Peka Peka to Ōtaki Expressway – Pre Project Hydraulic Model Report

29 October 2018

Revision 6

Aconex document number: T&T-DR-RPT-0005

NZ TRANSPORT AGENCY WAKA KOTAHI | Peka Peka to Ōtaki Expressway

New Zealand Government

More information

NZ Transport Agency
Published May 2017

ISBN TBC

If you have further queries, call our contact centre on 0800 699 000 or write to us:

NZ Transport Agency
Private Bag 6995
Wellington 6141

This document is available on the NZ Transport Agency’s website at www.nzta.govt.nz

REVISION HISTORY

Revision N°	Prepared By	Description	Date
1.	Kelsey Beckett	First issue	05.05.17
2.	Kelsey Beckett	Update for Ōtaki-Mangapouri and Mangaone models for revised hydrology, peer review and to increase model stability	25.08.17
3.	Kelsey Beckett	Update for Waitohu model for revised hydrology and peer review	25.10.17
4.	Kelsey Beckett	Update for Ōtaki-Mangapouri, Waitohu and Mangaone models for peer review and to increase model stability	29.03.18
5.	Kelsey Beckett and Lucy Whitelock-Bell	Finalised following review comments.	11.05.18
6.	Emma Boon	Rev 6 - No change following review	29.10.18

DOCUMENT ACCEPTANCE

Action	Name	Signed	Date
Prepared by	Dewi Knappstein and Kelsey Beckett		29.10.18
Reviewed by	Jon Rix		29.10.18
Reviewed by	Tom Bassett		29.10.18
Approved by	Bruce Symmans		29.10.18
on behalf of	Beca Ltd		

CONTENTS

TABLES

APPENDICES

1. Introduction and Objectives

1.1 The Project

Fletcher Construction Company Limited (Fletcher) has been commissioned by the NZ Transport Agency (NZTA) to provide the Detailed Design and Construction for the Peka Peka to Ōtaki Expressway (PP2Ō, the "Project").

PP2Ō forms part of the Wellington Northern Corridor from Levin to Wellington Airport. The Project consists of a 12.5km four lane expressway, approximately 9km of local road, ten bridges, including the 330m Ōtaki River Bridge, and realignment of approximately 1.6km of rail.

1.2 Report Scope

This report summarises the details of the hydraulic models that describe the pre-project situation, which is explained further in Section 1.5. The models are for the:

- Ōtaki River and Mangapouri Stream;
- Waitohu Stream; and
- Mangaone Stream.

The purpose of the report is to summarise the model build methodology, assumptions, data sources and results. The outputs from the pre-project model will be used to assess the post-project effects and compliance with the Resource Consents and Principal's Requirements.

The report should be read in conjunction with the "Stormwater 80% Design Report Rev 1" (PP2Ō, January 2018) and the "Hydraulic and Hydrological Modelling Schematisation Report" (Fletcher, March 2017).

1.3 Report Revision

1.3.1 Introduction

The subject document is Revision 5 of this report, which was previously issued as Revision 4 on 29 March 2018 for comment. Revision 4 presented the model build for the Ōtaki-Mangapouri, Waitohu and Mangaone 100% stage pre-project models.

Revision 5 represents the finalisation of the report, and incorporates the following:

- Changes associated with Stakeholder, Peer Review and Principal's Advisor Check comments (refer Section 1.3.2); and
- Correction to some hydrological inputs for the Ōtaki-Mangapouri model (refer Section 1.3.3).

1.3.2 Review Comments

Records of the Peer Review and Principal's Advisor Check are included in Appendix E.

No new comments were raised by the Principal's Advisor following review of Revision 4. Two comments, categorised as "C3: Discussion Items", were raised by the Peer Reviewer. All comments have been closed out.

The key change to the report, arising from the review process, is that Sections 2.2.6 and 2.3.6 now refer to the “Stormwater Design Philosophy Report Rev 2” (PP2Ō August 2017) as the definitive original source for the flow boundary conditions.

1.3.3 Correction to Hydrological Inputs

The Ōtaki-Mangapouri model has been re-run for the 0.2% AEP CC2130 base case and 0.2% AEP CC2130 breach scenario to correct a data entry error for hydrological inputs. Previously modelled flows for the “Ōtaki 1” catchment were too high. All discussion and figures have been updated for the corrected model results.

The corrected results were discussed with the Peer Reviewer and Principal’s Advisor before finalising the report.

1.4 Objective of the Hydraulic Modelling

Hydraulic modelling is required to assess compliance with the specified hydraulic performance standards for the Project, which are set out by:

- Resource Consents; and
- Principal’s Requirements, as modified by Notices to Tenderers, Notices to Contractor, and Approved Departures.

1.5 Method to Fulfil Objectives

The hydraulic models will assess compliance with the performance standards by:

- Modelling a pre-project situation: Quantifying the hydraulic behaviour of floods based on the pre-project arrangement, assuming climate change to 2130 and allowing for future land development;
- Modelling a post-project situation: Quantifying the hydraulic behaviour of floods based on the post-project arrangement, also assuming climate change to 2130 and allowing for future land development;
- Assessing compliance: The changes in flood patterns, depths, velocities and flows for the post-project arrangement compared with the pre-project arrangement have been identified by comparing the models developed for the two situations listed above.

This report summarises the method for hydraulic modelling of the pre-project situation only. The assessment of the post-project situation and assessment of compliance is discussed in a separate report “Post-Project Hydraulic Model Report Rev 3” (PP2Ō, March 2018).

Three hydraulic models have been developed (the “pre-project models”). The pre-project models include the following rivers and streams:

- Ōtaki-Mangapouri Model: Ōtaki River and floodplain, and Mangapouri Stream;
- Waitohu Model: Waitohu Stream and floodplain; and
- Mangaone Model: Mangaone Stream and alluvial fan.

Hydraulic models for other watercourses and streams are covered in separate design reports.

The models are valid for assessing compliance for this project, but may not be valid at other locations and for other purposes.

1.6 Coordinate System and Vertical Datum

The coordinate system and vertical datum adopted for the pre-project models is consistent with the Principal's Requirements (PRs, Section 7.2.2) and comprises:

- Coordinate system: NZTM 2000; and
- Vertical datum: NZVD 2009.

1.7 Model Schematisation

The model schematisation was described in the Peka Peka to Ōtaki Expressway Hydraulic & Hydrological Modelling Schematisation Report ("Schematisation Report"), (Fletcher, March 2017).

1.8 Historic Modelling

Previous peer-reviewed modelling of these catchments was undertaken by Opus in 2013 for the Consenting and Specimen Design stages of the Project. It is understood that these models (which will be referred to as the "2013 OPUS models") were adapted and developed from hydraulic models previously developed by Greater Wellington Regional Council (GWRC).

The model history, including validation carried out, is summarised in Table 1.

Table 1 – Model History

Versions	Mangapouri Catchment Model
GWRC	Steady state HEC-RAS model built 1997-98 (Wellington Regional Council, 1998; Ōtaki Floodplain Management Plan; Mangapouri Stream Upgrade Hydraulic Modelling Report) The Ōtaki Floodplain Management Plan (1998) states: *"Because there are no accurate data on flood levels it is not possible to accurately calibrate or validate the model".*
Opus, 2013	The Opus 2013 report (Peka Peka to North Ōtaki Expressway - Detailed Hydraulic Investigations for Expressway Crossing of Mangapouri Stream) states that a property owner provided anecdotal evidence of floodwaters in the Mangapouri Stream nearly reaching the house on the property at 22 County Road in the 28 October 1998 event. A flood peak of 22.0m^3/s was inferred by Opus from this event (approximately 7 year ARI event) based on hydrological assessment for a nearby catchment (Mangaone). Ground levels around the 22 County Road property (13.76 to 13.96mRL NZVD 2009) were determined to be similar to the flood levels simulated by Opus in the 5 and 10 year ARI events (13.92 and 14.01mRL NZVD 2009).
	Ōtaki Catchment Model
GWRC	A MIKE 11 model was originally constructed in 1992. The Opus 2013 report states "*It is unfortunate that the supporting documentation for the MIKE 11 model calibration appears to have been lost".* The Opus 2013 report includes email correspondence from GWRC which states that the 1992 model was calibrated to a March 1990 flood event (peak 1,170m^3/s, approximately 5 year ARI flood). The correspondence also states that the 1992 model was verified against an August 1991 event (peak 975m^3/s, approximately 2.5 year ARI flood) and the model produced a good match between recorded and modelled flood levels. The correspondence states that all March 1990 levels were modelled to within 0.61m and 60% of March 1990 levels were modelled to within 0.2m. A model update in 2007 (Wallace, P; March 2007; Hydraulic Assessment of Chrystalls Extended Stopbank) included checks against a single peak flood level recorded in January 2005 immediately upstream of the rail bridge (estimated 20 year ARI flood, Wallace, 2007). The quoted level that occurred during this event of 12.66mRL (NZVD 2009) was inferred from LiDAR data and an anecdotal report of flood levels (Opus 2013). The 2007 model produced a level of 13.12mRL (NZVD 2009), 0.46m higher than the inferred level. The higher level was attributed to conservative debris blockage (wider piers) in the 2007 report, and it was noted in the Opus 2013 report that higher mean bed levels may have also been a factor.
Opus, 2013	The 2013 Ōtaki model report (Opus, 2013; Peka Peka to North Ōtaki Expressway - Hydraulic Investigations for Expressway Crossing of Ōtaki River and Floodplain) indicates that "*A* [2007] *MIKE FLOOD model was adapted and enhanced",* but does not explicitly set out the changes made to the previous model. There are no references to additional validation within the report.
	Waitohu Catchment Model
GWRC	The model was built in 2003 (GWRC, July 2004; Waitohu Stream study – Hydraulic modelling). The 2004 GWRC report states that the 2003 model was initially calibrated to photos taken during the 1 to 2 October 2000 event and provides a modelled flood extent from that event, noting limited records to compare the extent against observed data. The 2004 report states that comments from landowners suggest that the modelled October 2000 flood extent overestimates the true flood extent. The 2004 GWRC report provides results from a model "calibration" against the 12 February 2004 event (approximately 2 year ARI event), noting that this event now forms the primary calibration event. Peak levels were recorded at eight locations across the model domain and modelled results produced an average absolute error level difference of 0.184m. These results are detailed below. (Levels have been converted into vertical datum NZVD 2009 for the purposes of this report).

Location	Measured Peak Flood Level	GWRC 2003 Model Peak Flood Level	Difference (m)
Waterworks Bridge US	81.126 mRL	81.178 mRL	+ 0.052
Ringawhati Bridge	76.21 mRL	76.601 mRL 76.515 mRL	+ 0.348
Waitohu Valley Rd Bridge	44.16 mRL	44.318 mRL	+ 0.158
SH1 – 25m US	29.275 mRL	28.946 mRL	- 0.329

	SH1 – immediately DS	28.511 mRL	28.292 mRL	- 0.219
	Railway	22.70 mRL	22.869 mRL	+ 0.169
	Convent Rd – 10m US	6.234 mRL	6.107 mRL	- 0.127
	Convent Rd – US face	6.12 mRL	6.107 mRL	- 0.013
Opus, 2013	Changes to the original model are documented in the report (Opus 2013; Peka Peka to North Ōtaki Expressway - Hydraulic Investigations for Expressway Crossing of Waitohu Stream and Floodplain), and the roughness values from the original 2003 model were maintained. The updated model was checked against the February 2004 event and a 100 year ARI flood in Waitohu Stream, 20 year ARI flood in Greenwood subcatchment. The predicted February 2004 results are detailed below. Levels have been converted into vertical datum NZVD 2009 for the purposes of this report.			
	Location	Measured Peak Flood Level	Opus 2013 Model Peak Flood Level	Difference (m)
	Waitohu Valley Rd Bridge	44.16 mRL	44.66 mRL	+ 0.50
	SH1 – 25m US	29.275 mRL	29.23 mRL	- 0.045
	SH1 – immediately DS	28.511 mRL	28.49 mRL	- 0.021
	Railway	22.70 mRL	23.18 mRL	+ 0.48
	Mangaone Catchment Model			
GWRC	The original model was built in 2002 although no validation or calibration was undertaken. The Opus 2013 report states "*The original MIKE 11 model developed for GWRC was not calibrated in the normal sense of a computational hydraulic model*."			
Opus, 2013	The Opus 2013 report (Peka Peka to North Ōtaki Expressway - Hydraulic Investigations for Expressway Crossing of Mangaone Stream and Floodplain) report states that model predictions were compared against anecdotal observations/aerial photos of the historic flood event on 28 October 1998 (approximately 7 year ARI). The model report states that "*there is some evidence to suggest that the predicted flood inundation pattern broadly reflects the pattern of inundation actually experienced.*"			

2. Model Build

2.1 Hydraulic Modelling Package

DHI MIKE FLOOD modelling package is used for the pre-project models. Details of the software used are set out in Table 2.

Table 2 – Flood Modelling Software

Software Type	MIKE 11 by DHI	MIKE 21 by DHI
Software Version	Version 2014	Version 2014
Service Pack	Service Pack 3	Service Pack 3

The MIKE FLOOD software includes a one–dimensional model (MIKE 11) and a two-dimensional model (MIKE 21). Generally, the MIKE 11 model is used to represent the in-channel flow and MIKE 21 represents the floodplains and overland flow paths. The software dynamically couples two hydraulic models so that flows can pass from one model to another.

2.2 MIKE 11 Model

2.2.1 Open Channel Extents

MIKE 11 (open channel) extents are provided in Figures 1-5 in Appendix B. These extents are generally consistent with those previously agreed in the "Schematisation Report", (Fletcher, March 2017); there are some minor modifications in areas based on survey data and aerial photography. Mangapouri Stream was also extended approximately 70m downstream to incorporate a surveyed culvert.

2.2.2 Cross Section Data

The cross section data is based on the following sources of information, in order of preference:

- Survey data, including;
    - 2017-2018 survey by BECA
    - 2014/2015 survey by Opus
    - Greater Wellington Regional Council (GWRC) cross section survey (Ōtaki River, 2016; Waitohu Stream, 2013)
- Modified Kāpiti Coast District Council (KCDC) LiDAR, collected in 2010; and
- GWRC LiDAR, collected in 2013/2014.

KCDC LiDAR has been used in preference to the more recent GWRC LiDAR because it was captured at a finer resolution, and is considered more representative. The KCDC LiDAR was modified by the Project team to represent the terrain more accurately following review of supplied data and survey checks. LiDAR modifications are described in more detail in the "Principal Supplied LiDAR QA Report", (BECA, March 2017).

In a small number of cases, cross sections have been added at locations required for hydraulic modelling purposes (e.g. inlets/outlets of culverts or at branch start/end), where existing section data was not available. The added cross sections have been estimated based on the nearest representative surveyed cross section and engineering judgement.

The data source of each cross section is described in the "Cross Section ID" section of the MIKE 11 cross section file and is summarised in Figures 1-5 in Appendix B.

Hydraulic radius is represented in the MIKE 11 model using "Total Area, Hydraulic Radius".

2.2.3 Spatial Resolution of MIKE 11 Model

A maximum dx value of 10m has been used for all the branches without a structure in the model. 10m was chosen based on two times the 2D grid size of 5m.

For branches with hydraulic structures, the spatial resolution of the calculations is determined by the cross section and structure locations.

2.2.4 Structures

Figures 1 to 5 in Appendix B provide the location of all structures within the model extents; they include identification of structures which have not been represented. Structures not represented in the model were considered unlikely to affect the model results in the areas of interest and therefore surplus to requirements. The dimensions and data sources for each of the structures are provided in Appendix A.

Modelled in-channel structures are represented using bridges, culverts and weirs within the MIKE 11 model. Culverts that sit within the 2D floodplain are also modelled using MIKE 11.

Overtopping of culverts is modelled using overtopping weirs in MIKE 11 or by representing the top of structure in the 2D domain. The modelled representation for each of the structures is provided in Appendix A. Data for culverts is from survey, as-built information, LiDAR data (for overtopping weirs) or 2013 Opus models (in descending order of preference).

The FHWA WSPRO method was the preferred method applied to represent the bridge structures in the models. Where there was insufficient information, the Energy Equation method was used. Both approaches are considered acceptable for the representation of bridges. Submergence, overflow and piers are applied on a case-by-case basis for each bridge structure. Data for bridges is based on survey data, as-builts, LiDAR data (for bridge deck levels), site photographs and the 2013 Opus models (in descending order of preference).

Some culverts are modelled as bridge structures with Energy Equation method for stability purposes. Details are provided in Appendix A.

Table 3 summarises the number of structures represented within each of the three pre-project models. Appendix A gives further information on the methodology and data sources for modelled structures.

Table 3 – Summary of Modelled Structures

Model	Structure Type	Total number modelled
Ōtaki-Mangapouri Model	Weirs	0 (all overtopping represented in 2D)
Ōtaki-Mangapouri Model	Culverts	11
Ōtaki-Mangapouri Model	Bridges	2
Waitohu Model	Weirs	3
Waitohu Model	Culverts	10
Waitohu Model	Bridges	5
Mangaone Model	Weirs	4
Mangaone Model	Culverts	5
Mangaone Model	Culverts (modelled as bridges)	1
Mangaone Model	Bridges	3

2.2.5 Bed Resistance

Channel bed resistance values from the 2013 Opus models were applied to the pre-project models as outlined in the “Schematisation Report" (Fletcher, March 2017). It was considered appropriate to maintain these values, since these have been peer reviewed and accepted during the consenting process.

Bed resistance in the Opus 2013 models was applied using a combination of:

- Global Manning’s n values applied in the hydrodynamic (hd11) file;
- Local Manning’s n values applied in the hydrodynamic (hd11) file; and
- Relative resistance factors applied in the cross section (xns11) file.

Bed resistance in the pre-project models has been applied using:

- A manning's n value within the cross section (xns11) file. The Manning's n value was selected to provide the same effective bed resistance as provided by the three methods used in the Opus 2013 models in combination.

Figures 6-8 in Appendix B provide a comparison of resistance values in 2013 Opus models and pre-project models.

2.2.6 Boundary Conditions

The inflow locations were agreed in the "Schematisation Report" (Fletcher, March 2017) and Figure 9 in Appendix B presents the inflow locations (note that there have been minor modifications from the Schematisation Report for some catchments).

Section 3 of the "Stormwater Design Philosophy Report Rev 2" (PP2Ō, August 2017)[1] presents the inflow hydrographs for each of the boundary locations, and describes the methodology used to develop these hydrographs.

The downstream boundaries for the models were set as a constant water level, which was estimated based on a nominal depth above the local topography ground level. Sensitivity assessments were carried out to ensure that the tailwater level did not impact flood levels in the PP2Ō area of interest, which confirmed that this approach was reasonable.

The Ōtaki model extends to the coast and the downstream water level was set to 1.27mRL. The level is approximately 400mm higher than Mean High Water Spring at the Manawatu River entrance, although testing of the downstream water level confirmed that the project area of interest was not affected by the downstream water levels.

2.3 MIKE 21 Model

2.3.1 2D Extents

The extents of the MIKE 21 (2D) models are shown in Figures 1 to 5 in Appendix B. These are consistent with the extents agreed in the "Schematisation Report" (Fletcher, March 2017).

2.3.2 Topography

Topography for the 2D model is based on 2010 KCDC LiDAR lowered 0.1 m and with survey data incorporated, as discussed in the "Principal Supplied LiDAR QA Report", (BECA, March 2017). Subsequent to the previous version of this report (Rev 3, PP2Ō October 2017), the pre project topography has been updated to incorporate additional survey of the existing rail between Chainage 2,300 and 2,900m and anticipated removal of temporary stockpiles between Chainage 3,300 and 3,500m.

---

[1] The hydrological information was also repeated for ease of reference in the "Stormwater 80% Design Report Rev 1" (PP2Ō January 2018) and the "Culvert 80% Design Report Rev 1" (PP2Ō February 2018), noting that the latter document includes further detail on rainfall-runoff model inputs in Appendix A.

The following minor alterations were made to support the modelling:

- 1D extent areas
  - Wide channels: 2D terrain levels within 1D model extents were set to 'land' value in order to remove areas from the 2D domain. This ensures the storage volume within these areas are accounted for once only;
  - Narrow channels: Where narrow channels were represented within the 1D model and were connected to the 2D terrain along the centreline, the channel within banks in the 2D terrain is raised to bank level. This ensures the storage volumes within these areas are accounted for once only and limits premature 1D-2D interactions;
- 2D boundaries: 2D terrain levels were lowered at the 2D boundaries to a constant water level boundary to reduce instabilities associated with shallow water and high velocity;
- Standard links: 2D terrain levels were modified to match 1D cross sections to reduce instabilities;
- Bank levels at lateral links: Minor adjustments were made to the 2D terrain at lateral links where coupled cells are a similar level to the surveyed cross section invert in order to reduce instabilities; and
- 2D refinement areas:
  - Channels are 'burned in' to 2D terrain at locations where channels are modelled in 2D. This includes two channels parallel with County Road (Ōtaki-Mangapouri model), downstream of Ngātotara Stream (Waitohu model) and the School Road Drain (Mangaone model). Refer to Figure 11.1 to 11.3 in Appendix B for locations;
  - 2D terrain levels are raised at Chrystall's Stopbank (Ōtaki-Mangapouri model) so the highest point of the stopbank is represented in the 2D model, to ensure breakout flows do not occur prematurely;
  - Minor adjustments to the 2D terrain at SH1/County Road junction (Ōtaki-Mangapouri model) to accurately represent overland flows in this area; and
  - 2D terrain levels at a gap in Chrystall's Stopbank for a rail siding are changed between scenarios to represent the presence of 'stop logs' which are put in place in large storm events. Table 7 in Section 4 below provides further details.

2.3.3 Resolution of MIKE 21 model

All pre-project models have a 2D resolution of 5m x 5m, as agreed in the review process for the "Schematisation Report" (Fletcher, March 2017).

2.3.4 Floodplain Resistance

Floodplain resistance values from the 2013 Opus models were applied to the pre-project models. This approach was agreed in the review process for the "Schematisation Report" (Fletcher, March 2017).

The Ōtaki-Mangapouri and Mangaone catchments have a constant Manning's M resistance value of 25 (n = 0.04) applied to the 2D model. The Waitohu model has a Manning's M resistance value of 25 (n = 0.04) applied to the majority of the 2D domain, with a higher resistance applied to the riparian margins (Manning's M = 16.67, n = 0.06). Refer to Figure 10 in Appendix B for the resistance map details for the Waitohu model.

2.3.5 Energy Losses due to Turbulence

The flux based eddy viscosity was used in MIKE 21 to represent the energy losses due to turbulence in the 2D domain. This is based on the grid spacing and time step used in the model. Table 4 outlines the viscosity used for each pre-project model.

Table 4 – MIKE 21 Eddy Viscosity

Model	Grid Size	Time Step	Flux-based Viscosity
Ōtaki-Mangapouri	5m x 5m	0.2s	$2.5m^2/s$
Waitohu	5m x 5m	0.5s	$1.0m^2/s$
Mangaone	5m x 5m	0.2s	$2.5m^2/s$

2.3.6 Boundary Conditions

The 2D inflow locations were agreed in the review process for the "Schematisation Report" (Fletcher, March 2017) and Figure 9 in Appendix B shows the inflow locations (note that there have been minor modifications for some catchments, in particular, areas of the Mangapouri catchment based on a site walkover). The hydrographs were loaded to overland flow paths using 2D source points and distributed among multiple cells to reduce the likelihood of model instabilities.

Section 3 of the "Stormwater Design Philosophy Report Rev 2" (PP2Ō, August 2017)[2] presents the inflow hydrographs for each of the boundary locations, and describes the methodology used to develop these hydrographs.

Direction has been set according to the slope of the terrain, and velocity set to 0m/s for the simulation period i.e. no momentum at the source point.

The 2D downstream boundaries were set as a constant water level, which was generally above ground and estimated based on local topography levels. Sensitivity assessments were carried out to ensure that the tailwater level did not impact flood levels in the PP2Ō area of interest.

2.3.7 Other Model Parameters

Flooding and drying depths of 0.03m and 0.02m respectively were used in the model.

2.4 Linkage between Models

The MIKE FLOOD model creates the linkage between the MIKE 11 and MIKE 21 models. "Lateral links" were used to represent inflows and outflows along the channel banks of the 1D and 2D models.

"Standard links" were used to represent inflows and outflows at the upstream and downstream ends of the MIKE 11 branches where they connect to MIKE 21.

2.4.1 Lateral Links

Generally, grid cells in MIKE 21 along both sides of open channels were linked with MIKE 11 branches. The following settings were used for lateral links:

- Link type = Lateral
- Lateral link line = left and right bank (unless coupled to centreline, see below)

[2] The hydrological information was also repeated for ease of reference in the "Stormwater 80% Design Report Rev 1" (PP2Ō January 2018) and the "Culvert 80% Design Report Rev 1" (PP2Ō February 2018), noting that the latter document includes further detail on rainfall-runoff model inputs in Appendix A.

- Structure method = "Cell to Cell"
- Structure type = "Weir 1"
- Structure source = "M21"
- Depth tolerance = "0m"
- Weir Coefficient = 1.838
- Fric (n) = 0.05.

Along a number of small and sinuous streams, the grid cells in MIKE 21 were linked with MIKE 11 branches along the centreline of the open channel. The following locations are linked at the MIKE 11 channel centreline:

- Between County Road and the Railway on the Mangapouri Stream; and
- Upstream of Taylors Road on the Greenwood Stream.

The models are not coupled (no lateral links) at branches containing structures. This is to prevent the instabilities that can occur at lateral links either side of structures. The branch length for branches that contain structures is kept similar to the structure length and therefore it is unnecessary to couple these branches.

The “exponential smoothing factor” (ESF), was reduced to 0.3 for the majority of the lateral links which is in accordance with the recommended range. The ESF of the lateral links at and upstream of the Ōtaki bridges (Ōtaki-Mangapouri model) was set to 1.0 which means that no smoothing was applied.

2.4.2 Standard Links

Grid cells in MIKE 21 at the start and end of open channels were linked with MIKE 11 branches where appropriate. The following settings were used:

- Mom Fact = 1.0
- Ext Fact = 0.0
- Depth Adjust = "Yes"
- ESF = 0.4.

3. Model Validation

This section provides a summary of the validation undertaken for pre-project models. Validation was undertaken for each model, where sufficient data was available. Supporting information for model validation, based on the historical models, is identified and presented in Section 1.8.

3.1 Ōtaki-Mangapouri Model Validation

3.1.1 Available information

GWRC (Wallace, 2007) and the OPUS 2013 reports note that the Ōtaki River had a peak flood level immediately upstream of the rail bridge for the January 2005 flood (approximately 20 year ARI flood) of 12.66mRL (NZVD 2009), which is based on LiDAR data and an anecdotal report of flood levels.

On the Mangapouri Stream/floodplain, anecdotal evidence from an event on 28 October 1998 was reported by Opus 2013 as follows:

“The property owner at 29 County Road provided anecdotal evidence at a recent PP2O Project Open Day in Otaki of floodwaters in the Mangapouri Stream inundating up to near the house on the adjacent property at 22 County Road in the 28 October 1998 flood (Mrs M Blaikie, pers. Comm.)”

Opus 2013 estimated the 28 October 1998 event to be a 7 year ARI event, based on hydrological assessments in a nearby catchment (Mangaone Stream). Ground levels in the vicinity of the house were reported[3] by Opus 2013 to be in the range 13.76 to 13.96mRL (NZVD 2009) and they concluded that the ground levels roughly coincided with predicted 5 to 10 year ARI flood levels from their 2013 models.

3.1.2 Model Performance

The January 2005 event was simulated through the pre-project Ōtaki-Mangapouri model. A peak level of 13.84mRL (NZVD 2009) was modelled upstream of the rail bridge. The modelled level is 1.18m higher than the anecdotal level and 0.72m higher than the level modelled in 2007 by GWRC (based on 2006 survey).

On the Mangapouri Stream/floodplain, the modelled peak levels[4] are 13.97mRL for the 10 year ARI (present climate) and 13.40mRL for the 2 year ARI events (with climate change) adjacent to 22 County Road. The levels are consistent with the estimated flood levels in the Opus 2013 models.

3.1.3 Comments

The model results for the Ōtaki River are consistent with the observations of GWRC (Wallace, 2007) where the water levels predicted by the model are higher than the recorded level. The 2017 modelling also predicts higher levels than the 2007 model results. The following reasons indicate why the 2017 models are higher than the recorded 2005 event and the 2007 model:

1. The Opus 2013 report highlighted that higher predicted water levels may be due to an increase in river bed levels between the 2005 event and 2006 survey. We note that bed level changes have continued since 2006 and a topographical and survey comparison is provided in Appendix C to show the significant changes in morphology and bed between 2006 and the surveyed levels in 2016.
2. There is also insufficient information to know how the 'single peak' water level was determined or what confidence to place in it.
3. The Chrystall's Stopbank upstream of the rail bridge has been modified since 2005 and historical imagery on Google Earth shows significant changes to the right bank floodplain between 2007 and 2010. The latest hydraulic model is therefore unlikely to replicate January 2005 conditions with regards to floodplain storage and water levels upstream of the rail bridge.

The latest modelled flood levels for the Mangapouri Stream/floodplain adjacent to 22 County Road are similar to the modelled flood levels for the Opus 2013 models. However, the flood extent from the current model for the 2 year ARI (with climate change) and 10 year ARI (present climate) events both encompass the house at 22 County Road, which is more extensive than indicated by the observation of flooding "up to near the house" for the 28 October 1998 event (approximately a 7 year ARI).

The ground levels at 22 County Road in the current flood models based on 2010 KCDC LiDAR are generally 13.1 to 13.3mRL, lower than those reported by Opus (2013) as 13.76 to 13.96mRL (NZVD

[3] Section 3.6 of "Peka Peka to North Otaki Expressway Hydraulic Investigations for Expressway Crossing of Mangapouri Stream" report (Opus, 2013) states "Inspection of ground levels in the vicinity of the house at 22 County Road indicates that these are in the range of 14.2-14.4m MSL Wellington 1953", which equates to 13.76 – 13.96mRL (NZVD 2009).

[4] The 2 year ARI CC event was not re-run for the Rev 4 model, but is unlikely to have changed significantly from the Rev 3 model. There was only 0.01m difference in the 10 year ARI flood level predicted by the Rev 3 and Rev 4 models.

2009). This area is not included in the 2D component of the Opus (2013) model, and Opus 2013 states that their reported ground levels at 22 County Road are based on "inspection of ground levels", but the specific source of the reported levels is unclear.

Comparisons with historical observations have been examined to the extent practicable and we agree with Opus (2013) that "*unfortunately no other anecdotal evidence of surveyed peak flood levels from other recent significant flood events have come to light during the course of these investigation that could be used to check the veracity of the model*".

3.2 Waitohu Model Validation

3.2.1 Available Information

In February 2004, an event occurred that was approximately a 2 year ARI storm (GWRC, July 2004). Some peak water levels and general observations were recorded (GWRC, July 2004). Four of the peak water levels recorded are located within the current model extents.

Two previous models of the Waitohu catchment carried out a model validation of the February 2004 event. These include the GWRC (2003) and Opus (2013) models. The results are summarised in the table below.

The Railway Bridge was upgraded in 2009 (Opus, 2013) and a comparison of the previous models representing pre-2009 geometry indicates that the cross sectional area of the bridge is now larger than in 2004.

3.2.2 Model Performance

The February 2004 event was simulated through the pre-project Waitohu model using hydrographs supplied during the PP2Ō tender process. These hydrographs were generated from a rainfall-runoff model developed in 2003, which used the data from a flow recorder at the Water Supply Intake on Waitohu Stream (GWRC, July 2004).

The geometry of the Railway Bridge was not altered in the current pre-project model to represent the likely 2004 dimensions for the validation event. Therefore flood levels for the validation event are expected to be underestimated near the Railway Bridge.

The results are summarised in the table below. Levels have been converted into vertical datum NZVD 2009 for the purposes of this report. A graph of these results is included in Appendix D.

Table 5 – Waitohu Validation

Source	Waitohu Valley Rd Bridge	SH1 25m upstream	SH1 immediately downstream	Railway
Measured Peak Flood Level	44.16 mRL	29.275 mRL	28.511 mRL	22.70 mRL
GWRC 2003 Model Peak Flood Level	44.318 mRL	28.946 mRL	28.292 mRL	22.869 mRL
GWRC 2003 Model Level Difference	+ 0.158 m	- 0.329 m	- 0.219 m	+ 0.169 m
Opus 2013 Model Peak Flood Level	44.66 mRL	29.23 mRL	28.49 mRL	23.18 mRL
Opus 2013 Model Level Difference	+ 0.50 m	- 0.045 m	- 0.021 m	+ 0.48m
Current Pre-Project Model Peak Flood Level	44.47 mRL	28.82 mRL	28.29 mRL	21.84 mRL
Current Pre-Project Model Level Difference	+ 0.31 m	-0.46 m	-0.22 m	- 0.86 m

3.2.3 Comments

The current model results for the Waitohu Stream are generally consistent with the observations for previous models GWRC (Wallace, 2004) and Opus (2013), where the water levels predicted by the model are higher than observed levels at the Waitohu Valley Road Bridge, and lower than observed levels around the SH1 Bridge.

The predicted water levels in the current pre-project model are more similar to those predicted by the 2003 GWRC model than those predicted by the Opus (2013) model.

The current pre-project model under-predicts the observed water level at the Railway Bridge by 0.86m. However due to the change in bridge geometry in 2009, the observed water levels at this specific location have limited relevance for validating modelled water levels. The under-prediction is likely due to the increase in bridge cross sectional area that resulted from the 2009 upgrade. Plots of the respective Railway Bridge geometries are included in Appendix D.

3.3 Mangaone Model Validation

As identified in Table 1, there is insufficient data with which to validate (or calibrate) a hydraulic model in the Mangaone catchment. The Opus 2013 models simulated the 28 October 1998 event and compared the predicted flood extents against the small amount of data that is available, namely two flood photographs taken at an unknown time during the 28 October 1998 storm. No obvious discrepancies in the predicted flood extents were observed, although the location that flows enter the Lucinsky Overflow was questioned.

The October 1998 event was not represented with the pre-project model due to the lack of data, which would only provide very basic conclusions or confidence in the model. Instead, as a very simple check, the 1% AEP CC2130 flood levels and extents were compared against the 2013 Opus model results. The latest pre-project model flood extents are greater upstream of SH1, however levels for the majority of the floodplain are within 0.25m. Given the differences in hydrological inputs and channel cross sections, we consider the differences to be acceptable.

The pre-project model for the Mangaone catchment is not validated due to the limited historical data. However, the Mangaone model is based on appropriate industry practise flood modelling techniques and parameters. Verification has been undertaken on models for adjacent catchments where data exists. On this basis, we consider the model suitable for the purposes of the Project.

4. Modelled Scenarios

There is a range of scenarios that the detailed catchment hydrological and hydraulic models are required to assess. These consist of "effects assessment" type scenarios which are carried out for pre-project and post-project situations, and the scenarios which are required for post-project representation only to ensure compliance with a particular performance standard.

Table 6 summarises the design storm scenarios that have been represented with the pre-project models. For the Ōtaki-Mangapouri model, the hydrology and bathymetry vary with the scenario being modelled. Refer to Table 7 below for model setup.

A stopbank breach in Chrystall's Stopbank (Ōtaki-Mangapouri model) was represented using the pre-project model. The breach was modelled using a time-varying bathymetry. The breach location is 300m upstream of the existing railway (in approximately the same location as modelled by Opus in the Specimen Design phase) and is used for both pre- and post-project breach scenarios. The location is expected to be conservative for assessing flood effects on the expressway in the post-project scenario since the breach is immediately upstream of the expressway i.e. flood effects on the expressway for the breach location adopted are expected to be worse than if a breach occurred further upstream. The same breach location is applied to the pre-project model for consistency of comparisons with the post-project model. The breach starts forming when the stopbank overtops, and progresses from an initial central breach to a full breach width of 140m over 2 hours and 20 minutes. Final invert levels are based on surrounding natural ground and vary between 14.3 and 14.6mRL, giving an average beach depth below stopbank crest level of around 0.7m.

Table 6 – Pre-Project Design Storm Scenarios

Scenario	Ōtaki-Mangapouri	Waitohu	Mangaone
0.04% AEP + CC2130		✓	✓
3,000m³/s - No CC	✓ (Ōtaki only)		
0.1% AEP + CC2130			✓
0.2% AEP + CC2130	✓		
1% AEP + CC2130 (High Range)		✓	✓
1% AEP + CC2130	✓	✓	✓
2% AEP + CC2130			✓
5% AEP + CC2130			✓
5% AEP – No CC		✓	
10% AEP + CC2130	✓	✓	✓
10% AEP - No CC	✓ (Mangapouri only)	✓	
3,000m³/s - No CC Stopbank Breach Scenario	✓ (Ōtaki only)		
0.2% AEP + CC2130 Stopbank Breach Scenario	✓		

Table 7 - Ōtaki-Mangapouri Model Setup

Scenario	Hydrology	Bathymetry
3,000m³/s - No CC	3,000 m³/s applied upstream of Rail Bridge. No other hydrological inputs applied to model.	2D levels modified at Chrystall's Stopbank floodgate to simulate "stoplogs" in place
0.2% AEP + CC2130	Pre-project schematisation	2D levels modified at Chrystall's Stopbank floodgate to simulate "stoplogs" in place
1% AEP + CC2130	Pre-project schematisation	2D levels modified at Chrystall's Stopbank floodgate to simulate "stoplogs" in place
10% AEP + CC2130	Pre-project schematisation	Gap left in Chrystall's Stopbank; to represent "no stoplogs"
10% AEP - No CC	Hydrological inputs applied to Mangapouri Catchment only. Ōtaki River not considered in scenario, noting that there is no interaction between the Ōtaki and Mangapouri catchments in this event.	Gap left in Chrystall's Stopbank; to represent "no stoplogs"
3,000m³/s - No CC Stopbank Breach	3,000 m³/s applied upstream of Rail Bridge. No other hydrological inputs applied to model.	2D levels modified at Chrystall's Stopbank floodgate to simulate "stoplogs" in place Time varying bathymetry representing stopbank breach
0.2% AEP + CC2130 Stopbank Breach	Pre-project schematisation	2D levels modified at Chrystall's Stopbank floodgate to simulate "stoplogs" in place Time varying bathymetry representing stopbank breach

5. Results

Model results for the design storm scenarios summarised in Table 6 are provided in Appendix B. Table 8 below references the figure numbers for modelled scenarios. The results have been used to represent the pre-project scenario which has been used as a baseline for assessments of the project against the modelling of the post-project situation and assessment of compliance, which is covered in separate reporting.

Table 8 – Pre-Project Model Results Figures

Scenario	Ōtaki-Mangapouri	Waitohu	Mangaone
0.04% AEP + CC2130	N/A	Fig. 19.1 – 19.2	Fig. 25.1 – 25.2
3,000m³/s - No CC	Fig. 12.1 – 12.3	N/A	N/A
0.1% AEP + CC2130	N/A	N/A	Fig. 26.1 – 26.2
0.2% AEP + CC2130	Fig. 13.1 – 13.3	N/A	N/A
1% AEP + CC2130 (High Range)	N/A	Fig. 20.1 – 20.2	Fig. 27.1 – 27.2
1% AEP + CC2130	Fig. 14.1 – 14.3	Fig. 21.1 – 21.2	Fig. 28.1 – 28.2
2% AEP + CC2130	N/A	N/A	Fig. 29.1 – 29.2
5% AEP + CC2130	N/A	N/A	Fig. 30.1 – 30.2
5% AEP – No CC	N/A	Fig. 22.1 – 22.2	N/A
10% AEP + CC2130	Fig. 15.1 – 15.3	Fig. 23.1 – 23.2	Fig. 31.1 – 31.2
10% AEP - No CC	Fig. 16.1 – 16.2	Fig. 24.1 – 24.2	N/A
3,000m³/s - No CC Stopbank Breach Scenario	Fig. 17.1 – 17.3	N/A	N/A
0.2% AEP + CC2130 Stopbank Breach Scenario	Fig. 18.1 – 18.3	N/A	N/A

6. Applicability

This report has been prepared for the exclusive use of our client NZ Transport Agency, 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.

Appendix A:

MODELLED STRUCTURES – AVAILABLE DATA AND MODELLING NOTES

Otaki-Mangapouri Modelled Structures - Available Data and Modelling Notes

Note: Data entered into hydraulic model has cell shaded green

Model Notes			Available Data																					
																Surveyed Coordinates				Indicative Coordinates				
Modelled Name	Modelled Type	Modelling Note	Spec Design Culvert No.	Detailed Design Culvert No.	Type	No. of Barrels	Size (m)		Invert Level (NZVD 2009)		Other Level (NZVD 2009)			Length (m)	Slope (%)	Upstream Coordinate		Downstream Coordinate		Upstream Coordinate		Downstream Coordinate		Source Material
							Width	Depth	u/s	d/s	u/s	d/s	Comment			x	y	x	y	x	y	x	y	
MangapouriCountyRdCulvert	M11 Culvert	- Note that culvert has negative grade	5	5	Circular	1	1.2		11.48	11.52				19.0	-0.19					1782355.092	5485472.619	1782346.48	5485489.44	Opus Specimen Design Drawing C301
							1.2		11.484	11.52				18.9	-0.19	1782355.092	5485472.619	1782346.48	5485489.44					Opus Survey 2014-2015
							1.2		11.5096			12.868	Top of pipe	18.7		1782355.029	5485472.546	1782346.64	5485489.311					Beca Survey 22.02.2017
MangapouriCountyRdRailCulvert	M11 Culvert	- Note that OPUS Specimen design drawing is preferred source of geometry	6	6	Custom - built arch	1	0.95	1.2	11.59	11.5				12.0	0.75					1782343.28	5485496.07	1782337.39	5485506.55	Opus Specimen Design Drawing C301
					Box		1	1.3	11.59	11.5				12.0	0.75	1782343.28	5485496.07	1782337.39	5485506.55					Opus Survey 2014-2015
MangapouriSH1Culvert1 MangpaouriSH1Culvert2	M11 Culvert		11	11	Circular	2	0.9		10.62	10.52														Opus Specimen Design Drawing C301
									10.666	10.452				23.1	0.93	1782219.29	5485692.01	1782204.24	5485709.572					Opus Survey 2014-2015
									10.597	10.557				23.2	0.17	1782218.36	5485691.27	1782203.78	5485709.38					Opus Survey 2014-2015
							0.9			10.592	11.6785		Top of pipe	22.4	4.85	1782219.31	5485692.11	1782205.15	5485709.445					Beca Survey 22.02.2017
							0.9				11.6206		Top of pipe			1782218.32	5485691.27							Beca Survey 22.02.2017
MangapouriMillRdDrivewayCulvert	M11 Culvert	- Length taken from KCDC asset data (9.88 m) - Downstream invert assumed as 8.5596mRL based on a 1% grade		114 (new)			1.34			8.6584								1781980.705	5485916.35					Beca Survey 16.03.2017
												10.1165	top of pipe					1781980.634	5485916.35					Beca Survey 16.03.2017
RacecourseRailCulvert	M11 Culvert	- Geometry and inverts taken from most recent survey data (Beca 20170328/20170316)		103 (new)					11.57	11.5						1782181.32	5485383.48	1782173.97	5485406.249					Opus Survey 2014-2015
			14	14	Square	1	1.25	1.13		11.711				24.1				1782173.93	5485406.062					Beca Survey 16.03.2017
							1.24	1.1	11.8502					24.1		1782181.238	5485383.091							Beca Survey 28.03.2017
RacecourseDunstanStCulvert	M11 Culvert	- Length calculated from surveyed up and downstream invert coordinates (145 m)	15	15	Circular	1	0.9		10.86	10.26				175.0	0.34					Not included in Opus xrefs, shown in KCDC GIS				Opus Specimen Design Drawing C301
					Circular	1	0.9			10.064	11.8691		Top of pipe	145.47		1782063.012	5485474.782	1781983.04	5485596.298					Beca Survey 16.03.2017
					Circular	1	0.9					11.043	Top of pipe					1781983.02	5485596.198					Beca Survey 28.03.2017
CountyRdCulvert	M11 Culvert			104 (new)	Circular	1	0.55		12.023	11.914				17.9	0.61	1782420.89	5485564.20	1782404.20	5485570.697					Beca Survey 22.02.2017
ChrystallsStopbankCulvert	M11 Culvert	- Note that only positive flow is allowed through structure to represent existing flood gate		105 (new)	Circular		0.6		13.761	13.5985				11.3	1.44	1781693.746	5484775.299	1781689.50	5484764.81					Beca Survey 22.02.2017
RailwayWetlandCulvert	M11 Culvert			116 (new)	Circular	1	0.375		16.8689	16.8062				6.7	0.94	1782424.187	5485787.02	1782417.52	5485786.41					Beca Survey 30.05.2017
RailwayWetlandCulvert	M11 Culvert			120 (new)	Circular	1	0.6		16.893	16.817				12.8	0.60	1782412.473	5485788.624	1782408.39	5485800.71					Beca Survey 30.05.2017
Otaki Rail Bridge	M11 Bridge FHWA WSPRO	- Entered as type: FHWA SWPRO: with submergence, overflow and piers - Bridge level bottom = 14.76 mRL. Taken from: Deck level at abutments = 17 mRL (base on modified 2010 LiDAR and scaling off as-built) Depth of obstruction below deck level = 7'4'' = 2.24m [60467] - Bridge level top = 18.4 mRL. Taken from: Deck level at centre span = 17.4 mRL (base on modified 2010 LiDAR and scaling off as-built) 1m high handrail [Otaki Rail Bridge 5-3-10-7524] - Type III chosen (based on as-builts Br 33 NIMT Bridge Card) - Waterway length = 3.9. Taken from: 1.651m bridge deck [42200s1] 2.232 m (footpath) [Otaki Rail Bridge 5-3-10-7524] - Bridge geometry and length taken from GWRC surveyed cross section - Pier blocking ratio = 0.144. Taken from: 18 piers total [Original elevation] Pier width assumed to be average of pier base and (widest) column width (2.4 m)																						
Otaki SH1 Bridge	M11 Bridge FHWA WSPRO	- Entered as type: FHWA SWPRO: with submergence, overflow and piers - Brige level bottom = 14.3 mRL. Taken from: Deck level at abutments = 15.2mRL (based on 2010 Modified LiDAR) Depth of obstruction below deck level= 0.9m (from as-built drawing) - Bridge level top = 17.5 mRL. Taken from: Deck level at centre span = 16.4 mRL (converted from measurement in feet in as-built) Depth of handrail above deck level = 1.1 m (scaled off as-built) - Bridge length perpendicular to river set to same as bridge cross section (210 m) - Entered as Type III based on as-built drawings [Otaki River Bridge Drawings.pdf] - Embankment slope of 1:1 set based on as-builts [Otaki River Bridge Drawings.pdf] - Bridge geometry and length taken from GWRC surveyed cross section - Pier blocking ratio = 0.057. Taken from: 14 piers [Otaki River Bridge Drawings.pdf] Pier width assumed to be average of base and pier (0.85 m)																						

Note 1: The resistance value set for the bridge structure is only applied at the 'abutments' of the bridge.
The adjacent cross sections' resistance is applied at the low flow channel by the software.

Waitohu Modelled Structures - Available Data and Modelling Notes

Note: Data entered into hydraulic model has cell shaded green

Modelled Name	Modelled Type	Modelling Note (Model Notes)	Spec Design Culvert No.	Detailed Design Culvert No.	Type	No. of Barrels	Size (m)		Invert Level (NZVD 2009)		Other Level (NZVD 2009)			Length (m)	Slope (%)	Surveyed Coordinates: Upstream Coordinate		Surveyed Coordinates: Downstream Coordinate		Indicative Coordinates: Upstream Coordinate		Indicative Coordinates: Downstream Coordinate		Source Material
							Width	Depth	u/s	d/s	u/s	d/s	Comment			x	y	x	y	x	y	x	y	
GreenwoodSH1CulvertNth	**M11 Culvert**	- Note that southern culvert has negative grade	1a	1a	Circular	1	1.05		22.669	22.525				20.9	0.69	1782953.972	5486968.018	1782941.685	5486984.886					Opus Survey 2014-2015
GreenwoodSH1CulvertSth	**M11 Culvert**				Circular	1	0.9		22.707	22.768				18.1	-0.34	1782952.723	5486966.1	1782936.92	5486974.94					Opus Survey 2014-2015
GreenwoodTaylorsRdCulvertSth	**M11 Culvert M11 Weir**	- Weir level taken from Modified 2010 LiDAR (20.1 mRL)		108 (new)	Circular	1	1.5		17.802	17.746				18.4	1.08	1782770.126	5487157.183	1782761.828	5487173.796					Beca Survey 16.03.2017
											19.548	19.349	Top of pipe			1782770.002	5487157.315	1782761.813	5487173.74					Beca Survey 16.03.2017
GreenwoodTaylorsRdRailCulvert	**M11 Culvert M11 Weir**	- Length approximated as 16 m using aerial - Weir level taken from Modified 2010 LiDAR (19.0 mRL)		106 (new)	Box	1	1.2	1.27	15.7878	15.6618								1782678.676	5487240.809	1782693.13	5487236.60	1782678.66	5487240.964	Beca Survey 16.03.2017 and 28.03.2017
GreenwoodTaylorsRdCulvertNth	**M11 Culvert M11 Weir**	- Length approximated as 14 m using aerial - Weir level taken from Modified 2010 LiDAR (17.5 mRL)		107 (new)	Circular	1	1.5		15.442	14.8839						1782672.727	5487243.487	1782658.917	5487249.117					Beca Survey 16.03.2017
											16.58	16.368	Top of pipe	14.3	1.49	1782672.613	5487243.701	1782659.134	5487248.401					Beca Survey 16.03.2017
GreenwoodNgatotaraSiphon	**M11 Culvert**	- Up- and downstream inverts taken from OPUS models due to no other data available: - (7.88 - 0.44) = 7.44 mRL - Levels tie in well with LiDAR. - Culvert size taken from T+T site visit - Overtopping not considered (weir not added)		115 (new)	Circular	1	~0.9						Culvert under Waitohu Stream	~20						1782189.12	5487975.35	4782159.08	5487985.919	T+T Site Visit 23.03.2017
					Circular	1	1.35		7.44	7.44				21.0										OPUS Model of Existing Scenario ("Waitohu2012_Exist_1in100cc2130_GW1in100_006C.sim11")
WaitohuValleyRdBridge	**M11 Bridge FHWA WSPRO**	- Entered as type: FHWA SWPRO: with submergence, overflow and piers - Bridge level bottom taken from BECA survey 20170530 = 46.25 mRL - Bridge level top taken from BECA survey 20170530 = 46.66 mRL - Channel geometry taken from survey data at centre of bridge - Opening Type I chosen based on TT site visit 20170323 photo (no wingwalls) - Waterway length approximated from BECA survey lines 20170530 = 5.7m (parallel with stream) - Pier blockage = 0.074. Taken from BECA survey 20170530 data: 2 piers at 0.93 m diameter each = 1.86 m/25.08 m width = 0.074 - Length perpendicular to stream taken from BECA survey 20170530 = 35.53 m																					
WaitohuSH1Bridge	**M11 Bridge FHWA WSPRO**	- Entered as type: FHWA SWPRO: with submergence, overflow and piers - Bridge level bottom taken from (min) Beca survey topo points 20170328 (29.73 mRL) - Bridge level top taken from (max) Beca survey topo points 20170328 (30.08 mRL) - Channel geometry taken from interpolated cross section at centre of bridge - Opening type I chosen based on T+T site visit photo 20170323 (no wingwalls apparent) - Waterway length taken from Beca survey topo points 20170328 (8.5 m) - Pier blockage approximated from Beca survey topo points 20170328 2 piers = average widths of 0.49 m and 0.48 m = 0.97 m /19.08 m width = 0.051 - Length perpendicular to stream taken from Beca survey topo points 20170328 (19.08 m)																					
WaitohuRailwayBridge	**M11 Bridge FHWA WSPRO**	- Entered as type: FHWA SWPRO: with submergence, overflow and piers - Bridge level bottom from BECA survey 20170530 = (23.76 mRL) - Bridge level top from BECA survey 20170530 = (25.07 mRL) - Channel geometry taken from interpolated cross section at centre of bridge - Opening type I chosen based on TT 20170323 site visit photo (no wingwalls) - Waterway length taken from BECA survey 20170530 = 2.4 m - Pier blockage taken from BECA survey 20170530 3 piers = widths of 0.9 9m + 0.99 m + 0.9 m = 2.88 m /33.97 m width = 0.0845 - Length perpendicular to stream from BECA survey 20170530 = 39.52m																					
Waitohu49TaylorsRdBridge	**M11 Bridge Energy Equation**	-Free-span bridge modelled as Energy Equation bridge with submergence (no overflow due to presence of handrails) - Bridge level bottom taken from BECA survey points 20170328 = (18.865 mRL) - Geometry assumed from surveyed cross section (GWRC2014_XS180) - No slope applied - Waterway length taken from BECA survey points 2010328 marked "Bridge Outline" = (3.6 m)																					
Waitohu51TaylorsRdBridge	**Not Modelled**	- Structure not modelled - BECA survey photos 20170328 shows that bridge has collapsed. Left bank side of bridge is sitting at top of bank, with right bank side of bridge deck sloping into the water.																					
Waitohu51TaylorsRdContainerBridge	**M11 Bridge Energy Equation**	- Bridge modelled as Energy Equation bridge with submergence (no overflow due to height of obstruction) - TT Site Visit photos 20170323 show shipping container placed over channel - Geometry assumed up- and downstream cross sections - Bridge level bottom assumed from T+T site visit 20170328 measurement 'indicative depth to underside' Invert (9.245 mRL) + Indicative depth (1.6 m) = 10.845 mRL - No slope applied - Waterway length set as 2.44 m based on 9'6'' shipping container standard dimensions																					
WaitohuTribSH1CulvertNth	**M11 Culvert**	- Length assumed as 30 m from aerial - Upstream invert assumed as 26.949 mRL based on a 1% grade		101 (new)			0.75			26.649								1782873.437	5486310.707					Beca Survey 22.02.2017
WaitohuTribSH1CulvertSth	**M11 Culvert**		4	4	Circular	1	0.75		27.2587	27.116				19.4	0.74	1782865.219	5486268.371	1782850.015	5486280.346					Beca Survey 22.02.2017
WakapuaRailCulvert	**M11 Culvert**	- All data taken from Opus pre-tender design model (noted as having details taken from Plan Wt12/3): Geometry: 0.92 W x 0.97 H rectangular culvert Length = 9.5 m Upstream invert = 20.28 -0.44 = 19.84 mRL (NZVD 2009) Downstream invert = 20.31 - 0.44 = 19.87 mRL (NZVD 2009) Structure roughness = 0.016 - Note that culvert has a negative grade																					
GreenwoodTribTaylorsRdCulvert	**M11 Culvert**	- All data taken from Opus pre-tender design model: Geometry:1.5 m diameter circular culvert Length = 12.32 m Upstream invert = 17.49 -0.44 = 17.05 mRL (NZVD 2009) Downstream invert = 17.38 - 0.44 = 16.94 mRL (NZVD 2009) Structure roughness = 0.016																					

Note 1: The resistance value set for the bridge structure is only applied at the 'abutments' of the bridge.
The adjacent cross sections' resistance is applied at the low flow channel by the software.

Mangaone Modelled Structures - Available Data and Modelling Notes

Note: Data entered into hydraulic model has cell shaded green

Model Notes														Available Data								
														Surveyed Coordinates				Indicative Coordinates				
Modelled Name	Modelled Type	Modelling Note	Spec Design Culvert No.	Detailed Design Culvert No.	Size (m)		Invert Level (NZVD 2009)		Other Level (NZVD 2009)			Length (m)	Slope (%)	Upstream Coordinate		Downstream Coordinate		Upstream Coordinate		Downstream Coordinate		Source Material
					Width	Depth	u/s	d/s	u/s	d/s	Comment			x	y	x	y	x	y	x	y	
MangaoneRailCulvert	M11 Culvert M11 Weir	- Weir level taken from Modified 2010 LiDAR (18.9 mRL)	25	25	2.83	2.44	15.777	15.872				4.6	-2.07					1779181.66	5481365.09	1779177.76	5481367.56	Fletcher measurements on site 13/10/17
					3	2.38	15.9	15.9				4.4	0.00					1779182.53	5481365.71	1779176.81	5481369.012	Opus Specimen Design Drawing C301
MangaoneSH1Culvert	M11 Culvert M11 Weir	- Weir level taken from Modified 2010 LiDAR (18.1 mRL)	26	26	5.08	1.53	16.07	15.77				15.5										Fletcher measurements on site 15/6/17
					4	1.76	16.2	15.86				15.0	2.27					1779169.78	5481374.10	1779157.18	5481383.065	Opus Specimen Design Drawing C301
Mangaone12TeHoroRdBridge	M11 Bridge Energy Equation	- Free-span bridge is modelled as Energy Equation bridge - Overflow not allowed (vegetated hand rail assumed blocked) - Bridge level bottom taken from Beca Survey points 20170328 (14.607 mRL) - Geometry assumed from interpolated XS at centre of structure - Waterway length is measured using Beca Survey 2017 points 'edge of road' (2.6 m)																				
Mangaone44TeHoroBridge	M11 Bridge Energy Equation	- Free-span bridge modelled as Energy Equation bridge - Bridge level top taken from (max) Beca 2017 survey topo points (12.703mRL) - Bridge level bottom taken from Beca Survey points 20170328 (12.242 mRL) - Geometry assumed from interpolated XS at centre of structure - Waterway length is measured using Beca 2017 survey points marked "Bridge Outline" (3.2m)																				
Mangaone46TeHoroBridge	M11 Bridge Energy Equation	-Free-span bridge modelled as Energy Equation bridge - Bridge level top taken from (max) Beca 2017 survey topo points (12.049mRL) - Bridge level bottom taken from Beca Survey points 20170328 (11.628 mRL) - Geometry assumed from interpolated XS at centre of structure - Waterway length is measured using Beca 2017 survey points marked "Bridge Outline" (3.0m)																				
MOverflowRailCulvert	M11 Culvert M11 Weir	- Geometry modelled as double barelled culvert with two culvert structures in same location - Weir level taken from Modified 2010 LiDAR (18.7 mRL)	29	29	2.94	2.01	15.511	15.461			North cell	4.8						1779047.08	5481154.68	1779043.06	5481157.229	Fletcher measurements on site 13/10/17
					2.98	2.01	15.52	15.475			South cell							1779045.17	5481151.59	1779041.13	5481154.177	
					6	2.05	15.09	15.04				5.0	1.00					1779048.743	5481155.14	1779042.91	5481156.861	Opus Specimen Design Drawing C301
									17.497, 17.505		Soffit, 2 points											Opus Survey 2014-2015
MOverflowSH1Culvert	M11 Bridge Energy Equation	- Weir level taken from Modified 2010 LiDAR (17.4 mRL) - Note that culvert is modelled as bridge structure due to model instabilities	30	30	3.7	1.95	14.64	14.64				13.6	0.00					1779030.315	5481156.05	1779015.86	5481164.777	Opus Specimen Design Drawing C301
									14.488	16.566	Soffit	13.9		1779030.276	5481156.57	1779018.36	5481163.683					Opus Survey 2014-2015
885SH1Culvert	M11 Culvert M11 Weir	-Weir level taken from (max) Beca Survey 20170328 topo points (18.3mRL)		111 (new)	0.9		17.36	17.258				7.5	1.35	1778806.46	5480825.713	1778801.632	5480819.92					Beca Survey 16.03.2017

Note 1: The resistance value set for the bridge structure is only applied at the 'abutments' of the bridge.
The adjacent cross sections' resistance is applied at the low flow channel by the software.

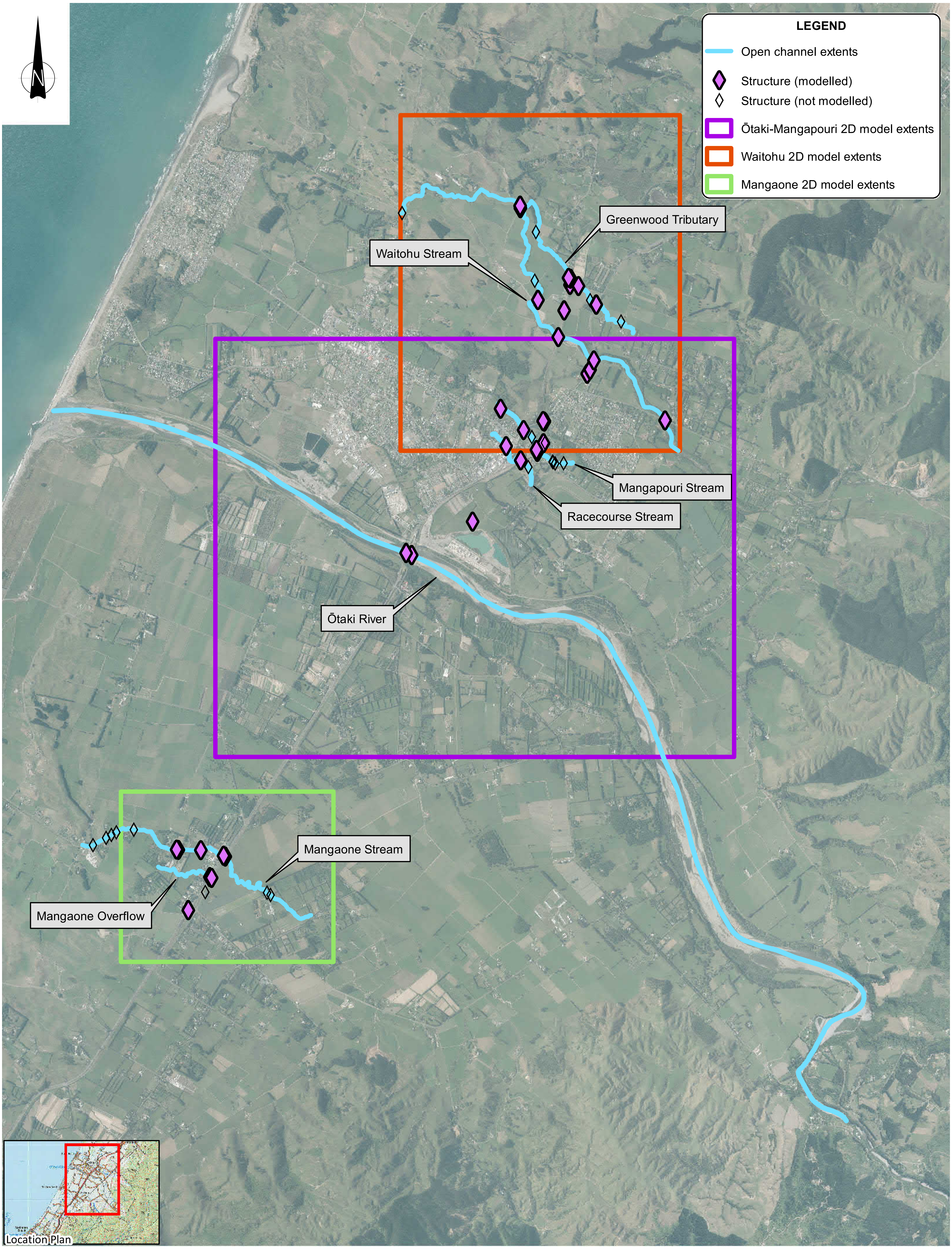
Note 2: Culverts are modelled as MIKE11 culvert structures for consistency wherever possible, and as bridge structures where required because of model instabilities.
Sensitivity tests have been carried out to confirm that modelling culverts as MIKE 11 bridge structures is appropriate. The testing showed that the bridge representation can match the culvert representation well, depending on the parameter settings.
The testing informed the selection of the following parameter settings where culverts are modelled as MIKE 11 bridge structures:

- Submergence level is set at soffit level in centre of culvert
- A weighted manning's n is applied to structure and immediately adjacent cross sections
- Contraction and expansion losses remain as default values

Appendix B:

FIGURES

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig1_PreProjectModelSchematisation.mxd Date: 24/03/2018 Time: 6:10:18 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō “the Project”, and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:35,000

0 0.4 0.8 1.2 1.6 2 (km)

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig1_PreProjectModelSchematisation.mxd

SCALE (AT A3 SIZE) 1:35,000

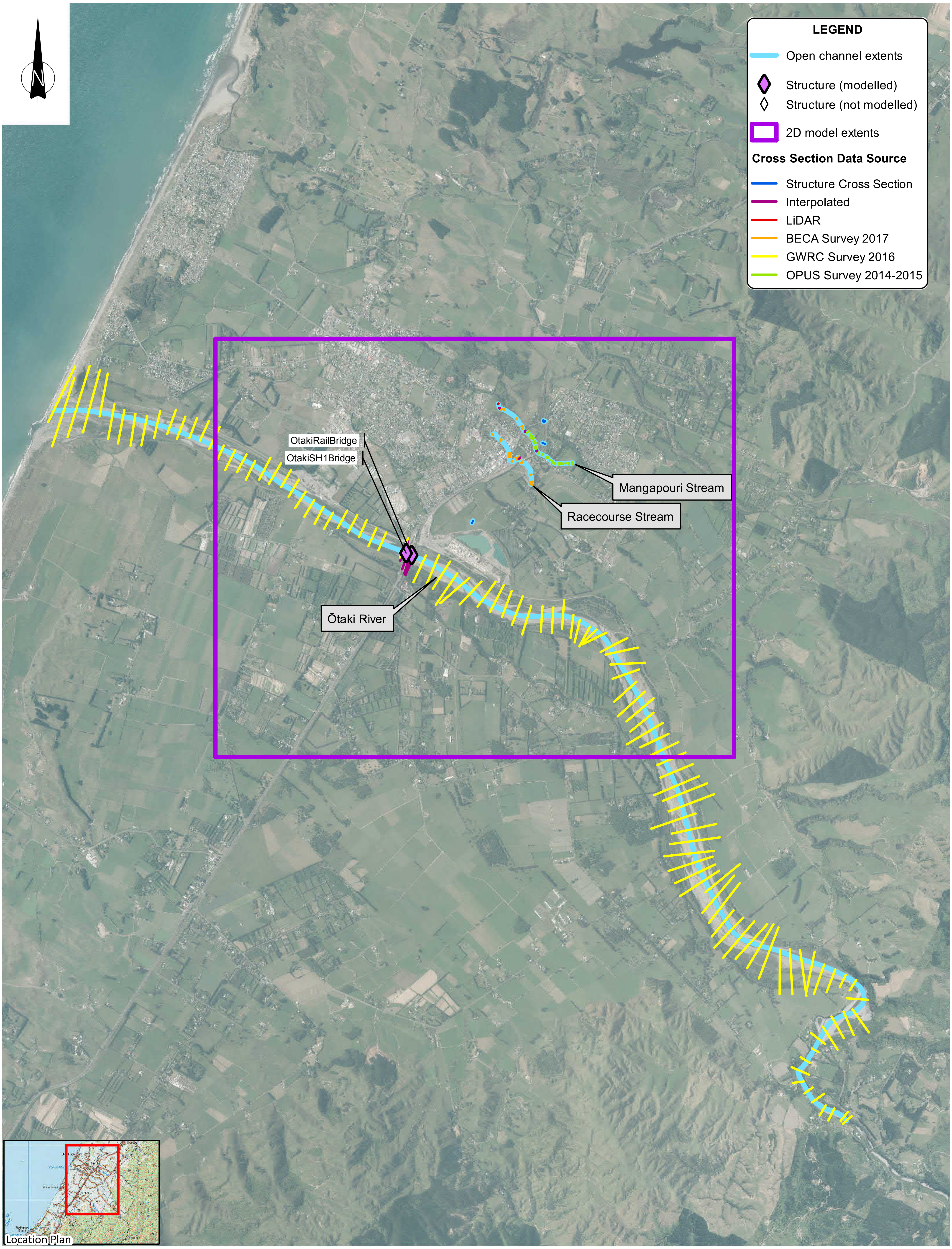
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Overview of Models

FIGURE No. Figure 1.

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig2_OM1_PreProjectModelSchem.mxd Date: 24/03/2018 Time: 6:19:03 p.m.



Notes: - Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:35,000

0 0.4 0.8 1.2 1.6 2 (km)

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig2_OM1_PreProjectModelSchem.mxd

SCALE (AT A3 SIZE) 1:35,000

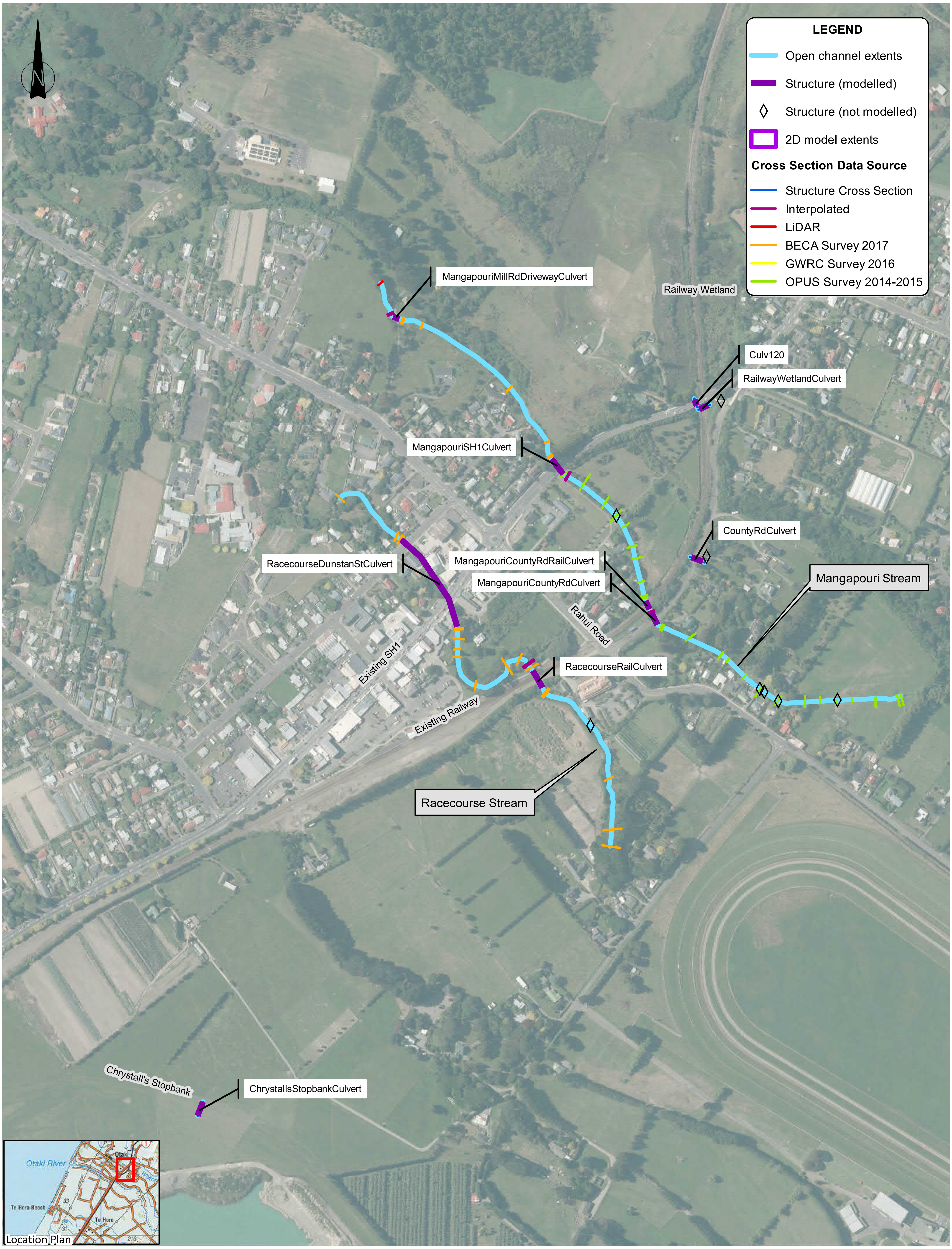
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Ōtaki-Mangapouri Model

FIGURE No. Figure 2.

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig3_OM2_PreProjectModelSchem.mxd Date: 24/03/2018 Time: 6:31:04 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō “the Project”, and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig3_OM2_PreProjectModelSchem.mxd

SCALE (AT A3 SIZE) 1:5,000

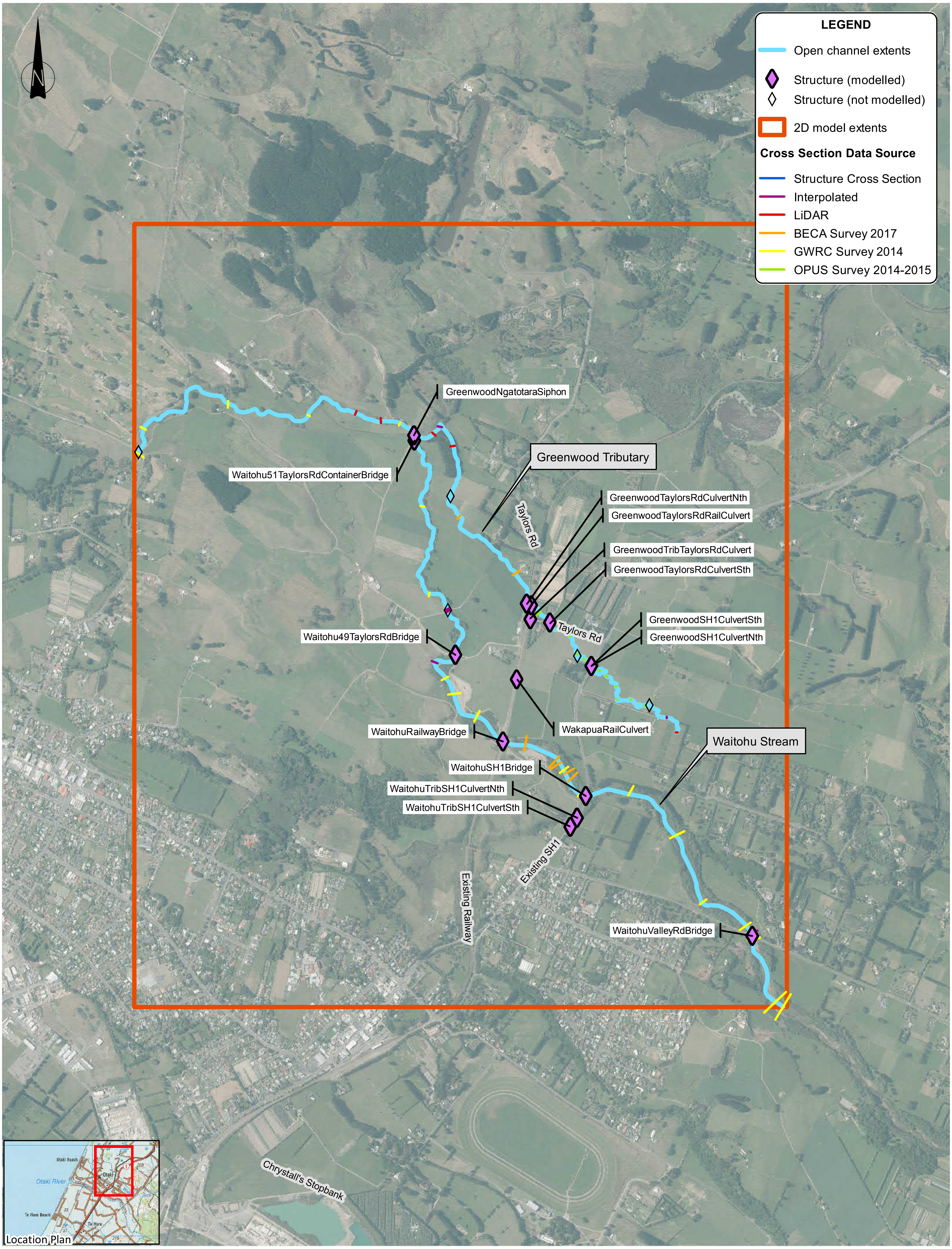
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Ōtaki-Mangapouri Model

FIGURE No. Figure 3.

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig4_Wai_PreProjectModelSchem.mxd Date: 24/03/2018 Time: 6:38:31 p.m.



Notes: - Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:15,000

0 0.2 0.4 0.6 0.8 1 (km)

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig4_Wai_PreProjectModelSchem.mxd

SCALE (AT A3 SIZE) 1:15,000

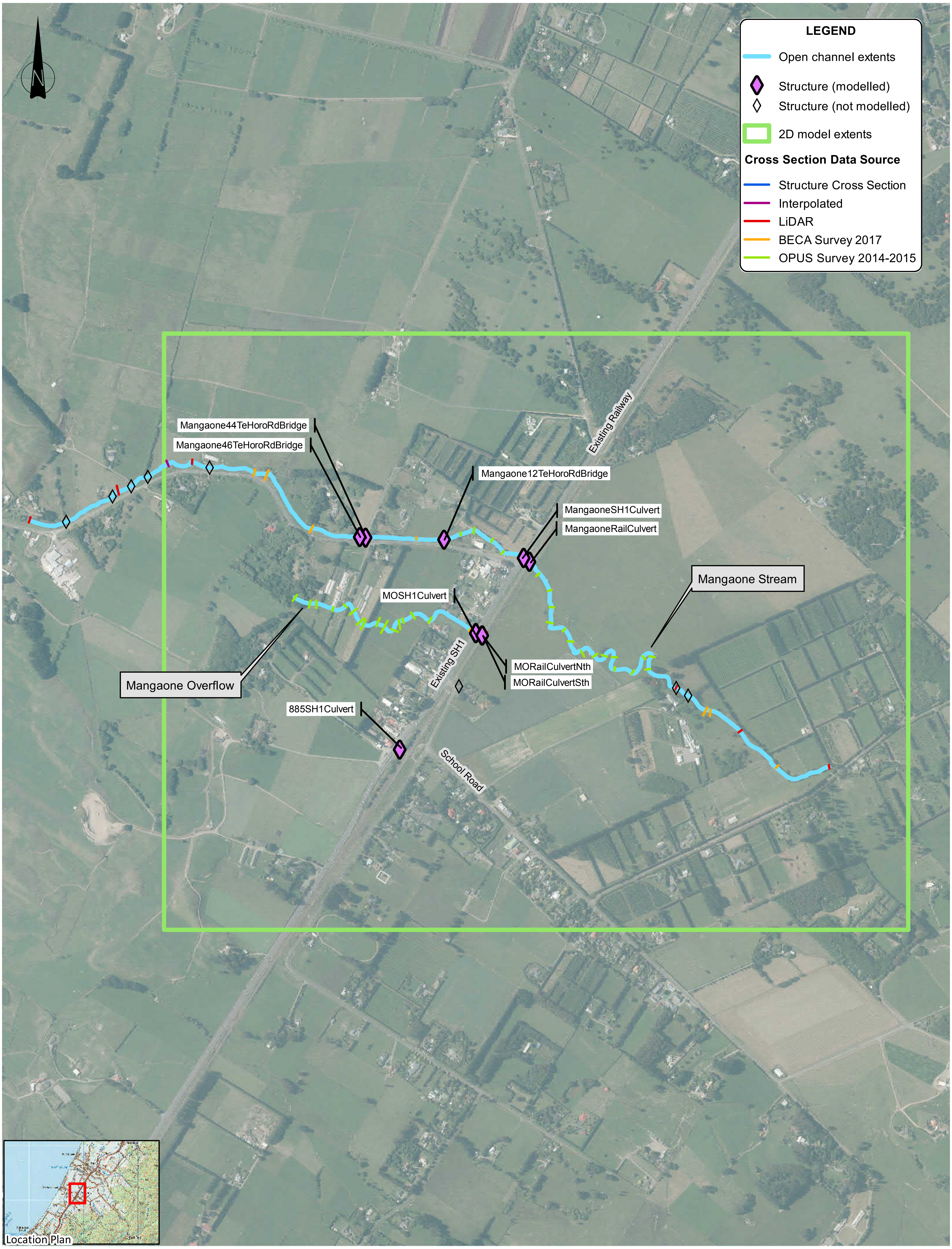
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Waitohu Model

FIGURE No. Figure 4.

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig5_Mang_PreProjectModelSchem.mxd Date: 24/03/2018 Time: 6:42:59 p.m.



Notes: - Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:10,000

0 100 200 300 400 500 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig5_Mang_PreProjectModelSchem.mxd

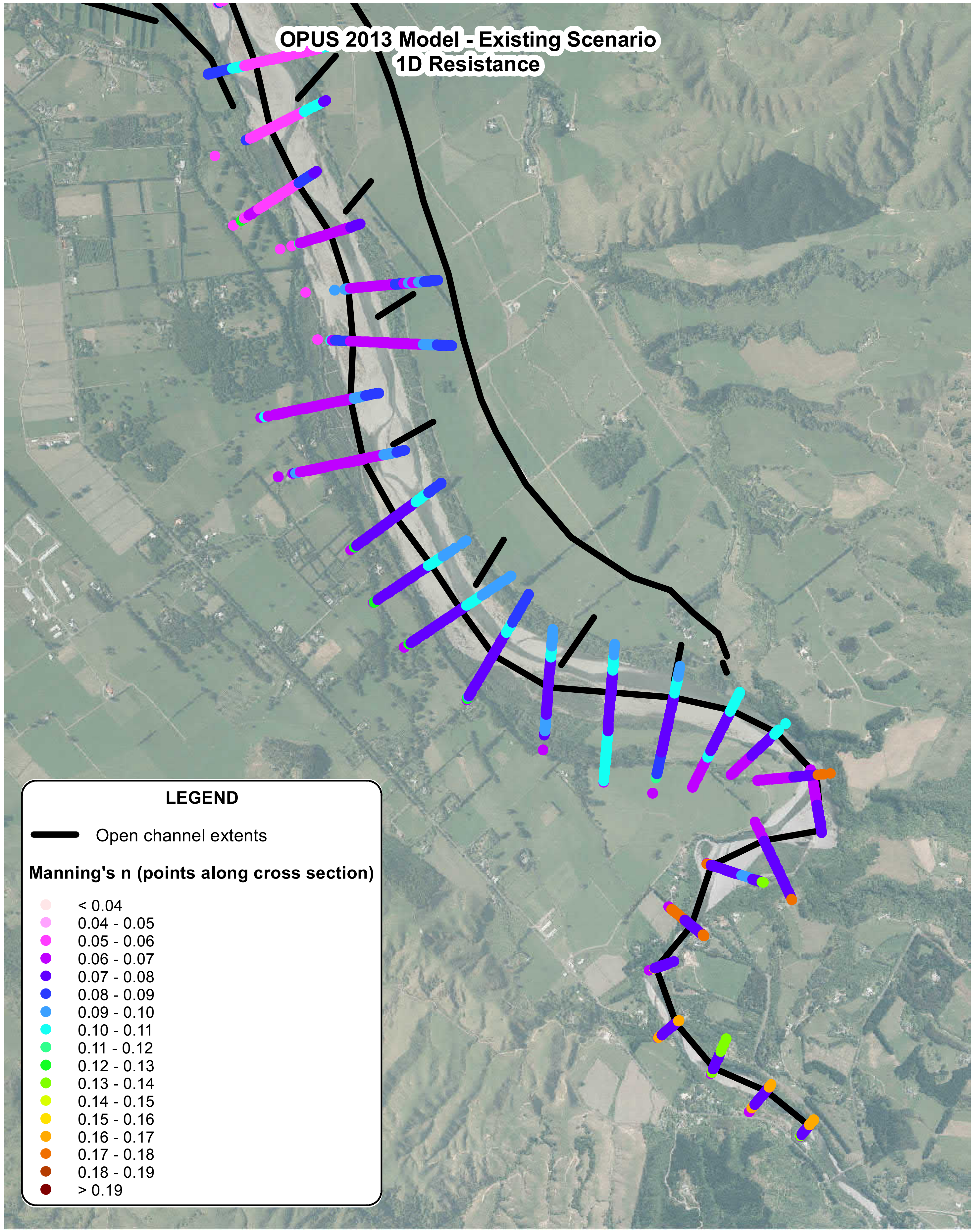
SCALE (AT A3 SIZE) 1:10,000

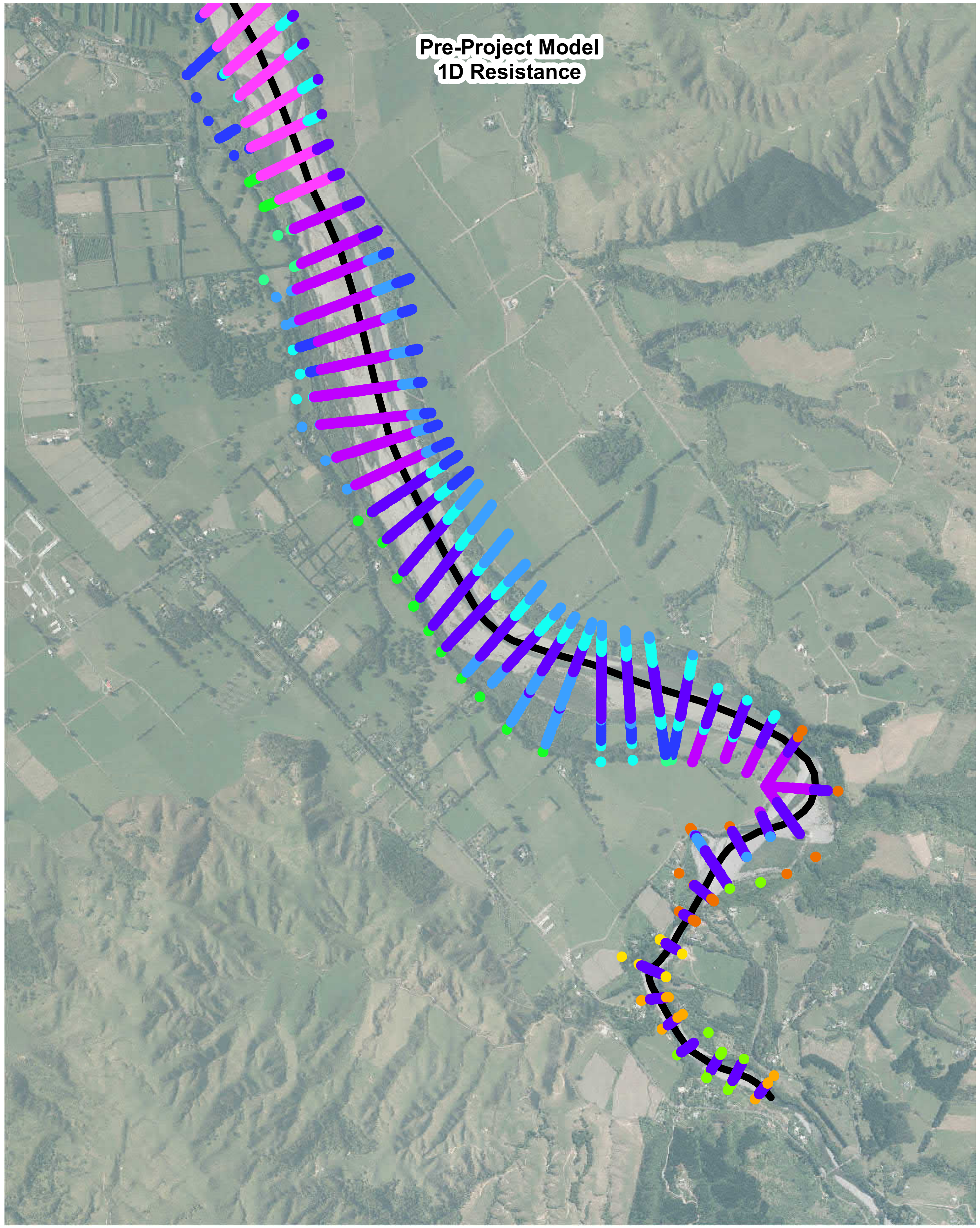
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Mangaone Model

FIGURE No. Figure 5.

Rev. 0





Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- OPUS 2013 model resistance values outside of the pre-project open channel extents have been excluded.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.
- Pre-Project cross sections presented in figure are based on hydraulic model before peer review process. Only minor changes to cross sections have occurred following peer review process.

A3 SCALE 1:20,000

0 0.2 0.4 0.6 0.8 1 (km)

N

NZ TRANSPORT AGENCY
WAKA KOTAHI
Peka Peka to Ōtaki Expressway

DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17

ARCFILE
Fig6_1_OM_1DBedResistance.mxd

SCALE (AT A3 SIZE)
1:20,000

PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Ōtaki-Mangapouri Model - 1D Bed Resistance

FIGURE No. Figure 6.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.007015000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig6_1_OM_1DBedResistance.mxd Date: 13/10/2017 Time: 12:20:41 p.m.

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig6_2_OM_1DBedResistance.mxd Date: 24/10/2017 Time: 5:45:22 p.m.

Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- OPUS 2013 model resistance values outside of the pre-project open channel extents have been excluded.
- Higher resistance applied in OPUS 2013 models to represent piers at bridges is ignored in pre-project models, which instead represents piers with a pier blocking ratio within the 1D bridge structure.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō “the Project”, and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.
- Pre-Project cross sections presented in figure are based on hydraulic model before peer review process. Only minor changes to cross sections have occurred following peer review process.

A3 SCALE 1:20,000

0 0.2 0.4 0.6 0.8 1 (km)

N

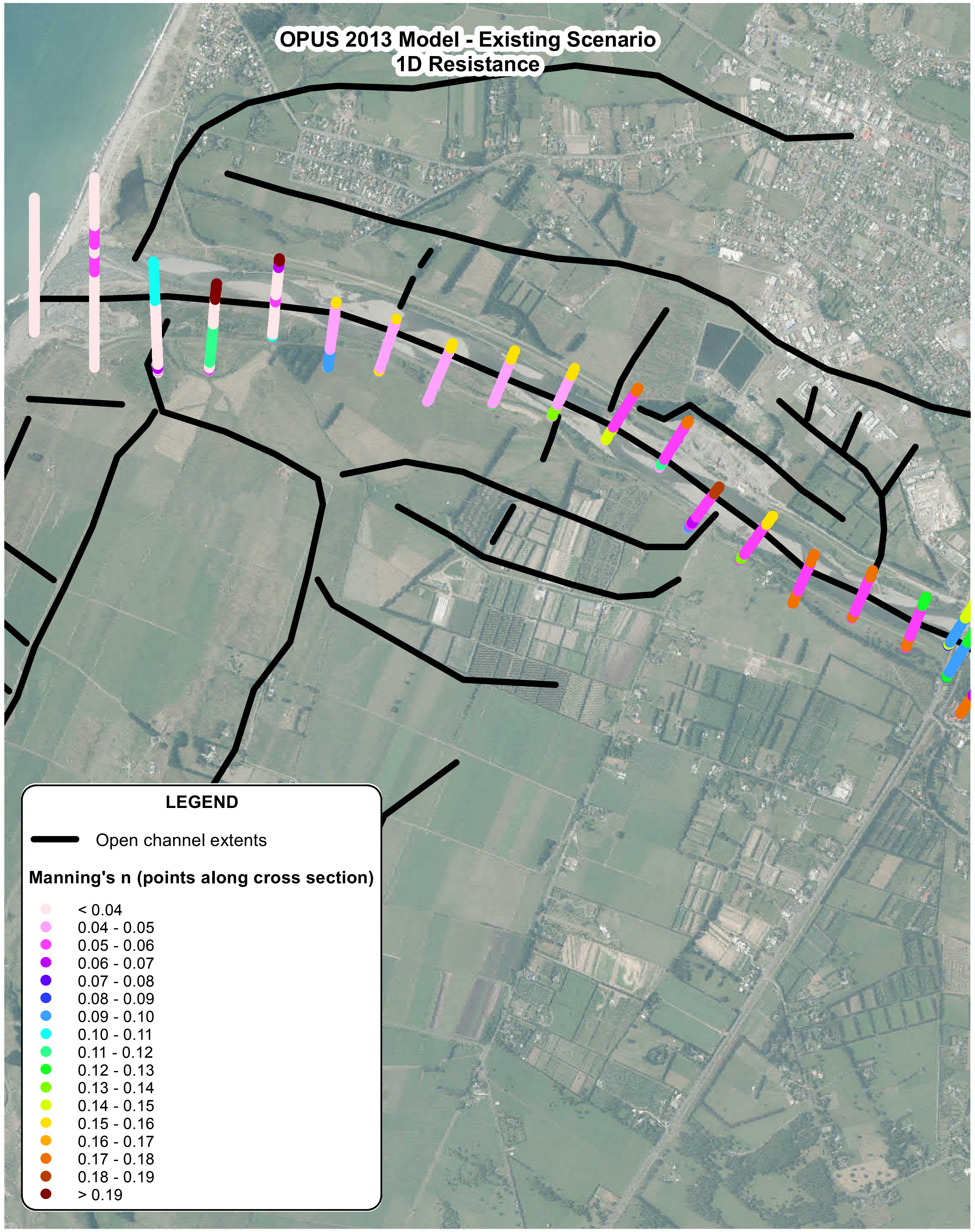
NZ TRANSPORT AGENCY
WAKA KOTAHI
Peka Peka to Ōtaki Expressway

DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17
ARCFILE Fig6_2_OM_1DBedResistance.mxd		
SCALE (AT A3 SIZE) 1:20,000		
PROJECT No. 85985.0070		

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Ōtaki-Mangapouri Model - 1D Bed Resistance

FIGURE No. Figure 6.2

Rev. 0



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- OPUS 2013 model resistance values outside of the pre-project open channel extents have been excluded.
- Higher resistance applied in OPUS 2013 models to represent piers at bridges is ignored in pre-project models, which instead represents piers with a pier blocking ratio within the 1D bridge structure.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.
- Pre-Project cross sections presented in figure are based on hydraulic model before peer review process. Only minor changes to cross sections have occurred following peer review process.

A3 SCALE 1:20,000

0 0.2 0.4 0.6 0.8 1 (km)

N

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17

ARCFILE Fig6_3_OM_1DBedResistance.mxd

SCALE (AT A3 SIZE) 1:20,000

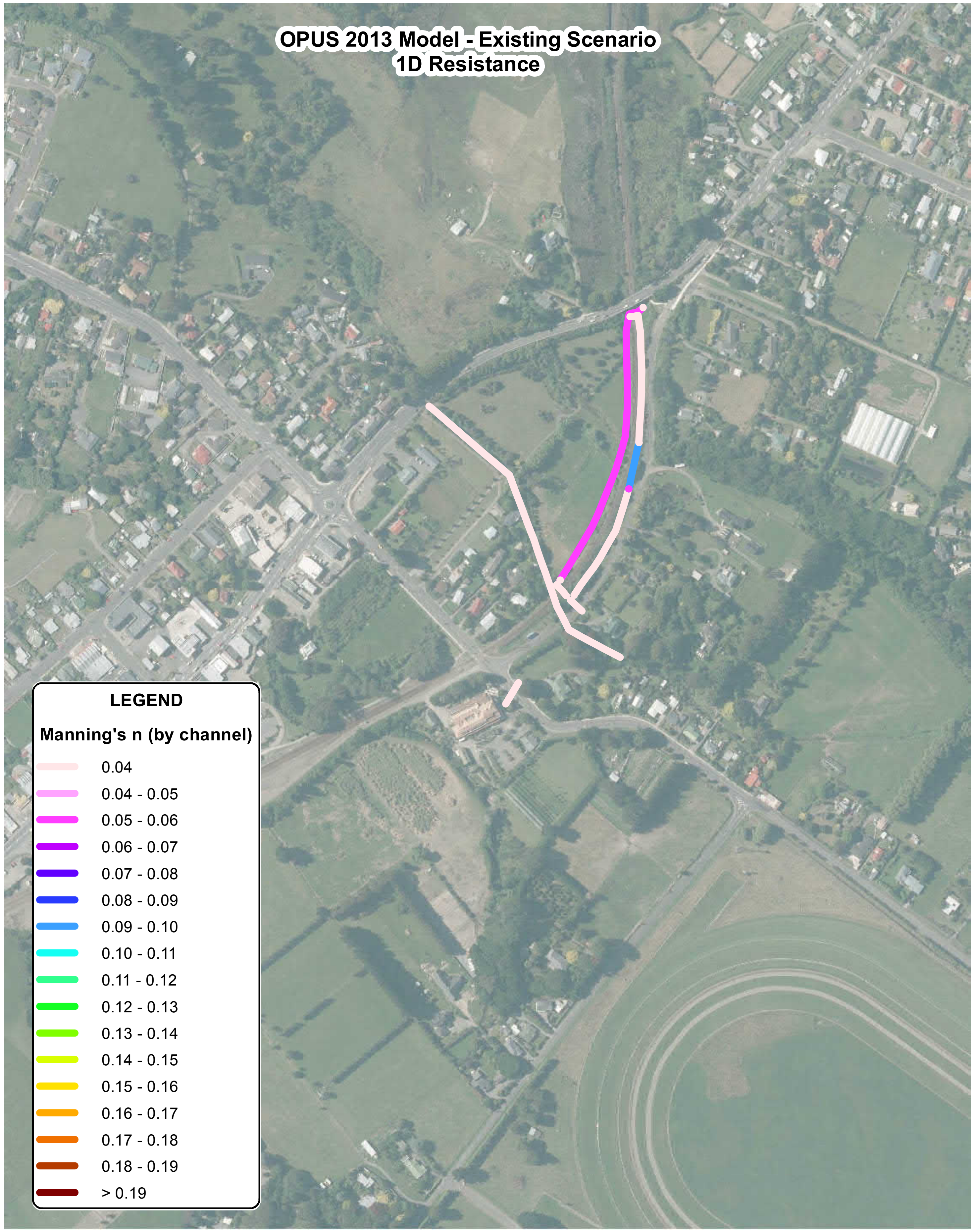
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Ōtaki-Mangapouri Model - 1D Bed Resistance

FIGURE No. Figure 6.3

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig6_3_OM_1DBedResistance.mxd Date: 24/10/2017 Time: 5:46:10 p.m.



LEGEND

Manning's n (by channel)

- 0.04
- 0.04 - 0.05
- 0.05 - 0.06
- 0.06 - 0.07
- 0.07 - 0.08
- 0.08 - 0.09
- 0.09 - 0.10
- 0.10 - 0.11
- 0.11 - 0.12
- 0.12 - 0.13
- 0.13 - 0.14
- 0.14 - 0.15
- 0.15 - 0.16
- 0.16 - 0.17
- 0.17 - 0.18
- 0.18 - 0.19
- > 0.19

Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- OPUS 2013 model resistance values outside of the pre-project open channel extents have been excluded.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 50 100 150 200 250 Meters

Location Plan

NZ TRANSPORT AGENCY
WAKA KOTAHI

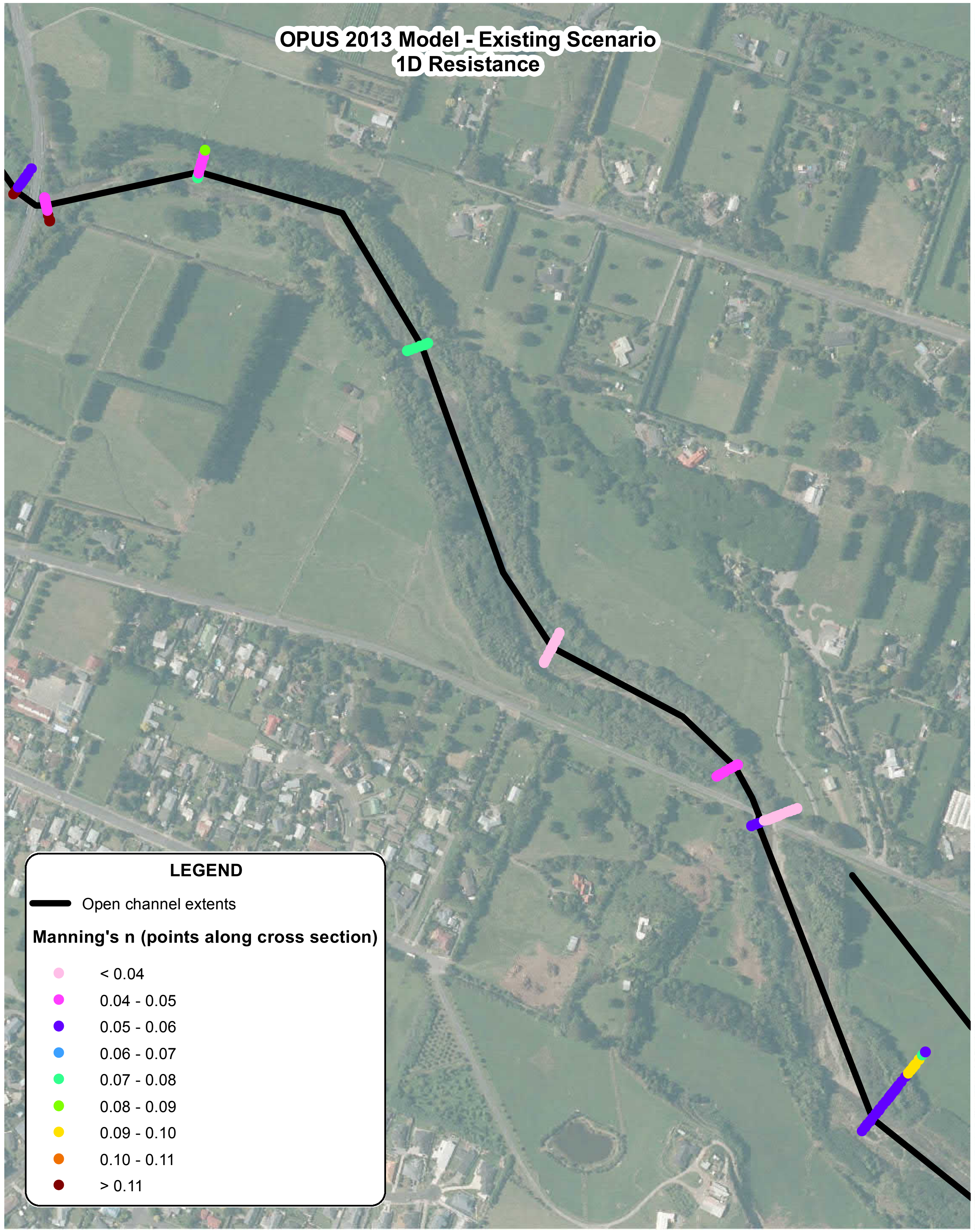
Peka Peka to Ōtaki Expressway

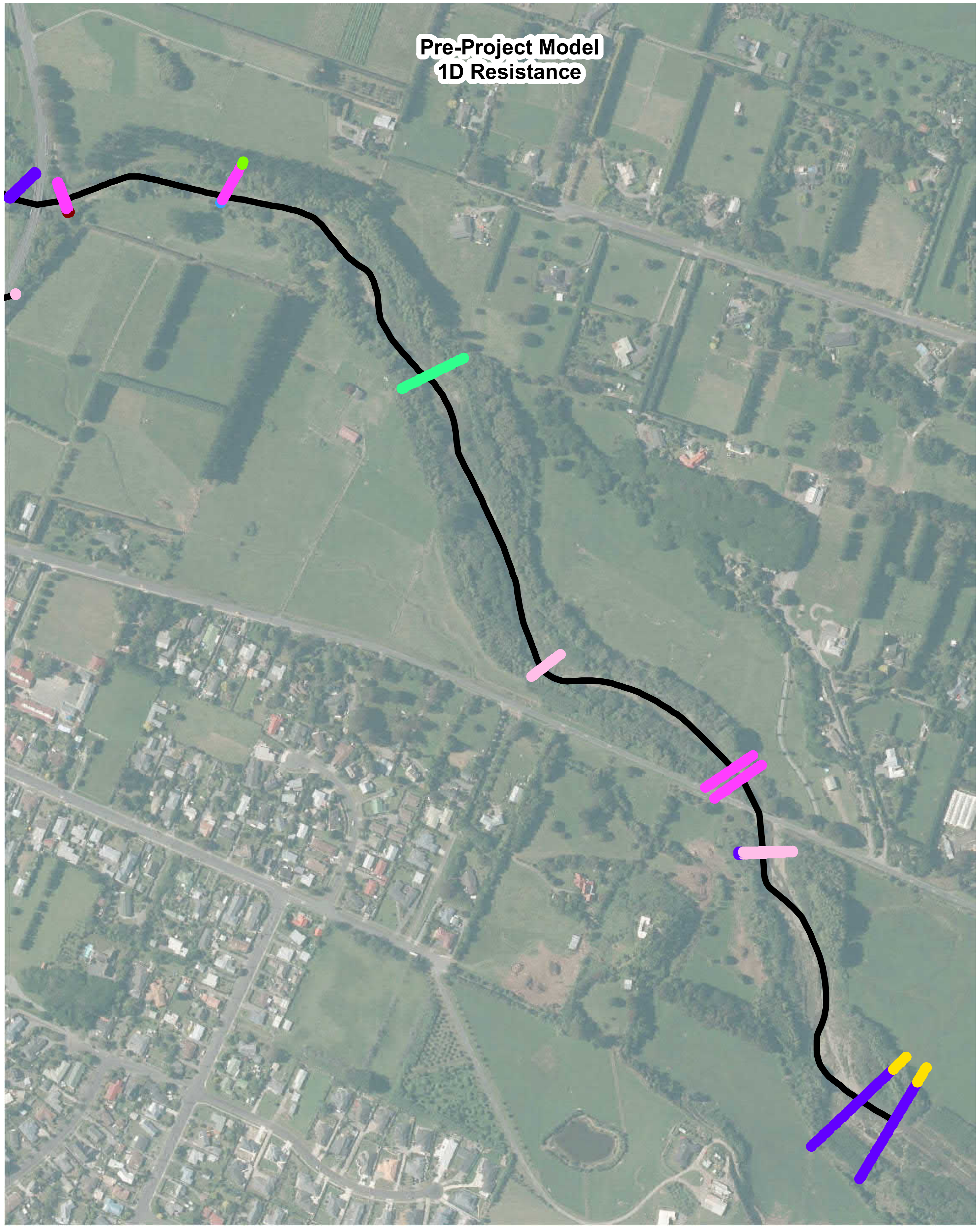
DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17
ARCFILE Fig6_4_OM_1DBedResistance.mxd		
SCALE (AT A3 SIZE) 1:5,000		
PROJECT No. 85985.0070		

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Ōtaki-Mangapouri Model - 1D Bed Resistance

FIGURE No. Figure 6.4 Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig6_4_OM_1DBedResistance.mxd Date: 13/10/2017 Time: 12:29:00 p.m.





Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- OPUS 2013 model resistance values outside of the pre-project open channel extents have been excluded.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō “the Project”, and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.
- Pre-Project cross sections presented in figure are based on hydraulic model before peer review process. Only minor changes to cross sections have occurred following peer review process.

A3 SCALE 1:5,000

0 50 100 150 200 250 Meters

N

Location Plan

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

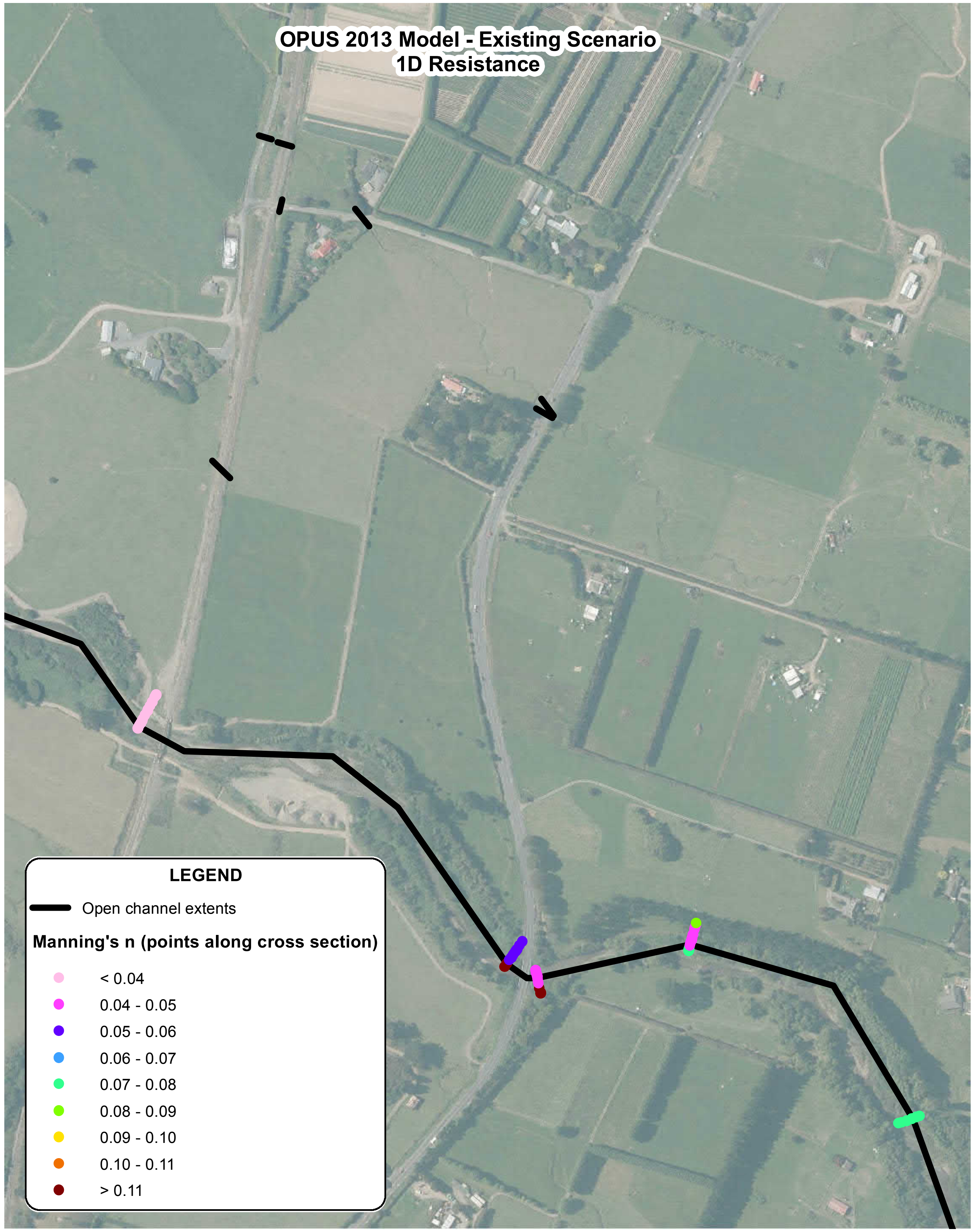
DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17
ARCFILE Fig7_1_Wai_1DBedResistance.mxd		
SCALE (AT A3 SIZE) 1:5,000		
PROJECT No. 85985.0070		

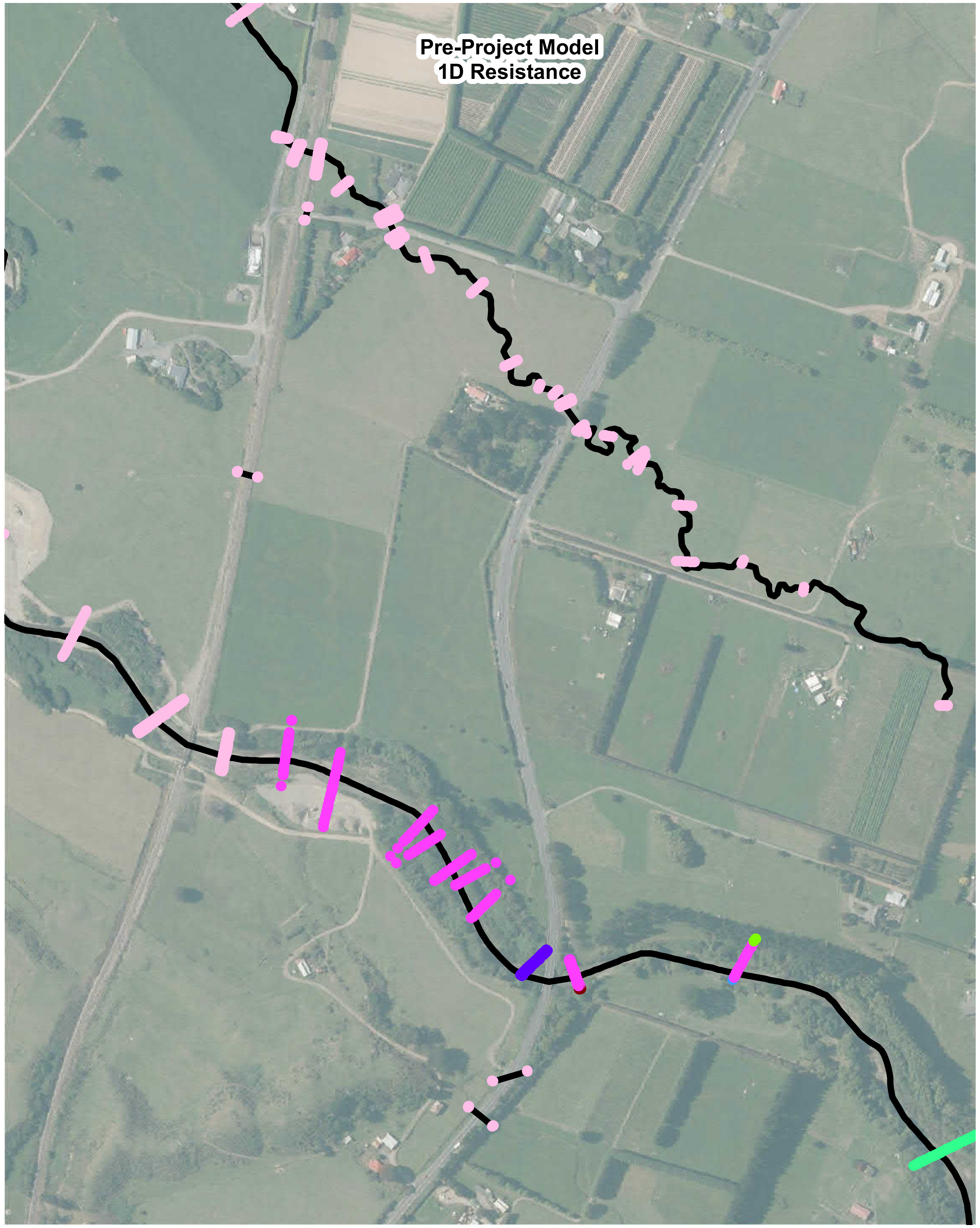
NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Waitohu Model - 1D Bed Resistance

FIGURE No. Figure 7.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig7_1_Wai_1DBedResistance.mxd Date: 13/10/2017 Time: 12:34:45 p.m.





Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- OPUS 2013 model resistance values outside of the pre-project open channel extents have been excluded.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.
- Pre-Project cross sections presented in figure are based on hydraulic model before peer review process. Only minor changes to cross sections have occurred following peer review process.

A3 SCALE 1:5,000

0 50 100 150 200 250 Meters

N

Location Plan

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17

ARCFILE
Fig7_2_Wai_1DBedResistance.mxd

SCALE (AT A3 SIZE)
1:5,000

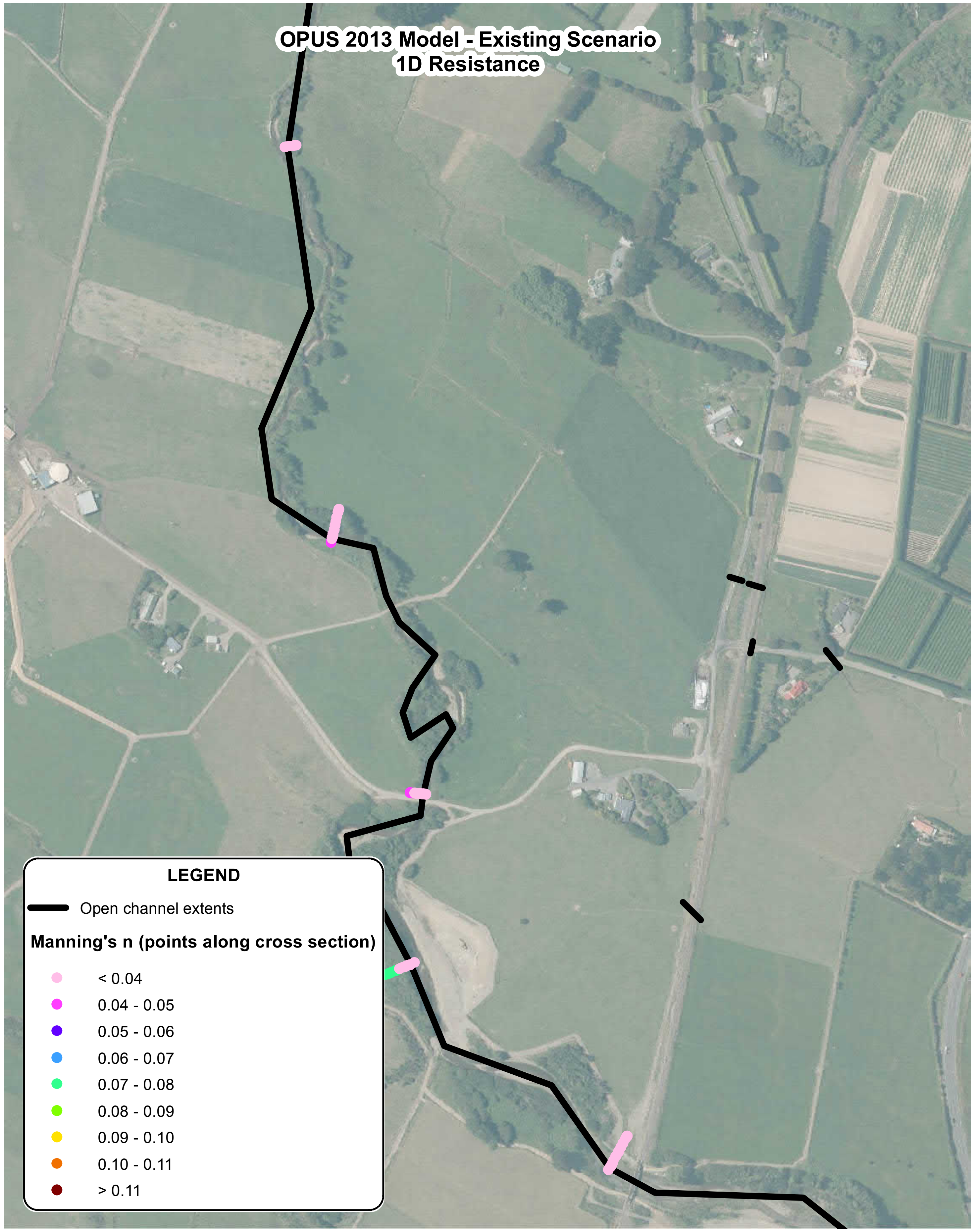
PROJECT No.
85985.0070

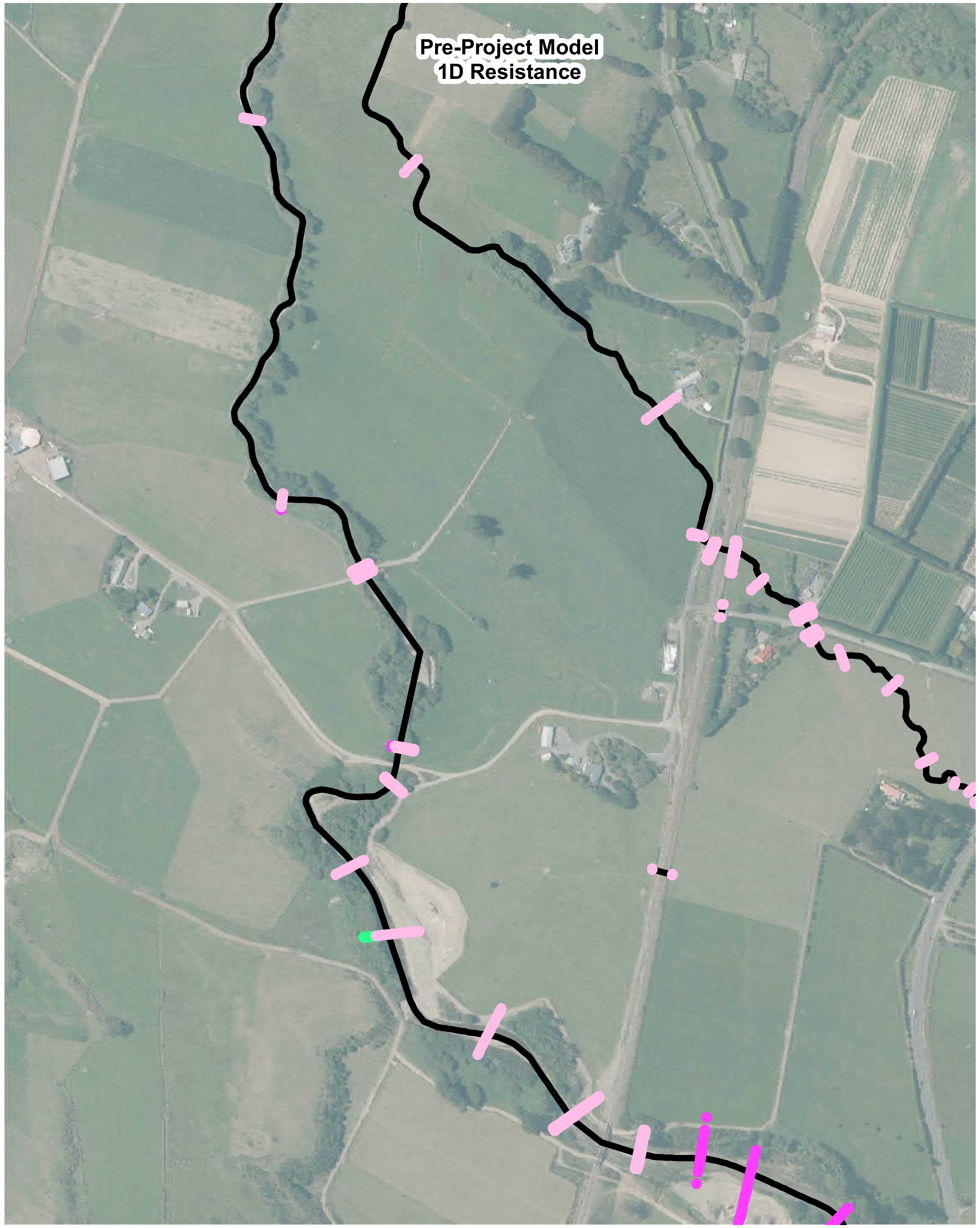
NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Waitohu Model - 1D Bed Resistance

FIGURE No. Figure 7.2

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig7_2_Wai_1DBedResistance.mxd Date: 13/10/2017 Time: 12:37:28 p.m.





Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- OPUS 2013 model resistance values outside of the pre-project open channel extents have been excluded.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō “the Project”, and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.
- Pre-Project cross sections presented in figure are based on hydraulic model before peer review process. Only minor changes to cross sections have occurred following peer review process.

A3 SCALE 1:5,000

0 50 100 150 200 250 Meters

N

Location Plan

NZ TRANSPORT AGENCY
WAKA KOTAHI
Peka Peka to Ōtaki Expressway

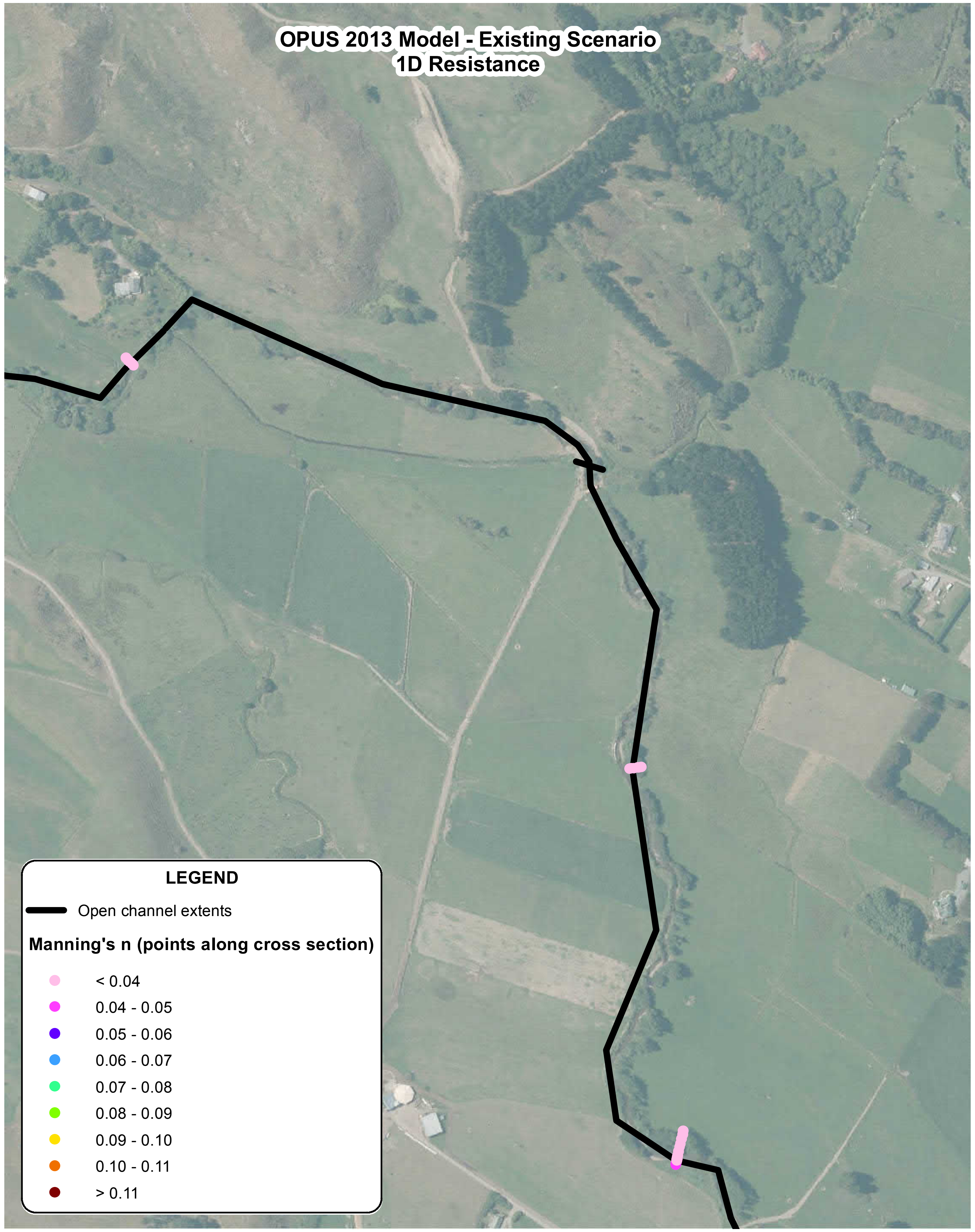
DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17
ARCFILE Fig7_3_Wai_1DBedResistance.mxd		
SCALE (AT A3 SIZE) 1:5,000		
PROJECT No. 85985.0070		

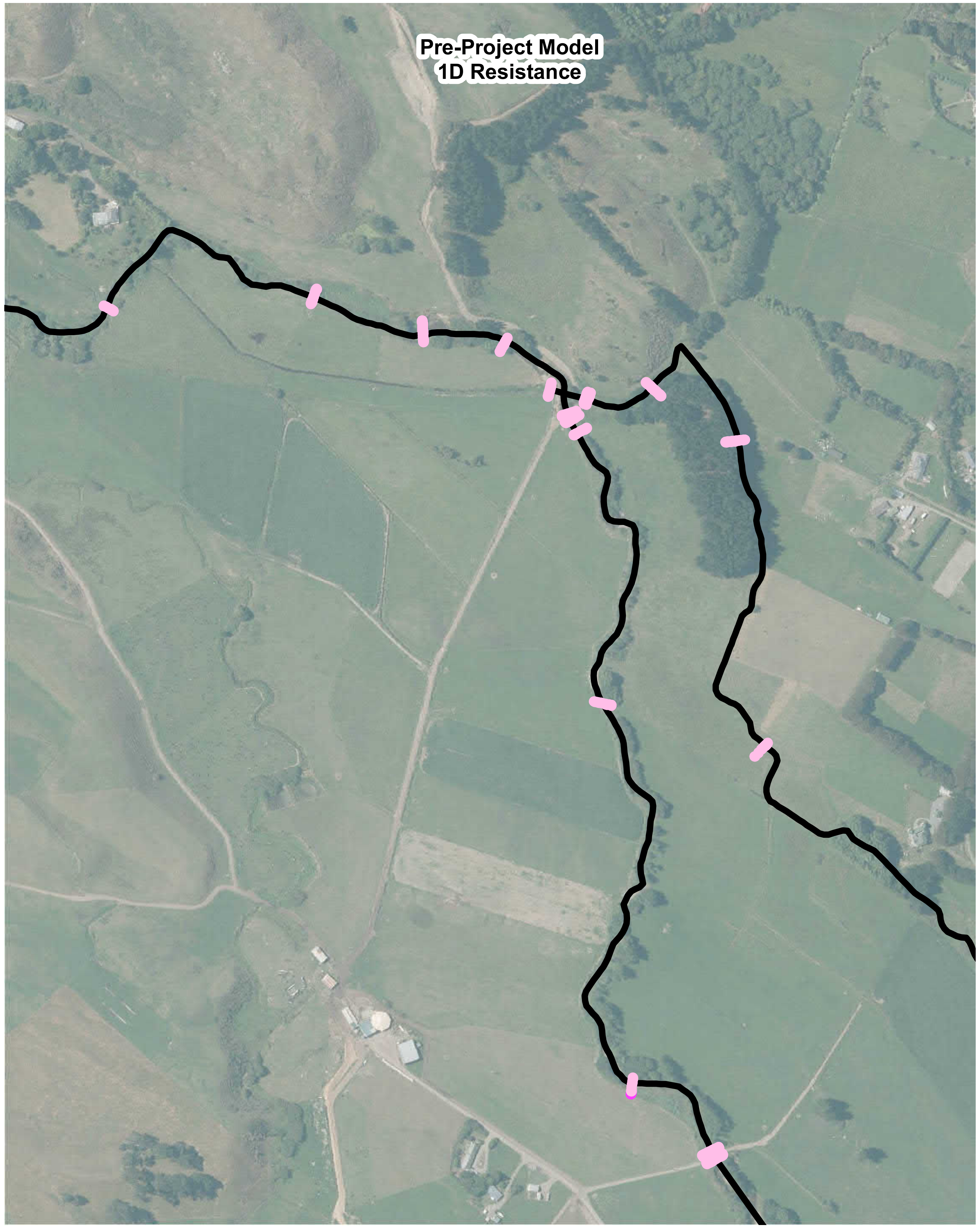
NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Waitohu Model - 1D Bed Resistance

FIGURE No. Figure 7.3

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig7_3_Wai_1DBedResistance.mxd Date: 13/10/2017 Time: 12:40:22 p.m.





Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig7_4_Wai_1DBedResistance.mxd Date: 13/10/2017 Time: 12:42:11 p.m.

Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- OPUS 2013 model resistance values outside of the pre-project open channel extents have been excluded.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.
- Pre-Project cross sections presented in figure are based on hydraulic model before peer review process. Only minor changes to cross sections have occurred following peer review process.

A3 SCALE 1:5,000

0 50 100 150 200 250 Meters

Location Plan

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17

ARCFILE
Fig7_4_Wai_1DBedResistance.mxd

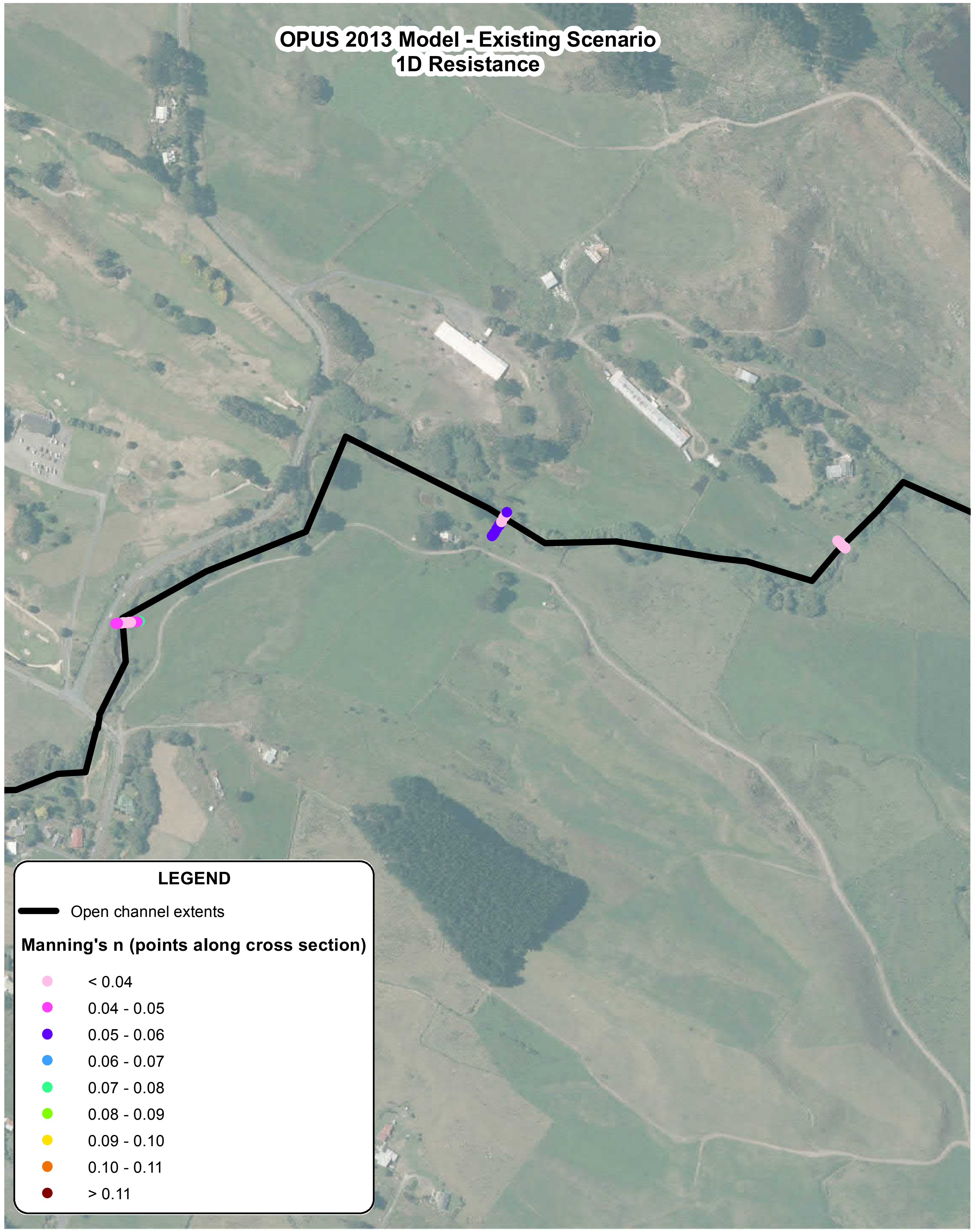
SCALE (AT A3 SIZE)
1:5,000

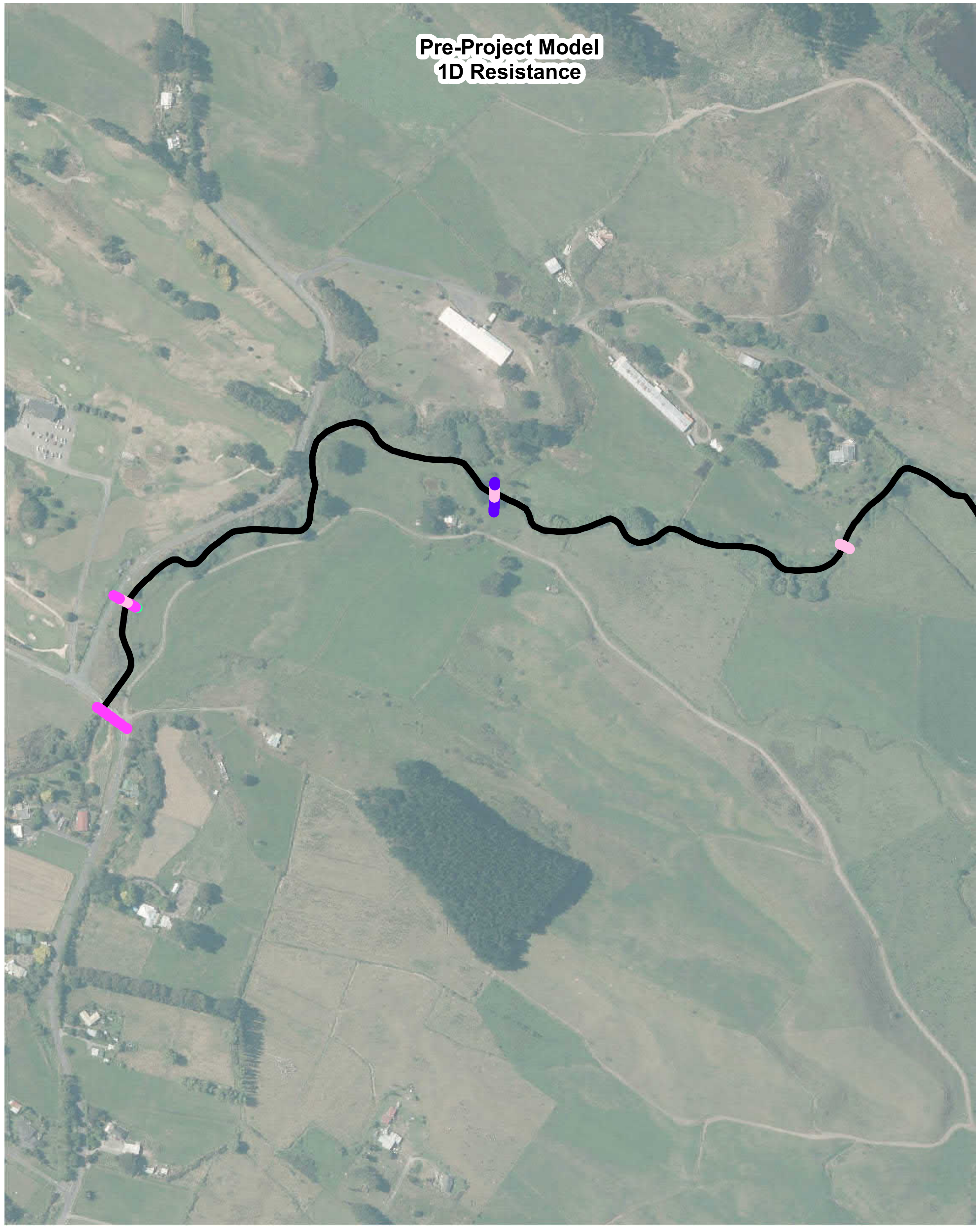
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Waitohu Model - 1D Bed Resistance

FIGURE No. Figure 7.4

Rev. 0





Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- OPUS 2013 model resistance values outside of the pre-project open channel extents have been excluded.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.
- Pre-Project cross sections presented in figure are based on hydraulic model before peer review process. Only minor changes to cross sections have occurred following peer review process.

A3 SCALE 1:5,000

0 50 100 150 200 250 Meters

Location Plan

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17

ARCFILE Fig7_5_Wai_1DBedResistance.mxd

SCALE (AT A3 SIZE) 1:5,000

PROJECT No. 85985.0070

NZ TRANSPORT AGENCY

PEKA PEKA TO ŌTAKI EXPRESSWAY

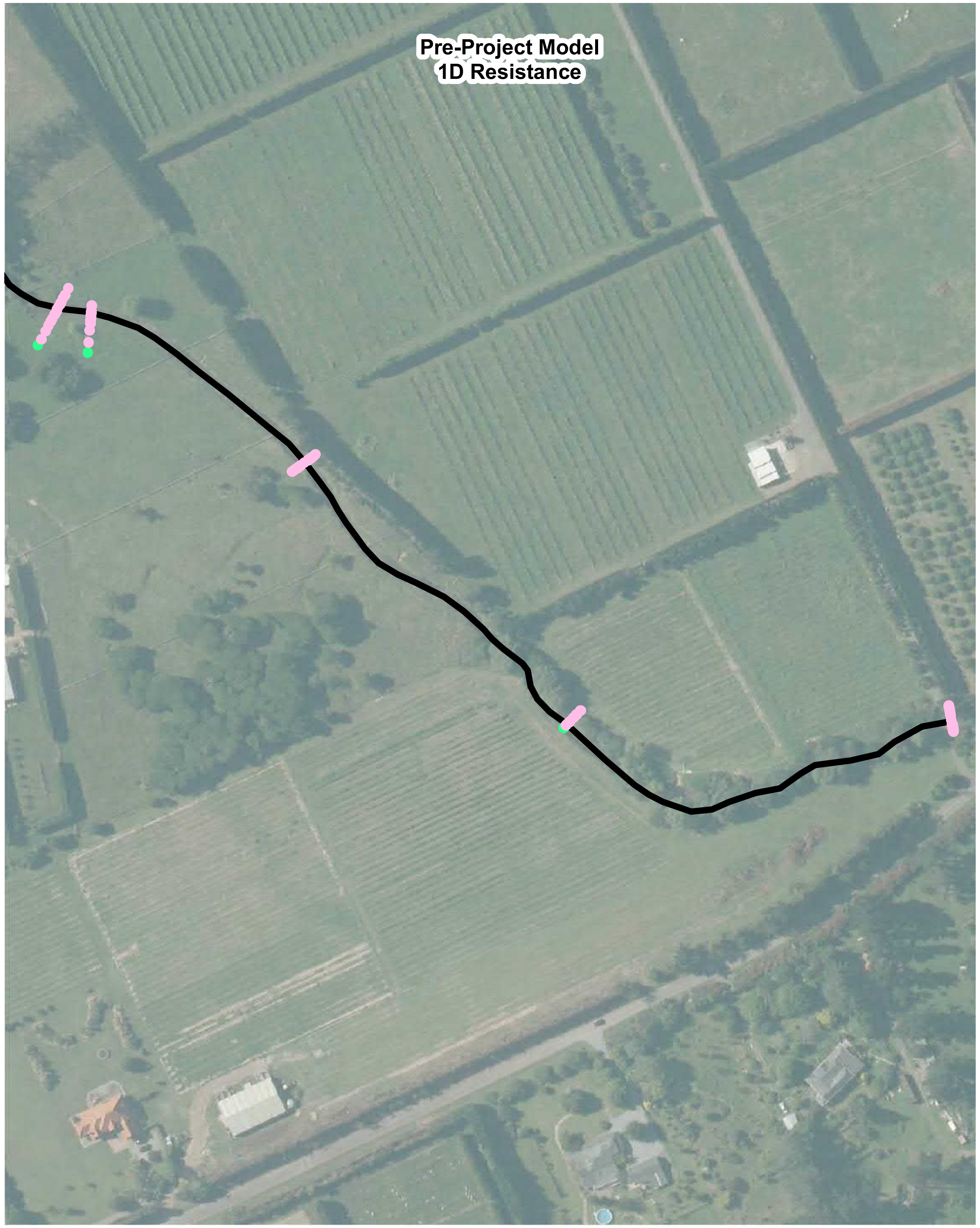
Pre-Project Hydraulic Model Schematisation

Waitohu Model - 1D Bed Resistance

FIGURE No. Figure 7.5

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig7_5_Wai_1DBedResistance.mxd Date: 13/10/2017 Time: 12:43:52 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- OPUS 2013 model resistance values outside of the pre-project open channel extents have been excluded.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.
- Pre-Project cross sections presented in figure are based on hydraulic model before peer review process. Only minor changes to cross sections have occurred following peer review process.

A3 SCALE 1:2,000

0 20 40 60 80 100 Meters

NZ TRANSPORT AGENCY
WAKA KOTAHI

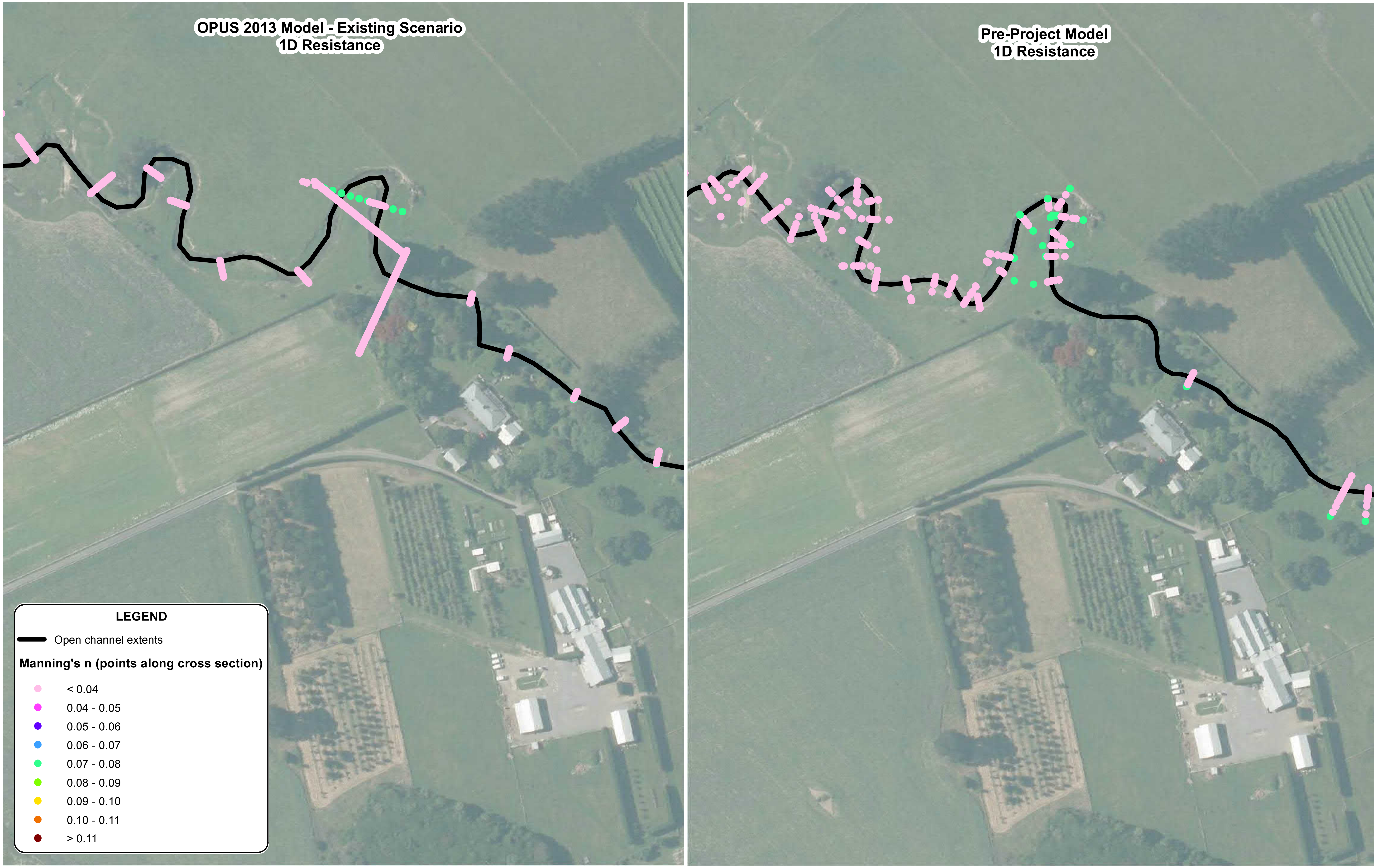
Peka Peka to Ōtaki Expressway

DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17
ARCFILE Fig8_1_Mang_1DBedResistance.mxd		
SCALE (AT A3 SIZE) 1:2,000		
PROJECT No. 85985.0070		

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Mangaone Model - 1D Bed Resistance

FIGURE No. Figure 8.1 | Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig8_1_Mang_1DBedResistance.mxd Date: 13/10/2017 Time: 12:45:18 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- OPUS 2013 model resistance values outside of the pre-project open channel extents have been excluded.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.
- Pre-Project cross sections presented in figure are based on hydraulic model before peer review process. Only minor changes to cross sections have occurred following peer review process.

A3 SCALE 1:2,000

0 20 40 60 80 100 Meters

NZ TRANSPORT AGENCY
WAKA KOTAHI
Peka Peka to Ōtaki Expressway

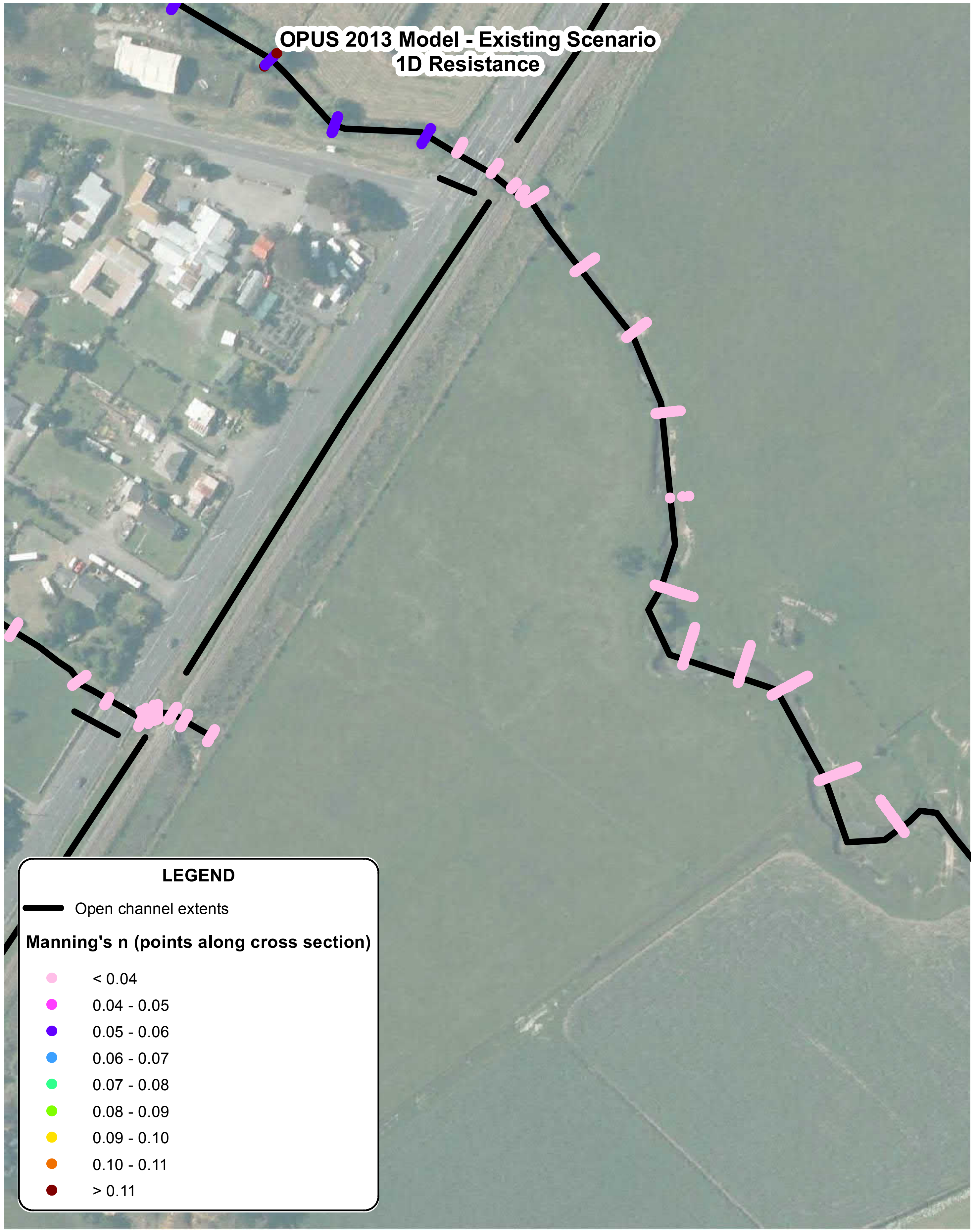
DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17

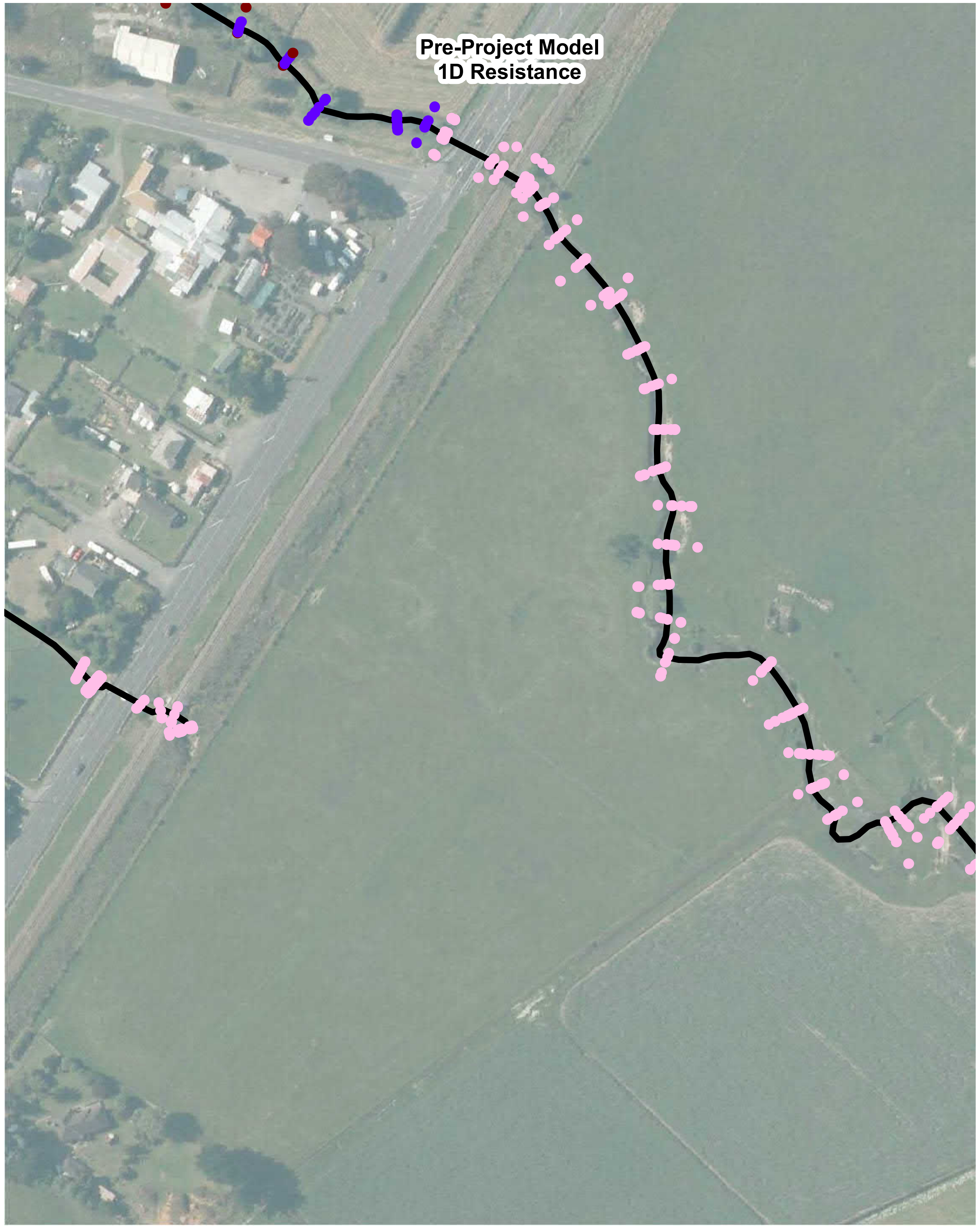
ARCFILE Fig8_2_Mang_1DBedResistance.mxd
SCALE (AT A3 SIZE) 1:2,000
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Mangaone Model - 1D Bed Resistance

FIGURE No. Figure 8.2
Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig8_2_Mang_1DBedResistance.mxd Date: 13/10/2017 Time: 12:46:32 p.m.





Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- OPUS 2013 model resistance values outside of the pre-project open channel extents have been excluded.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.
- Pre-Project cross sections presented in figure are based on hydraulic model before peer review process. Only minor changes to cross sections have occurred following peer review process.

A3 SCALE 1:2,000

0 20 40 60 80 100 Meters

N

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17

ARCFILE
Fig8_3_Mang_1DBedResistance.mxd

SCALE (AT A3 SIZE)
1:2,000

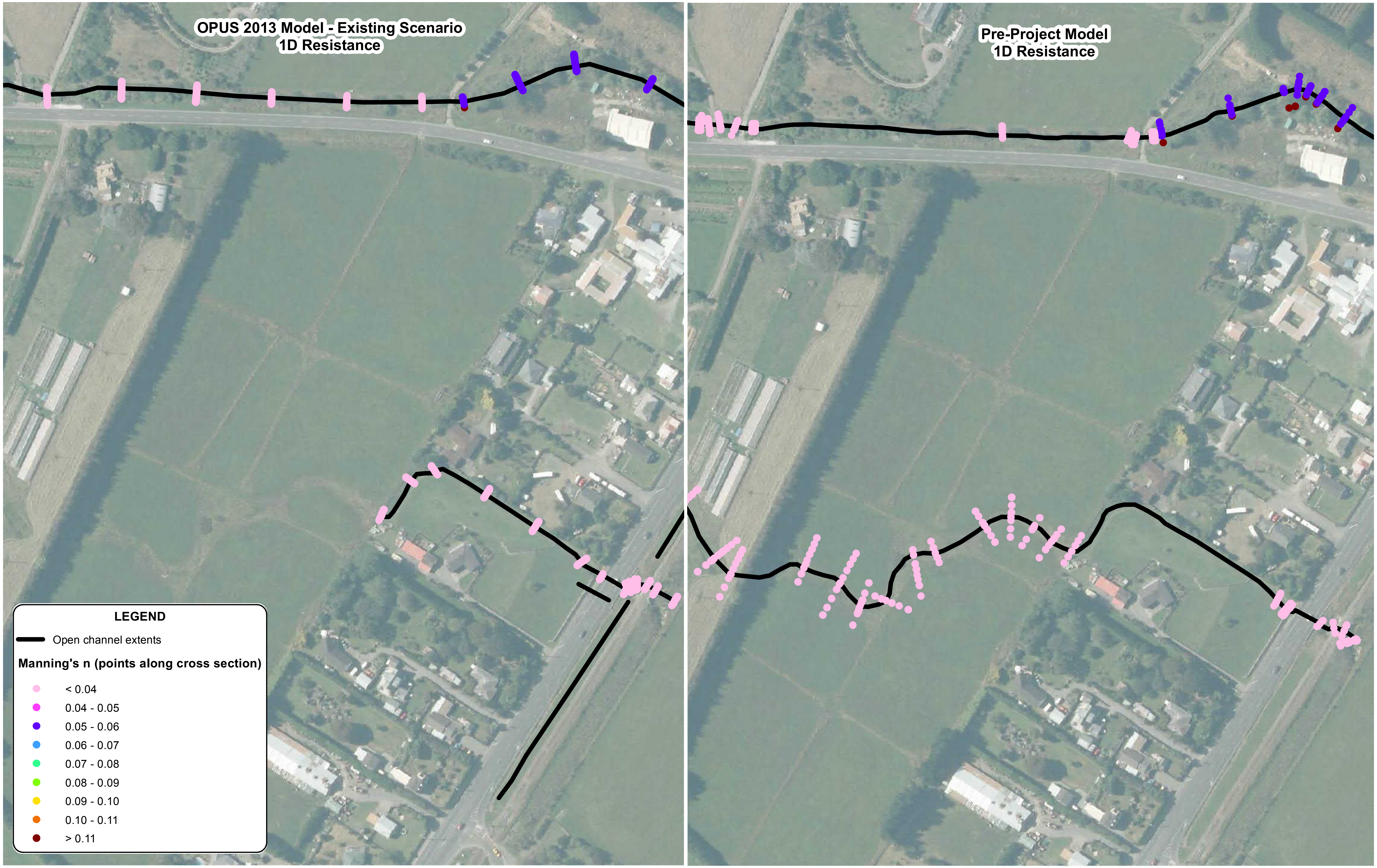
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Mangaone Model - 1D Bed Resistance

FIGURE No. Figure 8.3

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig8_3_Mang_1DBedResistance.mxd Date: 13/10/2017 Time: 12:47:39 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- OPUS 2013 model resistance values outside of the pre-project open channel extents have been excluded.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.
- Pre-Project cross sections presented in figure are based on hydraulic model before peer review process. Only minor changes to cross sections have occurred following peer review process.

A3 SCALE 1:2,000

0 20 40 60 80 100 Meters

N

NZ TRANSPORT AGENCY
WAKA KOTAHI
Peka Peka to Ōtaki Expressway

DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17

ARCFILE
Fig8_4_Mang_1DBedResistance.mxd

SCALE (AT A3 SIZE)
1:2,000

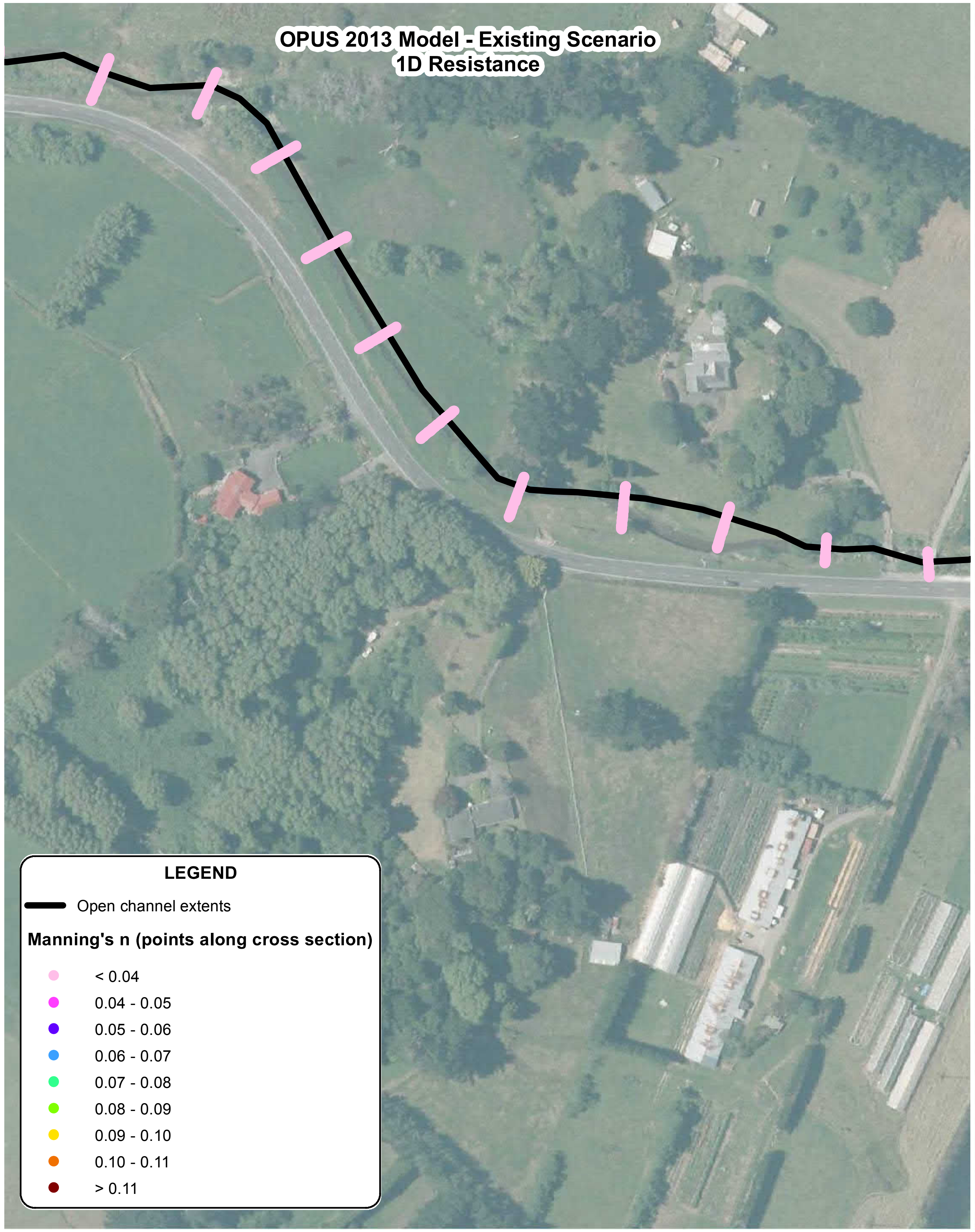
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Mangaone Model - 1D Bed Resistance

FIGURE No. Figure 8.4

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig8_4_Mang_1DBedResistance.mxd Date: 13/10/2017 Time: 12:48:45 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- OPUS 2013 model resistance values outside of the pre-project open channel extents have been excluded.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.
- Pre-Project cross sections presented in figure are based on hydraulic model before peer review process. Only minor changes to cross sections have occurred following peer review process.

A3 SCALE 1:2,000

0 20 40 60 80 100 Meters

N

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17

ARCFILE Fig8_5_Mang_1DBedResistance.mxd

SCALE (AT A3 SIZE) 1:2,000

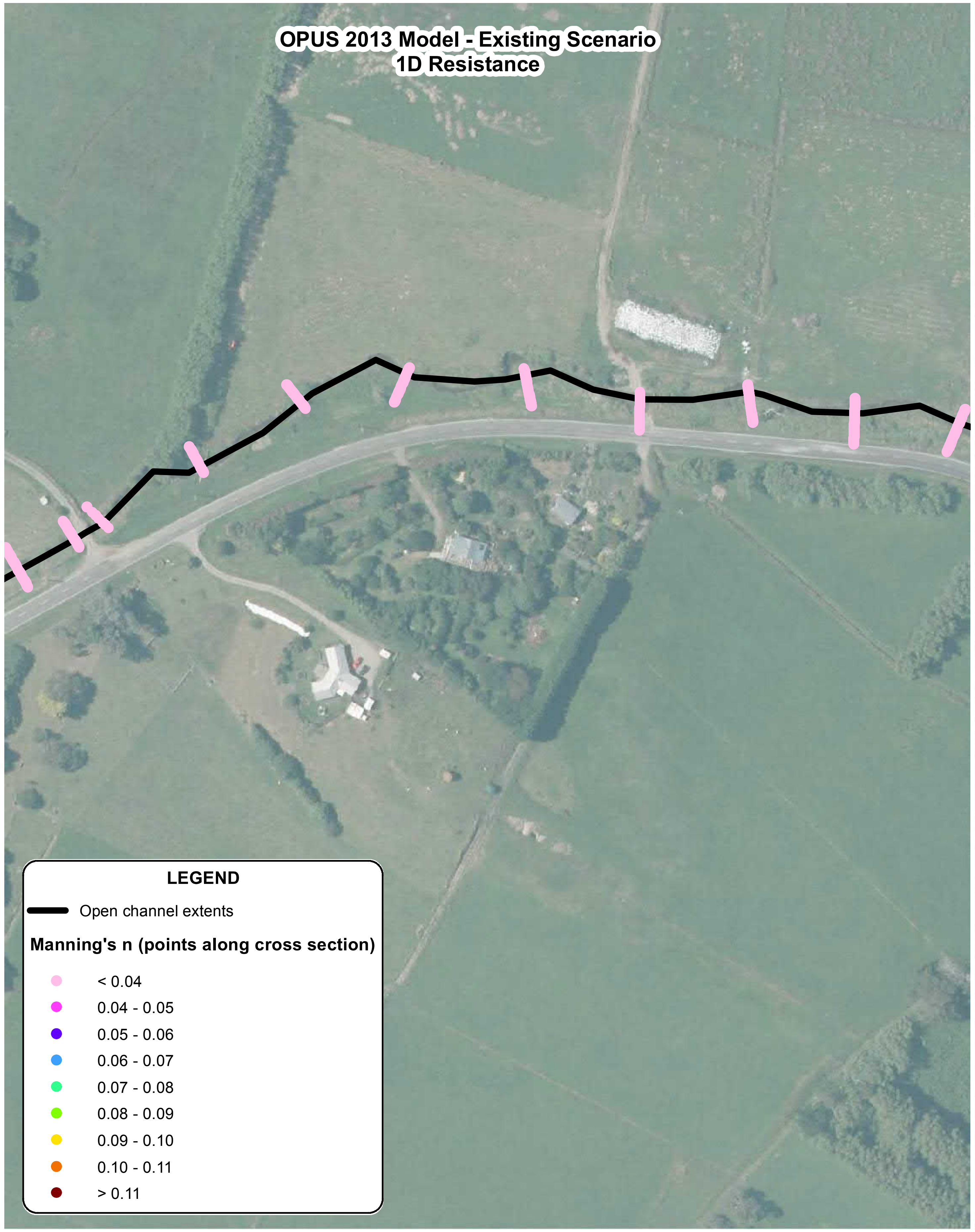
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Mangaone Model - 1D Bed Resistance

FIGURE No. Figure 8.5

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig8_5_Mang_1DBedResistance.mxd Date: 13/10/2017 Time: 12:49:50 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- OPUS 2013 model resistance values outside of the pre-project open channel extents have been excluded.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.
- Pre-Project cross sections presented in figure are based on hydraulic model before peer review process. Only minor changes to cross sections have occurred following peer review process.

A3 SCALE 1:2,000

0 20 40 60 80 100 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17

ARCFILE Fig8_6_Mang_1DBedResistance.mxd

SCALE (AT A3 SIZE) 1:2,000

PROJECT No. 85985.0070

NZ TRANSPORT AGENCY

PEKA PEKA TO ŌTAKI EXPRESSWAY

Pre-Project Hydraulic Model Schematisation

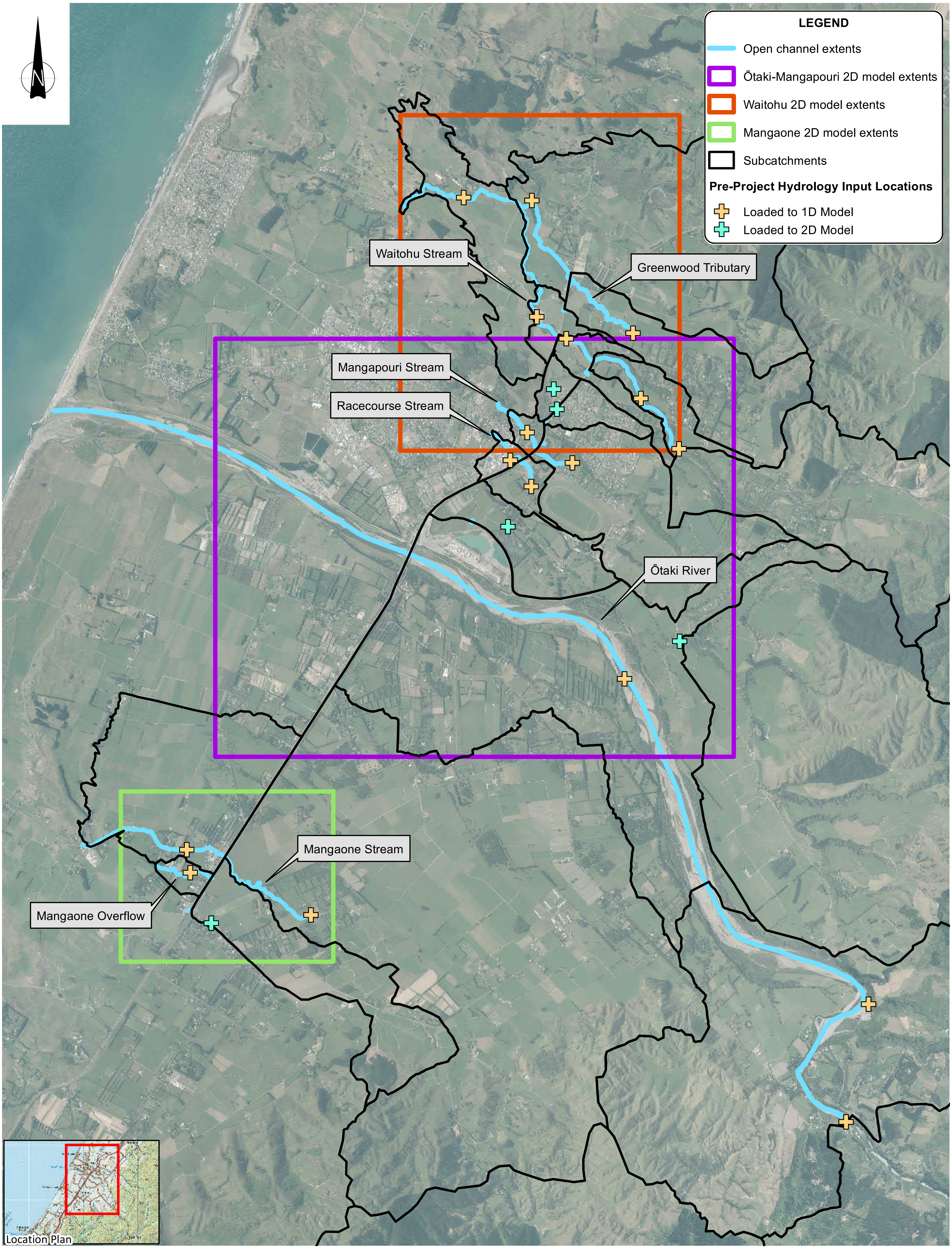
Mangaone Model - 1D Bed Resistance

FIGURE No. Figure 8.6

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig8_6_Mang_1DBedResistance.mxd Date: 13/10/2017 Time: 12:51:03 p.m.

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig9_HydrologyInputLocations.mxd Date: 13/10/2017 Time: 1:31:17 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:35,000

0 0.4 0.8 1.2 1.6 2 (km)

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17

ARCFILE Fig9_HydrologyInputLocations.mxd

SCALE (AT A3 SIZE) 1:35,000

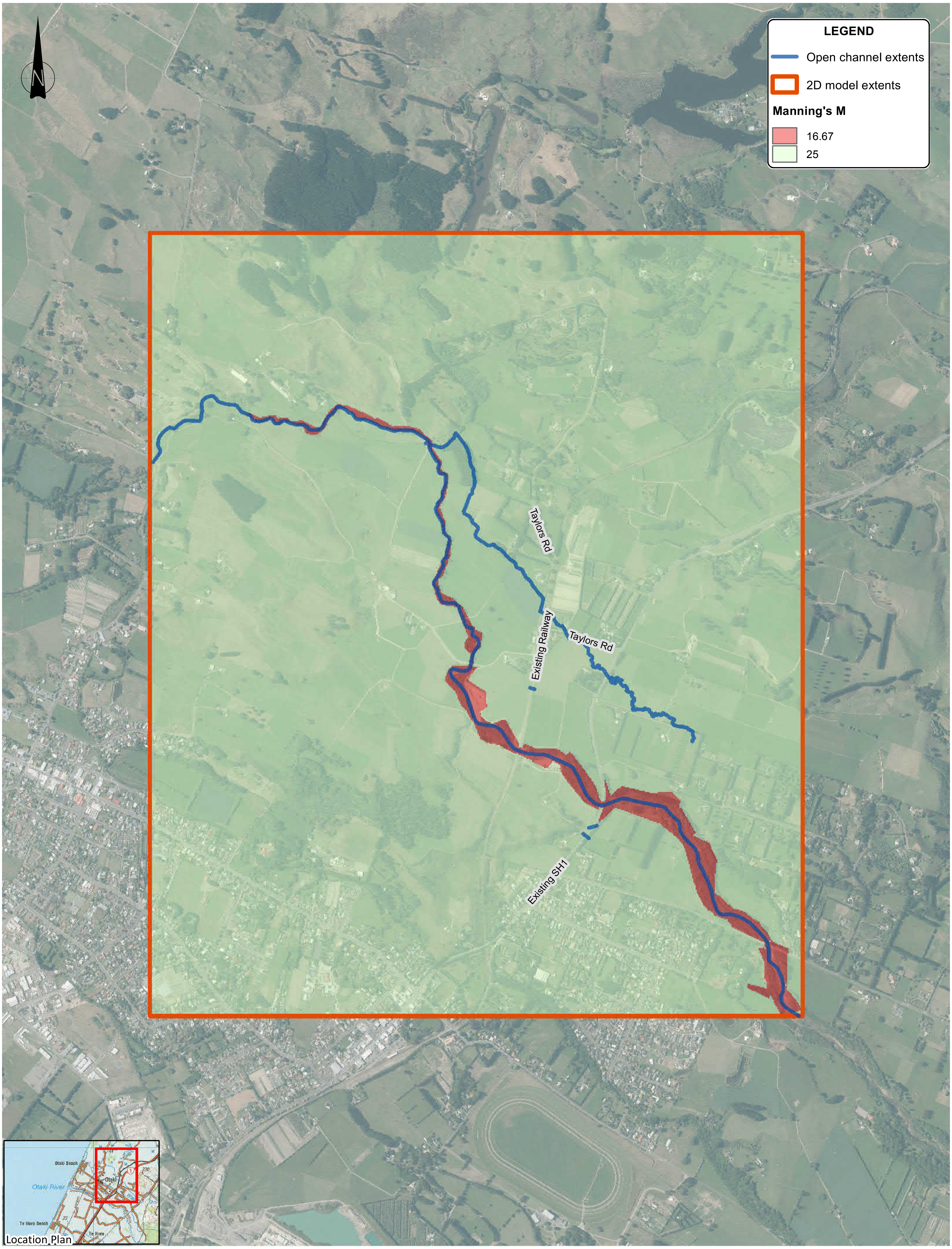
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Hydrology Input Locations

FIGURE No. Figure 9.

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig10_Wai_2DResistanceMap.mxd Date: 21/10/2017 Time: 2:51:57 p.m.



Notes: - Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:15,000

0 0.2 0.4 0.6 0.8 1 (km)

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17

ARCFILE Fig10_Wai_2DResistanceMap.mxd

SCALE (AT A3 SIZE) 1:15,000

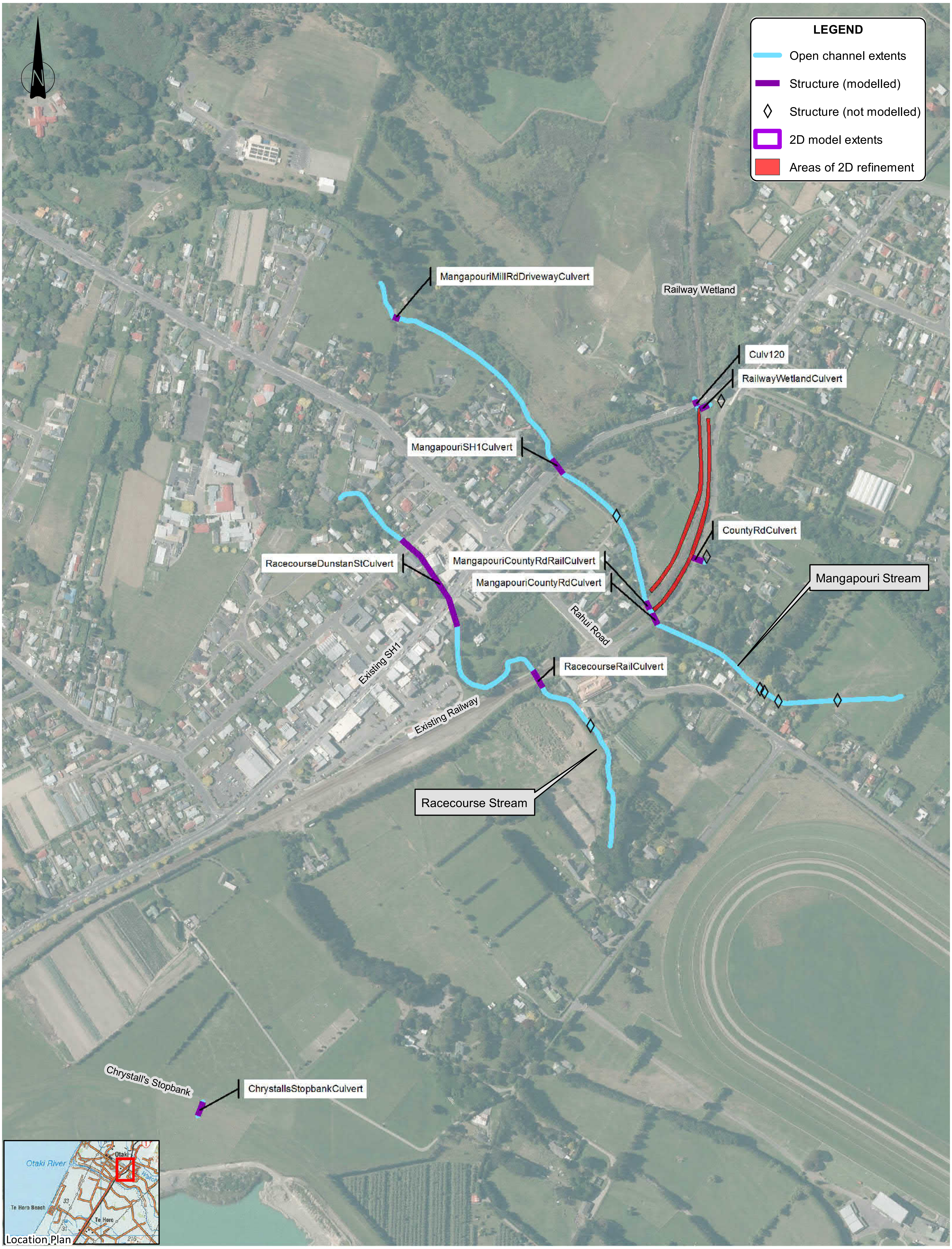
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Waitohu Model - 2D Resistance Map

FIGURE No. Figure 10.

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig11_1_OM_2DRefinement.mxd Date: 24/03/2018 Time: 7:06:25 p.m.



Notes: - Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig11_1_OM_2DRefinement.mxd

SCALE (AT A3 SIZE) 1:5,000

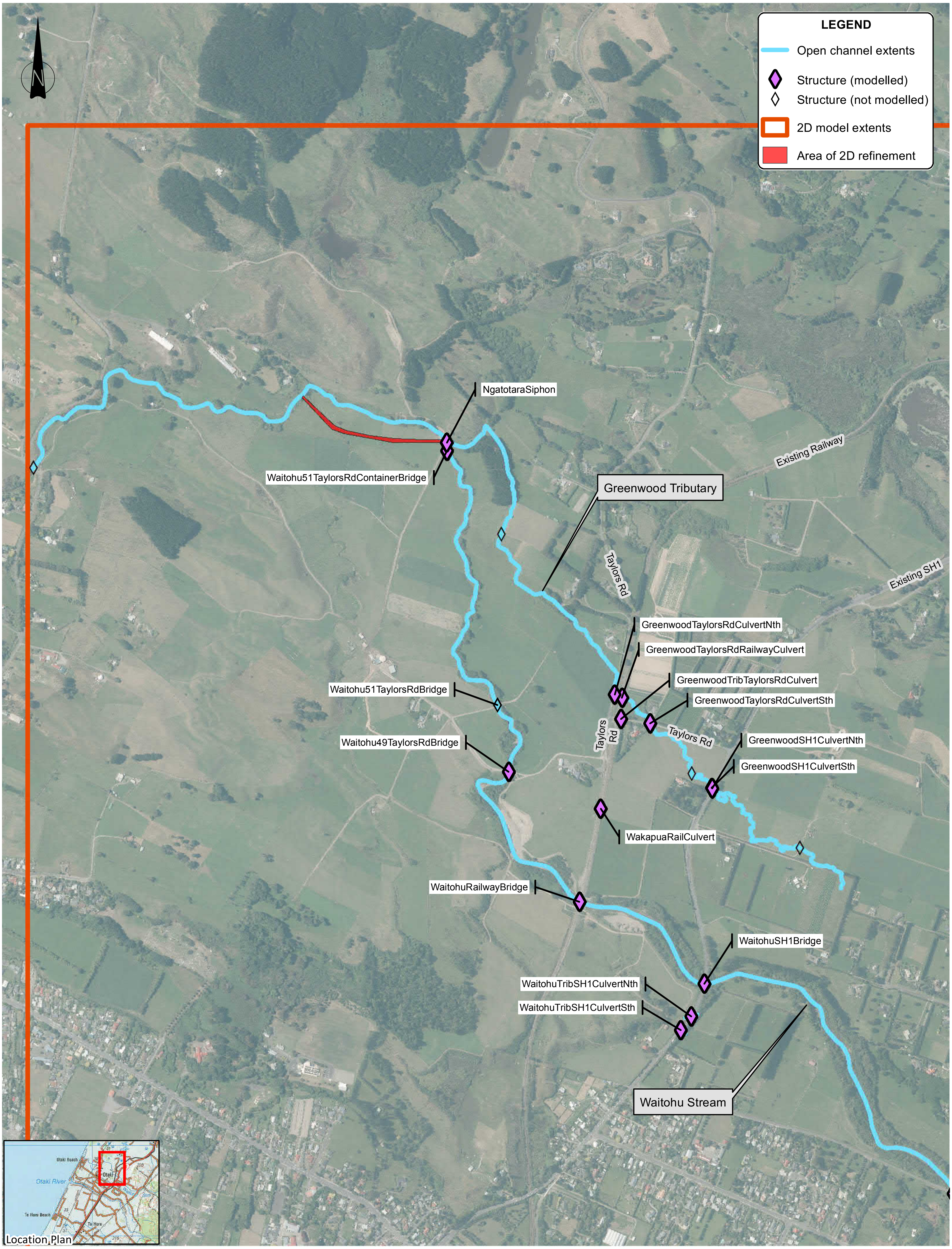
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Ōtaki-Mangapouri Model - 2D Refinement Channels

FIGURE No. Figure 11.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20171013_PreProjectModelReportRev3\Fig11_2_Wai_2DRefinement.mxd Date: 24/10/2017 Time: 5:41:14 p.m.



Notes: - Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:10,000

0 100 200 300 400 500 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	Oct.17
CHECKED	DMK	Oct.17
APPROVED	TSRF	Oct.17

ARCFILE Fig11_2_Wai_2DRefinement.mxd

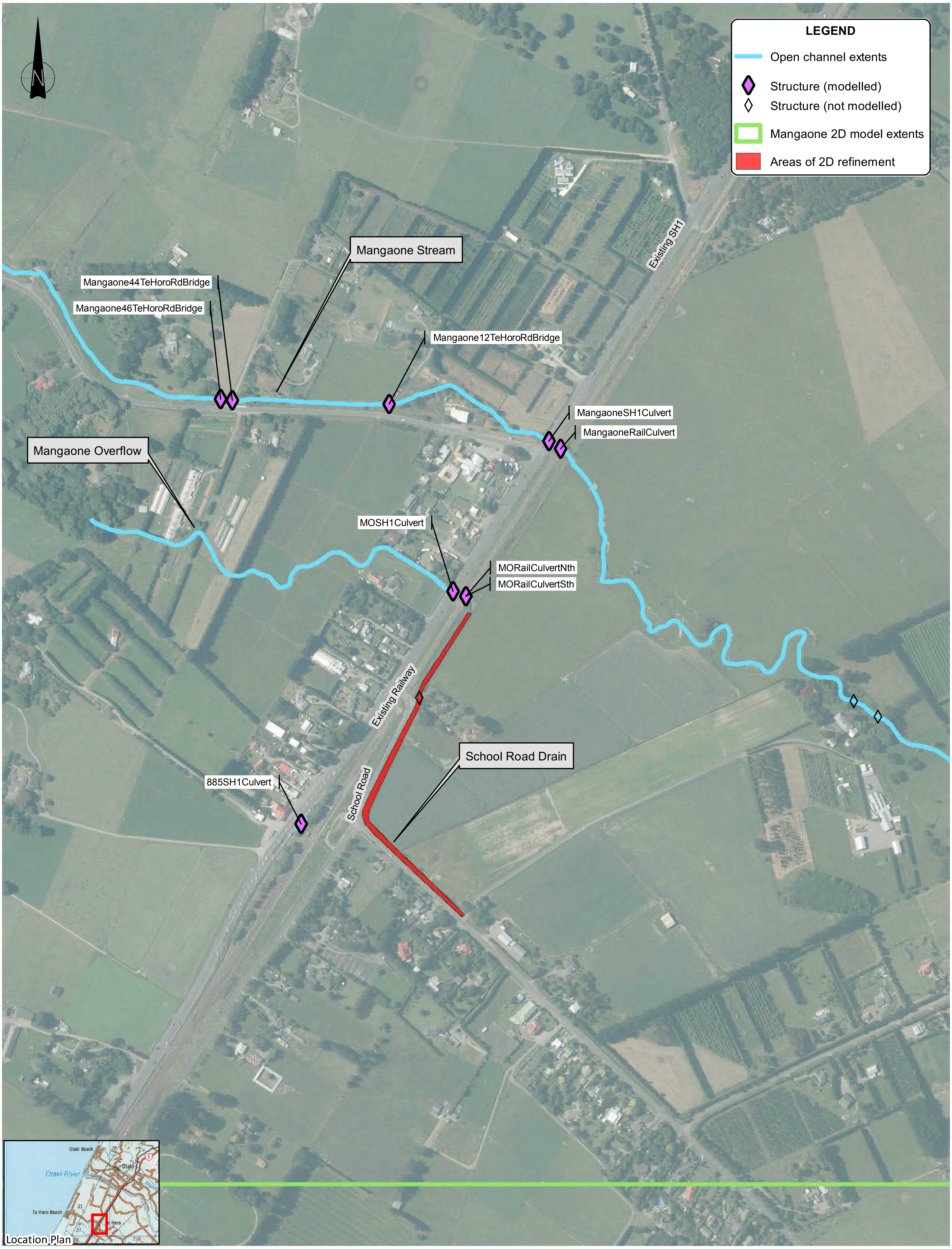
SCALE (AT A3 SIZE) 1:10,000

PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Waitohu Model - 2D Refinement Channels

FIGURE No. Figure 11.2

Rev. 0



Notes: - Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 50 100 150 200 250 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	Mar.18
CHECKED	DMK	Mar.17
APPROVED	TSRF	Mar.17

ARCFILE Fig11_3_Mang_2DRefinement.mxd

SCALE (AT A3 SIZE) 1:5,000

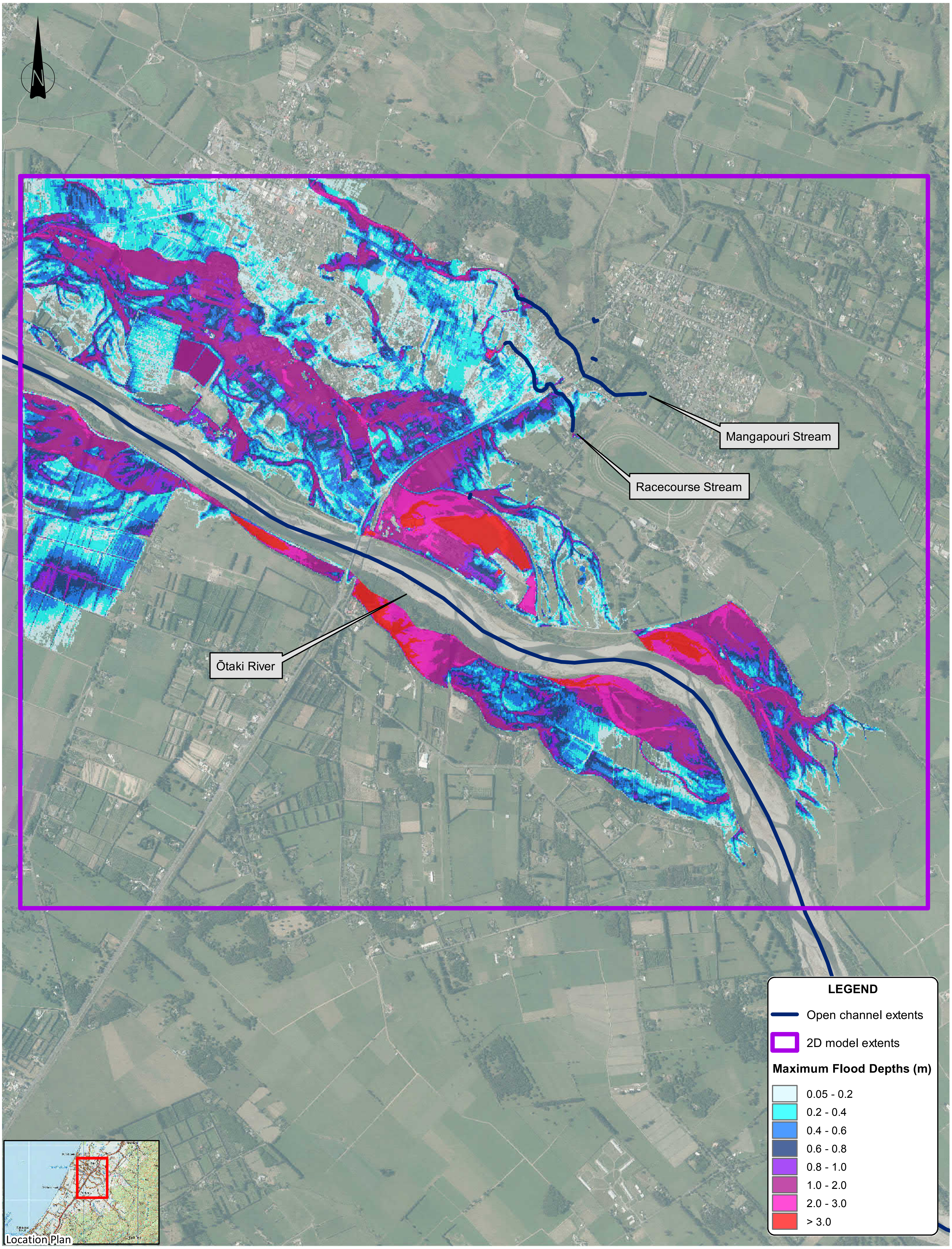
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Schematisation
Mangaone Model - 2D Refinement Channels

FIGURE No. Figure 11.3.

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180501_PreProjectReportRev5\Fig12_1_OM_ModelResults_3000Cumecs.mxd Date: 10/05/2018 Time: 7:11:52 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:20,000

0 0.2 0.4 0.6 0.8 1 (km)

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	May.18
CHECKED	DMK	May.18
APPROVED	TSRF	May.18

ARCFILE
Fig12_1_OM_ModelResults_3000Cumecs.mxd

SCALE (AT A3 SIZE)
1:20,000

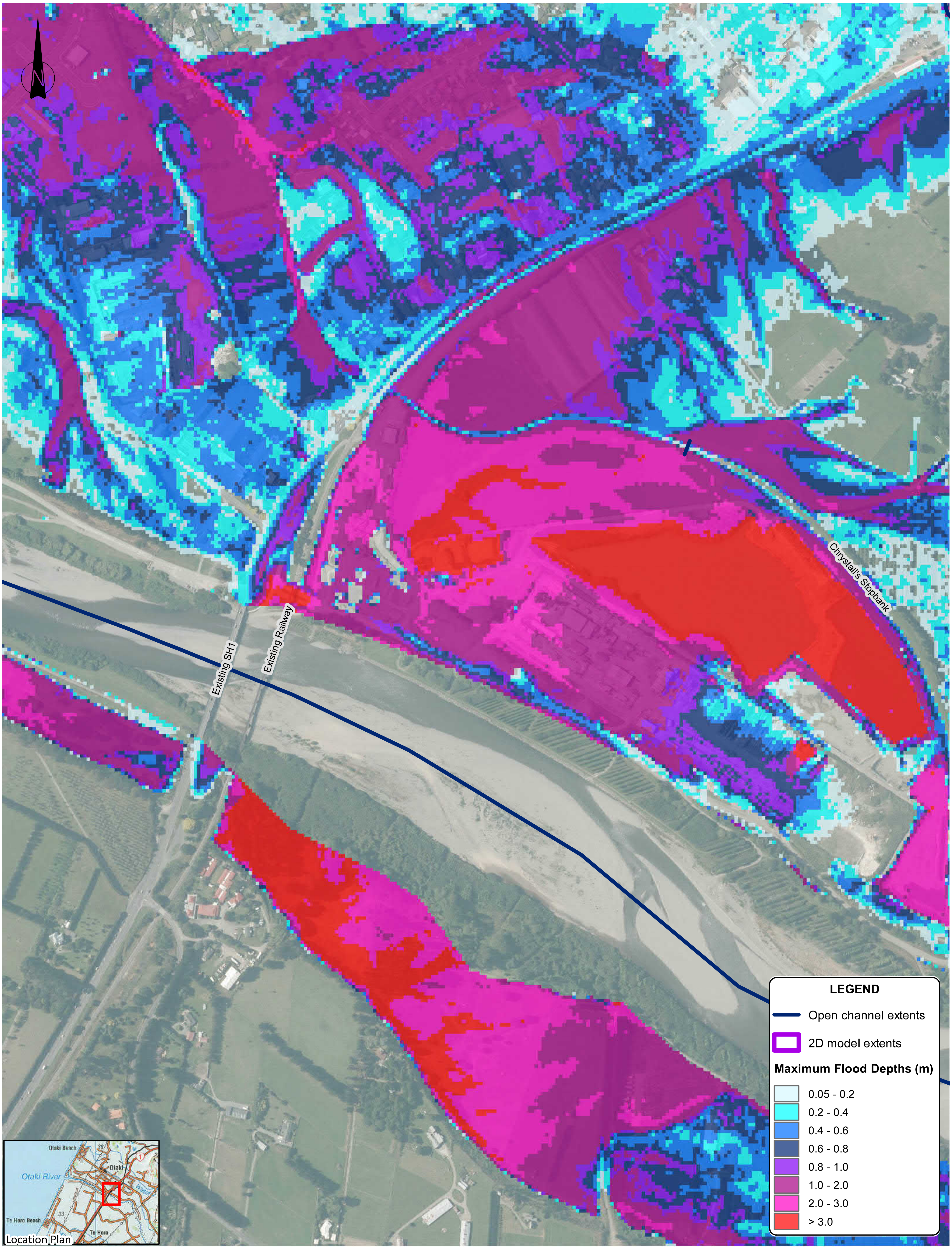
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Ōtaki-Mangapouri Model - 3000 m³/s (Ōtaki only)

FIGURE No.
Figure 12.1

Rev.
0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180501_PreProjectReportRev5\Fig12_2_OM_ModelResults_3000Cumecs.mxd Date: 10/05/2018 Time: 7:14:01 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	May.18
CHECKED	DMK	May.18
APPROVED	TSRF	May.18

ARCFILE Fig12_2_OM_ModelResults_3000Cumecs.mxd

SCALE (AT A3 SIZE) 1:5,000

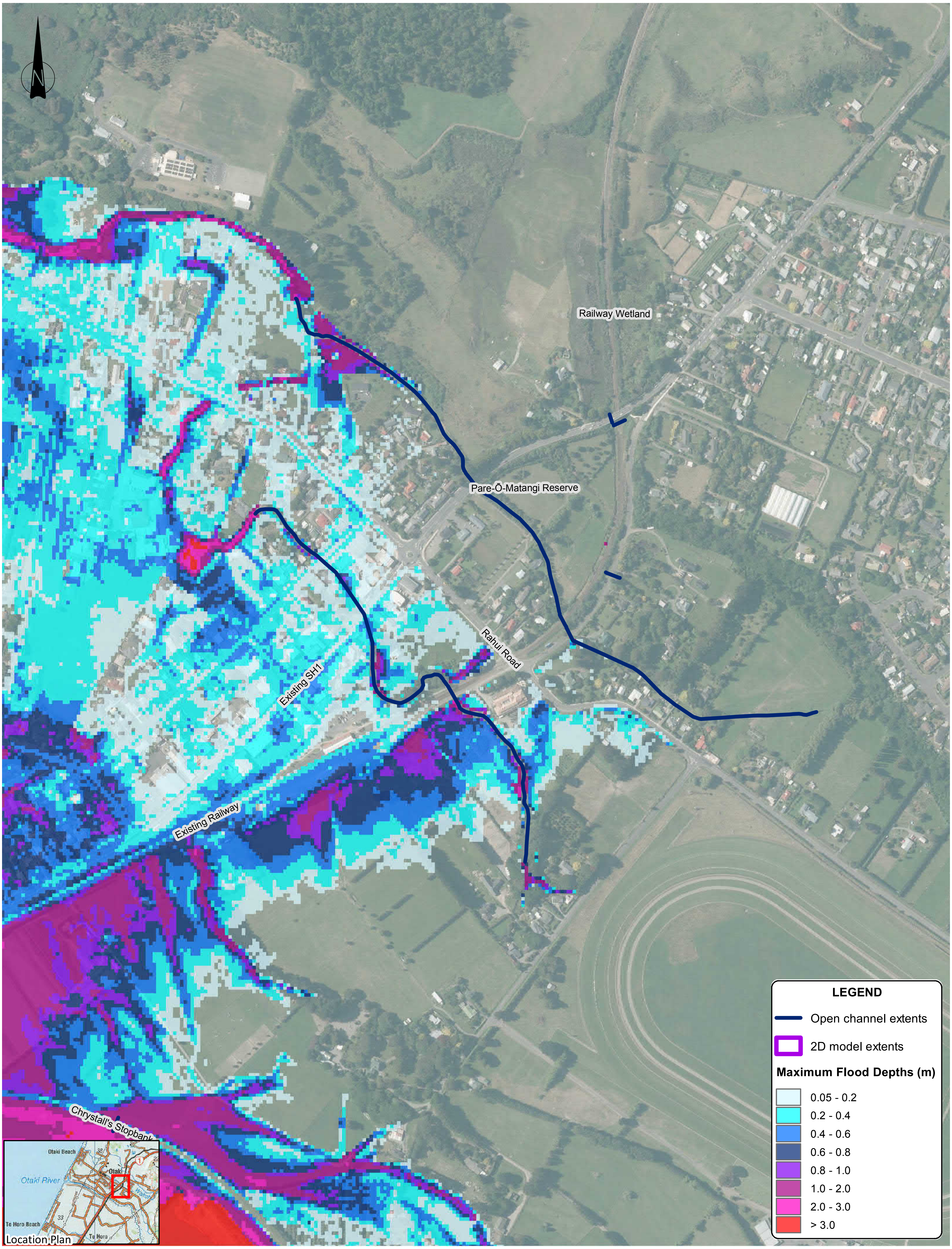
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Ōtaki-Mangapouri Model - 3000 m³/s (Ōtaki only)

FIGURE No. Figure 12.2

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180501_PreProjectReportRev5\Fig12_3_OM_ModelResults_3000Cumecs.mxd Date: 10/05/2018 Time: 7:14:59 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

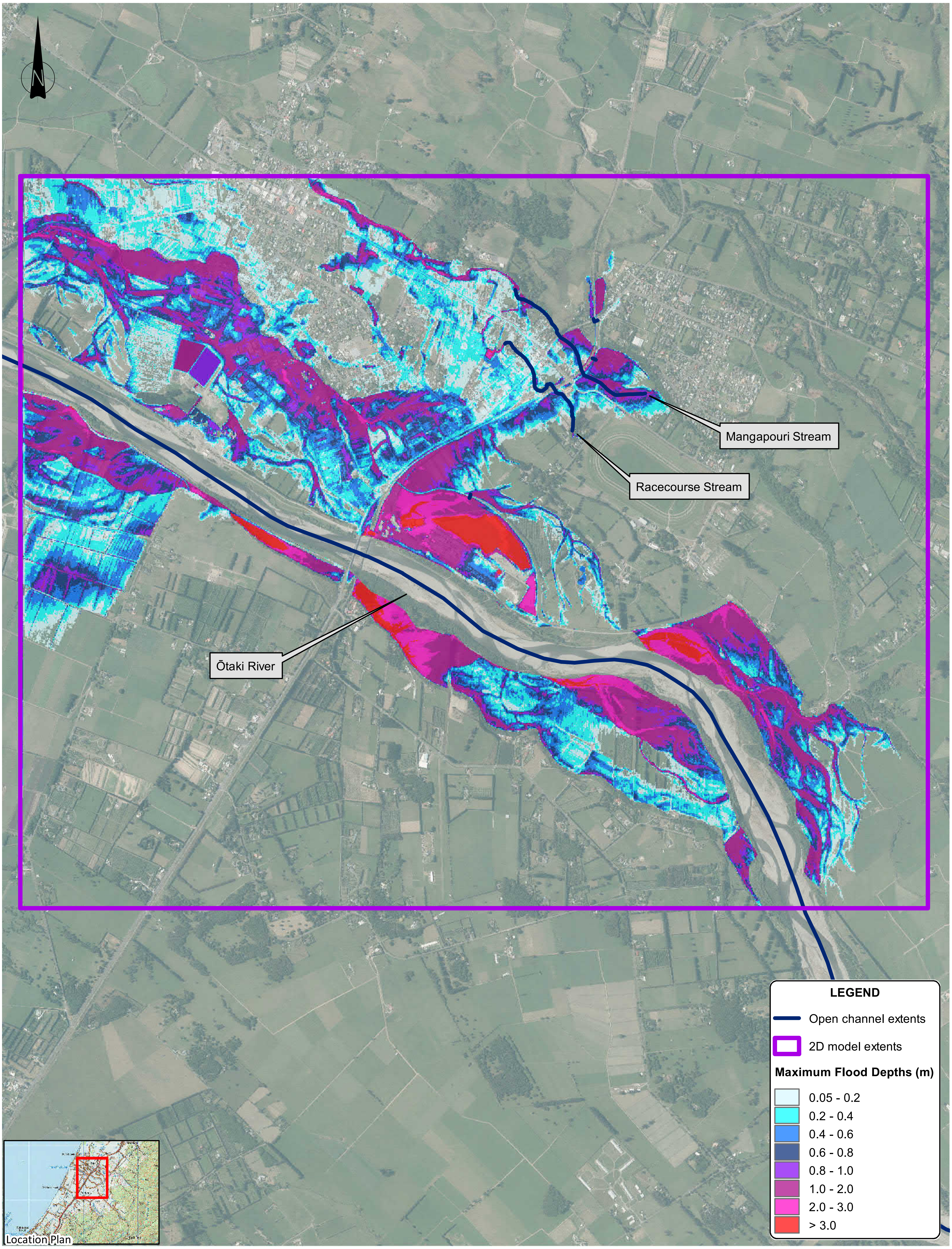
DRAWN	KBBB	May.18
CHECKED	DMK	May.18
APPROVED	TSRF	May.18
ARCFILE Fig12_3_OM_ModelResults_3000Cumecs.mxd		
SCALE (AT A3 SIZE) 1:5,000		
PROJECT No. 85985.0070		

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Ōtaki-Mangapouri Model - 3000 m³/s (Ōtaki only)

FIGURE No. Figure 12.3

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180501_PreProjectReportRev5\Fig13_1_OM_ModelResults_500yrCC.mxd Date: 10/05/2018 Time: 6:59:44 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:20,000

0 0.2 0.4 0.6 0.8 1 (km)

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	May.18
CHECKED	DMK	May.18
APPROVED	TSRF	May.18

ARCFILE Fig13_1_OM_ModelResults_500yrCC.mxd

SCALE (AT A3 SIZE) 1:20,000

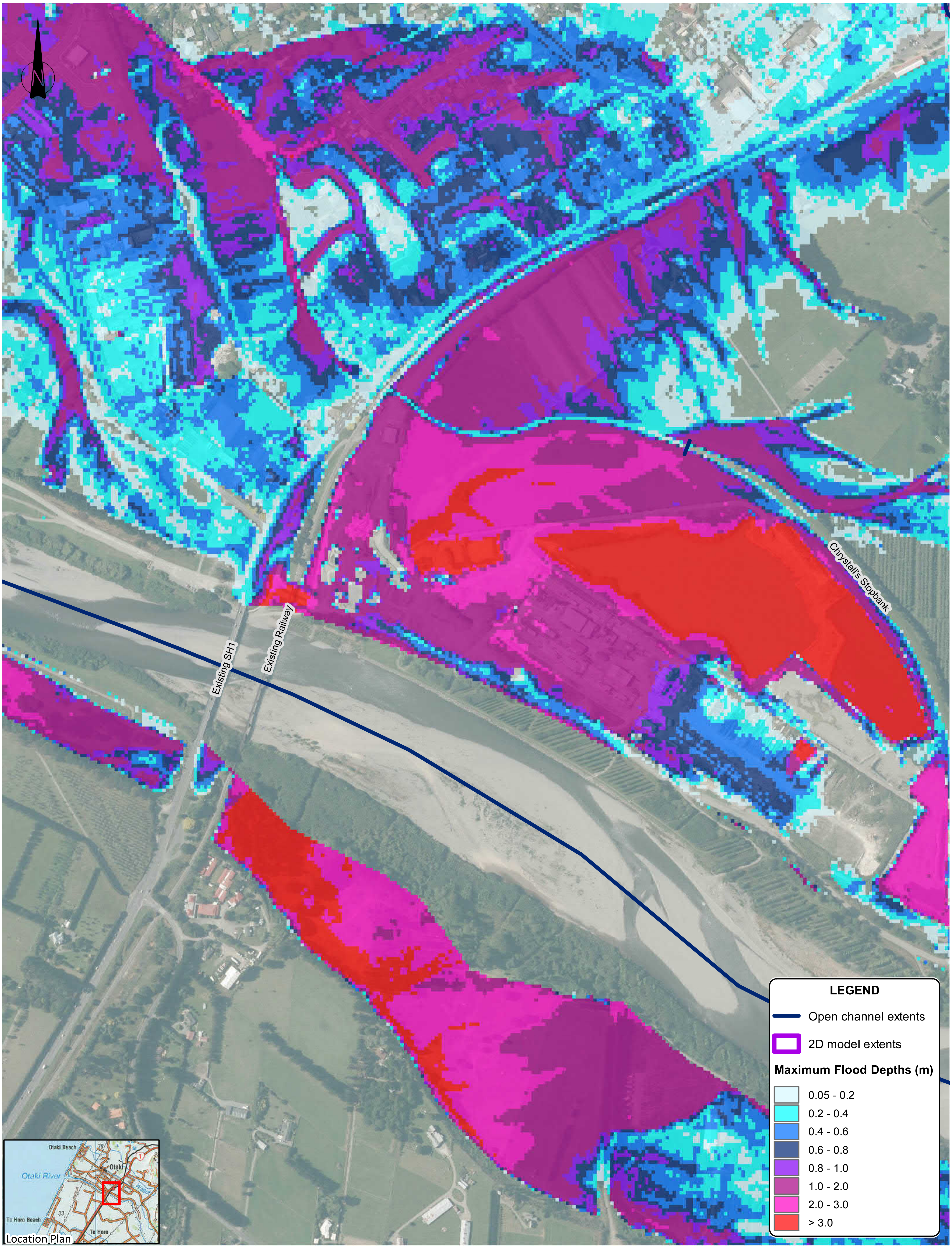
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Ōtaki-Mangapouri Model - 0.2% AEP CC2130

FIGURE No. Figure 13.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180501_PreProjectReportRev5\Fig13_2_OM_ModelResults_500yrCC.mxd Date: 10/05/2018 Time: 7:00:55 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	May.18
CHECKED	DMK	May.18
APPROVED	TSRF	May.18

ARCFILE
Fig13_2_OM_ModelResults_500yrCC.mxd

SCALE (AT A3 SIZE)
1:5,000

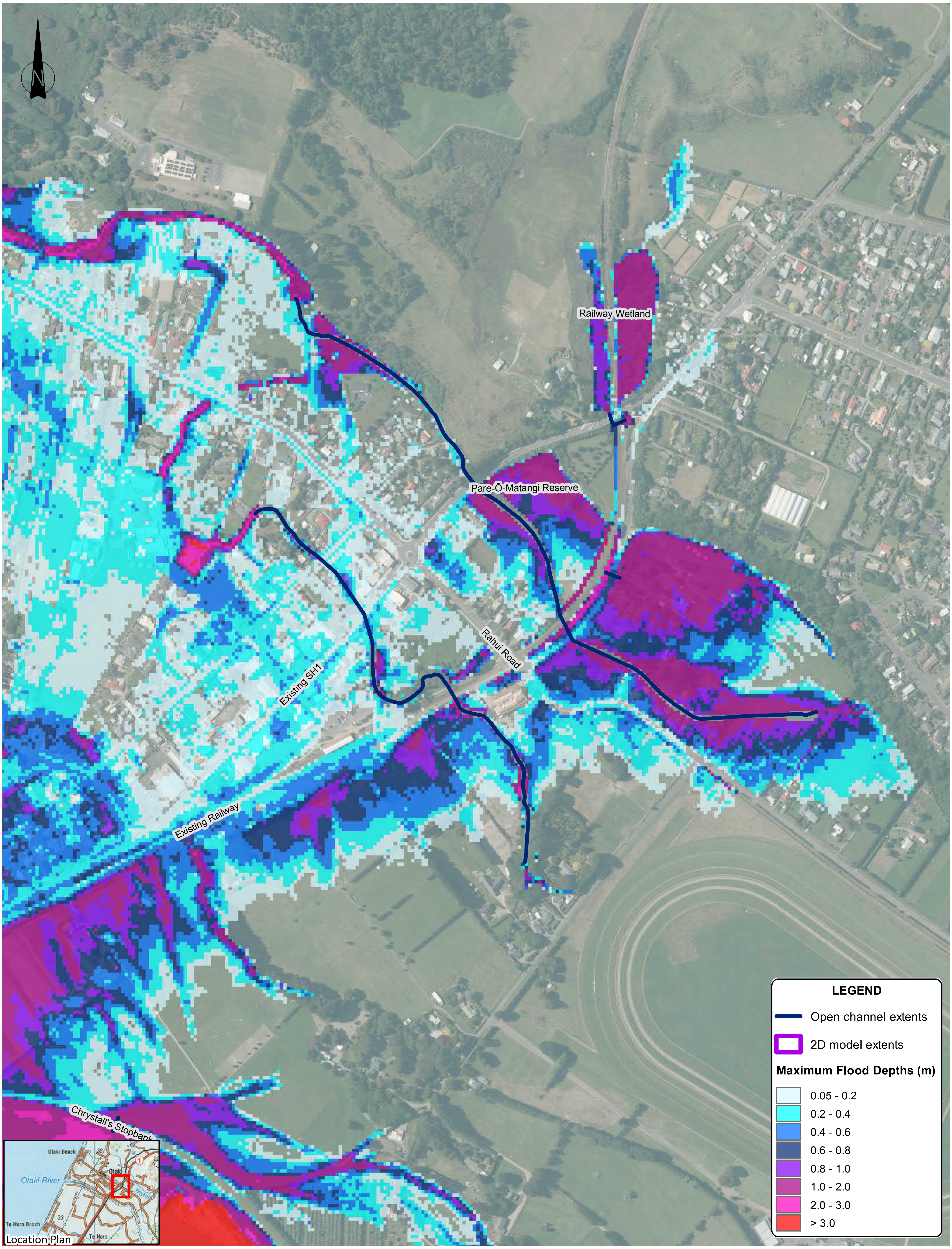
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Ōtaki-Mangapouri Model - 0.2% AEP CC2130

FIGURE No. Figure 13.2

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180501_PreProjectReportRev5\Fig13_3_OM_ModelResults_500yrCC.mxd Date: 10/05/2018 Time: 7:02:09 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	May.18
CHECKED	DMK	May.18
APPROVED	TSRF	May.18

ARCFILE
Fig13_3_OM_ModelResults_500yrCC.mxd

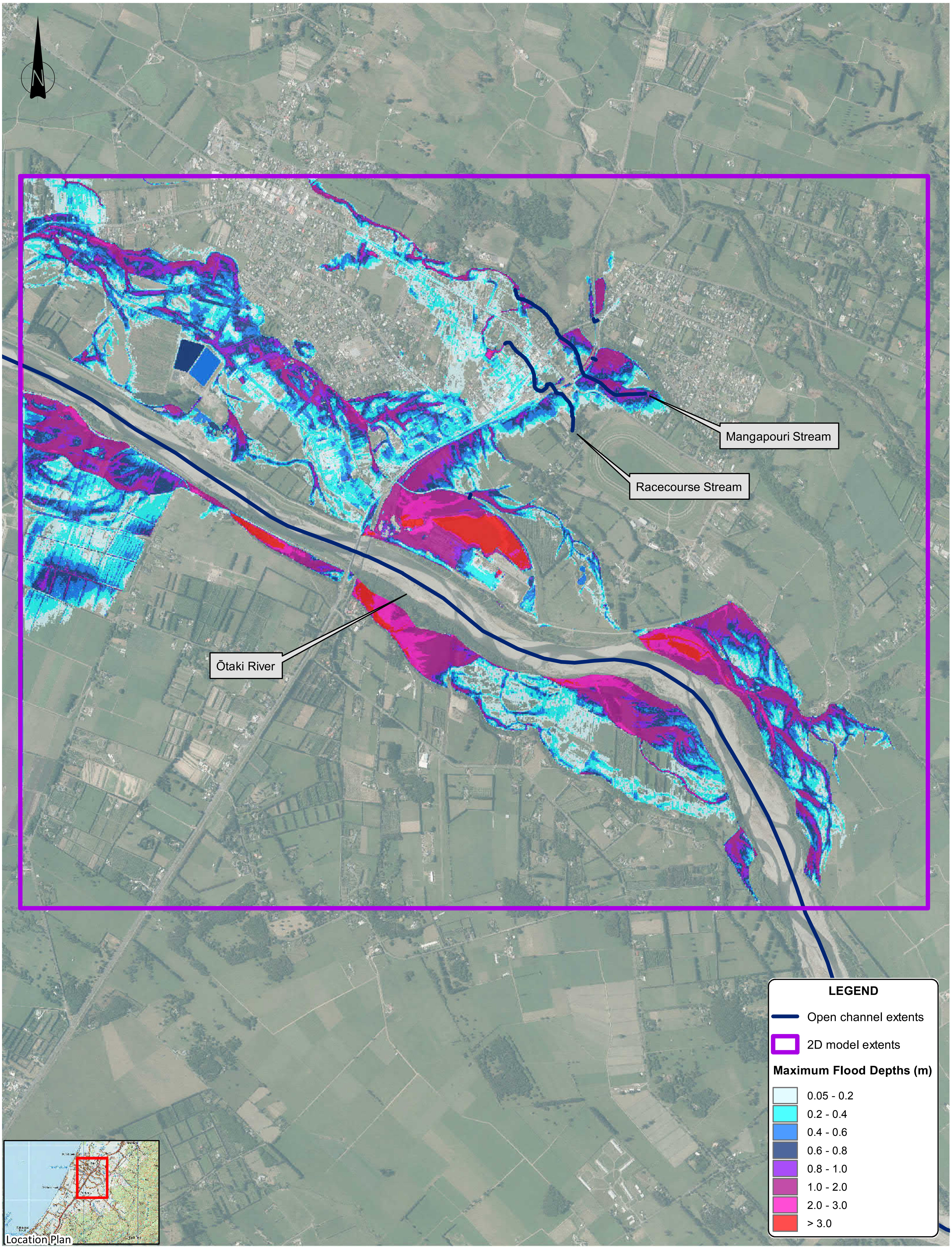
SCALE (AT A3 SIZE)
1:5,000

PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Ōtaki-Mangapouri Model - 0.2% AEP CC2130

FIGURE No.
Figure 13.3

Rev.
0



Notes: - Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:20,000

0 0.2 0.4 0.6 0.8 1 (km)

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig14_1_OM_ModelResults_100yrCC.mxd

SCALE (AT A3 SIZE) 1:20,000

PROJECT No. 85985.0070

NZ TRANSPORT AGENCY

PEKA PEKA TO ŌTAKI EXPRESSWAY

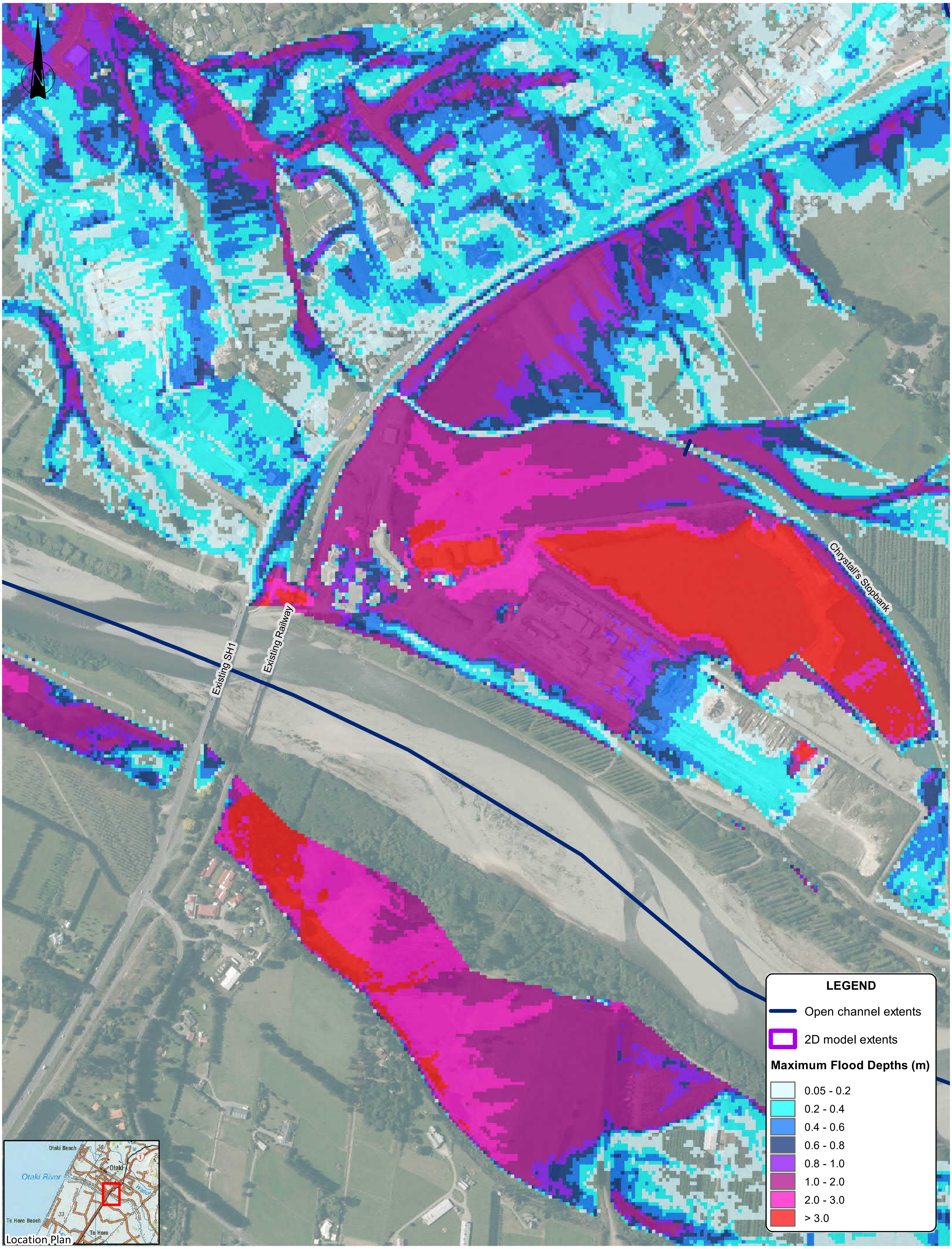
Pre-Project Hydraulic Model Results

Ōtaki-Mangapouri Model - 1% AEP CC2130

FIGURE No. Figure 14.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig14_2_OM_ModelResults_100yrCC.mxd Date: 22/03/2018 Time: 3:59:42 PM



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE
Fig14_2_OM_ModelResults_100yrCC.mxd

SCALE (AT A3 SIZE)
1:5,000

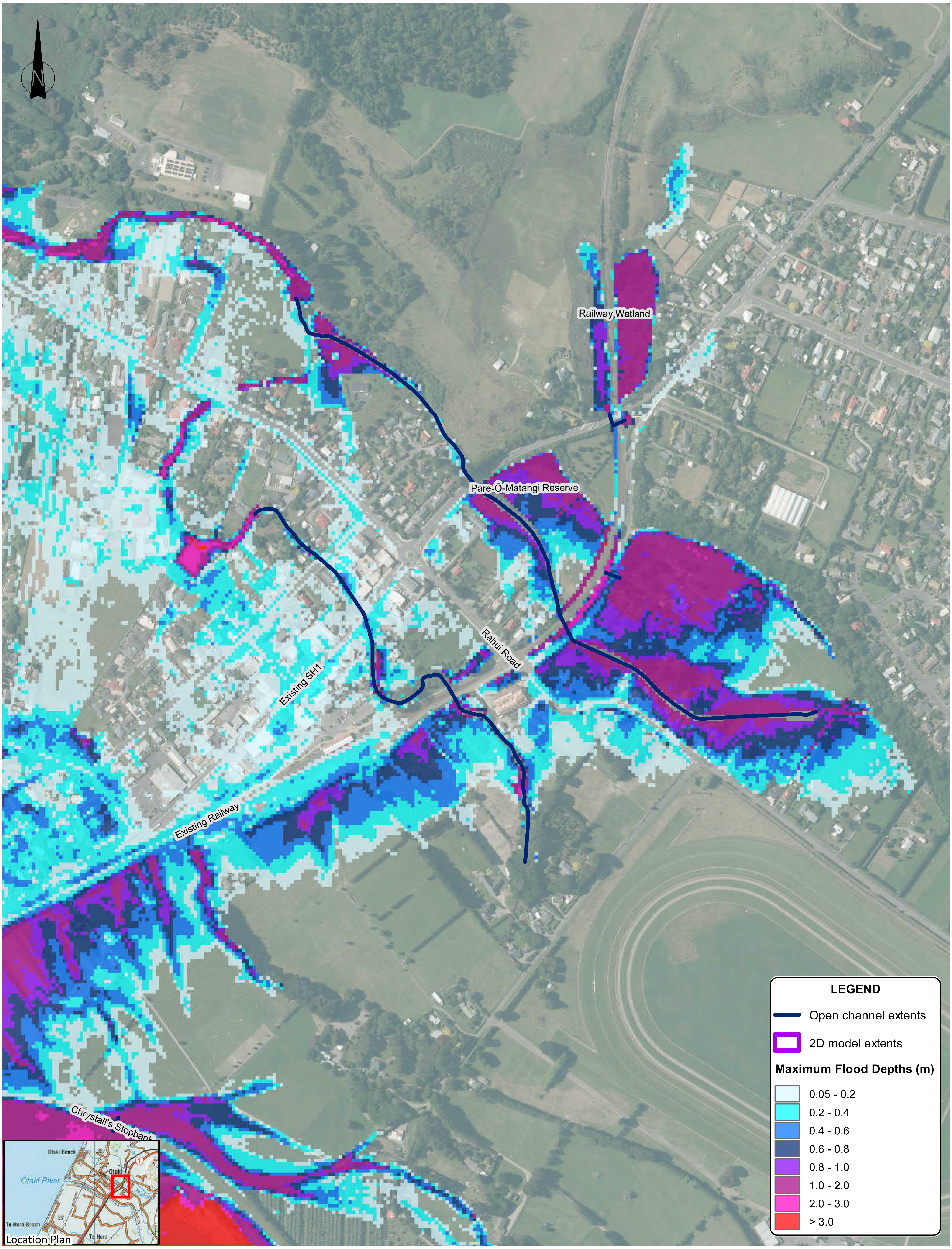
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Ōtaki-Mangapouri Model - 1% AEP CC2130

FIGURE No. Figure 14.2

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig14_3_OM_ModelResults_100yrCC.mxd Date: 22/03/2018 Time: 4:00:13 PM



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig14_3_OM_ModelResults_100yrCC.mxd

SCALE (AT A3 SIZE) 1:5,000

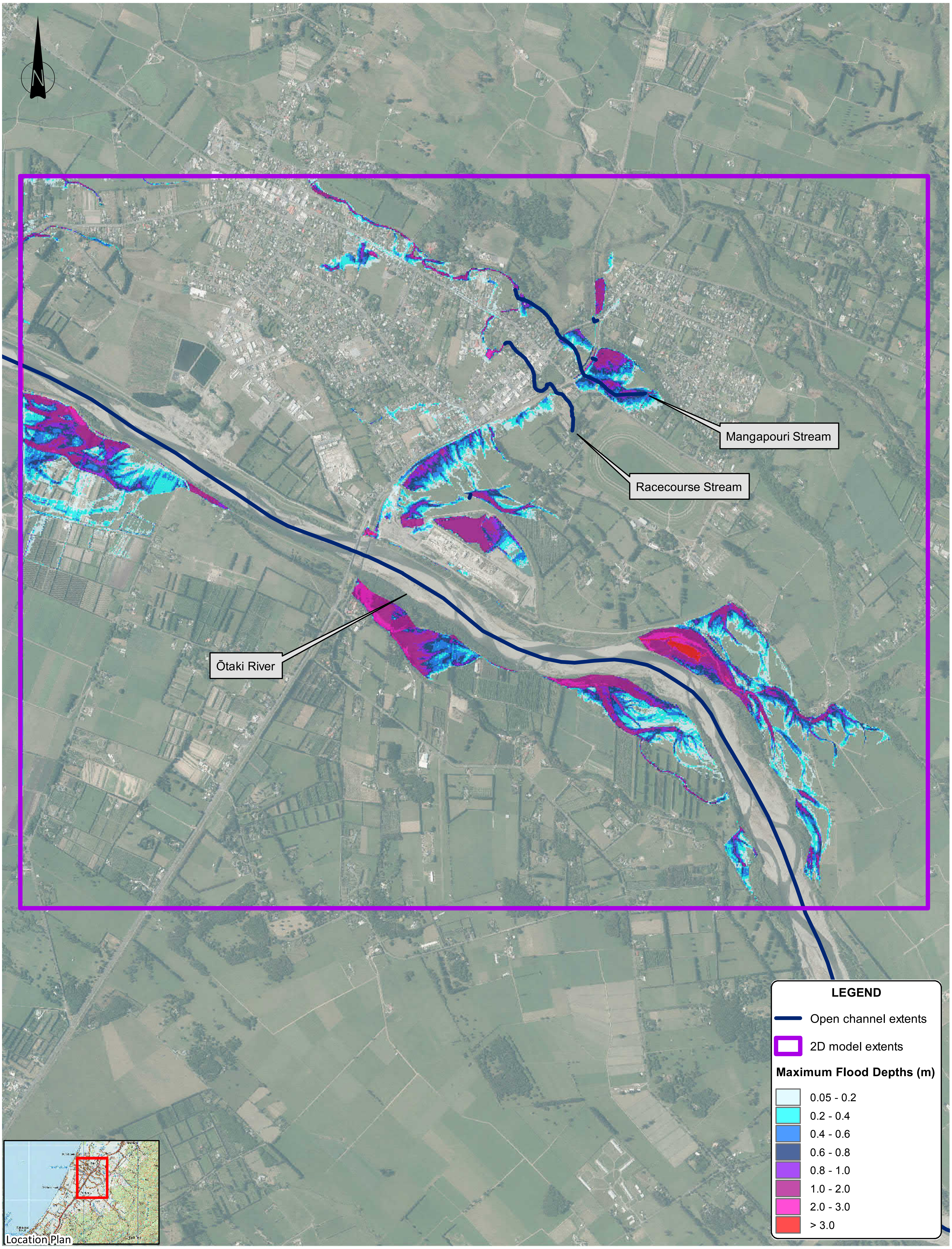
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Ōtaki-Mangapouri Model - 1% AEP CC2130

FIGURE No. Figure 14.3

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig15_1_OM_ModelResults_010yrCC.mxd Date: 25/03/2018 Time: 10:30:58 a.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:20,000

0 0.2 0.4 0.6 0.8 1 (km)

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig15_1_OM_ModelResults_010yrCC.mxd

SCALE (AT A3 SIZE) 1:20,000

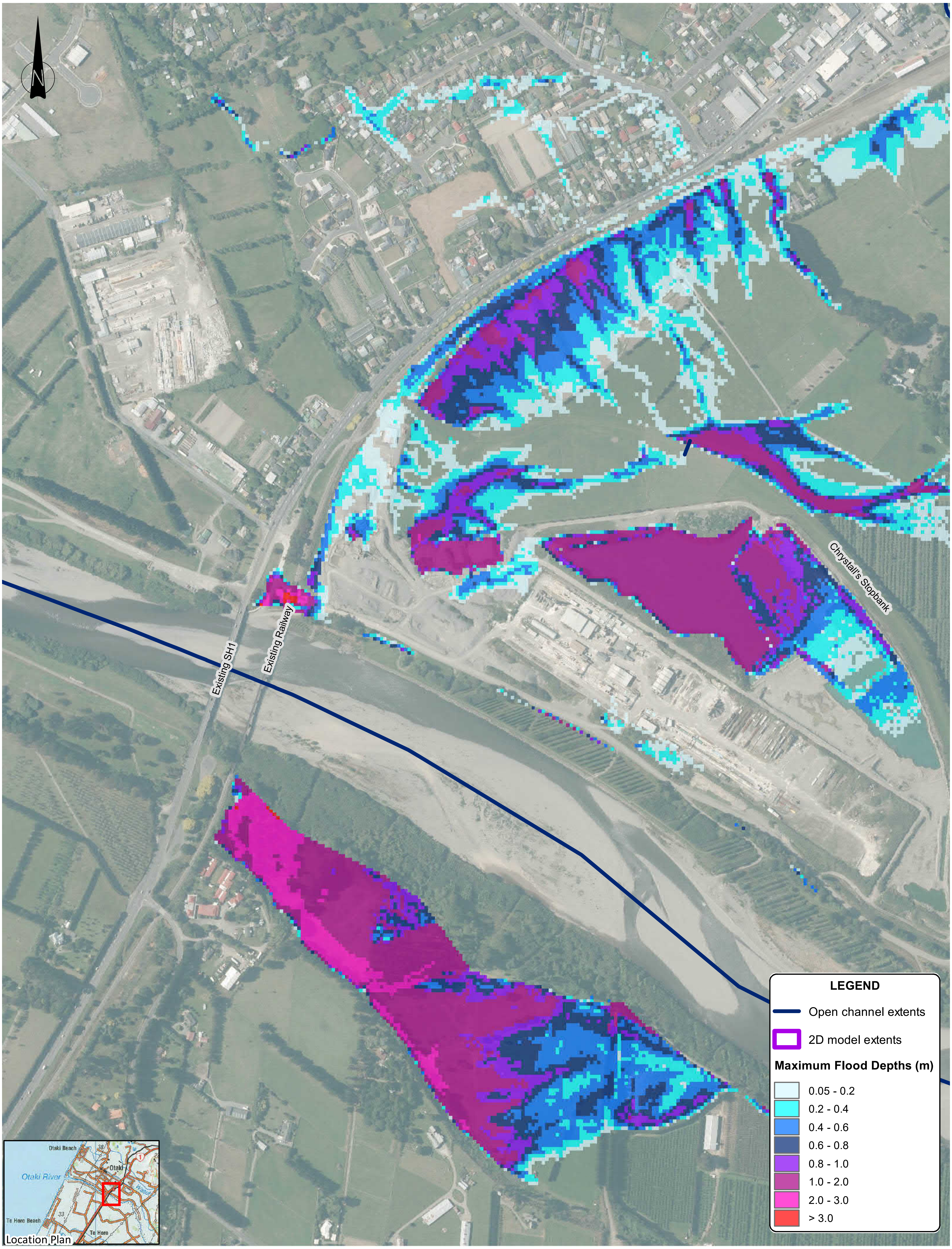
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Ōtaki-Mangapouri Model - 10% AEP CC2130

FIGURE No. Figure 15.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig15_2_OM_ModelResults_010yrCC.mxd Date: 22/03/2018 Time: 4:06:55 PM



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig15_2_OM_ModelResults_010yrCC.mxd

SCALE (AT A3 SIZE) 1:5,000

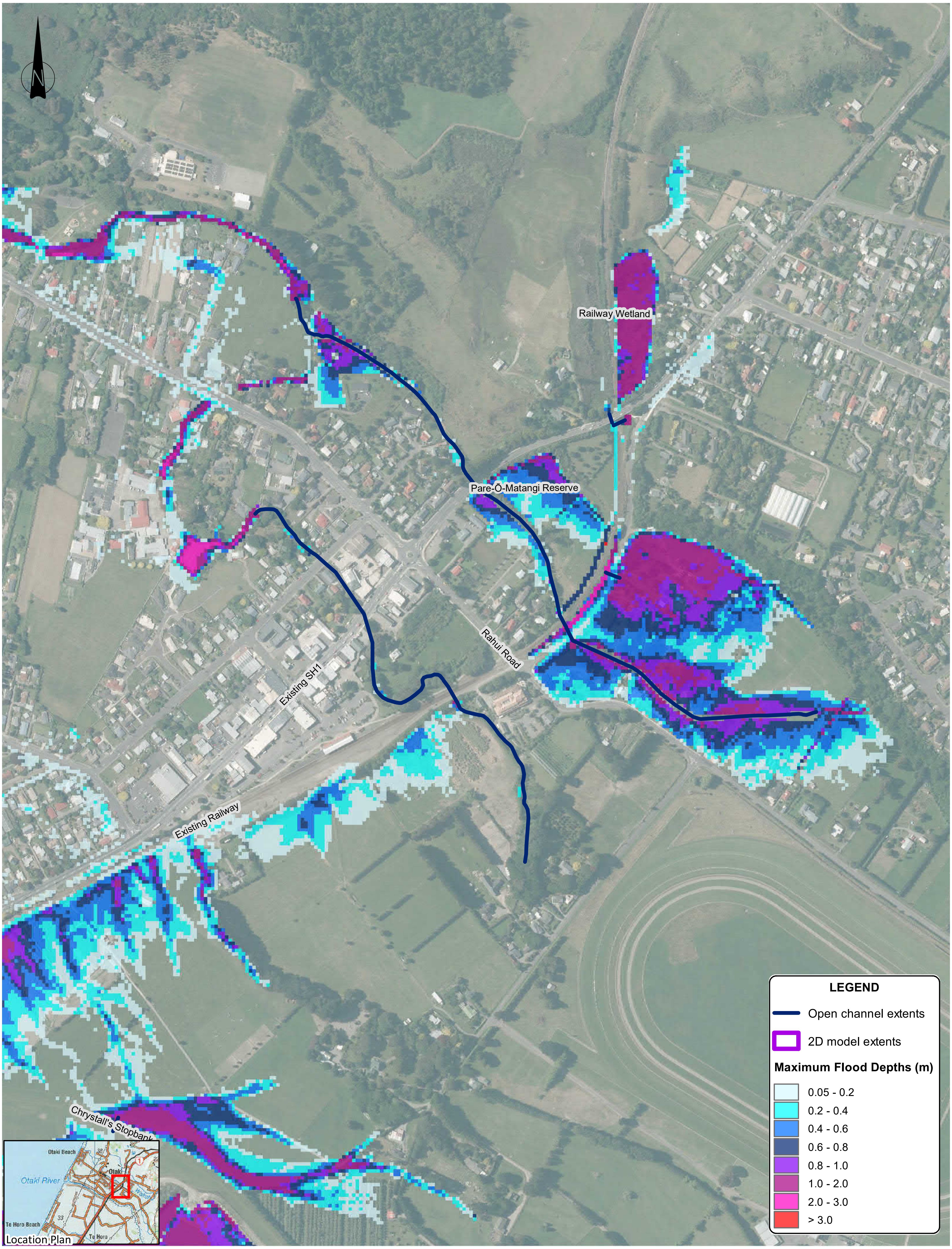
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Ōtaki-Mangapouri Model - 10% AEP CC2130

FIGURE No. Figure 15.2

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig15_3_OM_ModelResults_010yrCC.mxd Date: 22/03/2018 Time: 4:07:50 PM



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig15_3_OM_ModelResults_010yrCC.mxd

SCALE (AT A3 SIZE) 1:5,000

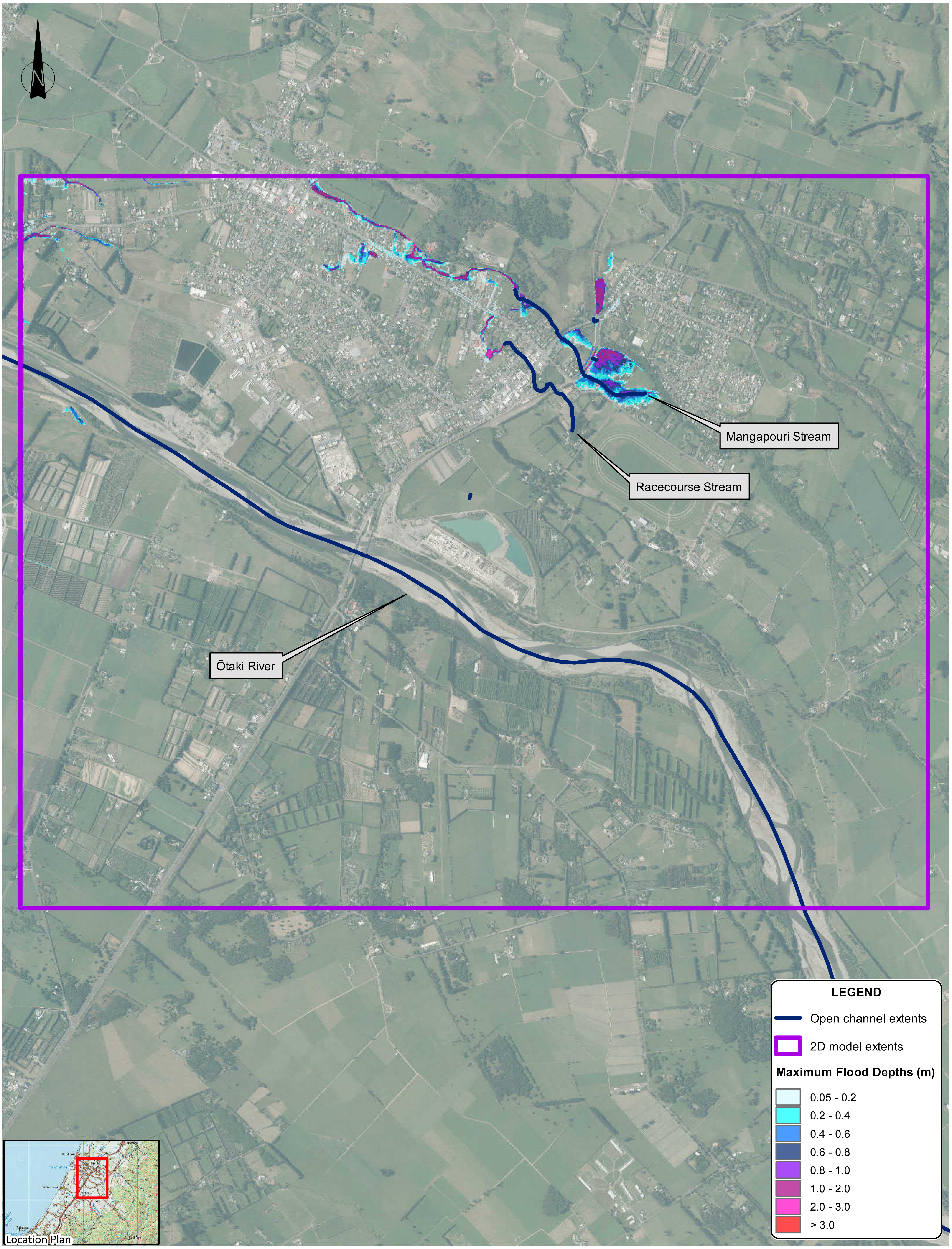
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Ōtaki-Mangapouri Model - 10% AEP CC2130

FIGURE No. Figure 15.3

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig16_1_OM_ModelResults_010yr.mxd Date: 25/03/2018 Time: 10:41:22 a.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:20,000

0 0.2 0.4 0.6 0.8 1 (km)

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig16_1_OM_ModelResults_010yr.mxd

SCALE (AT A3 SIZE) 1:20,000

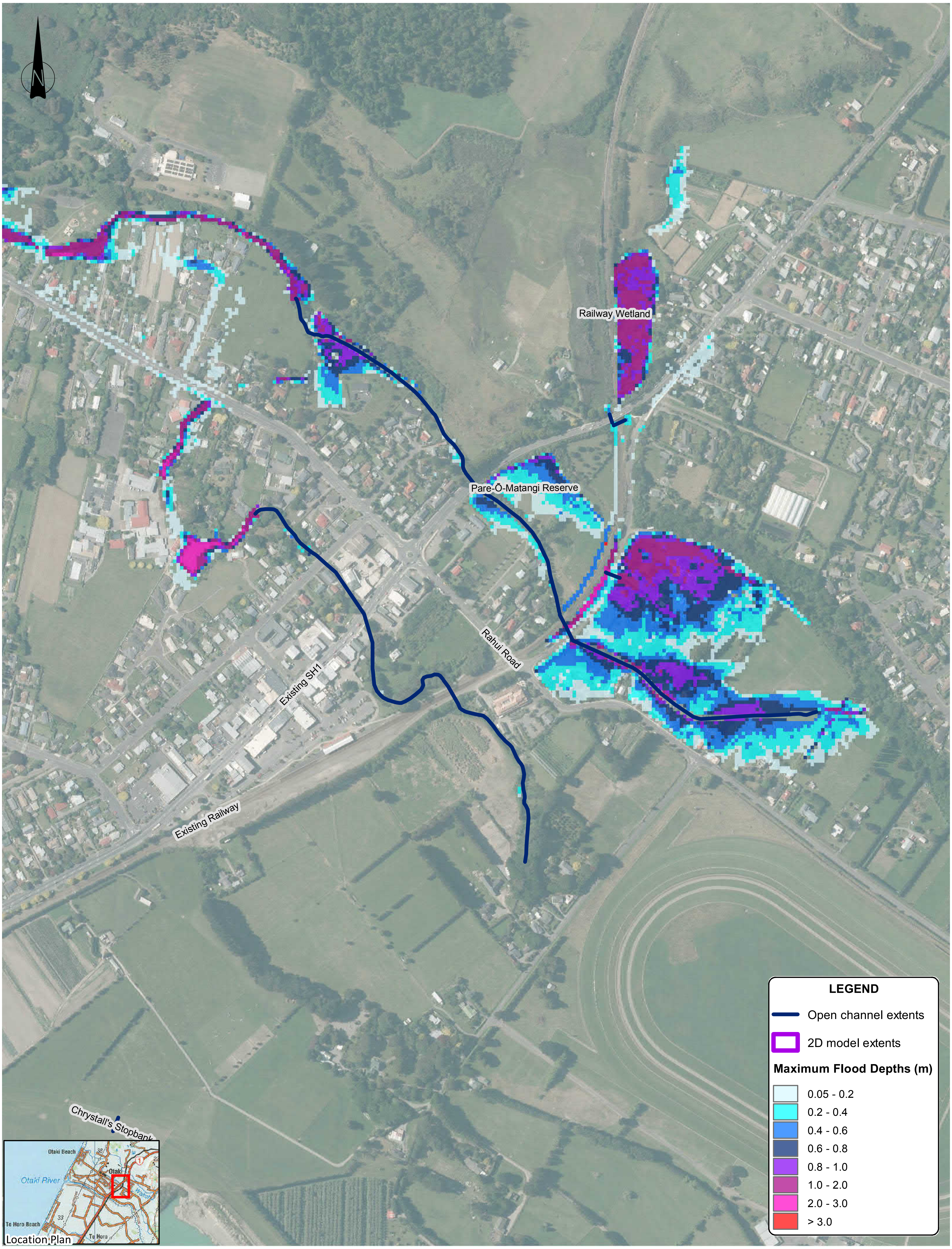
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Ōtaki-Mangapouri Model - 10% AEP (Mangapouri only)

FIGURE No. Figure 16.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig16_2_OM_ModelResults_010yr.mxd Date: 25/03/2018 Time: 10:42:55 a.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig16_2_OM_ModelResults_010yr.mxd

SCALE (AT A3 SIZE) 1:5,000

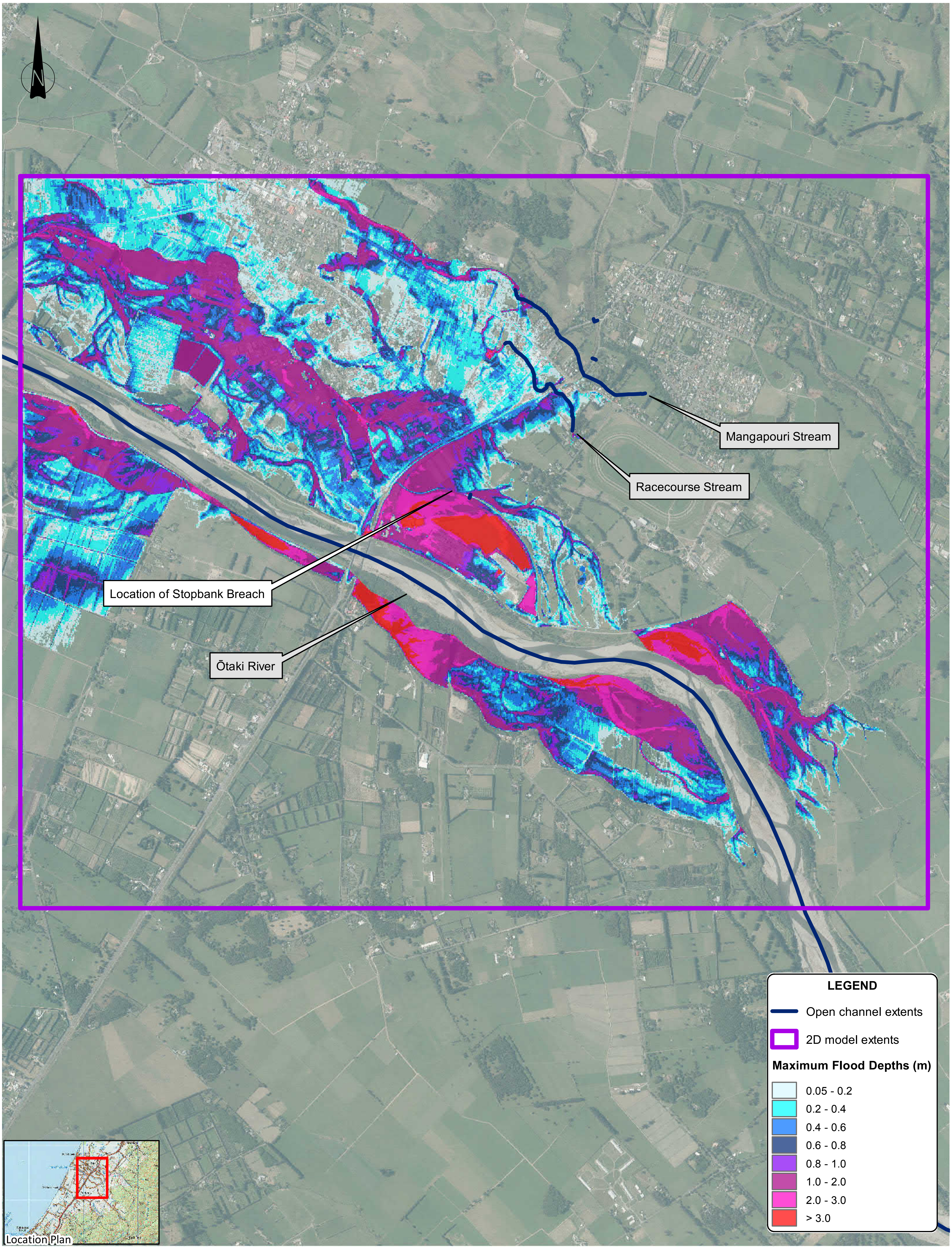
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Ōtaki-Mangapouri Model - 10% AEP (Mangapouri only)

FIGURE No. Figure 16.2

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180501_PreProjectReportRev5\Fig17_1_OM_ModelResults_3000Cu_Bre.mxd Date: 10/05/2018 Time: 7:17:17 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:20,000

0 0.2 0.4 0.6 0.8 1 (km)

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	May.18
CHECKED	DMK	May.18
APPROVED	TSRF	May.18

ARCFILE Fig17_1_OM_ModelResults_3000Cu_Bre.mxd

SCALE (AT A3 SIZE) 1:20,000

PROJECT No. 85985.0070

NZ TRANSPORT AGENCY

PEKA PEKA TO ŌTAKI EXPRESSWAY

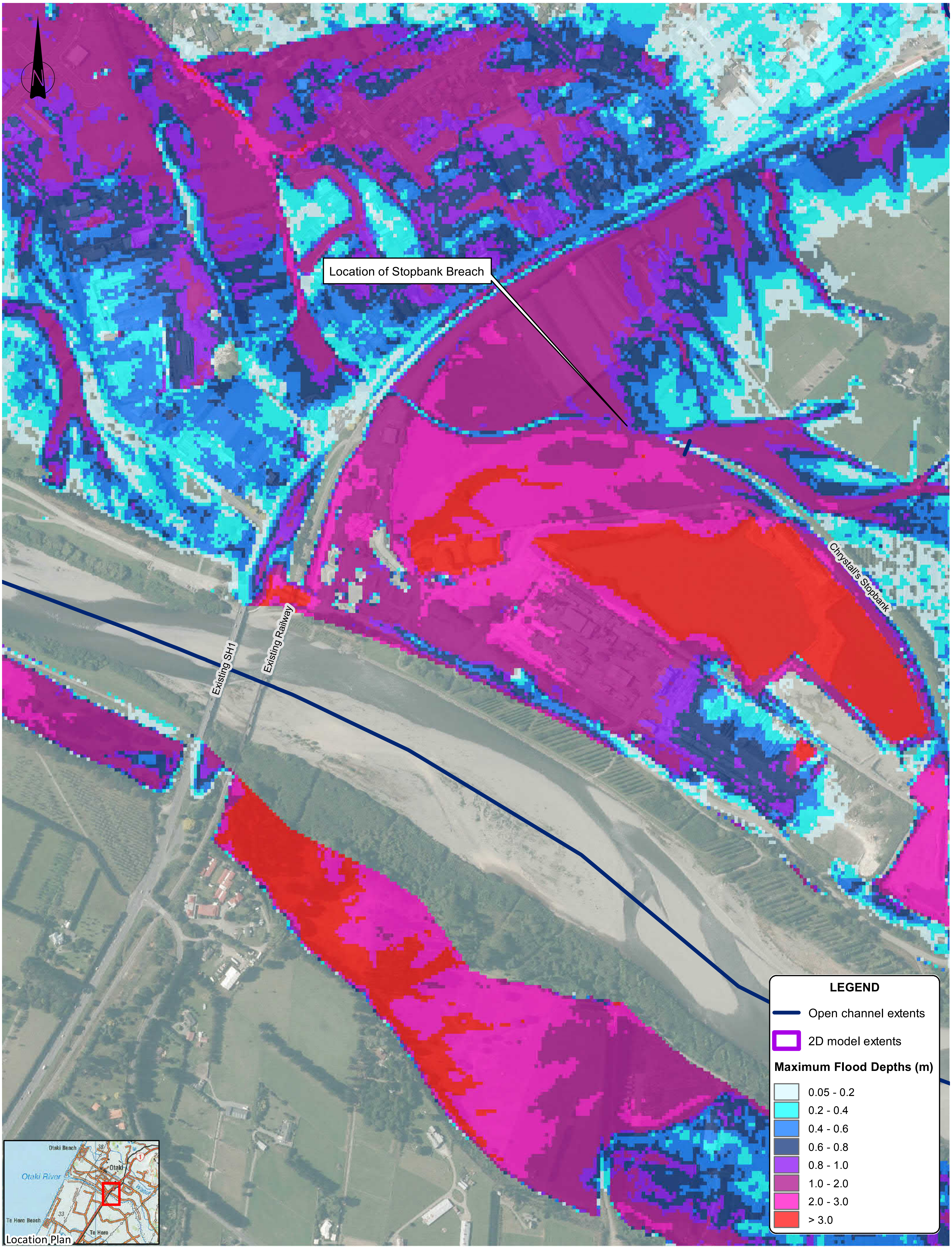
Pre-Project Hydraulic Model Results

Ōtaki-Mangapouri Model - 3000 m³/s (Ōtaki only) Stopbank Breach

FIGURE No. Figure 17.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180501_PreProjectReportRev5\Fig17_2_OM_ModelResults_3000Cu_Bre.mxd Date: 10/05/2018 Time: 7:24:50 p.m.



Notes: - Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	May.18
CHECKED	DMK	May.18
APPROVED	TSRF	May.18

ARCFILE Fig17_2_OM_ModelResults_3000Cu_Bre.mxd

SCALE (AT A3 SIZE) 1:5,000

PROJECT No. 85985.0070

NZ TRANSPORT AGENCY

PEKA PEKA TO ŌTAKI EXPRESSWAY

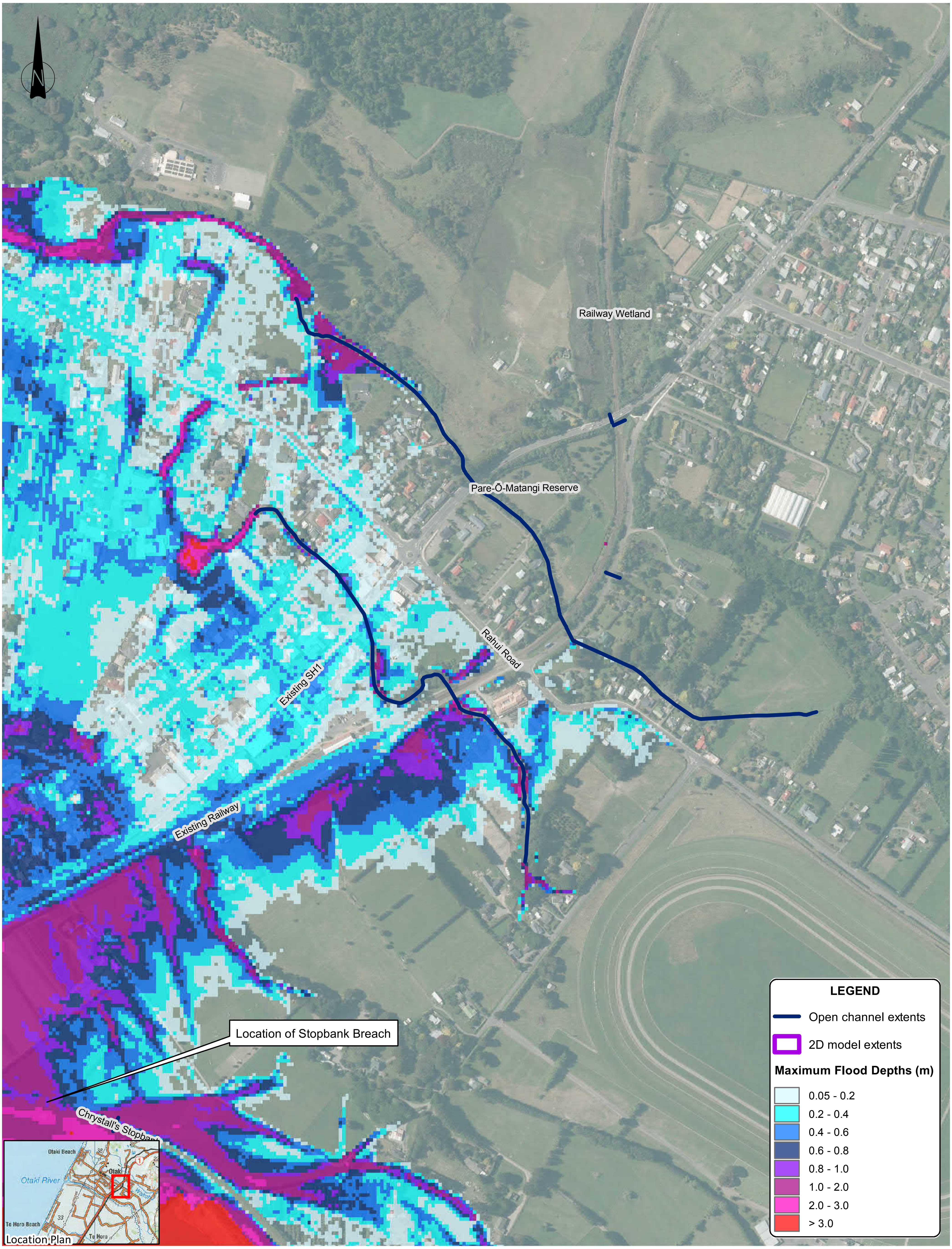
Pre-Project Hydraulic Model Results

Ōtaki-Mangapouri Model - 3000 m³/s (Ōtaki only) Stopbank Breach

FIGURE No. Figure 17.2

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180501_PreProjectReportRev5\Fig17_3_OM_ModelResults_3000Cu_Bre.mxd Date: 10/05/2018 Time: 7:27:43 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	May.18
CHECKED	DMK	May.18
APPROVED	TSRF	May.18

ARCFILE
Fig17_3_OM_ModelResults_3000Cu_Bre.mxd

SCALE (AT A3 SIZE)
1:5,000

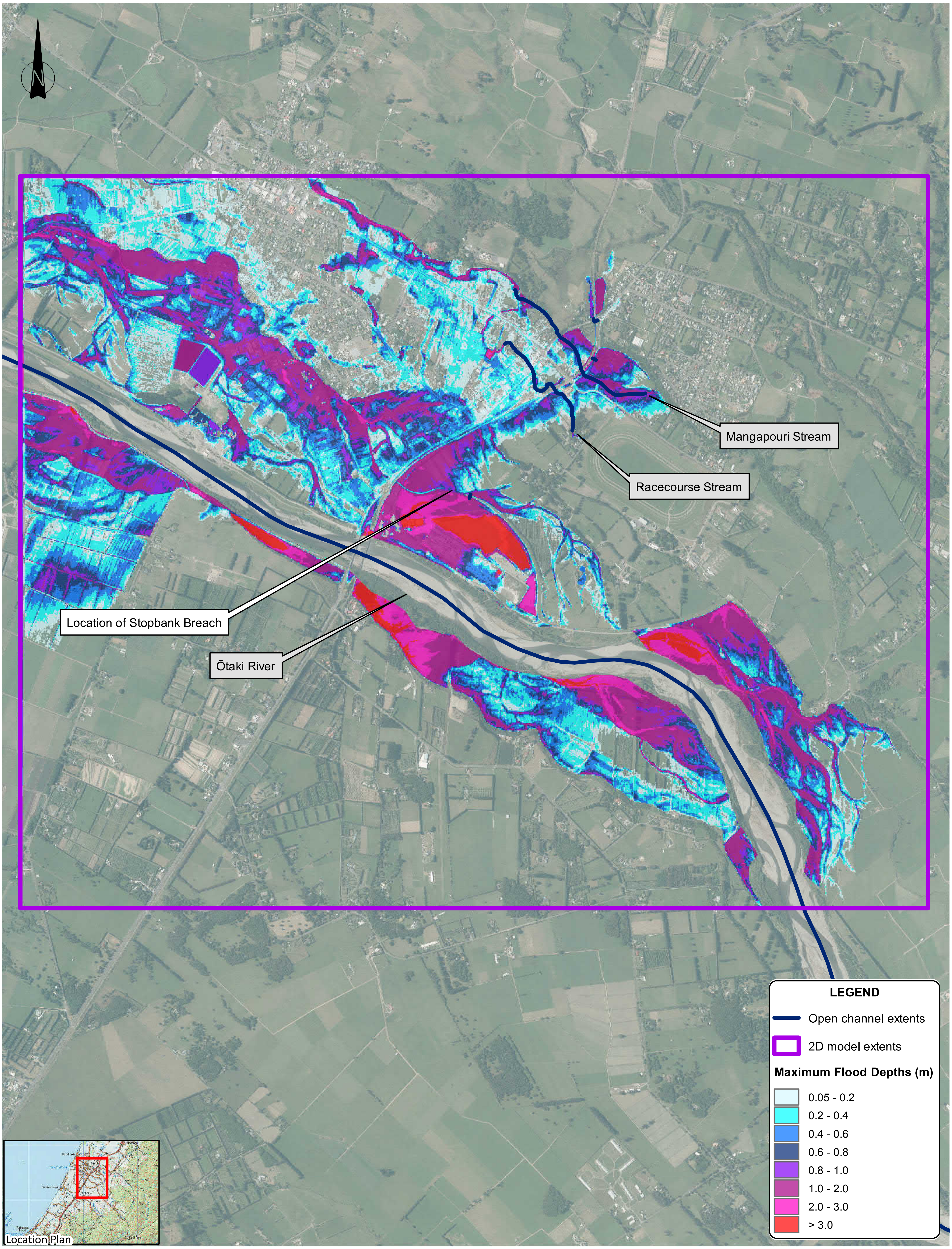
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Ōtaki-Mangapouri Model - 3000 m³/s (Ōtaki only) Stopbank Breach

FIGURE No. Figure 17.3

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180501_PreProjectReportRev5\Fig18_1_OM_ModelResults_500yrCC_Bre.mxd Date: 10/05/2018 Time: 7:05:06 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:20,000

0 0.2 0.4 0.6 0.8 1 (km)

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	May.18
CHECKED	DMK	May.18
APPROVED	TSRF	May.18

ARCFILE
Fig18_1_OM_ModelResults_500yrCC_Bre.mxd

SCALE (AT A3 SIZE)
1:20,000

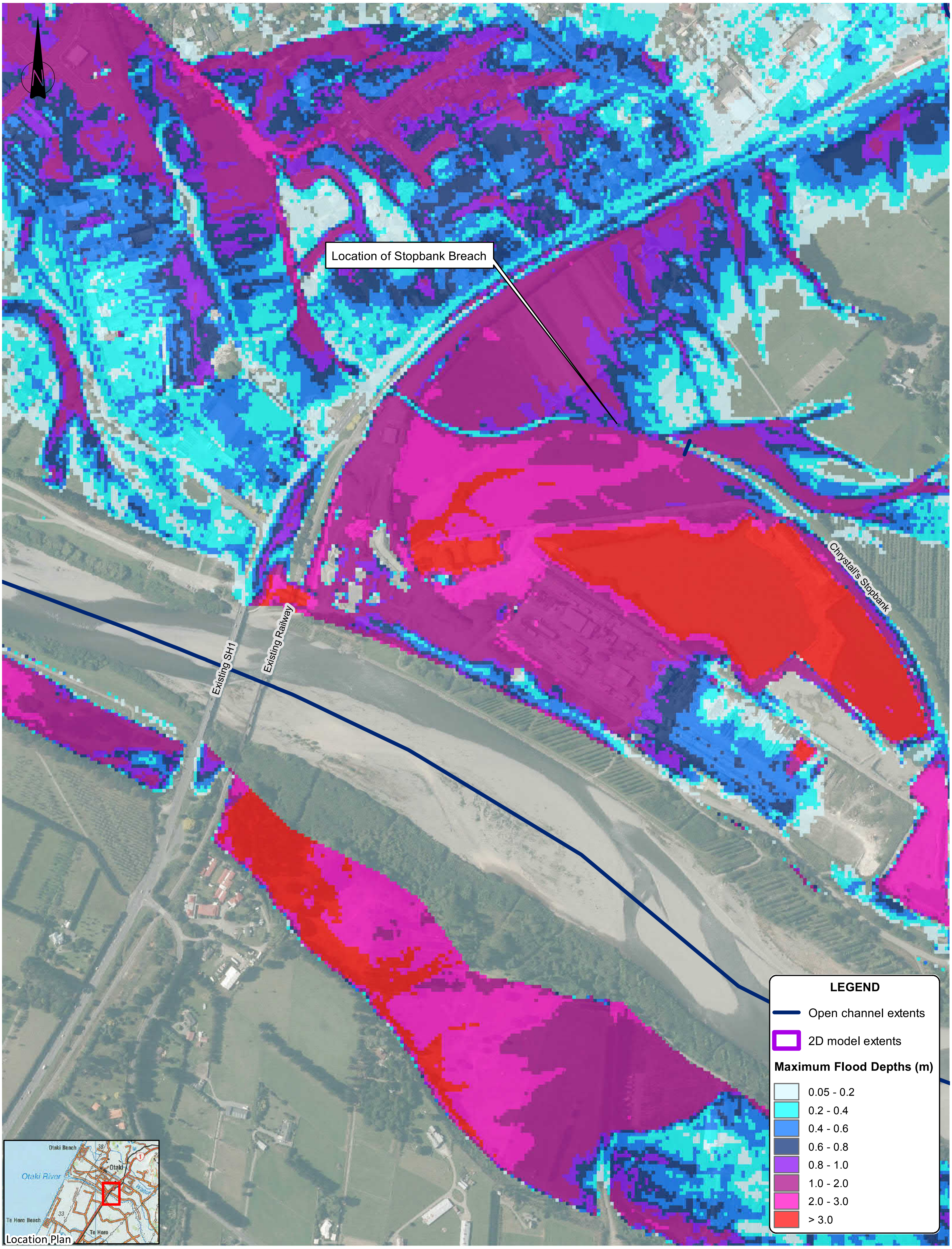
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Ōtaki-Mangapouri Model - 0.2% AEP CC2130 Stopbank Breach

FIGURE No.
Figure 18.1

Rev.
0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180501_PreProjectReportRev5\Fig18_2_OM_ModelResults_500yrCC_Bre.mxd Date: 10/05/2018 Time: 7:08:41 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	KBBB	May.18
CHECKED	DMK	May.18
APPROVED	TSRF	May.18

ARCFILE Fig18_2_OM_ModelResults_500yrCC_Bre.mxd

SCALE (AT A3 SIZE) 1:5,000

PROJECT No. 85985.0070

NZ TRANSPORT AGENCY

PEKA PEKA TO ŌTAKI EXPRESSWAY

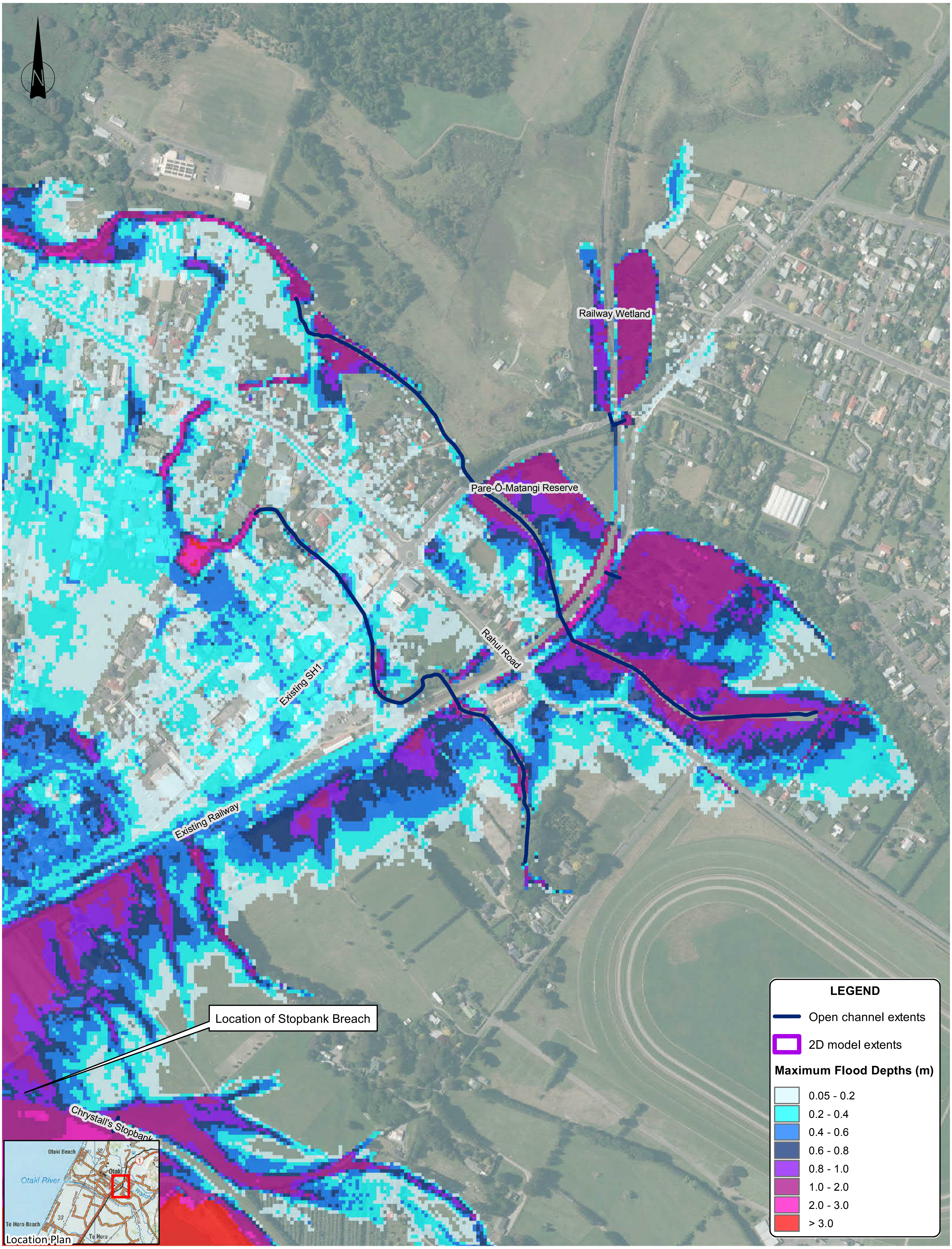
Pre-Project Hydraulic Model Results

Ōtaki-Mangapouri Model - 0.2% AEP CC2130 Stopbank Breach

FIGURE No. Figure 18.2

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180501_PreProjectReportRev5\Fig18_3_OM_ModelResults_500yrCC_Bre.mxd Date: 10/05/2018 Time: 7:10:33 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:5,000

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

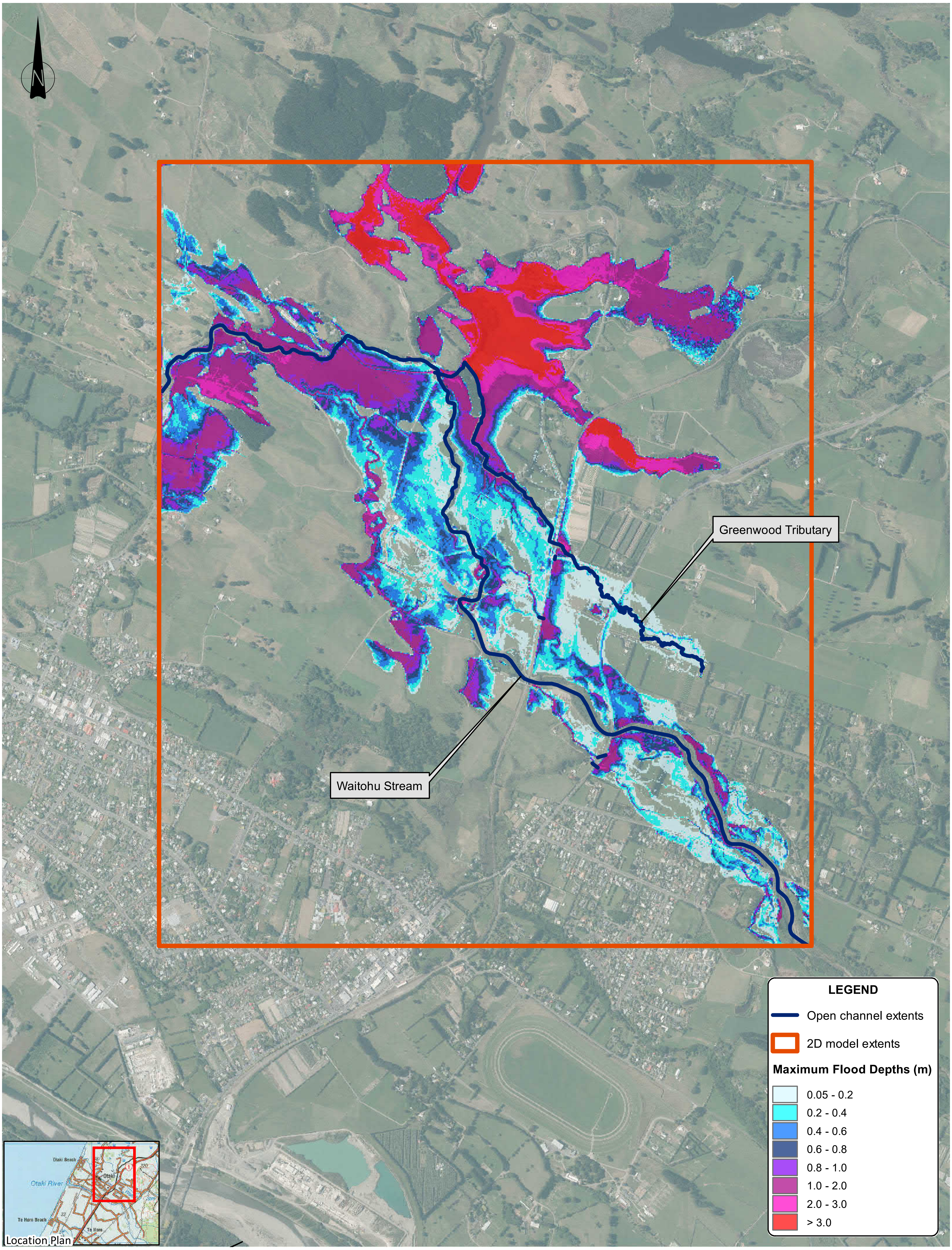
DRAWN	KBBB	May.18
CHECKED	DMK	May.18
APPROVED	TSRF	May.18
ARCFILE Fig18_3_OM_ModelResults_500yrCC_Bre.mxd		
SCALE (AT A3 SIZE) 1:5,000		
PROJECT No. 85985.0070		

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Ōtaki-Mangapouri Model - 0.2% AEP CC2130 Stopbank Breach

FIGURE No. Figure 18.3

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig19_1_Wai_ModelResults_2500yrCC.mxd Date: 23/03/2018 Time: 9:00:52 AM



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:15,000

0 0.2 0.4 0.6 0.8 1 (km)

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig19_1_Wai_ModelResults_2500yrCC.mxd

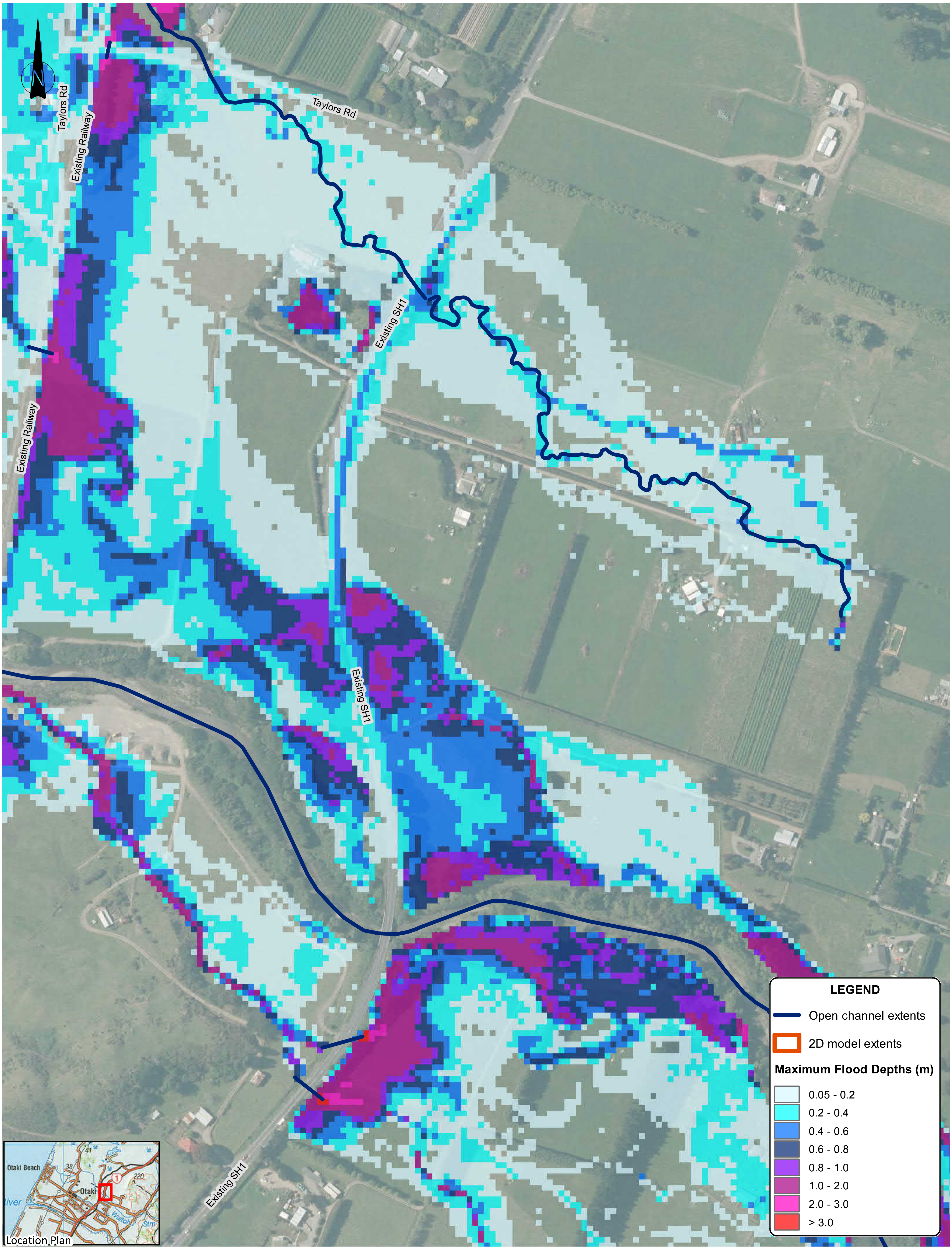
SCALE (AT A3 SIZE) 1:15,000

PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Waitohu Model - 0.04% AEP CC2130

FIGURE No. Figure 19.1

Rev. 0



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:3,000

0 20 40 60 80 100 Meters

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE
Fig19_2_Wai_ModelResults_2500yrCC.mxd

SCALE (AT A3 SIZE)
1:3,000

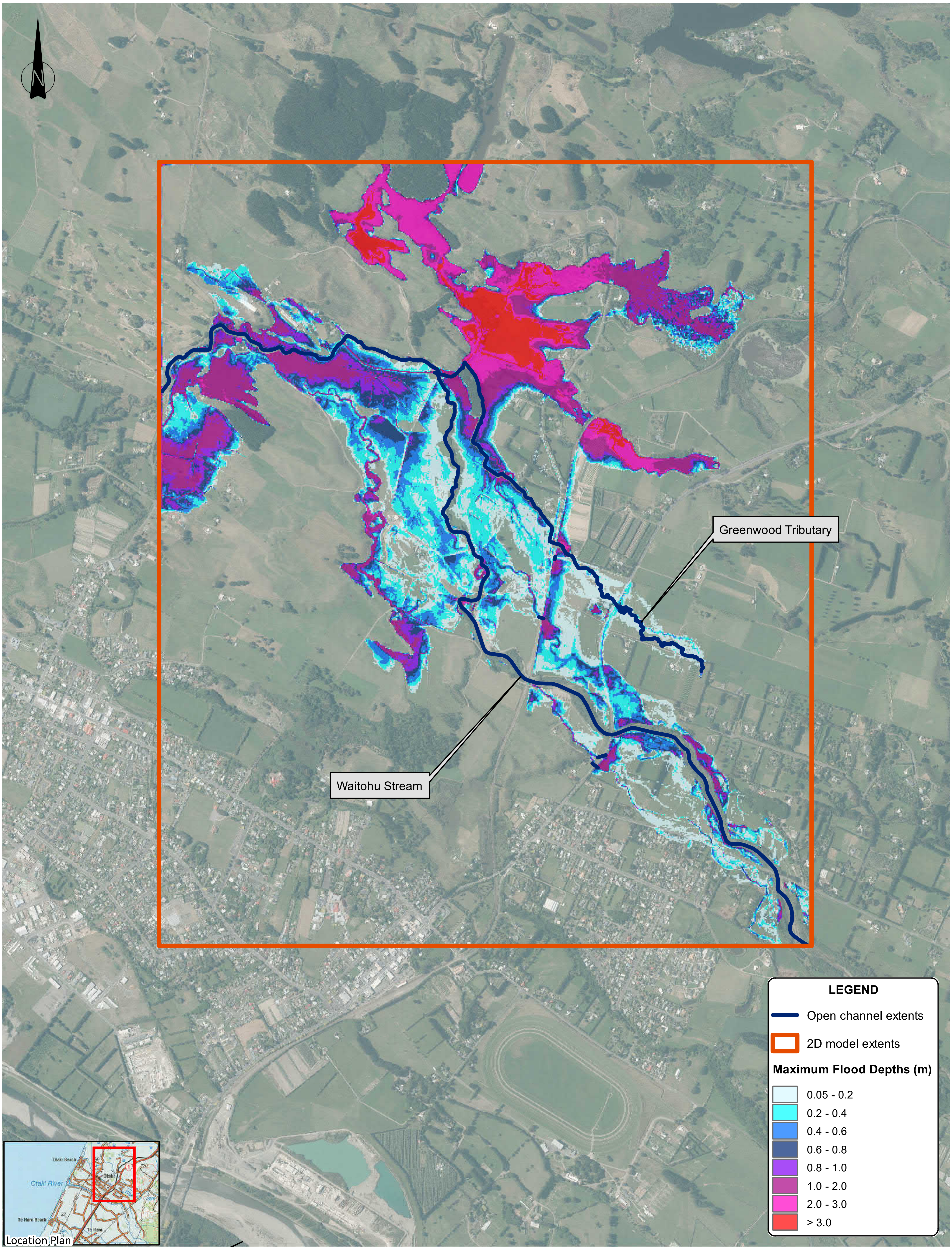
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Waitohu Model - 0.04% AEP CC2130

FIGURE No. Figure 19.2

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig20_1_Wai_ModelResults_100yrCCHR.mxd Date: 23/03/2018 Time: 9:19:12 AM



Notes: - Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:15,000

0 0.2 0.4 0.6 0.8 1 (km)

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig20_1_Wai_ModelResults_100yrCCHR.mxd

SCALE (AT A3 SIZE) 1:15,000

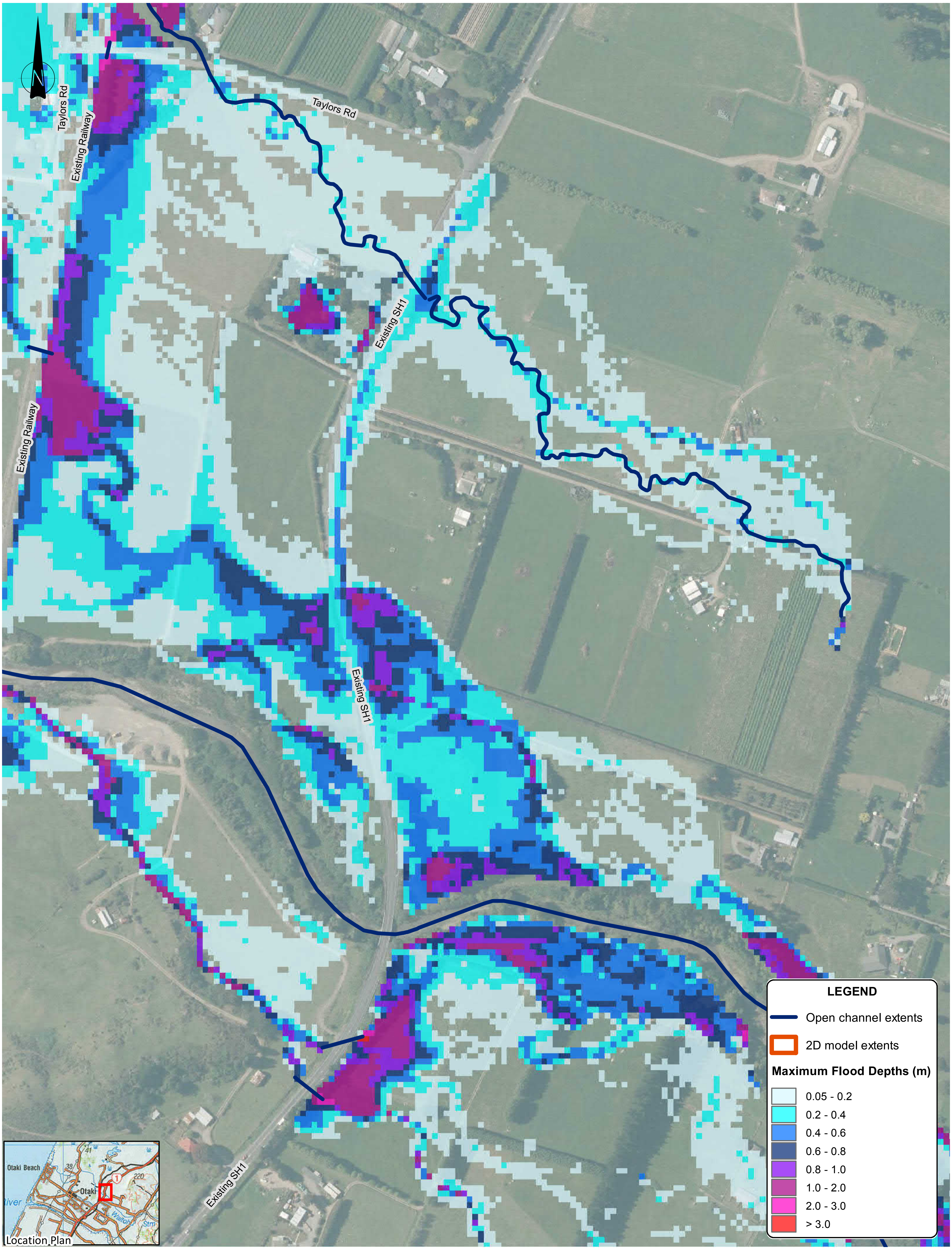
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Waitohu Model - 1% AEP CC2130 (High Range)

FIGURE No. Figure 20.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig20_2_Wai_ModelResults_100yrCCHR.mxd Date: 25/03/2018 Time: 2:19:32 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:3,000

0 20 40 60 80 100 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE
Fig20_2_Wai_ModelResults_100yrCCHR.mxd

SCALE (AT A3 SIZE)
1:3,000

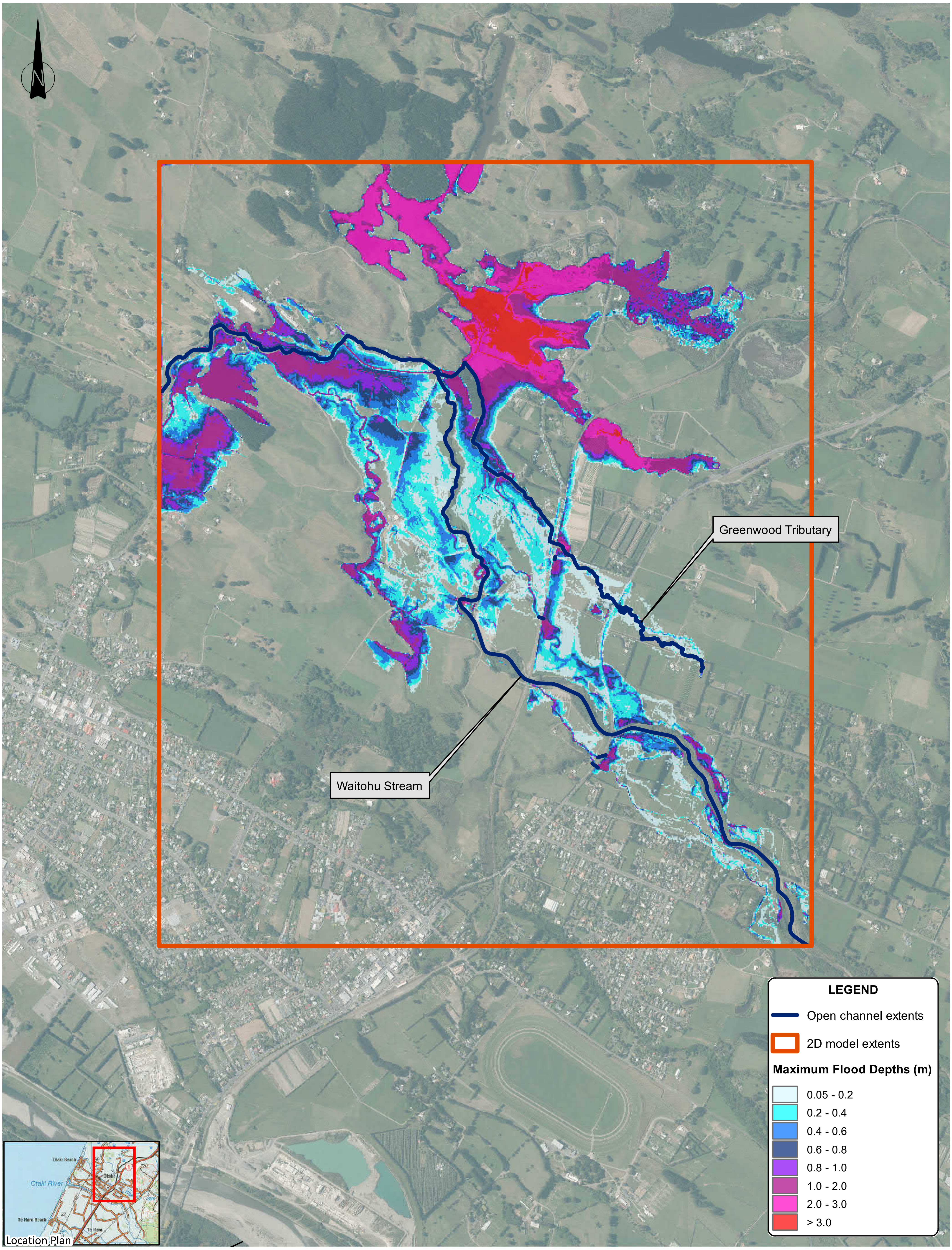
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Waitohu Model - 1% AEP CC2130 (High Range)

FIGURE No. Figure 20.2

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig21_1_Wai_ModelResults_100yrCC.mxd Date: 23/03/2018 Time: 9:21:02 AM



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:15,000

0 0.2 0.4 0.6 0.8 1 (km)

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

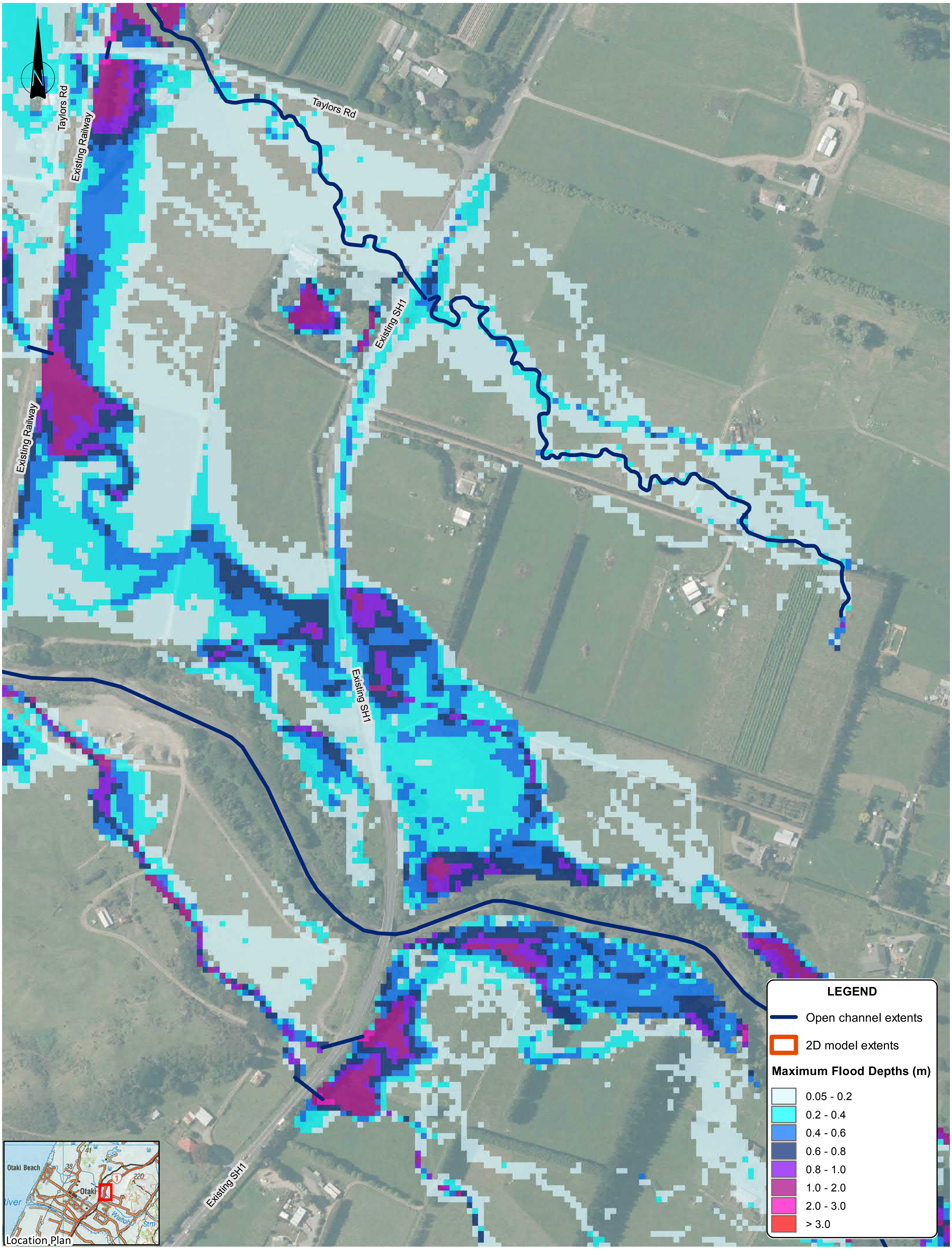
DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18
ARCFILE Fig21_1_Wai_ModelResults_100yrCC.mxd		
SCALE (AT A3 SIZE) 1:15,000		
PROJECT No. 85985.0070		

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Waitohu Model - 1% AEP CC2130

FIGURE No. Figure 21.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig21_2_Wai_ModelResults_100yrCC.mxd Date: 25/03/2018 Time: 2:20:30 p.m.



Notes: - Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:3,000

0 20 40 60 80 100 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig21_2_Wai_ModelResults_100yrCC.mxd

SCALE (AT A3 SIZE) 1:3,000

PROJECT No. 85985.0070

NZ TRANSPORT AGENCY

PEKA PEKA TO ŌTAKI EXPRESSWAY

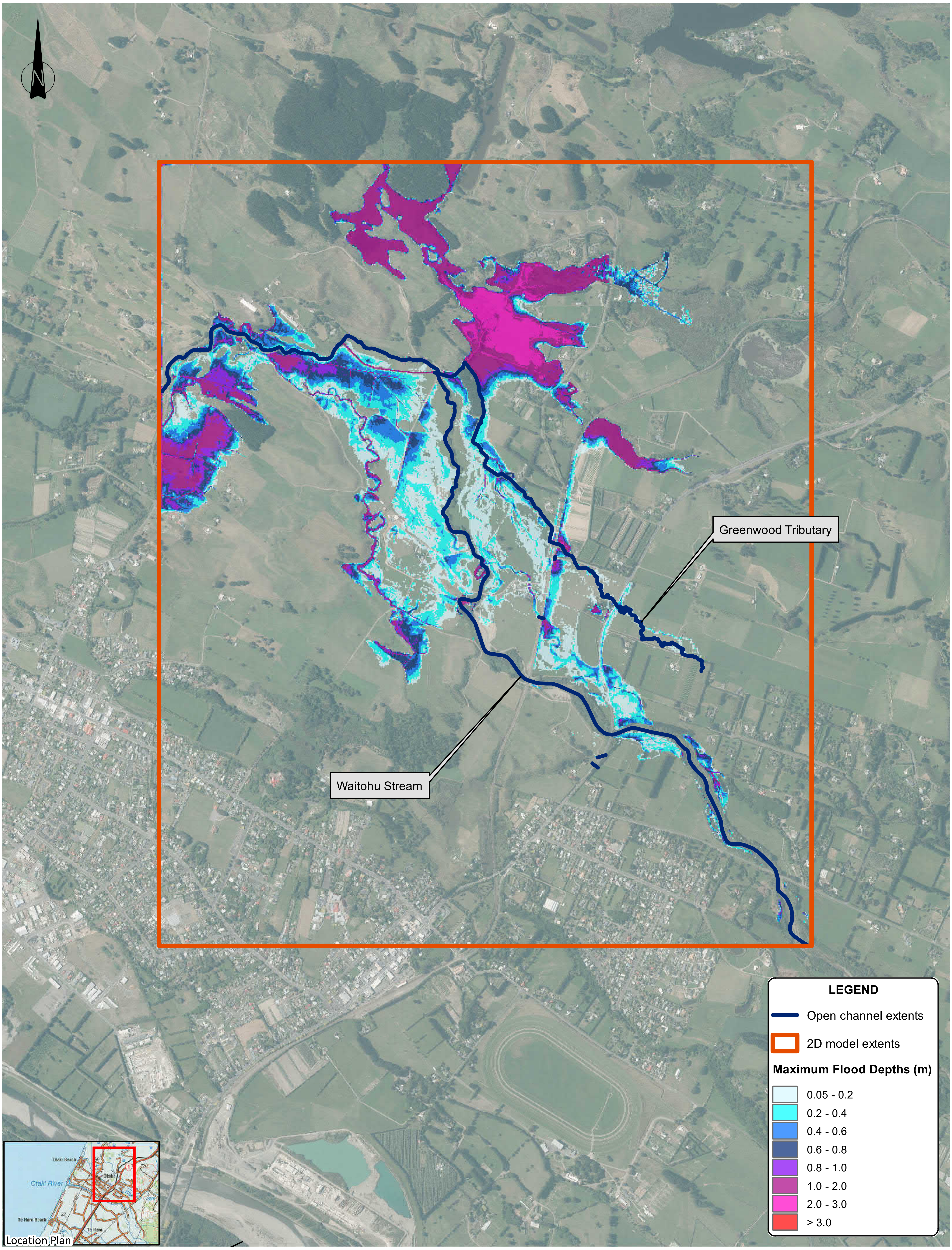
Pre-Project Hydraulic Model Results

Waitohu Model - 1% AEP CC2130

FIGURE No. Figure 21.2

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig22_1_Wai_ModelResults_20yr.mxd Date: 23/03/2018 Time: 9:24:55 AM



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:15,000

0 0.2 0.4 0.6 0.8 1 (km)

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig22_1_Wai_ModelResults_20yr.mxd

SCALE (AT A3 SIZE) 1:15,000

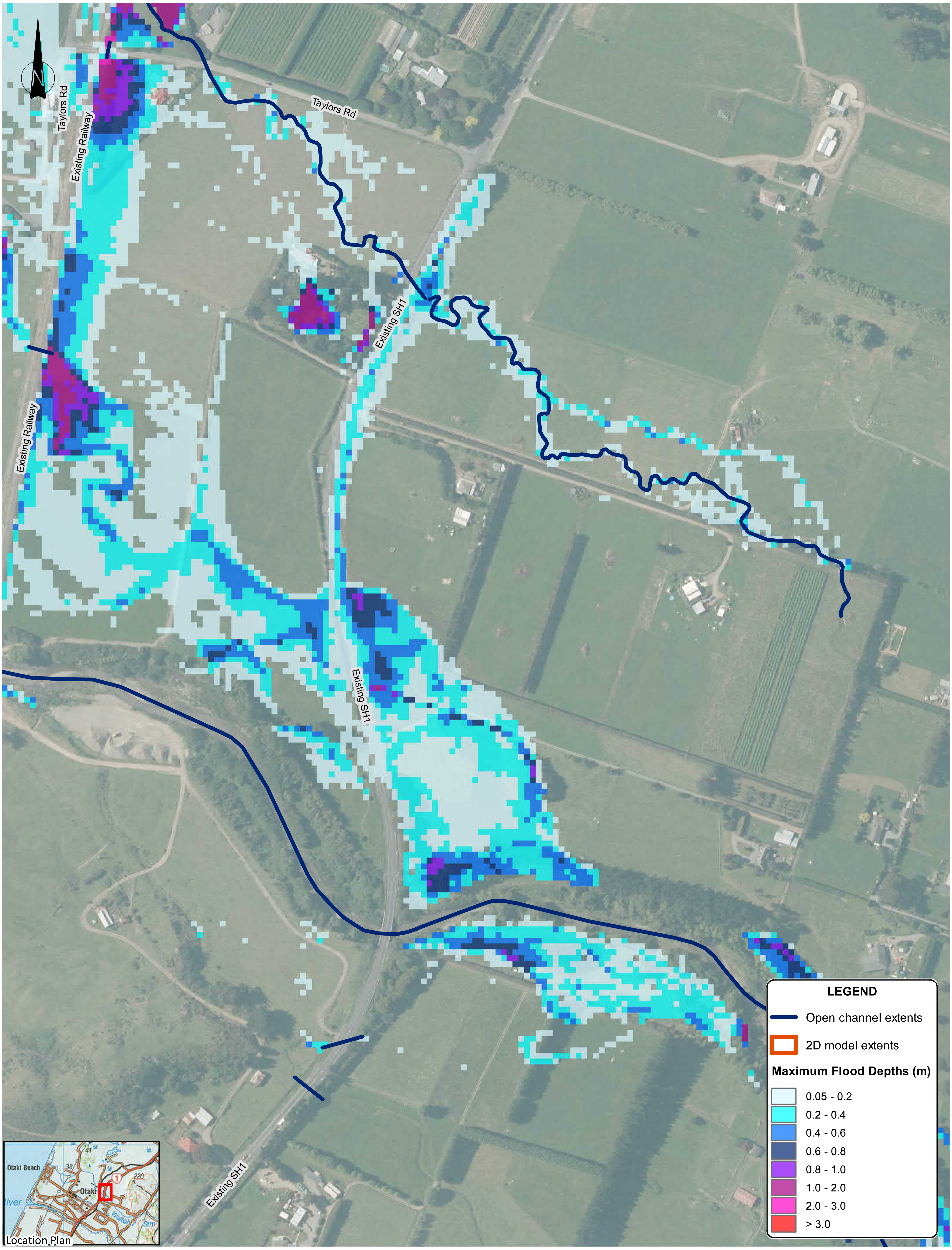
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Waitohu Model - 5% AEP

FIGURE No. Figure 22.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig22_2_Wai_ModelResults_20yr.mxd Date: 25/03/2018 Time: 2:21:02 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:3,000

0 20 40 60 80 100 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig22_2_Wai_ModelResults_20yr.mxd

SCALE (AT A3 SIZE) 1:3,000

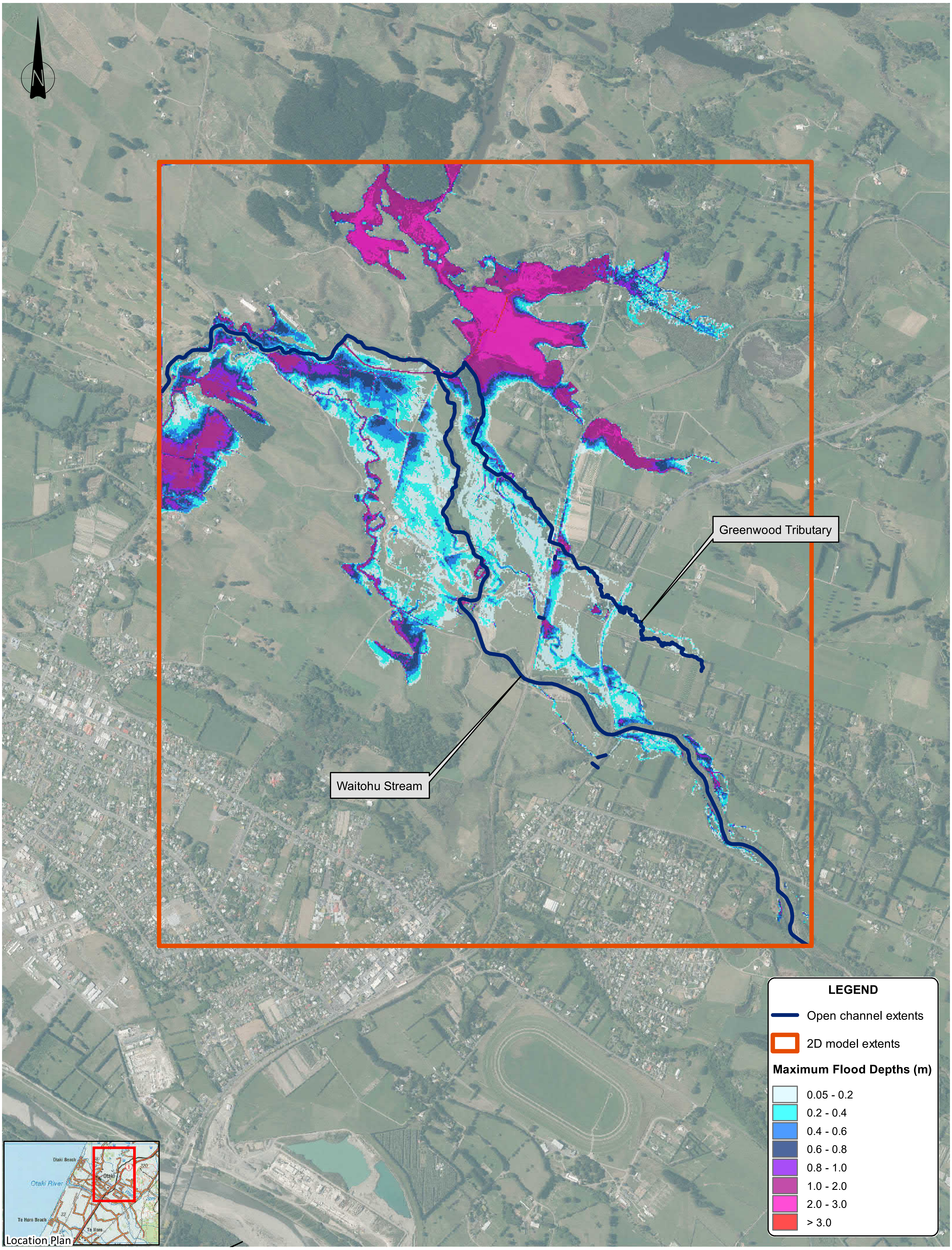
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Waitohu Model - 5% AEP

FIGURE No. Figure 22.2

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig23_1_Wai_ModelResults_10yrCC.mxd Date: 23/03/2018 Time: 9:35:02 AM



Notes: - Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:15,000

0 0.2 0.4 0.6 0.8 1 (km)

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE
Fig23_1_Wai_ModelResults_10yrCC.mxd

SCALE (AT A3 SIZE)
1:15,000

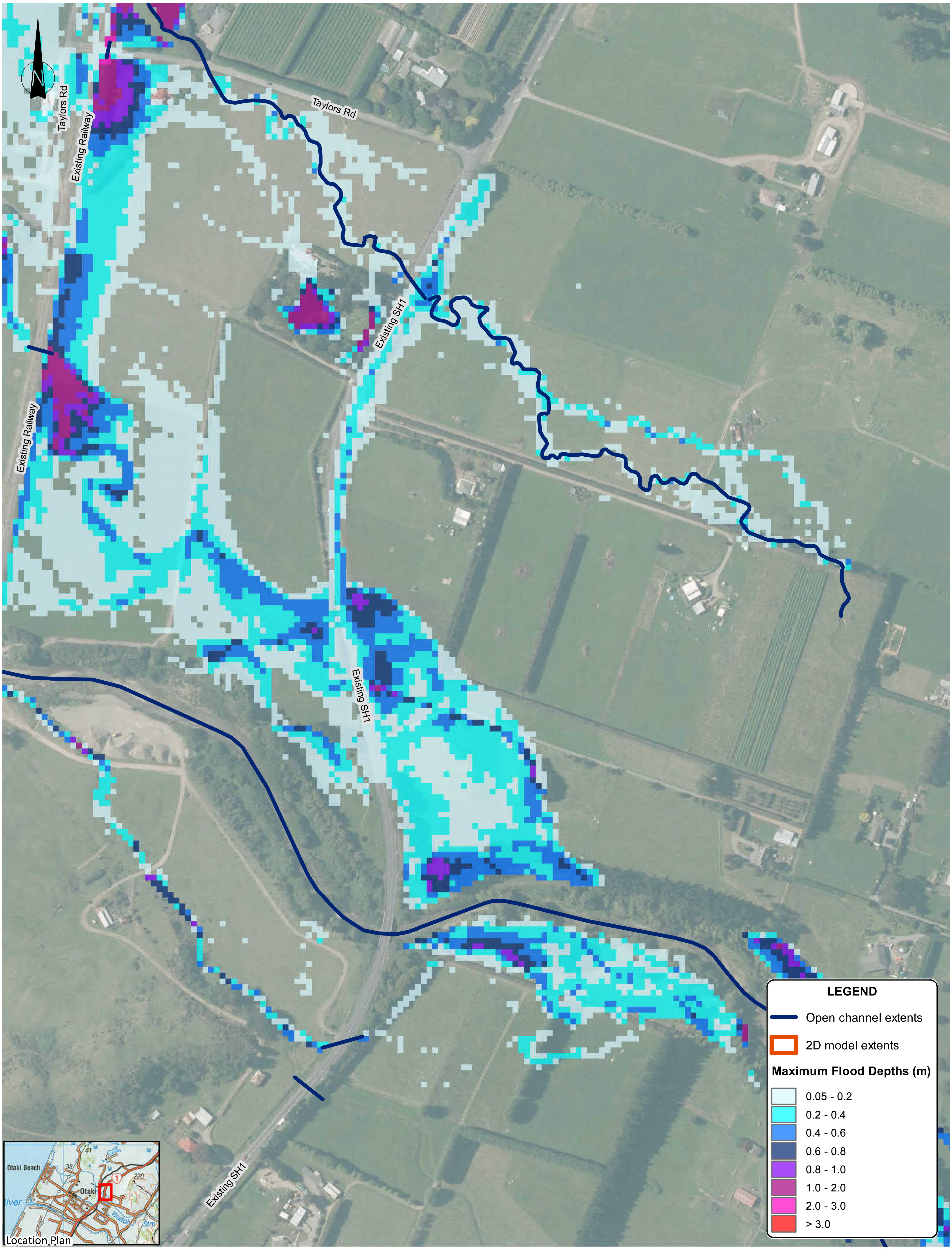
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Waitohu Model - 10% AEP CC2130

FIGURE No.
Figure 23.1

Rev.
0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig23_2_Wai_ModelResults_10yrCC.mxd Date: 25/03/2018 Time: 2:21:32 p.m.



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:3,000

0 20 40 60 80 100 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE
Fig23_2_Wai_ModelResults_10yrCC.mxd

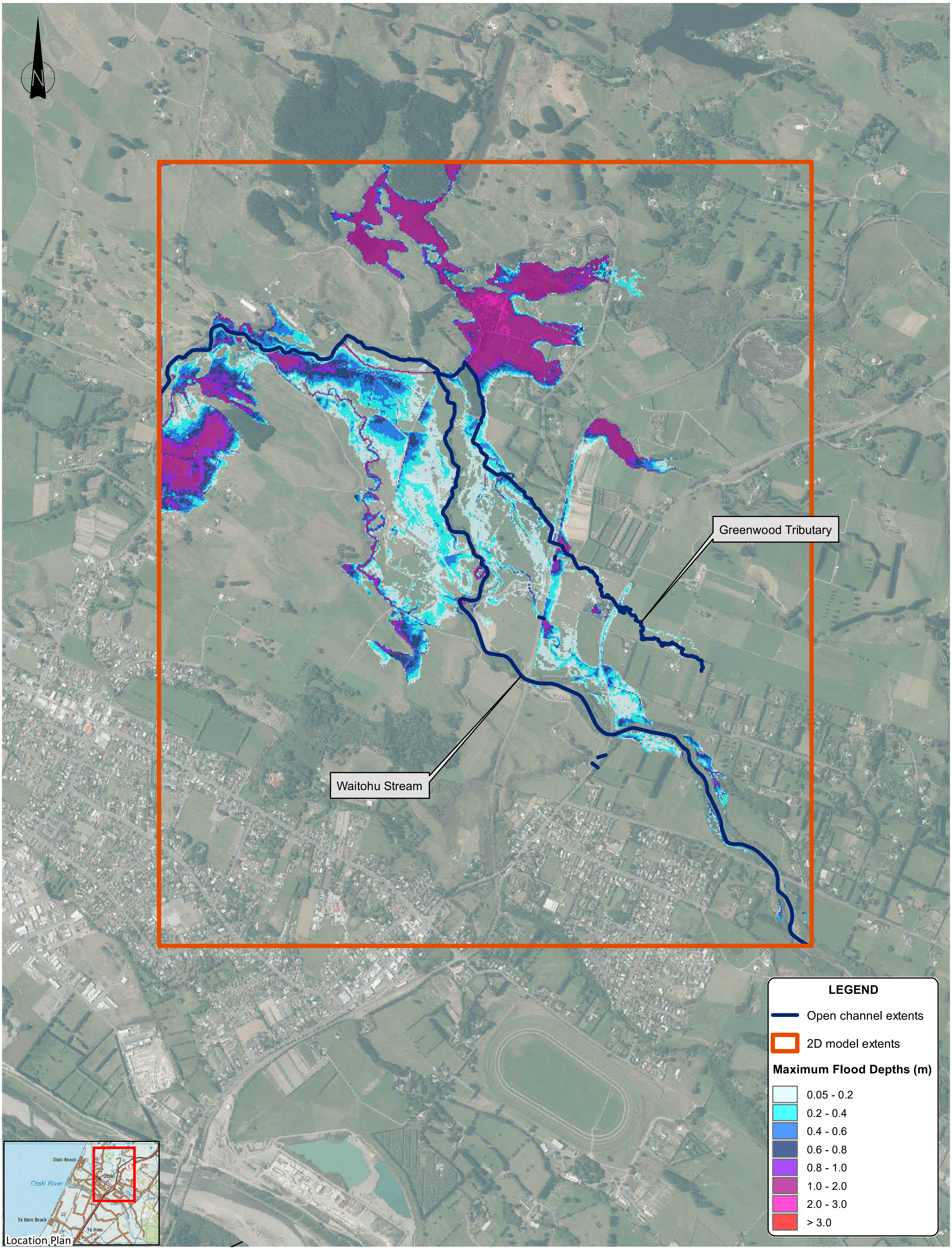
SCALE (AT A3 SIZE)
1:3,000

PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Waitohu Model - 10% AEP CC2130

FIGURE No. Figure 23.2

Rev. 0



Notes: - Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:15,000

0 0.2 0.4 0.6 0.8 1 (km)

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE
Fig24_1_Wai_ModelResults_10yr.mxd

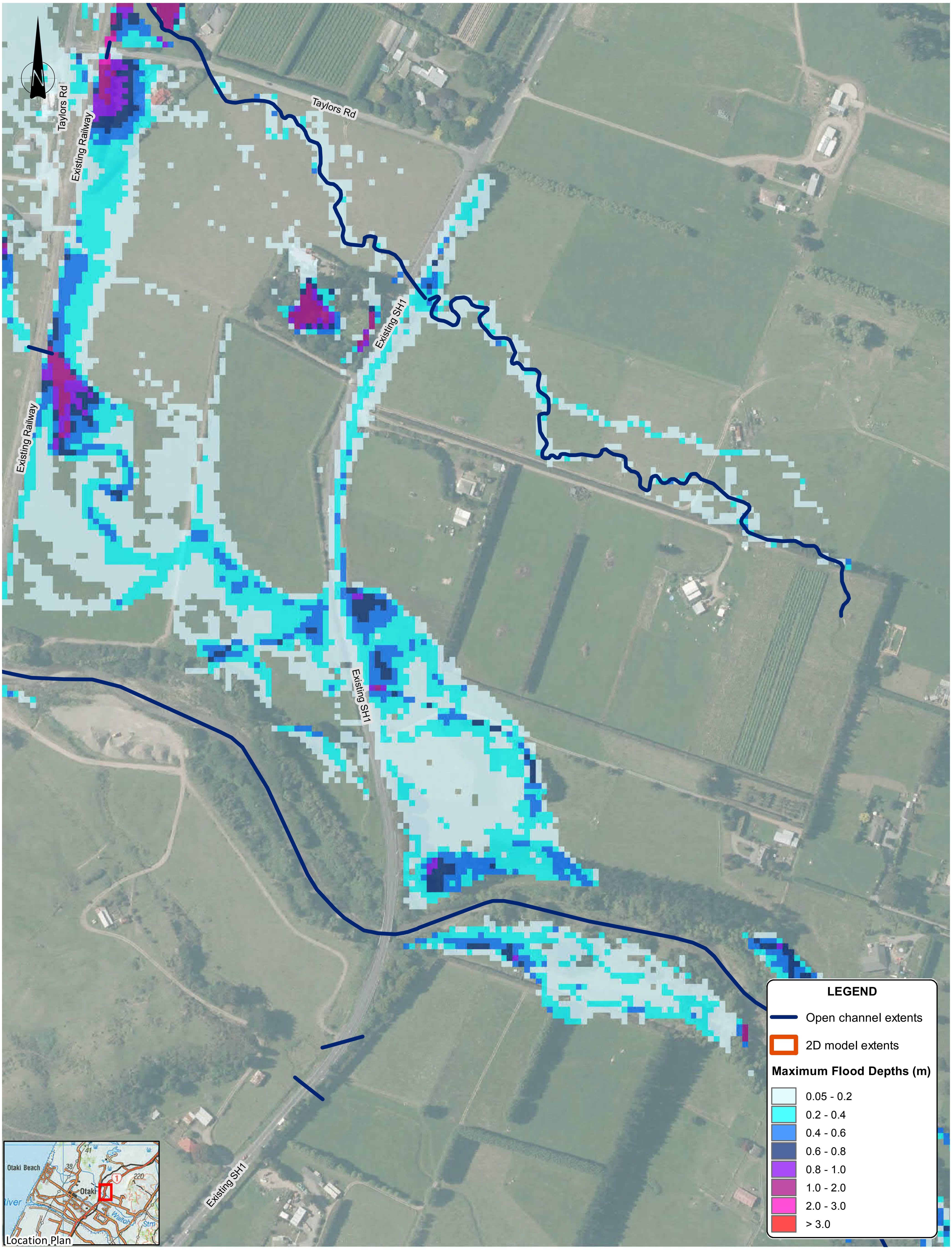
SCALE (AT A3 SIZE)
1:15,000

PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Waitohu Model - 10% AEP

FIGURE No. Figure 24.1

Rev. 0



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō “the Project”, and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:3,000

0 20 40 60 80 100 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE
Fig24_2_Wai_ModelResults_10yr.mxd

SCALE (AT A3 SIZE)
1:3,000

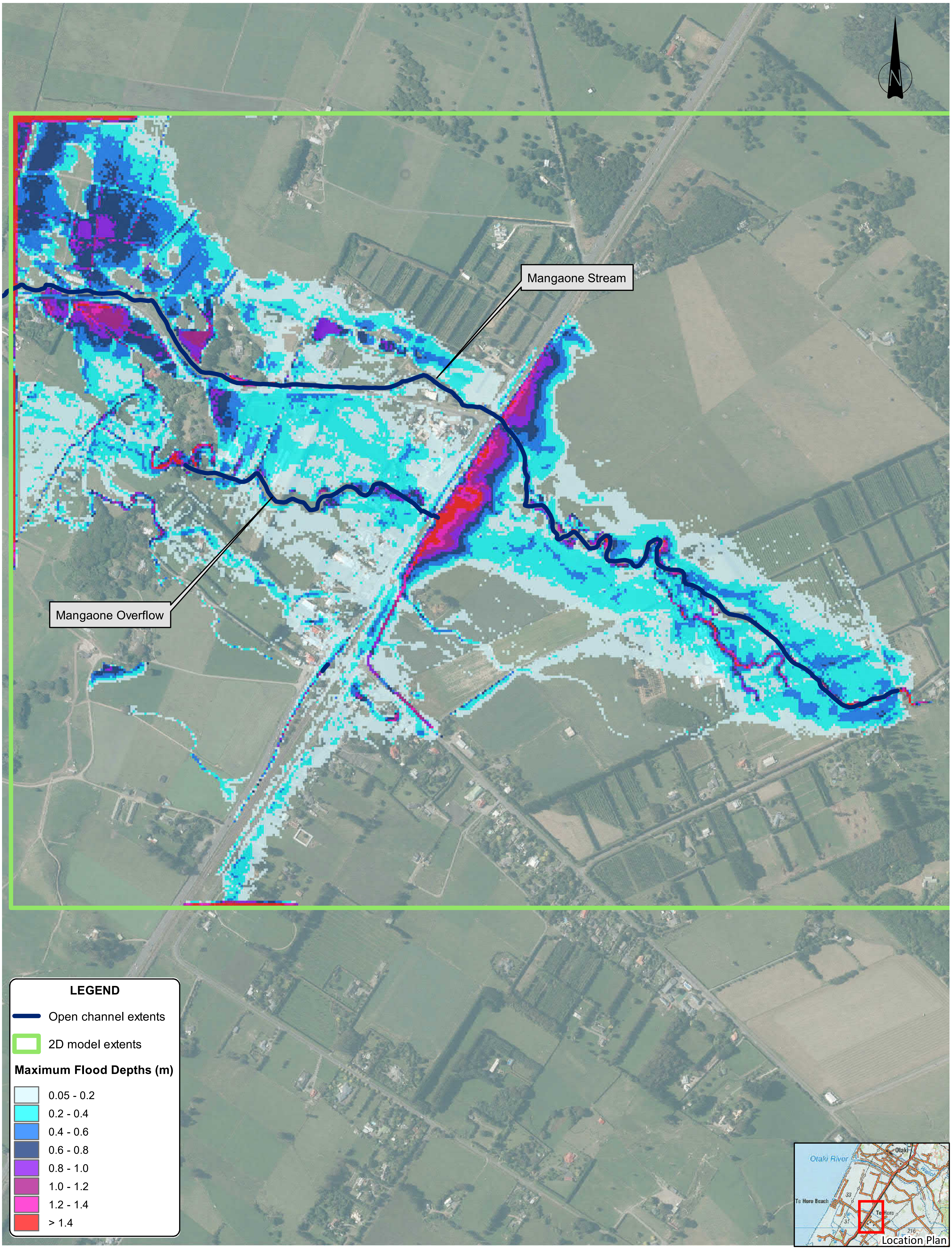
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Waitohu Model - 10% AEP

FIGURE No. Figure 24.2

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig25_1_Mang_ModelResults_2500yrCC.mxd Date: 23/03/2018 Time: 9:46:57 AM



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō “the Project”, and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:7,500

0 100 200 300 400 500 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig25_1_Mang_ModelResults_2500yrCC.mxd

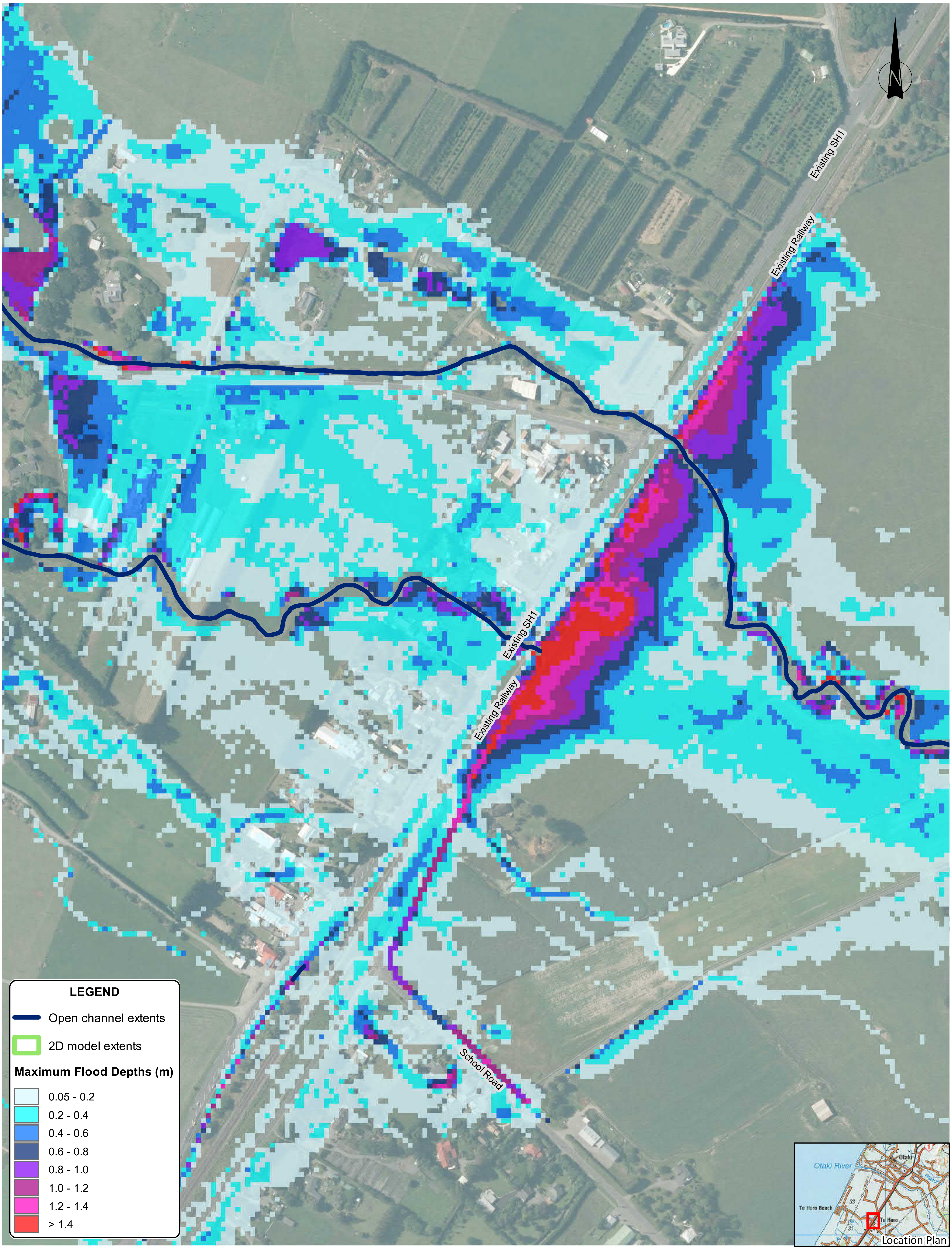
SCALE (AT A3 SIZE) 1:7,500

PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Mangaone Model - 0.04% AEP CC2130

FIGURE No. Figure 25.1

Rev. 0



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:3,500

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig25_2_Mang_ModelResults_2500yrCC.mxd

SCALE (AT A3 SIZE) 1:3,500

PROJECT No. 85985.0070

NZ TRANSPORT AGENCY

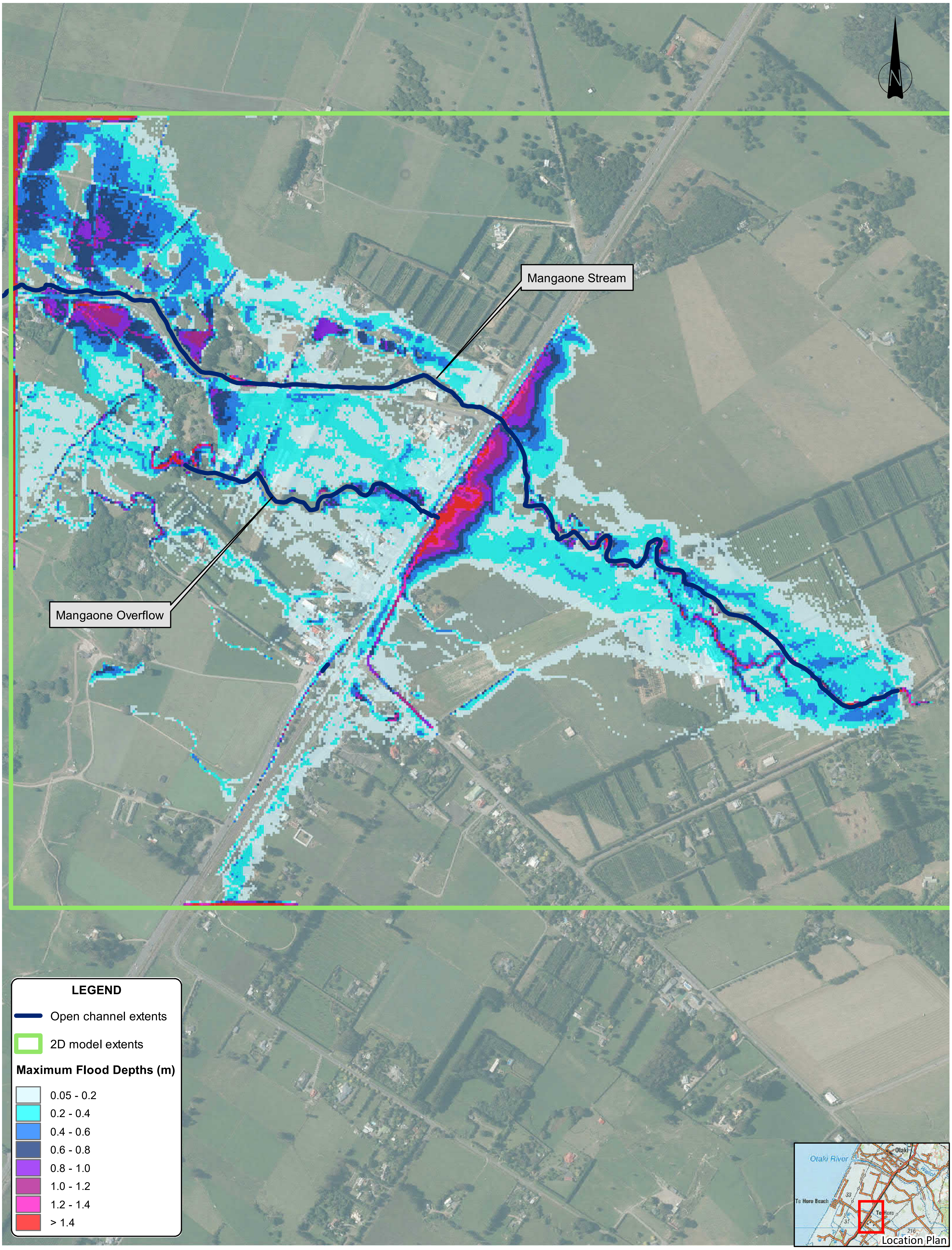
PEKA PEKA TO ŌTAKI EXPRESSWAY

Pre-Project Hydraulic Model Results

Mangaone Model - 0.04% AEP CC2130

FIGURE No. Figure 25.2

Rev. 0



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:7,500

0 100 200 300 400 500 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig26_1_Mang_ModelResults_1000yrCC.mxd

SCALE (AT A3 SIZE) 1:7,500

PROJECT No. 85985.0070

NZ TRANSPORT AGENCY

PEKA PEKA TO ŌTAKI EXPRESSWAY

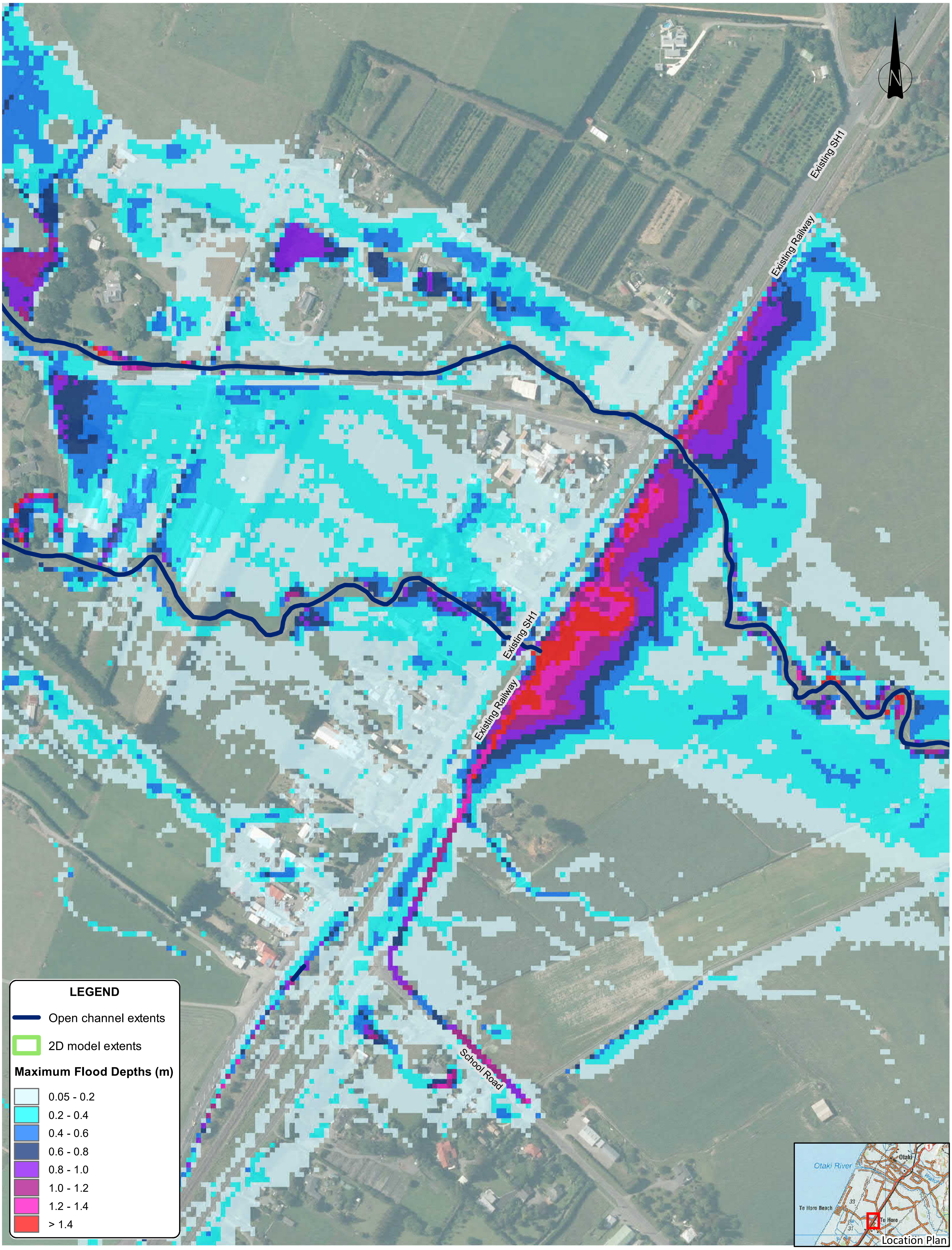
Pre-Project Hydraulic Model Results

Mangaone Model - 0.1% AEP CC2130

FIGURE No. Figure 26.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig26_2_Mang_ModelResults_1000yrCC.mxd Date: 23/03/2018 Time: 9:50:42 AM



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:3,500

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE
Fig26_2_Mang_ModelResults_1000yrCC.mxd

SCALE (AT A3 SIZE)
1:3,500

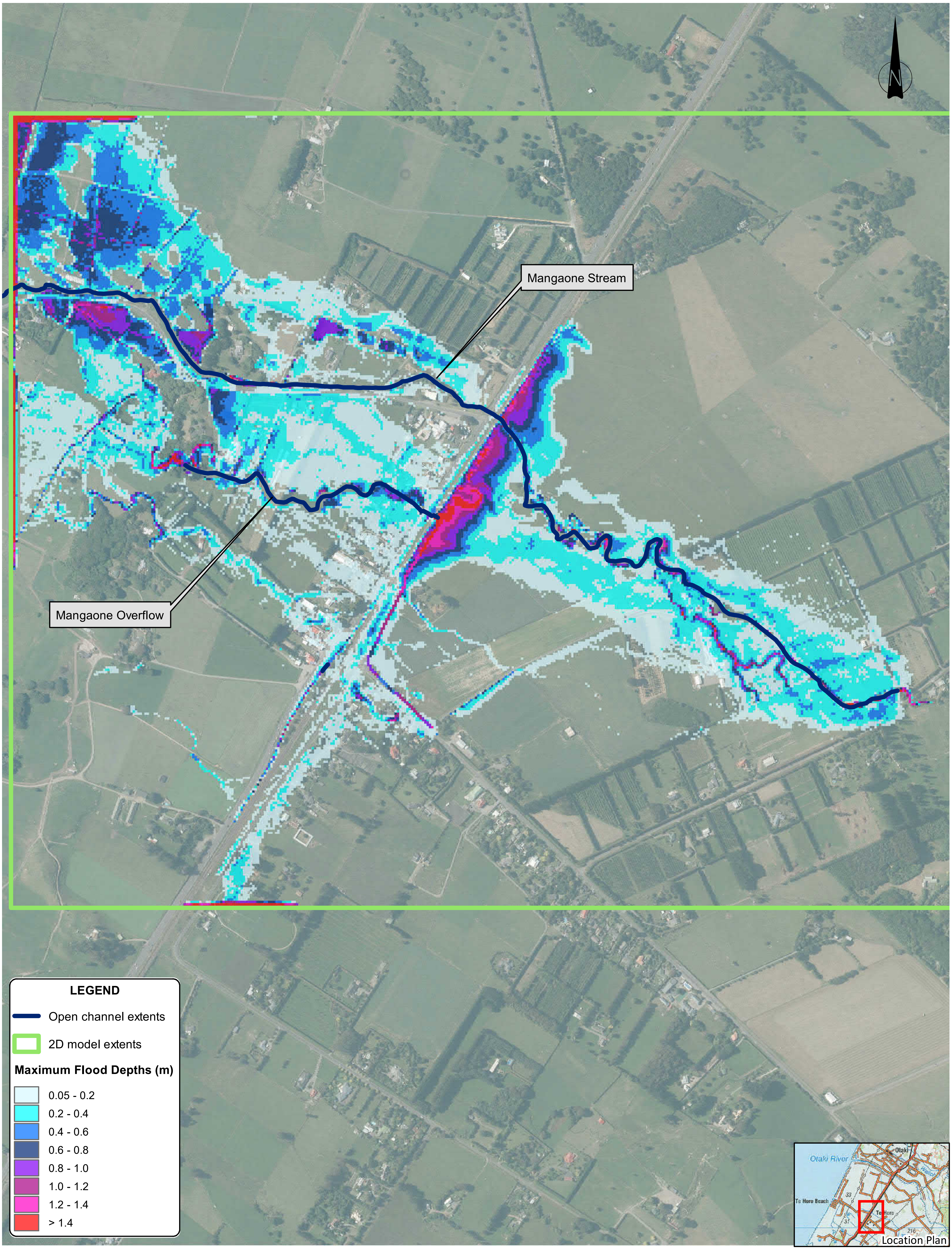
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Mangaone Model - 0.1% AEP CC2130

FIGURE No.
Figure 26.2

Rev.
0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig27_1_Mang_ModelResults_100yrCCHR.mxd Date: 23/03/2018 Time: 9:53:15 AM



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:7,500

0 100 200 300 400 500 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE
Fig27_1_Mang_ModelResults_100yrCCHR.mxd

SCALE (AT A3 SIZE)
1:7,500

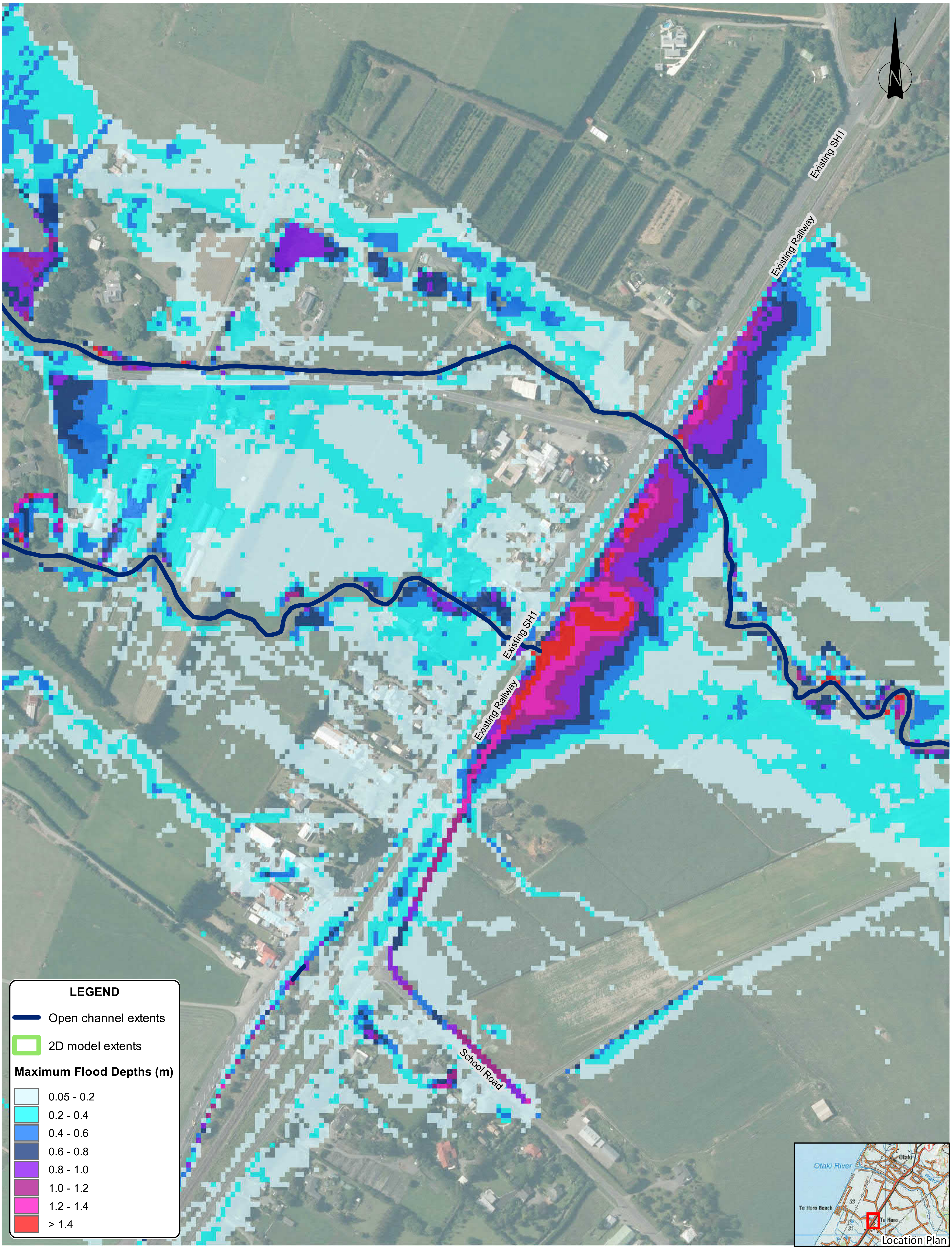
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Mangaone Model - 1% AEP CC2130 (High Range)

FIGURE No. Figure 27.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig27_2_Mang_ModelResults_100yrCCHR.mxd Date: 23/03/2018 Time: 9:54:19 AM



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō “the Project”, and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:3,500

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE
Fig27_2_Mang_ModelResults_100yrCCHR.mxd

SCALE (AT A3 SIZE)
1:3,500

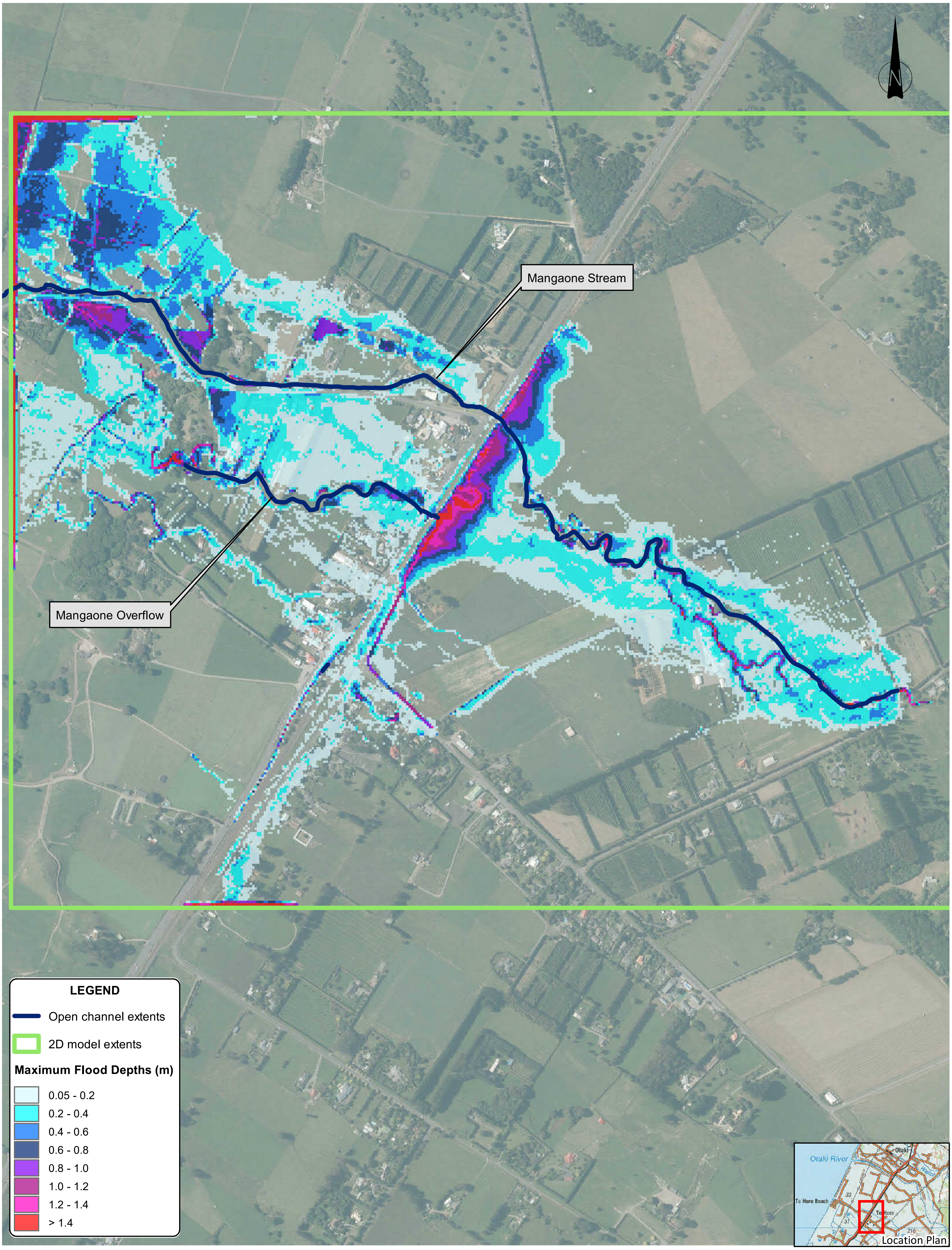
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Mangaone Model - 1% AEP CC2130 (High Range)

FIGURE No.
Figure 27.2

Rev.
0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig28_1_Mang_ModelResults_100yrCC.mxd Date: 23/03/2018 Time: 9:55:42 AM



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:7,500

0 100 200 300 400 500 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig28_1_Mang_ModelResults_100yrCC.mxd

SCALE (AT A3 SIZE) 1:7,500

PROJECT No. 85985.0070

NZ TRANSPORT AGENCY

PEKA PEKA TO ŌTAKI EXPRESSWAY

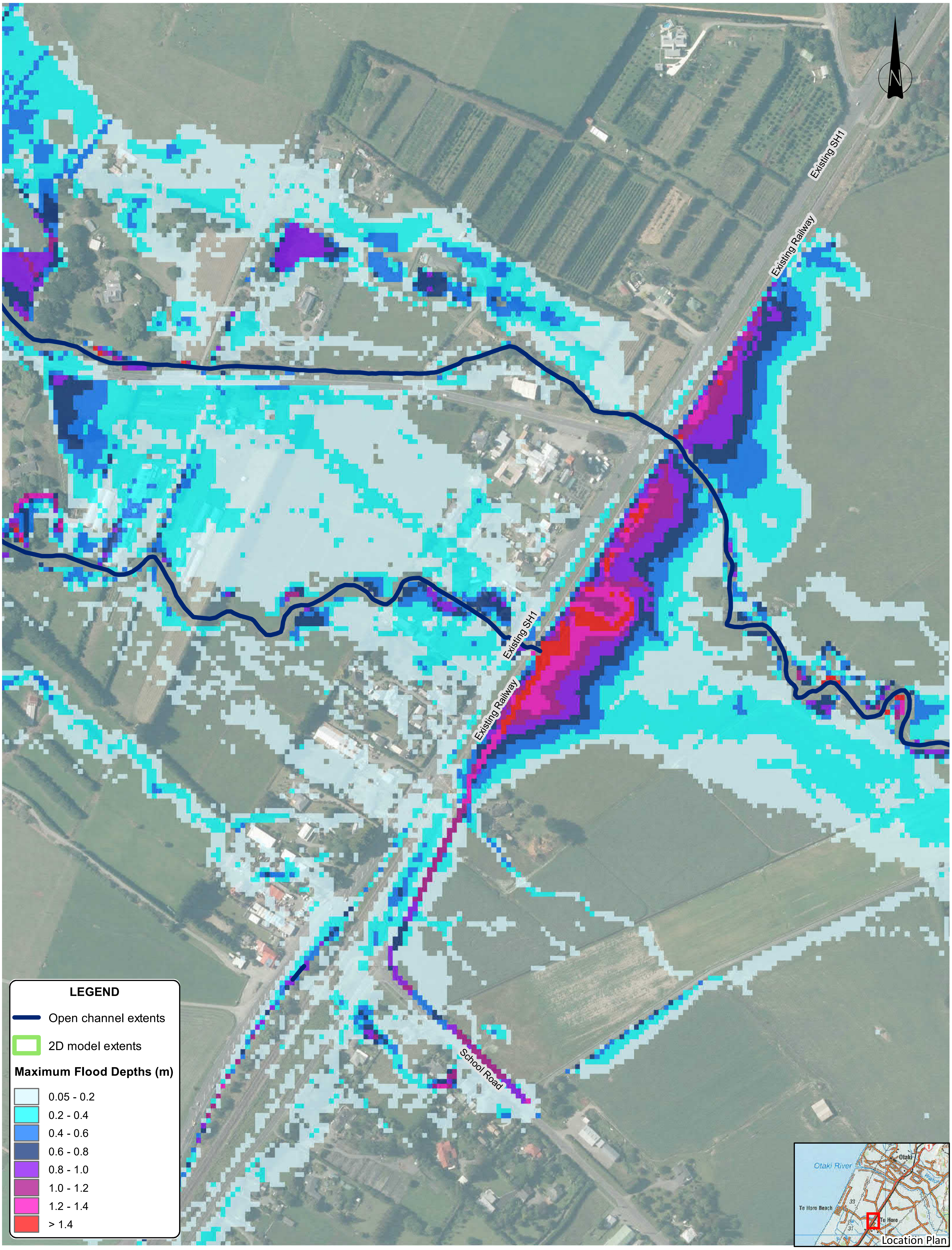
Pre-Project Hydraulic Model Results

Mangaone Model - 1% AEP CC2130

FIGURE No. Figure 28.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig28_2_Mang_ModelResults_100yrCC.mxd Date: 23/03/2018 Time: 9:56:49 AM



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:3,500

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE
Fig28_2_Mang_ModelResults_100yrCC.mxd

SCALE (AT A3 SIZE)
1:3,500

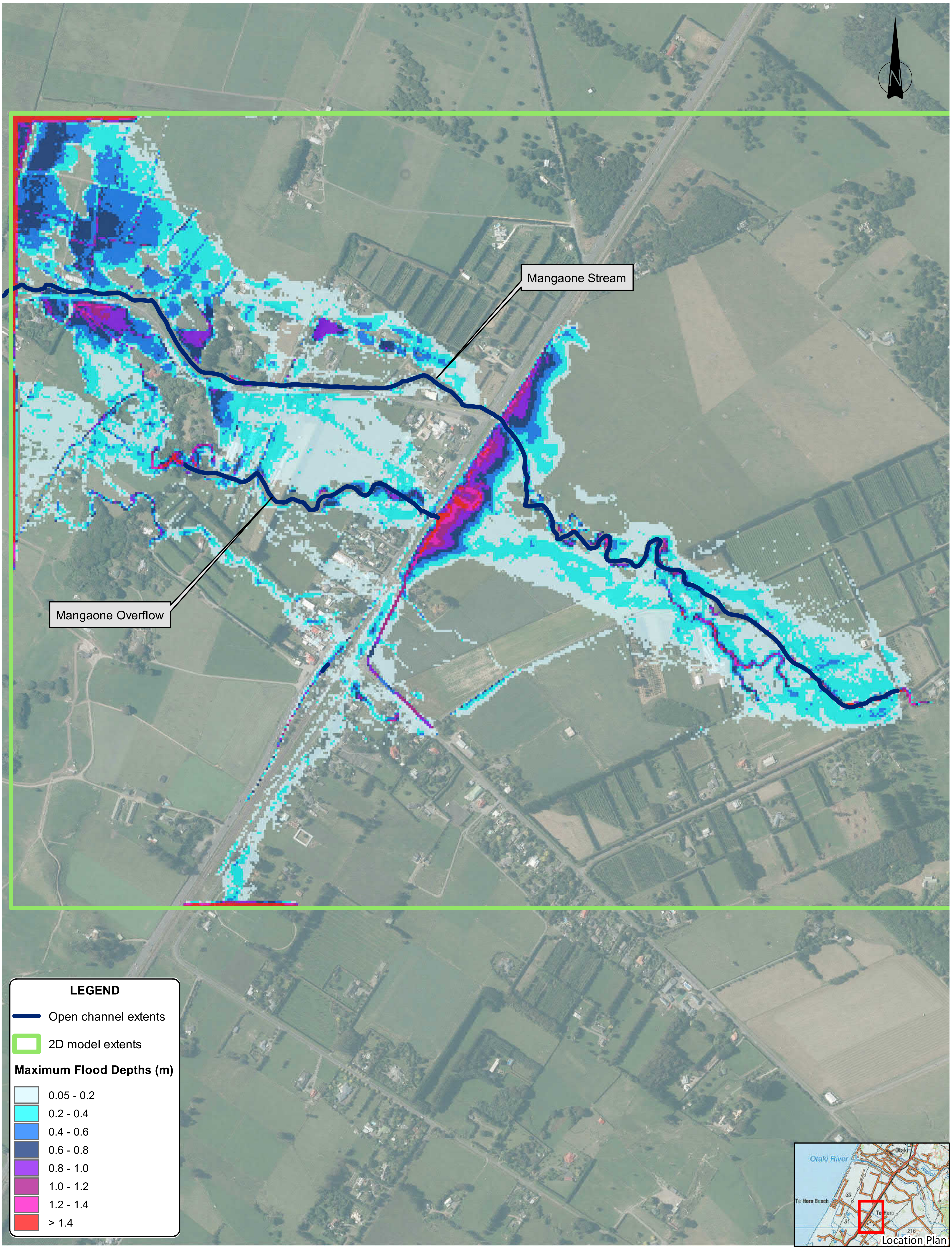
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Mangaone Model - 1% AEP CC2130

FIGURE No.
Figure 28.2

Rev.
0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig29_1_Mang_ModelResults_50yrCC.mxd Date: 23/03/2018 Time: 10:00:38 AM



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō “the Project”, and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:7,500

0 100 200 300 400 500 Meters

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Ōtaki Expressway

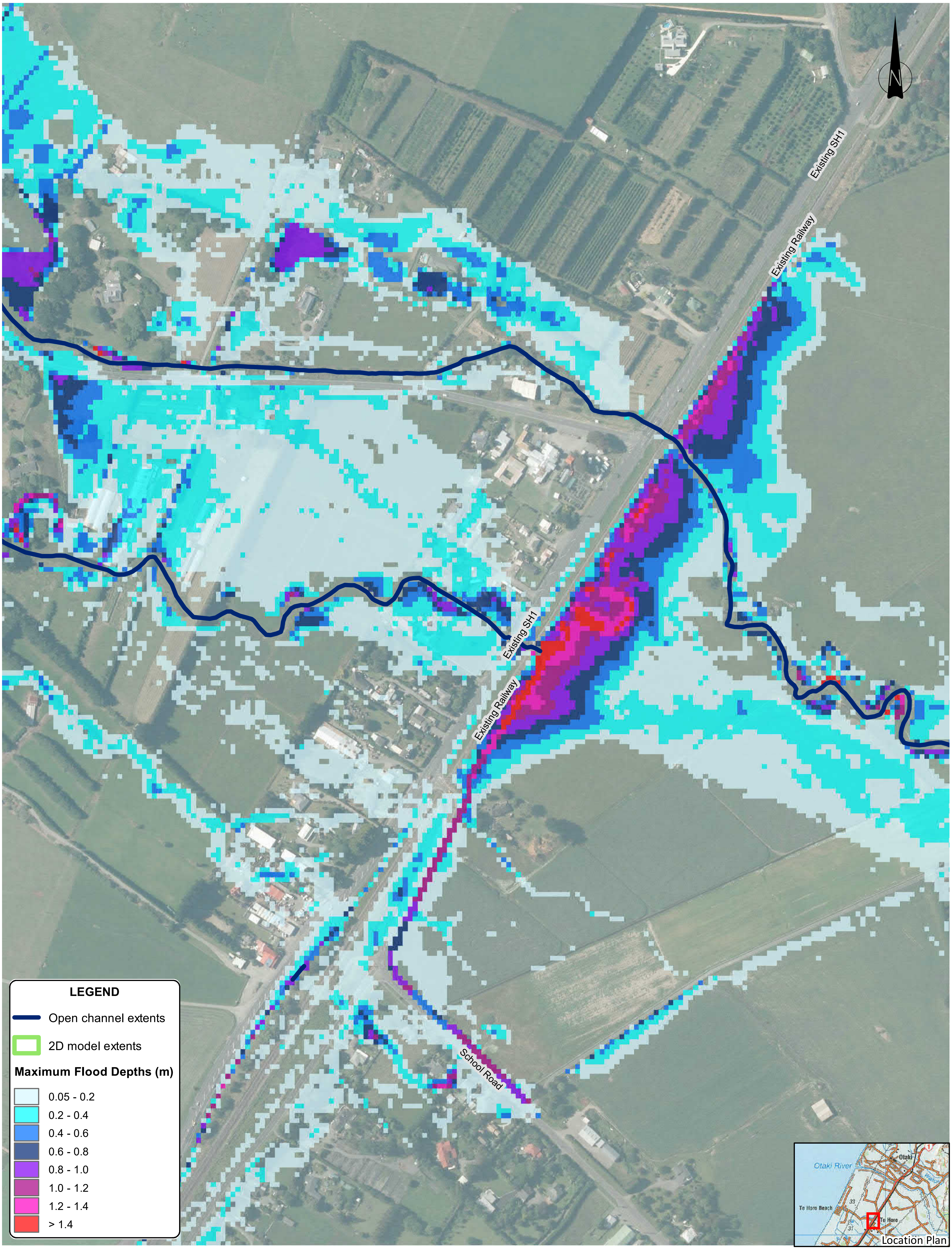
DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18
ARCFILE Fig29_1_Mang_ModelResults_50yrCC.mxd		
SCALE (AT A3 SIZE) 1:7,500		
PROJECT No. 85985.0070		

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Mangaone Model - 2% AEP CC2130

FIGURE No. Figure 29.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig29_2_Mang_ModelResults_50yrCC.mxd Date: 23/03/2018 Time: 10:01:51 AM



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:3,500

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig29_2_Mang_ModelResults_50yrCC.mxd

SCALE (AT A3 SIZE) 1:3,500

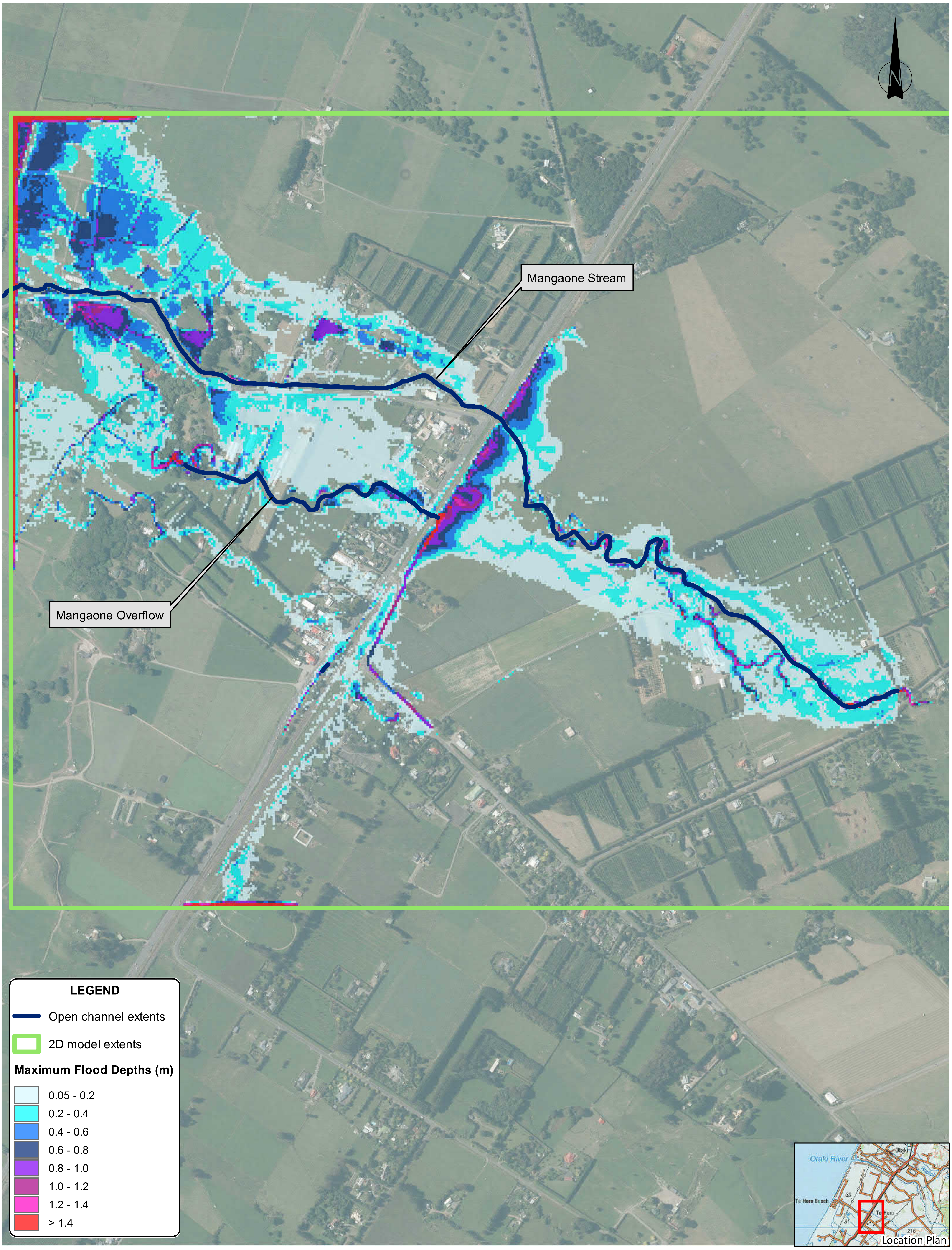
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Mangaone Model - 2% AEP CC2130

FIGURE No. Figure 29.2

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\New folder (2)\Fig30_1_Mang_ModelResults_20yrCC.mxd Date: 23/03/2018 Time: 10:03:28 AM



Notes: - Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:7,500

0 100 200 300 400 500 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig30_1_Mang_ModelResults_20yrCC.mxd

SCALE (AT A3 SIZE) 1:7,500

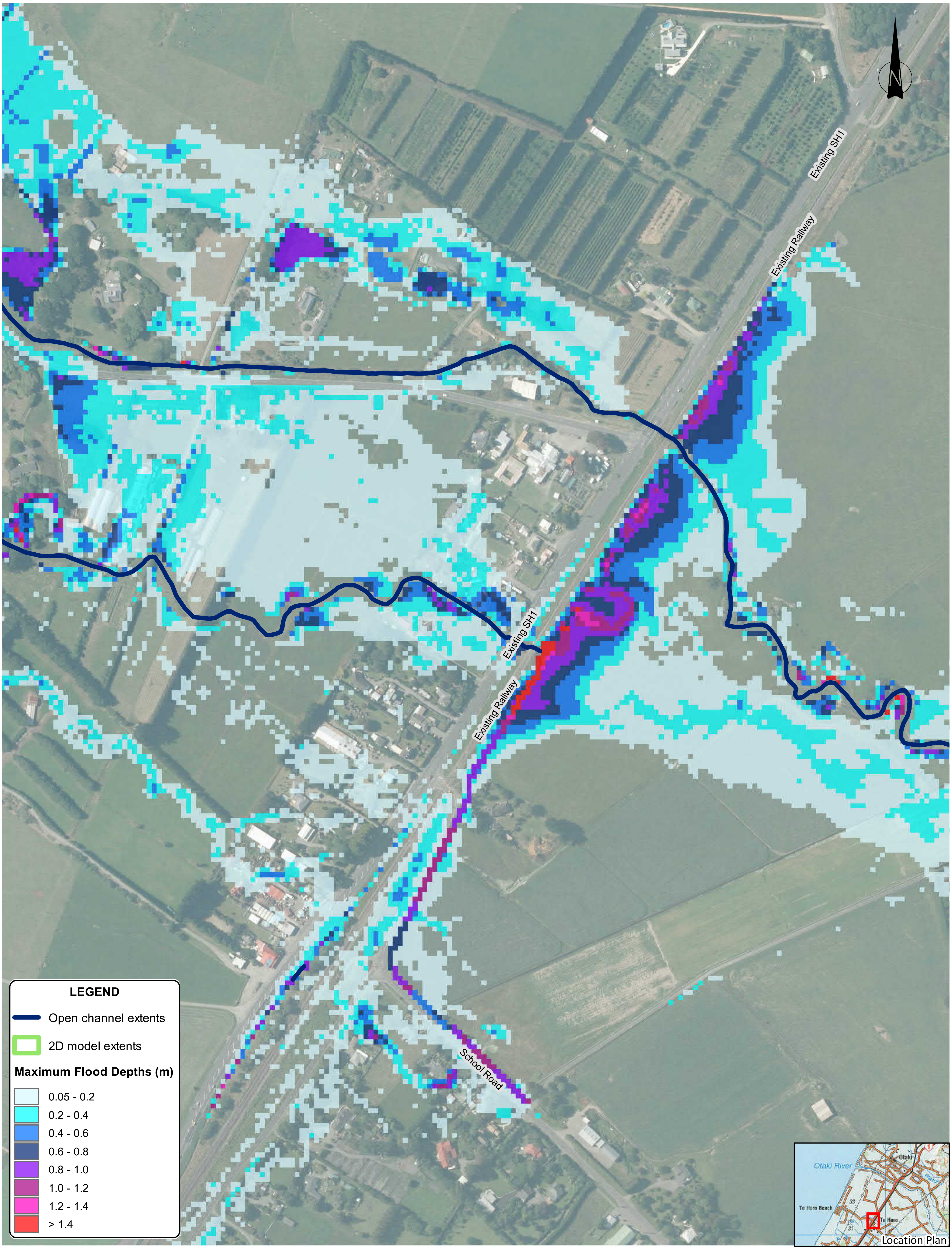
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Mangaone Model - 5% AEP CC2130

FIGURE No. Figure 30.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig30_2_Mang_ModelResults_20yrCC.mxd Date: 23/03/2018 Time: 10:05:26 AM



Notes: - Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō “the Project”, and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:3,500

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE
Fig30_2_Mang_ModelResults_20yrCC.mxd

SCALE (AT A3 SIZE)
1:3,500

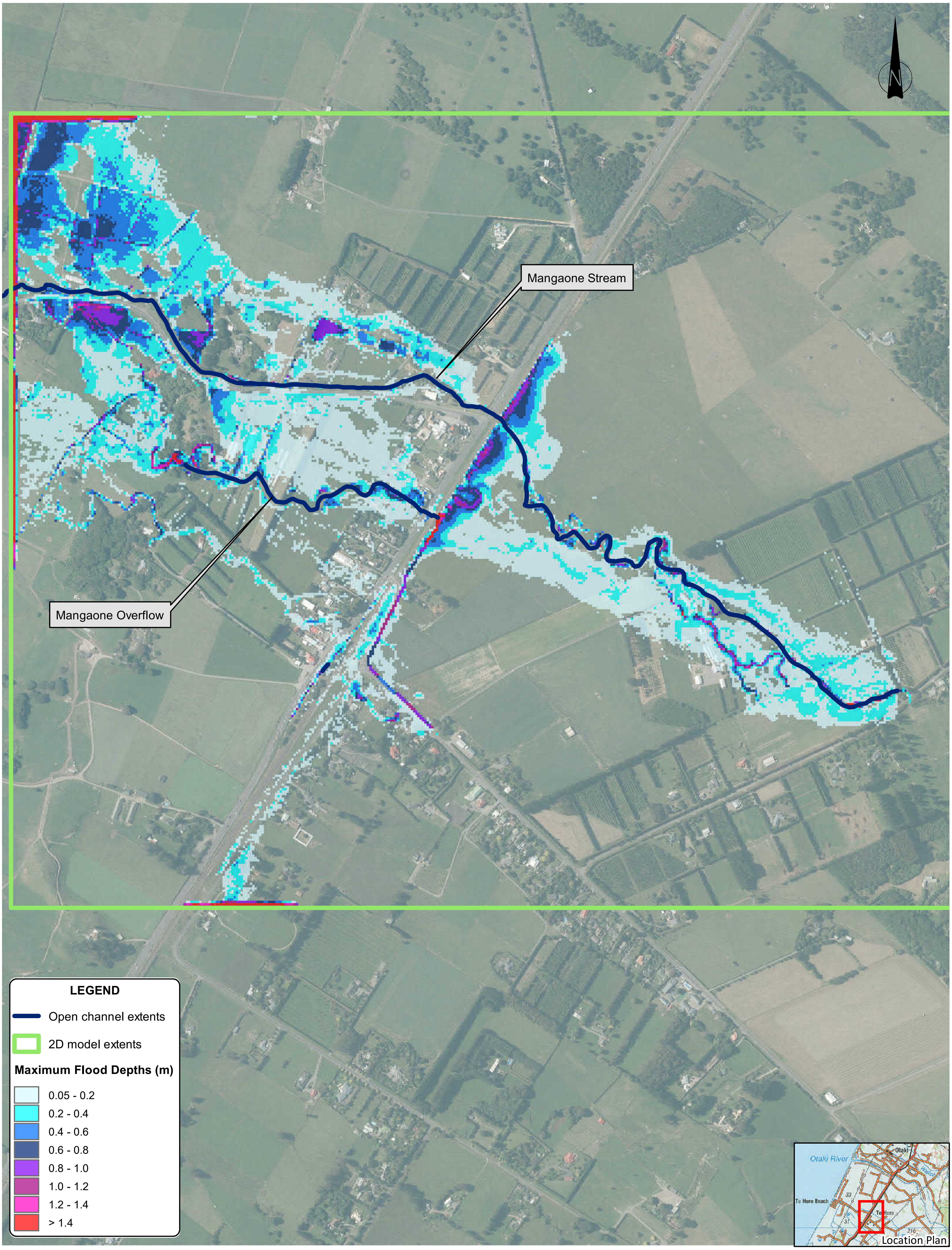
PROJECT No.
85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Mangaone Model - 5% AEP CC2130

FIGURE No.
Figure 30.2

Rev.
0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig31_1_Mang_ModelResults_10yrCC.mxd Date: 23/03/2018 Time: 10:07:21 AM



Notes:
- Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:7,500

0 100 200 300 400 500 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig31_1_Mang_ModelResults_10yrCC.mxd

SCALE (AT A3 SIZE) 1:7,500

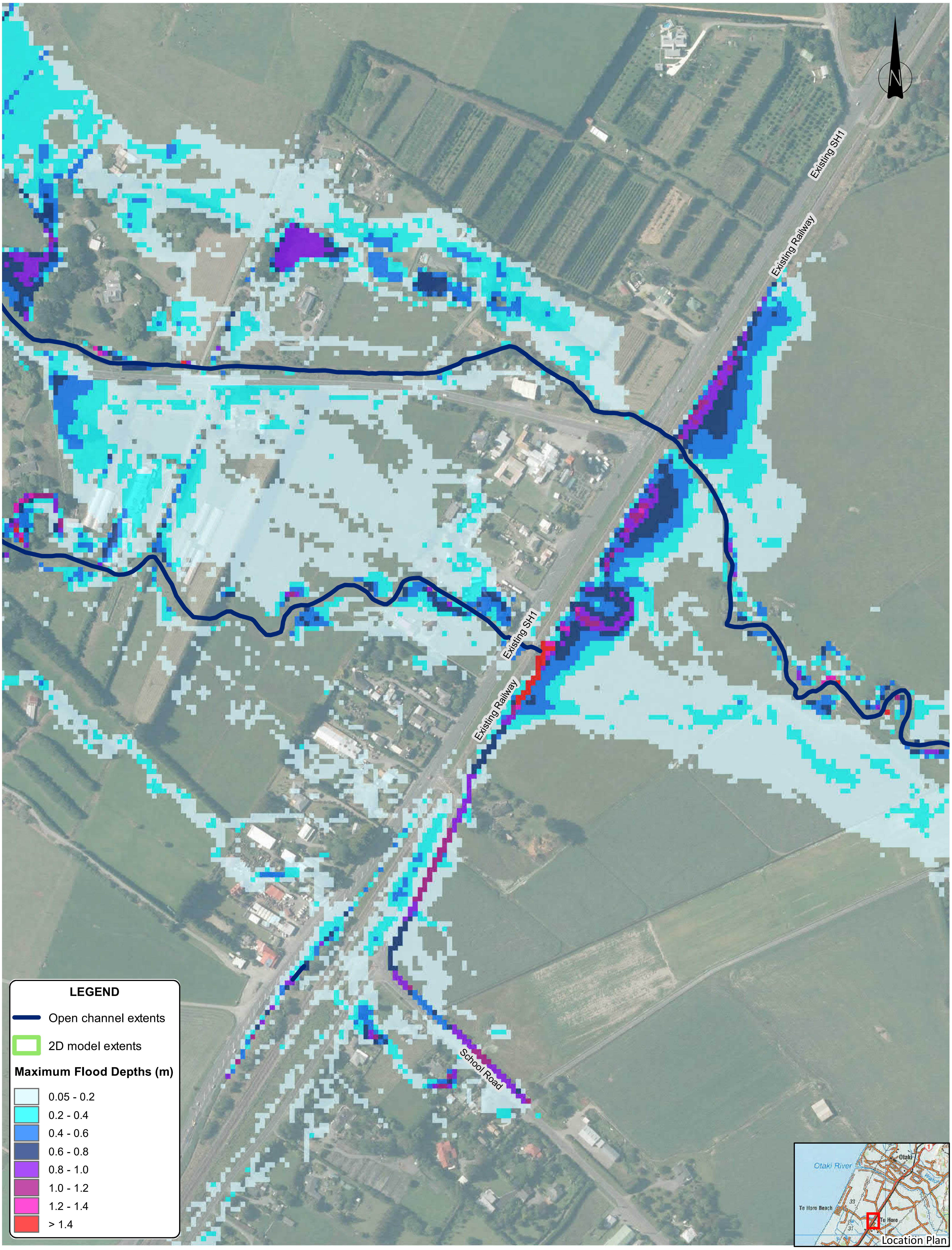
PROJECT No. 85985.0070

NZ TRANSPORT AGENCY
PEKA PEKA TO ŌTAKI EXPRESSWAY
Pre-Project Hydraulic Model Results
Mangaone Model - 10% AEP CC2130

FIGURE No. Figure 31.1

Rev. 0

Path: T:\Wellington\TT Projects\85985\85985.0070\5000 Stormwater\4 Hydraulic Modelling Schemetisation\GIS\FIGURES\20180321_PreProjectReportRev4\Fig31_2_Mang_ModelResults_10yrCC.mxd Date: 23/03/2018 Time: 10:08:21 AM



Notes: - Aerial photograph sourced from Greater Wellington Regional Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
- All levels are New Zealand Vertical Datum 2009.
- The flood modelling presented in this figure has been completed for the purposes of the Detailed Design and Construction Phase of PP2Ō "the Project", and may not be suitable for other uses. Model results may not be accurate outside the area of interest for the Project.

A3 SCALE 1:3,500

0 40 80 120 160 200 Meters

NZ TRANSPORT AGENCY WAKA KOTAHI

Peka Peka to Ōtaki Expressway

DRAWN	JOPA	Mar.18
CHECKED	DMK	Mar.18
APPROVED	TSRF	Mar.18

ARCFILE Fig31_2_Mang_ModelResults_10yrCC.mxd

SCALE (AT A3 SIZE) 1:3,500

PROJECT No. 85985.0070

NZ TRANSPORT AGENCY

PEKA PEKA TO ŌTAKI EXPRESSWAY

Pre-Project Hydraulic Model Results

Mangaone Model - 10% AEP CC2130

FIGURE No. Figure 31.2

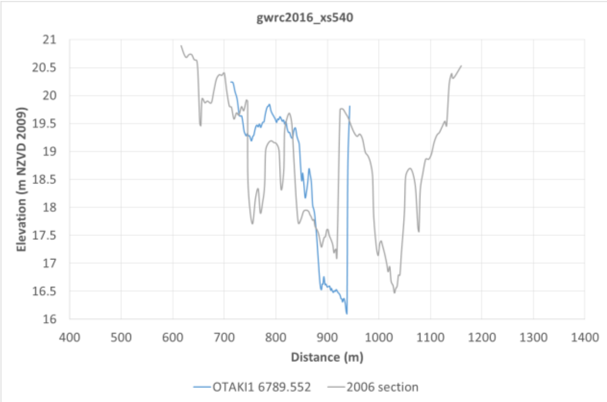
Rev. 0

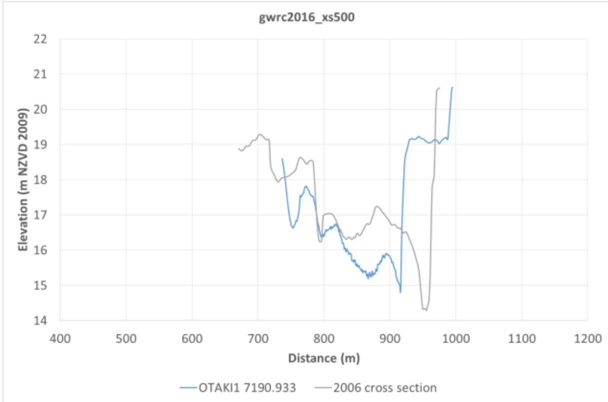
Appendix C:

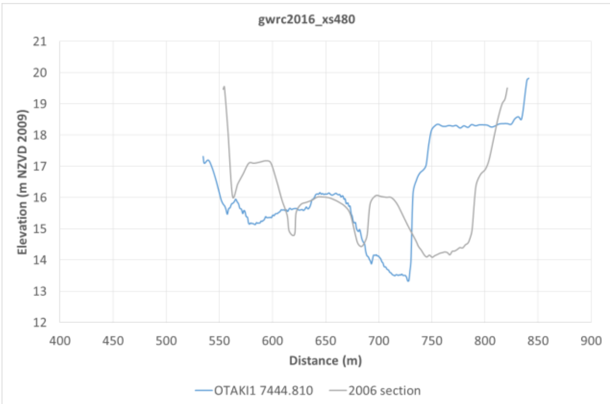
ŌTAKI CHANNEL TOPOGRAPHY COMPARISON

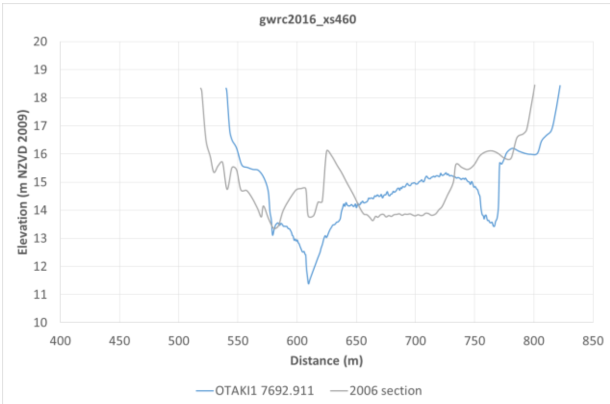
Appendix C: Ōtaki channel topography comparison

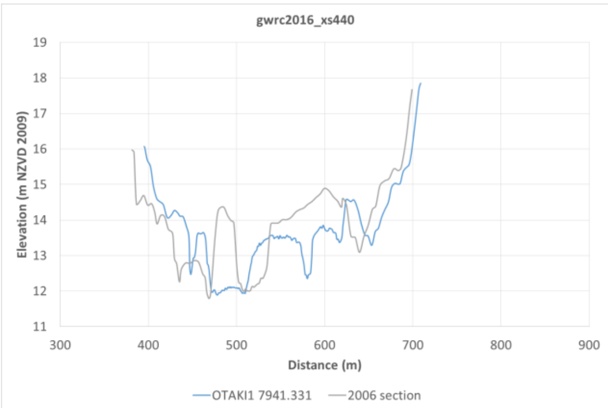
Topographical survey comparison (2006 and 2016 datasets) on the Ōtaki River show that significant changes to the channel morphology and bed levels have occurred upstream of the railway bridge. The latest hydraulic model (2016 channel survey) is therefore not representative of the January 2005 validation event channel conditions.

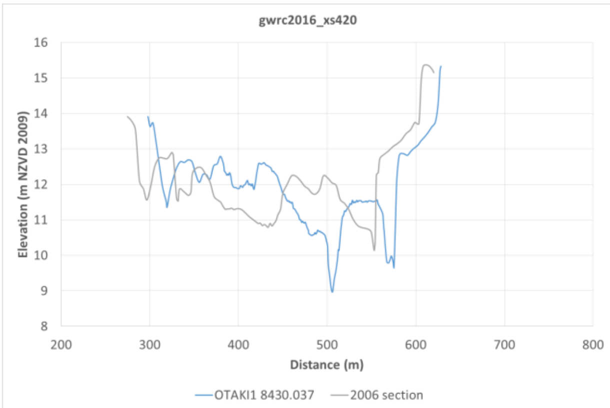


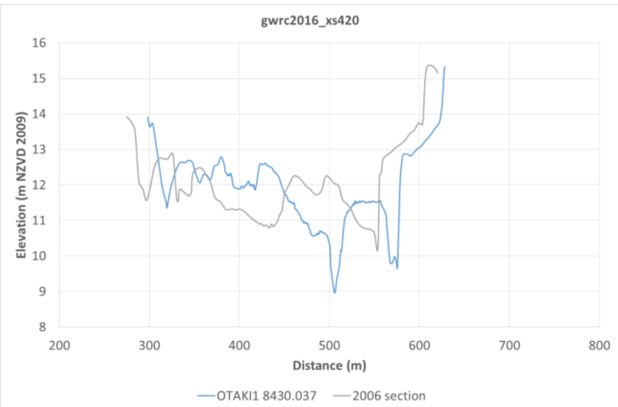


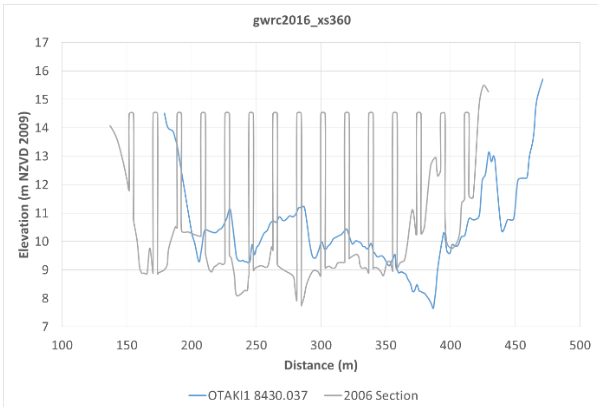






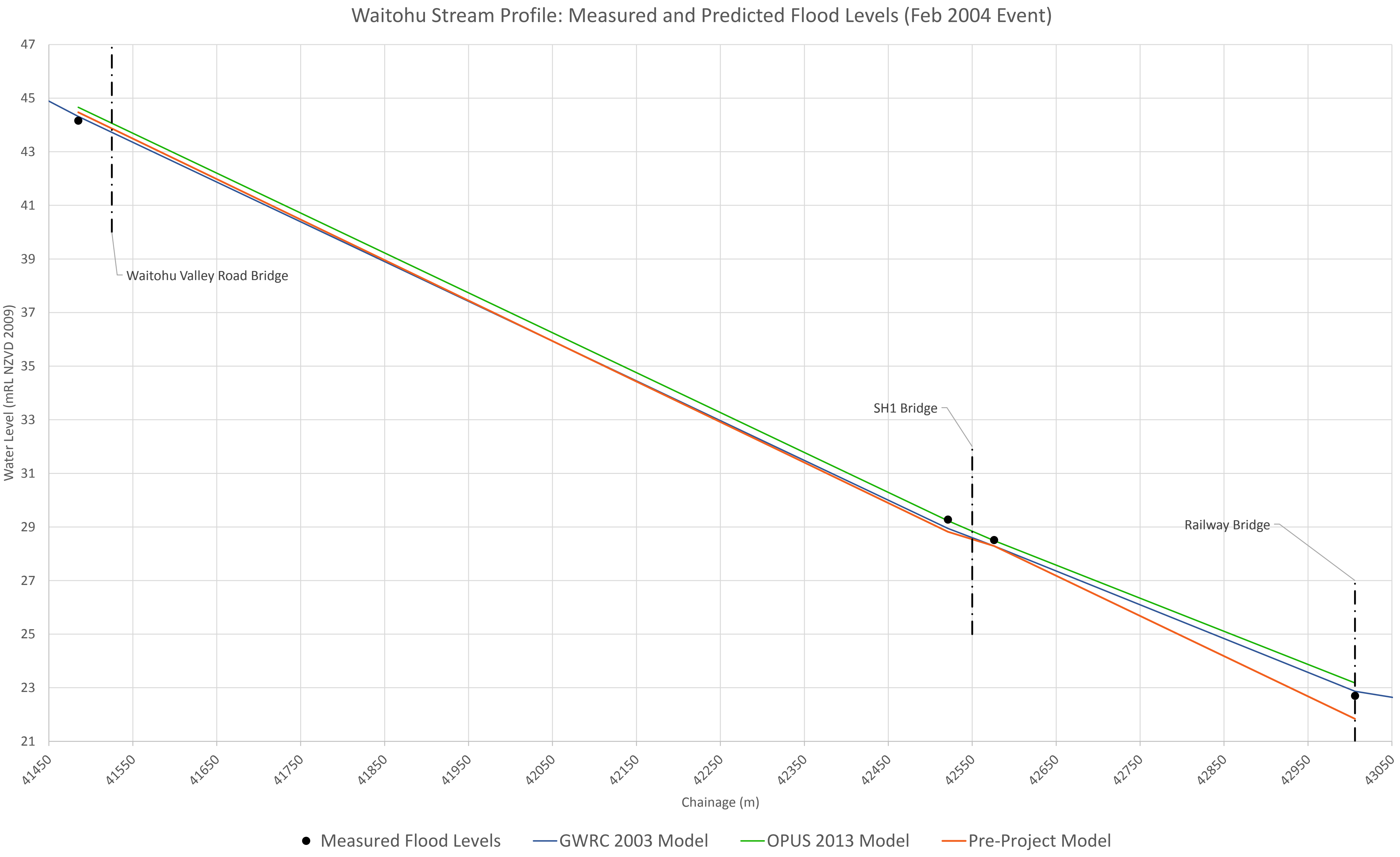






Appendix D:

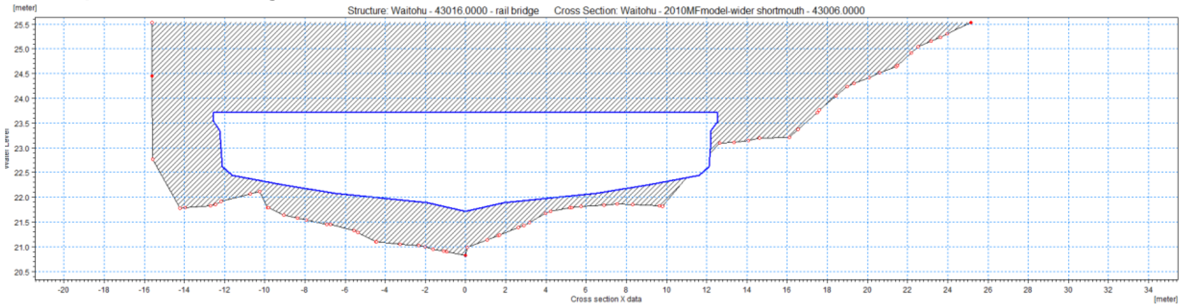
WAITOHU VALIDATION AND RAILWAY BRIDGE GEOMETRY COMPARISON

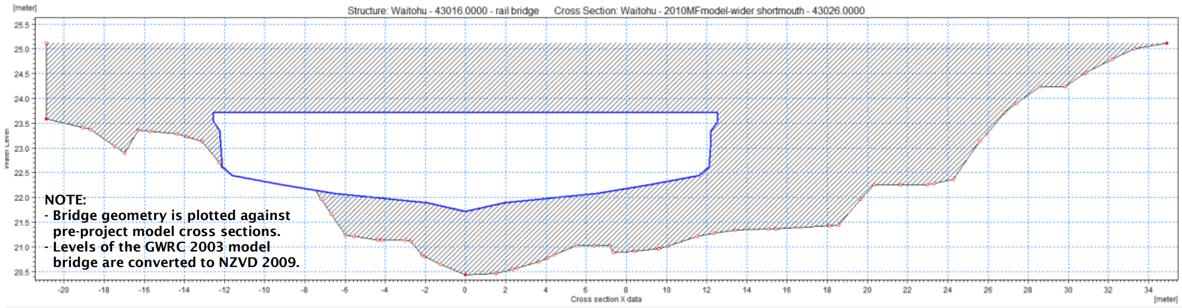


NOTE:
Only four data points are shown in the graph.
Model result lines shown here interpolate between 'measured flood level' locations.

Pre-2009 Rail Bridge (GWRC 2003 Model)

Extracted from Opus 2013 Existing Scenario Model

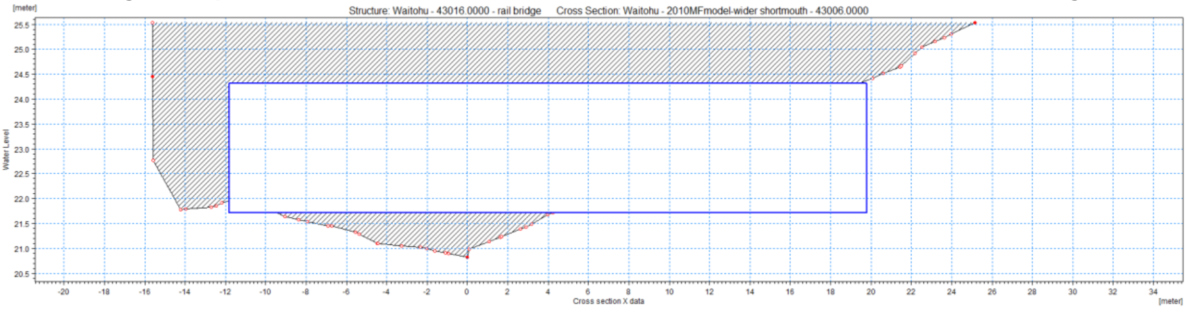


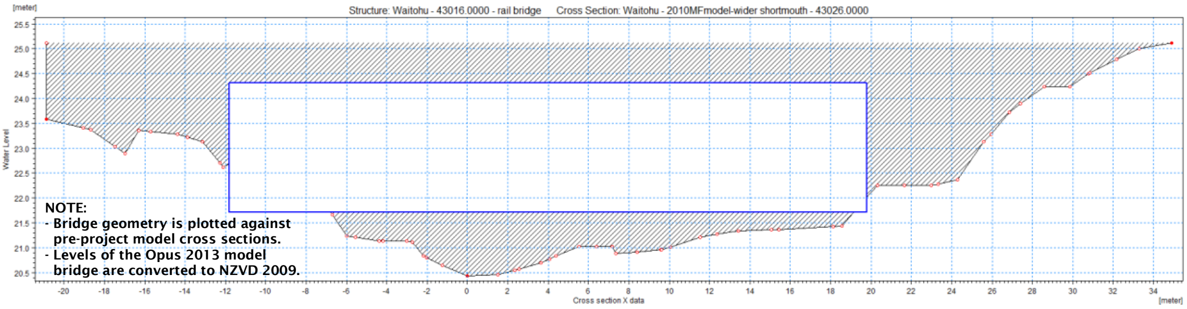


Post-2009 Rail Bridge (Opus 2013 Model)

Extracted from Opus 2013 Existing Scenario Model

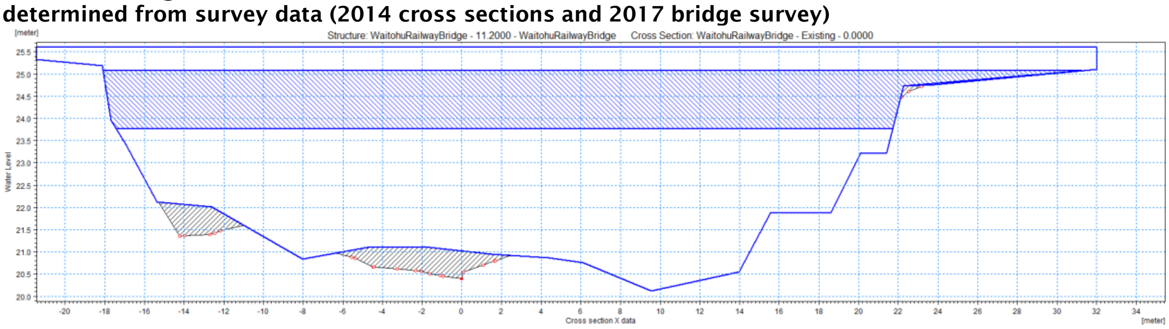
Rectangular culvert: geometry redefined (from GWRC model) based on details derived from as-built drawing

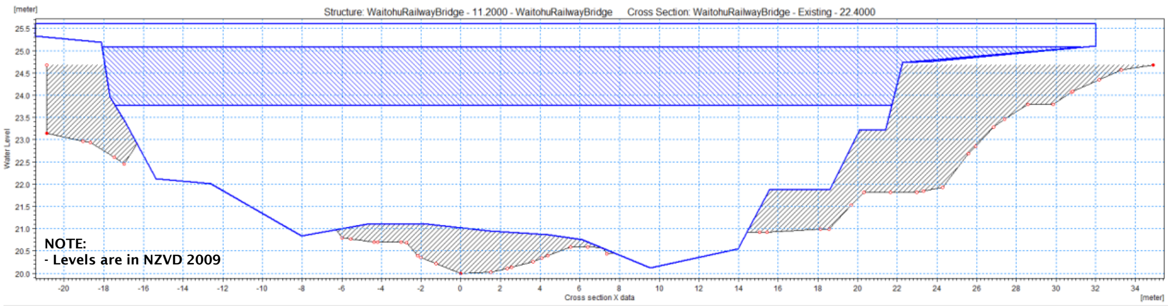




Pre-Project Rail Bridge

Geometry determined from survey data (2014 cross sections and 2017 bridge survey)





Appendix E:

PEER REVIEW AND PRINCIPAL'S ADVISOR CHECK COMMENTS

DESIGN REVIEW RECORD SHEET

Project Name	*PP2O*
Title of Document Reviewed:	*Pre-Project Hydraulic Model Build Report*
Reference No. of Document Reviewed:	*Rev 4*
Date of Document Reviewed:	*29/03/2018*
Comments:	

External Reviewer Name:	*Hugh MacMurray*		
Reviewer Discipline:			
Review Revision No.	A	Review Date	*14-Jun-17*
	B		*28-Feb-18*
	C		

Category Level	Status Level
C1: Critical Issue (to be resolved)	**S1: Resolve before proceeding with next stage of design**
C2: Important Issue (Request change)	**S2: Update during next stage of design**
C3: Discussion Item (Potential change needed)	**S3: Consider during next stage of design**
C4: Note (for consideration - no change needed)	**S4: Closed**

Item No	Drawing No./ Document Reference	Principal's Requirements Reference	Category Level	Disciplines affected	Review Revision	Review Comment	Design Response	Status
1	Pre project hydraulic model report		C1		A	Please include a section on calibration or validation of models against recorded flood levels	Included in Rev 2 of report.	S4
					B			
					C			
2	Waitohu model validation		C1		A	Please specify validation event and comparison of modelled and recorded peak levels in the report. Also please assess differences in cross secctions between validation event and latest survey, as used in model.	Included in Rev 3 of report.	S4
					B			
					C			
3	Waitohu 1%AEP+CC2130 peak level difference map Fig 4b		C3		A	Over most of the floodplain the peak levels are close to those predicted by the specimen design model. On the true left upstream of SH1 and NIMT, the specimen design predicted higher levels. Noted that the reduction of Lidar levels by 0.1m may explain why there would be more water on the floodplain.	Noted.	S4
					B			
					C			
4	First pre project hydraulic review meeting		C1		A	Please provide detail of where 2d cell levels were adjusted for coupling to 1d model	Check completed with latest version of model and provided to peer reviewer as part of Revision 2 bundle.	S4
					B			
					C			
5	First pre project hydraulic review meeting		C1		A	Please provide reference for setting eddy viscosity, Noted that eddy viscosity probably has little influence on resistance in shallow floodplain flows.	Recommended settings for MIKE by DHI. Formula is 0.02 dx^2/dt, where x is grid spacing and t is timestep.	S4
					B			
					C			

6	First pre project hydraulic review meeting		C1		A	Please confirm that the ULS event for Otaki should be the 3000m3/s event, rather than the 0.04%AEP+CC2130 event. Also please clarify whether this event is intended by the PRs to be at the rail bridge.	The Principal's Advisor has confirmed in NTC-148 that the 3,000 m3/s in the Otaki River is to be taken as the ULS event for the Expressway crossing of the Otaki floodplain. The NTC advises that it is reasonable for the ULS to be less stringent than the approaches at other major watercourses because of the unique situation for the Expressway crossing (floodplain generally dry and protected by stopbank) and uncertainty extrapolating a 60 year record to a 2500 year event. The Principal's Advisor has also issued an NTC-147 specifying that the climate change adjustment should be based on the out-of-date projections in MfE 2008 and MfE2010 as applied in OPUS 2014. Based on discussions with the Principal's Advisor, we understand that the intention of the NTC is for the detailed design to be based on a 26.4% adjustment to both rainfall and flows for climate change to 2130 (noting this omits the 1.33 peak flow amplification factor proposed in Rev 1 of our SW Design Philosophy Report). Based on the revised approach to climate change specified in NTC-147, the estimated peak flow at Pukehinau is 2941m3/s for the 0.04% AEP CC 2130 event, slightly less than the 3000m³/s event.	S4
					B			
					C			
7	Otaki - Mangapouri 1%AEP peak level difference map Fig 2c		C1		A	The pre project hydraulic model apparently shows a significantly greater area of flooding outside the Otaki river channel than the specimen design model. Please confirm that is due to different model schematisation - 1d branches in specimen design model and 2d domain in pre project model	Comparison has been updated and provided for latest version (Rev 2) of model. Note that in OPUS 2013 model, 2D area is reduced in Otaki model, and Mangapouri is represented in 1D only.	S4
					B			
					C			
8	Otaki - Mangapouri 1%AEP peak level difference map Fig 2c		C1		A	In some of the 2d domain that can be directly compared, Opus model gives significantly higher levels. Noted that lowered Lidar surface may be partly the reason. Please check in revised version of model (with some stopbank cells adjusted as discussed)	Noted. Check redone with revised version of model and provided to peer reviewer as part of Revision 2 bundle.	S4
					B			
					C			
9	Otaki river model		C1		A	Please specify the validation event in the report, and include the comparison of modelled and recorded flood levels.	Included in Rev 2 of report.	S4
					B			
					C			

10	Mangapouri model		C4		A	Noted that 1%AEP flood levels in pre project model are close to those in specimen design model. Specimen design model was validated against an observed level in the (de facto) detention basin upstream of the railway line.	Noted.	S4
					B			
					C			
11	Mangapouri model		C4		A	Noted that generally the peak flood levels are close to the specimen design over most of the floodplain, except at Ngatotara stream. Levels are significantly higher there, but the project could not have any effect on the SH1 or NIMT there, so the matter is not important with respect to the PRs or the resource consent conditions. Noted that the Ngatotara hydrograph in pre project model has higher peak flow and higher volume than that used in the specimen design modelling.	Noted.	S4
					B			
					C			
12	Otaki river model		C4		A	Noted that the cross sections around the bridges have significantly greater cross sectional area now than in the survey used to build the specimen design model (ref comparison plots made by T+T June 17).	Noted.	S4
					B			
					C			
13	Otaki river model		C1		A	Please check the effect of changing the hydraulic radius to resistance radius (as in the specimen design model).	Sensitivity run completed. Resistance radius does not have an effect on results.	S4
					B			
					C			
14	Otaki river model		C1		A	Please check the effect of moving the end of the coupled reach closer to the railway bridge. In reality a lot of the return flow to the river probably occurs close to the bridge, and the model should not restrict or prevent the return flow.	Test runs discussed at meeting 13/06/2017. Location of cross sections upstream of bridge has impact on water levels at structure. XS to be placed a nominal distance ~20m upstream (c.f. to original distance of around 250m), which will allow coupling to be more accurately represented.	S4
					B			
					C			
15	Pre project hydraulic models		C1		A	Please indicate where 1d channels have been represented by "burning in" to the 2d domain, and justify this representation	Figure to be added in next iteration of report (Rev 2). We consider that the "burned" in channels are sufficiently represented. Discussed at meeting 13/06/17.	S4
					B			
					C			

16	Mangaone stream model		C4		A	Generally over the floodplains, the peak flood levels in the pre project model are close to those in the specimen design model, in the 1%AEP+CC2130 event.	Noted.	S4
					B			
					C			
17	Mangaone stream model		C1		A	In the 1%AEP+CC2130 event, the culvert flows reported in the specimen design model are significantly higher than those in the pre project model. Also the pre project model has a steeper hydraulic gradient between the road and railway than through the culverts. In investigating this at T+T opffice 13 June 2017 it was noted that the inflow hydrograph has greater peak flow and greater volume in the pre project model than in the specimen design model, and that the former model has greater flows over the railway line. It seems possible that in the pre project model the culvert flows are limited by backwater effect from the floodplain flows downstream. Please make water level time series plots to confirm that the culvert flows are realistic. In investigating this problem at T+T office 13 June 2017, it was found that the a substantial part of the flow is carried over the railway line, and that the Mangaone stream culvert is at a slightly higher part of the railway, and near the edge of the flow over the railway line. The pre project model was checked in detail and appears to represent the physical features well. Please also run the Mike 11 1d branches representing the Mangaone stream rail and highway culverts on its own, to check that coupling with the 2d model does not cause anomalous behaviour in the area between the road and the rail.	Discharge plots issued to peer reviewer 14/06/2017. Head loss issues resolved in next iteration (Rev 2) of model.	S4
18	Mangaone stream model		C1		A	Noted that the specimen design model included a northern subcatchment on the east side of the railway line, and that was used to assess the adequacy of the arrangements used to carry flow southwards under the local link road overbridge. How will this matter be addressed in the project design?	The width of the culvert (Culvert 23a) to convey flows from the northern subcatchment under the local link road embankment is specified in PR A21.5.6s as 5m. We have adopted the 5m width in accordance with PR A21.5.6s, rather than re-examining the capacity required, recognising that this depends on the accuracy of the earlier flood modelling undertaken to support development of the PRs.	S4
evision 2 - issued 25/8/17 evision 3 - issued 25/10/17								
19	Table 1		C4		A	Useful summary of model history	Noted.	S4
					B			
					C			

20	Sec 3.1				A	The Otaki River level at the rail bridge in the 2005 event is higher than the observed flood level, but that level is quite uncertain as it is not supported by any other flood level, and it is not a surveyed debris mark even, being estimated from Lidar data and an anecdotal report. Considering that, it is appropriate that the model appears somewhat conservative.	Noted.	S4
					B			
					C			
21	Sec 3.2		C4		A	Validation against the Feb 2004 storm acceptable, considering that it is a small storm, the model has new cross sections downstream of the SH1 bridge, and the lower level at the rail bridge as a result of the new bridge there.	Noted.	S4
					B			
					C			
22	Sec 3.3		C4		A	In view of the lack of calibration data, the approach of comparing 1%AEP CC2130 results with the Opus 2013 model is appropriate.	Noted.	S4
					B			
					C			
23	Fig 11.1		C3		A	Understood to be in response to Item 4 above. Why was it necessary to modify the ground levels on both sides of the railway as shown?	There are two small channels on either side of the railway which convey flow from the Railway Wetland to the Mangapouri Stream. These channels were 'burned in' to the 2D terrain to provide connectivity between the Wetland and the Stream.	S4
					B			
					C			
24	Pre Project TT internal review spreadsheet, Comparison of flood levels in 1%AEP CC2130 flood with Opus 2013 model for Mangaone				A	Mangaone comparison with Opus 2013 acceptable. But noted that the Opus model simulates flow over SH1 north of the T&T model extent. To be considered when designing the Te Horo east flood bund.	Noted. The Te Horo Eastern Flood Bund will extend to chainage 6,500m in the north as per the Specimen Design.	S4
					B			
					C			
25	Pre Project TT internal review spreadsheet, Comparison of flood levels in 1%AEP CC2130 flood with Opus 2013 model for Otaki				A	Otaki comparison with Opus 2013 acceptable. Pre project model generally gives lower levels on the floodplains in the range 0.1 to 0.25m. However the pre project model flooding extent is significantly greater, which may partly explain the difference.	Noted.	S4
					B			
					C			

26	Pre Project TT internal review spreadsheet, Comparison of flood levels in 1%AEP CC2130 flood with Opus 2013 model for Waitohu				A	Waitohu comparison with Opus 2013 generally acceptable. However pre project model gives lower levels on the true left of the Waitohu upstream and downstream of SH1. The links of Waitohu 1d branch to 2d were checked and found ok. The pre project model has greater extent of flooding on floodplains upstream of SH1, which partly explain the difference.	Noted.	S4
					B			
					C			
Comments for Revision 4 issue of 100% Waitohu and Mangaone models only - issued 22/02/18								
27	Waitohu model validation		C3		A			
					B	Greenwood 4 and Greenwood 3 are unstable in regions of backwater (upstream of Ngatotara siphon and upstream of taylors rd railway culvert). The effect in the areas of interest is probably minor.	Noted.	S4
					C			
Comments for Revision 4 - issued 29/3/2018								
28	Sec 2.2.6		C3		A			
					B			
					C	The Culvert 80% Design report is given as the reference for the flow boundary conditions. But that report just contains the same material as the Design Philosophy report. I suggest that as the Design Philosophy report is the definitive original source it should be quoted.	We will revise the reference to include the Design Philosophy Report as the original source, but for ease of reference, we will also note that the information is reiterated in the Stormwater 80% Design Report and Culvert 80% Design Report, with additional detail on rainfall-runoff model inputs in Appendix A of the Culvert 80% Design Report.	S4
29	Table 6	SW.2 (a)	C3		A			
					B			
					C	1%AEP+CC2130 is not ticked as a scenario for Otaki Mangapouri model, and there are no figures for this case in Appendix B. Resource consent conditions require that the effects of the project be sensitivity tested for climate change uncertainties by simulating the 1%AEP+CC2130 event. That doesn't necessarily require a pre project case simulation of that event. Further comments on this are included in the Post Project model report review.	We understand you are referring to the 1% AEP CC2130 (High Range) since the 1% AEP CC2130 (Mid Range) is included in the table and figures. In the final version of the Post Project report, we will assess the sensitivity for climate change uncertainty by preparing water level difference plots of the 1% AEP CC2130 High Range versus Mid Range scenarios (both for the Post Project situation).	S4

DESIGN REVIEW RECORD SHEET

Project Name	PP2O
Title of Document Reviewed:	Pre-Project Hydraulic Model Build Report
Reference No. of Document Reviewed:	Rev 4
Date of Document Reviewed:	29/03/2018
Comments:	

External Reviewer Name:	Daniel McMullan		
Reviewer Discipline:	Hydraulics		
Review Revision No.	A	Review Date	29-May-17
	B		16-Jun-17
	C		6-Sep-17
	D		6-Nov-17

Category Level	Status Level
C1: Critical Issue (to be resolved)	**S1: Resolve before proceeding with next stage of design**
C2: Important Issue (Request change)	**S2: Update during next stage of design**
C3: Discussion Item (Potential change needed)	**S3: Consider during next stage of design**
C4: Note (for consideration - no change needed)	**S4: Closed**

Item No	Drawing No./ Document Reference	Principal's Requirements Reference	Category Level	Disciplines affected	Review Revision	Review Comment	Design Response	Status
1	Section 2.3.2		C3	Flood Management	A	Are the channels that were 'burned in' to the terrain sufficiently represented in the 5m grid?	We consider that the "burned" in channels are sufficiently represented. We will also discuss this aspect with the Peer Reviewer at a meeting scheduled for 13/6/17 to make sure he is also satisfied with our approach.	
					B	Noted. Considered acceptable provided Peer Reviewer approves the schematisation.	[Refer to Item 15 of Design Review Record from Peer Reviewer Hugh MacMurray, dated 14-Jun-17]	S3
					C	Noted - comment closed		S4
2	Section 2.3.4		C1	Flood Management	A	Similar to Figure 10, please include a figure of the resistance map for the Waitohu catchment floodplain. The Opus 2013 model of the Waitohu catchment floodplain had a Manning's M of 16.67 for the stream banks, not a constant Manning's M of 25 as the report indicates has been used.	We will include the requested figure in the next iteration of the report.	
					B	Noted. Variable Manning's M in MIKE21 is expected to be shown.	[Provided in Peka Peka to Otaki Expressway - Pre Project Hydraulic Model Report Rev 3]	
					C	Noted - comment closed		S4
3	Section 3	A21.4.4	C1	Flood Management	A	Please include a table of all the peak inflows following T+T's hydrological analysis. For the PR departure of the Waitohu Stream hydrology, please include an inflow hydrograph of the Waitohu Stream for the 1% AEP + CC2130 comparing the Specimen Design inflow with the updated hydrology. The updated hydrology will also need to be agreed with the appropriate GWRC hydrologist.	The hydrological assessment is relevant across most elements of the stormwater design, and our intent is to provide a consistent framework. Although the hydrology is relevant to both the Pre-Project Hydraulic Model Build Report as well as the Stormwater Design Philosophy Report (DPS), we have decided to present the hydrological assessment (including the table and comparison of inflow hydrographs) in the DPS since the DPS has a wider focus that is more suited to the broad relevance of the hydrological approach. Comments regarding the departure for the Waitohu Stream hydrology noted.	
					B	Noted - comment closed		S4
					C			

4	Appendix B		C2	Flood Management	A	Mangapouri catchment is difficult to see in the combined Otaki-Mangapouri figures. Please include separate figures for Mangapouri.	We will include a "zoomed in" figure of the Mangapouri area in the next iteration of the report.	
					B	Noted	[Provided in Peka Peka to Otaki Expressway - Pre Project Hydraulic Model Report Rev 2]	S4
					C	Noted - comment closed		
5	Section 1.7	A21.4.10	C1	Flood Management	A	Consider including in the section that where possible the Fletchers have attempted to ensure the Fletcher's model approximately matches the calibration of the GWRC models (Otaki & Waitohu), and is approximately in line with the OPUS Mangapouri and Mangaone models. Large differences in water level (i.e. greater than 200mm) should be discussed with the Peer Reviewer.	Following extensive discussion with the Peer Reviewer regarding calibration, we have validated Fletcher model results against observed flooding in historic events directly (noting the limited data available), rather than relying on calibration of previously developed models. A section on this validation process will be included in the next iteration of the report. This will also be discussed further with the Peer Reviewer at the meeting scheduled for 13/6/17.	
					B	Noted. We'll look forward to seeing the results of the validation process. Model results are expected to be more in line with the Specimen Design model to ensure flood risk is not excessively under or overestimated.	[Validation section provided in Peka Peka to Otaki Expressway - Pre Project Hydraulic Model Report Rev 2]	S3
					C	Noted - comment closed		S4

Comments for Revision 2 - issued 25/8/17								
6	Section 3.1.3		C3	Flood Management	A	T+T levels are reportedly 0.5m lower than Opus models, and the report states that the source of the Opus (2013) ground levels is unclear. Section 1.7 of "Peka Peka to North Otaki Expressway Hydraulic Investigations for Expressway Crossing of Otaki River and Floodplain" report (2013) states that the topographic data was sourced from LiDAR collected by KCDC in 2010. Could the source of the 0.5m difference be due to the model differences in datums. i.e. Opus (2013) models used Wellington (1953) MSL, whereas T+T have used NZVD2009? A 0.5m difference in topographic ground levels would be significant and would need further investigation.	This section is referring to the Ōtaki-Mangapouri model validation, and specifically the ground levels around the property of 22 County Road. The 2D component of the Opus (2013) model does not include the area around this property. The comment that the source of the ground levels is unclear relates to Section 3.6 of "Peka Peka to North Otaki Expressway Hydraulic Investigations for Expressway Crossing of Mangapouri Stream" report (Opus, 2013) where the following statement is made: "Inspection of ground levels in the vicinity of the house at 22 County Road indicates that these are in the range of 14.2-14.4m MSL Wellington 1953." This equates to 13.76-13.96mRL NZVD 2009 as noted in Section 3.1.1 of the Pre Project Hydraulic Model Report (PP2Ō, October 2017). KCDC 2010 LiDAR indicates that ground levels on this property range from 12.9-13.8mRL NZVD 2009, but are generally 13.2-13.4mRL NZVD 2009, i.e. approximately 0.5m lower than the levels reported in Opus 2013. The ground levels in the latest Pre-Project models are 13.1-13.3mRL NZVD 2009 in this same area (incorporating a 0.1m adjustment to the KCDC 2010 LiDAR as discussed in the "Principal Supplied LiDAR QA Report", (BECA, March 2017).	
					B	Noted - comment closed		S4
					C			
Comments for Revision 3 - issued 25/10/17								
7	Figure 25.2		C3	Flood Management	A	Flood extents for the Greenwood Stream appear significantly less than the previous Opus models. It is noted that the only other changes to the model in this area include the extension of the Greenwood Stream in the MIKE11 model and a small reduction in the inflows. Please provide a comment as to the cause of the reduction in flood extents and associated ~0.5m drop (from the Specimen Design models) in peak water level immediately upstream of the existing SH1.	Model instabilities were noted along Greenwood Stream and addressed in the latest model iteration. Flood extents have now altered in the Greenwood area and flood levels are within 100-200mm of the Specimen Design models upstream of the existing SH1.	
					B	Noted - comment closed		S4
					C			