OKAHUNE TOWNSHIP FLOOD MODELLING

Addendum Report - July 2017

31 July 2017

Prepared by Hydro-Electric Corporation
ABN48 072 377 158

t/a Entura 89 Cambridge Park Drive,
Cambridge TAS 7170 Australia

WE OWN. WE OPERATE. WE CONSULT.

Entura in Australia is certified to the latest version of ISO9001, ISO14001, and OHSAS18001.

Document information

Document title	Okahune Township Flood Modelling
	Addendum Report - July 2017
Client organisation	Horizons Regional Council
Client contact	Jeff Watson
ConsultDM number	ENTURA-D6F2A
Project Manager	Craig Ludlow
Project number	E306424 - P512505

Revision history

Revision 1.0

Revision description	Draft report submitted to client		
Prepared by	Craig Ludlow		28 July 2017
Reviewed by	Aleksandar Jokanovic		28 July 2017
Approved by	Craig Ludlow		28 July 2017
	(name)	(signature)	(date)
Distributed to	Jeff Watson (name)	Horizons Regional Council (organisation)	28 July 2017 (date)

This page is left intentionally blank

Contents

List of figures

List of tables

1. Introduction

In 2010 Entura (then Hydro Tasmania Consulting) was commissioned by Horizons Regional Council (HRC) to carry out a flood study for the township of Ohakune and the surrounding rural and semi-rural areas that are potentially affected by flooding from stormwater and the coincident flooding from the Mangawhero River and its tributaries.

The scope of the project involved developing hydrologic and hydraulic models to estimate flooding for the 1 in 50 AEP, 1 in 100 AEP and 1 in 200 AEP design events.

The hydrologic model was calibrated to a flood frequency curve derived by Entura at the Hagleys gauge site on the Mangawhero River (Ludlow C. , 2010).

In 2014 HRC reviewed the Mangawhero at Hagleys flood frequency curve taking into consideration of the three following sites:

- Burns Street: 1975-1981
- Hagleys: 1999-2006
- Pakihi: 2007-2013

The peak flood discharges from the HRC analysis resulted in peak discharges for the 1 in 100 AEP and 1 in 200 AEP events being approximately 30% higher than those previously estimated. The difference was caused by the Burns Street data was not being used in the original flood frequency analysis. Entura was subsequently commissioned by HRC in 2014 to:

- re-calibrate the Ohakune hydrologic model
- based on the revised flood hydrographs re-run the MIKE Flood hydraulic models for the 6hr 1 in 100 AEP and 6hr 1 in 200 AEP flood events
- assess flood protection measures proposed for the sewerage ponds servicing Ohakune for the 6hr 1 in 200 AEP flood event
- update the rotation of the MIKE 11 model which previously had a different rotation to the MIKE 21 model
- provide an update on the revised work
- submit the revised MIKE 11 and 21 model files.

In 2017 HRC acquired additional LiDAR survey (refer to Figure 1.1) and commissioned Entura to update the Ohakune Township flood modelling with the following scope:

- Flood frequency review and update of design flood discharges.
- Extension of existing hydrologic model to include catchments covered by the new LiDAR extent.
- Update of design flood discharges from the existing hydrologic model for the 1 in 200 year 6hr sotrm event.

- Update the existing MIKE Urban flood model including:
  - Combining existing three models into a single model, 2.5m grid.
  - Including the new LiDAR data.
  - Rotating MIKE 11 to be consistent with MIKE 21.
  - Including key hydraulic structures within the extended section of the model.
- Update existing flood model extents with the new MIKE Urban model for the 1 in 200 6hr flood event.
- Conversion of MIKE 21 results file into WaterRIDE format.
- Provision of MIKE11, MIKE 21 and MIKE Urban results files and WaterRIDE file to HRC.
- Preparation of a brief addendum report.

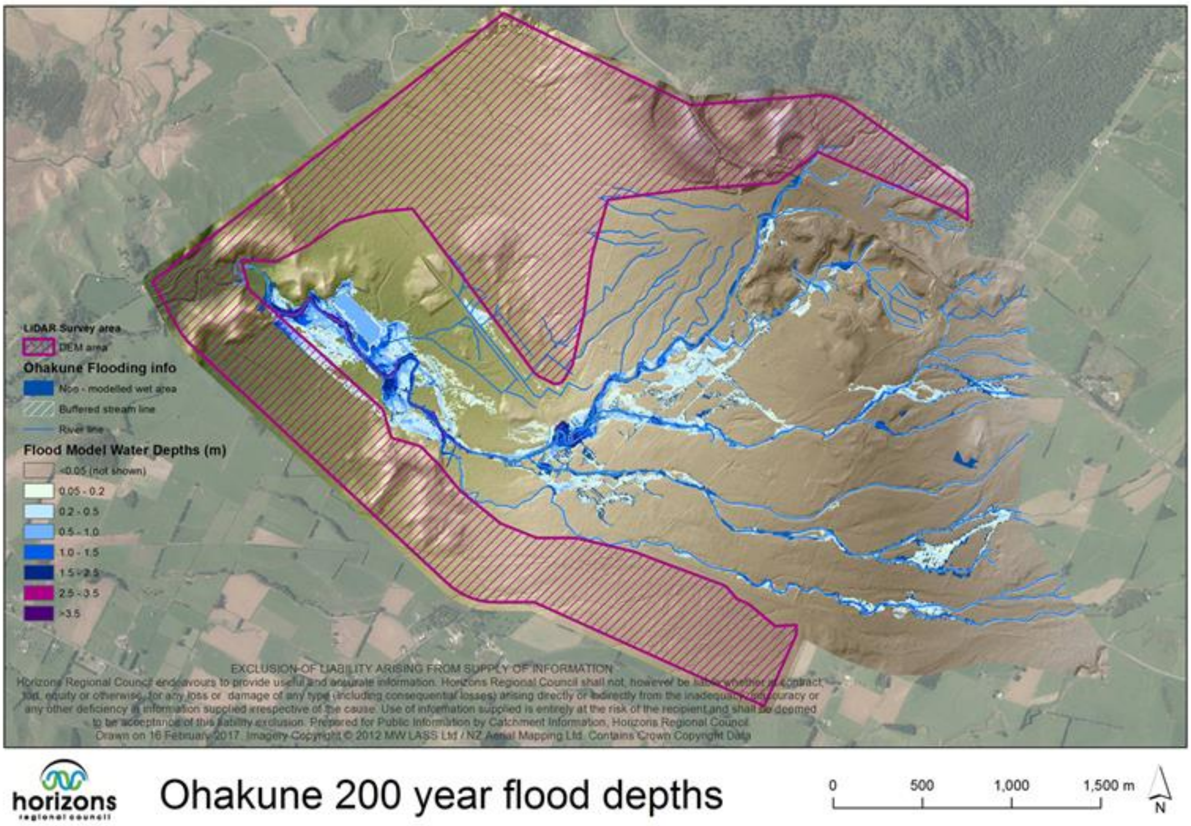

Figure 1.1: Location of additional LiDAR (purple hatched area)

entura
Hydro Tasmania
The power of natural thinking

2. Study datum

The modelling was carried out using the Moturiki Vertical Datum using the New Zealand Map Grid (NZMG) projection.

The original MIKE Flood model was based on LiDAR gathered in 2009 and is in the NZMG projection. The new 2016 LiDAR is in the New Zealand Transverse Mercator 2000 (NZTM2000) projection.

For consistency with the previous modelling the 2016 LiDAR was converted to the NZMG projection.

This page is left intentionally blank

3. Hydrology update

3.1 Introduction

The hydrology update included the following:

- flood frequency review.
- re-calibration of the hydrologic model
- update of design 1 in 200 AEP flood hydrographs and development of new flood hydrographs for additional catchment area covered by the new LiDAR.

The hydrologic update was carried out based on the following assumptions:

- The 1 in 100 AEP and 1 in 200 AEP 6hr durations design flood event hydrographs would be updated.
- The critical duration for flooding in catchment areas covered by the new LiDAR would not be reviewed.

3.2 Flood frequency review and hydrologic model re-calibration

A summary of the flood frequency review provided below:

- The flood frequency curves were supplied by Horizons Regional Council for Mangawhero at Hagleys and Makotuku at SH49. Recent annual flood maxima at all suitable stream flow gauges were also made available. The flood frequency curves are provided in Table 3.1.
- Since Entura's original Ohakune flood study[1] a significant flood occurred in the Mangawhero River during 2013, estimated at 150 m^3/s at Hagleys. This is the largest recorded flood peak from any of the three flow gauges on the Mangawhero River over 27 years of combined record. A flood peak of 80 m^3/s occurred in 1997 in the neighbouring Makotuku River, which has a catchment area that is 35% the size of Hagleys. No concurrent flow record is available on the Mangawhero River during 1997.
- The methodology and data from Entura's originals Ohakune report was reviewed. It is believed that the correlation between the flood peaks of Makotuku at SH49 and Mangawhero at Hagleys is too weak to have confidence in the factors used to transpose peak flows in that study.
- The supplied flood frequency curve was reproduced by using the same data including Mangawhero River at Burns St (which is believed to have uncertain data quality). Flows at Pakihi Road have been adjusted based on weighted area. $Q_{Hagleys} = Q_{Pakihi}$ x $(Area_{Pakihi} / Area_{Hagleys})^{0.8}$. The resultant frequency curve (Figure 3.1) matches the supplied data from HRC.

[1] Ludlow C, 2010, Ohakune Township Flood Modelling Study Report, ref E300492-Report-01

These results are comparable to the addendum report done in March 2015[2]. The adopted 1:100 peak flow at Hagleys is 160 m^3/s and the 1:200 peak flow is 185 m^3/s.

- The hydrological model was re-run to refine the model parameters and best fit the updated frequency curve. As a result a higher proportional runoff (PR) is used to achieve the higher runoff required. The adopted PR is 52.5% compared with 32.5% used in the original study. This is at the higher end of the values adopted during the event calibration of the original study.
- Other flood frequency curves were produced based on including or removing data from the flow sites in the area. They are plotted in Figure 3.2, Figure 3.3 and Figure 3.4. In each case the "Supplied" series is from HRC, and the "Modelled" series are the modelled results from the previous study. These alternatives results in a range of 1:100 AEP peak flows from 100 m^3/s to 200 m^3/s. The figure captions briefly state the reasons why these curves were not adopted in preference to Figure 3.1.

Table 3.1: Mangawhero at Hagleys, Burn's Street and Pakihi Road transposed to Hagleys and adjusted for weighted area AND Makotuku at SH49 (1968-2015) (Supplied by HRC)

Return period, AEP in in X	Discharge (m^3/s)	
	Mangawhero	Makotuku
1.1	20	16,122
1.5	39	21,905
2	49	25,767
2.33	55	27,668
5	77	36,937
10	97	45,860
20	114	55,778
25	122	59,236
50	142	70,937
100	162	84,305
200	182	99,622
500	201	123,392

[2] Ludlow C, 2015, Ohakune Township Flood Modelling Addendum Study Report, ref ENTURA-9917F

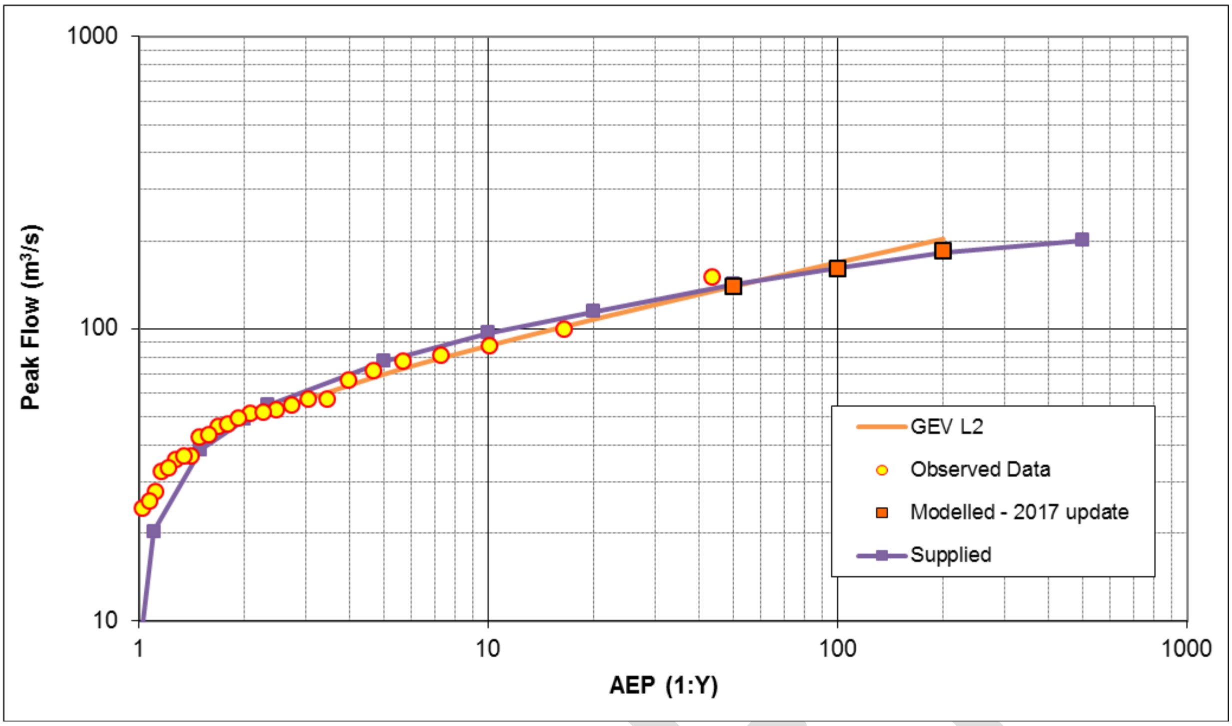

Figure 3.1: Adopted flood frequency curve and model results at Mangawhero at Hagleys

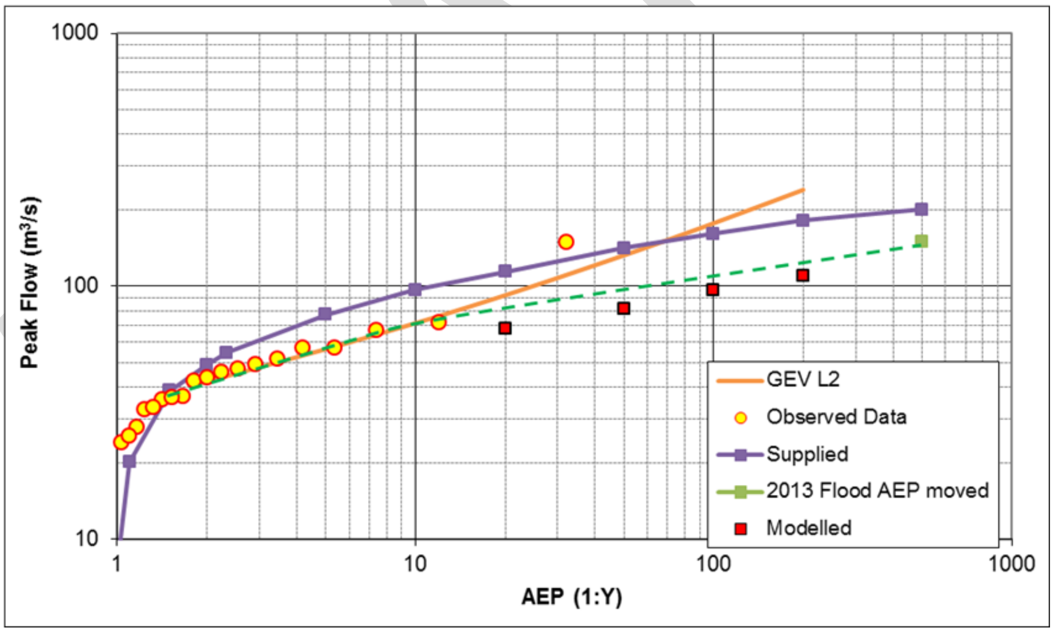

Figure 3.2: Flood frequency curve using Hagleys and Pakihi data only. Curve excluded due to insufficient length of data.

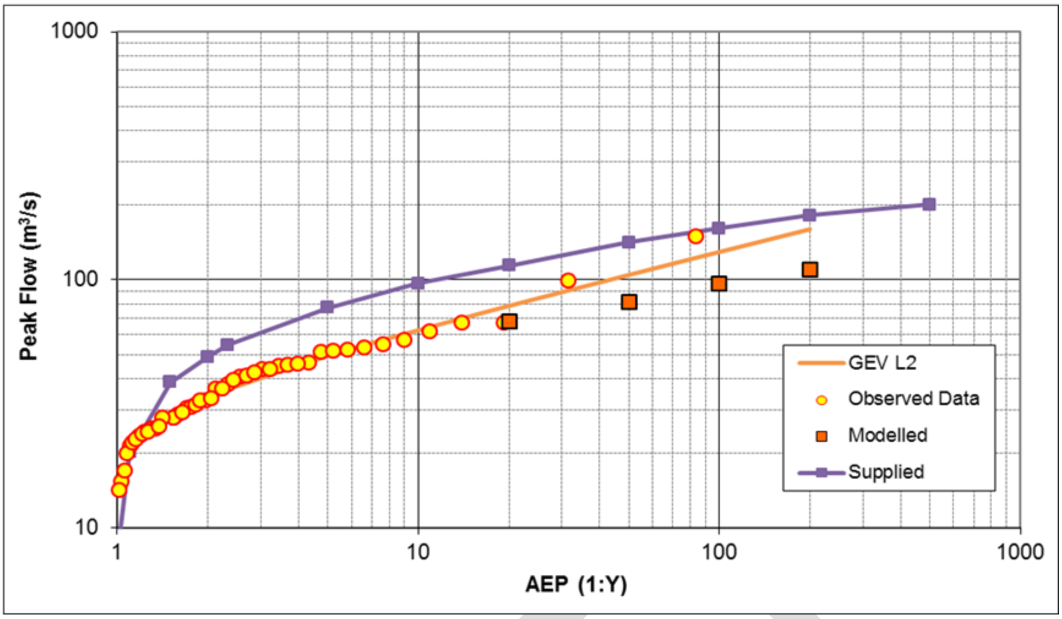

Figure 3.3: Flood frequency curve including Makotuku flood data scaled based on the factors used in previous study. Scaled Makotuku flood data seems too low.

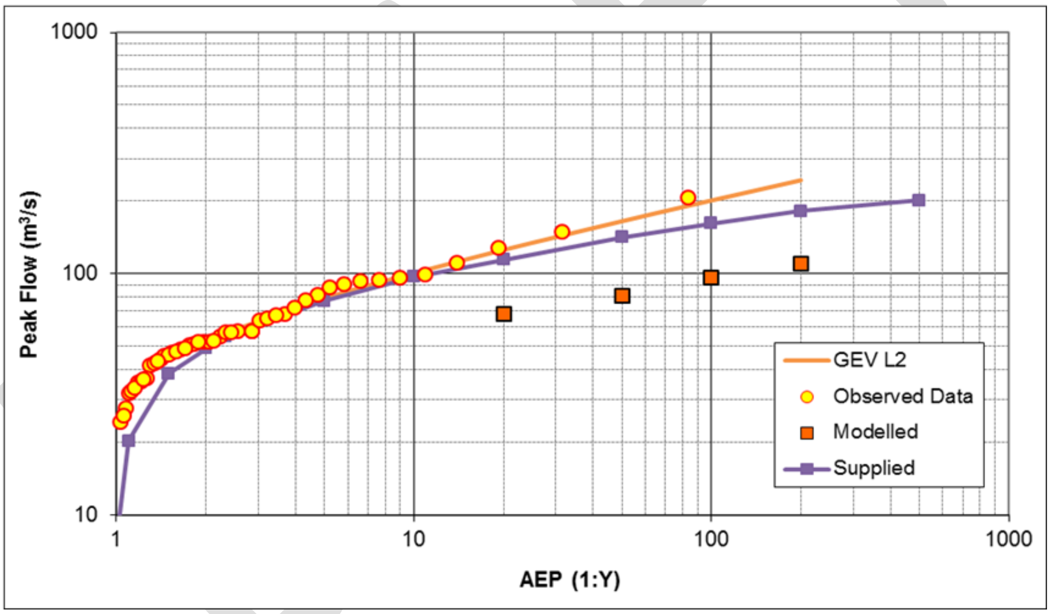

Figure 3.4: Flood frequency curve including Makotuku flood data scaled based on weighted catchment area. Scaled Makotuku flood data causes 1997 event to be largest on record.

3.3 Design flood hydrographs

3.4 Catchment areas

The original rural catchment boundaries for the sub-catchments in the vicinity of Ohakune are shown in Figure 3.5 along with the inflow locations to the MIKE Flood hydraulic model (all catchments). The new catchments associated

Catchment details are provided in Table 3.2.

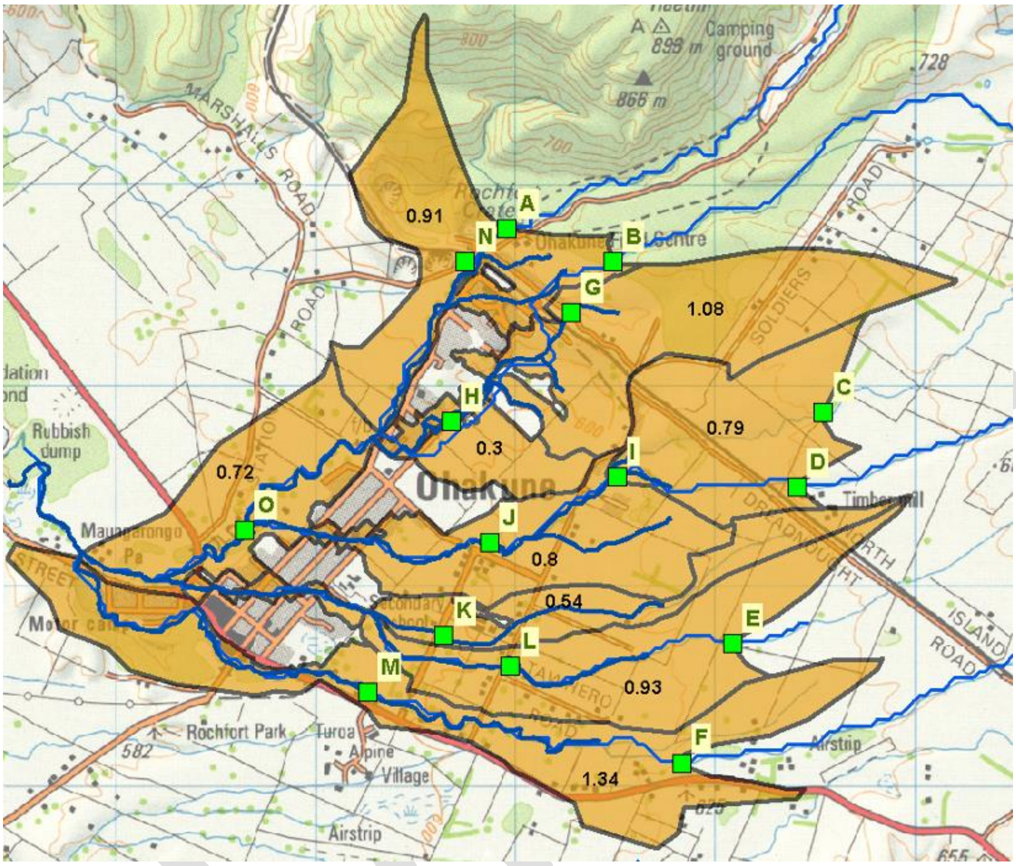

Figure 3.5: Rural sub-catchment boundaries and inflow locations

Table 3.2: Catchment details

Catchment ID	Inflow location (un-rotated coordinates)		Area (km^2)	Baseflow (m^3/s)	Delay (min)
	Easting	Northing			
Original model					
A	2,717,970	6,197,774	27.3	2.84	100
B	2,718,499	6,197,610	4.6	0.48	50
C	2,719,551	6,196,859	0.9	0.00	0
D	2,719,419	6,196,484	8.1	0.84	100
E	2,719,097	6,195,706	1.5	0.16	50
F	2,718,843	6,195,109	16.11	1.68	100
G	2,718,287	6,197,357	1.08	0.00	0
H	2,717,690	6,196,812	0.3	0.00	0
I	2,718,520	6,196,537	0.79	0.00	0
J	2,717,880	6,196,209	0.8	0.00	0
K	2,717,653	6,195,743	0.54	0.00	0
L	2,717,986	6,195,590	0.93	0.00	0
M	2,717,272	6,195,463	1.34	0.00	0

Catchment ID	Inflow location (un-rotated coordinates)		Area (km^2)	Baseflow (m^3/s)	Delay (min)
	Easting	Northing			
N	2,717,759	6,197,610	0.91	0.00	0
O	2,716,653	6,196,272	0.72	0.00	0
Updated model					
P	2,716,238	6,198,166	0.11	0.00	0
Q	2,716,656	6,197,903	0.20	0.00	0
R	2,717,043	6,197,616	0.06	0.00	0
S	2,716,104	6,198,113	0.09	0.00	0
T	2,716,219	6,197,891	0.10	0.00	0
U	2,717,467	6,197,508	0.20	0.00	0
V	2,715,854	6,197,946	0.08	0.00	0
W	2,716,567	6,197,582	0.10	0.00	0
X	2,716,914	6,197,401	0.11	0.00	0
Y	2,716,249	6,197,671	0.09	0.00	0
Z	2,716,488	6,197,418	0.05	0.00	0
AA	2,715,687	6,197,934	0.18	0.00	0
AB	2,716,617	6,197,303	0.04	0.00	0
AC	2,716,311	6,197,345	0.05	0.00	0
AD	2,715,637	6,197,697	0.14	0.00	0
AE	2,716,913	6,197,172	0.08	0.00	0
AF	2,716,074	6,197,438	0.05	0.00	0
AG	2,716,997	6,197,002	0.09	0.00	0
AH	2,716,749	6,196,820	0.02	0.00	0
AI	2,715,497	6,197,450	0.09	0.00	0
AJ	2,716,894	6,196,798	0.06	0.00	0
AK	2,716,395	6,197,083	0.17	0.00	0
AL	2,715,911	6,197,105	0.16	0.00	0
AM	2,716,398	6,196,765	0.16	0.00	0
AN	2,716,404	6,196,614	0.07	0.00	0
AO	2,716,006	6,196,710	0.03	0.00	0
AP	2,716,662	6,196,453	0.02	0.00	0

Catchment ID	Inflow location (un-rotated coordinates)		Area (km²)	Baseflow (m³/s)	Delay (min)
	Easting	Northing			
AQ	2,715,463	6,197,009	0.16	0.00	0
AR	2,716,327	6,196,494	0.11	0.00	0
AS	2,715,729	6,196,710	0.21	0.00	0
AV	2,714,832	6,197,129	0.24	0.00	0
AW	2,715,202	6,196,810	0.05	0.00	0
AX	2,715,965	6,196,325	0.04	0.00	0
AY	2,717,168	6,195,296	0.11	0.00	0
AZ	2,717,263	6,195,241	0.14	0.00	0
BA	2,716,760	6,195,382	0.06	0.00	0

3.5 Design flood hydrographs

The design flood hydrographs were modelled for Catchments A to F are as per those used in the previous study (Ludlow C. , 2 June 2015).

Hydrographs for Catchments G to AT have been scaled based on Catchment C area as per the original study.

Inflow hydrographs were developed for the 1 in 200 AEP 6hr storm duration and used as inputs to the MIKE Flood hydraulic model.

4. Hydraulic model update

4.1 Introduction

The existing MIKE Flood model was updated as per below:

- increased model extent to allow for new LiDAR.
- the three previous models were combined into a single model with a 2.5m grid.
- the MIKE 11 was rotated to be consistent with MIKE 21.
- including key hydraulic structures within the extended section of the model.

4.2 MIKE Flood model

4.2.1 Introduction

A brief summary of the updated MIKE Flood model is provided below.

The original modelling was carried out in the Version 2009 of the software. The updated model was developed in Version 2014 (Service Pack 3).

4.2.2 Model extent

The original modelling extent and location of the three models (A, B and C) is shown in Figure 4.1. The modelling area was originally split to reduce model run times. For the intended modelling area, current computer processing speed allows a single 2.5m gridded model. The revised modelling extent for the single 2.5m gridded model is shown in Figure 4.2.

4.2.3 MIKE 21

The combined MIKE 21 model was set-up using a 2.5m using both the original 2009 and more recent 2016 LiDAR made available by HRC.

The grid cell locations and rotation point for the previous Model B were retained for the combined model to ensure no changes would be required to link cells (MIKE 11 to MIKE 21, MIKE Urban to MIKE 21 and MIKE Urban to MIKE 11) and consistency of levels between the MIKE 21 grid and MIKE Urban manhole lid levels.

The rotation coordinates for the model are:

- Rotation angle: 22.5 degrees.
- Rotation point:
  - Easting: 2718610m
  - Northing: 6194620m

Land uses for the extended MIKE 21 model were consistent with those in the original modelling and are provided in Table 4.1.

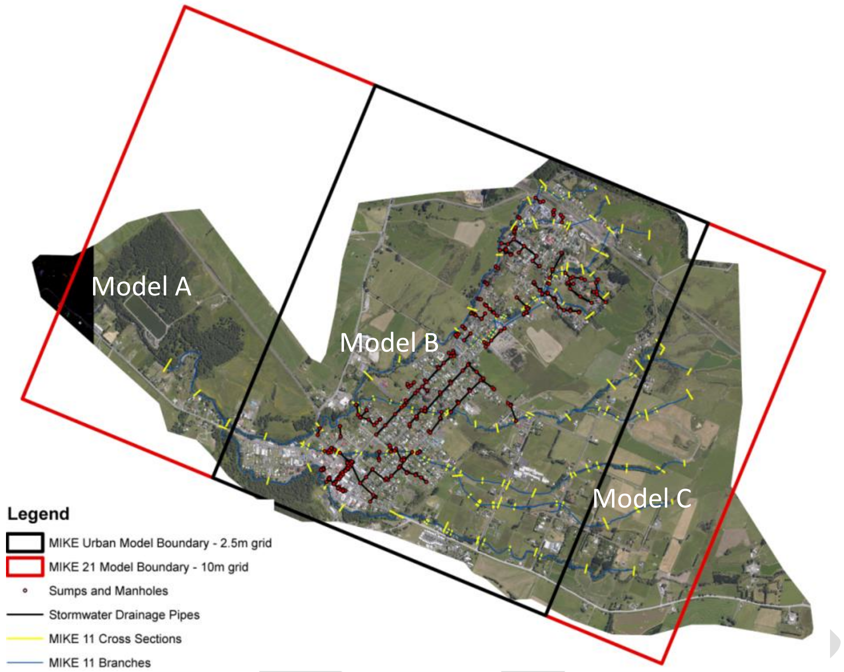

Figure 4.1: Original modelling extent

Figure 4.2: Revised modelling extent for single 2.5m gridded model

Table 4.1: MIKE 21 Manning's n values

Land Type	Equivalent Manning's 'n'
Built up Areas	0.167
Dense Vegetation	0.067
Open Space	0.037
Waterways	0.029
Roads	0.018

4.2.4 MIKE 11

The original MIKE 11 model extended from Model B upstream and downstream into Models C and A respectively. However the sections of the MIKE 11 model in Models A and C were not linked to the MIKE 21 model and were not used for estimating flood extents.

For the combined MIKE Flood model the original MIKE 11 model extent was trimmed to the original extent of Model B.

The coordinates of the points representing the MIKE 11 branches were rotated to be consistent with the MIKE 21 modelling domain. The original model was not rotated.

A number of small changes were made to the MIKE 11 model to achieve model stability in the different version of the software.

The downstream boundary condition used for the original MIKE 11 model was removed and the model was linked directly to the MIKE 21 grid as discussed below.

Within the new modelling extent six (6) additional culverts were added as MIKE 11 branches. The details of the additional culvert structures are provided in Table 4.2.

Table 4.2: Additional hydraulic structures included in the MIKE 11 model

MIKE 11 Branch	Length (m)	Structure Name	Type	Dimensions
104-106	15	104	Circular	0.75m diameter concrete
108-110	8.5	108	Circular	0.9m diameter concrete
112-113	25	112	Circular	0.37m diameter PVC
115-117	18	115	Circular	0.38m diameter PVC
119-120	12	119	Rectangular	0.38m diameter PVC
122-124	8	122	Rectangular	0.38m diameter PVC

4.2.5 MIKE Urban

No changes were made to the original MIKE Urban model.

4.2.6 Links

The updated MIKE Flood model links the three separated MIKE 21, MIKE 11 and MIKE Urban models. In the updated model:

- MIKE 21 and MIKE 11 are linked using lateral and standard links.
- MIKE 21 and MIKE Urban are linked using urban links.
- MIKE 11 and MIKE Urban are linked using river/urban links.

The following changes were made to the original links when developing the updated model:

- All existing cell coordinates were adjusted based on the new modelling extent.
- Lateral link cells at the downstream end of the MIKE 11 model were adjusted to suit the revised model.
- Flow over lateral links was adjusted to be based on the MIKE 21 grid (M21) rather than the highest value of the MIKE 11 cross-section or the MIKE 21 grid (HGH).
- Standard links were added to pass flow from the 2.5m MIKE 21 grid to the MIKE 11 model branches. These locations are at the upstream and downstream extent of the original Model B. Previous the flows were manually transferred between Model C to B and Model B to A.
- Six new culverts in MIKE 11 were linked to MIKE 21 using standard links.

No changes were made to the river/urban links.

4.2.7 Inflow locations

Inflows from the previous MIKE 11 model were transferred to MIKE 21. Transferred inflow locations are shown in the Table 4.3 below.

Table 4.3: Inflows transferred from MIKE 11 to MIKE 21

Previous model		**Updated model**			
		MIKE 21 Rotated Coordinates		MIKE 21 Un-rotated Coordinates	
MIKE 11 Branch	Chainage	Easting	Northing	Easting	Northing
H	0	2,717,820	6,196,496	2,718,598	6,196,656
K	0	2,718,113	6,196,266	2,718,781	6,196,331
L	0	2,718,256	6,195,850	2,718,754	6,195,892
M	0	2,718,278	6,195,593	2,718,676	6,195,646
N	0	2,718,220	6,195,101	2,718,434	6,195,214

Inflows from Table 3.2 (P-BA) were inserted at respective locations into the MIKE 21 model.

5. Hydraulic modelling of design flood events

5.1 Introduction

The MIKE Flood model was used to run the 1 in 200 AEP flood event. Only the 6hr duration was modelled as this was found to the critical duration event in the previous studies. It should be noted that this event may not result in worst case flooding in the extended sections of the model.

5.2 Provision of Results to HRC

The following information was provided to HRC:

- raw MIKE URBAN, MIKE 21 and MIKE 11 results files.
- waterRIDE (*.wrr) files of the MIKE 21 results.

The naming convention adopted for the result files is outlined in Table 5.1.

Table 5.1: Result file naming convention

File Name	Description
6hr_200AEP_RunoffBase.CRF	1:200 AEP 6hr duration MIKE URBAN (MOUSE calculation engine) catchment runoff results.
Ohakune_6hr_200AEPBase.PRF	1:200 AEP 6hr duration MIKE URBAN (MOUSE calculation engine) stormwater network results.
6hr_200AEP_2017.res11 6hr_200AEP_2017HDAdd.res11	1:200 AEP 6hr duration MIKE11 results.
6hr_200AEP_2017.dfs2	1:200AEP 6hr duration MIKE21 model results (water depth, level and velocity).
6hr_200AEP_2017.wrr	1 in 200 AEP MIKE 21 results converted to waterRIDE and un-rotated.

It should be noted that:

- MIKE 21 results at the edge of the LiDAR extent were clipped when converting to waterRIDE format.
- When un-rotating the MIKE 21 results to waterRIDE format the following should be used:
  - Target X Origin: 2,714,119.21m
  - Target Y Origin: 6,196,008.52m
  - Target orientation: 22.5 deg

This page is intentionally blank

6. Conclusions

The MIKE Flood model for Ohakune was updated to include recently collected LiDAR survey. The model was also modified to combine the three previous models into one single model with a 2.5m MIKE 21 grid.

The updated model was run for the 1 in 200 AEP 6hr duration flood event and the MIKE 21 flooding results were converted to waterRIDE format.

The raw MIKE Urban, MIKE 11 and MIKE 21 results files were provided to HRC along with the waterRIDE file containing the converted MIKE 21 results.

This page is intentionally blank.

7. References

Ludlow, C. (2 June 2015). *Okahine Township Flood Modelling.* Hobart: Entura.
Ludlow, C. (2010). *Ohakune Township Flood Modelling - Study Report.* Hobart: Entura.