

Nelson Plan Flood Model Updates

Maitai/Brook/York and Wakapuaka flood models

1 Introduction

This letter reports on updates made in 2020/2021 to Nelson City Council's (NCC's) Maitai/Brook/York and Wakapuaka flood models.

The main reason for the model updates is to bring the models in line with the most recent climate change advice from the Ministry for the Environment (MfE) and NIWA, including making use of recent joint probability analysis by NIWA for the Maitai River, Orphanage Stream and Wakapuaka River catchments. This has resulted in a change to the design tidal boundary that NCC has adopted across the city for modelling extreme river flow events. Recalibration of the Maitai/Brook/York hydraulic model has also been undertaken, and a number of other minor updates have also been incorporated, as described below.

The updated models are to be used by NCC as the basis for preparing flood hazard maps for the Whakamahere Whakatū (Nelson Plan), which is expected to be taken out for public consultation in August/September 2021. The models provided to NCC are able to show the present day and 2130 river flood hazard scenarios and provide information relating to flow depth and velocity to inform NCC's flood hazard maps.

The updates have been made to the existing flood models that were developed between 2013 and 2019 and peer reviewed by MWH. The models were developed using DHI Software's Mike Flood software package and are 1D/2D coupled models. The primary piped stormwater networks are not included in these models except where a stream's main channel is piped for a section (e.g. York Stream), as the purpose of the models is to understand river/stream flood hazard.

Table 1.1 describes the climate change and storm scenarios assessed as part of this project. These climate scenarios were as advised by NCC and were based on MfE's latest projections using the locally adjusted climate change models by NIWA.

Table 1.1: Modelled scenarios

Climate change condition	Storm event	Tidal boundary	Associated temperature increase	Associated sea level rise (relative to 2008-2017 baseline)
PRESENT DAY	5% AEP ¹	MHHW ²	0°C	0 m (i.e. none)
PRESENT DAY	2% AEP	MHHW	0°C	0 m (i.e. none)
PRESENT DAY	1% AEP	MHHW	0°C	0 m (i.e. none)
Year 2070 RCP8.5M ³	1% AEP	MHHW + SLR ⁴	1.84°C	+0.38 m
Year 2090 RCP8.5M	1% AEP	MHHW + SLR	2.58°C	+0.60 m
Year 2130 RCP8.5M	1% AEP	MHHW + SLR	3.4°C	+1.11 m

Note: various storm durations are assessed for each storm event.

1: AEP = annual exceedance probability

2: MHHW = mean higher high water (average of the highest of the two daily astronomical tides)

3: RCP8.5M = Representative concentration pathway 8.5 with median (M) sea level rise projection. MfE guidelines promote consideration of a range of scenarios for assessment of future coastal hazards, and it was decided (by NCC) that RCP8.5M is appropriate for use in the production of these flood hazard maps as:

- the flooding being analysed is mainly fluvial (i.e. not coastal hazard) and;
- NIWA HIRDS v4 rainfall data is based on mid-range scenarios (i.e. there is no H+ temperature/rainfall scenario included in HIRDS v4)

4: SLR = sea level rise

2 Maitai/Brook/York flood model

The model version that the updates are described for is version 202103_v016. Changes made to the models are detailed below. In broad terms, the changes have been required as a result of the following:

- Update to rainfall data (depths and storm profiles) to NIWA's High Intensity Rainfall Design System (HIRDS) v4, updated August 2018.
- Update to the downstream boundary condition to Mean Highest High Water (MHHW), as adopted by NCC.
- Update to the cross sections and bridge details based on the latest (2020) UAV survey of the Maitai River.
- Update to Hanby Park stopbank crest and Clouston bridge floodwall (at Maitai Valley Road/Nile Street intersection) with the latest (2020) UAV survey data of the Maitai River.
- Refinement of observed December 2011 flood levels and re-calibration of Maitai River (including consideration of 1986 flood observations).

Figures 1 and 2 in Appendix A detail the schematisation of the Maitai/Brook/York hydraulic model.

Table 2.1: Maitai/Brook/York Model updates

Model element update	Update comment
Climate change	Revised extreme climate change scenario (RCP8.5H+ 2130 changed to RCP8.5M 2130) at NCC's request. Refer to Note 3 in Table 1.1.
Sea Level:	<ul style="list-style-type: none"> • Tidal boundary updated following NCC instruction June/July 2020 from 63% AEP tide to MHHW tidal condition of 13.6 mRL (present day, NCC Datum). This level was adopted by NCC following NIWA's joint probability analysis on the Maitai River, Orphanage Stream and Wakapuaka River catchments (river flow vs. tidal level).

Model element update	Update comment
	<ul style="list-style-type: none"> Tidal boundary of the 24-hour duration event simulation shifted 2.25 hours later to coincide tidal peak tide level with Maitai River peak flow at the river mouth (as noted in peer review).
Topographical data (2D terrain)	<ul style="list-style-type: none"> Modification to open channel at 34 Vanguard Street (Rebel Sports/Briscoes carpark section of York Stream that was modified during construction of new building in 2019/2020). 2D mesh terrain updated at Hanby Park stopbank using 2020 UAV survey data (better representation of crest).
Cross sections	<ul style="list-style-type: none"> Resistance radius updated to "Total Area, Hydraulic Radius" for consistency with other Nelson Plan models. Cross sections were cut from 2020 UAV data provided by NCC from Maitai River chg 10750 - chg 15466 (i.e. where UAV data was available) to replace 2015 LiDAR sections in this area. Cross sections were extracted every 25 m (c.f. 50 m previously) due to resolution of 2D mesh.
Bridges	<ul style="list-style-type: none"> Bridges along the Maitai River were updated with 2020 bridge scan data provided by NCC (including soffit/deck levels, section, grade). The following bridges were updated: <ul style="list-style-type: none"> Jickells bridge Gibbs bridge Clouston bridge Nile Street bridge Bridge Street bridge Collingwood bridge Trafalgar bridge SH6 bridge (Queen Elizabeth II Drive) Domett bridge
Recalibration	<p>Recalibration of hydraulic model using observations made during/after December 2011 event. This was required following the updated cross sections incorporated into the model from the UAV data and updated field survey of the December 2011 event observed flood levels. The recalibration also considered observations made during the 1986 flood event.</p> <p>Channel (1D) roughness values were varied along the urban reach of the Maitai River to improve the match between the modelled and observed peak flood levels. In general, roughness values were reduced to achieve this match.</p> <ul style="list-style-type: none"> 1D roughness was updated as follows: <ul style="list-style-type: none"> Maitai River chg 11500 – 11750 <ul style="list-style-type: none"> High flow manning's $n = 0.06$ Maitai River chg 11750 – 12175 <i>swimming hole transition zone</i> <ul style="list-style-type: none"> High flow manning's $n = 0.06$ Low flow manning's $n = 0.045$ Maitai River chg 12200 – 13025 <i>Hanby Park</i> <ul style="list-style-type: none"> High flow manning's $n = 0.04$ Low flow manning's $n = 0.035$ Maitai River chg 12650 – 12800 <i>Hanby Park subsection</i> <ul style="list-style-type: none"> High flow manning's $n = 0.045$ (right bank) Maitai River chg 12924 <i>Clouston Bridge rock weir</i> <ul style="list-style-type: none"> Low flow manning's $n = 0.045$ Maitai River chg 12937 – 13175 <i>Hanby Park to Girlies Hole</i>

Model element update	Update comment
	<ul style="list-style-type: none"> ○ Low flow manning's $n = 0.04$ - Maitai River chg 13050 – 13587 <i>Girllies Hole section</i> <ul style="list-style-type: none"> ○ High flow manning's $n = 0.05$ ○ Low flow manning's $n = 0.035$ - Maitai River chg 13600 – 14467 <i>Avon Terrace section</i> <ul style="list-style-type: none"> ○ High flow manning's $n = 0.035$ ○ Low flow manning's $n = 0.035$ - Maitai River chg 14011 – 14013 <i>Downstream of Bridge Street bridge</i> <ul style="list-style-type: none"> ○ Low flow manning's $n = 0.045$ - Maitai River chg 14581 – 15150 <ul style="list-style-type: none"> ○ High flow manning's $n = 0.03$ ○ Low flow manning's $n = 0.025$ - Maitai River chg 15150 – 15466 <i>Maitai River to estuary</i> <ul style="list-style-type: none"> ○ High flow manning's $n = 0.03$ ○ Low flow manning's $n = 0.025$ - Cross sections Brook Stream chg 3413.8 - 4045 (section in vicinity of Seymour Avenue gauge) have roughness increased from $n = 0.015$ to $n = 0.02$. • 2D roughness map was updated using a combination of NCC zoning and LCDB v5.0. The following manning's n values were applied: <ul style="list-style-type: none"> - Building 0.345 - Indigenous Forest 0.149 - Deciduous Hardwoods 0.149 - Exotic Forest 0.149 - Forest - Harvested 0.149 - Herbaceous Saline Vegetation 0.110 - Built-up Area (settlement) 0.100 - Transport Infrastructure 0.100 - Broadleaved Indigenous Hardwoods 0.060 - Mixed Exotic Shrubland 0.053 - Manuka and/or Kanuka 0.053 - Gorse and/or Broom 0.053 - Low Producing Grassland 0.050 - High Producing Exotic Grassland 0.050 - Estuary/Ocean 0.043 - Gravel or Rock 0.039 - River 0.035 - Urban Parkland/Open Space 0.033 - Surface Mine or Dump 0.027 - Sand or Gravel 0.021 - Lake or Pond 0.020 - Impervious Surface 0.020 - Road 0.020 <p>Refer to Appendix C for details showing model results following calibration.</p> <p>Refer to Appendix C for rating curves at gauged location.</p>
Pipe network	Pipe concrete roughness increased from Manning's $n = 0.013$ to Manning's $n = 0.016$ as a part of calibrating model velocity results with gauging data in the York Stream at Victory Square gauge data.

Model element update	Update comment
Other changes	<ul style="list-style-type: none"> • Lateral links between 1D and 2D model re-checked and updated, particularly around bridge structures, to better represent outbreak flows. • Lateral links set to spill at the 1D bank level where critical terrain features are represented within 1D cross section. • Miscellaneous minor adjustments for stability purposes.

3 Wakapuaka flood model

The model version that the updates are described for is version 20200701. Changes to the model are detailed below. In broad terms, the changes have been required as a result of the following:

- Update to rainfall data (depths and storm profiles) to NIWA's High Intensity Rainfall Design System (HIRDS) v4, updated August 2018.
- Update to the downstream boundary condition to Mean Highest High Water (MHHW).

We note that model performance was checked during the previous stage of model development using a flood level from the December 2011 event and was found to be acceptable.

Figure 3 in Appendix A details the schematisation of the Wakapuaka hydraulic model.

Table 3.1: Wakapuaka Model updates

Model element update	Update comments
Rainfall	<ul style="list-style-type: none"> • Minor updates to hyetograph distribution to use revised method of distributing rainfall depths. • Rainfall-runoff links corrected in M11 file following peer review. • Updates to sub-catchment areas of Floodplain 8, 7, 6, 5 to correct minor errors.
Climate change	Revised extreme climate change scenario (RCP8.5H+ 2130 changed to RCP8.5M 2130), at NCC's request. Refer to Note 3 in Table 1.1.
Sea Level:	<ul style="list-style-type: none"> • Tidal boundary updated following NCC instruction June/July 2020 from 63% AEP tide to MHHW tidal condition of 13.59 mRL (present day, NCC Datum), following NIWA's joint probability assessments of Maitai River, Orphanage Stream and Wakapuaka river flows/sea levels.
Topographical data (2D terrain)	<ul style="list-style-type: none"> • Mesh element levels updated at: <ul style="list-style-type: none"> – Residential development in Todds Valley (9-23 Todd Bush Road) – Tidal boundary due to revised tidal level – Standard link (due to remeshing).
Other changes	<ul style="list-style-type: none"> • Schematisation of coastal model boundary updated following revised tidal condition. • The Haven coastal boundary is not included in 2D, as Boulder Bank Drive does not overtop in the maximum tidal scenario modelled (MHHW+1.11m SLR, RCP8.5M to 2130 = 14.70 mRL NCC Datum). Rather, the coastal boundary in the Haven is applied to the end of the 1D model.

4 Applicability

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

We understand and agree that this report will be used by Nelson City Council in undertaking its regulatory functions in connection with Nelson City Plan.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

Report prepared by:



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Sarah Basheer
Senior Water Engineer

Authorised for Tonkin & Taylor Ltd by:



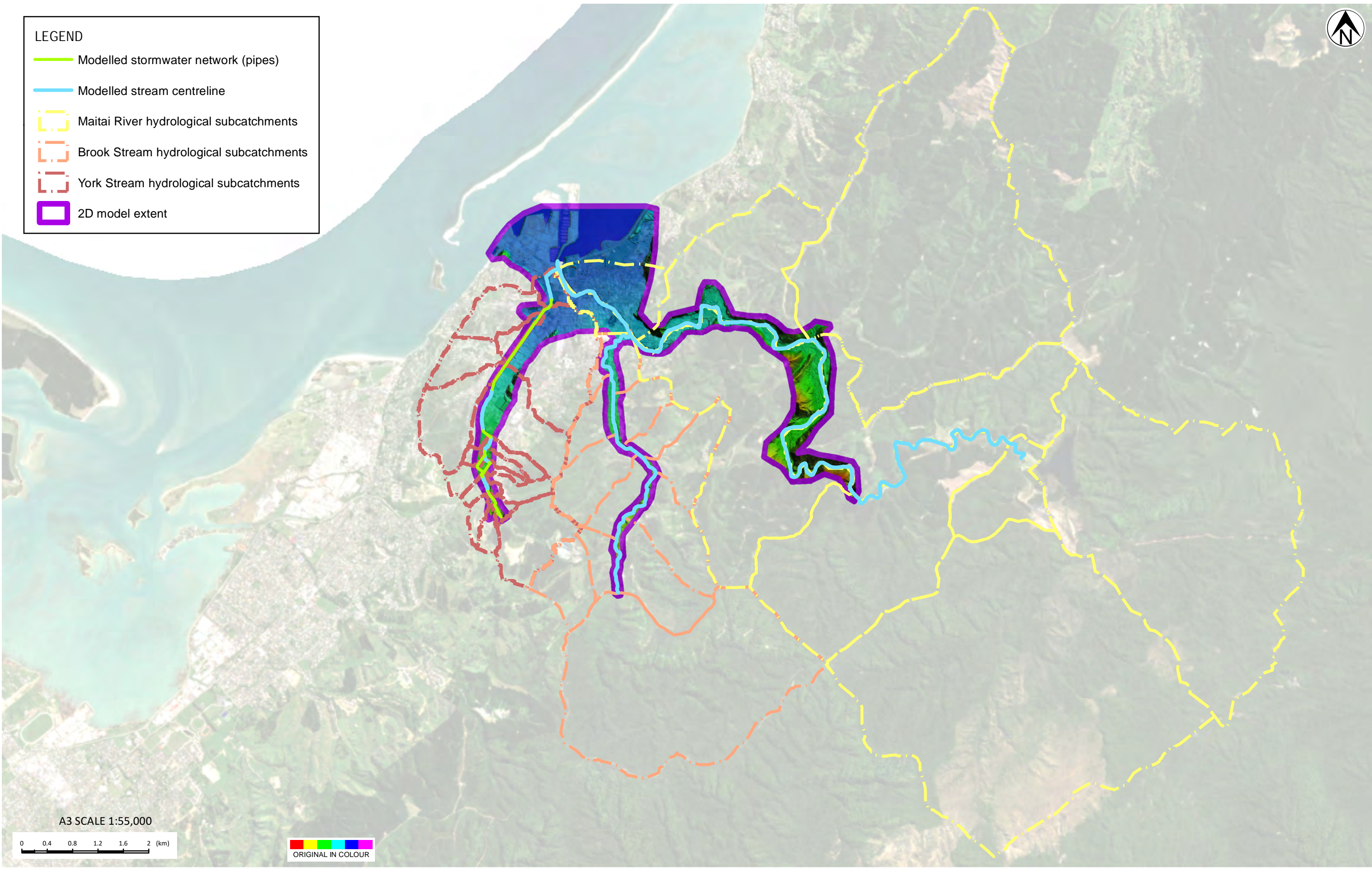
.....
Damian Velluppillai
Project Director


SGB

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Appendix A: Hydraulic model schematisation

- **Figure 1 - Hydraulic model schematisation: Maitai/Brook/York flood model (1:55,000 scale)**
- **Figure 2 - Hydraulic model schematisation: Maitai/Brook/York flood model (1:25,000 scale)**
- **Figure 3 - Hydraulic model schematisation: Wakapuaka flood model**





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NOTES:

Basemap: Eagle Technology, Land Information New Zealand
Model version shown is "MaiBkYk_202103_v016".

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First version

KBBB

SGB

23/07/21


REVDESCRIPTIONGISCHKDATE

PROJECT No. 870888.0012

DESIGNED KBBB JUL.21


DRAWN KBBB JUL.21

CHECKED SGB JUL.21

 27.7.21

APPROVED DATE

LOCATION PLAN



CLIENT NELSON CITY COUNCIL

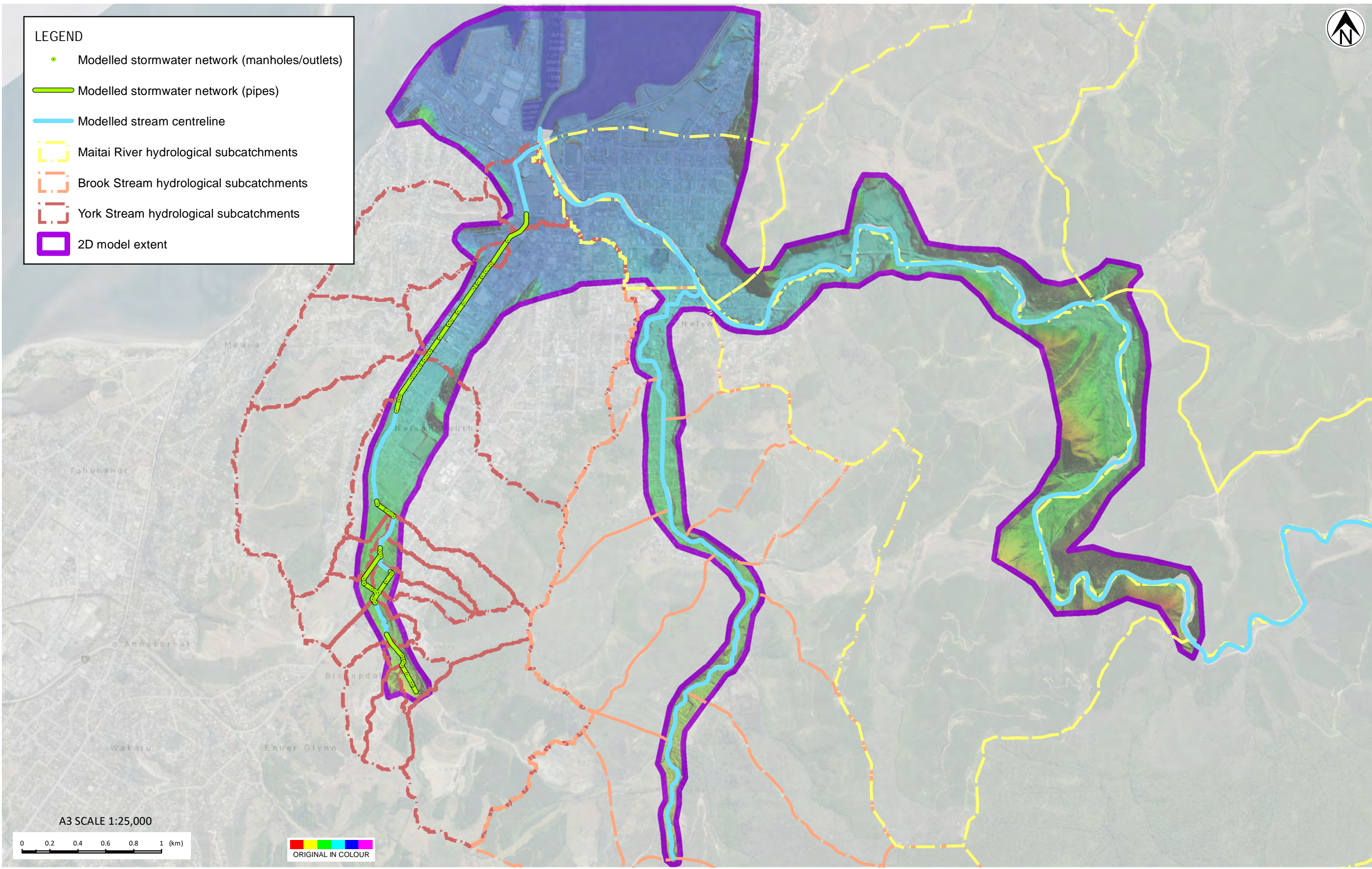
PROJECT NELSON CITY PLAN MODEL UPDATES




TITLE HYDRAULIC MODEL SCHEMATISATION:
MAITAI/BROOK/YORK FLOOD MODEL

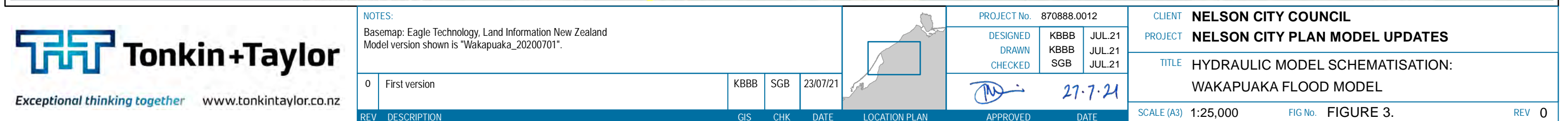
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FIG No. FIGURE 1.

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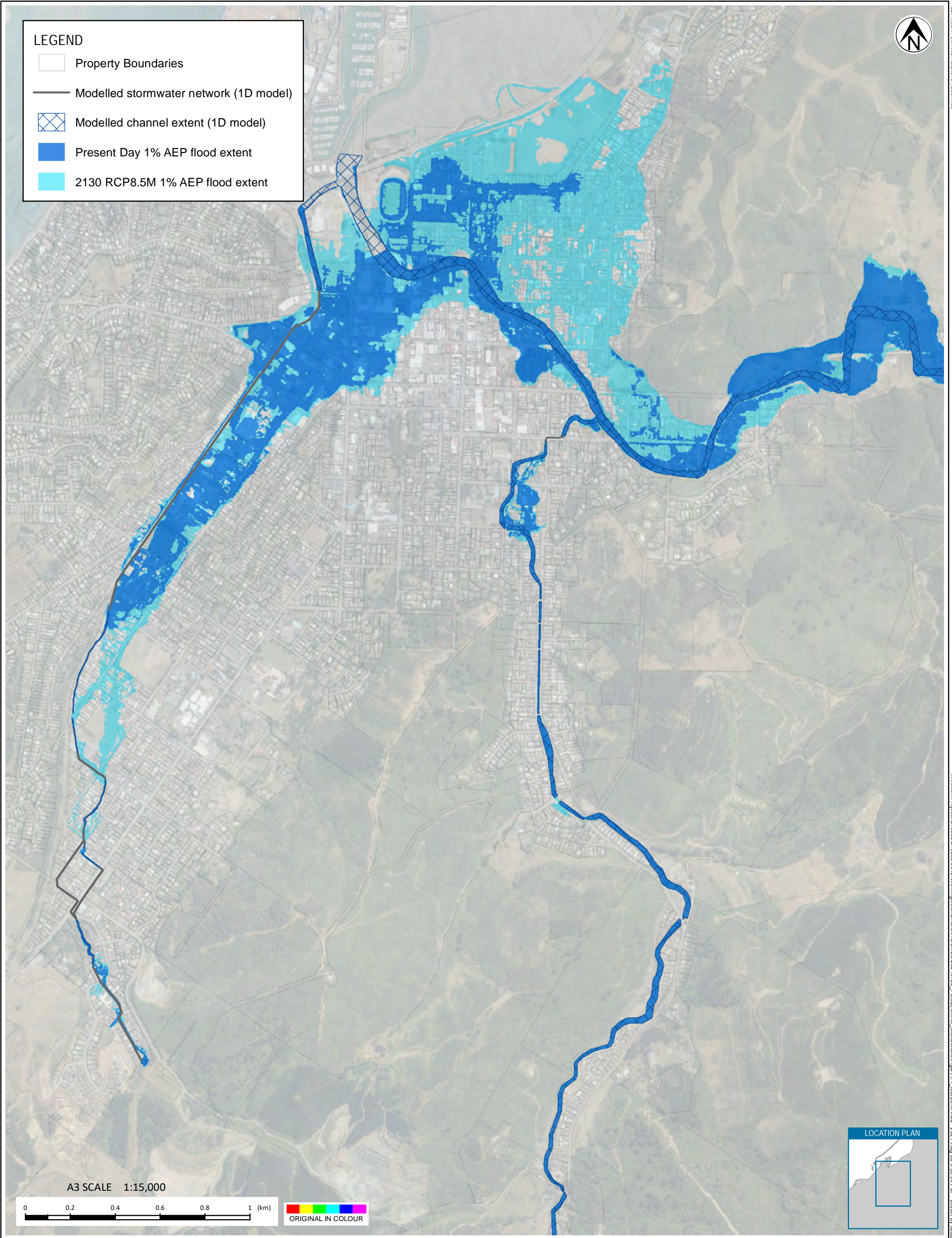


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	<div>DESIGNED</div> <div>DRAWN</div> <div>CHECKED</div>			<div>KB</div> <div>BB</div> <div>SG</div>	<div>JUL.21</div> <div>JUL.21</div> <div>JUL.21</div>		<div>PROJECT</div> <div>NELSON CITY PLAN MODEL UPDATES</div>				
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	<div>SCALE (A3)</div> <div>1:25,000</div> <div>FIG No.</div> <div>FIGURE 2.</div> <div>REV</div> <div>0</div>										
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REV	DESCRIPTION	GIS	CHK	DATE	LOCATION PLAN	APPROVED	DATE				




Appendix B: Hydraulic model flood extent maps

- **Figure 1.1 - 1.2 – Flood extents: Maitai/Brook/York**
- **Figure 2 – Flood extents: Wakapuaka**




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NOTES:
1. Basemap: Eagle Technology, Land Information New Zealand
2. Property boundaries: Top of the South maps
3. Model version: MaiBKYY_202103_v016
4. 2D model results are trimmed at coastal boundary and extents with areas less than 20m² are removed in post-processing.

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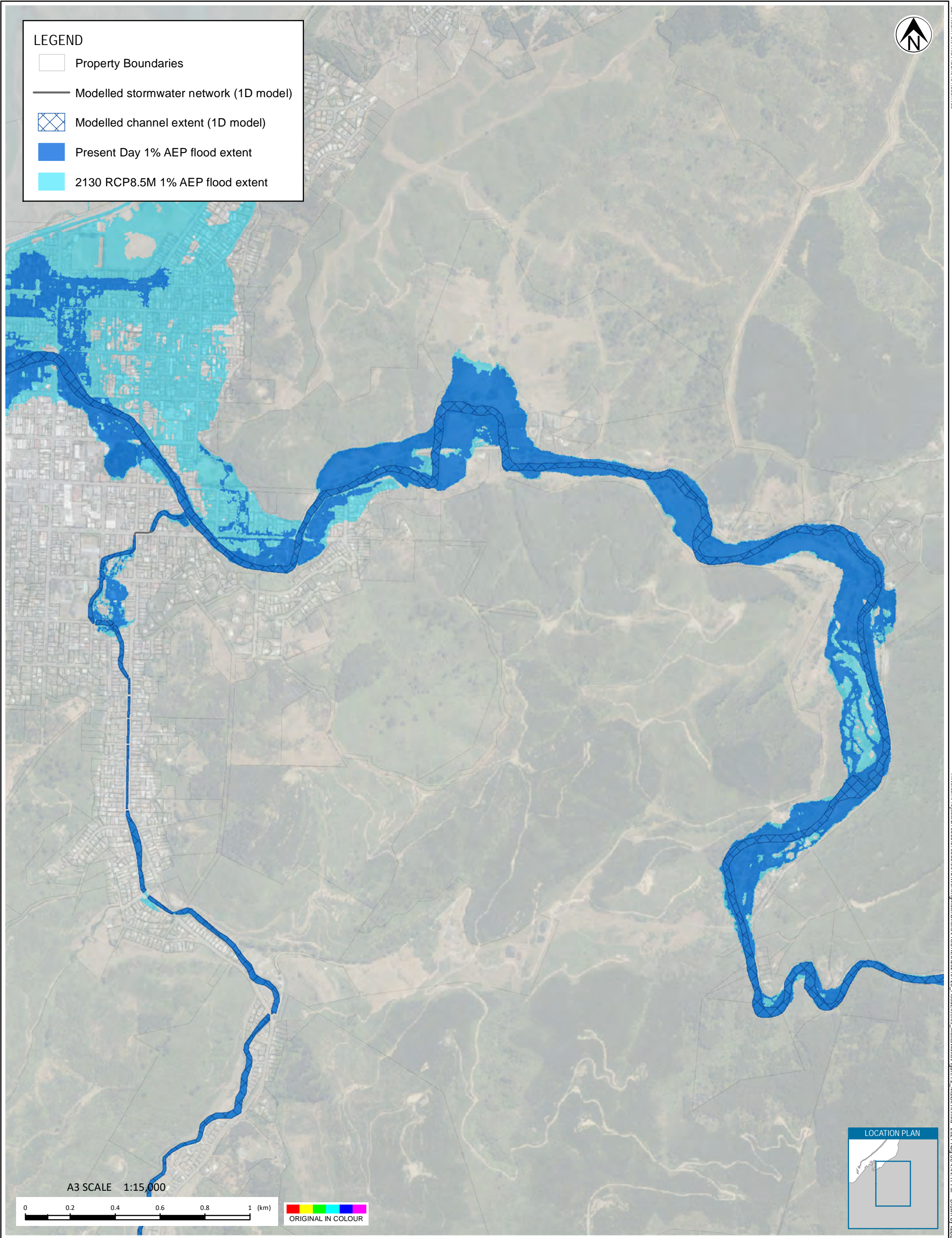


28/07/21


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CLIENT	NELSON CITY COUNCIL		
PROJECT	NELSON CITY PLAN MODEL UPDATES		
TITLE	FLOOD EXTENTS: MAITAI/BROOK/YORK		

SCALE (A3)	1:15,000	FIG No.	FIGURE 1.1	REV	0
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T:\Nelson\Projects\870888\870888_001\2\Working\Drawings\FIGURE 1.2_Flood Extents_Maitai\Brook\York_2021_Aug_06_4:44:11 PM Drawn by KBBB




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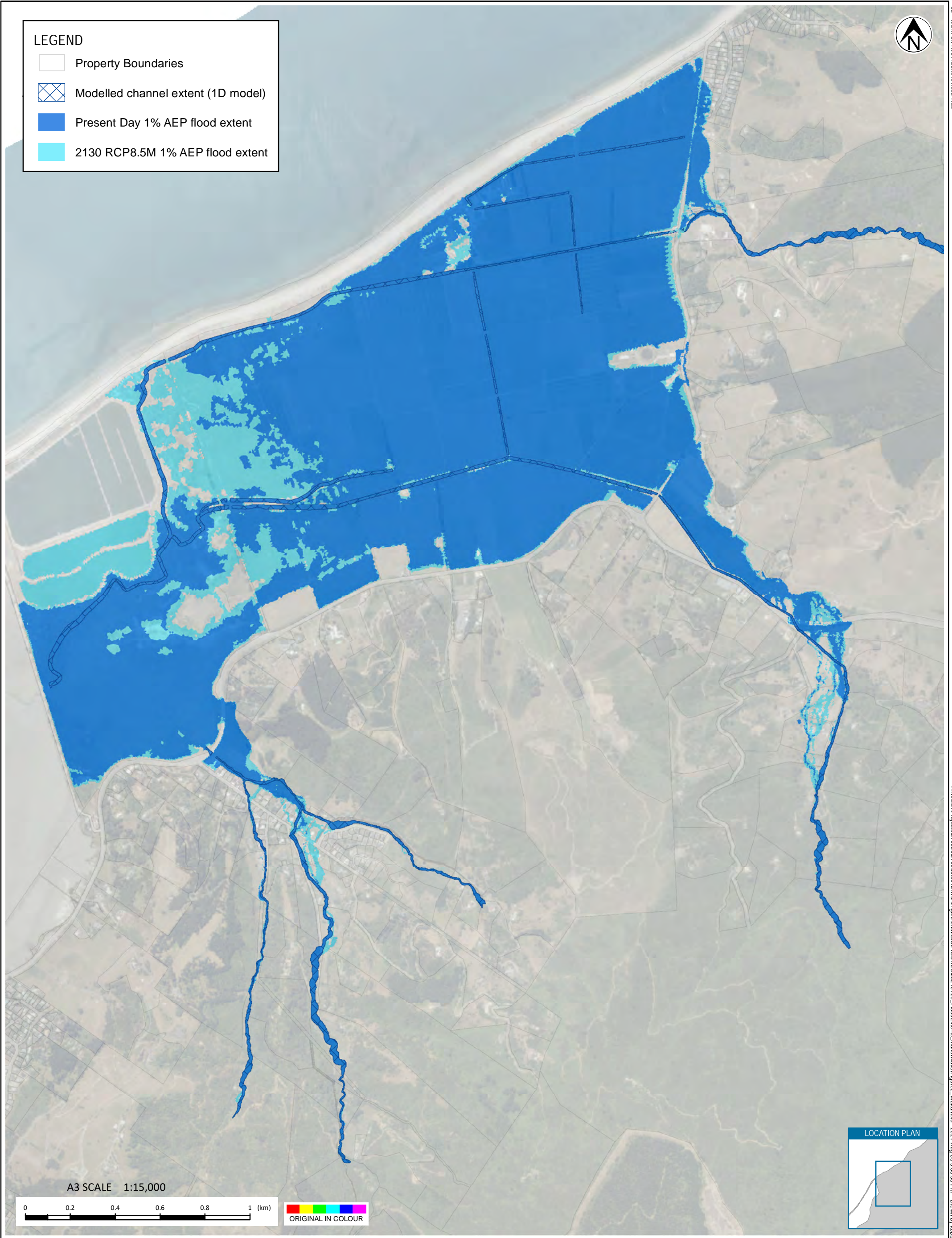
NOTES:
1. Basemap: Eagle Technology, Land Information New Zealand
2. Property boundaries: Top of the South maps
3. Model version: MaiBKYYK_202103_v016
4. 2D model results are trimmed at coastal boundary and extents with areas less than 20m² are removed in post-processing.

PROJECT No.	870888.0012		
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CHECKED	SGB	JUL.21	


CLIENT	NELSON CITY COUNCIL		
PROJECT	NELSON CITY PLAN MODEL UPDATES		
TITLE	FLOOD EXTENTS: MAITAI/BROOK/YORK		

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REV	DESCRIPTION	GIS	CHK	DATE	APPROVED	DATE

SCALE (A3)	1:15,000	FIG No.	FIGURE 1.2	REV	0
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NOTES:
1. Basemap: Eagle Technology, Land Information New Zealand
2. Property boundaries: Top of the South maps
3. Model version: Wakapuaka_20200701
4. 2D model extents with areas less than 20m² are removed in post-processing.

PROJECT No.	870888.0012		
DESIGNED	KBBB	JUL.21	
DRAWN	KBBB	JUL.21	
CHECKED	SGB	JUL.21	

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CLIENT	NELSON CITY COUNCIL		
PROJECT	NELSON CITY PLAN MODEL UPDATES		
TITLE	FLOOD EXTENTS: WAKAPUAKA		

SCALE (A3)	1:15,000	FIG No.	FIGURE 2.	REV	0
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Appendix C: Maitai/Brook/York December 2011 calibration and validation results

- **December 2011 calibration: Long section results**
- **Model results at gauges**
- **Validation: Long section results**

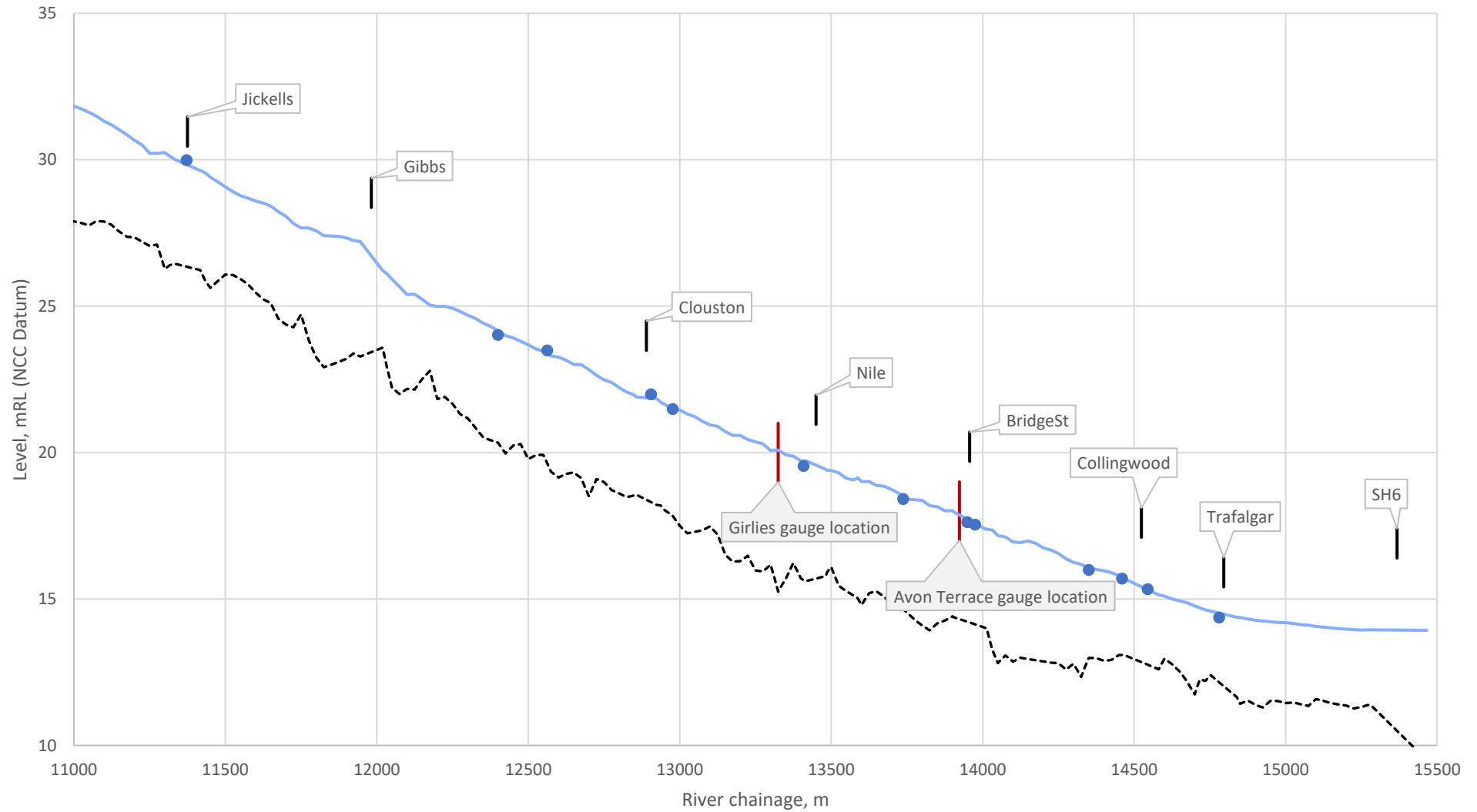
December 2011 event - Maitai/Brook/York model calibration

Point #	Approx Location	Model	Chainage (m)	Observed flood level (NCC Datum)	Maitai/Brook/York 202103_v016 (NCC Datum)	
					Modelled Water Level	Diff from Observed
A	Upstream Jickells	1D	11372.2	29.99	29.834	-152 mm
B	Hanby Park 1	2D	12400.0	24.02	24.159	+140 mm
C	Hanby Park 2	2D	12562.6	23.49	23.381	-112 mm
D	Downstream Clouston	1D	12905.5	21.99	21.852	-138 mm
E	End of Clouston Tce	1D	12977.0	21.49	21.508	+23 mm
F	Upstream Nile St Bridge	1D	13409.2	19.54	19.715	+175 mm
G	Maitai Esplanade 1	2D	13737.9	18.42	18.456	+41 mm
H	Upstream Bridge St	1D	13949.0	17.62	17.730	+110 mm
I	Downstream Bridge St	1D	13975.1	17.54	17.583	+41 mm
J	Riverside Drive	2D	14350.0	15.99	16.100	+107 mm
K	Upstream Collingwood	1D	14460.3	15.70	15.737	+41 mm
L	Downstream Collingwood	1D	14545.0	15.34	15.317	-20 mm
M	Upstream Trafalgar Bridge	1D	14780.5	14.36	14.519	+155 mm

Notes:

1. Observed flood levels are based on locations shown in T+T photos taken near peak of flood event. Locations were then mapped onto 2020 UAV DEM data provided by NCC to obtain flood levels.

Maitai/Brook/York hydraulic model: December 2011 calibration event, water level long section



— Girlies gauge location

— Bridges

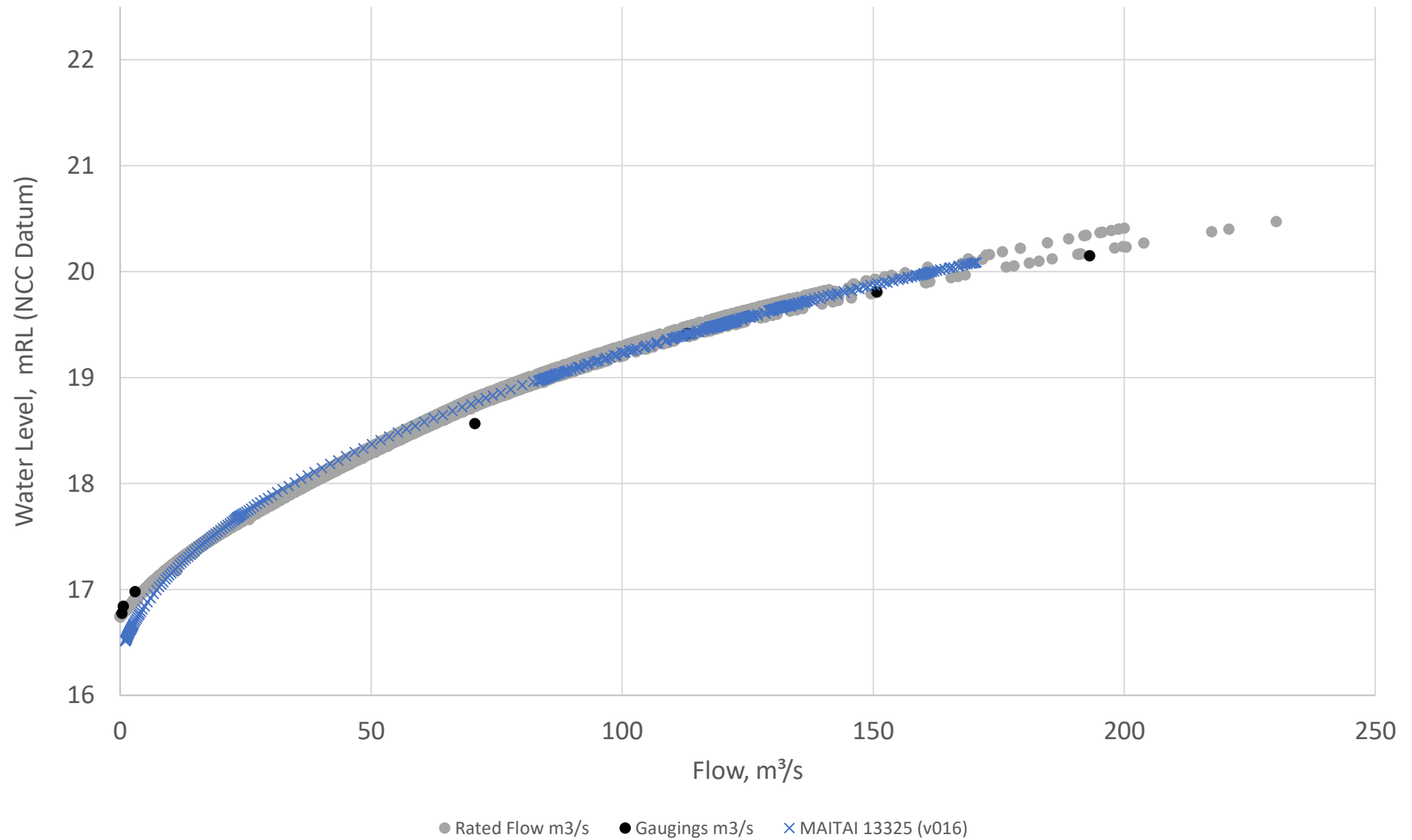
— Avon Terrace gauge location

- - - - - Approx. Channel Invert

● 2011 event observed flood level

— Dec 2011 modelled water level

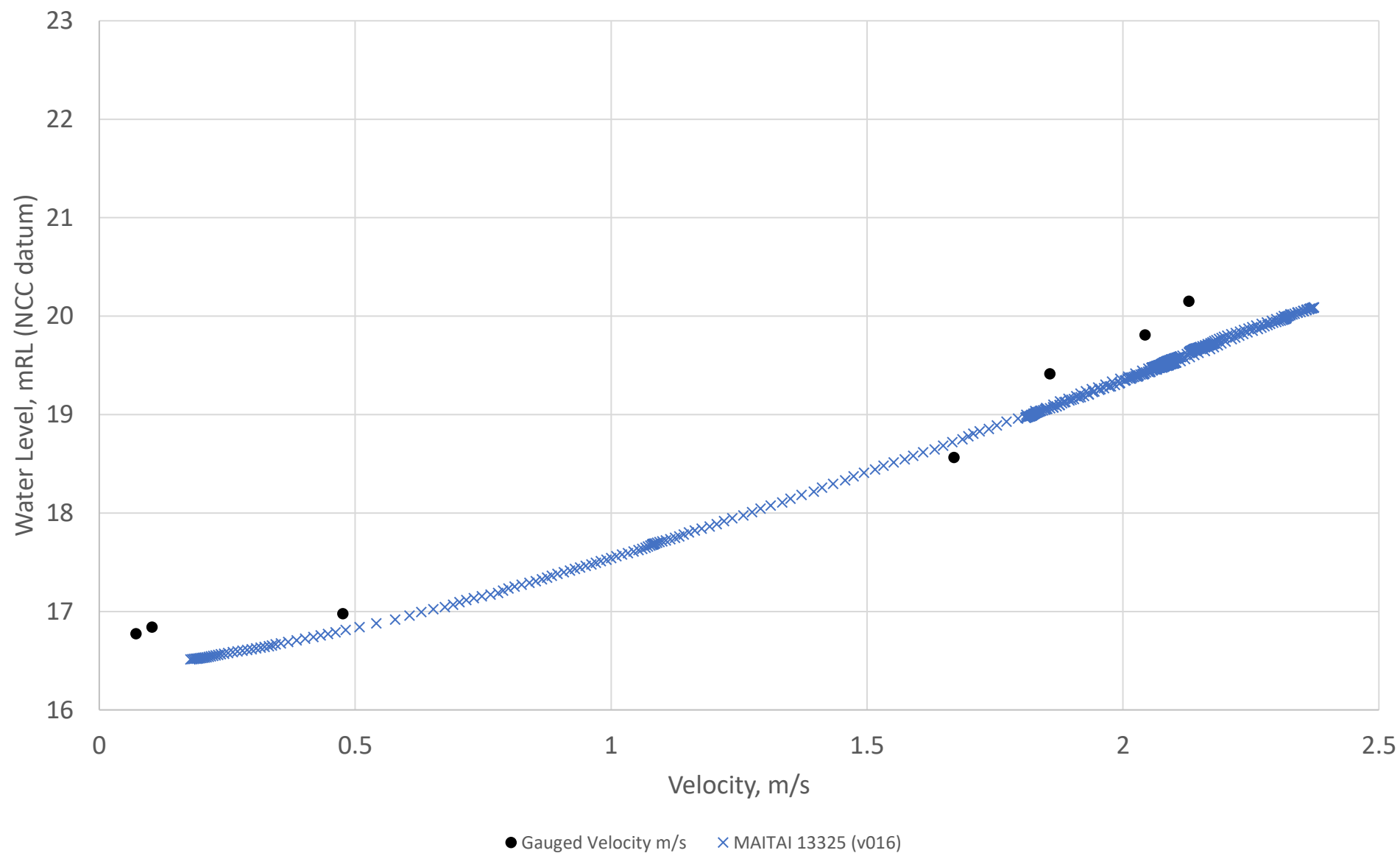
Q-h: Maitai at Girlies Hole (MAITAI 13325)



Notes:

1. Blue 'X' marker indicates modelled results (e.g. Q-h) at location of interest (for example Maitai River branch, chainage 13,325) for the Maitai/Brook/York hydraulic model version 202103_v016

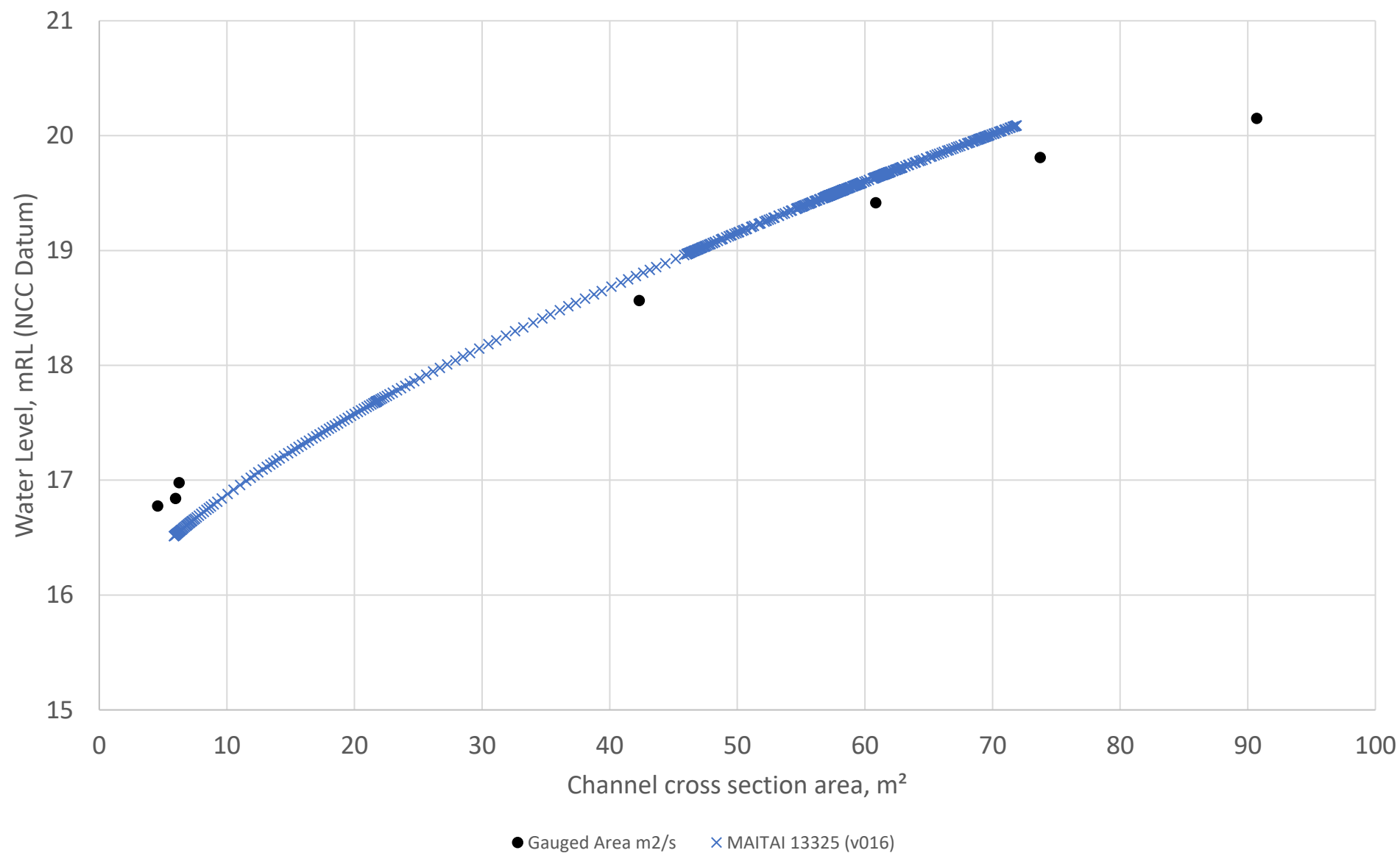
V-h: Maitai at Girlies Hole (MAITAI 13325)



Notes:

1. Blue 'X' marker indicates modelled results (e.g. Q-h) at location of interest (for example Maitai River branch, chainage 13,325) for the Maitai/Brook/York hydraulic model version 202103_v016

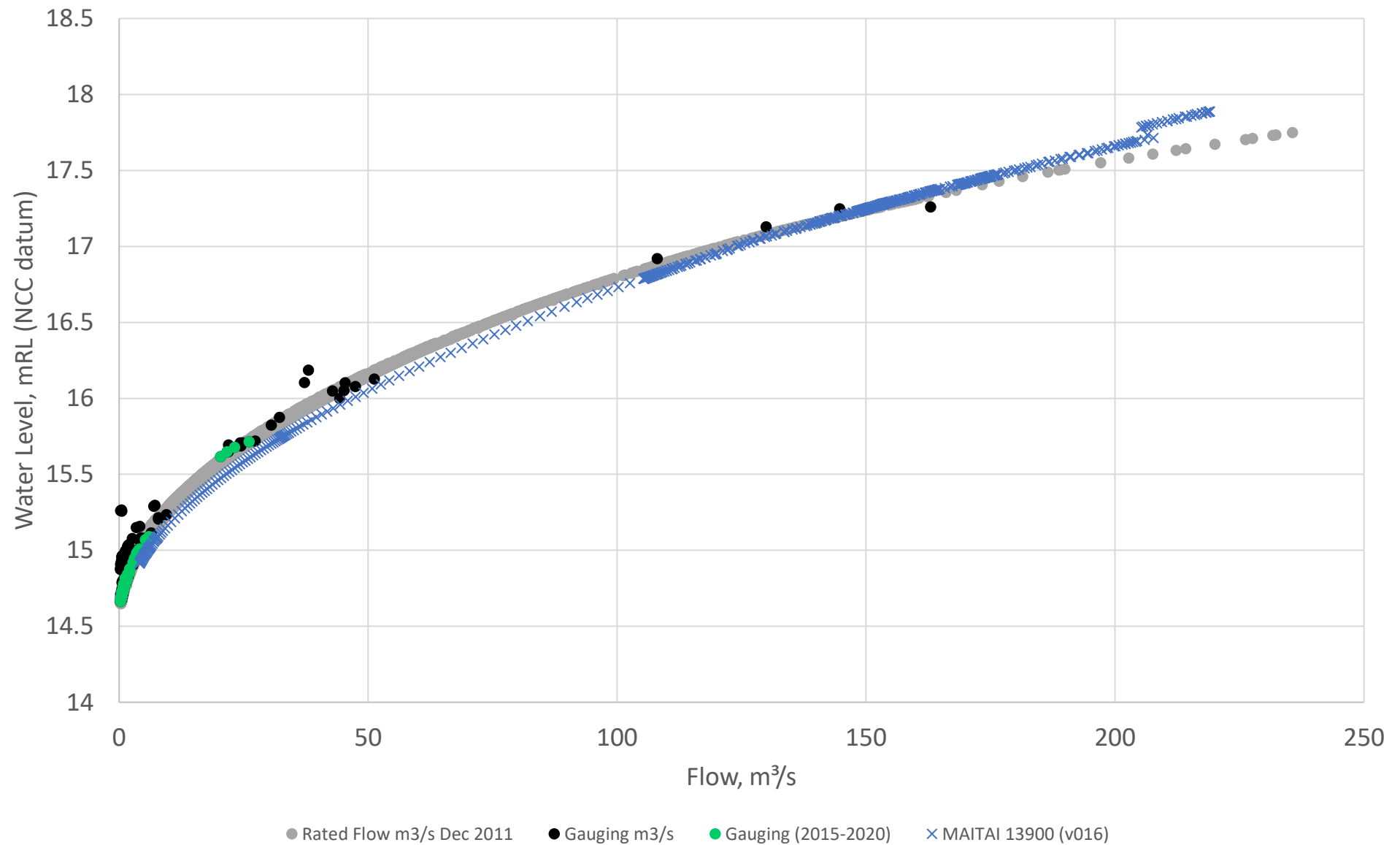
A-h: Maitai at Girlies Hole (MAITAI 13325)



Notes:

1. Blue 'X' marker indicates modelled results (e.g. Q-h) at location of interest (for example Maitai River branch, chainage 13,325) for the Maitai/Brook/York hydraulic model version 202103_v016

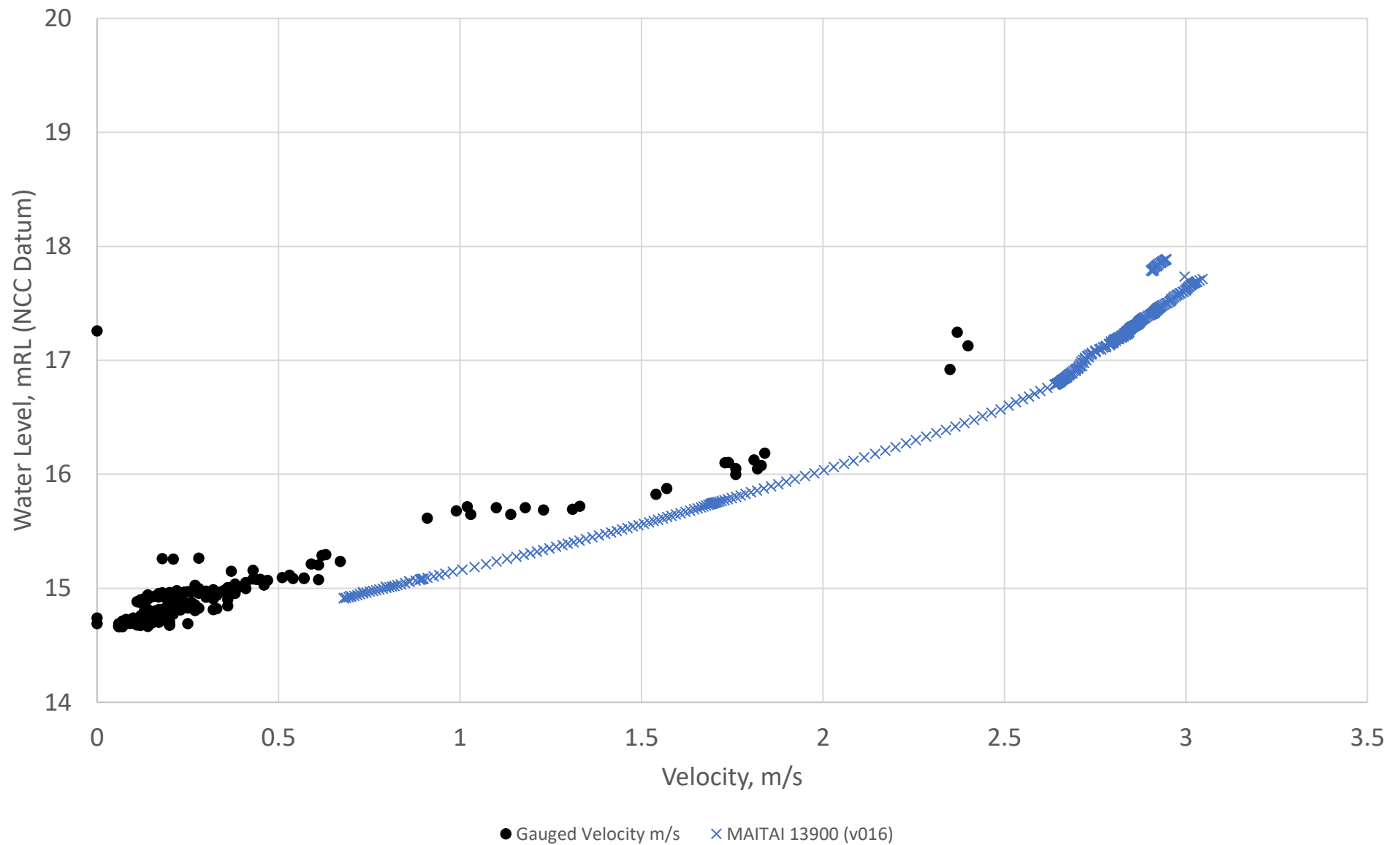
Q-h: Maitai At Avon Terrace (MAITAI 13900)



Notes:

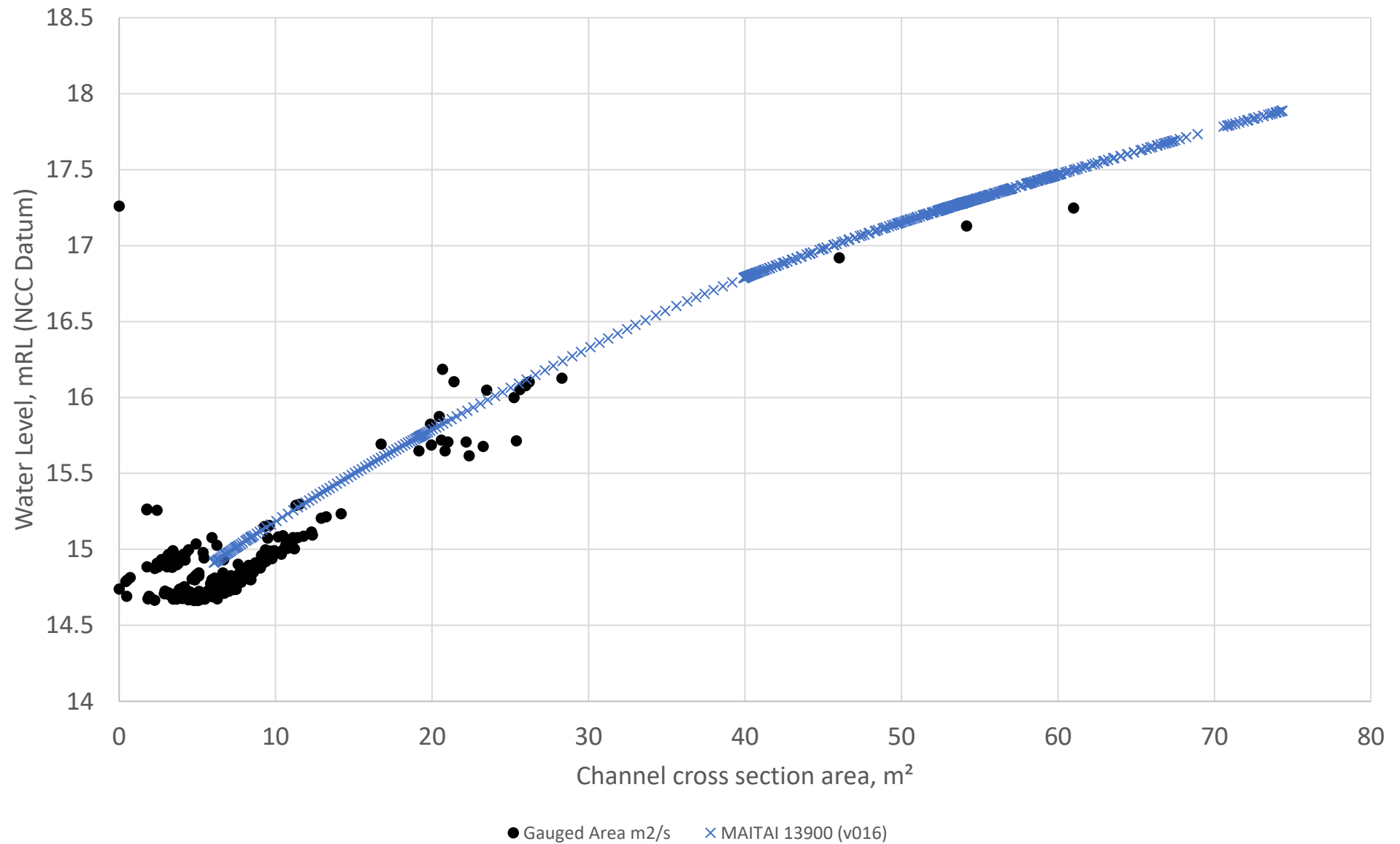
1. Blue 'X' marker indicates modelled results (e.g. Q-h) at location of interest (for example Maitai River branch, chainage 13,325) for the Maitai/Brook/York hydraulic model version 202103_v016

V-h: Maitai At Avon Terrace (MAITAI 13900)

**Notes:**

1. Blue 'X' marker indicates modelled results (e.g. Q-h) at location of interest (for example Maitai River branch, chainage 13,325) for the Maitai/Brook/York hydraulic model version 202103_v016

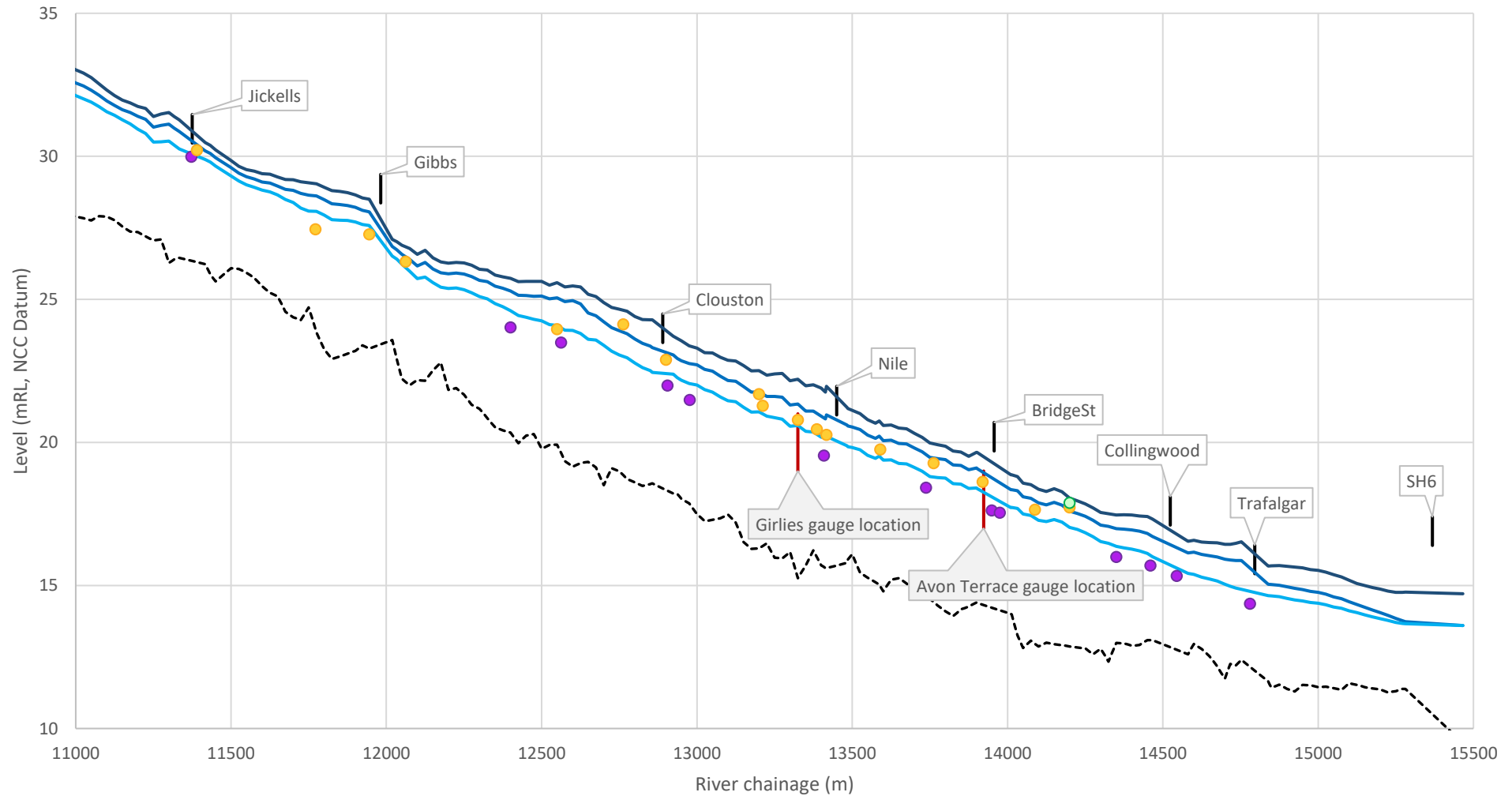
Maitai At Avon Terrace (MAITAI 13900)



Notes:

1. Blue 'X' marker indicates modelled results (e.g. Q-h) at location of interest (for example Maitai River branch, chainage 13,325) for the Maitai/Brook/York hydraulic model version 202103_v016

Maitai/Brook/York hydraulic model: Design storm validation, water level long section



- Girlies gauge location
- 2011 event observed flood levels
- 1983 event observed flood level
- Present Day 1% AEP 24 hour storm modelled water level
- Bridges

- Avon Terrace gauge location
- 1986 event observed flood levels
- Present Day 1% AEP 24 hour storm modelled water level
- 2130 RCP8.5M 1% AEP 24 hour storm modelled water level
- Approx. Channel Invert