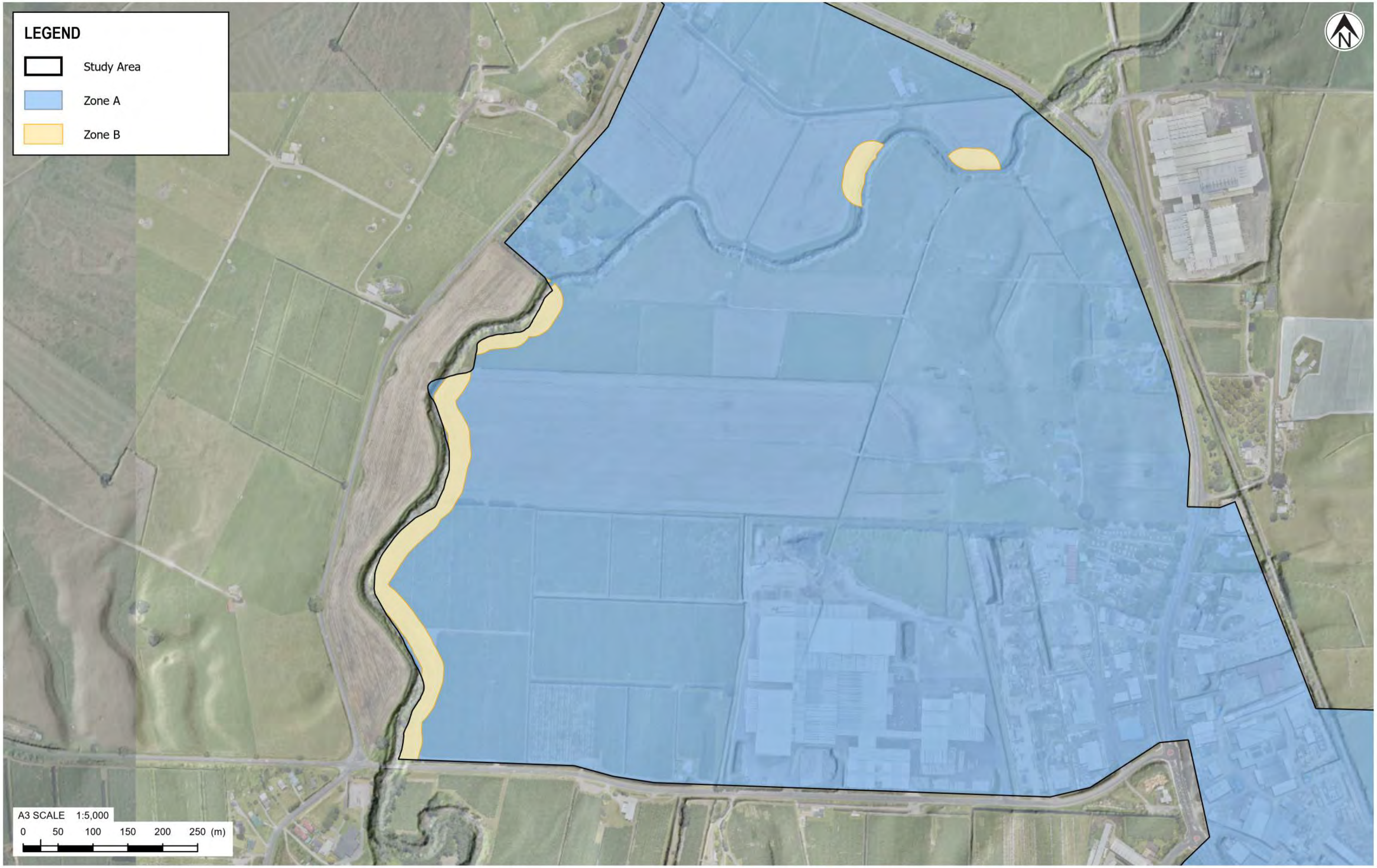
PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS

TITLE SOAKAGE ZONES- OVERVIEW

SCALE (A3) 1:20,000 FIG No. FIGURE B1 REV 0

COPYRIGHT ON THIS FIGURE IS RESERVED DO NOT SCALE FROM THIS FIGURE.

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_Soakage 2022-Jul-20 2:22 pm Drawn by MOLI

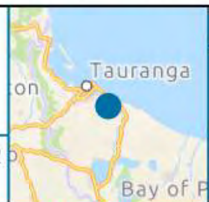


Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22



LOCATION PLAN

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

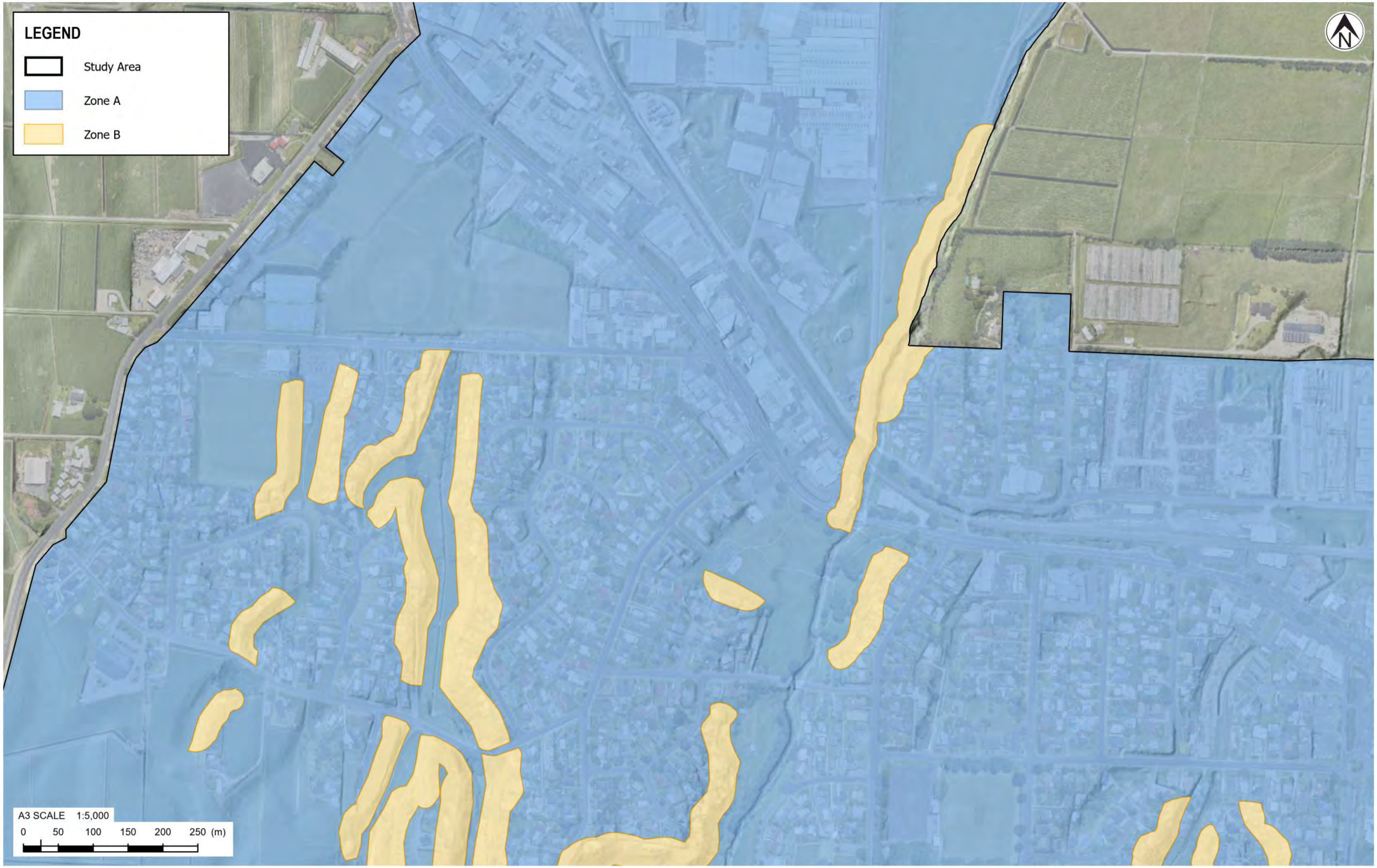
CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL

PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS

TITLE SOAKAGE ZONES

SCALE (A3) 1:5,000 FIG No. FIGURE B2 REV 0

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_Soakage 2022-Jul-20 2:22 pm Drawn by MOLI



Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

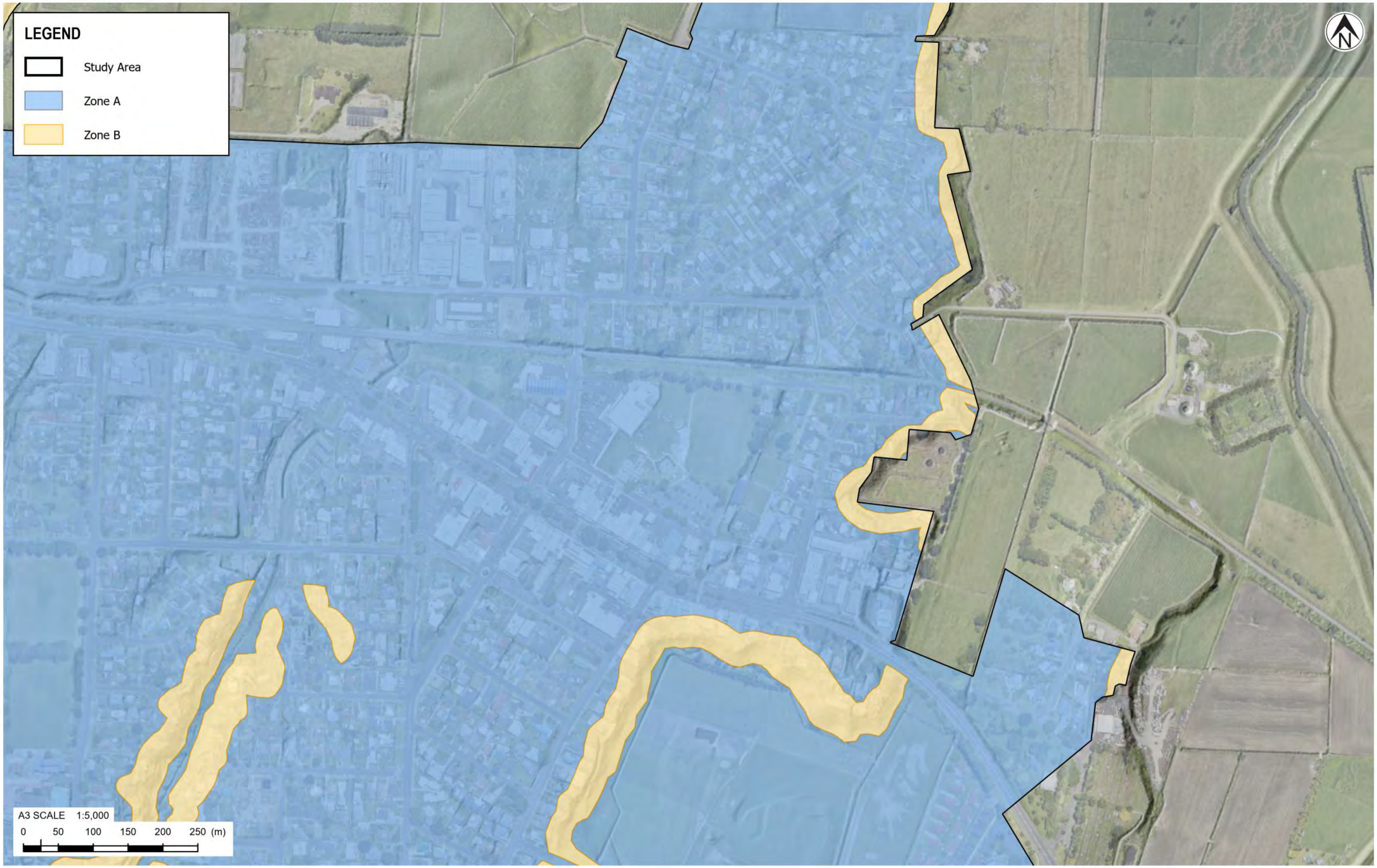
REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS
TITLE SOAKAGE ZONES
SCALE (A3) 1:5,000 FIG No. FIGURE B3 REV 0

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_Soakage 2022-Jul-20 2:52 pm Drawn by MOLI



Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL

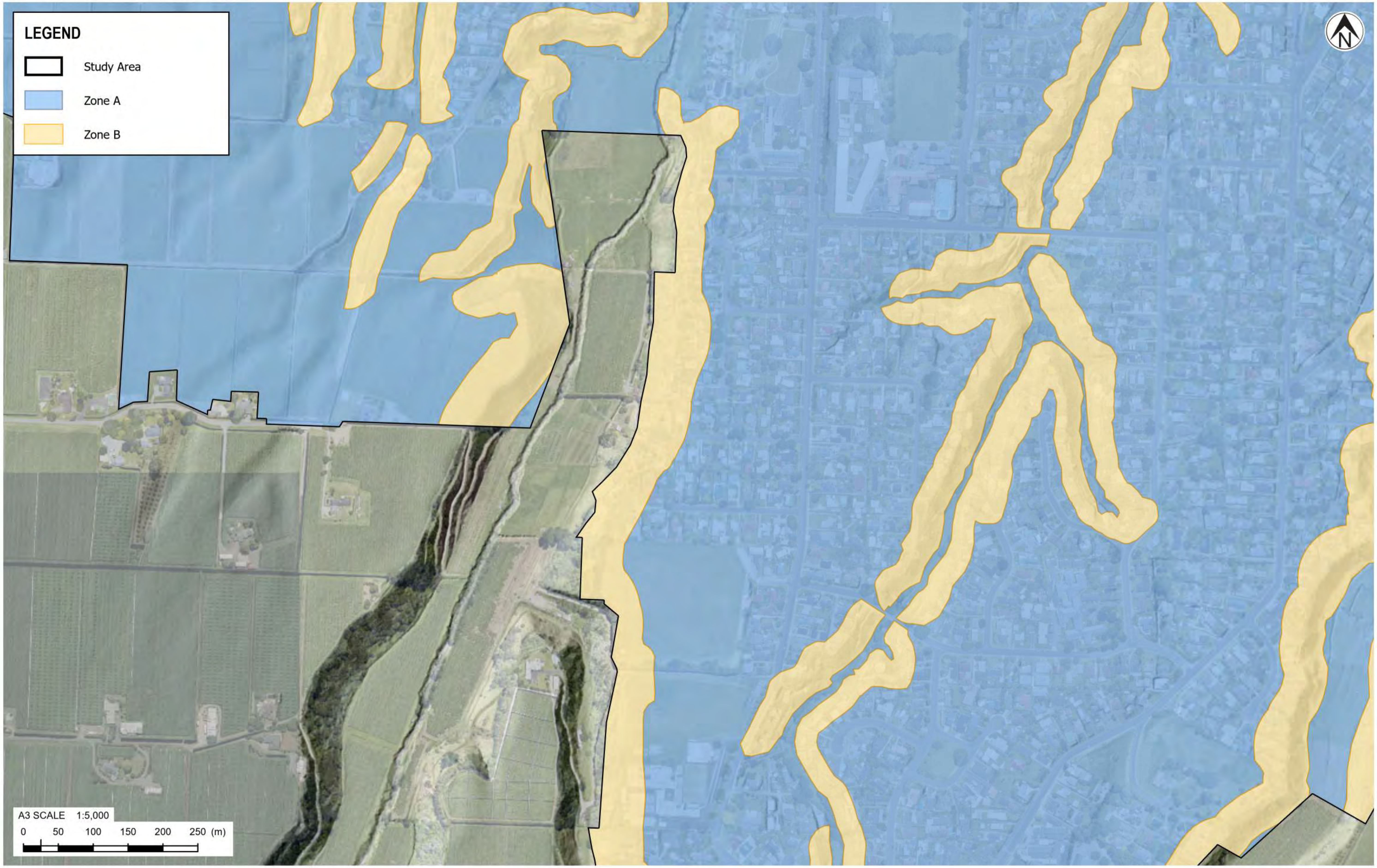
PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS

TITLE SOAKAGE ZONES

SCALE (A3) 1:5,000   FIG No. FIGURE B4   REV 0

COPYRIGHT ON THIS FIGURE IS RESERVED   DO NOT SCALE FROM THIS FIGURE.

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_Soakage 2022-Jul-20 2:52 pm Drawn by MOLI



Tonkin+Taylor

Exceptional thinking together   www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL

PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS

TITLE SOAKAGE ZONES

SCALE (A3) 1:5,000   FIG No. FIGURE B5   REV 0

COPYRIGHT ON THIS FIGURE IS RESERVED DO NOT SCALE FROM THIS FIGURE.

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_Soakage 2022-Jul-20 2:52 pm Drawn by MOLI

Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN: Tauranga, Bay of P

PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

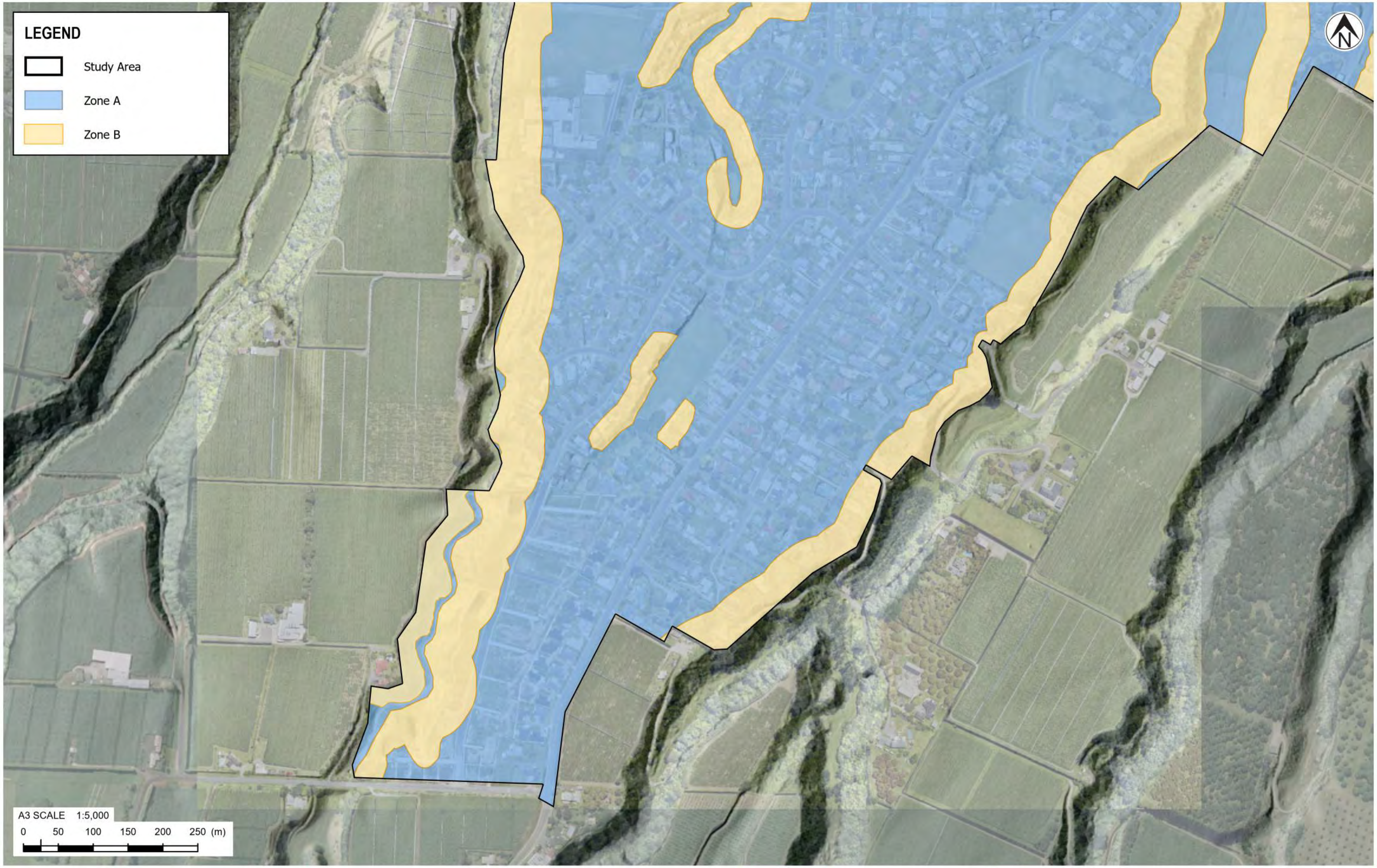
CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL

PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS

TITLE SOAKAGE ZONES

SCALE (A3) 1:5,000 FIG No. FIGURE B6 REV 0

T:\Tauranga\Projects\1020515\WorkingMaterial\GIS\MapDocuments\TePukeSoakage_Figures\TePukeSoakage_Figures.aprx Layout: Appendix_Soakage 2022-Jul-20 2:52 pm Drawn by MOLI



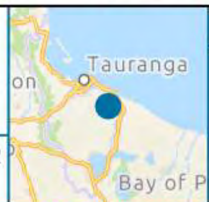
Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
Basemap NZ - Imagery: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	MOLI	JORB	18/07/22

LOCATION PLAN



PROJECT No.	1020515.000	
DESIGNED	MOLI	JUL.22
DRAWN	MOLI	JUL.22
CHECKED	JMB	JUL.22
APPROVED		JUL.22

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL

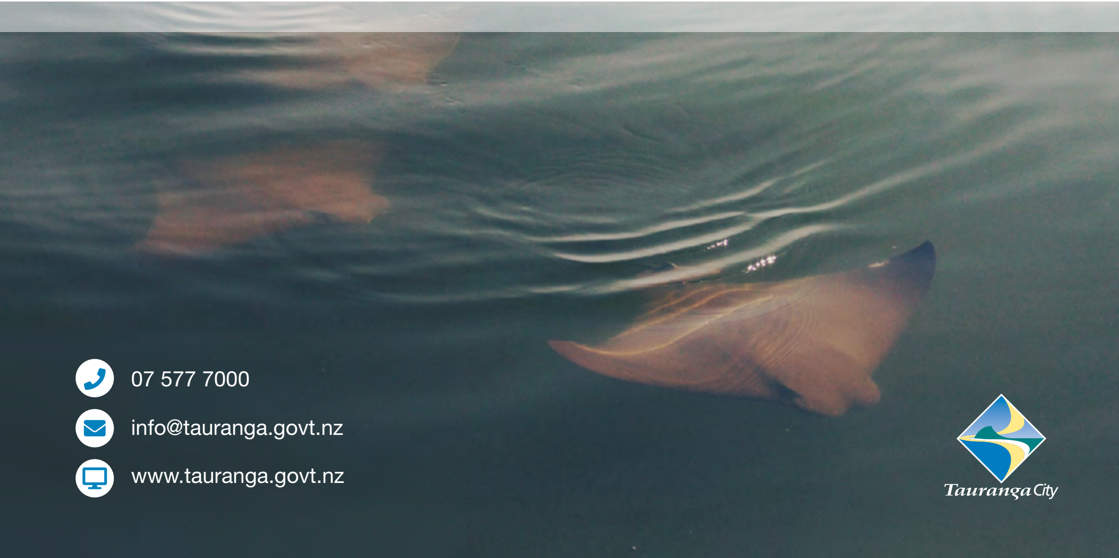
PROJECT TE PUKE STORMWATER GROUND SOAKAGE RECOMMENDATIONS

TITLE SOAKAGE ZONES

SCALE (A3) 1:5,000 FIG No. FIGURE B7 REV 0

Sediment and erosion control guideline

Appendix B



07 577 7000

info@tauranga.govt.nz

www.tauranga.govt.nz

Tauranga City

Contents

Sediment and erosion control guideline

To help you meet the City Plan's sediment and erosion control requirements, we've created this guide so you know how to run an efficient and compliant building site.

If your site has 100m^2 or more of exposed ground, this guide will help you plan your sediment and erosion control in advance and:

Save time, so you can focus on your project, not compliance issues.

Save money, by avoiding fines and costly clean ups.

Save the environment, by keeping soil and sediment out of stormwater drains.

In this guide, you will find information about:

- Why compliance matters.
- Legal obligations.
- Penalties.
- Common activities that may require sediment and erosion control.
- Best practice.

Why compliance matters

Tauranga prides itself on its picturesque harbour, clean beaches and vibrant marine habitat - but this unique environment is being threatened by poorly managed construction activities. Without proper controls in place, sediment and soil run-off enters our stormwater system and ends up in our waterways, polluting and degrading our harbour.

Compliance measures such as the ones outlined in this guide are there to protect our communities and the environment for future generations.

Your legal obligation

Any construction project or development work that creates a nuisance to the public or causes unauthorised discharges to the environment is against the law. This includes dust, noise, litter and any pollution entering the stormwater system, streams and harbour.

Before you start any work onsite, ensure you understand whether you need a resource consent or not. Any activities that are not permitted by the Resource Management Act (RMA) or a rule in the City Plan will require a resource consent before they are carried out.

Even if your project does not require a resource consent, it must comply with the City Plan rules, bylaws (particularly the Stormwater (Pollution Prevention) Bylaw 2015) and the Resource Management Act 1991.

Property owners, developers and contractors are all responsible for knowing what the requirements are and ensuring that they are met.

Penalties

Failure to correctly manage earthworks can result in:

- Infringement fines up to $300.
- Abatement notices.
- Prosecution with fines of up to $600,000.

Common activities that may require the use of sediment and erosion controls

- Erecting a new building or structure or undertaking an extension.
- Undertaking earthworks in conjunction with subdivision – e.g. installing services/infrastructure, driveway formation, retaining walls and formation of building platforms.
- Carrying out earthworks over an area greater than $100m^2$.

Getting things right at the start will save time, money, and stress

A typical construction project will consist of several areas that you can minimise your impact on the environment from sediment and soil run-off. The following pages highlights those areas and what you can do to protect our environment.

Remember - it is your responsibility to ensure that soil is kept on your site, and to ensure that the road is clean.

Failure to do so can result in a fine or prosecution.

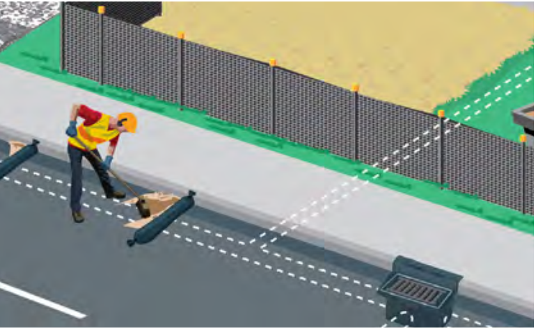
Use best practice to protect the environment and your project

Key to site diagram

1. Minimise exposed areas
2. Manage stockpiles
3. Clean water diversion
4. Connect to the stormwater system as soon as the roof is complete
5. Stabilise construction entranceway
6. Silt fences
7. Drain/catchpit protection
8. Earth bunds retain soil and prevent run-off
9. Maintenance and inspections


WASH AREA
BUND
NON BIO WASTE
CEMENT WASTE
GREEN WASTE

1 Minimize exposed areas



How?

- Retain as much vegetation cover as possible.
- Do your work in stages.
- Use mulch, hay, pea straw or other material to cover exposed areas.
- Keep a berm of grass around the outside of the site to keep hold of water and allow another layer of filtration.
- Revegetate exposed areas as rapidly as possible.

Why?

- Uncovered areas can be easily eroded.
- The less soil that is exposed, the less that can be washed away.

How?

- Cover stockpiles with mulch, straw or a tarpaulin as soon as practicable to prevent soil loss.
- Soil and other materials should be stockpiled away from kerbs and areas where run-off may enter the stormwater system or drains.
- Use a silt fence around a stockpile or on the downhill side of the stockpile to contain sediment.
- Avoid locating a stockpile in a low-lying area which may form part of the natural drainage pattern of the site.

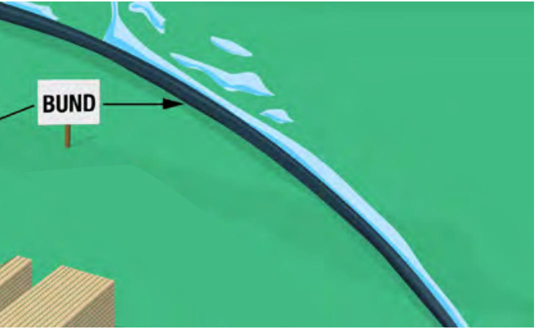
Why?

- Exposing soil stockpiles to rainfall can result in surface run-off.
- Uncovered soil can be blown off the site.

Maintenance

- Check after each rainfall event.

3 Clean water diversion



How?

- Create a diversion channel or contour drain above the earthworks on the site so clean water does not enter the work area.
- Ensure sediment-laden water from the works area is channelled to an appropriate area where it can be retained onsite.

Why?

- Left unmanaged, dirty water will contaminate clean water and increase the amount of treatment control devices required to prevent sediment leaving the site.
- Divert clean rainwater away from your exposed worksite to prevent it from dislodging sediment.
- Prevent diverted water from adversely affecting neighbouring properties or public areas.

Maintenance

- Ensure diversion channels and bunds have not been eroded by rainfall.
- Remove accumulated sediment from retention area.

How?

- Use temporary downpipes once you have installed your roof and gutters.
- Alternatively, non-erosive, temporary ground cover shall be placed under downpipes to prevent splash erosion and divert water to turfed areas on the site.

Why?

- Installing drainage early enables you to remove clean water from your site – keeping clean water clean.
- Reduces the amount of water requiring treatment.

Maintenance

- Regularly check that the temporary downpipes are securely fastened before and after rainfall events.

5 Stabilise construction entranceway

How?

- A minimum entranceway should:
    - have a 150mm thick layer of 65-100mm aggregate
    - be long enough for your site with “wings” (to allow for vehicles cutting corners)
    - be 4m minimum width, with 1.5m wide “wings” on either side to cater for larger delivery vehicles
- Use large washed aggregate.
- Do not use materials such as sand, crushed concrete or asphalt to make your entranceway as they are not effective.

Why?

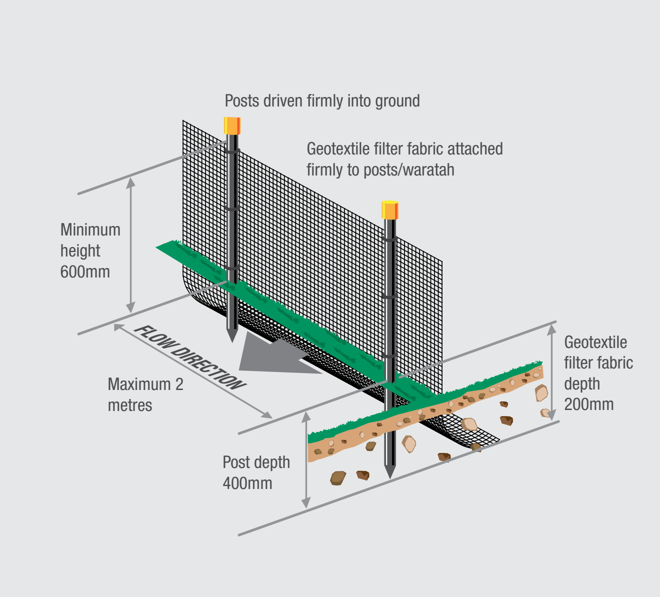
- A stabilised entrance way will enable vehicles to be kept off exposed soil and clay.
- A stabilised entrance way is required to prevent vehicles tracking mud and clay onto the road (which is a common source of complaints to Council).
- Soil and contaminants can be washed directly off your site onto the road making it slippery and dangerous. They can then enter the stormwater system by rain or create a dust nuisance in dry weather.

Maintenance

- Inspect weekly and after each rainfall event.
- Maintain the stabilised driveway to prevent sediment from leaving the construction site.
- Remove sediments from sealed pavements by sweeping. Do not use a water truck to wash the road as this will wash any sediment into the stormwater system.
- Soil or other aggregate material should be swept back onto the site and not onto the road.

6

Silt fences



How?

- Correct installation of a silt fence is critical to its performance. To be effective a silt fence needs to:
  - be installed in a trench 200mm deep by 100mm wide.
  - have waratahs or posts hammer-staked at least 400mm deep on the downhill side of the fabric, no more than 2m apart.
  - be 600mm high above the ground, with an additional 200mm of cloth below ground in the trench.
  - have each end of the fence return up the slope by roughly 2m to prevent water going around the edges.

- be anchored by backfilling the trench and placing soil on top of the fabric.
- it is recommended that woven 100-micron geotextile cloth is used.
- weedmat and other materials (including tarpaulins) do not work properly as silt fences and should not be used.

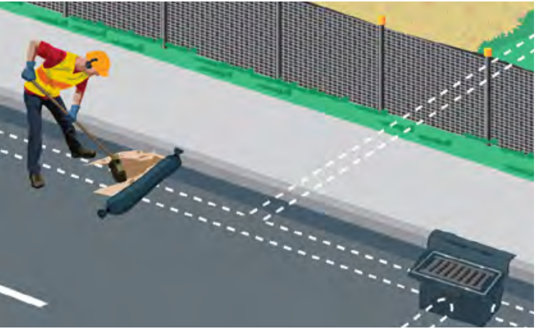
Why?

- A silt fence is a temporary barrier used to intercept dirty water and retain sediment on site.
- A silt fence is installed around the downhill side of your site to contain sediment – to ensure that when rainfall events occur, muddy water stays behind the fence.
- Silt fences should be used for containing stockpiles of earth or other areas of disturbed soil or clay on your site.

Maintenance

- Inspect silt fences at least once a week and after a rain event. Fences should also be checked for wind damage.
- Remove accumulated sediment to a secure area when it reaches 50% of the fabric height. This will reduce pressure and allow for adequate sediment storage.
- Check the integrity of the fence to confirm effectiveness - replace or reinstate where required.
- A silt fence should remain in place until the site is stabilised or the exposed area is less than $100m^2$.
- Where water ponds behind the fence, extra support should be provided.

Drain/catchpit protection



How?

When installing catchpit controls:

- Protection measures should be installed before works start.
- Ensure the filter cloth covers the extent of the grate and the inlet at the back.
- Install a series of sand socks in the kerb and channel before the catchpit to intercept the stormwater – this will slow the velocity of the water allowing more sediment to settle out of the water.
- Remember to remove the filter cloth after you have completed your project.

Why?

- Catchpit/drain protection measures are placed within or around stormwater inlets to intercept sediment-laden run-off before it enters the Council's stormwater system.
- Drain or catchpit protection should only be considered as your secondary protection and is designed to assist your primary site controls such as a bund or silt fence.

Maintenance

- Ensure that your catchpit protection remains effective by checking it once a week and following large rain events.

Drain/catchpit protection should not be used as your only means of control. Talk to your compliance officer about what option would best suit your site.

How?

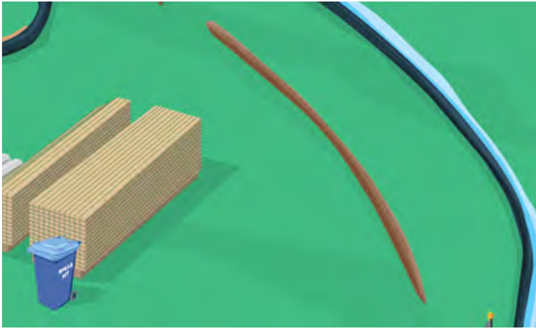
- Construct a compacted earth bund around the outer edges of your site.
- Construct a bund through compacting clay or topsoil and cover them with geotextile cloth.

Why?

- Earth bunds will divert clean rainwater from the exposed works and provide a barrier for the retention of dirty water allowing sediment to settle out.

Maintenance

- Earth bunds need to be checked regularly throughout the build to ensure they are still providing an effective barrier.
- Soil needs to be recompacted to provide an effective barrier should damage occur.



9 Maintenance and inspections

- Regularly check and systematically carry out audits to ensure the controls onsite are maintained to the appropriate standard.
- Be ready to alter your site controls as the site or conditions change.
- Create a checklist to ensure all appropriate measures are in place on the site.
- Continue to educate staff and share ideas on how to maintain sediment and erosion controls on your site.
- Work as a team to get it right and take pride in doing your part in protecting our environment and region.

Best practice sediment control

A sediment fence that has worked on a steep site. The fence has contained the water, providing enough time for the sediment to settle before the water leaves the site. This fence will need to be checked and cleared out prior to the next rain event.

Even on relatively flat sites, inadequate sediment controls can result in drains blocking and not working effectively during heavy rain. This can cause localised flooding.

Best practice sediment control

The site manager has installed a sediment fence at the lowest point of the site. Note the sediment-laden water is contained.

Without proper controls, sediment can leave the site and be deposited on the road. This can make its way to waterways, affecting fish and other aquatic life in Tauranga's harbour and streams.

Best practice sediment control

A builder has installed a sediment fence around the site, reducing the likelihood of sediment leaving the site.

A stabilised entrance to the site would have prevented sediment from covering the footpath, curb and channel. Any cost to ratepayers for cleanup will be recovered from the party responsible.

07 577 7000

info@tauranga.govt.nz

www.tauranga.govt.nz

Tauranga City

Memorandum

To:	Phillip Martelli, Resource Management Manager
Copy:	
From:	Coral-Lee Ertel, Asset and Capital Works Manager
Date:	13 July 2022
Subject	**Te Puke Intensification Infrastructure Report**

The following memo summarises key information and reports used in reviewing infrastructure requirements for intensification in Te Puke.

<u>Water</u>

Council engaged Aurecon to undertake a water modelling study to identify any potential issues in the existing water network, that would result from intensification (refer to *Te puke Intensification – Water Supply Modelling*). The modelling exercise identified several minor issues in the water supply network, however many of these issues have already been identified in Council's structure plan and/or Long-Term Plan and are currently being addressed. To summarise, the following issues were identified:

- Insufficient bore supply – currently being addressed through the development of new bores.
- Increased strain on the water network in the No 3 Road and Seddon Street areas – existing network upgrades are planned to address.
- Network issues within the middle of the gravity zone in Te Puke (around Hookey Drive) – existing issue currently being addressed through network adjustments.
- An increase of reservoir storage, in time, to maintain current performance measures. – the Long term Plan includes for extra storage.

Based on the modelling exercise undertaken and the planned identified upgrades, Council's infrastructure staff are comfortable that with the planned upgrades, the water network has sufficient capacity to cater for intensification as outlined in the document *Te Puke Yield –Existing and Potential Greenfield'.*

<u>Wastewater</u>

Council engaged Aurecon to undertake a wastewater modelling study to identify any potential issues in the existing wastewater network as a result of intensification. Aurecon utilised Council's existing wastewater model for Te Puke, which was developed by Mott

Macdonald. A copy of the modelling report is included as an attachment to this memo '*Te Puke Intensification Wastewater Modelling – June 2022'.* The modelling used the '*Te Puke Yield –Existing and Potential Greenfield'* document to review the future yield of Te Puke and estimate the total wastewater generation and impact on Council's network. It looked at both intensification scenarios and full development of all Greenfields sites (combined).

This information was used to identify areas within the network that would spill or result in large overflows following intensification in Te Puke (due to capacity). A list of infrastructure upgrades has been included in the Structure Plan based on this assessment. Planned upgrades are shown on plan '*Te Puke Intensification upgrades plan June 2022'.* A focus was put on undersized infrastructure as a result of intensification and/or development of greenfield areas.

It is proposed a 40%/60% rates/financial contribution split be applied to all wastewater upgrades. This split is based on the age of the infrastructure (approximately halfway through its life) and cost to upgrade to a larger size. Overall, a total of $1.7M of wastewater upgrades have been added to Council's structure plan schedule for Te Puke over a 30-year period.

It should be noted that this modelling exercise has been undertaken on an uncalibrated wastewater model. Council is currently undertaking network monitoring to calibrate the model later in the 2022 year. The intensification scenario should be re-run through the model once calibrated and upgrades identified in the structure plan reviewed.

Council is currently undertaking a significant upgrade of the Te Puke wastewater treatment plant (WWTP). Council engineering staff reviewed the capacity of the upgrade to ensure the future planned yield (as summarised in '*Te Puke Yield –Existing and Potential Greenfield')* could be catered for by the WWTP. Any further intensification beyond what has been outlined will need to be reviewed as it is likely it will impact the future capacity of the wastewater treatment plant.

Stormwater

In 2015 Council engaged Opus International to develop a stormwater model for the Te Puke area. The model identified flood prone areas for the 2%AEP and undersized infrastructure. It assessed an existing impervious area for developed Te Puke to be 50%. From the modelling results it can be seen that a significant amount of Councils stormwater infrastructure does not have capacity to cater for the 5-year return period (Councils levels of service for the piped network). This is typical of stormwater networks around the country due to changing design standards as a result of climate change. To upgrade the stormwater network to meet this standard is cost prohibitive.

Bay of Plenty Regional Councils Rivers and Drainage team (BOPRC-RAD), manage a drainage scheme directly downstream from Te Puke. A significant portion of Te Pukes stormwater network drains into this scheme. There is concern that increased intensification within Te Puke will result increased flooding within the BOPRC-RAD area. Increased stormwater runoff from intensification within Te Puke will therefore need to be carefully managed to ensure no downstream properties are impacted.

To enable further development of Te Puke without having a negative impact on existing stormwater infrastructure or impact on downstream properties, Council is proposing to use several alternative stormwater management methods. These include:

- Limiting impervious areas within stormwater areas (existing developed areas) where intensification occurs to 50%. This will ensure existing issues are not made worse due to further development.
- Where the 50% impervious areas limit can not be achieved, require developments to manage increased stormwater onsite using rain tanks etc. Impermeable pavement will also be encouraged.
- Encourage onsite soakage where appropriate. This will best mimic the current environment and will ensure no further strain is put onto the existing stormwater network.

Council engaged Tonkin & Taylor to undertake a review of stormwater ponds required within Te Puke Area 3, considering current comprehensive development is underway. As a result, the structure plan schedule has been reviewed and the number of ponds rationalised. Council has a comprehensive stormwater consent for Te Puke and all development should ensure they comply with the conditions in this consent.

Te Puke Stormwater Modelling Report

Project No. 44801858

15 August 2022

Prepared for Western Bay of Plenty District Council

The expert in **WATER ENVIRONMENTS**

Te Puke Stormwater Modelling Report

Project No. 44801858

Prepared for: Western Bay of Plenty District Council
Represented by Mr Nik Kumar

Contact person:	Greg Whyte, gmw@dhigroup.com, +64 21 273 4464
Project Manager:	Greg Whyte
Quality Supervisor:	Antoinette Tan
Author:	Greg Whyte
Project No.:	44801858
Approved by:	Antoinette Tan
Approval date:	15 August 2022
Revision:	FINAL 1.0
Classification:	**Restricted:** This document may be shared within DHI whereas sharing it outside the DHI Group entities is subject to the client's prior approval.
File name:	44801858_Report.docx

DHI Water & Environment Ltd • B:HIVE, Smales Farm • 74 Taharoto Road • 0622 Takapuna, Auckland • New Zealand
Telephone: +64 9 912 9638 • lap@dhigroup.com • www.dhigroup.com

Contents

1 Introduction

DHI was engaged by Western Bay of Plenty District Council (WBoPDC) to use the 2019 Te Puke model to simulate some future development scenarios. The scope of the work is detailed in the DHI proposal 44801858, dated 26th April 2022. Key points from the modelling are:

- Existing development scenario represents the year 2019. Which is referred to as the 2019 model.
- Maximum Probable Development (MPD) scenario is 70% imperviousness for existing residential with no change in imperviousness for any Greenfield development (any development in these areas will need to mitigate any increases in runoff)
- Future Intensification (Plan Change 2021/22) scenario is also 70% imperviousness for existing residential with no change in imperviousness for any Greenfield development (any development in these areas will need to mitigate any increases in runoff). Please note that there is a different extent for this scenario compared to the MPD scenario, which includes the Washer Road Industrial Zone and Seddon Street Medium Density Residential Zone
- DHI subcontracted Peter West to use the Non Linear Reservoir (NLR), rainfall-runoff model, to generate the climate change inflows
- The existing MOU between WBoPDC and Bay of Plenty Regional Council (BoPRC) allows the 2019 model to be used
- WBoPDC will use results from this modelling exercise to:
  - Update their website (including the online natural hazard maps).
  - Refer to in Land Information Memoranda (LIMs).
  - Process resource consents and building consents (including the use of flood levels to set minimum floor levels).
  - Support / inform changes to the District Plan for Te Puke (including for existing and new areas of development).

2 Scenarios

Twelve scenarios have been modelled as described in Table 1. The scenarios differ in the level of development which varies the land use and imperviousness within the catchment. The design rainfall varies between scenarios from 2% to 0.2 % AEP, with a constant sea level rise of 1.25m. Figure 1 to Figure 3, shows the extent of the development scenarios.

Scenarios 1-3 are the 2019 model setup from the previous study, /1/ DHI 2021, but have been rerun with climate change adjusted rainfall and a sea level rise of 1.25 metres. Also the surface roughness was modified as described in Section 3.2.4.

Scenarios 4-6 have the same rainfall and sea level rise allowances applied as for Scenarios 1-3, but have a larger extent of “developed” area as shown in Figure 1. These scenarios have a 70% impervious area applied for the residential areas and 90% impervious for the industrial/commercial areas.

Scenarios 7-9 are very similar to scenarios 4-6 in all ways apart from they have a very slightly larger potential “developed” area as shown in Figure 2.

Scenario 10 is very similar to scenario 8 in all ways except it has a 50% impervious area applied for the residential area rather than 70% impervious. This event is using the climate change adjusted 1% AEP design rainfall.

Scenarios 11-12 have a modified development extent as shown in Figure 3 and have a 50% impervious applied to the residential area or 70% impervious applied, respectively. Both events are using the climate change adjusted 1% AEP design rainfall.

Table 1 - Scenarios Modelled

No.	Development Scenario	Design Rainfall	Imperviousness (%)	Sea Level Rise (m)
1	Existing	2% AEP 2130 RCP 8.5	2019 Model Setup	1.25
2	Existing	1% AEP 2130 RCP 8.5	2019 Model Setup	1.25
3	Existing	0.2% AEP 2130 RCP 8.5	2019 Model Setup	1.25
4	Maximum Probable Development	2% AEP 2130 RCP 8.5	70 Residential /90 Industrial/Commercial	1.25
5	Maximum Probable Development	1% AEP 2130 RCP 8.5	70 Residential /90 Industrial/Commercial	1.25
6	Maximum Probable Development	0.2% AEP 2130 RCP 8.5	70 Residential /90 Industrial/Commercial	1.25

No.	Development Scenario	Design Rainfall	Imperviousness (%)	Sea Level Rise (m)
7	Future Intensification (Plan Change 2021/22)	2% AEP 2130 RCP 8.5	70 Residential /90 Industrial/Commercial	1.25
8	Future Intensification (Plan Change 2021/22)	1% AEP 2130 RCP 8.5	70 Residential /90 Industrial/Commercial	1.25
9	Future Intensification (Plan Change 2021/22)	0.2% AEP 2130 RCP 8.5	70 Residential /90 Industrial/Commercial	1.25
10	Future Intensification (Plan Change 2021/22)	1% AEP 2130 RCP 8.5	50 Residential /90 Industrial/Commercial	1.25
11	Alternative 1 Development (50% Imp)	1% AEP 2130 RCP 8.5	50 Residential /90 Industrial/Commercial	1.25
12	Alternative 1 Development (70% Imp)	1% AEP 2130 RCP 8.5	70 Residential /90 Industrial/Commercial	1.25

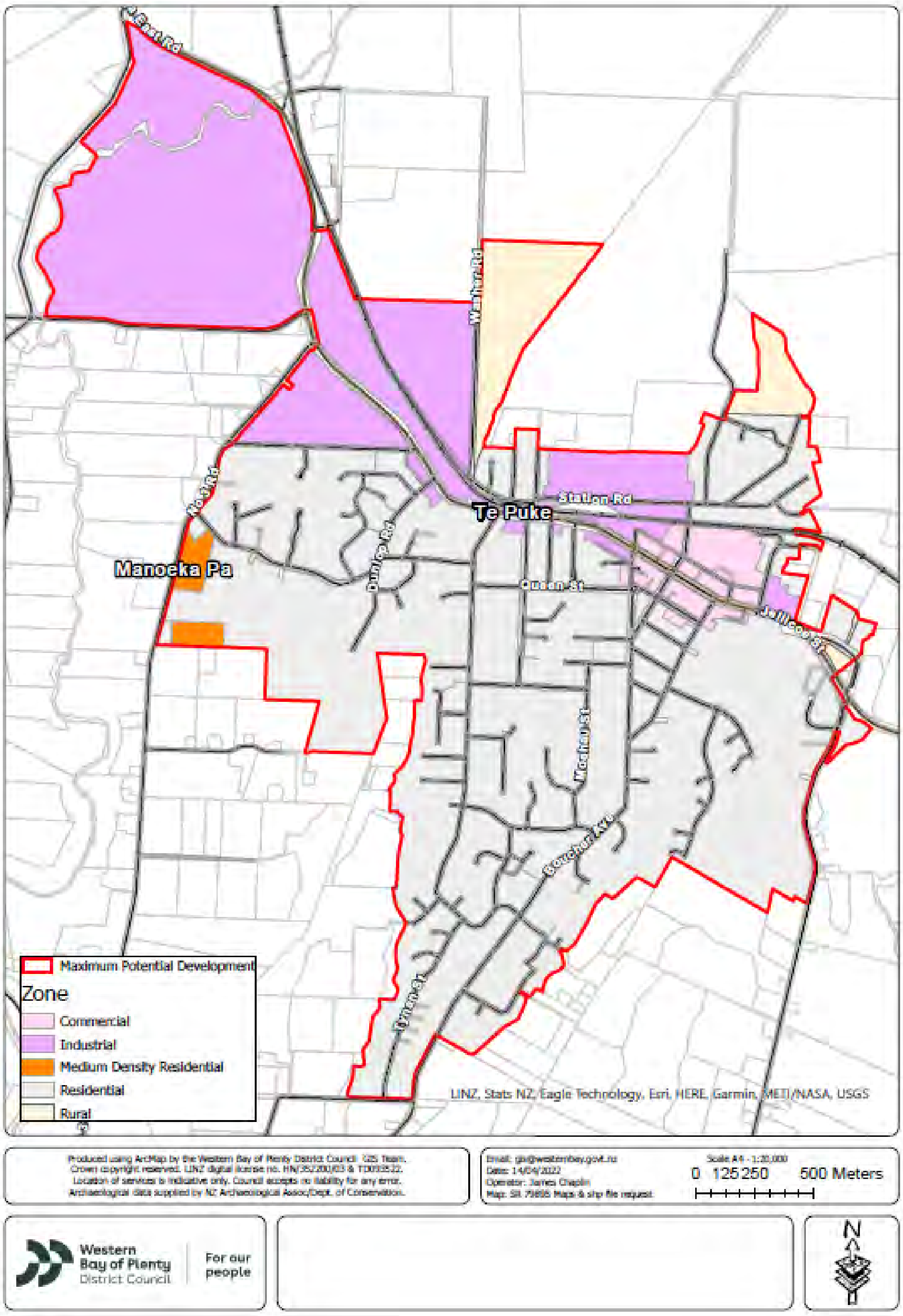


Figure 1 – MPDv3 supplied by WBoPDC

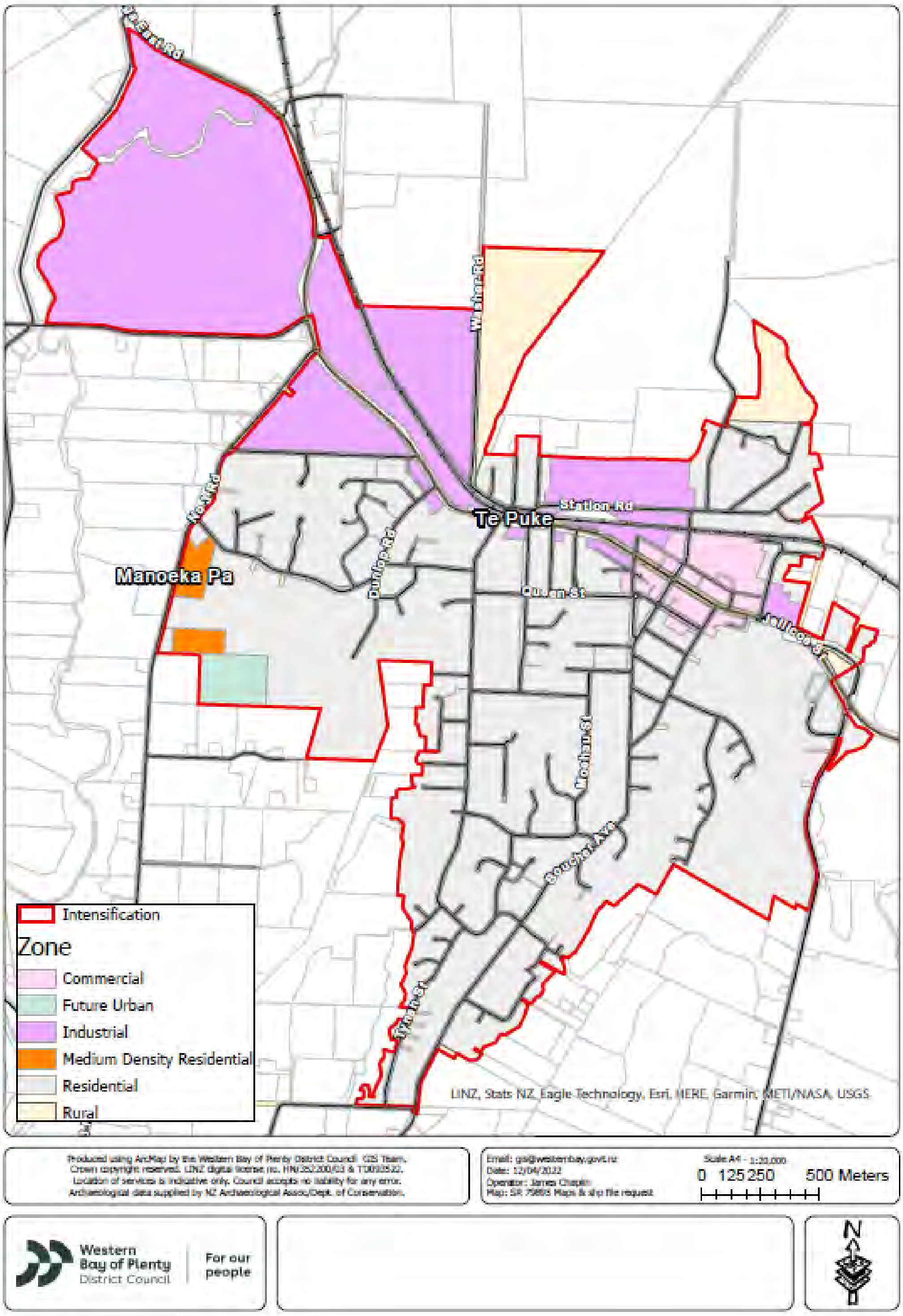


Figure 2 – Intensification map v2 supplied by WBoPDC

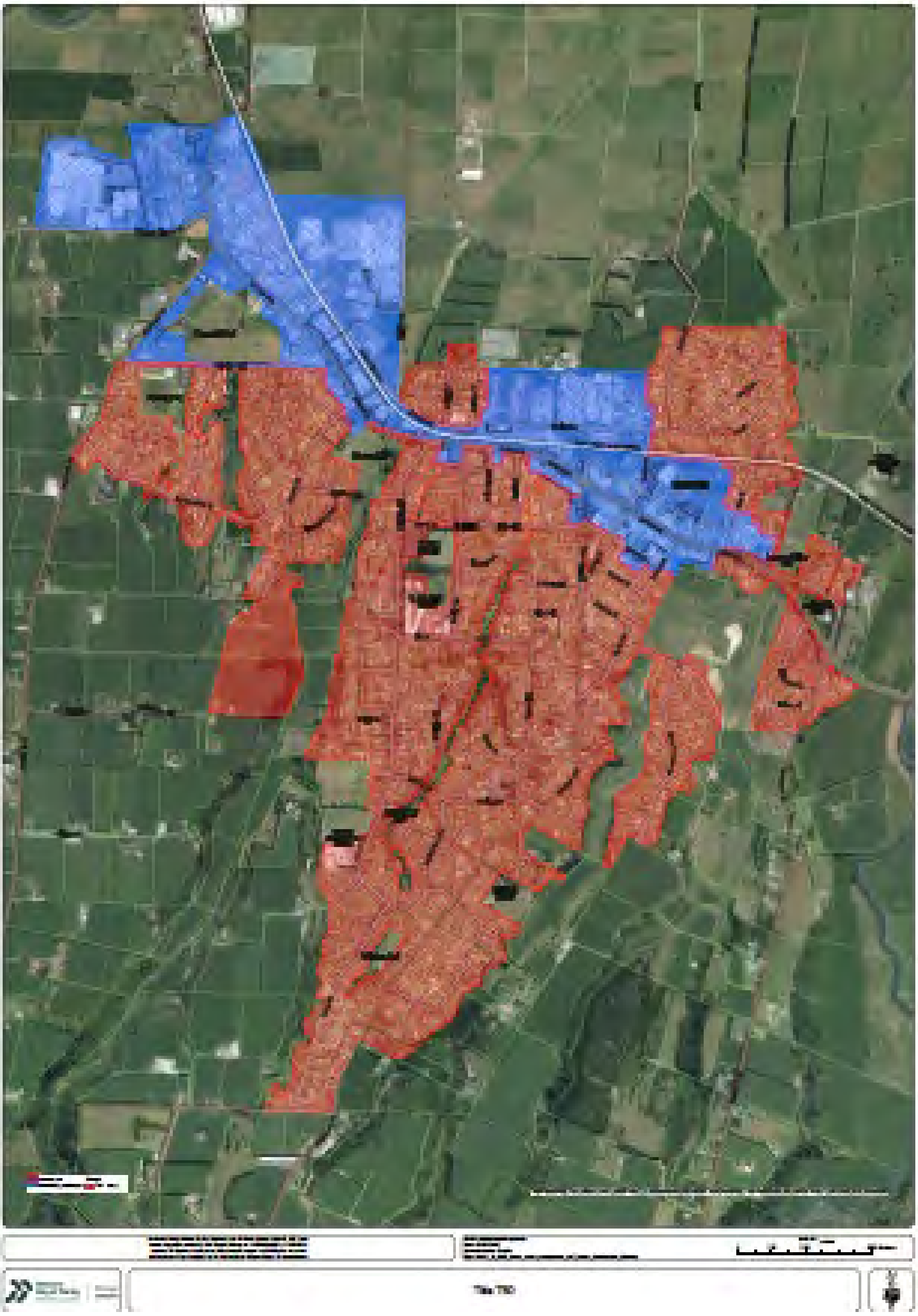


Figure 3 – Alternative 1 development scenario supplied by WBoPDC

3 Methodology

3.1 Previous Modelling

DHI previously completed a study for BoPRC and WBoPDC to build a flood model focussing on the Te Puke township and downstream floodplain. The purpose of the modelling was to assess the impact of development in the catchment over the last 20 years, to assess the effectiveness of the Kaituna flood scheme built pre 1999 and to have a model capable of assessing flood mitigation options completed at a later stage.

The model (known as the 2019 model) was created using the MIKE FLOOD software. The model setup was derived from previous model setups of the Kaituna River catchment, pipe and manhole asset data and LiDAR (2018 and 2011) survey. This model was calibrated to the June 2014 flood event and was found to match well where validation data was available.

Input rainfall and runoff were all derived by Blue Duck Consulting, using a Non Linear Reservoir (NLR) rainfall-runoff model that has been used as inputs to other hydraulic models of the Kaituna River catchment. Three different sized storm events were modelled the 1%, 10% and 20% AEP, with three storm shapes used; Te Puke centred, Mangorewa centred and a heavy-ended storm (Te Puke centred). The design events allowed for analysing the various levels of service required in the area and the impacts of different storm shapes on the local flood hazard. The heavy-ended storm shape proved to be the most critical of the three storm events modelled, and it is a recommendation to consider using this in future modelling.

A comprehensive modelling report was produced for this work, and the reader should refer to this report for further details, /1/ DHI 2021

3.2 Current Study

The 2019 model was modified for this study to extend the area that has rain on mesh hydrology applied. Other changes included land use, imperviousness, roughness, runoff inflow boundaries, and rain on mesh design rainfall (the last two provided by Blue Duck Consulting). Each of these changes to the 2019 model is detailed below:

3.2.1 Rain on Grid Extension

Part of the current catchment within the NLR rainfall runoff model was converted to using rain on grid hydrology so we could understand flood extents for the existing development scenario and other development scenarios, see Figure 4. The runoff inflow boundary at this location was removed from the model so as to not double count any runoff.

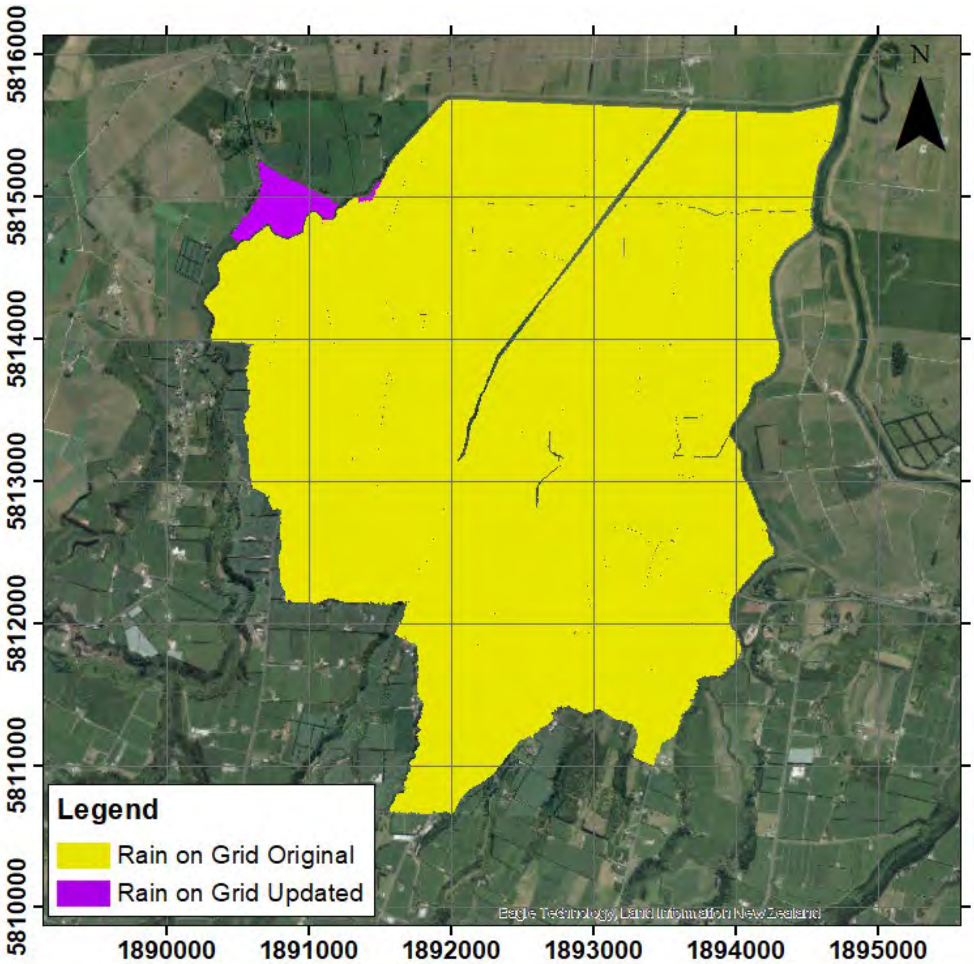


Figure 4 - Rain on Grid Extension

3.2.2 Land Use Changes

Land use and associated soil types are used in the model to apply varying infiltration as detailed in /1/ DHI 2021, Section 3.2.4.

The Land Resource Information Systems Portal (LRIS) gives access to the New Zealand Land Cover Database (LCDB). For the 2019 Te Puke model, soil types fall into three main drainage types, Very well Drained, Poorly Drained and Very Poorly Drained. Each soil type has an associated leakage rate calibrated for the 2019 model. See Leakage Rates and distribution in Appendix A, Figure 5 to Figure 10.

3.2.3 Imperviousness Changes

Imperviousness within the model is also accounted for, so the right balance of infiltration and runoff occurs during a rainfall event. It was assumed in the previous study, /1/ DHI 2021, and the 2019 model that all roads were entirely impervious, the residential areas were 50% impervious, and the industrial areas were 90% impervious. Where an area was impervious, the leakage rates were scaled, i.e. for the residential areas; the leakage rates were reduced by 50%. The scaling was done in-lieu, including individual detail of driveways, grassed/vegetated areas and roof areas.

3.2.4 Roughness

The roughness of the land surface is represented in the 2D part of the model and has been simplified compared to the 2019 model setup. The 2019 model setup has a detailed roughness definition with property level information represented. The new areas to be developed do not have this level of detail, so we needed to simplify how the roughness is characterised so we can compare between scenarios. The roughness is assigned based on land use in combination with the impervious percentages.

Figure 11 to Figure 15, in Appendix B, show the different roughness applied for each development scenario.

3.2.5 Runoff Inflow Boundaries & Rain on Grid Design Rainfall

Blue Duck Consulting have provided all required runoff inflow boundaries for the "Heavy Ended" design storm shape for the 2%, 1% and 0.2% AEP events. These design storm scenarios include increased rainfall intensities from 3.68 degrees of atmospheric warming (the year 2130 RCP 8.5) applied per NIWA's 2018 HIRDS v4 guidelines. Rain on grid design rainfall was also provided for the same events with the same allowance for atmospheric warming used.

The most upstream point of the Kaituna River in the 2019 model is at Te Matai bridge, where a synthetic hydrograph is applied. This is detailed in /1/ DHI 2021, Section 3.2.3. For this study, we have used the 100-year synthetic hydrograph for all model simulations. This synthetic hydrograph was produced for the previous study, /1/ DHI 2021, by Blue Duck Consulting.

4 Results

All twelve scenarios have been modelled, and results have been provided to WBoPDC. Results have been post-processed for maximum water level, depth, velocity and duration of inundation, provided as raster files in several geodatabases. Results contain full maximum results and a filtered version with 50 millimetres of water depth removed. The basis of removing 50 millimetres of depth is that a 50-millimetre depth is only a minor nuisance and not flooding of any significance. Also very shallow flood water could be regarded as outside the accuracy of the model.

1D and 2D model result files have also been provided.

A number of water level difference maps have been generated to compare the results between scenarios. Difference maps are a very good way to understand the impact of different scenarios on water levels. Nine key difference maps are included in Appendix C, Figure 16 - Figure 24, with a summary at selected locations in Table 2 to Table 4. These are the same reporting locations as for the previous study, /1/ DHI 2021, and Figure 5 below is a copy of Figure 5.2 from that study. It should be noted that a positive value in Table 2 to Table 4 means an increase in water level and a negative value mean a decreased in water level when compared to the existing 2019 base scenario.

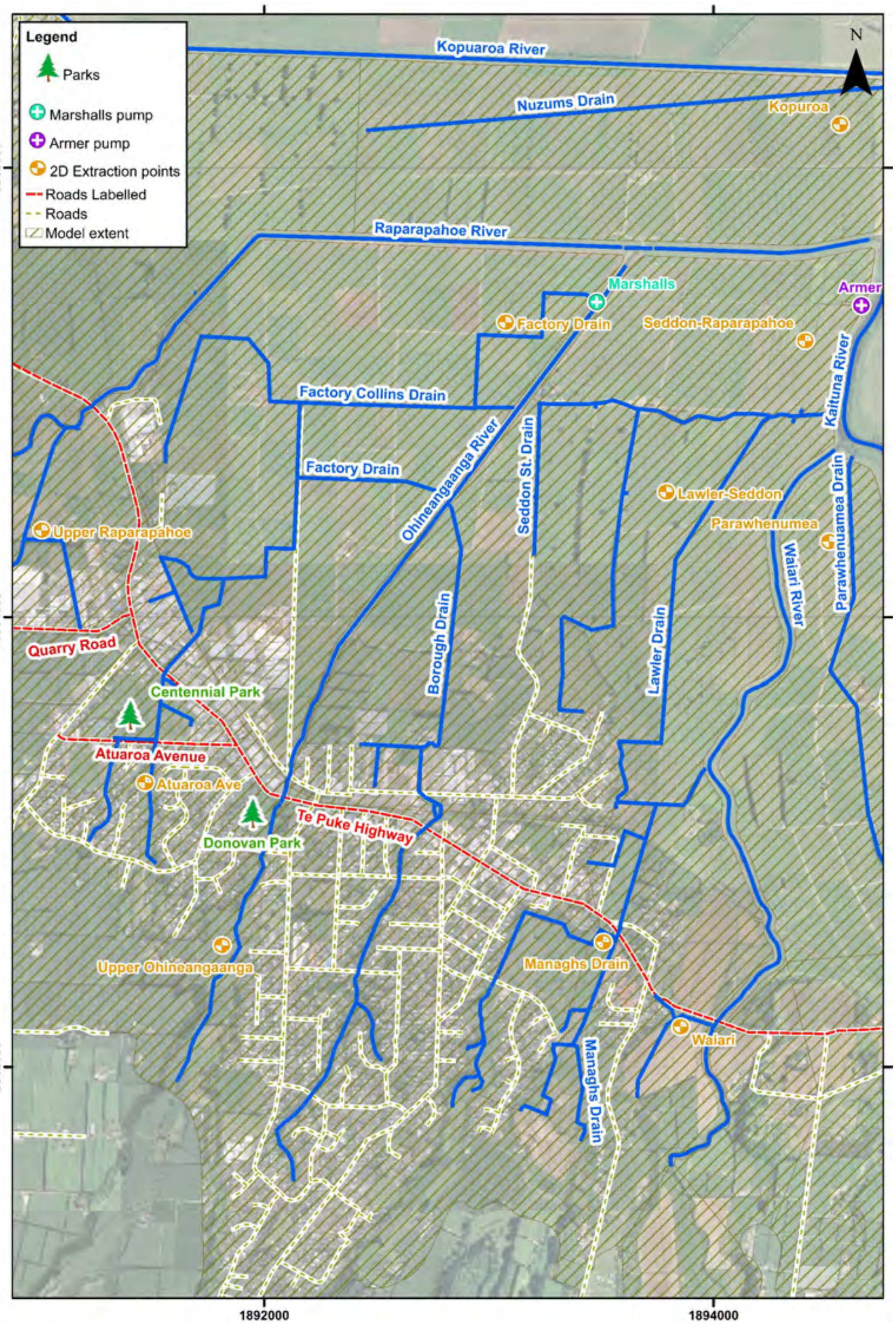


Figure 5 – Copy of Figure 5.2 from /1/ DHI 2021, showing selected 2D results extraction locations

Table 2 – Water Level Difference Summary for 2% AEP 2130 RCP 8.5

Water Level Difference to Existing (mm)		2% AEP 2130 RCP 8.5	
ID	Location	Maximum Probable Development	Future Intensification (Plan Change 2021/22)
0	Kopuaroa	3	3
1	Seddon-Raparapahoe	21	21
2	Factory Drain	54	57
3	Lawler-Seddon	11	11
4	Upper Raparapahoe	133	133
5	Upper Ohineangaanga	17	16
6	Managh's Drain	0	0
7	Waiari	9	9
8	Parawhenumea	1	1
9	Atuaroa Ave	48	58

Table 3 - Water Level Difference Summary for 1% AEP 2130 RCP 8.5

Water Level Difference to Existing (mm)		1% AEP 2130 RCP 8.5				
ID	Location	Maximum Probable Development	Future Intensification (Plan Change 2021/22)	Future Intensification Alternative 1	Alternative 1 Development (50% Imp)	Alternative 2 Development (70% Imp)
0	Kopuaroa	6	6	6	2	3
1	Seddon-Raparapahoe	28	28	3	-9	8
2	Factory Drain	47	50	36	20	26
3	Lawler-Seddon	13	13	1	-4	4
4	Upper Raparapahoe	144	143	143	1	1
5	Upper Ohineangaanga	29	27	23	2	4
6	Managh's Drain	0	0	0	0	0
7	Waiari	3	3	-4	4	7
8	Parawhenumea	0	0	-1	-2	-1
9	Atuaroa Ave	22	27	23	-9	3

Table 4 - Water Level Difference Summary for 0.2% AEP 2130 RCP 8.5

Water Level Difference to Existing (mm)		0.2% AEP 2130 RCP 8.5	
ID	Location	Maximum Probable Development	Future Intensification (Plan Change 2021/22)
0	Kopuaroa	7	7
1	Seddon-Raparapahoe	33	32
2	Factory Drain	36	38
3	Lawler-Seddon	33	32
4	Upper Raparapahoe	159	159
5	Upper Ohineangaanga	48	42
6	Managh's Drain	1	1
7	Waiari	1	1
8	Parawhenumea	0	0
9	Atuaroa Ave	23	17

5 References

/1/ DHI, November 2021, Te Puke Stormwater Investigation Stage 1 & 2

Appendix A Leakage Rates

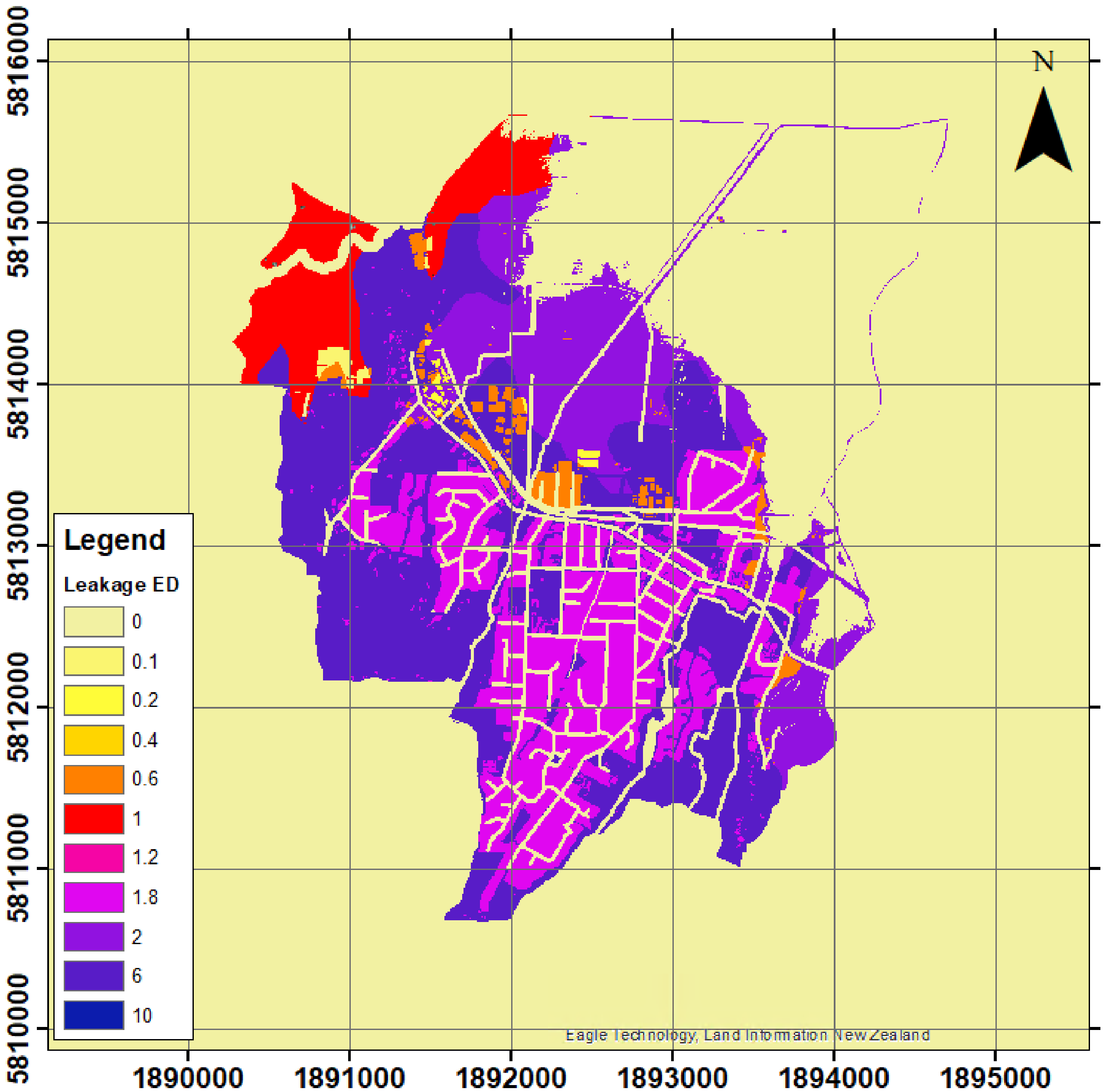


Figure 6 - Leakage Rates Existing 2019 Scenario

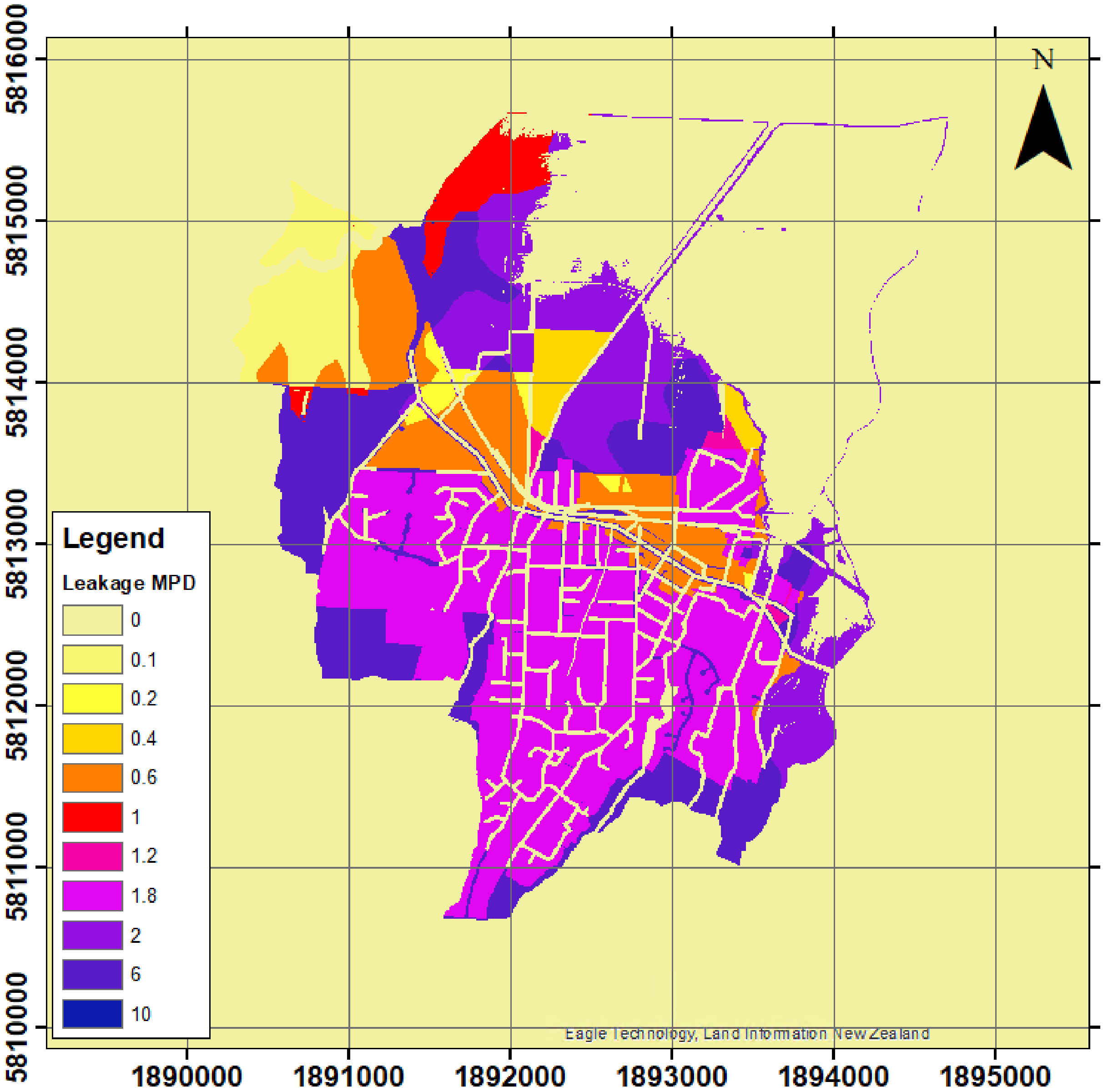


Figure 7 – Leakage Rates MPD Scenario

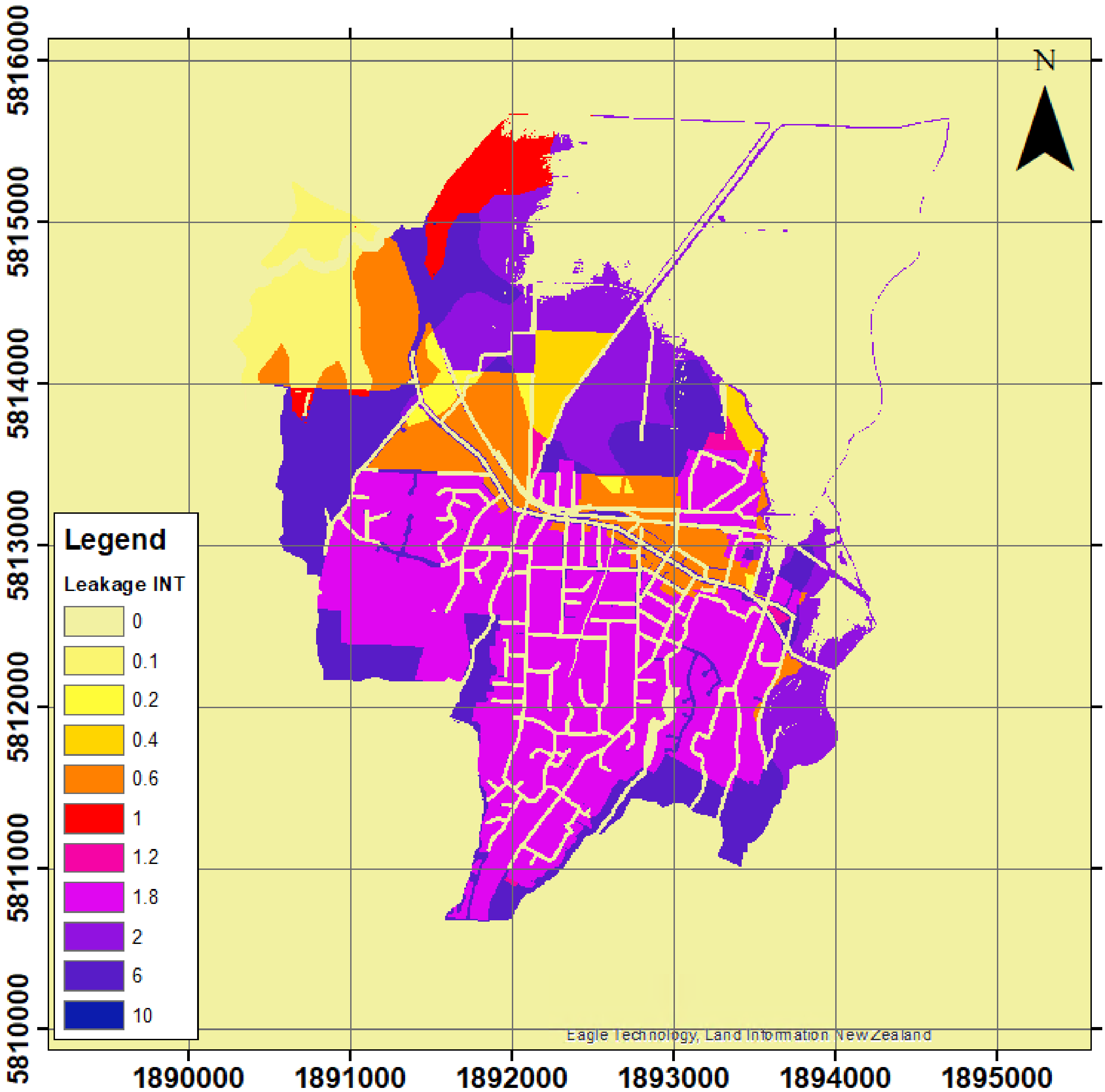


Figure 8 - Leakage Rates Intensification Scenario 70% Imperviousness

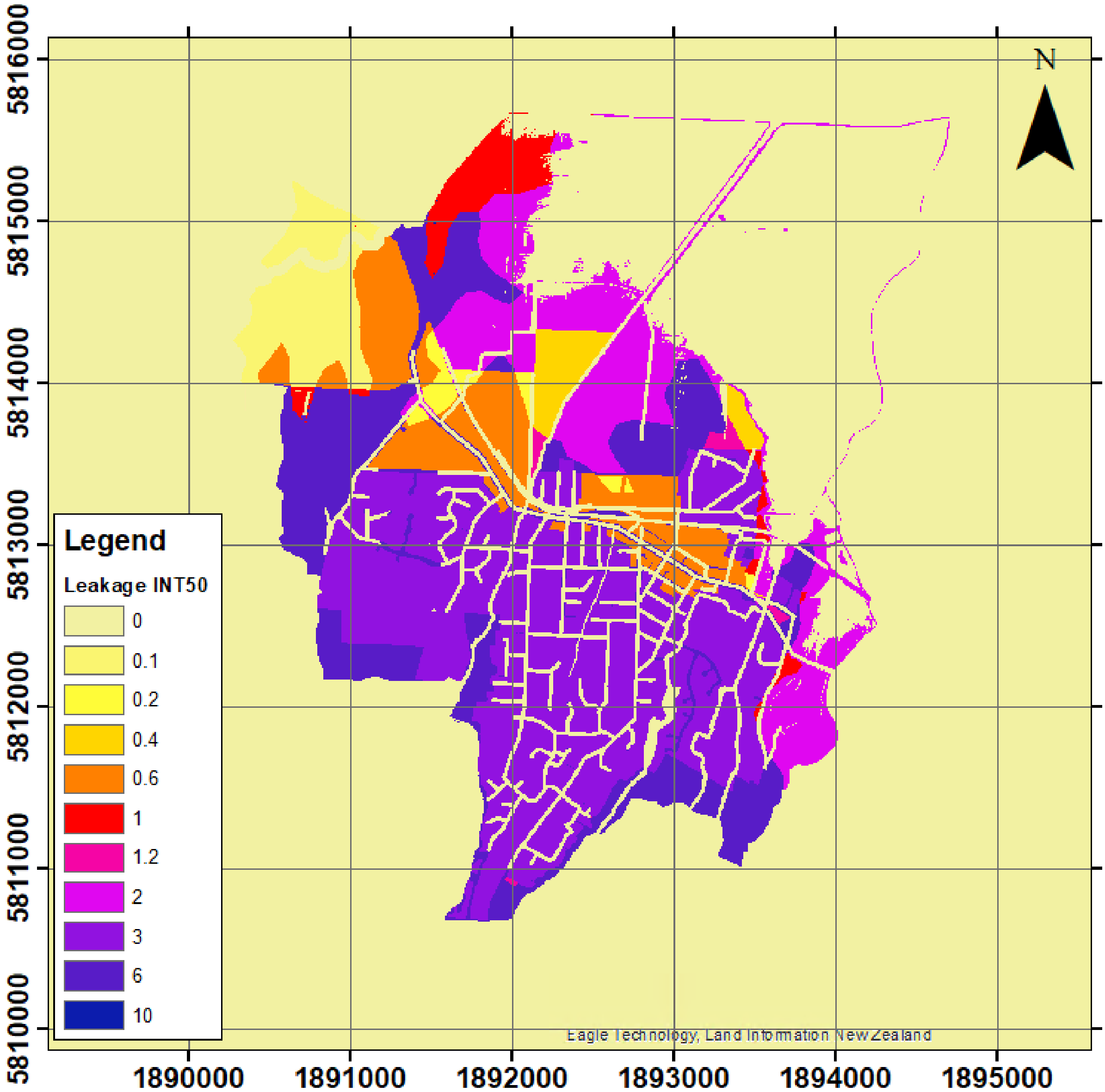


Figure 9 - Leakage Rates Intensification Scenario 50% Imperviousness

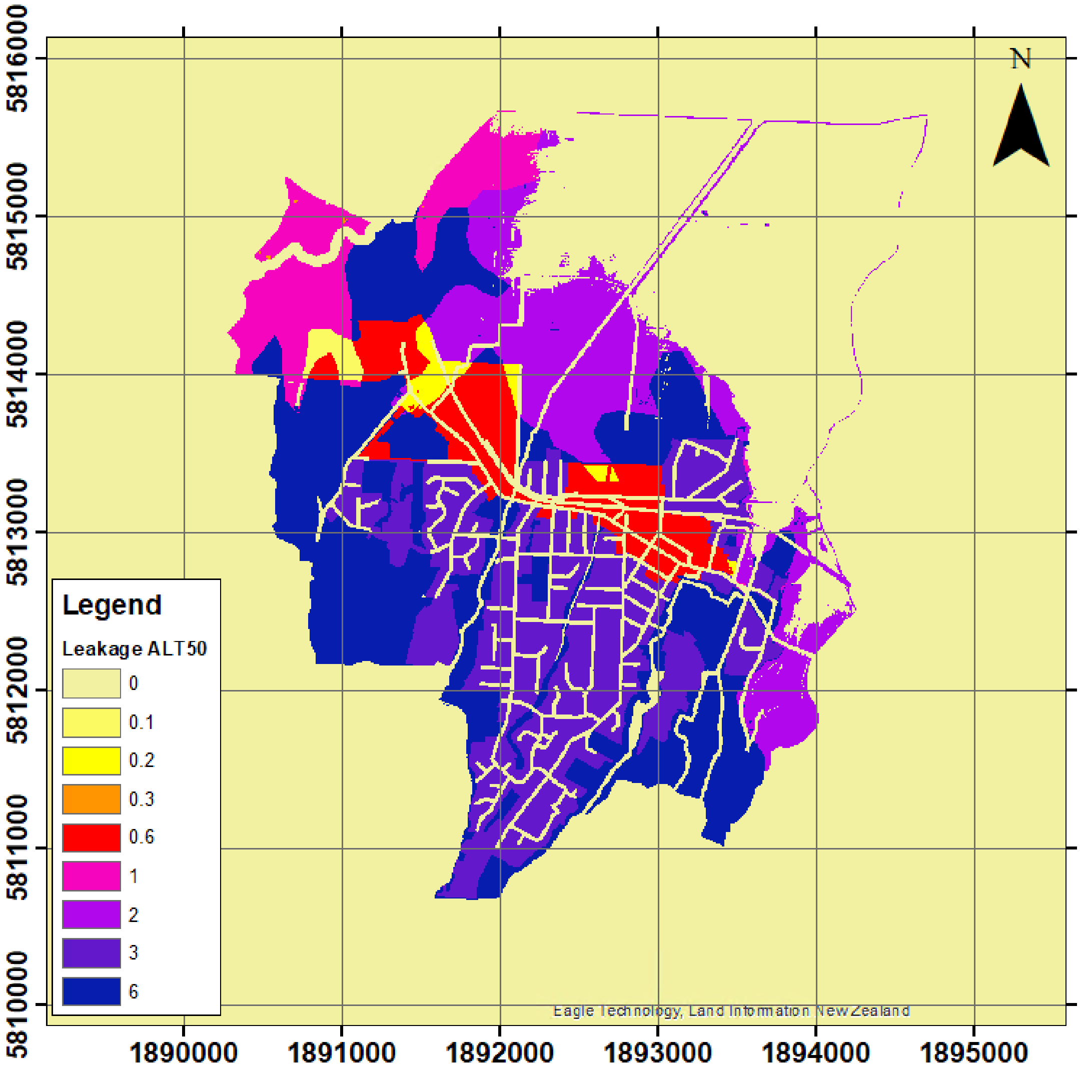


Figure 10 - Leakage Rates Alternative 1 Scenario with 50% residential

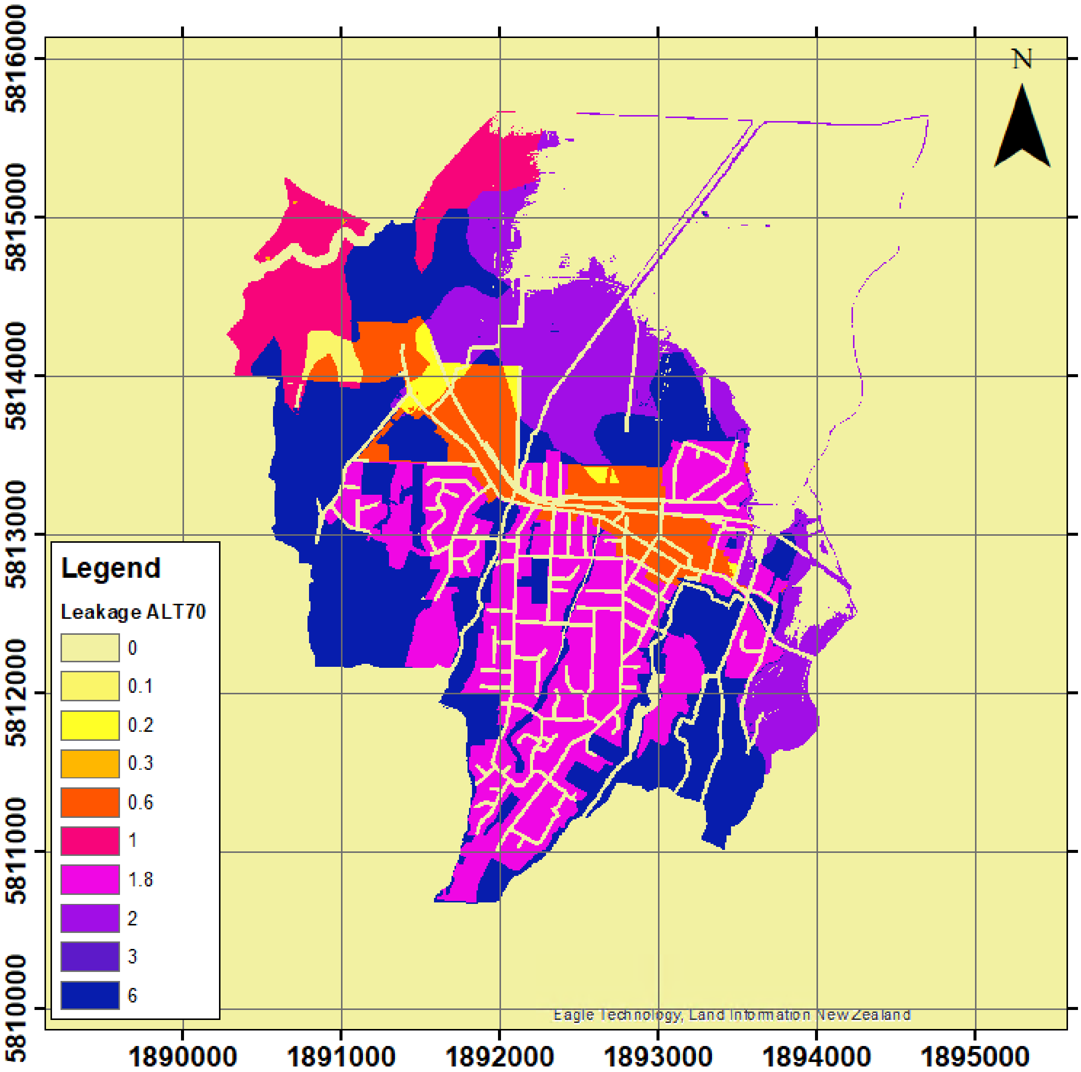


Figure 11 - Leakage Rates Alternative 1 Scenario with 70% residential

Appendix B Surface Roughness

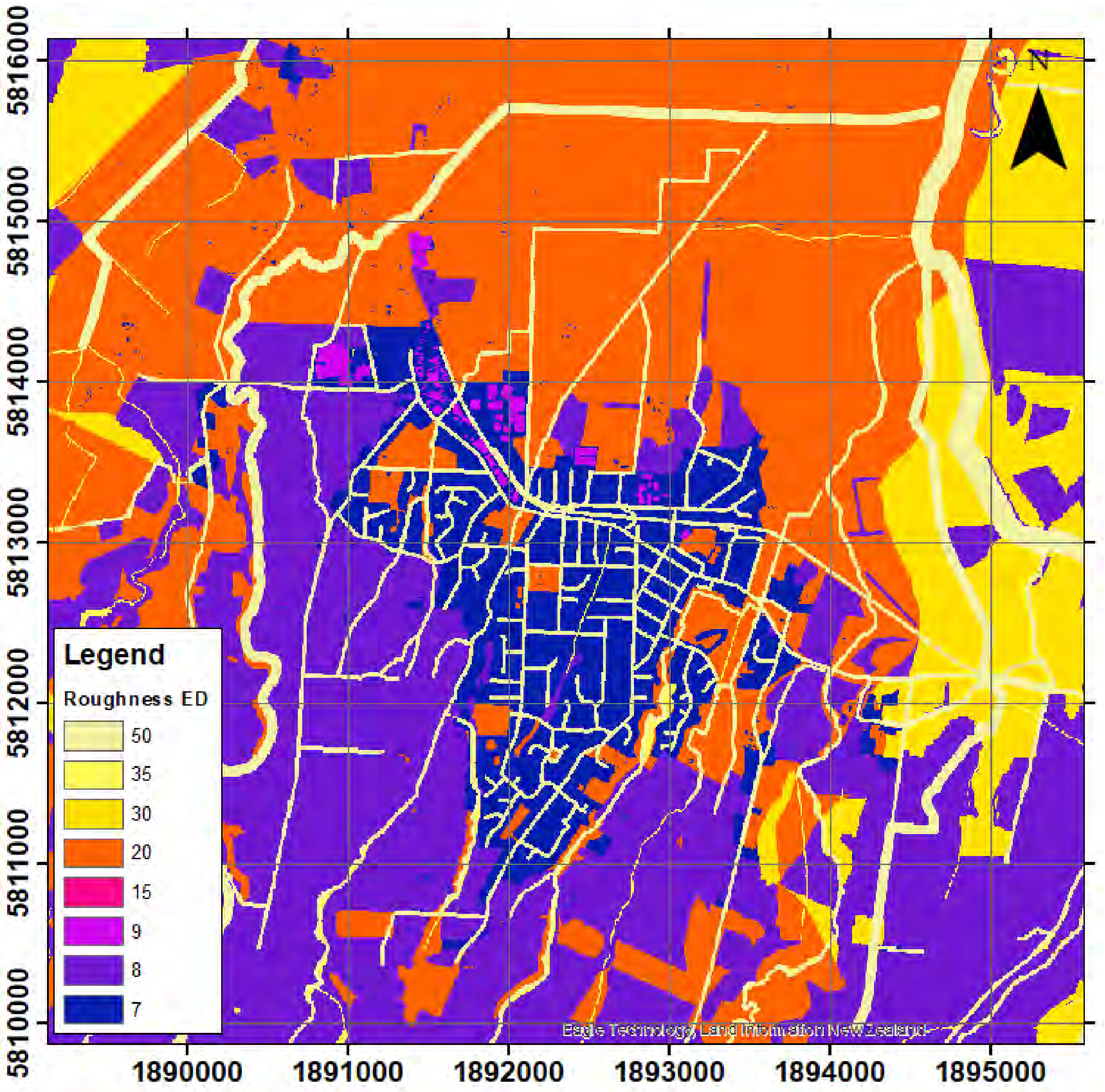


Figure 12 – Existing (2019) Scenario Manning's Roughness

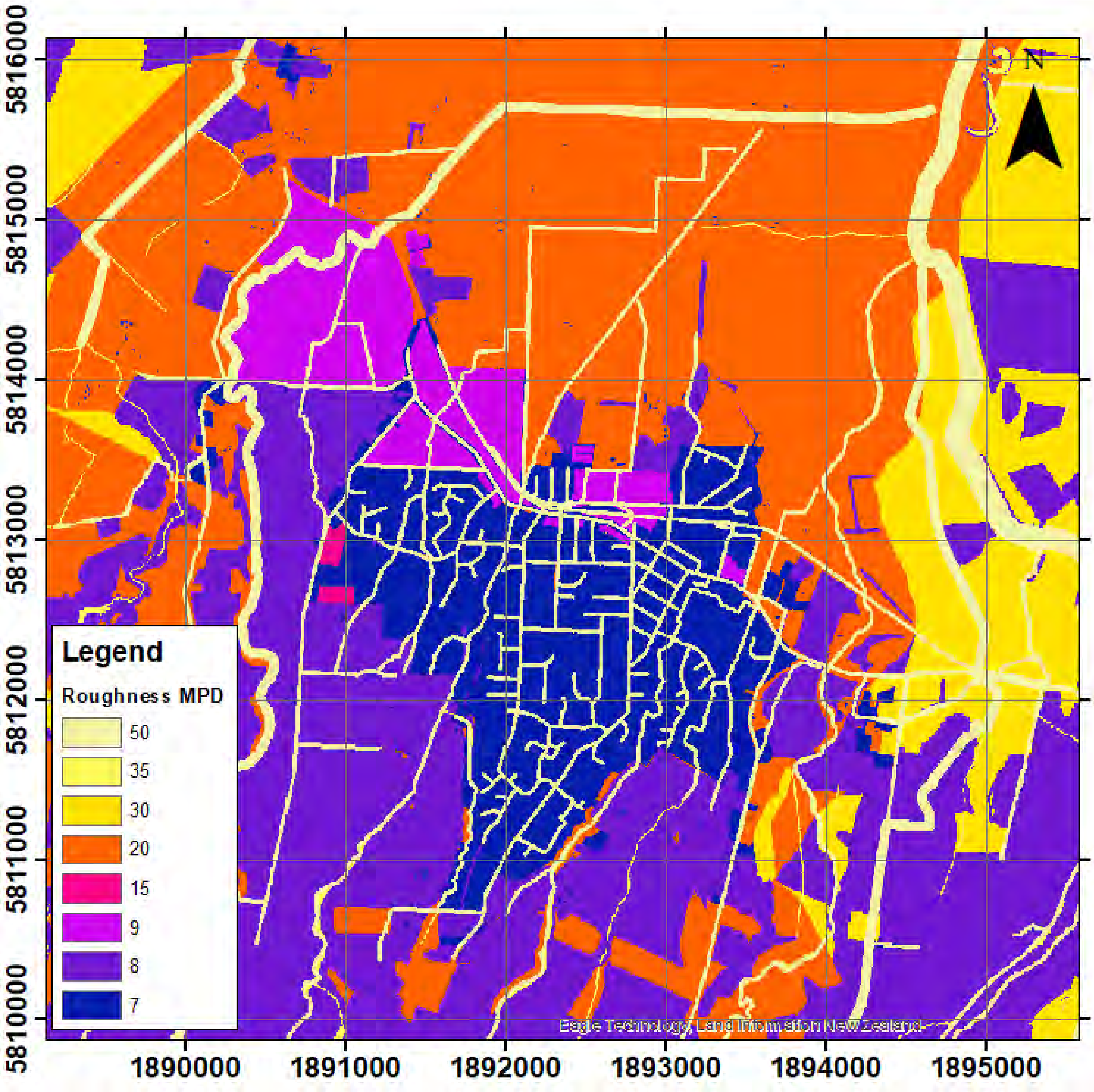


Figure 13 - MPD Scenario Manning's Roughness

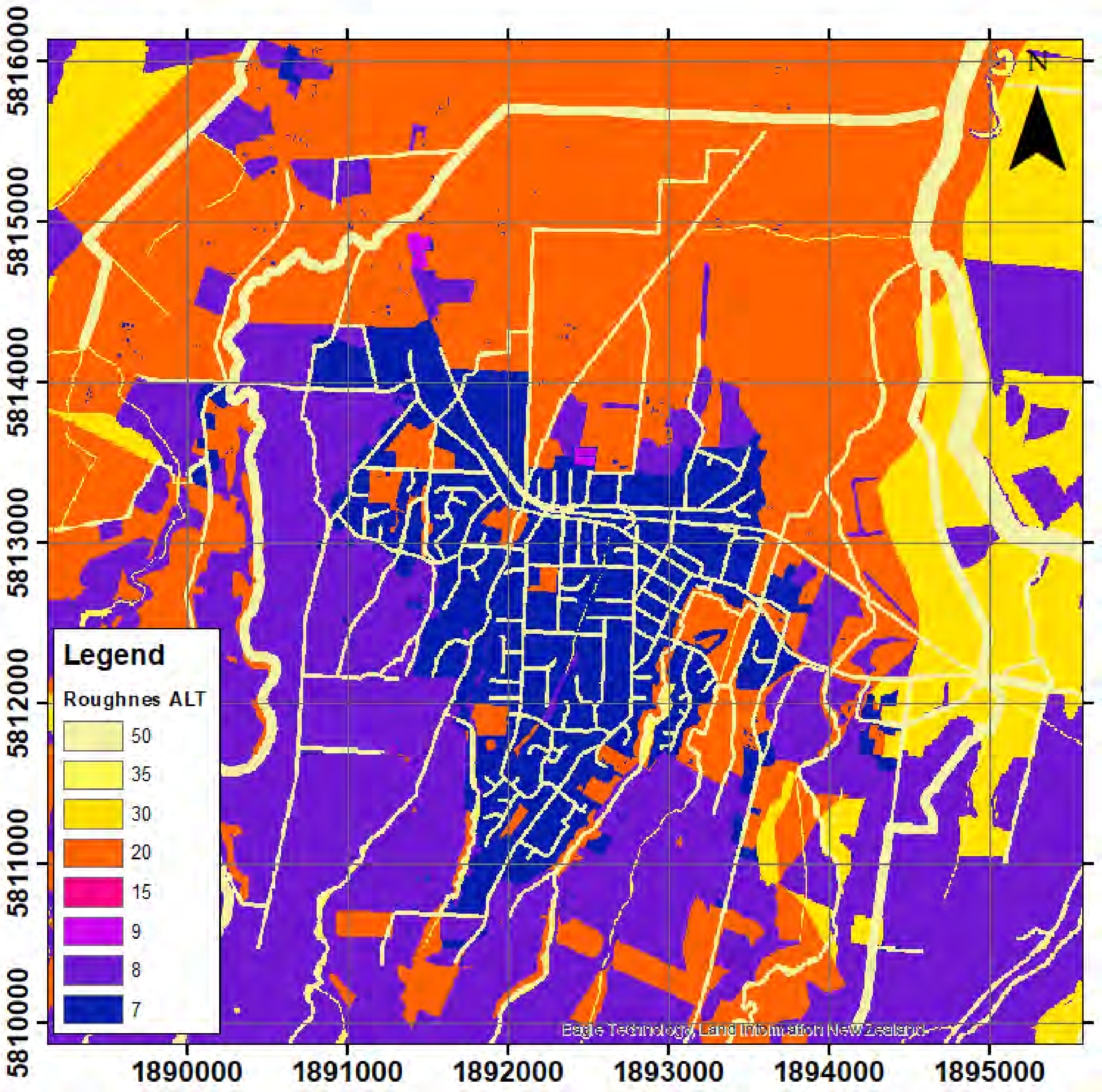


Figure 14 – Alternative 1 Development Scenario Manning's Roughness

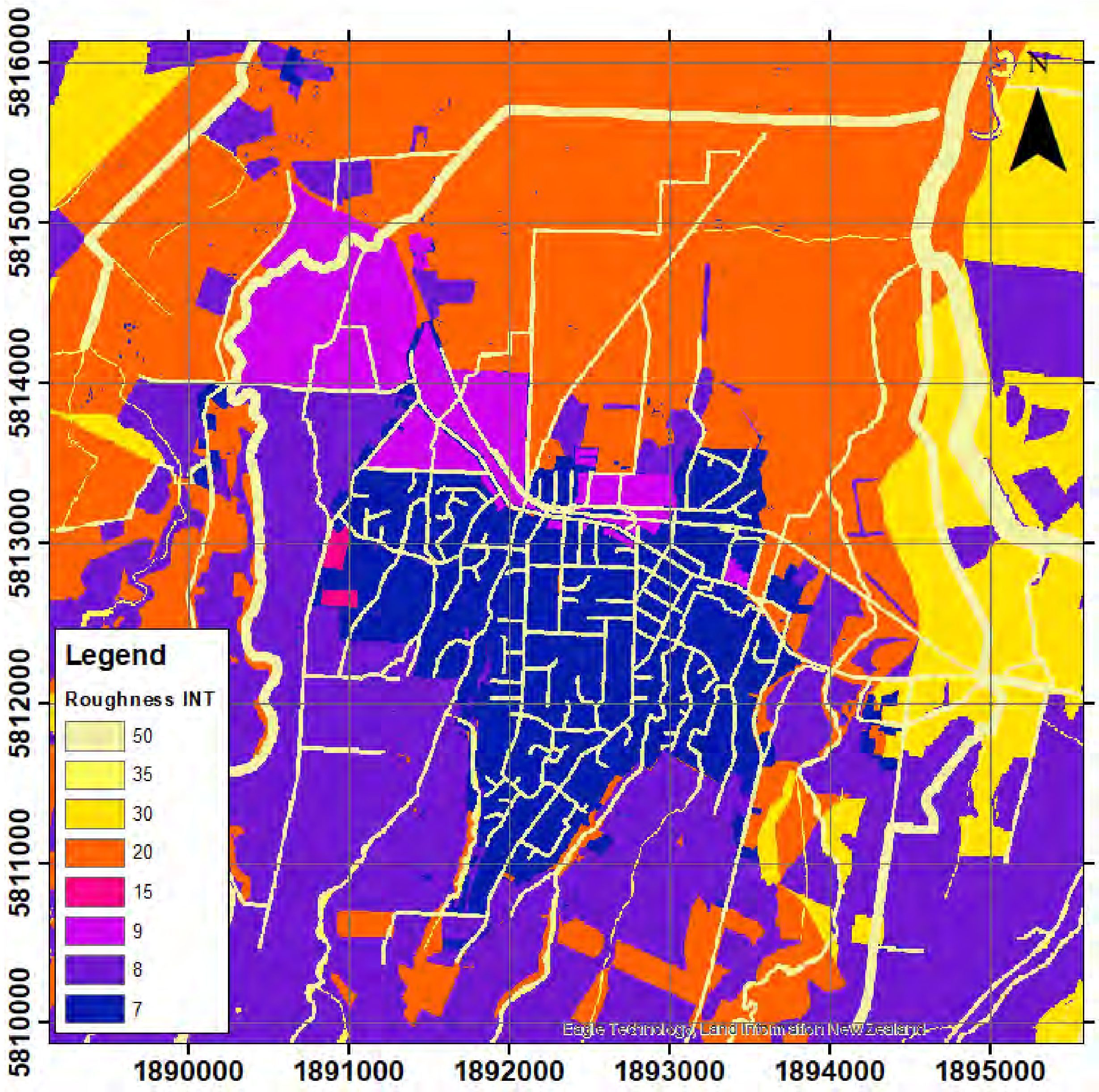


Figure 15 - Intensification Scenario Manning's Roughness

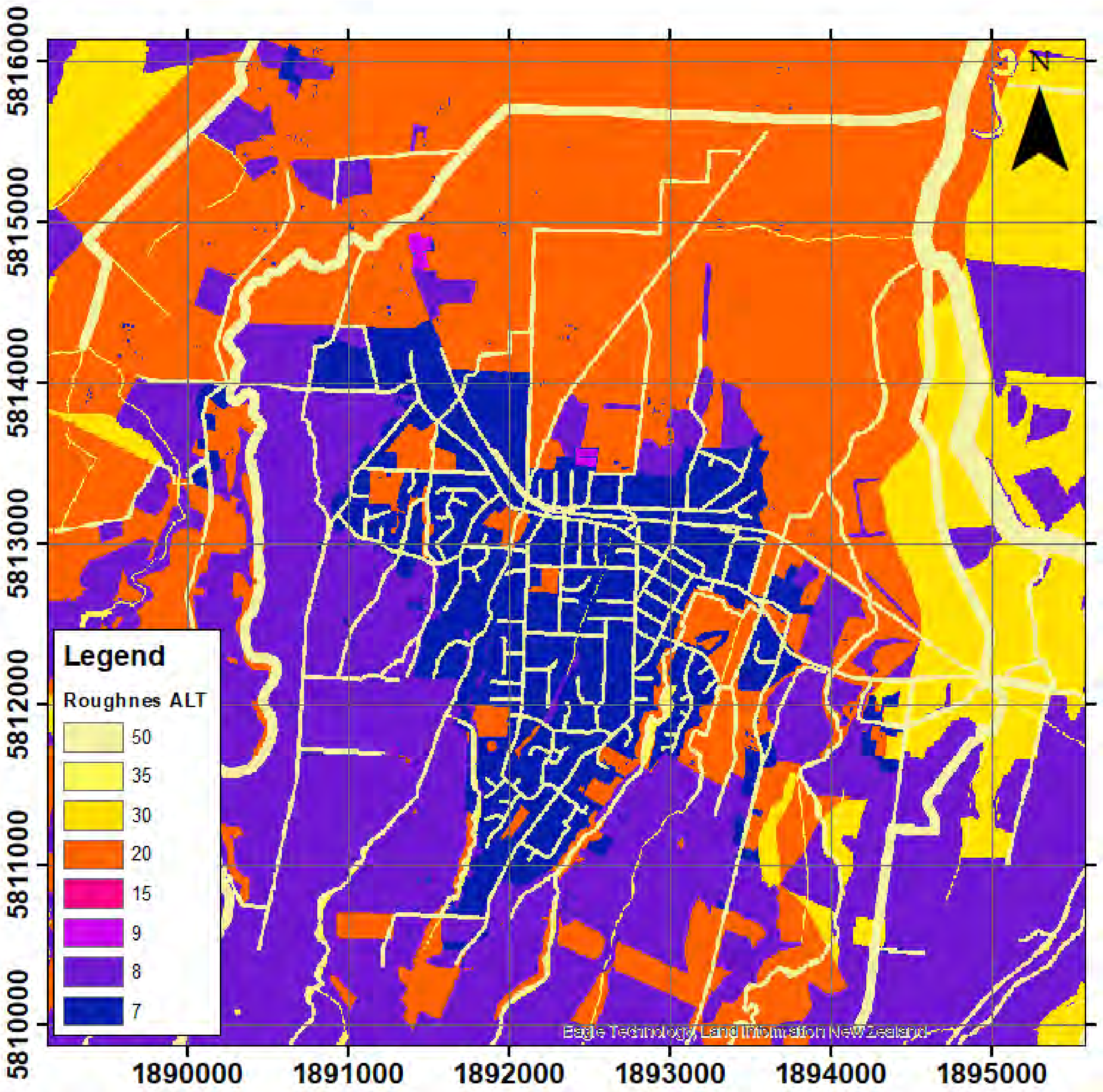


Figure 16 - Alternative 1 Scenario Manning's Roughness

Appendix C Water Level Difference Maps

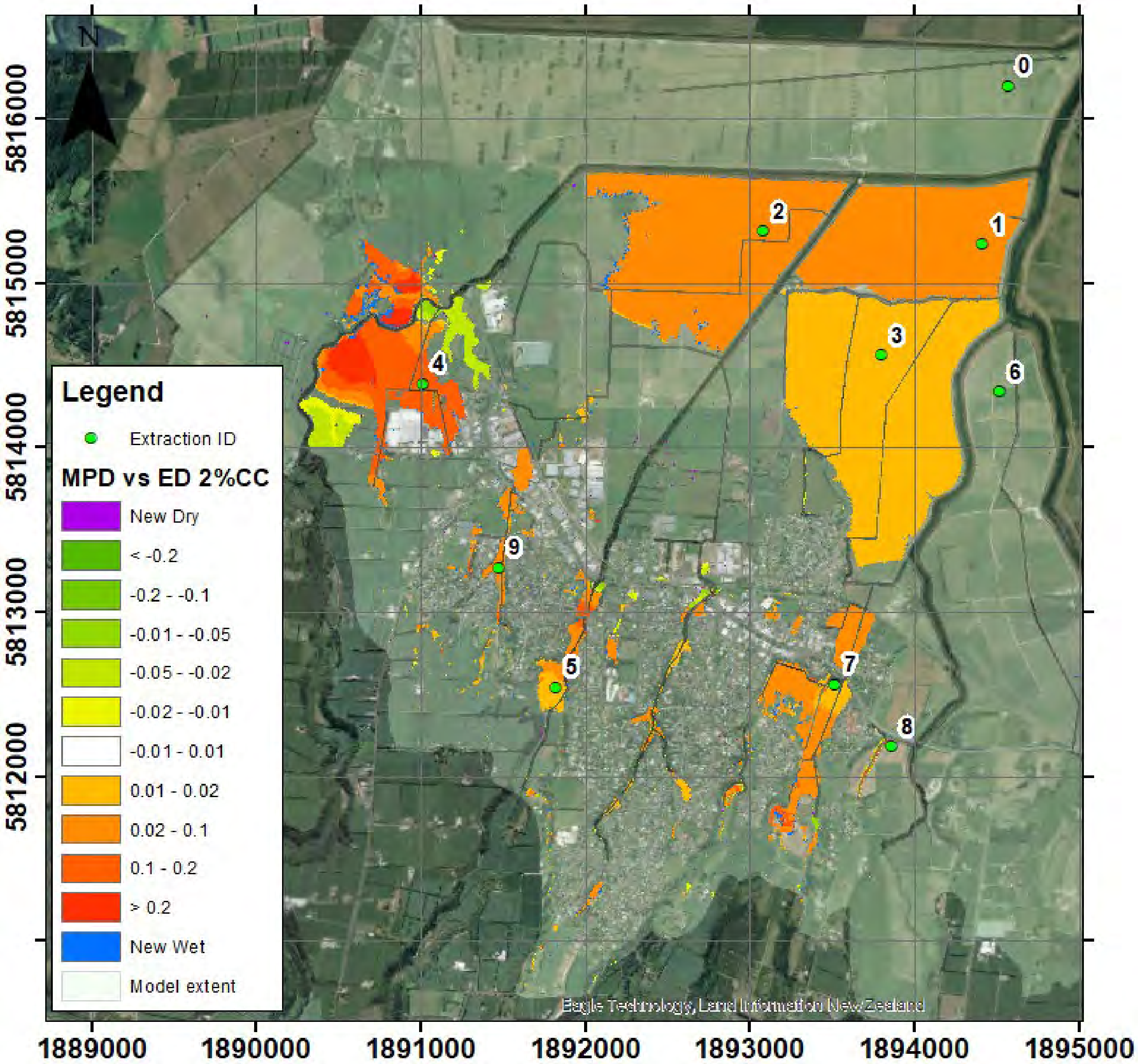


Figure 17 - Difference map between Maximum Probable Development vs Existing Development for the 50-year 2130 RCP 8.5 event

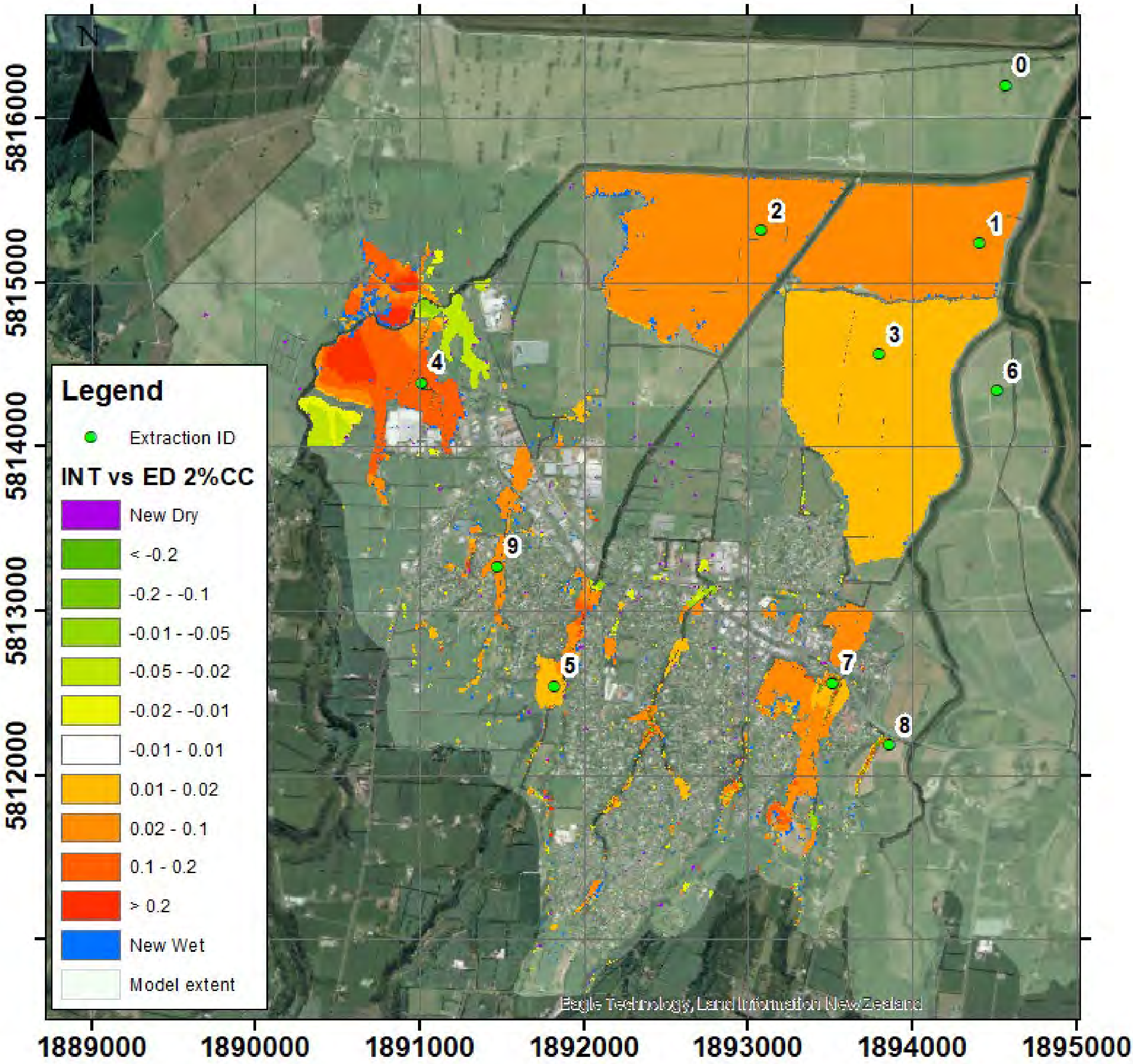


Figure 18 - Difference map between Future Intensification (Plan Change 2021/22) vs Existing Development for the 50-year 2130 RCP 8.5 event

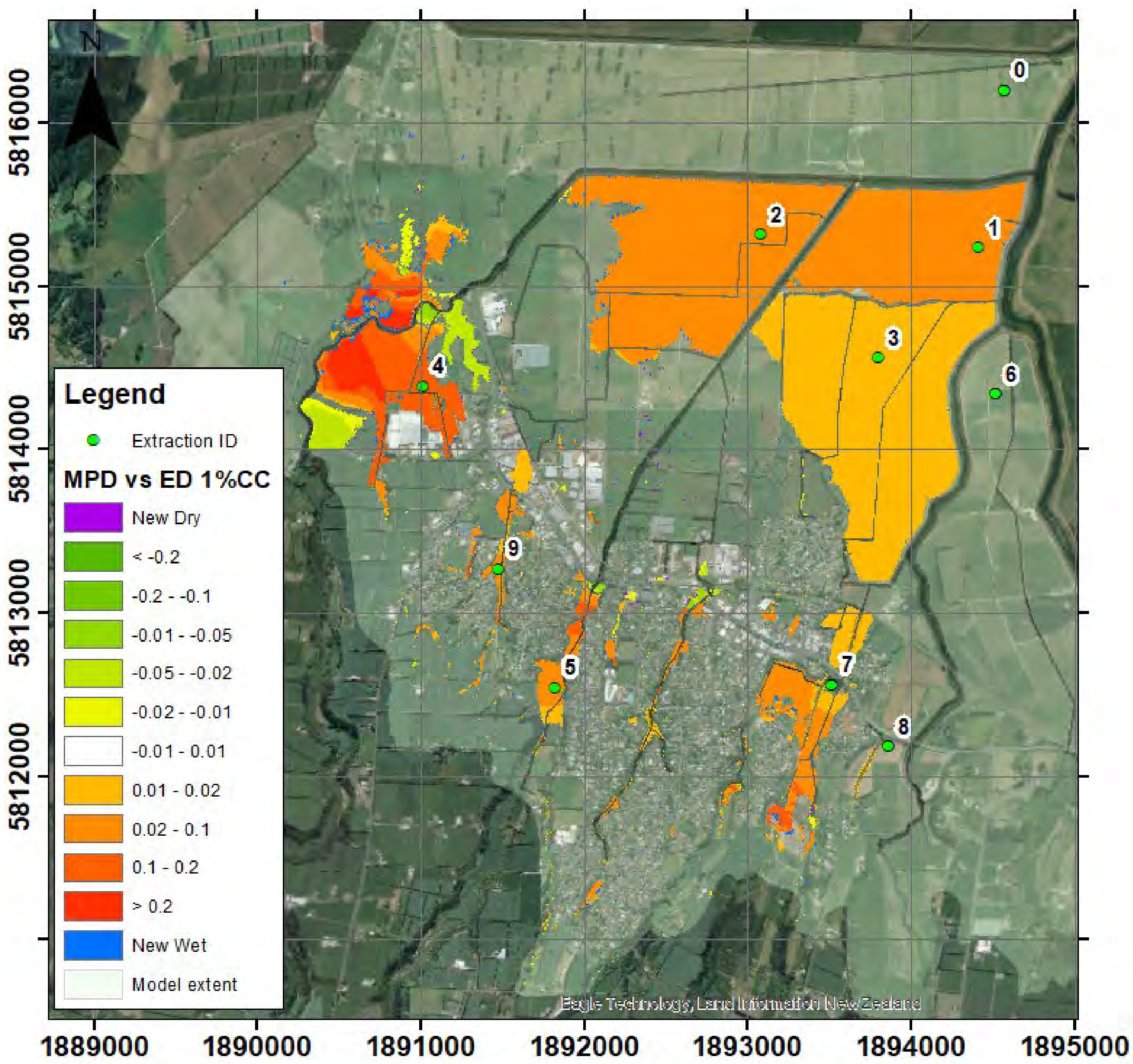


Figure 19 - Difference map between Maximum Probable Development vs Existing Development for the 100-year 2130 RCP 8.5 event

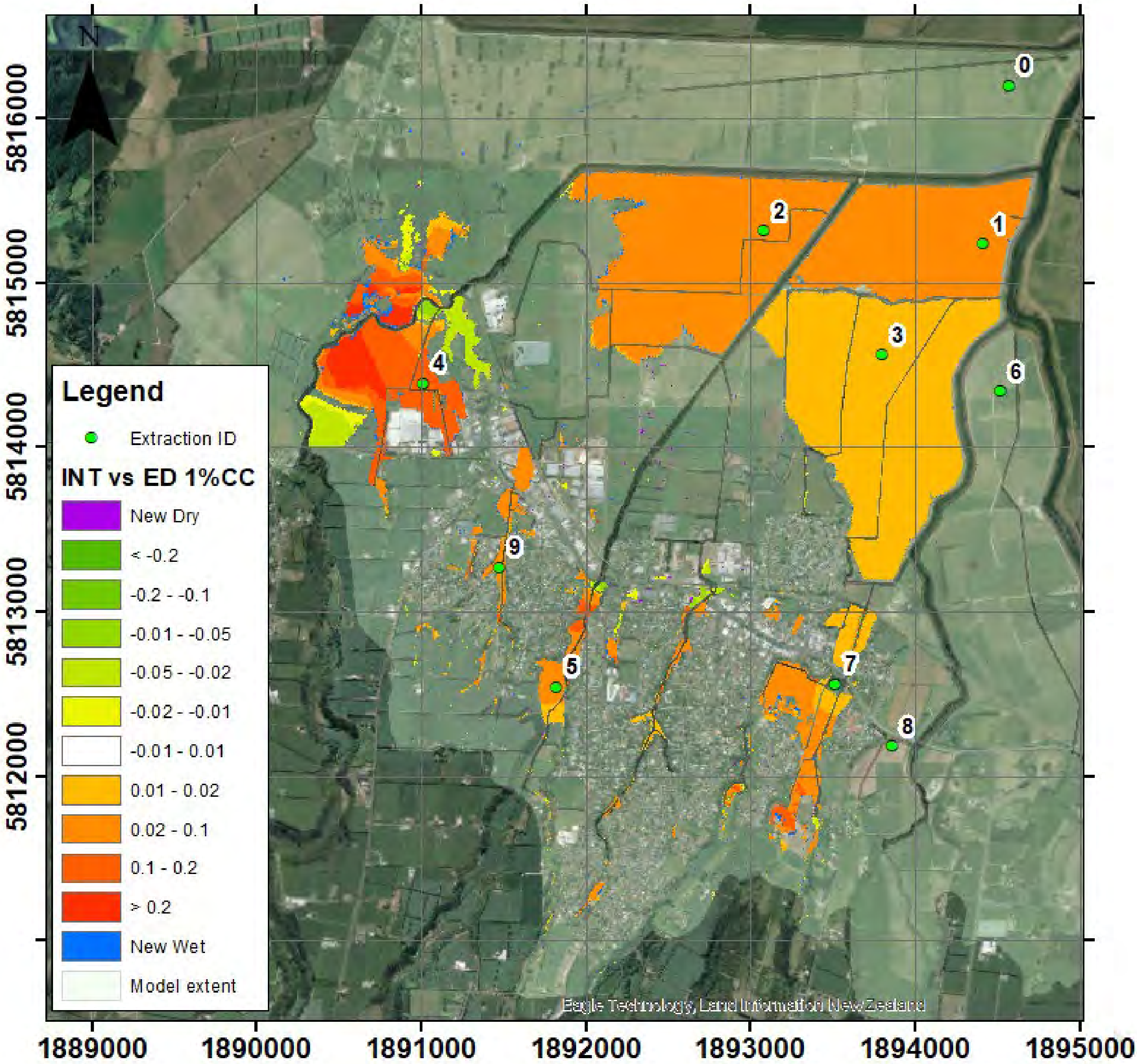


Figure 20 - Difference map between Future Intensification (Plan Change 2021/22) vs Existing Development for the 100-year 2130 RCP 8.5 event

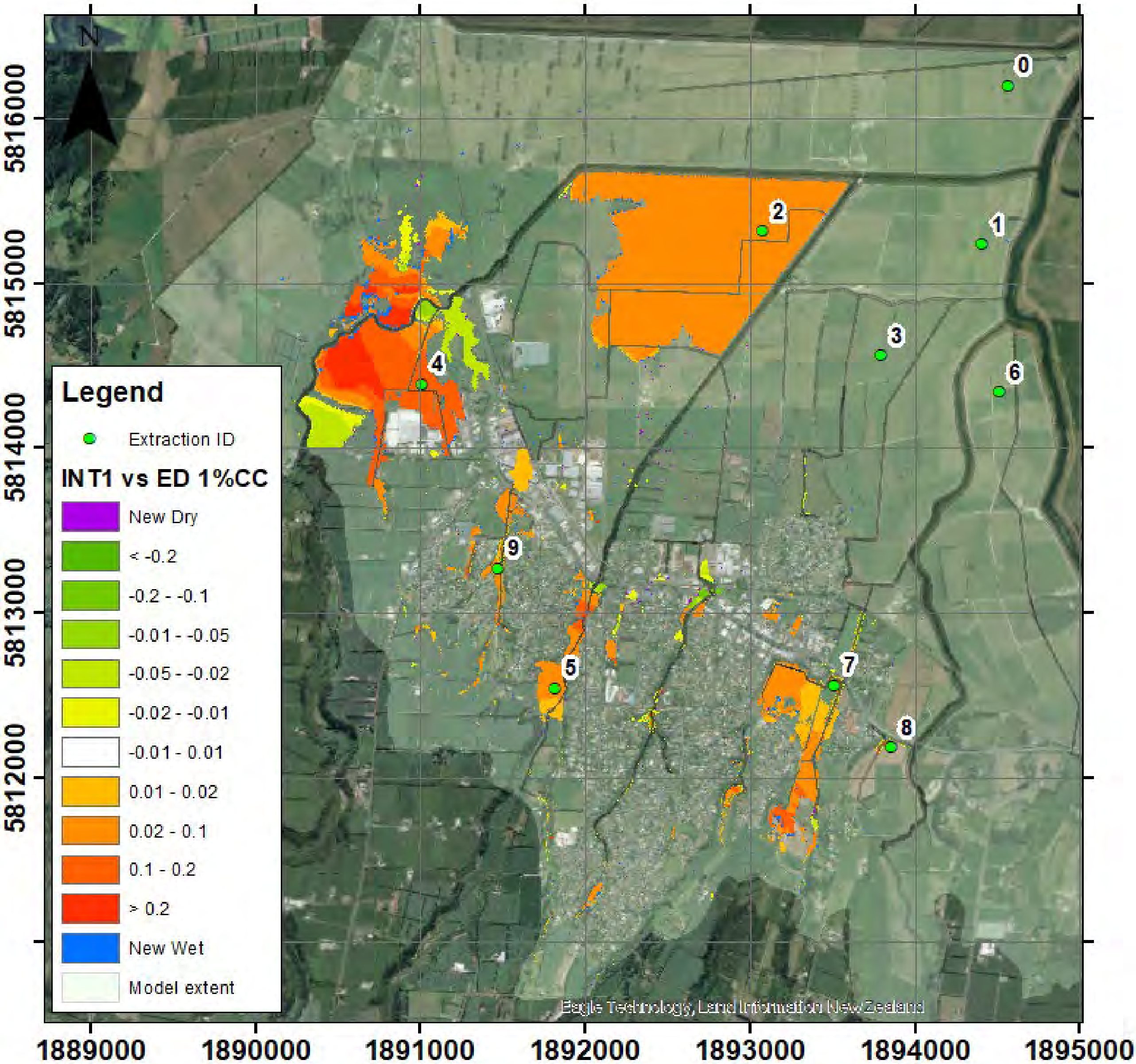


Figure 21 - Difference map between Future Intensification (Plan Change 2021/22) Alternative 1 vs Existing Development for the 100-year 2130 RCP 8.5 event

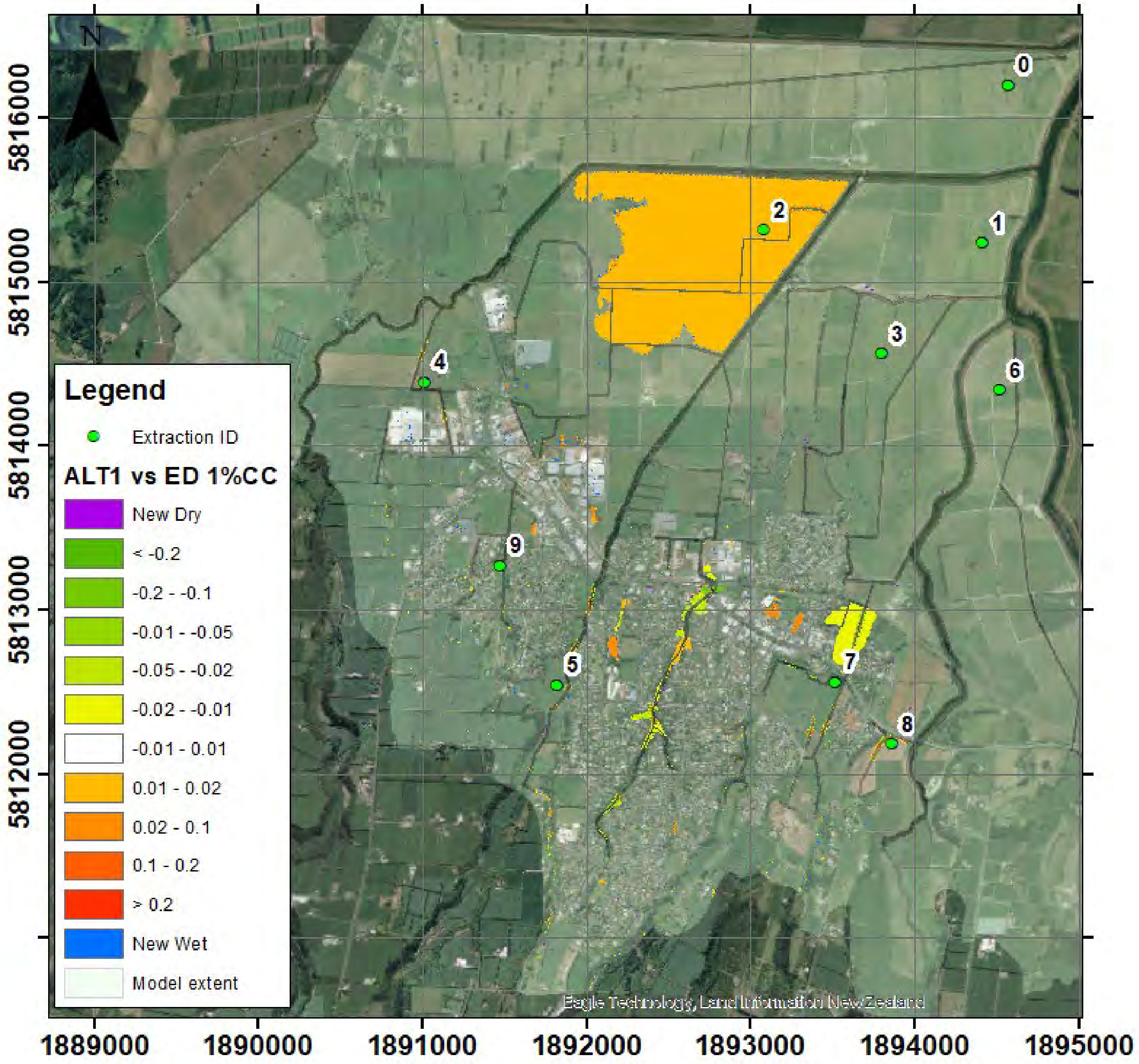


Figure 22 - Difference map between Alternative Future 1 (Imperviousness) vs Existing Development for the 100-year 2130 RCP 8.5 event

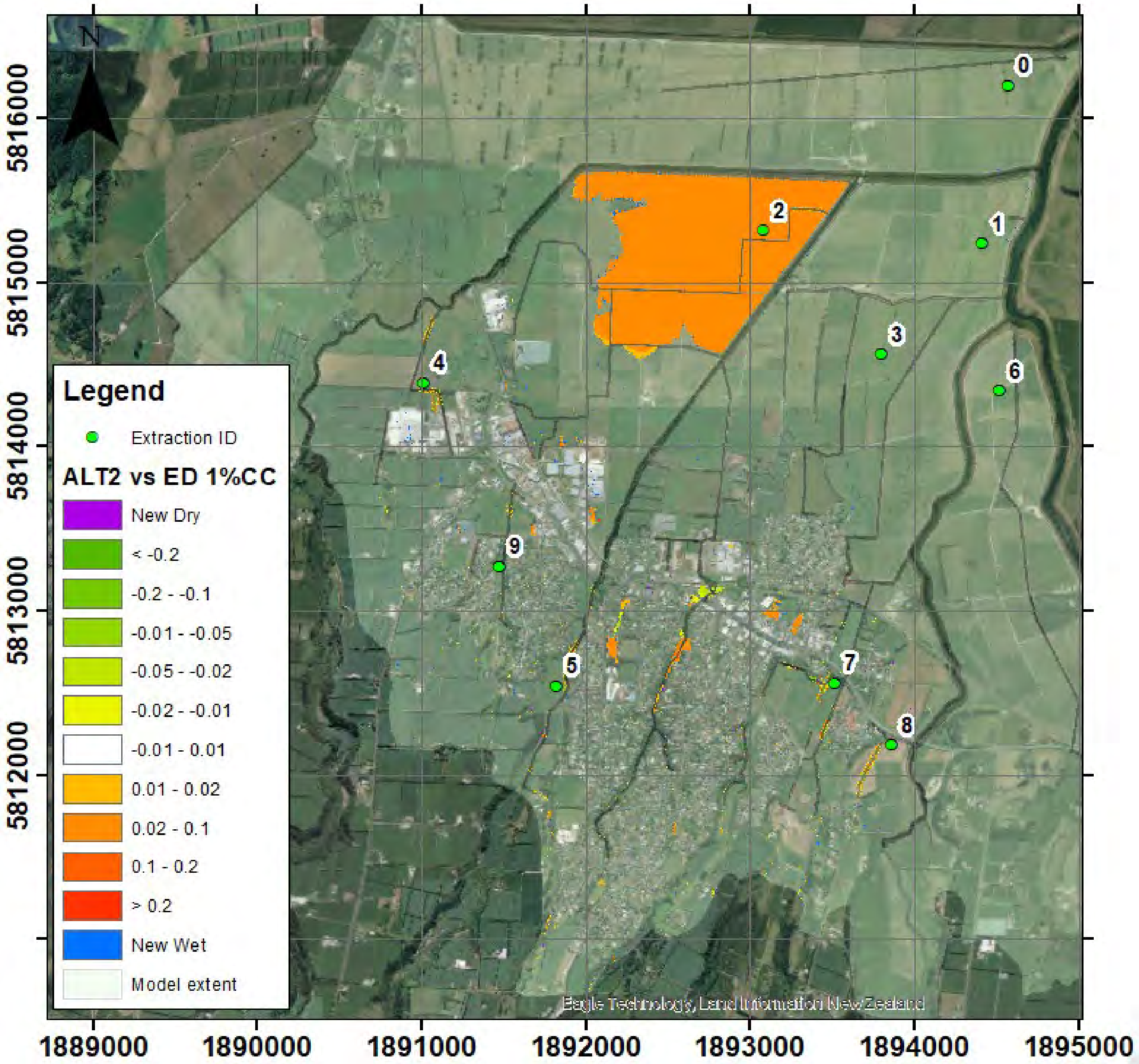


Figure 23 - Difference map between Alternative Future 2 (Imperviousness) vs Existing Development for the 100-year 2130 RCP 8.5 event

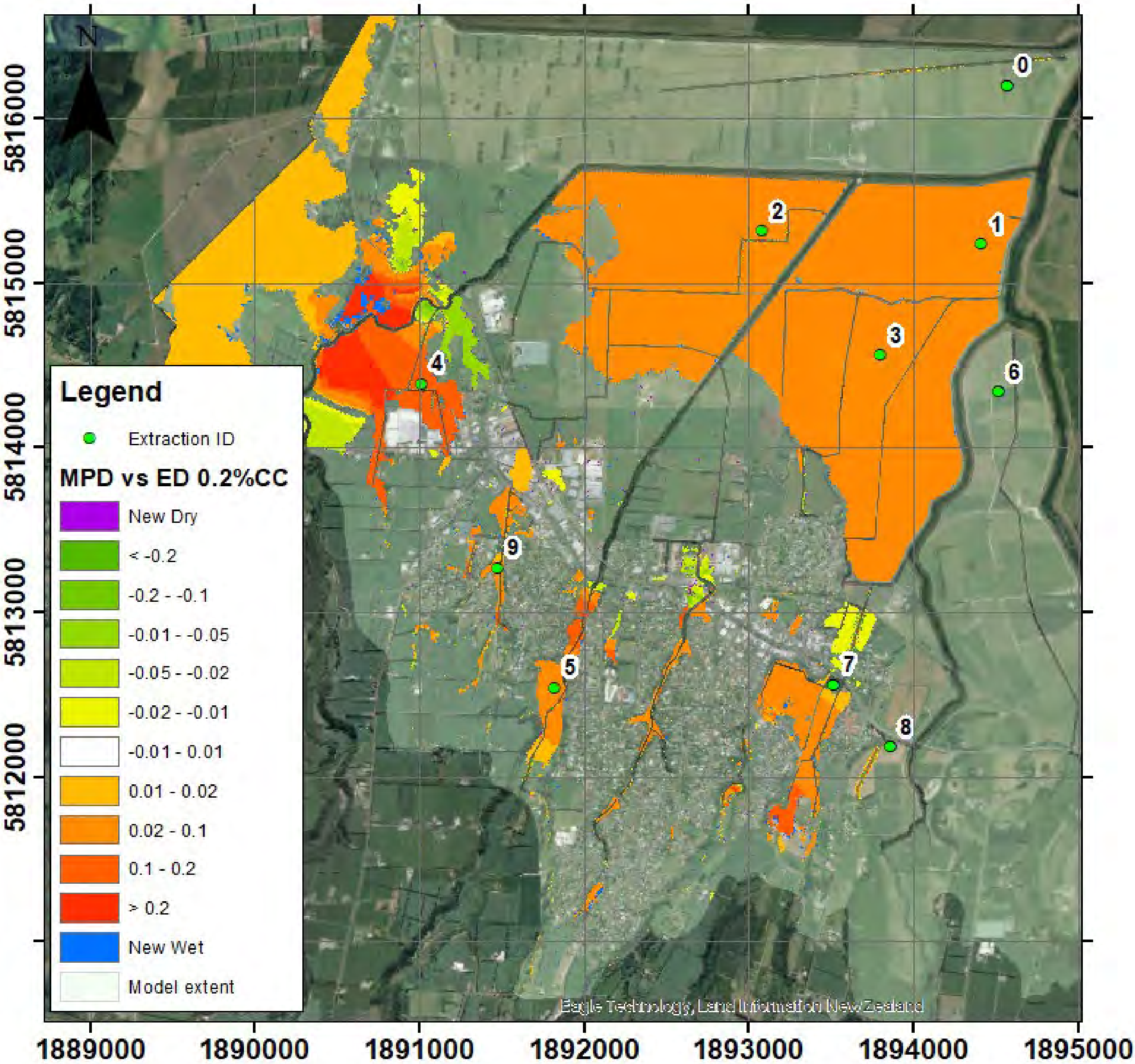


Figure 24 - Difference map between Maximum Probable Development vs Existing Development for the 500-year 2130 RCP 8.5 event

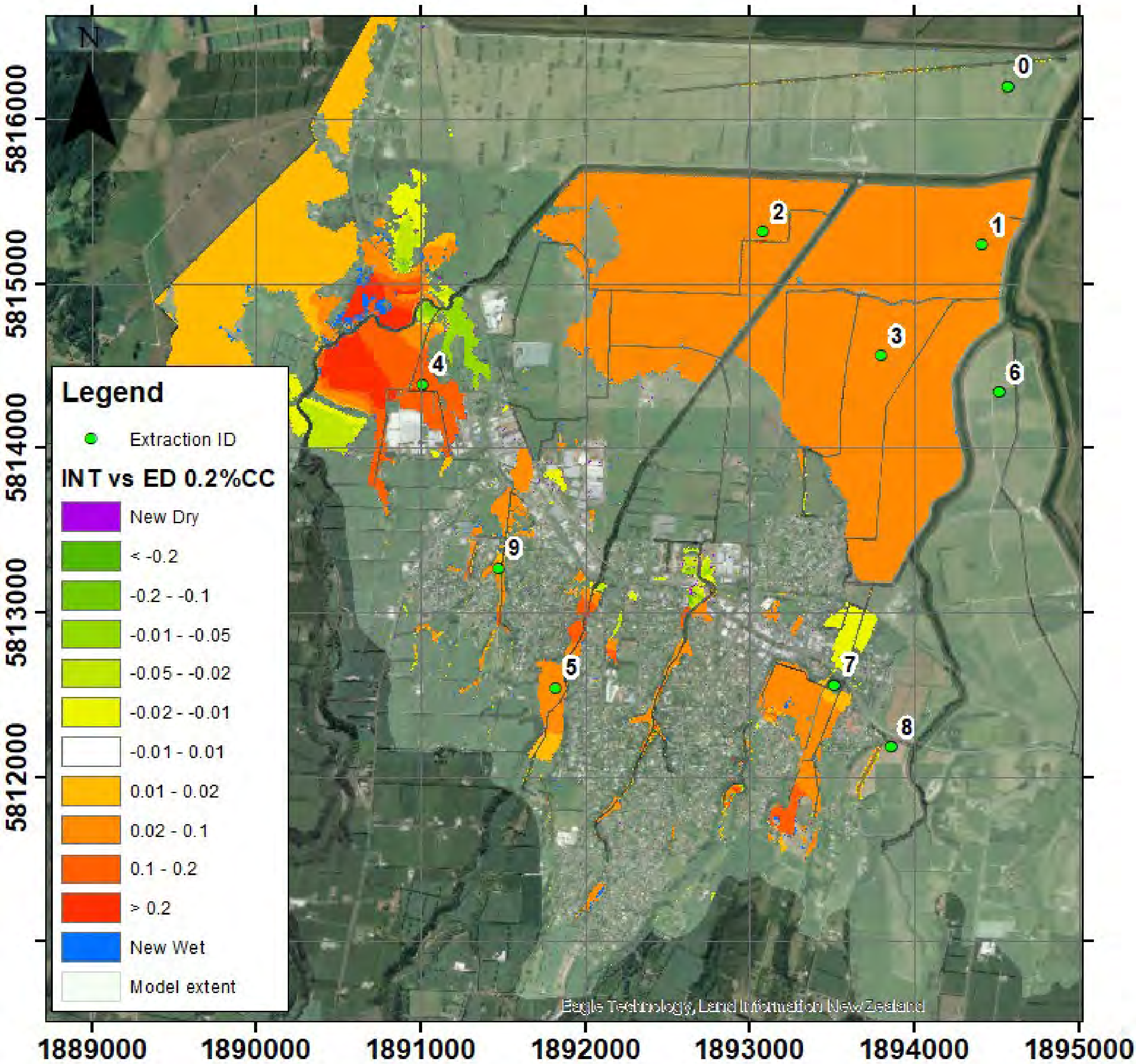


Figure 25 - Difference map between Future Intensification (Plan Change 2021/22) vs Existing Development for the 500-year 2130 RCP 8.5 event

Job No: 1010582.0000
26 June 2020

Western Bay of Plenty District Council
Private Bag 12803
Tauranga 3143

Attention: Tony Clow

Dear Tony

Omokoroa Structure Plan Stage 3
High-Level Slope Stability Hazard and Risk Assessment

1 Background

Western Bay of Plenty District Council (WBOPDC) has prepared a preliminary Structure Plan (refer Figure A3 of Appendix A) for "Omokoroa Stage 3" as an urban growth area for their district. To fulfil the requirements of the Bay of Plenty Regional Policy Statement (RPS), WBOPDC engaged several consultants to define natural hazard susceptibility areas and carry out risk assessments of these hazards against the RPS.

WBOPDC has engaged Tonkin & Taylor Ltd (T+T) to complete a high-level rainfall-induced slope stability hazard (landslip) assessment using Appendix L of the RPS as a guide to understanding the risk the development is exposed to by the hazard. This letter report presents the landslip hazard and risk assessment.

WBOPDC intends to use the results of this landslip hazard and risk assessment conducted by T+T to assist with the finalisation of the Structure Plan for the site, particularly in the layout of development areas, reserve areas/non-development areas and trunk infrastructure. This scope of work has been in accordance with the contract between T+T and WBOPDC dated 11 April 2019 and the variation dated 22 April 2020.

There are two other workstreams related to this landslip hazard and risk assessment:

- Bay of Plenty Regional Council (BOPRC) engaged T+T to produce Hazard Susceptibility Maps and undertake a risk assessment of the liquefaction hazard at the site. The results of this study are provided in T+T's report *Omokoroa Stage 3 Structure Plan Area – Supplementary Level B Liquefaction Assessment*[1].
- WBOPDC engaged T+T to complete a natural hazards risk assessment using the RPS for rainfall-induced flooding, tsunami, coastal inundation, coastal erosion, and active fault hazards. The results of this study are provided in T+T's report *Omokoroa Stage 3 Natural Hazard Risk assessment*[2]*.*

[1] Dated May 2020 T+T reference 1008683.0000v2.
[2] Dated June 2020, Reference: 1010582.v1

2 The site

2.1 Site description

Stage 3 of the Omokoroa Structure Plan area extends from State Highway 2 in the south and the East Coast Main Trunk (ECMT) railway in the north and is bound by the Waipapa River to the west and Mangawhai Estuary to the east. The Stage 3 area is approximately 280 hectares, and has a development area of approximately 150 hectares (Refer to Figure A3). As shown in Figure A1, the site topography is generally characterised as gently undulating terraces interrupted by incised stream gullies and several knolls. Elevations range from 0 m RL adjacent to the harbour to 75 m RL in the middle of the site. The sides of the stream gullies are steep in places, but the slope angles decrease within the gully floors. Slope gradients vary from 1V:1H to 1V:3H with most slopes approximately 1V:2H in stream gullies and on the harbour margins. Away from the stream gullies and harbour margins, the slopes within the site are generally less than 1V:6H.

2.2 Geology

Based on geotechnical investigations completed in February 2020[3], the Stage 3 area is shown to have geological conditions that comprise 'terrace' deposits of the Matua Subgroup in the elevated portions of the site (where development is likely to take place). A typical volcanic ash sequence of Younger Ash (including the Rotoehu Ash) and Hamilton Ash overlies the Matua Subgroup.

In the stream gully areas Holocene-aged alluvium has been deposited in the gully floors by alluvial processes, and eroding the surficial ash sequence away.

Near the estuary and Waipapa River, alluvial silts and gravels are likely to be interlayered with marine clays, silts, and sandy silts.

2.3 Proposed development

The proposed structure plan is shown in Figure A3. Constrained land has been defined in stream gullies and areas where slopes are typically steeper than 1V:4H. The proposed development primarily comprises zones of residential land with smaller areas zoned for industrial, retail, commercial, and educational activities.

3 Slope instability hazard identification

3.1 Background to slope instability

Slope instability occurs where either soil and/or rock move downslope under gravity. Typically, slope instability occurs on relatively steep slopes in response to an external trigger such as heavy rainfall or earthquake shaking. Slope instability typically causes damage to the built environment in the form of either "evacuation" of the land underlying structures or "inundation" of structures with the debris generated.

The Omokoroa Peninsula (northeast of the study area) has been affected by significant rainfall-induced landsliding in recent years. This landsliding has primarily been associated with the tall and steep slopes, and coastal cliffs to the northeast of the Stage 3 area (i.e. Beach Grove, Bramley Drive, Harbour View Road, Kowai Grove, McDonnell Street, Ruamoana Terrace, and Waterview Terrace during ex-Cyclone Debbie (March/April 2017)). These landslides were either deep-seated failures involving large blocks of soil, or superficial failures, comprising surface soils and vegetation.

[3] Tonkin & Taylor Ltd, Omokoroa Stage 3 Structure Plan Area, Geotechnical Factual Report, Prepared for Western Bay of Plenty District Council, dated February 2020, 1008683.1000.v2

The large, block-type failures are often associated with a build-up of groundwater pressure and layers of sensitive soil (e.g. Pahoia Tephra). The superficial failures are likely caused by the wetting of the surface soils due to heavy rainfall. The slopes that failed along the coastal margin were also often affected by erosion at the toe of the slope caused by wave action from the harbour (Kluger et al., 2019).

No recent, large-scale landslides were observed within Stage 3 during a walkover by T+T on 22 November 2019. The slopes appear to have been largely unaffected by ex-cyclones Debbie and Cook. However, some small-scale slope failures and signs of slope creep (slow downward movement of surface soils) were observed. In addition to this, the slopes adjacent to the streams and harbour margin are locally high and steep.

3.2 Hazard zone definition

Several studies have been undertaken to better understand the mechanism of instability and the likely hazard extent that could affect slopes around Tauranga Harbour. These studies were undertaken in areas with similar geology and geomorphology to the Stage 3 area. These studies include Houghton & Hegan (1980), T+T (1980), Bird (1981), WBoPDC (1992), and Oliver (1997).

The most relevant study to the proposed Stage 3 area is the T+T 1980 study of the Omokoroa Peninsula. The findings of this study indicated that the evacuation zone of the landslip typically occurs between a projection line of 1V:1.8H to 1V:2.2H. None of the observed failures exceeded the 1V:2.2H projection line. On the Omokoroa Peninsula, a 6 m building setback was added to the 1V:2.2H hazard line to allow separation between landslip processes and building development. These zones and setbacks are shown schematically in Figure 3.1.

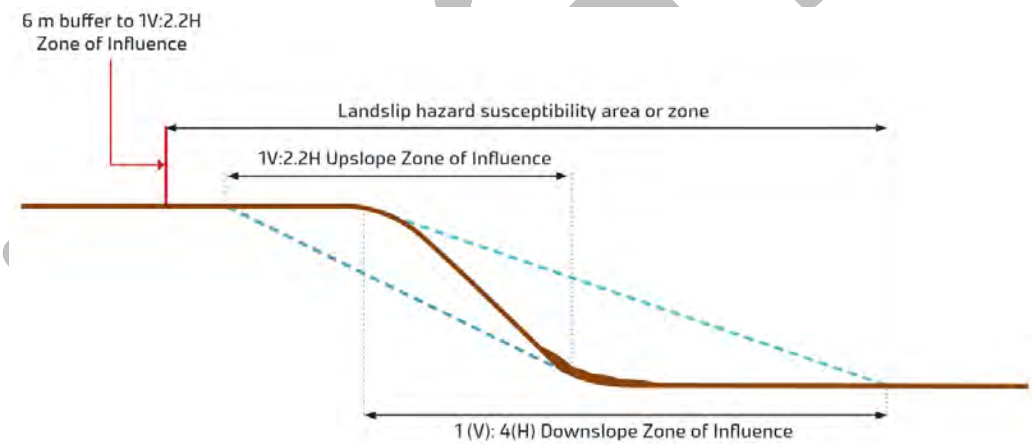


Figure 3.1: Schematic cross-section of the expected 1V:2.2H upslope zone of influence + 6 m buffer and 1V:4H downslope zone of influence. This defines the landslip hazard susceptibility zone

Landslip debris runout distances typically extend to 1V:4H below the slope crest as shown in Figure 3.1. However, runout hazards are unlikely to affect this development because the development area is typically located on terraces upslope of a defined slope crest.

3.3 Hazard susceptibility area

To understand the potential extent of the hazard susceptibility area and its effect on the development area, a high-level qualitative assessment has been completed by applying the 1V:2.2H hazard line and 6 m buffer to five cross-sections across the development area. These cross-sections were selected based on Figure A2 where the steeper slopes come closest to the development boundary and are representative of a worst-case ground profile where the hazard susceptibility area is likely to extend furthest into the development area.

The cross-section ground profiles (in Figure A4) show that Section 5 has the largest hazard susceptibility area (HSA), which extends into the development area by about 15 m. The other cross-sections (cross-section 2 to 4) show less or no development area exposed to the HSA. A conservative average HSA width of 5 m would be expected around the terraces edges of the development. Cross-section 5 is shown in Figure 3.2.

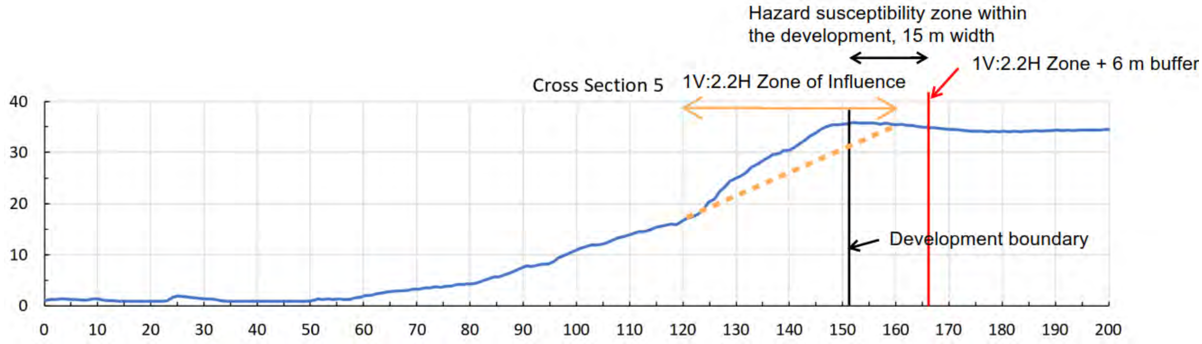


Figure 3.2: Cross-section 5 which portrays the largest hazard susceptibility area/zone affecting the development

By applying a conservative average width of 5 m around the development area, the HSA is conservatively estimated as 8 ha.

This assessment portrays the overall hazard at a high level. It is based on eight slope profiles across five cross sections only and is therefore subject to some uncertainty away from the cross-section locations. Section 5 (below) provides recommendations for further assessment to reduce this uncertainty at future development stages.

4 Regional Policy Statement (RPS) risk assessment

Appendix L of RPS sets out a process to define the risk of development being exposed to natural hazards. The risk assessment process combines the likelihood and consequence to assess this risk.

Based on the assessment above, the hazard susceptibility area (HSA) is conservatively estimated to be an area of 8 hectares within the site. As a percentage, this is approximately 5% of the development area (excludes constrained land in Figure A3). If we assumed that all the buildings within the HSA were functionally compromised, the consequence level would be "minor" under Table 21 of the RPS.

However, because landslip hazards are localised and unlikely to occur over the full HSA at the same time, the likelihood of occurrence of the hazard is considered to be low enough such that there would be even less buildings functionally compromised. This would result in a consequence level of "insignificant" under Table 21 of the RPS. Overall, this results in the site being exposed to a "low risk" with respect to rainfall-induced slope instability as a natural hazard using a qualitative high-level assessment against the RPS.

This hazard susceptibility assessment does not explicitly account for the seismic slope instability hazard. Some seismic slope displacement could occur upslope of the 1V:2.2H extent. A detailed quantitative assessment would be required at future development stages to define this hazard extent and its effect on buildings, and lifeline utilities. However, the seismic slope instability hazard extent is unlikely to alter the conclusions of this risk assessment to support the structure plan.

5 Conclusions on slope stability and recommendations for development

This assessment concludes that the seismic and rainfall-induced landslip risk is "low" as a result of a high-level RPS risk assessment of the Omokoroa Stage 3 Structure Plan. These instability risks and mechanisms will require further assessment at future development stages.

The following geotechnical assessment practices should be incorporated as part of the future subdivision and building works to define this hazard in more detail and determine its effect on specific elements of the development:

1 Assessment of land instability for construction of buildings, roads, and infrastructure in accordance with DS10 (Natural Hazards and Earthworks) of the WBOPDC Development Code. The geotechnical engineer shall define any development restrictions and complete certificate 10b (geotechnical suitability of land for development) and 10c (geotechnical suitability of land for building). Potential land instability triggered by rainfall and seismic mechanisms should be assessed on a lot by lot basis at this time.

2 Active infiltration systems (such as soak pits) and concentrated stormwater flows can adversely affect slope instability. These elements should be located and designed such that they do not increase slope instability risk. A geotechnical engineer should review these elements as part of the future development stages. Further information is provided in the T+T Conceptual Water Sensitive Design Plan Report[4].

6 Applicability

This report has been prepared for the exclusive use of our client Western Bay of Plenty District 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 understand and agree that this report will be used by Western Bay of Plenty District Council in connection with the development of the Omokoroa Stage 3 Structure Plan.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
....	....
Guy McDougall Geotechnical Engineer	Richard Reinen-Hamill Project Director

Technical Review by James Russell and David Milner

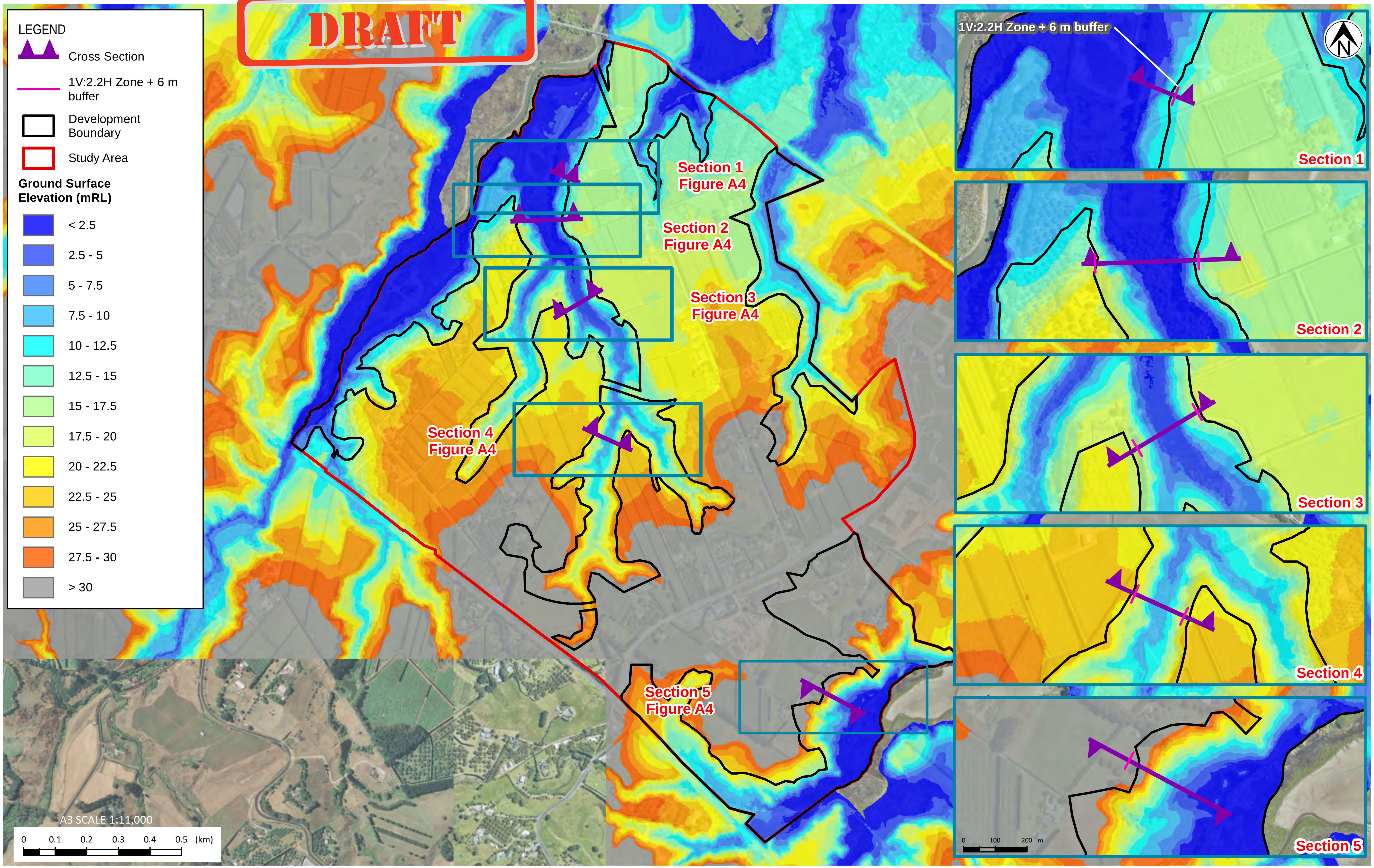
GUMC
\\ttgroup.local\corporate\tauranga\projects\1010582\issueddocuments\draft slope stability report\20200626.gumc.omok.s3.stability_draft.docx

[4] Tonkin & Taylor Ltd, Omokoroa Stage 3 Structure Plan Area, Conceptual Water Sensitive Design Plan Report, Prepared for Western Bay of Plenty District Council, dated February 2020, 1012404.1000.v2

Appendix A: Figures

- **Figure A1: Boundary of proposed development area overlaid on 2015 lidar**
- **Figure A2: Boundary of proposed development area overlaid on ground slopes**
- **Figure A3: Structure plan area**
- **Figure A4: High level slope stability hazard assessment ground profile cross sections, 1V:2.2H**

T:\Tauranga\Projects\1010582\WorkingMaterial\GIS\Map_Documents\1010582_FIGA1_080620.mxd 2020-Jun-16 9:30:13 AM Drawn by GUMC

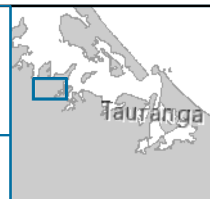


Tonkin+Taylor
Exceptional thinking together www.tonkintaylor.co.nz

NOTES: Basemap: Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand license.
Project specific geotechnical Investigations sourced from the New Zealand Geotechnical Database and other geotechnical investigations (Hand Augers) sourced from the 70A Francis Road Central Land Information Memorandum.
Horizontal Datum: New Zealand Transverse Mercator, Vertical Datum: NZVD 2016.
Slope is based on 2015 LiDAR

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	JORB	YYYY	21/05/20

LOCATION PLAN

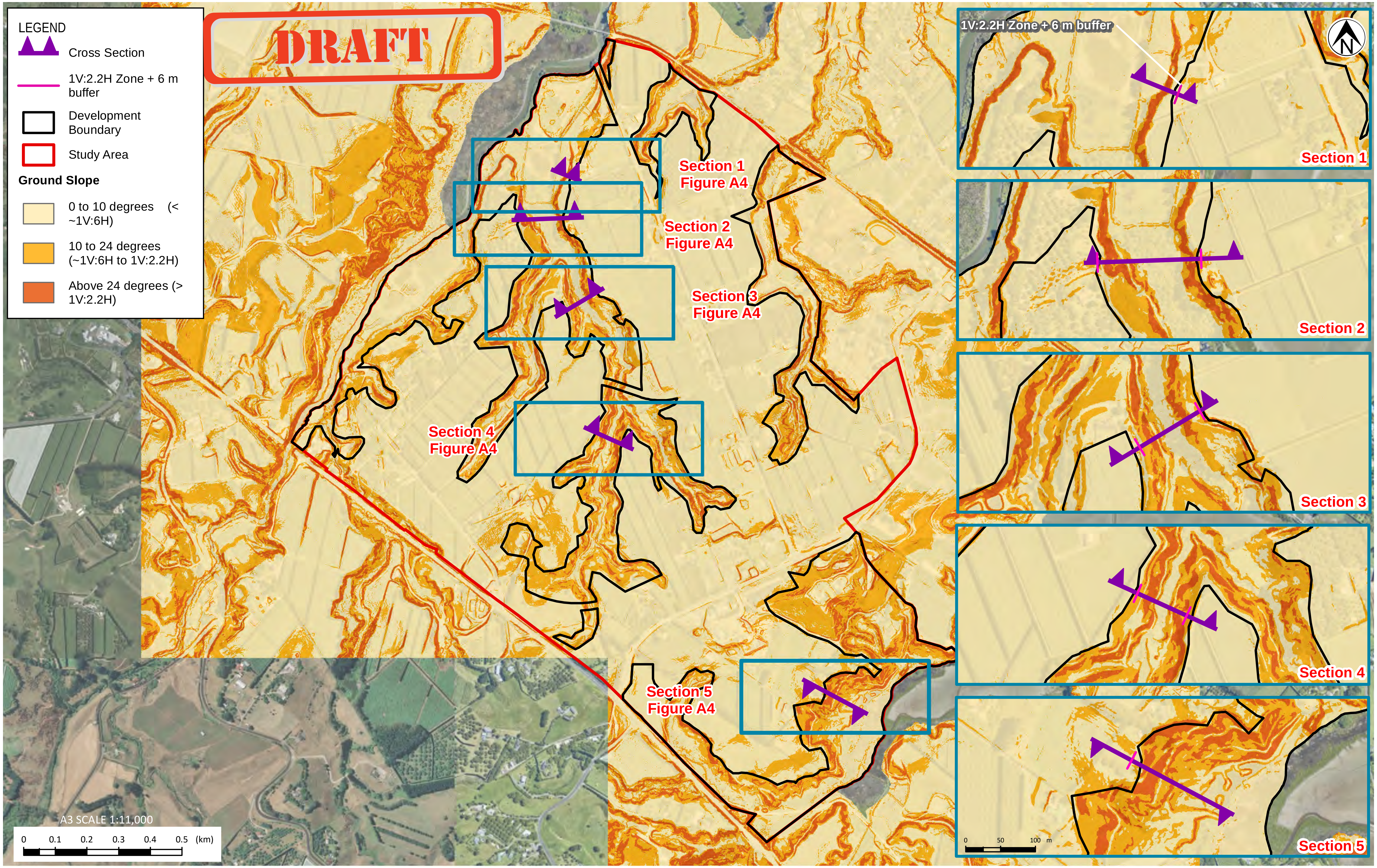


PROJECT No.	1010582.0000	
DESIGNED	GUMC	JUN.20
DRAWN	JORB	JUN.20
CHECKED	DMM	JUN.20
APPROVED		DATE

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT OMOKOROA STRUCTURE PLAN STAGE 3
TITLE HIGH LEVEL SLOPE STABILITY HAZARD ASSESSMENT BOUNDARY OF PROPOSED DEVELOPMENT OVERLAID ON 2015 LIDAR

SCALE (A3) 1:11,000 FIG No. FIGURE A1 REV 0

T:\Tauranga\Projects\1010582\WorkingMaterial\GIS\Map_Documents\1010582_FIGA2_080620.mxd 2020-Jun-08 12:09:42 PM Drawn by GUMC



Tonkin+Taylor
Exceptional thinking together www.tonkintaylor.co.nz

NOTES: Basemap: Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand license.
Project specific geotechnical Investigations sourced from the New Zealand Geotechnical Database and other geotechnical investigations (Hand Augers) sourced from the 70A Francis Road Central Land Information Memorandum.
Horizontal Datum: New Zealand Transverse Mercator, Vertical Datum: NZVD 2016.
Slope is based on 2015 LiDAR

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	JORB	YYYY	21/05/20

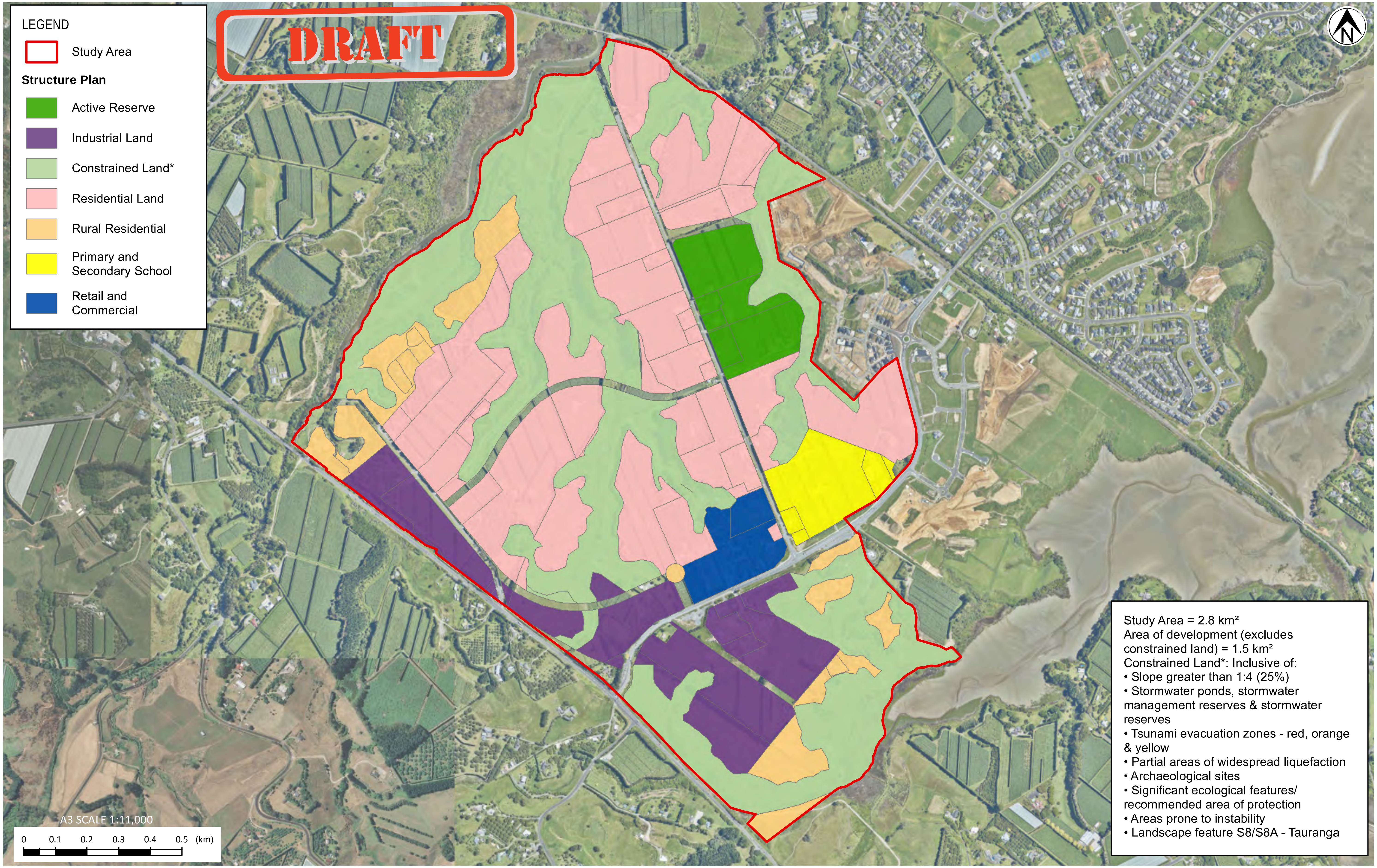
LOCATION PLAN

Tauranga

PROJECT No.	1010582.0000	
DESIGNED	GUMC	JUN.20
DRAWN	JORB	JUN.20
CHECKED	DMM	JUN.20
APPROVED		DATE

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT OMOKOROA STRUCTURE PLAN STAGE 3
TITLE HIGH LEVEL SLOPE STABILITY HAZARD ASSESSMENT BOUNDARY OF PROPOSED DEVELOPMENT OVERLAID ON GROUND SLOPES

SCALE (A3) 1:11,000 FIG No. FIGURE A2 REV 0



Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

NOTES: Basemap: Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence
Project specific geotechnical Investigations sourced from the New Zealand Geotechnical Database.
Structure Plan layout is based on the structure plan file provided by WBOPDC within email from T. Clow to G. McDougall dated 19/03/2020 Subject: RE: Omokoroa Structure Plan Stage 3. File name: Preferred Option CAD Format - MASTER COPY do not alter.dwg

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	JORB	YYYY	02/06/20

LOCATION PLAN: Tauranga

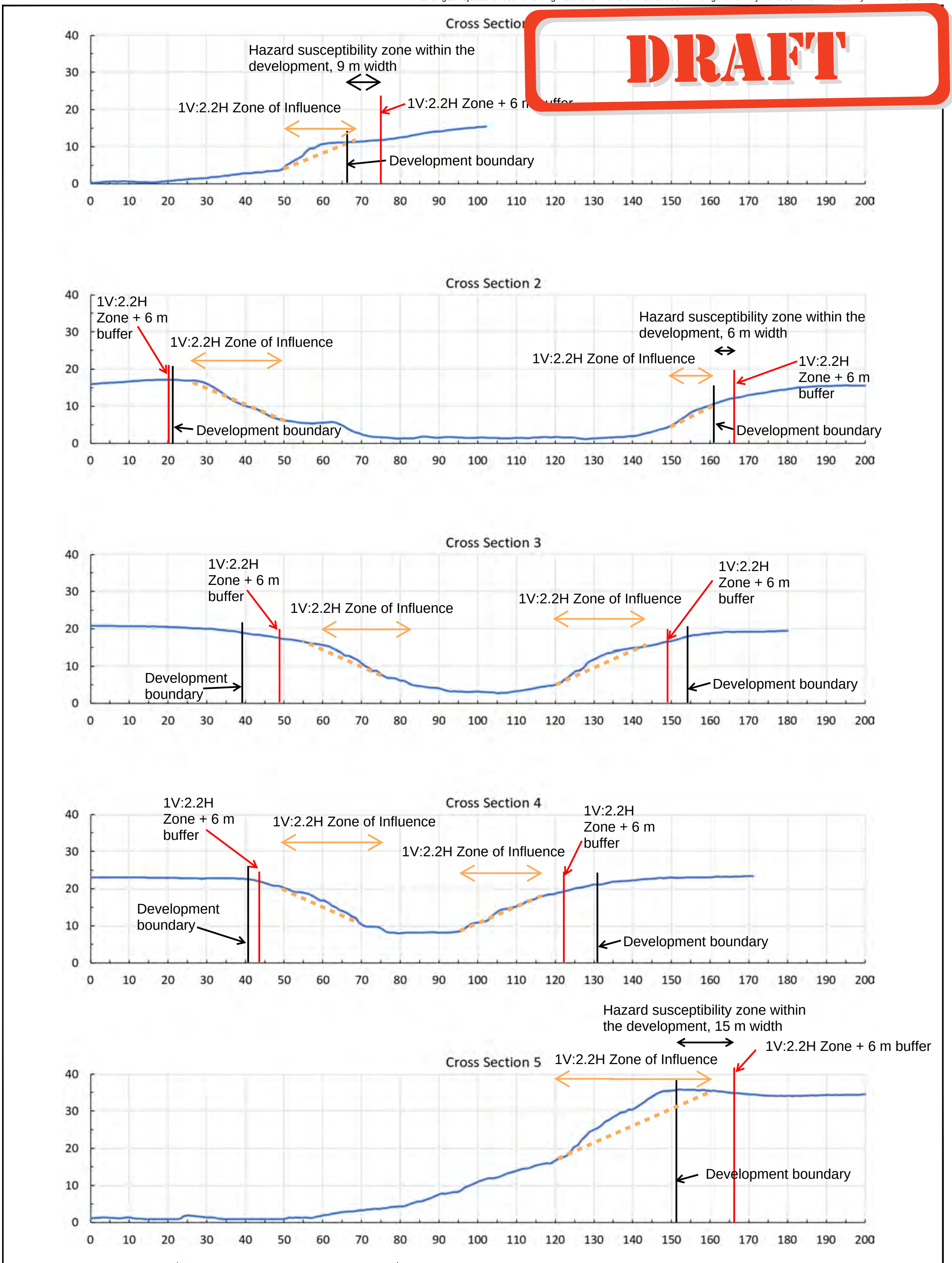
PROJECT No.	1010582.0000	
DESIGNED	GUMC	JUN.20
DRAWN	JORB	JUN.20
CHECKED	DMM	JUN.20
APPROVED		DATE

CLIENT **WESTERN BAY OF PLENTY DISTRICT COUNCIL**

PROJECT **OMOKOROA STRUCTURE PLAN STAGE 3**

TITLE HIGH LEVEL SLOPE STABILITY HAZARD ASSESSMENT STRUCTURE PLAN AREA

SCALE (A3) 1:11,000 FIG No. FIGURE A3 REV 0



Tonkin+Taylor
www.tonkintaylor.co.nz
Exceptional thinking together

PROJECT No.	1234567.1000	
DESIGNED	GUMC	May.20
DRAWN	GUMC	May.20
CHECKED	MLO	May.20
APPROVED		DATE

CLIENT WETSERN BAY OF PLENTY DISTRICT COUNCIL

PROJECT OMOKOROA STRUCTURE PLAN STAGE 3

TITLE HIGH LEVEL SLOPE STABILITY HAZARD ASSESSMENT GROUND PROFILE CROSS SECTIONS, 1V:2.2H

SCALE (A4) AS SHOWN FIG No. A4 REV 1

6 April 2018

1 Fairway Drive, Avalon
Lower Hutt 5010
PO Box 30368
Lower Hutt 5040
New Zealand
T +64-4-570 1444
F +64-4-570 4600
www.gns.cri.nz

Natural Hazards Advisor
Bay of Plenty Regional Council Toi Moana
PO Box 364
Whakatāne 3158, New Zealand

Attention: Mark Ivamy

Dear Mark Ivamy,

Interim results on active faults around the Omokoroa-Katikati development sites, Tauranga

1.0 SUMMARY

To assess the potential presence or absence of active faults at the Katikati and Omokoroa development sites, we: reviewed the existing published and unpublished literature and maps of the area; reviewed 1940s and 1960s aerial photographs (NZ Aerial Mapping, see references for list); and analysed the landforms from a digital elevation model derived from Light Detecting and Ranging (LiDAR) data (provided by Bay of Plenty Regional Council).

The Katikati site overlies mostly old river deposits (Tauranga Group; 128,000 years to 2 million years old), with parts of the sites overlying low terraces containing younger river sediments (Holocene; 0 to ~12,000 years) (Figures 1 and 2). The Omokoroa site overlies both Tauranga Group sediments and volcanic rock (aged around 2 million years) (Figures 1 and 2). Prior to this study, no active faults at those sites had been identified through geological mapping (Edbrooke, 2001; Heron, 2014) and active fault mapping (New Zealand Active Fault Database, Langridge et al., 2016).

We cannot identify any geomorphic features in the landforms at either the Katikati or Omokoroa sites that can be classified as active faults. There may be old faults (such as the Tuapiro Fault; Figure 1) that are buried beneath the sediments and volcanic rock at these sites, but these would not likely have ruptured in at least the last 128, 000 years, as the surfaces of that age does not seem to be displaced by any faults.

There are also no known offshore faults near the development sites (Lamarche and Barnes, 2005).

1.1 GEOLOGY

The Omokoroa and Katikati development sites lie within the Tauranga basin, a depression which has been infilled with river and estuarine sediment, ignimbrite and volcanic-derived sediment since around 2 million years (Brathwaite & Christie 1996, Briggs et al. 1996).

The development sites at Omokoroa and Katikati are flanked to the west by the Kaimai Range, which comprises volcanic rocks that erupted nearby around 2-5 million years ago (Coromandel Group). The sites themselves overlie fluvial sediments of gravel, sand, silt and loess (Tauranga Group) that were deposited between 2 million years and around 128,000 years ago (see Figure 1). The Omokoroa development site overlies both Tauranga and Coromandel group rocks.

1.2 KATIKATI SITES

The western-most site at Katikati is located on higher hill terrain of alluvial fan sand and silt that is composed mostly of older Tauranga Group sediment aged between around 500,000 and 128,000 years old, with a smaller section of the site located on a Holocene valley (~12,000 years old or younger). The eastern sites overlie topographically lower hill terrain that is composed of younger Tauranga Group alluvial sediments of sand and silt; although the absolute maximum age of these sediments are 2 million years it is likely to be younger than those of the western-most Katikati development site but not younger than 128,000 years.

The closest known mapped faults to the Katikati development site is the Tuapiro Fault, which lies about 600 m west to the west of the sites (Figure 1); it is a concealed fault the location of which is inferred from the presence of warm springs, a steep gradient in Bouguer gravity data and absence of sediments in drillholes to the west of the fault (Brathwaite & Christie 1996). We do not see the surface expression of this fault on the digital elevation model generated from LiDAR data and the aerial photos; this implies that the Tuapiro fault and any other potentially buried fault in the area have not ruptured the ground surface in the last 128,000 years.

1.3 OMOKOROA SITE

The development site at Omokoroa overlies Coromandel Group ignimbrite (2-5 million years) and Tauranga Group (2 million years to 128,000 years) alluvial gravel, sand and silt. The nearest faults to this site are the Tuapiro and Hauraki faults that are 14 km and 16 km to the north and west respectively (Figure 1). Neither of those faults has been described as active in the literature and they do not show recent signs of movement based on our geomorphic study.

We cannot see visible evidence of geomorphic features that can be classified as an active fault at the Omokoroa site or in the surrounding area.

2.0 CONCLUSIONS

We conclude that no active faults have been identified in the present-day geomorphology at both the Katikati and Omokoroa development sites. The buried Tuapiro Fault that lies west of the Katikati site and other potentially buried faults that may lay in close proximity to the sites last moved before 128,000 years ago, and thus are not considered active under the current definition of active faults in the New Zealand Active fault database (Langridge et al, 2016).

3.0 REFERENCES

Brathwaite RL, Christie AB. 1996. Geology of the Waihi area: part sheets T13 and U13 [map]. Lower Hutt (NZ): Institute of Geological & Nuclear Sciences. 1 folded map + 64 p., scale 1:50,000. (Institute of Geological & Nuclear Sciences geological map; 21).

Briggs RM, Hall GJ, Harmsworth GR, Hollis AG, Houghton BF, Hughes GR, Morgan MD, Whitbread-Edwards AR. 1996. Geology of the Tauranga area: sheet U14 [map]. Hamilton (NZ): University of Waikato. 1 folded map + 57 p., scale 1:50,000. (Occasional report / Department of Earth Sciences, University of Waikato; 22).

Edbrooke SW. 2001. Geology of the Auckland area [map]. Lower Hutt (NZ): Institute of Geological & Nuclear Sciences Limited. 1 folded map + 74 p., scale 1:250,000. (Institute of Geological & Nuclear Sciences 1:250,000 geological map; 3).

Heron DW, custodian. 2014. Geological map of New Zealand 1:250,000. Lower Hutt (NZ): GNS Science. 1 CD. (GNS Science geological map; 1).

Lamarche G, Barnes PM. 2005. Fault characterisation and earthquake source identification in the Offshore Bay of Plenty. Wellington (NZ): NIWA. Client Report No.: WLG2205-51.

Langridge RM, Ries WF, Litchfield NJ, Villamor P, Van Dissen RJ, Barrell DJA, Rattenbury MS, Heron DW, Haubrock S, Townsend DB; et al. 2016. The New Zealand Active Faults Database. New Zealand Journal of Geology and Geophysics. 59(1):86-96. doi:10.1080/00288306.2015.1112818.

New Zealand Aerial Mapping photos 1940s: Run and photo numbers - 3000 (19-25), 3001 (18-25), 3002 (18-27), 3006 (15-22)

New Zealand Aerial Mapping photos 1960s: Run and photo numbers - 499 (33-40), 495 (33-43), 493 (84-91), 498 (28-36)

Yours sincerely

Julie Lee
Scientist

Pilar Villamor
Senior Scientist

This report was undertaken by Julie Lee and Pilar Villamor. It was internally reviewed by Rob Langridge.

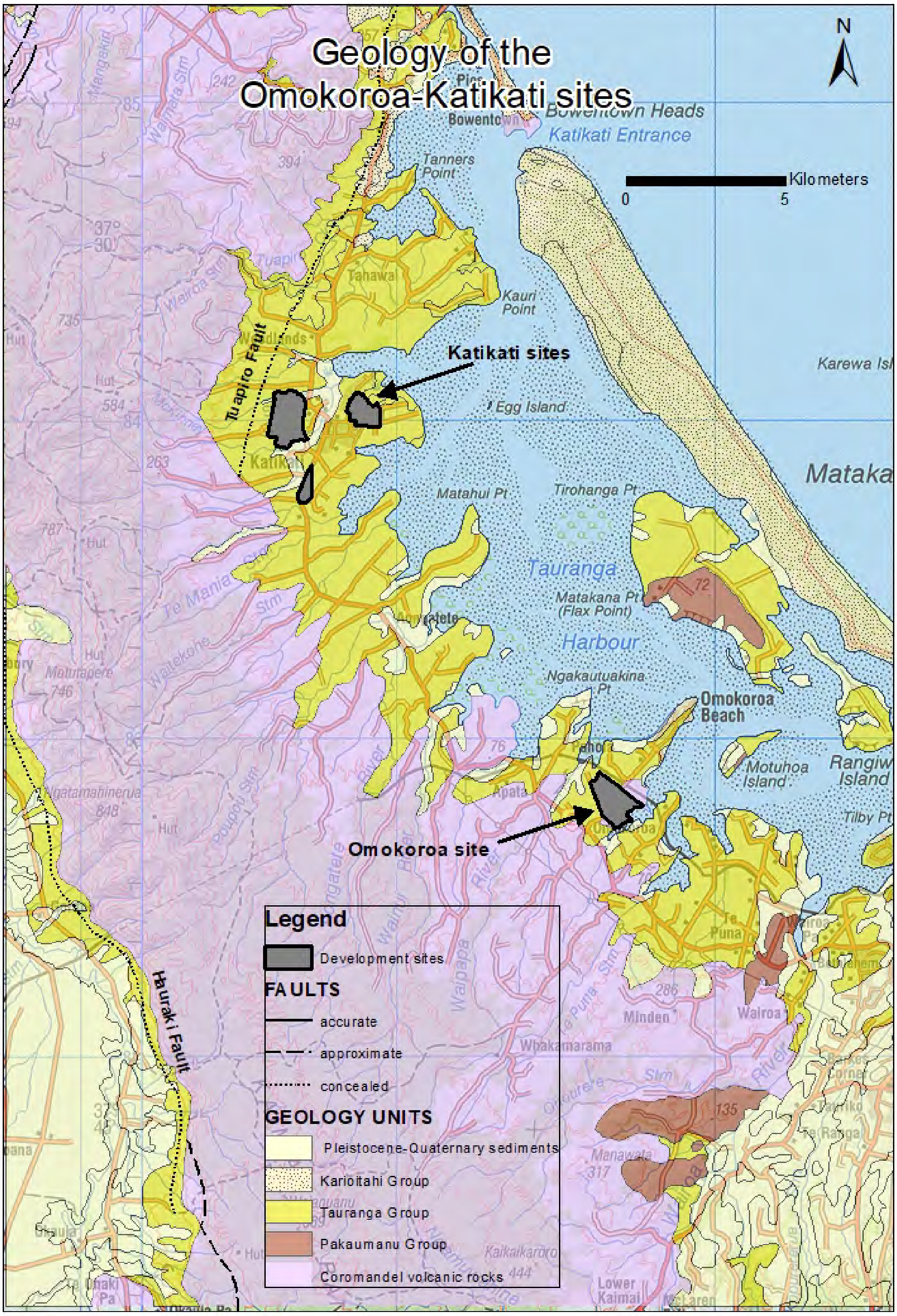


Figure 1 A generalised geological map of the area surrounding the Katikati and Omokoroa development sites (grey polygons). Volcanic rock of ignimbrite, lava flows, domes and other volcaniclastic sediment (2-5 Million years) form the Kaimai Range, which is bound to the west by the Hauraki Fault. Most of the volcanic rock was sourced from the Coromandel area although there are some outcrops of Pakaumanu Group ignimbrite that originated from Taupo area. The Tauranga Basin refers to the area east of the Kaimai Range where younger 2 Million years to 128,000 year old alluvial sediment infilled the depression. The geology and ages of the geological units are from Heron (2014).

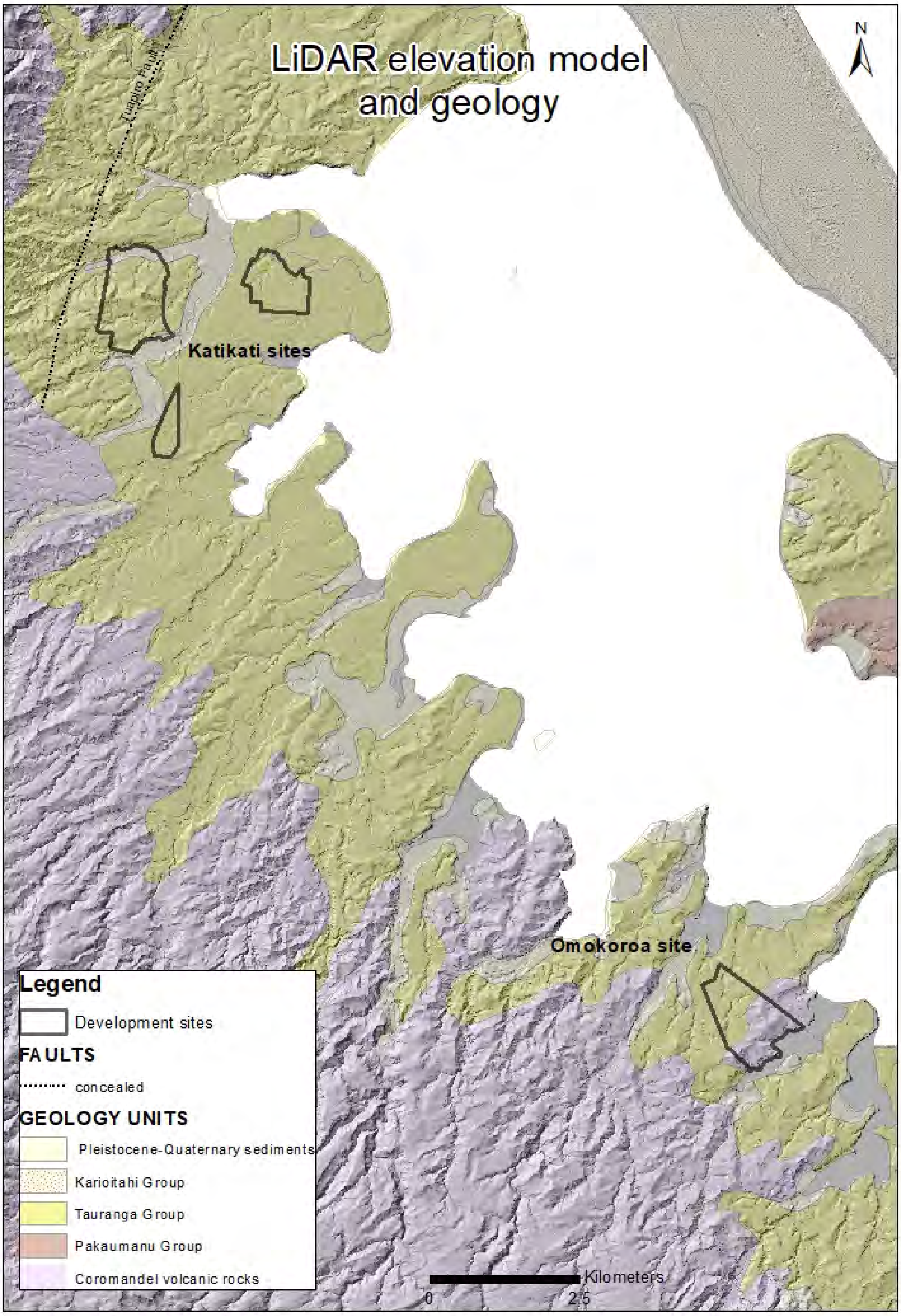


Figure 2 A 2 m LiDAR elevation model with geology for the Omokoroa and Katikati development sites. The landforms show the Coromandel volcanic rocks (purple) dip down towards the coast. Younger fan and river sediments (dark and light yellow) are deposited where streams and rivers carry their bedload downstream. There is no evidence of active faulting (recent displacement of the ground surface by faults) at the study sites. The geology is from Heron (2014).

Natural Hazard Risk Assessment

for:

Seddon Street Development,

Te Puke,
Western Bay of Plenty

Lot 1 DPS 31556 and Lot 4 DPS 39737 - RT SA40C/561

Developed for: Lyndon Marshall

Generation Homes Tauranga

Our Ref: 31327-02

Prepared by: Shrimpton & Lipinski (S&L)

Shrimpton and Lipinski Limited Partnership (S&L)
94 Grey Street, Tauranga 3110
Telephone: 07 577 6069 Email: info@sltga.co.nz

Shrimpton & Lipinski Ltd Partnership

Document Control Record

PROJECT RECORD

Client	GENERATION HOMES (TAURANGA)
Project	Seddon Street Development
S & L Project No.	21-31327-02
S & L Document No.	21-31327-02 – Risk Assessment

ISSUE AND REVISION RECORD

Date of Issue	08-11-2021
Status	Final
Originator	Chris Hammerich
Reviewed	Paul Howard
Approved for Issue	Paul Howard
Telephone	07 577 6069
Email	chammerich@sltga.co.nz

Contents

Appendices

1.0 Executive Summary

Seddon Street Limited Partnership (in conjunction with Generation Homes) is currently undertaking a private plan change to Residential Zoning to carry out a multi-lot residential subdivision at Seddon Street in Te Puke. Concept plans show a potential for the creation of over 120 residential and medium density allotments, with road access to Seddon Street and Harris Street, including a playground and stormwater management areas.

Meetings have been held with both the Bay of Plenty Regional Council and Western Bay of Plenty District Council to discuss the development. The feedback from the Councils is generally positive with the normal topics discussed.

Some of the more significant issues discussed were:

- Post development stormwater runoff is to be 80% that of pre-development.
- Consideration will be needed for the floodplain that lies along the western boundary. Design around this area will impact on the stormwater storage required, if any existing 'flood plain' area is reduced. Flood levels cannot be provided until the Regional Council has completed hydraulic modelling for the area.
- It has been determined that stormwater management will require more land take than the concept plans indicate.
- Water take allowance for development purposes (dust control etc…) is very limited – a chemical solution may be required.
- We are advised the development falls outside of the Western Bay of Plenty's Comprehensive Stormwater Consent so a separate consent will be needed.
- A comprehensive plan will be required considering future development within the area.
- The downstream wastewater reticulation system is at capacity in some areas. Western Bay of Plenty District Council development programmes will need to consider Council system upgrades which are planned for 2023. Council is happy to work with the developer in this matter. Pump stations and upgrades may be required.
- Regional Council still has not provided minimum floor levels; this will dictate earthworks quantities. Regional Council has stated they will need more detail before providing these.
- A Private Plan Change will be required to have the development zoned as residential.

Pending final geotechnical testing, NES reviews of the property and finalised flood details from the Regional Council, S&L considers the initial concept for the property can support the proposed plan change and development.

2.0 Site Description

The subject site is legally described as Lot 1 DPS 31556 and Lot 4 DPS 39737 held in Computer Freehold Register SA40C/561. It is a Fee Simple Title and consists of 6.1235 hectares more or less. The site is legally owned by CLM Trustees 2018 Limited and Alistair Henry Lawler.

The subject site also includes a portion of neighbouring Lot 1 DPS 39737 held in Computer Freehold Register SA40C/562, which is expected to be subdivided and allotments included within the subject site for access to Seddon Street and for stormwater management purposes. This Title is legally owned by Mavis Beverley Lawler.

The subject site is depicted as Figure 1 below.

Figure 2.1: Lot 1 DP 31556 of the Subject Site (boundaries are approximate) – Seddon Street, Te Puke

The subject site extends to Seddon Street in the south west corner and hence would gain access to Seddon Street and also has a potential connection to Harris Street.

With respect to the topography, the site falls approximately 6m in elevation east to west, and 2m in elevation south to north. Flood risk area is identified in the south-west corner of the site and up the western boundary. Flood risk area is also identified along the northern and western boundaries where the boundary line appears to extend along a natural rise in the landform.

The site is located entirely within the boundaries of the Western Bay of Plenty District Council.

3.0 Summary of findings

With consideration of the geotechnical investigation completed by ENGeo (refer 'table 6, Natural hazards Summary' below) this review has determined that, based on data shown within the WBOPDC GIS, the following natural hazards do not affect the areas of proposed development within the site:

- Earthquake – Fault Rupture.
- Tsunami.
- Coastal erosion.
- Coastal/Harbour inundation.

Consequently, this risk assessment is based on the consequences to buildings resulting from:

- Flooding (including floor height)
- Instability/settlement
- Liquefaction
- Assessment of life line utilities

1. Flooding/Floor Height

An assessment has been undertaken with the following assumptions about future building floor levels within the site, based on the Building Consent Authority (BCA) imposing the mandatory regulatory controls contained in the New Zealand Building Code (NZBC):

- In areas where there is a 2% AEP flood extent, buildings will have floor levels set 500 mm above the 2% AEP water level (based on NZBC Verification Method E1/VM1 Clause 4.3.1 to meet NZBC Clause E1.3.2), or 150 mm above surrounding ground (based on NZBC Acceptable Solution E1/AS1 Clause 2.0.1). We have assumed the BCA would apply the most stringent/higher of the two controls.
- In areas where there is no 2% AEP flood extent, buildings will have floor levels set 150 mm above surrounding ground level (based on NZBC Acceptable Solution E1/AS1 Clause 2.0.1).

Based on the BCA applying these two controls for the setting of building floor levels on site, potential functionally compromised buildings have been estimated. This estimation has been based on the proportion of proposed development areas where either:

- Flood depth is greater than 150 mm; or
- Water level is higher than the 2% AEP water level + 500 mm (freeboard) and flood depth is greater than 150 mm (e.g., Case 1 below).

The outcome of the flooding and floor height hazard risk assessment for the Seddon Street Development is that the resultant risk level is 'Low'. When detailed design is undertaken there is potential to further reduce the level of risk associated with rainfall induced flood hazard by establishing easements for overland flowpaths or locating these within road corridors and by removing areas of ponding or incorporating these into public open spaces.

As the proposed development is within the BOPRC managed Kaituna Catchment Control Scheme the BOPRC has indicated that the following conditions will need to be imposed on the development during the consenting stage;

- On-site detention will be provided to prevent an increase in volume of the runoff from the site in a 72-hour 100 year including climate change rain event.

- The post development runoff shall be limited to a minimum standard of 80% of the pre-development discharge for multiple design rain events (for example and to be confirmed, 2-, 10-, 50- and 100-year events)

- All floodwater displacement volumes up to the 100 year 72-hour climate event shall be 100% mitigated.

Currently the BOPRC has no flood level assessment for this property. Hydraulic modelling of the Kaituna River and flood plain is currently underway with no results available at this point of time. BOPRC has advised that the results of the hydraulic modelling may be available later this year.

The proposed stormwater ponds and associated stormwater management strategies (refer to the Engineering Assessment report) shown on the concept plans will be designed such that the three conditions above can be complied with once the flood levels have been derived from the hydraulic modelling.

2. Instability/settlement

The site investigation results as outlined in section 4.2.1 of the geotechnical investigation, identify areas within the site as being fill material overlaying peat deposits. These locations are predominantly along the edges of the open drain running along the western edge of the development and considered to be fill within the historical channel (refer Figure1 within the geotechnical investigation document).

It is this area that may be prone to instability and settlement.

To mitigate this the earthworks within the site will be designed such that the unsuitable material will be removed and replaced with engineered fill (predominantly from other areas within the site) and the drain edge confined with an environmentally aesthetic Mechanically Stabilised Earth retaining wall (MSE).

3. Liquefaction

Liquefaction, as referred to in section 5.3 of the geotechnical investigation document, is considered low risk with minimal lateral spreading expected. It is noted that the specific geotechnical report holds precedence over the WBoPDC GIS information.

The site will also be reviewed as part of the building foundation design criteria which may mitigate this further should that be required.

4. Lifeline Utilities

S&L have not assessed in detail the risk level for “lifeline utilities” and “health and safety” within the site because due to the detailed design for underground services and roading not being completed to date. S&L have not approached the utility providers to gain input at his stage. The site is currently zoned rural and a Structure Plan does not exist for this area.

A high level assessment of the level of consequence of disruption of lifeline utilities has incorporated a review of the natural hazard risk. This covers:

- Flooding – the utility providers will design their equipment for worst case scenarios to mitigate any outage from flooding. Any areas at higher risk from flooding will be recognised and highlighted in the design request. These will also have suitable overland flow paths nominated to further reduce risk to assets.
- Instability – areas of recognised instability will be removed and mitigated through engineered solutions. This is predominantly adjacent to the drain and utilities will also avoid this area.
- Liquefaction – this is considered a low risk in this area and will be mitigated via the providers design.

As this proposed development is directly adjacent to the existing urban infrastructure of the Te Puke township and the lifeline utilities will connect to the existing utilities it is expected that the levels of consequence of disruption will be at the same level as the existing utilities.

Table 6: Natural Hazards Summary

Natural Hazard	Applicable to Site	Mitigation / Comment
Land below minimum building platform level	Yes	Land to be developed to achieve minimum development levels.
Specific design of stormwater disposal	Yes	Overland flow will be directed to site specific stormwater system, along with all water from roads and houses. Stormwater system is subject to detailed design and engineering approval. Site is not considered suitable for universal site wide in-ground soakage application. Refer section 6.7.
Stormwater sensitive	Yes	
Overland flows	Yes	
Coastal Flooding	Yes	Land to be developed to achieve minimum development levels.
Harbour inundation	No	Land situated between 9 m RL and 4 m RL.
Slope instability	Yes	Refer to section 6.1
Settlement	Yes	Refer to section 5.5 & 6.3
Liquefaction	Yes	Refer to section 5.3 & 6.3
Falling debris	No	N/A

Please note, references in the above table are to the geotechnical report for the Seddon Street development.

4.0 Hazard Susceptibility Maps

Hazard susceptibility mapping has been undertaken by various consultants as separate studies to inform this risk assessment undertaken by S&L for the Seddon Street Development. Hazard susceptibility maps have been included for earthquakes (fault rupture), tsunami, coastal inundation, coastal erosion and rainfall-induced flooding hazards.

<u>Earthquake</u>

- No hazard susceptibility map has been produced for fault ruptures at the site. The map below exported from the GNS website shows there are no known active faults within or close proximity to Te Puke.

Figure 4.1: GNS – Active Faults

Tsunami

- Tsunami and coastal Inundation – The map below exported from the WBOPDC GIS shows no reference to Tsunami or Coastal Inundation for the Seddon Street Development.

Figure 4.2: WBOPDC GIS – Tsunami and Coastal Inundation

Coastal Erosion

- Coastal Erosion – The map below exported from the WBOPDC GIS shows no reference to Coastal erosion for the Seddon Street Development.

Figure 4.3: WBOPDC GIS – Coastal Erosion

Flooding

- Rainfall-induced flooding – The map below exported from the WBOPDC GIS shows the floodable areas adjacent and within the proposed Seddon Street Development.

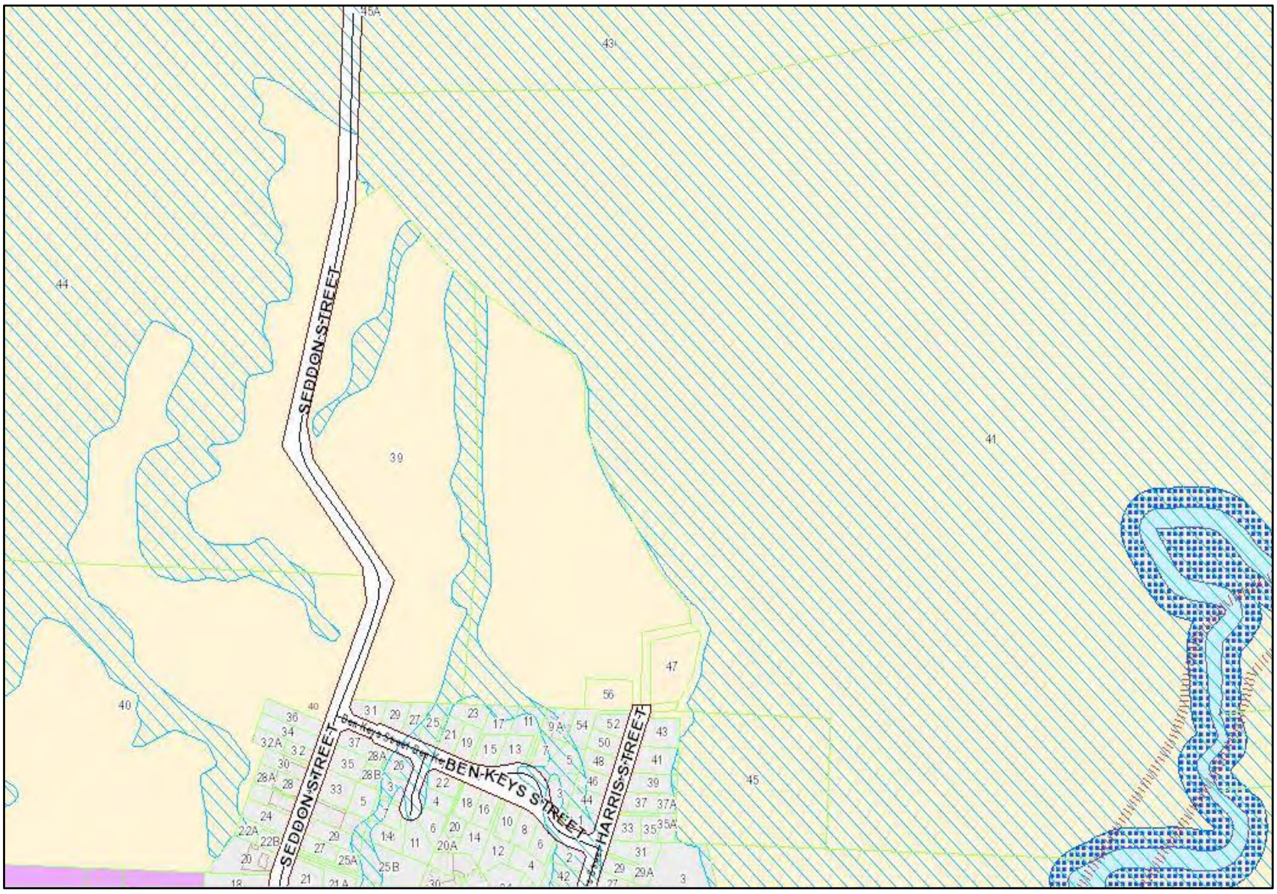


Figure 4.4: WBOPDC GIS – Floodable Areas

Figure 4.5: WBOPDC - Flood Levels

Liquefaction

- Earthquake - Liquefaction – The map below exported from the WBOPDC GIS shows the potential for liquefaction as "Moderate" (LIQHAZVAL: 4) within the proposed Seddon Street Development. The geotechnical report that will be performed over the site will provide recommendations for building foundations at the completion of subdivision earthworks and field testing.
- Note that the specific Geotechnical report considers the liquefaction risk specific to the Seddon Street site as low.

Figure 4.6: WBOPDC Liquefaction zones

The hazard susceptibility maps above indicate that rainfall-induced flooding and liquefaction are the only significant hazards (mapped) that potentially affect the areas of proposed development within the site.

5.0 Methodology

5.1 General

The natural hazard risk assessment for the Seddon Street Development has been undertaken in accordance with Appendix L of the RPS.

5.2 Events Assessed

The risk screening matrix in Appendix L assigns a risk level based on consequence and likelihood. The event likelihoods that have been used in the risk assessment for rainfall-induced flooding are based on Table 20 of the RPS (refer Figure 5.1).

Hazard	Column A: Likelihood for initial analysis AEP (%)	Column B: Likelihood for secondary analysis	
		AEP (%) - More likely	AEP (%) - Less likely
Volcanic hazards (including geothermal)	0.1	0.2	0.005
Earthquake (liquefaction)	0.1	0.2	0.033
Earthquakes (fault rupture)	0.017	0.2	0.005
Tsunami	0.1	0.2	0.04
Coastal erosion	1	2	0.2
Landslip (rainfall related)	1	2	0.2
Landslip (seismic related)	0.1	0.2	0.033
Flooding (including coastal inundation)	1	2	0.2

Figure 5.1: Likelihoods for risk assessment (Table 20 in the RPS)

5.3 STORMWATER ASSESSMENT

Stormwater modelling is currently underway by the Bay of Plenty Regional Council as per the correspondence in appendix 2. It is noted that the stormwater modelling would include analysis for the 1% AEP 100 year and include the 100-year climate change.

When the stormwater modelling has been completed and flood levels are known the development will be designed to these parameters. Stormwater ponds will be designed to attenuate the discharge from the proposed development such that downstream effects are managed.

In areas where there is flooding, buildings will have floor levels set 500 mm above the water level (based on NZBC Verification Method E1/VM1 Clause 4.3.1 to meet NZBC Clause E1.3.2), or 150 mm above surrounding ground (based on NZBC Acceptable Solution E1/AS1 Clause 2.0.1). We have assumed the Building Consent Authority would apply the most stringent/higher of the two controls.

In areas where there is no flooding, buildings will have floor levels set 150 mm above surrounding ground level (based on NZBC Acceptable Solution E1/AS1 Clause 2.0.1).

Given these two controls for the setting of future building floor levels it would not be possible for buildings to be functionally compromised provided the regulatory controls of the NZBC are adopted.

6.0 Conclusions

The outcome of the natural hazard risk assessment for the Seddon Street Development has deemed the resultant risk level as 'Low'. Through the future detailed design of landform, road and reserve areas within the Proposed Structure Plan area there is an opportunity to further reduce the level of risk associated with rainfall induced flood hazard. This opportunity relates to the identification of overland flow-paths and ponding areas and then:

- Locating these within roading corridors and/or public reserves.
- Locating these in private land in areas not required for building, access etc and then creating appropriate easements or similar instruments over these areas to ensure they can continue to function effectively on an ongoing basis.

Earthworks associated with the development of the site have the potential to change the flood hazard prediction by the modelling work currently underway and the conclusions of this risk assessment.

7.0 Applicability

This report has been prepared for the exclusive use of our client Generation Homes (Tauranga), 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 understand and agree that this report will be used by WBOPDC in connection with development of the Seddon Street Development.

Shrimpton and Lipinski Limited Partnership

Report prepared by:	Report Authorised by:
Chris Hammerich	Paul Howard
Project Manager	Client Principal

APPENDIX 1

Property Maps

Figure 1: Aerial and locality

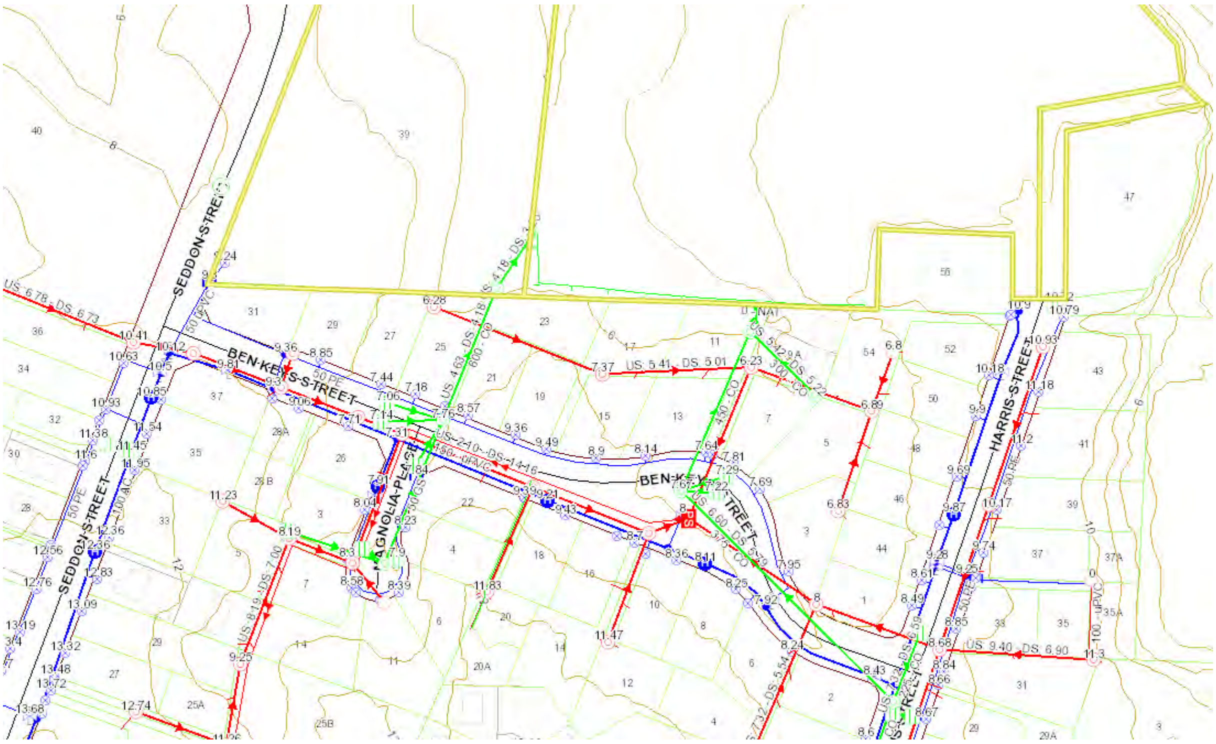


Figure 2: Utilities along surrounding streets to the South

Land Specialists
Your Property, Our Environment

APPENDIX 2

BOPRC Correspondence

BAY OF PLENTY REGIONAL COUNCIL TOI MOANA

Our Ref: ENG- 639337

31 March 2021

Paul Howard
Shrimpton and Lipinski Ltd
phoward@sltga.co.nz

Dear Paul,

Re: Flood level query

I have reviewed the information we have available for Lot 1 DPS31556 Seddon Street, Te Puke. The location of the area investigated by the desktop study is outlined in the attached map. Please note that the area of investigation (highlighted) does not reflect the property boundaries.

The elevation of the land within the proposed property development boundary generally ranges between 2.2 m and 11.0 m RL (Moturiki Datum 1953). The first map shows the elevation of the land (from the Digital Elevation Model); with the lower elevation represented by the yellow colour. The lower lying parts of the property are within the floodable area as identified in the District Plan, shown in the second map.

In general, the area is protected from flooding from the Kaituna River and its tributaries by stopbanks that are designed to contain a 1% Annual Exceedance Probability (AEP) event. The stopbanks do offer protection from the design storm event but associated risks include stopbank failure and events that exceed the design capacity. Another potential source of flooding is local stormwater/surface water and the nearby drains.

Flood level

The Bay of Plenty Regional Council has no flood level assessment for this property. Hydraulic modelling of the Kaituna River and flood plain is currently underway but no results are available at this point in time. We can therefore not quantify how frequently the property is expected to flood or what the flood level would be. Results are expected to be available later this year.

It is advised to limit any development to the well elevated parts of the property and keep development away from the low lying land.

Please note that there are significant parts of the low lying land shown as floodable on the Western Bay of Plenty District Plan maps. The areas shown hatched in the second map below are not the 1% AEP floodable areas and certainly would not include 100 years climate change.

Additionally, if an identified house site is located within an overland flow path, the design 1% AEP flood level should be set a minimum of 0.5 m above general ground level and the building should not obstruct any existing flow paths. This level includes an allowance for estimate imprecision and phenomena not explicitly included in the calculations. This requirement is not applicable to those house sites located on ridges.

BOPRC ID: A3768192

This is not a guarantee that any new dwelling will not be affected by flooding. It is also possible that in the future, the flood levels may be superseded by more up-to-date information. The information in this letter is valid for one year from the letter date.

Minimum Floor Level

Minimum Floor Levels are set by Territorial Authorities with consideration to the New Zealand Building Code, the Resource Management Act, the applicable District Plan and the latest information available. Please contact Western Bay of Plenty District Council for the Minimum Floor Level for this property.

Please contact me if you have any further questions.

Yours sincerely

Rachael Medwin
Engineering Hydrologist

BOPRC ID: A3768192

3

BOPRC ID: A3768192