Kainga Ora – Homes and Communities

6 Teitei Drive, Ohakune

Hydrology Assessment

220528
8 March 2023

Kainga Ora – Homes and Communities

6 Teitei Drive, Ohakune

Hydrology Assessment

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3. Hydrological & Hydraulic Calculations
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1. INTRODUCTION

1.1. Purpose of Report

Cheal Consultants Limited (Cheal) has been engaged by Kainga Ora – Homes and Communities (the client) to carry out a hydrology assessment at 6 Teitei Drive, Ohakune, in support of a proposed multi lot residential development.

This report summarises the hydrology assessment, presents the predicted flows for the mean annual flow (MAF), 50-yr (for access) and 200-yr (for building levels) storm events and determining the flood risk extents for the 50-yr and the 200-yr storm events as per the NZ Building Code and Horizons Regional Council rules for flood risk. The report assesses site suitability for the proposed development and is intended to support a resource consent application.

Figure 1: Site location plan (OpenStreetMap)

1.2. Scope

Cheal Consultants scope in preparing this report included the following tasks:

- Collate District & Regional Council flood information for the site.
- Undertake hydrological modelling of stormwater for the catchment and determine flood extents for the 50-yr and 200-yr ARI storm events.
- Provide recommendations with respect to flood levels and minimum floor levels for the proposed lots.

Detailed engineering design is excluded from the scope of this report and can be provided at engineering approval stage.

1.3. Site Description

As shown in Figure 1, the site is located approximately 500m to the southeast of the Ohakune town centre and 400m west to the centre of Turoa Village. The Mangateitei Stream is located approximately 230m to the north of the site.

In general, the site comprises flat to undulating topography and is currently used for farming. Access to the site and existing farming infrastructure is off Teitei drive to the north.

The site is bounded to the west by Rochfort Park, to the east by residential development of Turoa Village, to the north by a park reserve area and to the south by farmland. The ground levels are shown in drawing 220528-TP001 Rev. A in Enclosure 1.

The Mangateitei Stream runs east to west until it joins the Mangawhero River which is generally flowing northeast to southwest and is located to the northwest of the site.

As part of the Mangawhero River catchment, the site is located within two hydrology sub catchments. The northern catchment has an area of 17.5ha and the southern catchment has an area of 25.7ha, with the flows from both catchments meeting at the western boundary of the proposed development.

1.3.1. Existing Drainage

Sometime between the years 1967 and 2000, the flow from the northern catchment has been diverted from flowing to the Mangateitei Stream to the north and is now directed to a constructed open channel flowing along the western boundary between the site and Rochford Park.

The southern catchment flow is directed through two open channels that enter the site mid-way along the eastern boundary and the southern end of the eastern boundary. They meet within the site and then traverse from east to west across the site.

These open channels appear to have been constructed with the southern catchment channel being formalised into an overland flow path. Existing channels and flow paths are shown in Figure 2 below.

Within the neighbouring development these channels have been modified, landscaped and planted. Within the site, the channels appear to be minimally maintained and are overgrown with weeds and brush.

The channels have very flat gradients and along with the thick vegetation pooling occurs in the channels which was observed during Cheal site visits. This pooling appears to be temporary and soaks into the ground or evaporates over extended dry periods.

Historic aerial imagery (obtained from Retrolens - https://retrolens.co.nz and Google Earth Pro) identify overland flow paths and lower lying areas to retain water in wetter periods but it appears over time that these areas while still existing have been modified by cultivation and the differing vegetation appears to be based on land usage and maintenance.

Figure 2: Drainage Sketch

1.4. Proposed Development

The proposed subdivision is for a residential subdivision to create approximately 150 lots over three stages of the lot designated as Lot 2 DP 54909. Conceptual options can be found in Enclosure 2.

1.5. Current Stormwater Data

1.5.1. NIWA Flow Data

Flow gauge data for the Mangawhero River has been sourced from NIWAs' New Zealand River Flood Statistics website (https://www.arcgis.com/apps/webappviewer/index.html?id=933e8f24fe9140f99dfb57173087f27d).

NIWA has three river flow gauge sites on the Mangawhero River. One at Hagleys by the Ohakune Oxidation Ponds, one at Pakihi Road Bridge and one at Ore Ore. The data sets were collected for 7, 8 and 52 years, respectively.

Table 2 – NIWA flood frequency flows – gauging sites

	Area (km^2)	2.33-yr	5-yr	10-yr	20-yr	50-yr	100-yr	250-yr	500-yr	1000-yr
Hagleys	70	37.6	46.05	52.93	59.52	68.06	74.45			74.45
Pakiri Road Bridge	138		89.32	108.46	126.81	150.57	168.38	191.82	209.52	227.21
Ore Ore	506	252.57	333.67	399.7	463.57	545.89	607.58	688.80	750.13	811.41

1.6. Recent Flood Events

A high-level search did not yield any information with regard to specific extensive flooding within the site area. There has been extensive flooding around the Ohakune township and to the north of State Highway 49.

2. STORMWATER MODELLING

2.1. Methodology

2.1.1. Existing Drainage Capacity

Autodesk's' Hydraflow Express was used to determine the existing capacities of the northern and southern channels.

Given the overgrown vegetative nature of the unmaintained channels, a Manning's of 0.1 was assumed.

Cross- sections were taken through each channel and a longitudinal gradient of 0.1 % used to make an estimation each channel flow.

It was determined that the northern and southern channels had an existing capacity of 0.2 and 0.85 $m^3 s^{-1}$, respectively.

Calculations can be found in Enclosure 3.

2.1.2. Determining Model Flood Flows

The gauging sites providing calculated flows catchment runoff, from the Mangawhero River adjacent to the site, has been estimated using the method proposed in Flood Frequency in New Zealand (McKerchar & Pearson, 1989) and the gauge sites as a comparative catchment (see Figure 3 for flow measurement locations).

Flow data for the smallest available catchment was obtained from New Zealand River Flood Statistics website (see Figure 3 for locations) and are presented in Tables 3 and 4. Discharge return period curves are presented below in Figures 4 and 5.

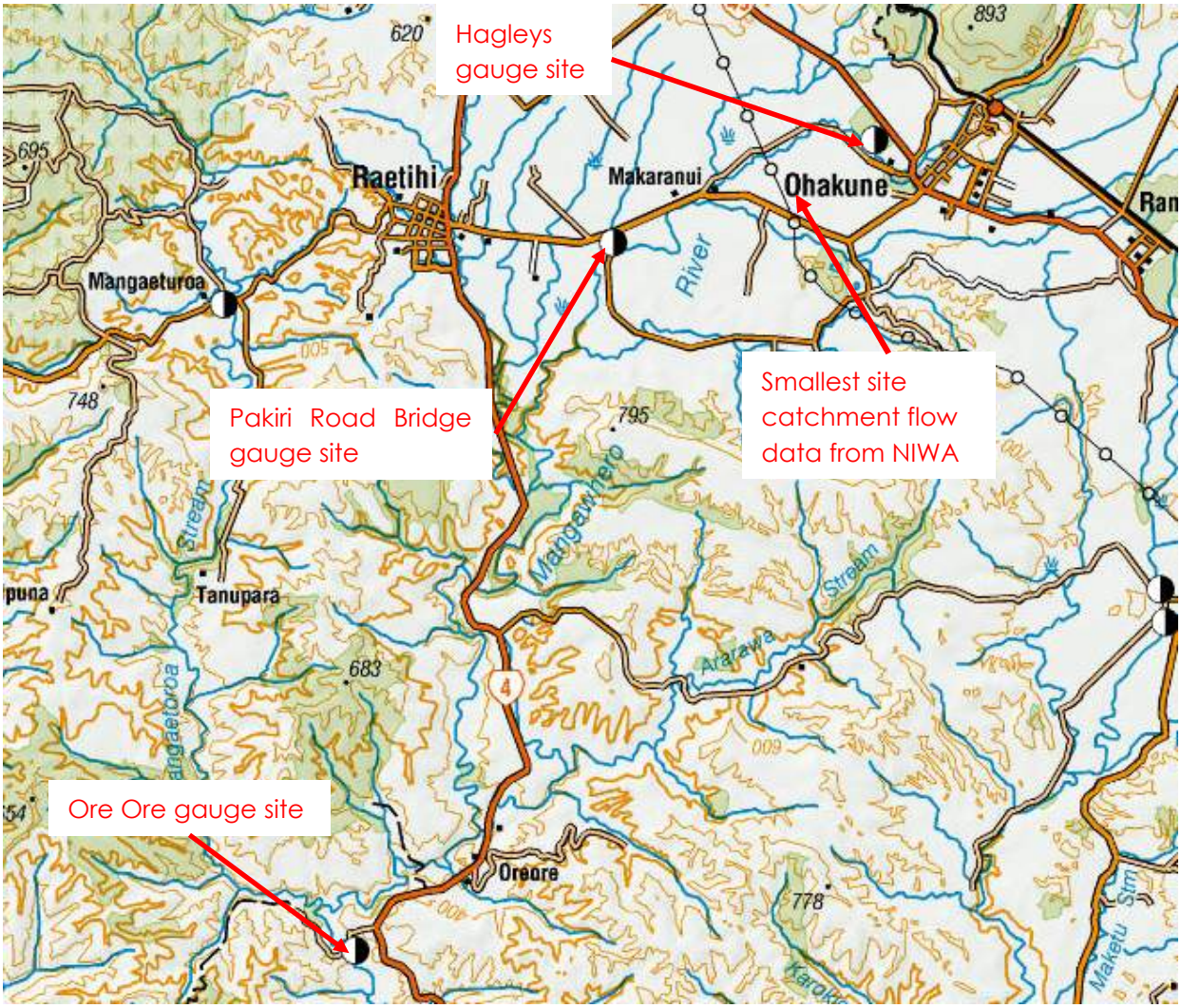

Figure 3 – New Zealand River Statistics flood frequency flow locations

Table 3 – New Zealand River Statistics flood frequency flows (m^3s^{-1}) – Smallest Catchment flow incorporating the site.

Area (km2)	MAF	5-yr	10-yr	20-yr	50-yr	100-yr	1000-yr
1.46	0.70	0.85	0.98	1.10	1.26	1.38	1.77

Table 4 – Calculated model flows (m^3s^{-1}) for the catchments of the northern and southern open channels.

Channel	Area (km2)	2.33-yr	5-yr	10-yr	20-yr	50-yr	100-yr	1000-yr
Northern	0.175	0.13	0.16	0.18	0.21	0.24	0.26	0.33
Southern	0.257	0.17	0.21	0.24	0.27	0.31	0.34	0.44

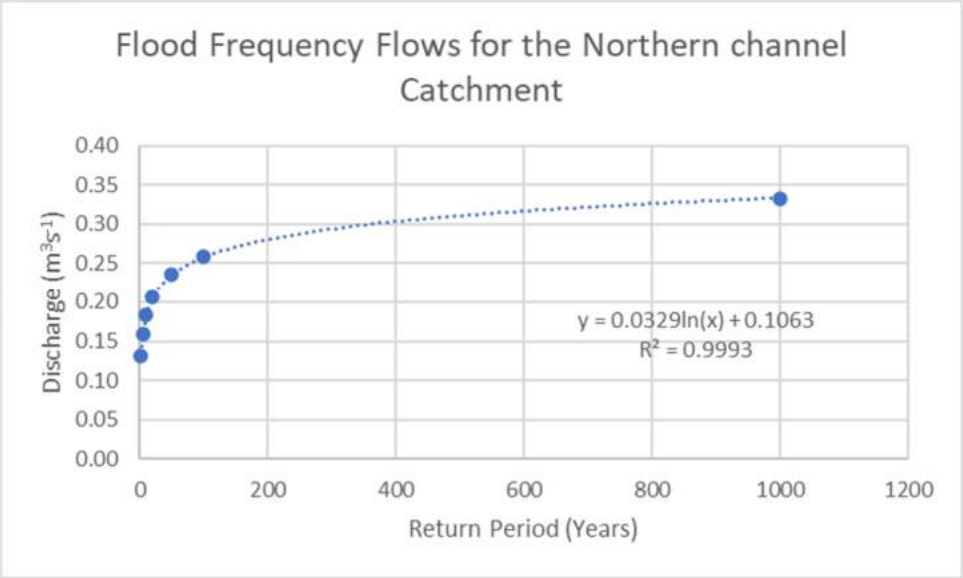

Figure 4 – flood frequency flows and return periods for catchment at site.

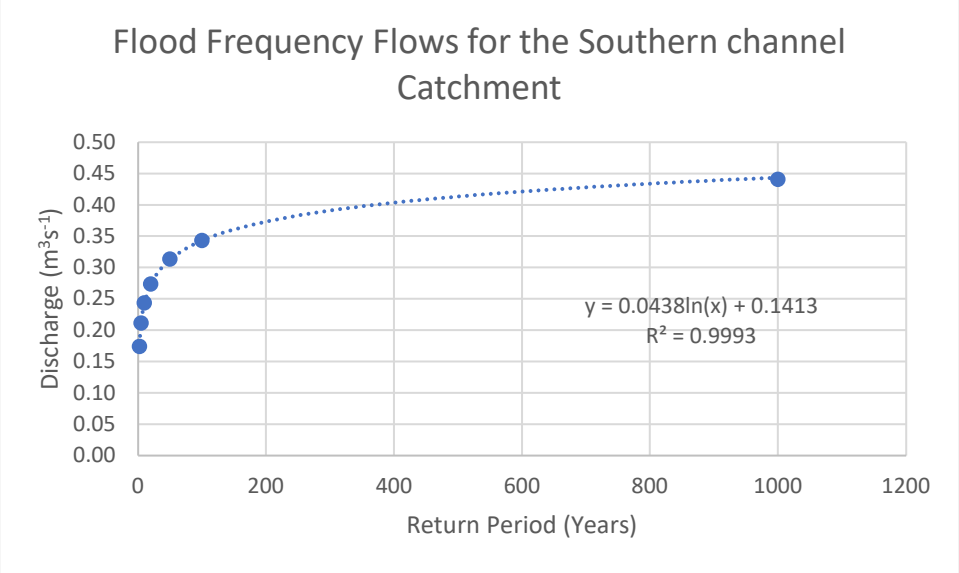

Figure 5 – flood frequency flows and return periods for catchment at site.

2.1.3. Climate Change

In the Ministry for the Environments' Tools for Estimating the Effects of Climate Change on Flood Flow May 2010, it states:

> 'It is possible to use results from McKerchar and Pearson (1989) to suggest that over much of New Zealand (places where the 100-year ARI flood is between two and three times the mean annual flood), the average recurrence interval would approximately halve if flood peaks all increased by a hypothetical 10 per cent.'

This means that for every 10 % increase due to climate change a 100-yr AR storm in the present would be equivalent to a 50-yr storm in the future.

With this in mind, there has been an allowance for a 20 % increase and the flows to be used in the modelling are presented in Table 5 below.

Table 5 – Future flows at the site due to climate change.

	Current	20% increase equated return period	Future flood flow	
			Northern Channel	Southern Channel
Return period	50-yr	200-yr	0.281 m^3s^{-1}	0.303 $m3s^{-1}$
	100-yr	400-yr	0.373 m^3s^{-1}	0.404 m^3s^{-1}

2.1.4. Modelling in HEC RAS and Hydraflow Express

The software used to model the stream flow was HEC RAS v6.0 and Autodesk Hydroflow Express. The following inputs/assumptions were used:

- Terrain has been input by creating a TIFF surface in Autodesk Civil 3D 2022 from Cheal's Drone data. This data was verified by Cheal by surveying spot heights around the site.
- HEC RAS models the open channels as they run through or adjacent to the proposed development site.
- Critical flow boundary conditions were used.
- Flows were modelled as sub-critical and as a steady state flow.
- Due to the thick vegetation with the open channels, Manning's n was assumed to be 0.1.
- Future 1 in 100-yr storm flows, accounting for climate change, were modelled in Hydraflow Express to determine the typical cross section that had the capacity to contain the modelled flood discharges, these are found in Enclosure 4.

3. RESULTS

3.1. Flood Extents

3.1.1. 50-year Flood

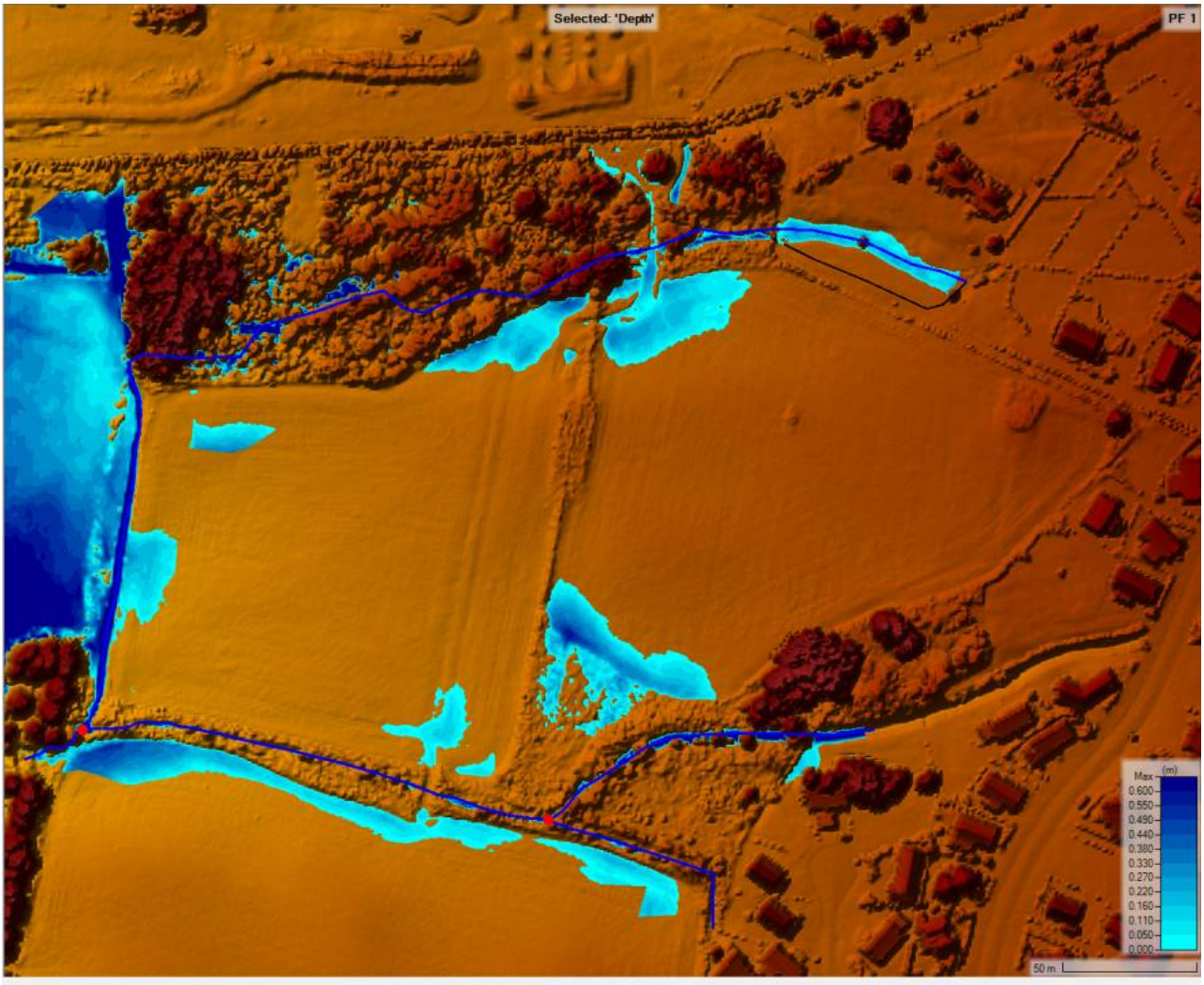

Figure 6 – Modelled 50-year flood extents.

3.1.2. 100-year Flood

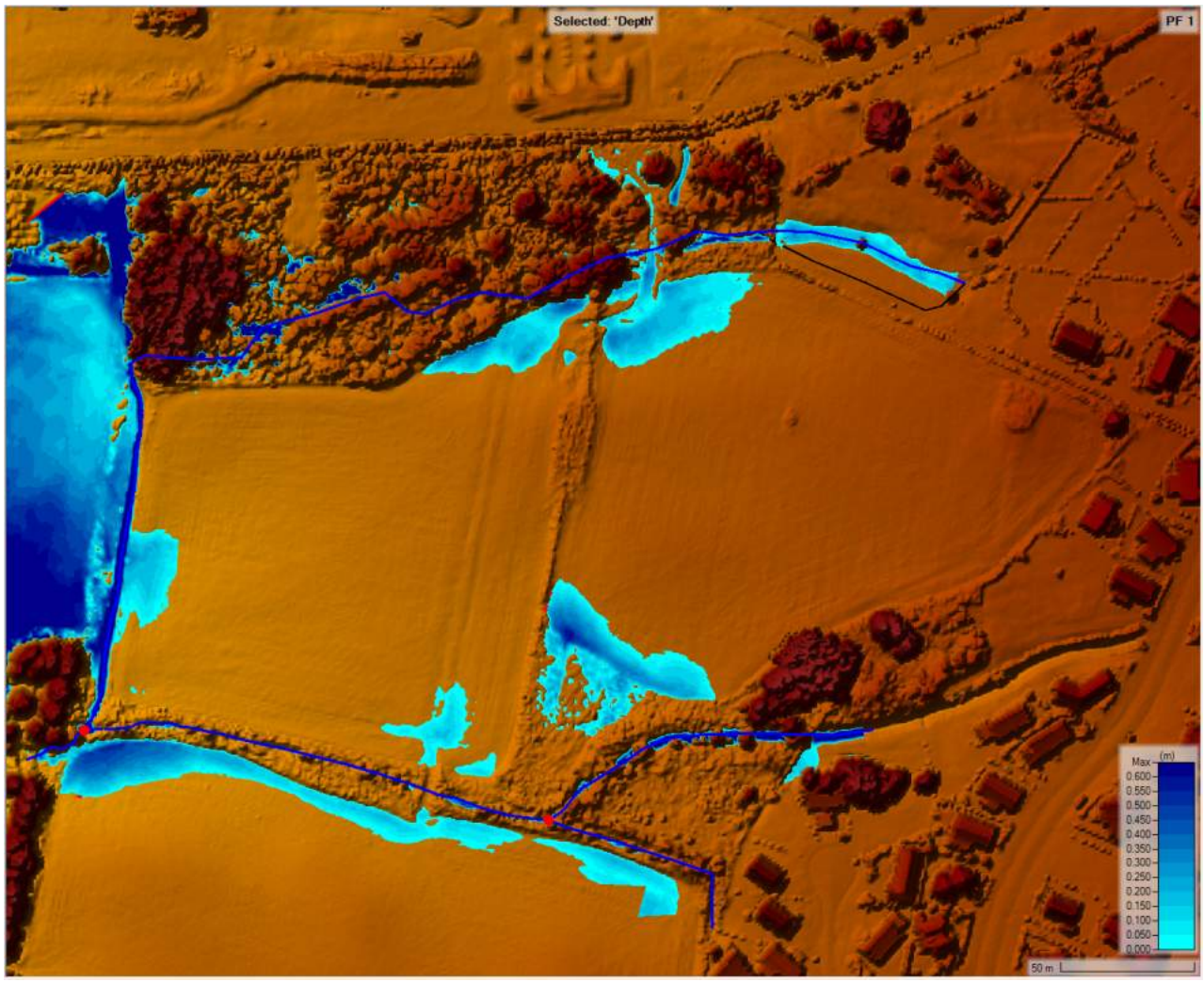

Figure 7 – Modelled 100-year flood extents.

3.1.3. Model Summary

Figures 6 and 7 show that:

- Flooding will occur in localised low-lying areas to a maximum depth of 0.6 m with most of the flooding less than of 0.1 m.
- No water velocities are greater than 0.5 ms^{-1} with the majority being less than 0.2ms^{-1}.
- Hydroflow Express shows that an open channel with a base width of 0.5m with 1:1 side slopes and a depth of 0.8m could contain the current 1:400 ARI storm event for both channels (Calculation found in Appendix 2).

Model results are attached in Enclosure 3.

3.2. Minimum Floor Level

To further mitigate possible inundation risk:

- Drains should be constructed as per the development to the east with two stages to accommodate the MAF (up to 0.15m^3s^{-1}) and the 100-yr storm event (up to 0.4 m^3s^{-1}). An expected channel section can be found in enclosure 3 with a total depth of 0.8 m and a Total width of 7m.

- These channels, once constructed, will determine the ground levels for earthworks within the development which should not be subjected to flooding.

- The current flood level has an approximate RL of 590.2 m. Therefore, **if earthworks filling of low-lying areas was not to occur,** then by local and regional authority rules the minimum **finished floor level should be an RL of 590.7 m**.

- **It is expected with drainage modification and earthworks that the minimum floor level shall be set at 0.3 m above the finished ground level within future lots.**

4. DISCUSSION

- The flooding from the Horizons 1:200 flood model appears to be caused by banks preventing water from entering the current channels (mounds have built up with drain maintenance creating levees either side of the southern open channel), and culvert crossings. The Horizons District Council flood map can be found in Enclosure 4.

- The concept drawings may allow for the possibility of bringing the northern catchment flows to the southern channel through the property.

- The fence line and the western boundary open channel drain are not on the boundary. Relocation will need to be considered during detailed design.

5. SUMMARY

Cheal Consultants Ltd (Cheal) has been engaged by Kainga Ora – Homes and Communities (Client) to undertake a stormwater assessment for a subdivision at 6 Teitei Drive, Ohakune.

The site is largely flat and has been identified by HDC as located in an area at risk of inundation from the 1 in 200-yr flood event.

The Mangateitei Stream is located to the north of the site. The future 50-year and 100-year (equated as the current 200-yr and 400-yr events) flows of the catchments affecting the site have been calculated to be 0.281 m^3s^{-1} and 0.373 m^3s^{-1} , for the northern channel and be 0.303 m^3s^{-1} and 0.404 m^3s^{-1}, for the southern channel, using the method developed by McKercher and Pearson (1989)

utilising the stream gauges found along the Mangawhero River and the New Zealand River Statistics website.

These are the recommendations to mitigate any stormwater flooding hazard onsite:

- The minimum floor level shall be:
  - 590.7 m RL (NZVD 2016 Datum) if no earthworks and drainage modification is undertaken at the site.
  - 0.3 m above finished ground level, if drainage modification was to occur to accommodate larger storm events and earthworks, filling of up to 0.5 m was undertaken to fill in the low-lying areas adjacent to the drains to be modified.

6. DISCLAIMER

This Report has been prepared solely for the use of our client with respect to the particular brief given to Cheal Consultants Limited (Cheal).

No liability is accepted in respect of its use for any other purpose or by any other person or entity. All future owners of this property should seek professional geotechnical advice to satisfy themselves as to its ongoing suitability for their intended use.

The opinions, recommendations and comments given in this Report are the result from the application of accepted industry methods.

CHEAL CONSULTANTS LIMITED
8 March 2023

Enclosure 1

Topography Plan
220528-TP001 Rev A

Survey Control Marks			
Description	RL	Northing	Easting
IS 1	591.71	810099.84	379582.84
M64/A(AGJF)	592.56	810258.48	379596.27
BM XII DP 363875 (EBC5)	592.24	809823.24	379644.71
IS 2	593.47	810007.21	379683.28

AutoCAD

cheal

www.cheal.co.nz

NOTES:

Asbuilt utilities may have other services in close proximity which are not shown for the purposes of this plan. Please identify existing utility locations and depths with the Ruapehu District Council GIS before any field investigation or construction.

Underground services shown here are indicative only. It is the Contractors responsibility to identify existing utility locations and depths prior to construction.

Coordinates are in terms of New Zealand Geodetic Datum 2000, Tuhirangi Circuit.
Reduced Levels are in terms of New Zealand Vertical Datum 2016.
Origin: BM XII DP 363875
809823.24 mN
379644.71 mE
RL: 592.24m
Source: Land Information New Zealand Geodetic Database
Authorised date: 30/11/2018
Calculation Date: 30/11/2018
Contours Interval 0.25 m

Aerial Imagery has been captured with a DJI Matrice M300. Topographic information has been captured with a DJI Matrice M300, a DJI Zenmuse P1 Camera and a DJI Zenmuse L1 LiDAR unit, and a Leica GNSS System.

Areas of dense vegetation may not accurately reflect true ground levels due to obstructing a clear view of the ground beneath.

Aerial Imagery outside the extent of the UAV imagery has been obtained from the Land Information New Zealand and is provided under a Creative Commons Public License. It has been provided as a guide to where other features are positioned, or proposed on the ground, but may not be absolute.

Boundary information has been sourced from DP54909.

Rev	Date	Amendment	By	Chk	App
A	24/11/22	First Issue	GR	BG	GR

Project Title
Kainga Ora
Homes and Communities
6 Teitei Drive, Ohakune

Drawing Title
Topographic Survey of
Lot 2 DP 54909

Surveyed	G.Ripoll	02/11/22	GR
Designed			
Drawn	G.Ripoll	04/11/22	GR
Checked	B.Greer	24/11/22	BG
Approved	G.Ripoll	24/11/22	GR

Status **INFORMATION**

Scale A1
A3 1:1500 | A3

Drawing Number
220528-TP001 | Rev A

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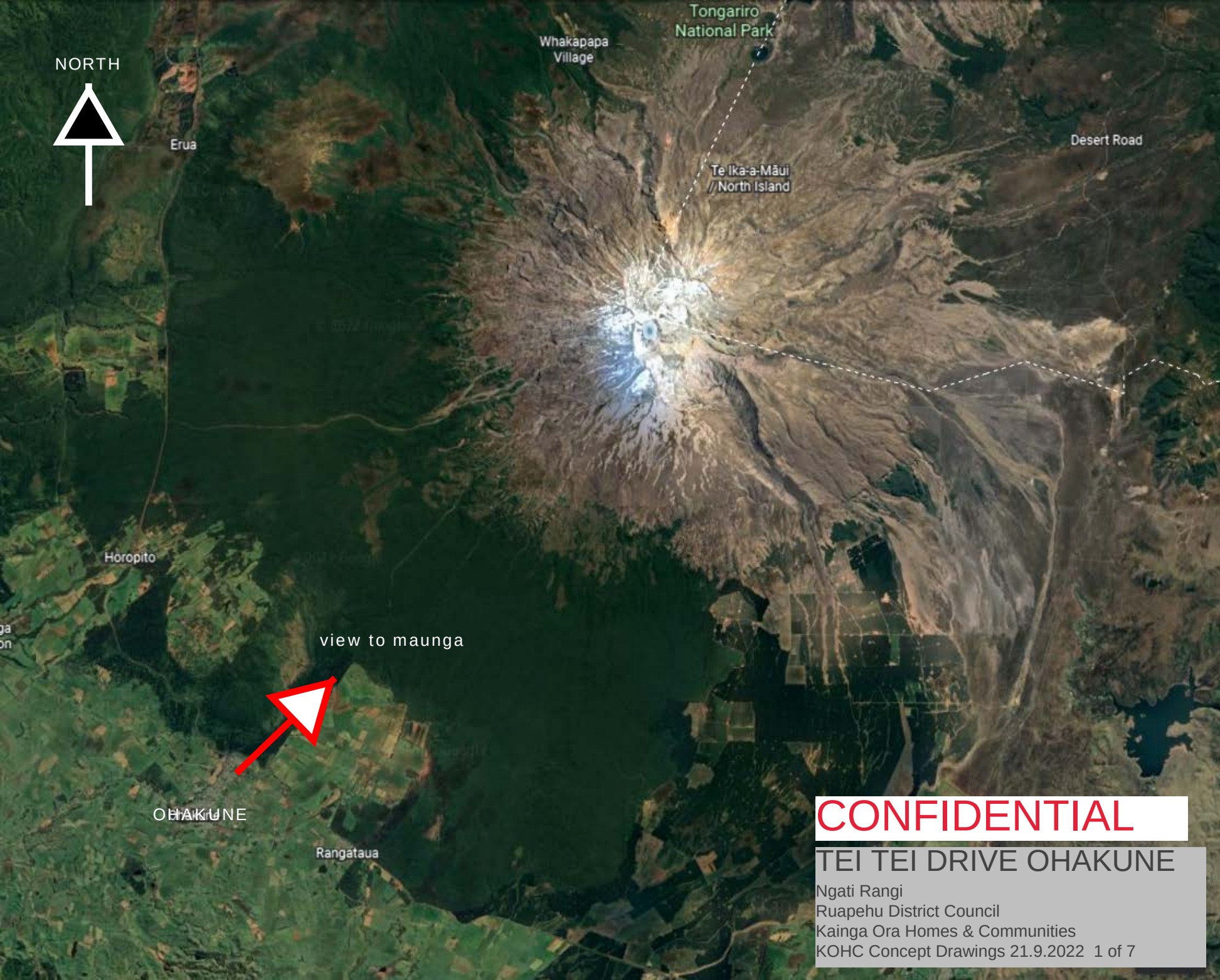
Enclosure 2

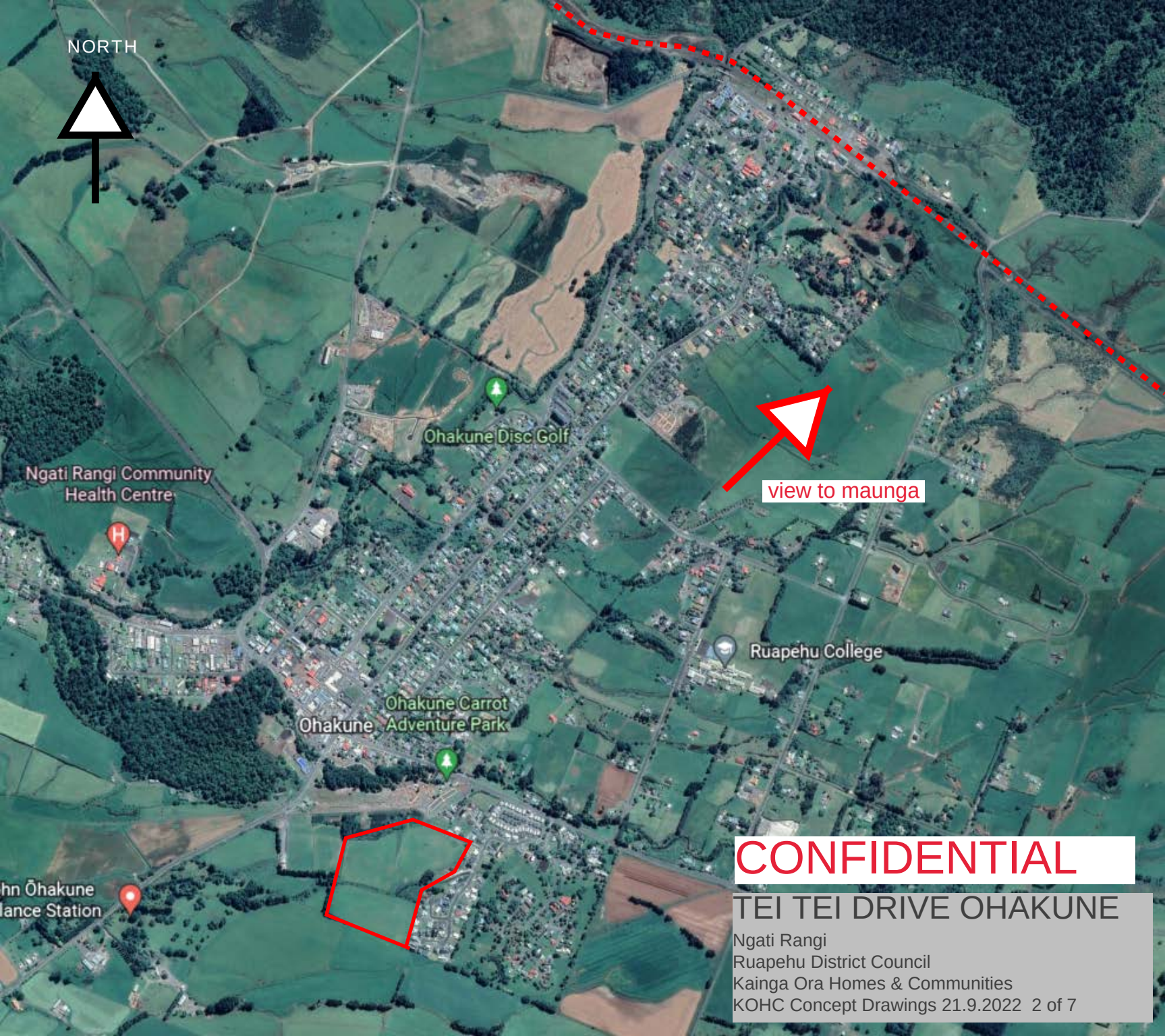
Kainga Ora Development Options



CONFIDENTIAL

TEI TEI DRIVE OHAKUNE

Ngati Rangi
Ruapehu District Council
Kainga Ora Homes & Communities
KOHC Concept Drawings 21.9.2022



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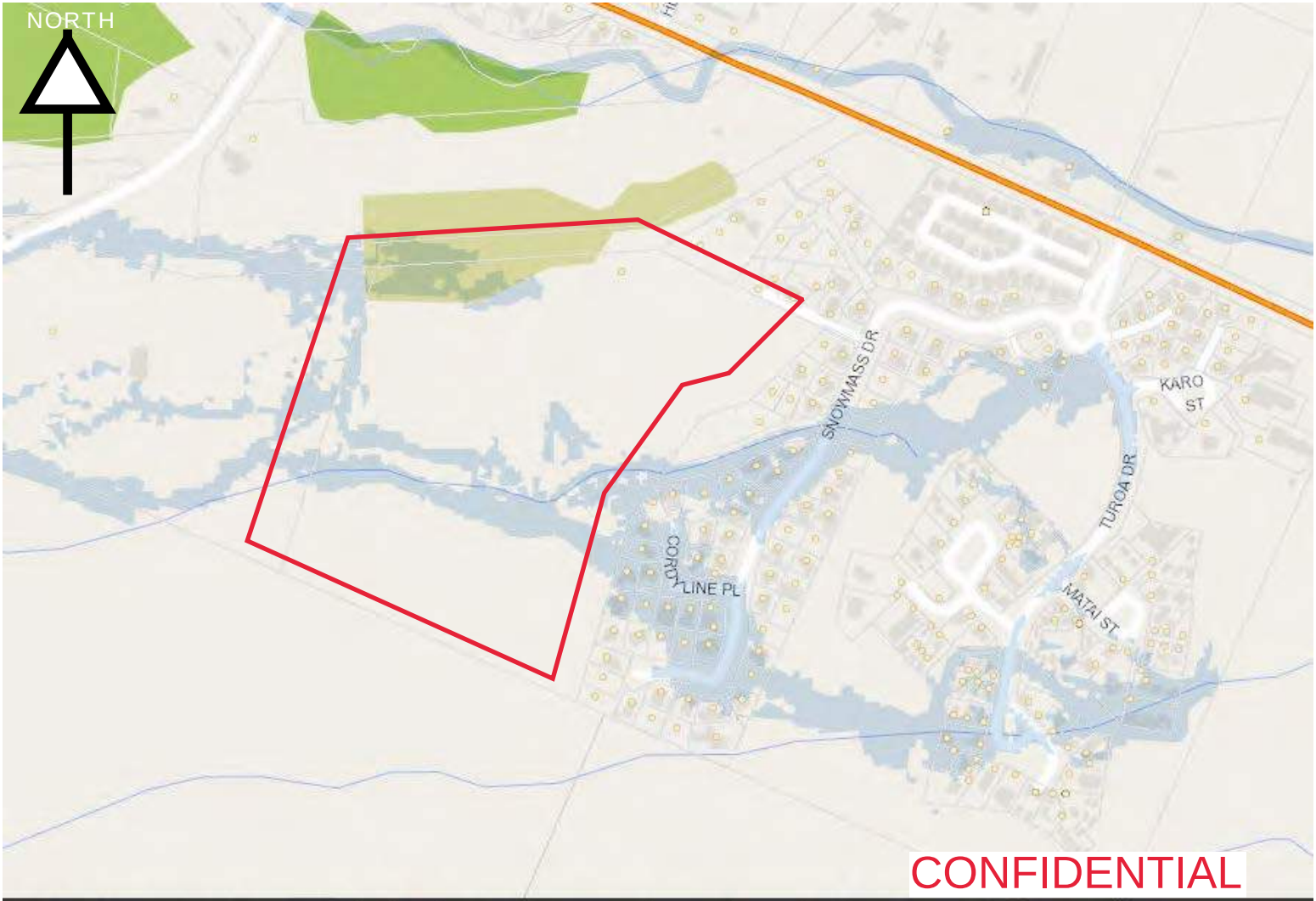
TEI TEI DRIVE OHAKUNE

Ngati Rangi
Ruapehu District Council
Kainga Ora Homes & Communities
KOHC Concept Drawings 21.9.2022 2 of 7



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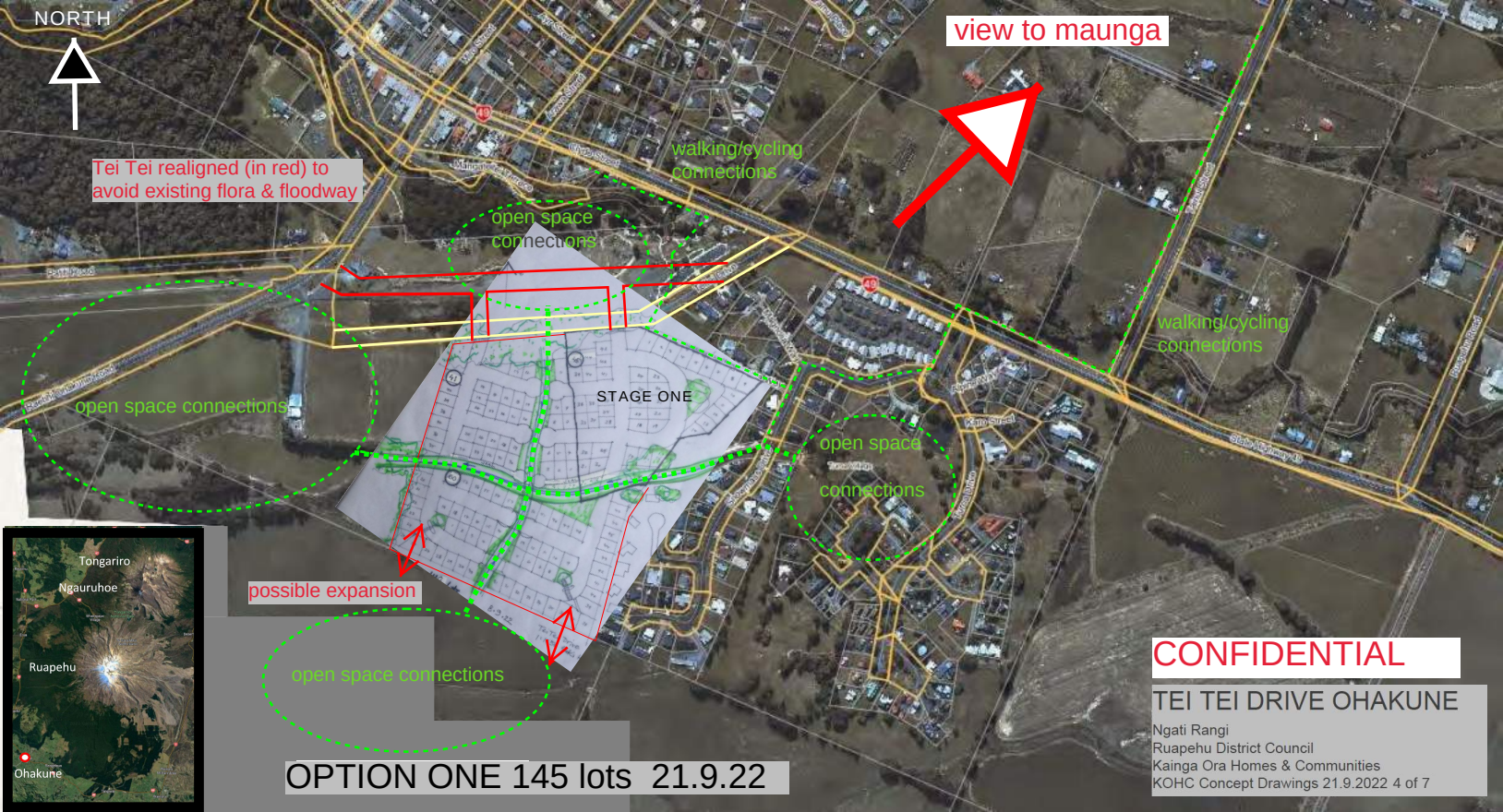
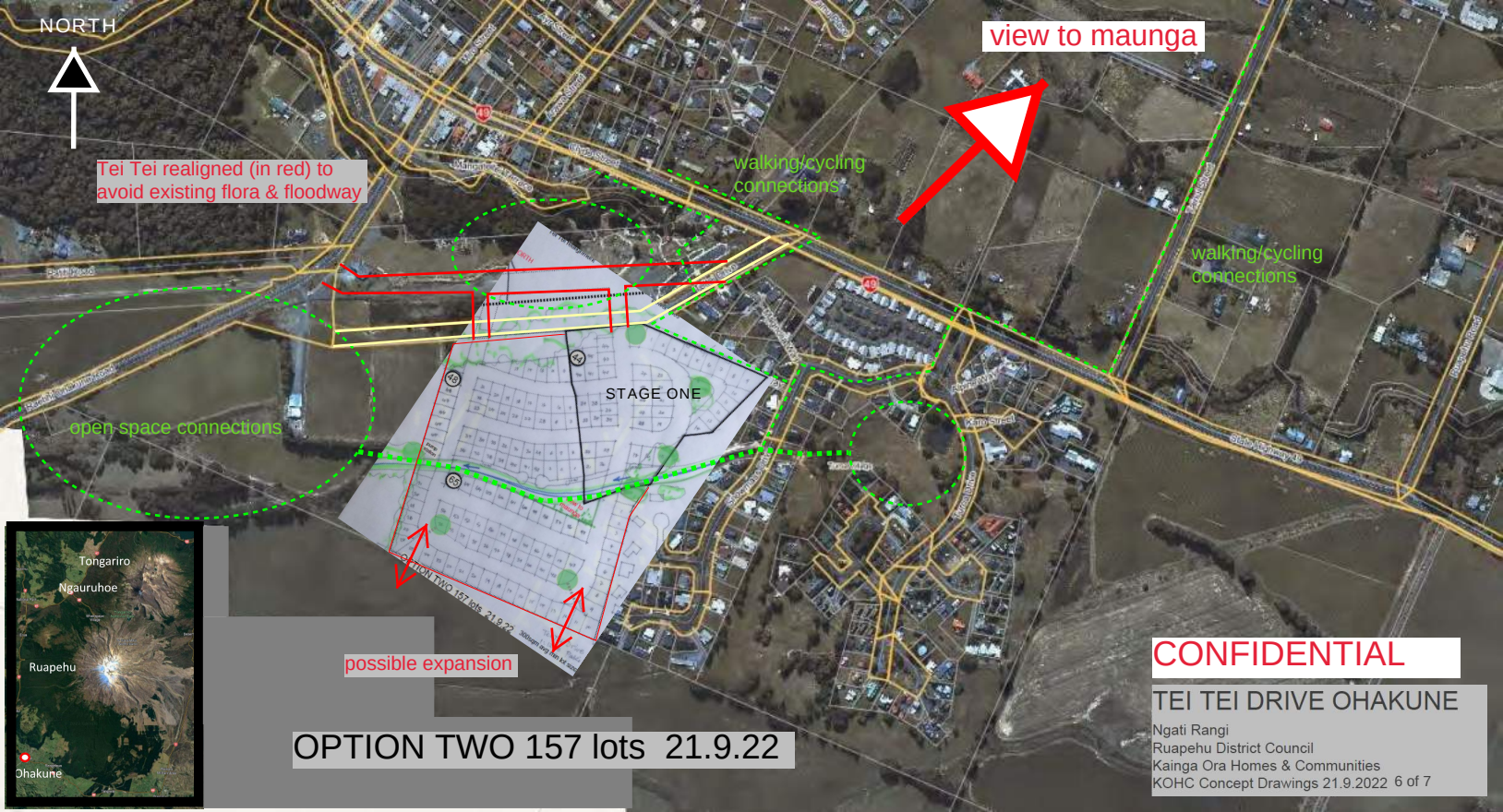
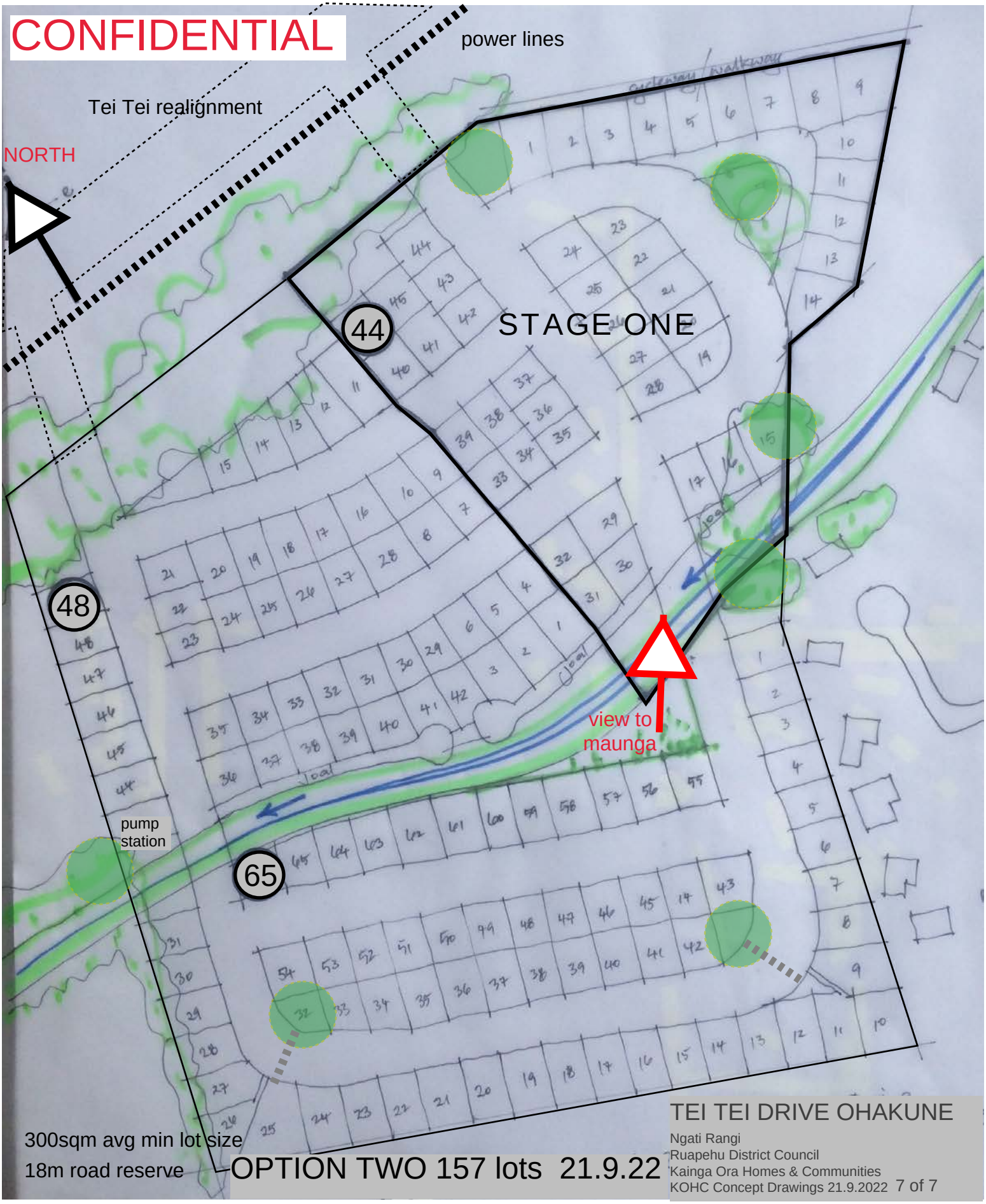
Ruapehu District Council
Kainga Ora Homes & Communities
KOHC Concept Drawings 21.9.2022 3 of 7


NORTH
view to maunga
Tei Tei realigned (in red) to avoid existing flora & floodway
walking/cycling connections
open space connections
STAGE ONE
open space connections
walking/cycling connections
open space connections
possible expansion
open space connections
Tongariro
Ngauruhoe
Ruapehu
Ohakune
CONFIDENTIAL
TEI TEI DRIVE OHAKUNE
Ngati Rangi
Ruapehu District Council
Kainga Ora Homes & Communities
KOHC Concept Drawings 21.9.2022 4 of 7
OPTION ONE 145 lots 21.9.22


CONFIDENTIAL
power lines
Tei Tei realignment
NORTH
STAGE ONE
45
40
60
SW run-off into swale
& pedestrian landscape
view to
maunga
pump
station
300sqm avg min lot size
18m road reserve
OPTION ONE 145 lots 21.9.22
TEI TEI DRIVE OHAKUNE
Ngati Rangi
Ruapehu District Council
Kainga Ora Homes & Communities
KOHC Concept Drawings 21.9.2022


NORTH
view to maunga
Tei Tei realigned (in red) to avoid existing flora & floodway
walking/cycling connections
walking/cycling connections
open space connections
STAGE ONE
possible expansion
Tongariro
Ngauruhoe
Ruapehu
Ohakune
OPTION TWO 157 lots 21.9.22
CONFIDENTIAL
TEI TEI DRIVE OHAKUNE
Ngati Rangi
Ruapehu District Council
Kainga Ora Homes & Communities
KOHC Concept Drawings 21.9.2022 6 of 7


CONFIDENTIAL
power lines
Tei Tei realignment
NORTH
STAGE ONE
44
48
65
pump station
view to maunga
300sqm avg min lot size
18m road reserve
OPTION TWO 157 lots 21.9.22
TEI TEI DRIVE OHAKUNE
Ngati Rangi
Ruapehu District Council
Kainga Ora Homes & Communities
KOHC Concept Drawings 21.9.2022

Appendix 3

Hydrological & Hydraulic Calculations

Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Monday, Feb 27 2023

Southern channel existing capacity scection

User-defined

Invert Elev (m)	= 89.0000
Slope (%)	= 0.1000
N-Value	= Composite

Calculations

Compute by:	Q vs Depth
No. Increments	= 10

Highlighted

Depth (m)	= 0.6500
Q (cms)	= 0.085
Area (sqm)	= 0.6435
Velocity (m/s)	= 0.1328
Wetted Perim (m)	= 2.3690
Crit Depth, Yc (m)	= 0.2316
Top Width (m)	= 1.9800
EGL (m)	= 0.6509

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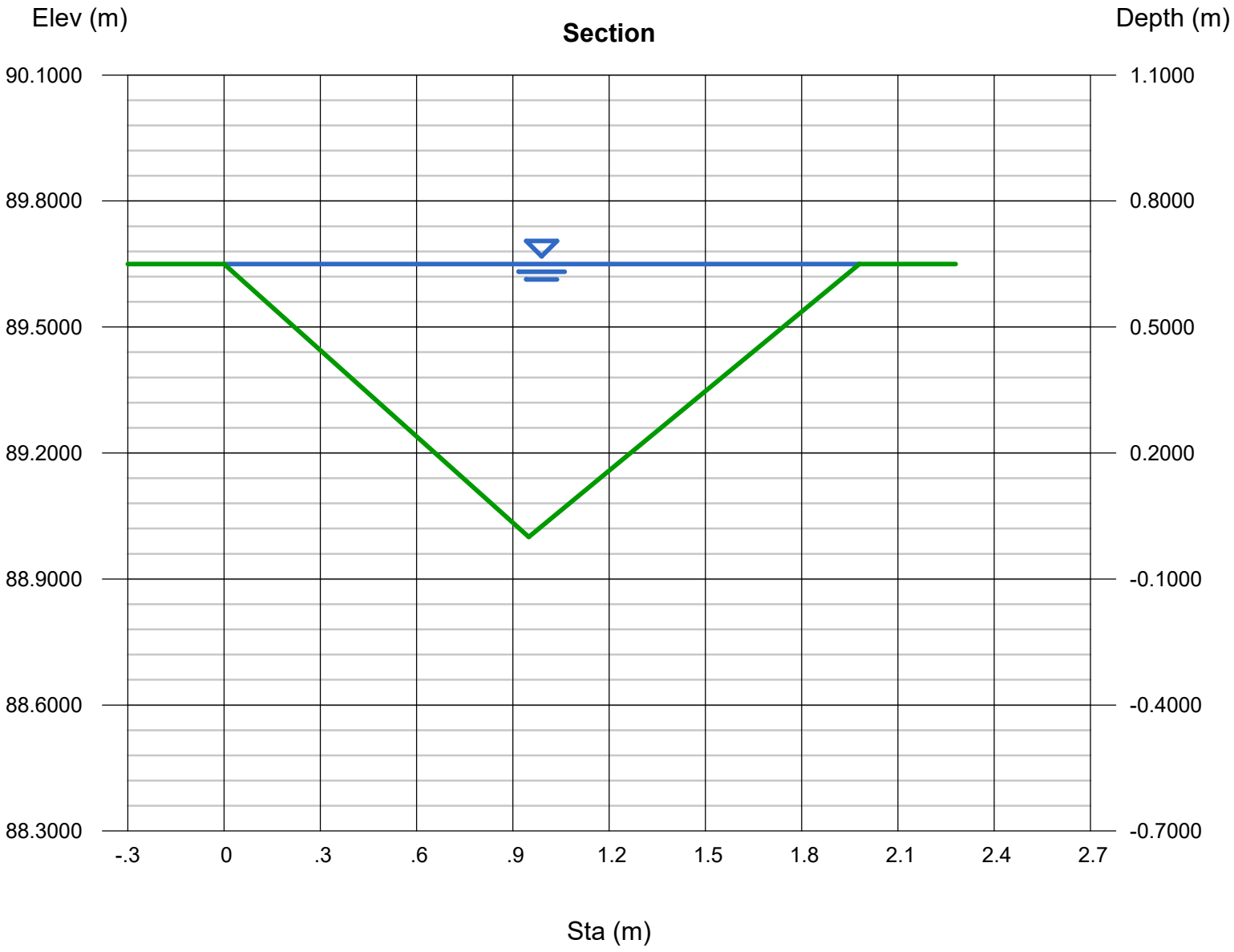

Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Monday, Feb 27 2023

Northern Channel Existing Capacity Section

User-defined

Invert Elev (m)	= 89.0000
Slope (%)	= 0.1000
N-Value	= Composite

Calculations

Compute by:	Q vs Depth
No. Increments	= 10

Highlighted

Depth (m)	= 0.7500
Q (cms)	= 0.204
Area (sqm)	= 1.3125
Velocity (m/s)	= 0.1552
Wetted Perim (m)	= 3.8252
Crit Depth, Yc (m)	= 0.2774
Top Width (m)	= 3.5000
EGL (m)	= 0.7512

(Sta, El, n)-(Sta, El, n)...

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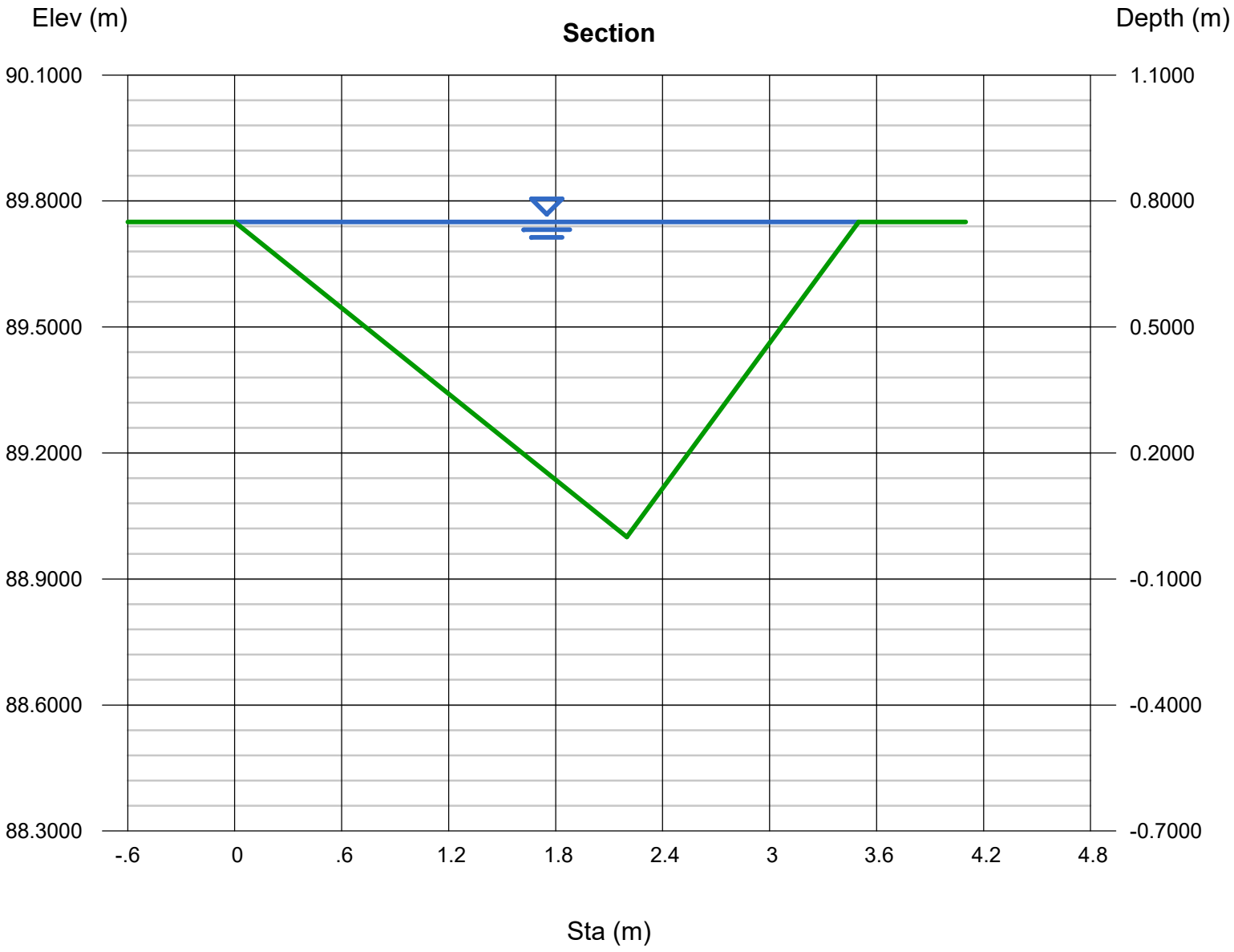


Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Monday, Feb 27 2023

Concept section for future flows

User-defined

Invert Elev (m)	= 89.0000
Slope (%)	= 0.1000
N-Value	= Composite

Calculations

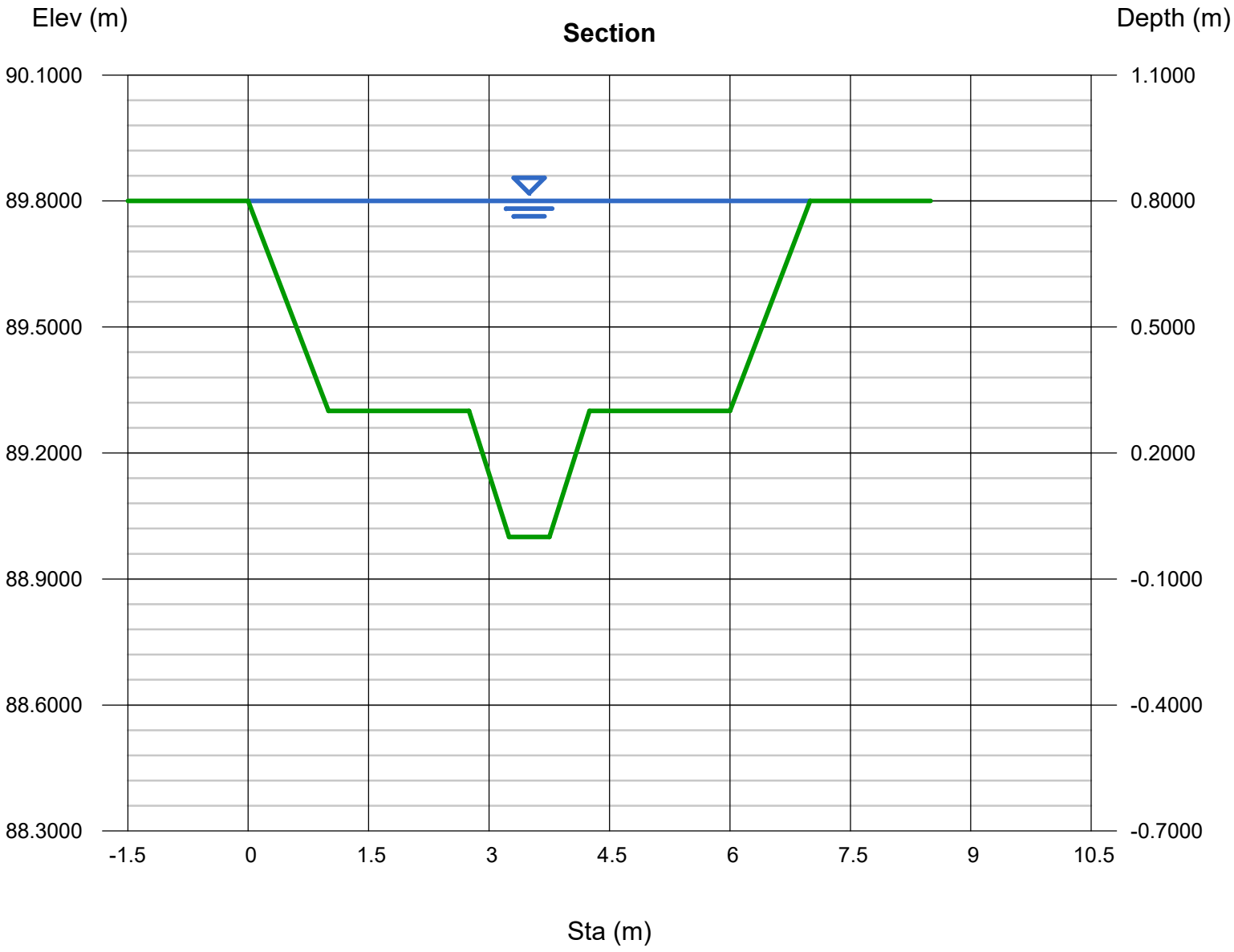
Compute by:	Q vs Depth
No. Increments	= 15

Highlighted

Depth (m)	= 0.8000
Q (cms)	= 0.6098
Area (sqm)	= 3.3000
Velocity (m/s)	= 0.1848
Wetted Perim (m)	= 7.4023
Crit Depth, Yc (m)	= 0.3566
Top Width (m)	= 7.0000
EGL (m)	= 0.8017

(Sta, El, n)-(Sta, El, n)...

(0.0000, 89.8000)-(1.0000, 89.3000, 0.100)-(2.7500, 89.3000, 0.100)-(3.2500, 89.0000, 0.100)-(3.7500, 89.0000, 0.100)-(4.2500, 89.3000, 0.100)-(6.0000, 89.3
-(7.0000, 89.8000, 0.100)



Depth	Q	Area	Veloc	Wp
(m)	(cms)	(sqm)	(m/s)	(m)
0.0533	0.001	0.031	0.0397	0.7073
0.1067	0.004	0.072	0.0583	0.9146
0.1600	0.009	0.123	0.0724	1.1220
0.2133	0.015	0.183	0.0842	1.3293
0.2667	0.024	0.252	0.0948	1.5366
0.3200	0.023	0.401	0.0569	5.2556
0.3733	0.053	0.677	0.0784	5.4942
0.4267	0.093	0.965	0.0965	5.7326
0.4800	0.142	1.265	0.1125	5.9712
0.5333	0.200	1.576	0.1269	6.2097
0.5867	0.266	1.898	0.1401	6.4482
0.6400	0.340	2.231	0.1523	6.6867
0.6933	0.422	2.576	0.1638	6.9252
0.7467	0.512	2.932	0.1746	7.1637
0.8000	0.610	3.300	0.1848	7.4023

Yc	TopWidth	Energy
(m)	(m)	(m)
0.0091	0.6778	0.0534
0.0213	0.8555	0.1068
0.0335	1.0333	0.1603
0.0457	1.2111	0.2137
0.0579	1.3889	0.2671
0.0579	5.0800	0.3202
0.0945	5.2933	0.3736
0.1311	5.5067	0.4271
0.1676	5.7200	0.4806
0.2042	5.9333	0.5342
0.2377	6.1467	0.5877
0.2713	6.3600	0.6412
0.3322	6.5733	0.6947
0.3444	6.7867	0.7482
0.3566	7.0000	0.8017

HEC-RAS Plan: 100 yr plan Profile: PF 1

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Southern Stream	1	257	PF 1	0.20	590.29	590.45	590.36	590.46	0.003280	0.13	1.54	13.92	0.13
Southern Stream	1	225	PF 1	0.20	590.07	590.20		590.21	0.035881	0.36	0.56	6.83	0.40
Southern Stream	1	209	PF 1	0.20	589.80	590.03		590.03	0.005124	0.16	1.29	12.51	0.16
Southern Stream	1	192	PF 1	0.20	589.65	589.73	589.73	589.76	0.269393	0.78	0.26	4.46	1.03
Southern Stream	2	152	PF 1	0.40	589.13	589.25	589.24	589.26	0.014398	0.45	0.89	18.55	0.66
Southern Stream	2	130	PF 1	0.40	588.84	588.98	588.95	588.98	0.010920	0.42	0.96	18.21	0.58
Southern Stream	2	98	PF 1	0.40	588.34	588.47	588.47	588.50	0.021902	0.80	0.50	6.08	0.89
Southern Stream	2	73	PF 1	0.40	587.70	587.83	587.83	587.87	0.028846	0.90	0.45	5.56	1.01
Southern Stream	2	49	PF 1	0.40	587.23	587.43	587.35	587.43	0.004335	0.42	0.97	9.30	0.41
Southern Stream	2	28	PF 1	0.40	587.01	587.43		587.43	0.000050	0.08	4.88	18.56	0.05
Northern Stream	1	496	PF 1	0.30	591.80	592.07	591.95	592.08	0.008171	0.26	1.15	7.16	0.21
Northern Stream	1	485	PF 1	0.30	591.75	591.92		591.93	0.028366	0.40	0.76	6.54	0.37
Northern Stream	1	474	PF 1	0.30	591.48	591.70		591.71	0.014514	0.30	1.01	8.20	0.27
Northern Stream	1	463	PF 1	0.30	591.32	591.48		591.49	0.025467	0.35	0.86	8.30	0.35
Northern Stream	1	449	PF 1	0.30	591.08	591.29		591.30	0.008615	0.26	1.14	7.47	0.22
Northern Stream	1	437	PF 1	0.30	592.00	591.20		591.20	0.008125		1.17	7.51	0.00
Northern Stream	1	420	PF 1	0.30	591.18	591.06		591.07	0.007236		0.82	2.63	0.00
Northern Stream	1	409	PF 1	0.30	591.55	590.91		590.92	0.032721		0.80	12.58	0.00
Northern Stream	1	397	PF 1	0.30	590.84	590.82		590.82	0.003659		1.90	14.77	0.00
Northern Stream	1	384	PF 1	0.30	590.70	590.78		590.78	0.002268	0.05	2.03	13.81	0.09
Northern Stream	1	366	PF 1	0.30	590.67	590.74		590.74	0.002279	0.05	2.49	21.40	0.09
Northern Stream	1	349	PF 1	0.30	590.99	590.61	590.56	590.63	0.055260		0.48	3.27	0.00
Northern Stream	1	330	PF 1	0.30	589.96	590.10		590.11	0.016262	0.28	1.18	13.38	0.28
Northern Stream	1	312	PF 1	0.30	589.58	589.83		589.83	0.013993	0.30	1.07	10.65	0.27
Northern Stream	1	291	PF 1	0.30	589.59	589.62		589.63	0.007022	0.05	1.15	6.47	0.12
Northern Stream	1	265	PF 1	0.30	588.91	589.27		589.29	0.032026	0.57	0.53	2.57	0.40
Northern Stream	1	248	PF 1	0.30	588.20	588.83		588.84	0.021511	0.47	0.64	2.78	0.31
Northern Stream	1	227	PF 1	0.30	587.74	588.81		588.81	0.000368	0.10	3.17	7.88	0.05
Northern Stream	1	206	PF 1	0.30	587.92	588.80		588.80	0.001061	0.13	2.34	8.63	0.08
Northern Stream	1	189	PF 1	0.30	587.99	588.70	588.70	588.74	0.315990	0.82	0.37	5.52	1.01
Northern Stream	1	169	PF 1	0.30	587.12	587.44	587.27	587.44	0.000550	0.07	4.47	28.31	0.05
Northern Stream	1	141	PF 1	0.30	586.19	587.44		587.44	0.000048	0.03	12.02	53.66	0.02
Northern Stream	1	132	PF 1	0.30	586.11	587.44		587.44	0.000019	0.02	15.63	52.21	0.01
Northern Stream	1	112	PF 1	0.30	585.95	587.44		587.44	0.000008	0.02	19.81	47.52	0.01
Northern Stream	1	90	PF 1	0.30	585.79	587.44		587.44	0.000004	0.01	26.17	62.72	0.01
Northern Stream	1	72	PF 1	0.30	586.00	587.44		587.44	0.000004	0.01	25.00	50.93	0.01
Northern Stream	1	53	PF 1	0.30	586.17	587.44		587.44	0.000003	0.01	22.19	30.81	0.01
Northern Stream	1	43	PF 1	0.30	586.14	587.44		587.44	0.000108	0.07	4.55	6.94	0.03

HEC-RAS Plan: 100 yr plan Profile: PF 1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Northern Stream	1	36	PF 1	0.30	585.91	587.43		587.44	0.000422	0.12	2.51	4.35	0.05
Northern Stream	2	16	PF 1	0.71	593.39	587.42		587.42	0.000738		2.27	8.51	0.00
Northern Stream	2	7	PF 1	0.71	587.19	587.33	587.33	587.40	0.020954	0.71	0.64	4.87	0.83
Northern Stream	2	1	PF 1	0.71	586.39	586.55	586.68	587.06	0.226182	3.14	0.23	1.96	2.95
Central Stream	1	127	PF 1	0.20	589.60	590.76	589.88	590.76	0.000140	0.08	2.58	4.14	0.03
Central Stream	1	111	PF 1	0.20	589.41	590.75		590.75	0.000076	0.06	3.30	4.88	0.02
Central Stream	1	92	PF 1	0.20	589.58	590.75		590.75	0.000119	0.07	2.73	4.25	0.03
Central Stream	1	74	PF 1	0.20	590.67	590.73	590.73	590.74	0.218406	0.49	0.42	12.33	0.85
Central Stream	1	55	PF 1	0.20	589.42	590.19	589.64	590.19	0.000349	0.06	3.22	15.94	0.04
Central Stream	1	43	PF 1	0.20	589.72	590.18		590.18	0.000027	0.02	11.19	55.08	0.01
Central Stream	1	33	PF 1	0.20	590.00	590.17		590.18	0.126106	0.46	0.44	9.04	0.67
Central Stream	1	18	PF 1	0.20	589.38	589.82		589.83	0.009763	0.38	0.53	1.95	0.23

Hydrological Catchment Analysis

Stream Name: **Northern Channel**
Reference: 220528 Kainga Ora Ohakune
Location: 6 Teitei Drive Northern Catchment
Calculated: R Kilgour **Date:** 8-Mar-23

FFINZ

Area: A = 0.2 km²

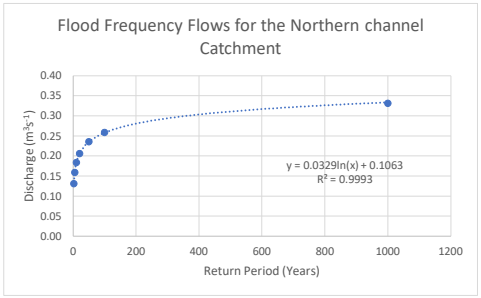
Comparative Catchment Area: NZREACH 7017262, A2 = 1.46 km²

		2.33 year	5 year	10 year	20 year	50 year	100 year	1000 year
Comparison flow	Q2	0.7	0.9	1.0	1.1	1.3	1.4	1.8
Subject flow rate	Q1	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**	**0.3**	**0.3**

Design Method Selected:

	2.33 year	5 year	10 year	20 year	50 year	100 year	1000 year	
FFINZ	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**	**0.3**	**0.3**	m^3/s

2.33	5	10	20	50	100	1000
0.13	0.16	0.18	0.21	0.24	0.26	0.33



Hydrological Catchment Analysis

Stream Name: **Southern Channel**
Reference: 220528 Kainga Ora Ohakune
Location: 6 Teitei Drive Southern Catchment
Calculated: R Kilgour **Date:** 20-Oct-21

FFINZ

Area: A = 0.26 km²

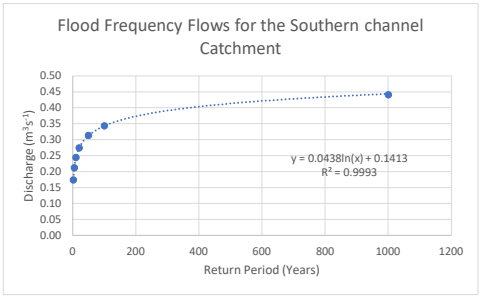
Comparative Catchment Area: NZREACH 7017262, A2 = 1.46 km²

		2.33 year	5 year	10 year	20 year	50 year	100 year	1000 year
Comparison flow	Q2	0.7	0.9	1.0	1.1	1.3	1.4	1.8
Subject flow rate	Q1	**0.2**	**0.2**	**0.2**	**0.3**	**0.3**	**0.3**	**0.4**

Design Method Selected:

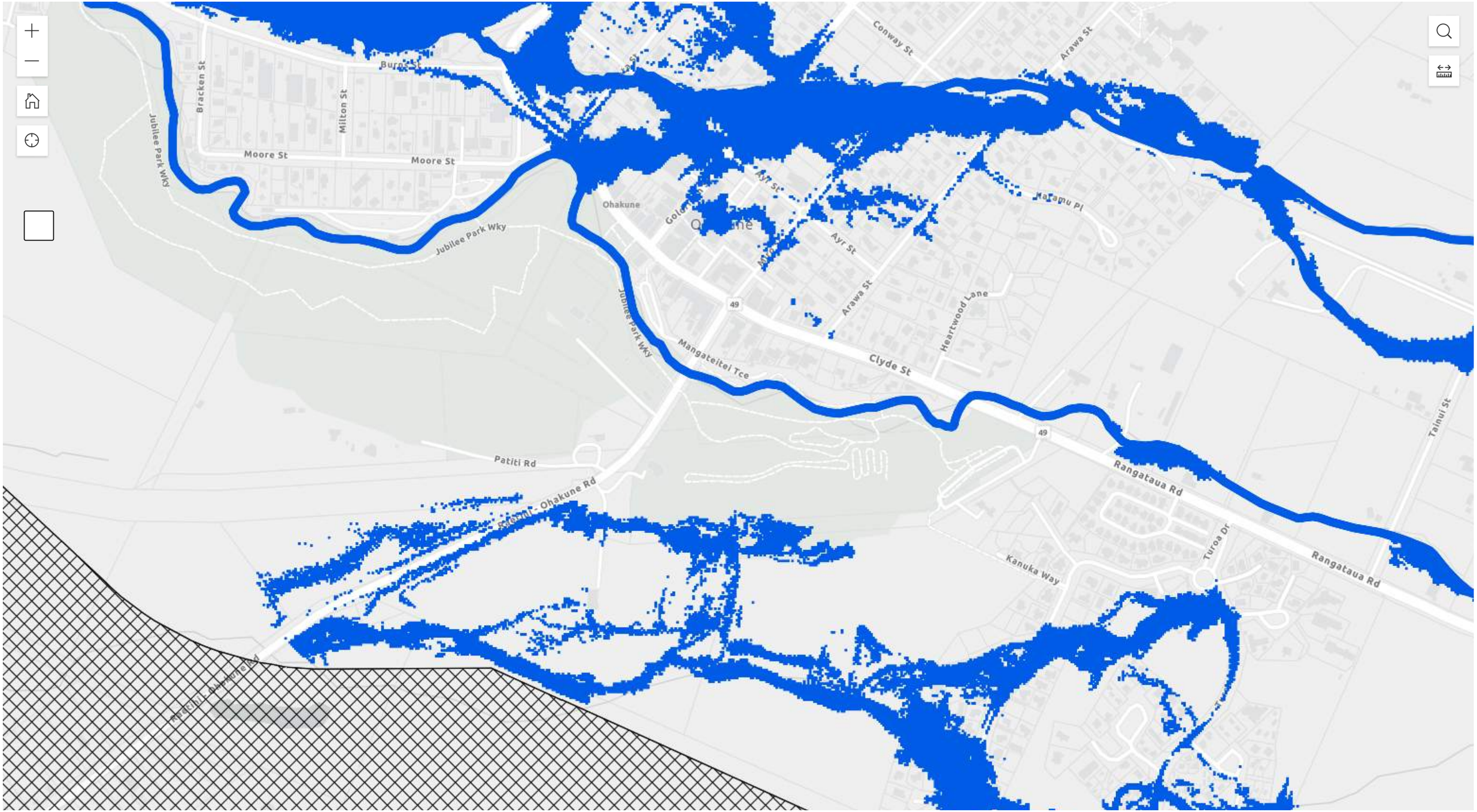
	2.33 year	5 year	10 year	20 year	50 year	100 year	1000 year	
FFINZ	**0.2**	**0.2**	**0.2**	**0.3**	**0.3**	**0.3**	**0.4**	m^3/s

2.33	5	10	20	50	100	1000
0.17	0.21	0.24	0.27	0.31	0.34	0.44



Appendix 4

Horizons District Council 1
in 200-yr Flood Map



Horizons region modelled wet extents from flood plain mapping analysis

Map navigation tools are at top-left.
Search and **measurement** tools are at top-right.

400 ft