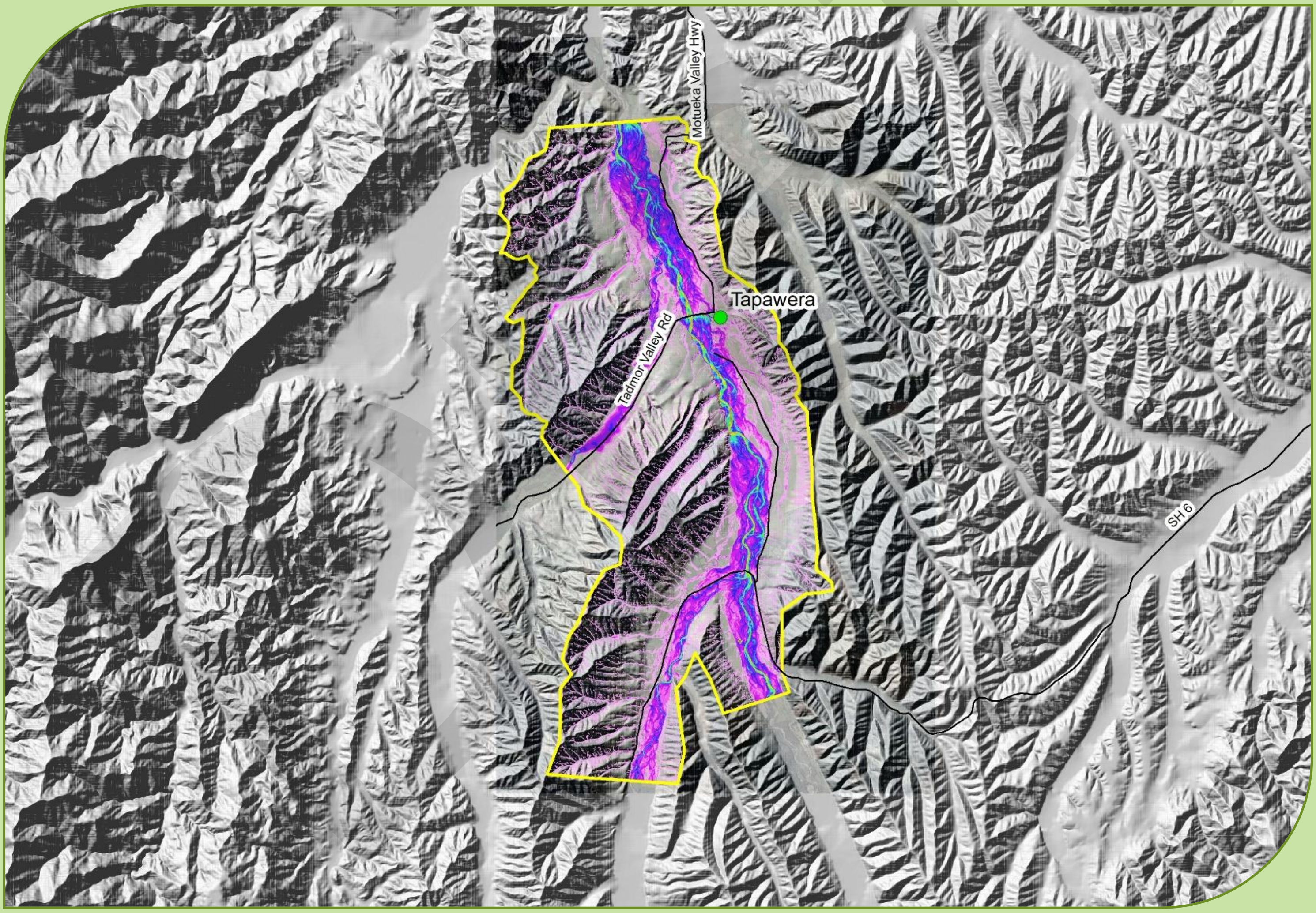
Upper Motueka River Modelling Report

Phase 2

Tasman District Council

09/11/2020



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EXECUTIVE SUMMARY

Tasman District Council (TDC) engaged e2Environmental Ltd. (e2) to conduct a flood modelling exercise to assess the flood risk on the Upper Motueka River and its floodplain for the existing land use, future land use, and climate change (RCP 8.5 for the period 2081 - 2100) scenarios. The primary area of interest covers a section of the Upper Motueka floodplain from upstream of the confluence of the Upper Motueka River and the Wangapeka River to the Norths Bridge upstream of Kohatu.

A two-dimensional only approach and direct rainfall method (DRM) using DHI MIKE Flood software package was adopted following a scoping workshop between TDC and e2. To develop a model with accurate enough resolution while maintaining practical model runtime, the flood model was divided into two components: the hydrology model and the hydraulic model. The hydraulic model covers the primary area of interest and its adjacent hillside catchments. The hydrology model covers the catchments upstream of the hydraulic model, which include Tadmor, Motupiko and Upper Motueka catchments. The results from the hydrology models were used as the inflow boundary conditions in the hydraulic model.

The hydrology models were calibrated so that the model results at the gauging sites match the TDC's flood frequency analysis. For the hydraulic model, a sensitivity testing on a selection of model input parameters including bed roughness values, infiltration rates, rainfall depths and activation of Eddy viscosity was conducted to provide a level of certainty in all the modelling results presented in the study.

For the hydraulic model, the existing land use condition without climate change, future land use condition with and without climate change scenarios for the 5% AEP, 2% AEP, 1% AEP and 0.4% (1 in 250) AEP storm events were simulated. The results were compared to analyse the impacts of land use change and climate change.

The analysis shows that the majority of the Near-future hop industry development area, the southern part of the Current hop industry development area and the area immediately south of the Tapawera township have an increase in flood depth as a result of land use change. The increase mostly ranges between 50 mm and 100 mm.

The climate change has a relatively larger impact. The comparison shows that the flood extents are similar, but the flood depth in the river channel and its adjacent floodplain is significantly higher for the climate change scenarios. The amount of increases becomes greater as the rainfall intensity increases. For the 5% AEP event, the increase is mostly between 200 mm to 400 mm. For the 2% AEP event, the increase is mostly between 300 mm to 600 mm. For the 1% AEP event, the increase is mostly between 300 mm to 700 mm. For the 1 in 250 AEP event, the increase is mostly between 400 mm to 1 m.

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1 INTRODUCTION

1.1 Background

Tasman District Council (TDC) is seeking to carry out an assessment on the flood risk on the Upper Motueka River and its floodplain, and the potential effects of a large flood event on the river channel and surrounding environment. e2Environmental Ltd. (e2) was engaged by TDC to develop a thorough and well documented flood model approach (Phase 1), and to conduct model build and simulations (Phase 2) to assist the assessment.

1.2 Description of the Area of Intetest

There are essentially two areas of interest: primary and secondary. Figure 1 shows the primary area of interest. The area covers the floodplain from upstream of the confluence of the Upper Motueka River and the Wangapeka River to Norths Bridge upstream of Kohatu. The main township is Tapawera.

The reach in question is managed by TDC for river control purposes. The Nelson Catchment Board managed this reach previously including the establishment and maintenance bank edge protection works (particularly willows) to confine the channel.

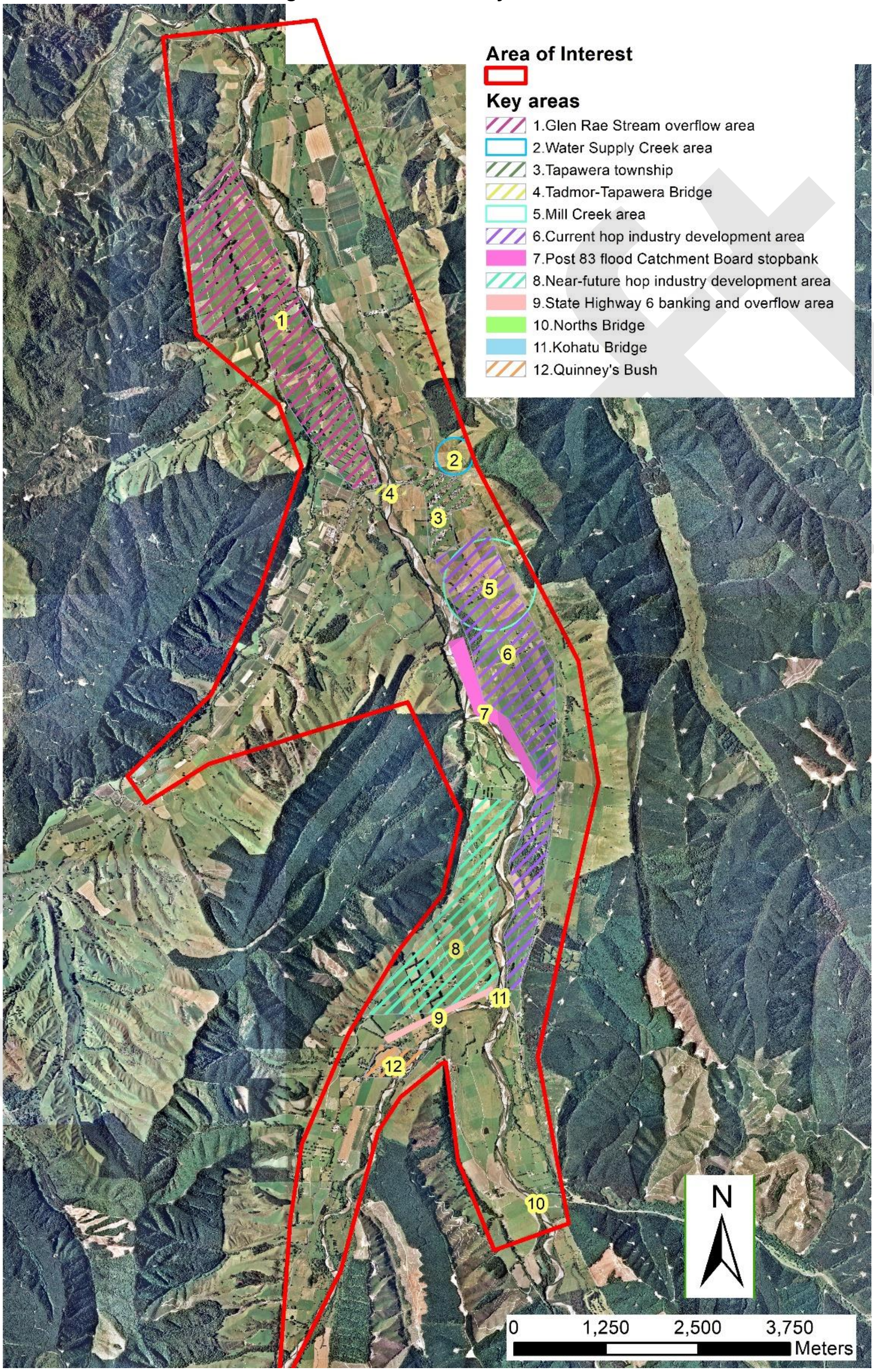
The adjacent floodplain is currently undergoing an accelerated period of land-use change due to the popular hop industry.

Tapawera, which is located 53km south west of Nelson, is the main township in the area of interest. It is a small town of approximately 290 residents. The town is located on a terrace along this reach of the river. It is a small town with a school, petrol station, community centre, pub, grocery store and rural service businesses with the next nearest towns being Wakefield and Motueka.

There has not been a significant flood affecting this area since 1990 other than relatively small events that have caused bank erosion and flooding of low-lying land close to the river channel.

The secondary area of interest is one of hydrology only and includes the major flow inputs into the primary area of interest. The secondary area of interest covers the Upper Motueka, Motupiko, and Tadmor catchments. Section 4 provides a detailed description of the catchments.

Figure 1 – The area of interest.



1.3 Study Objectives

The objectives of this modelling exercise are to:

1. Assess flood hazards on the floodplain for large flood events (>=5% AEP) for the existing and future land use conditions, including climate change scenario.
   The key areas include (see Figure 1 for the location of the key areas):

- Tapawera township (3), including the impacts from Mill Creek (5) and Water Supply Creek (2) areas and Tapawera-Tadmor Bridge (4).
- Current (6) and near-future (8) hop industry development area.
- Glen Rae Stream overflow area (1), which is currently occupied by farmland.
- Quinney's Bush Camp (12), which has increased usage in the recent years.

2. Assess the effects of land use type changes (the effects of the growth of hop industry).
3. Inform river management work (bank edge protection). The model output will be able to assess scour protection velocity, effects of private stopbanks and breach of those infrastructures.
4. Create good model flexibility so that the model can be updated and re-run when new data becomes available.
5. Maintain practical model runtime, which was determined as 2-days maximum per simulation.

1.4 Purpose of the Report

This modelling report documents the review of the collected data, the relevant characteristics of the catchments studied, the hydrology and hydraulic modelling approaches, the schematisation of the models, the assessments of the model confidence and the modelling results.

The intent of this report is to document the complete process of this modelling exercise without the need to refer to the report produced in Phase 1, therefore some of the content overlaps. The work done in Phase 1 was documented in the report "Upper Motueka River Model Development – Phase1, Revision No.01" issued on May 22, 2020. Some of the modelling methods recommended were revised during the model build phase (Phase 2) and were updated in this report.

2 DATA COLLECTION AND REVIEW

2.1 Previous Model

TDC confirmed that no hydraulic modelling exercise has been conducted in the upper Motueka catchment prior to this study.

2.2 Data Collection and Review

The list of data collected and reviewed is attached in Appendix A. The following sections provide the description of a number of important data.

2.2.1 Topographical Data

The most recent topographic data for the floodplain area is obtained from Land Information New Zealand (LINZ) Data Service "Nelson and Tasman LiDAR 1m DEM (2008-2015)". The LiDAR data was captured between 2008 and 2015. However, this data set only covers the floodplain area.

For the rest of the catchment area, the most recent topographic data were obtained from LINZ Data Service "NZ 8m Digital Elevation Model 2012". This DEM (digital elevation model) was primarily derived from January 2012 LINZ Topo50 20m contours. The contour was interpolated with post-processing and filtering.

2.2.2 Historic Rainfall Record

The three most relevant rainfall gauging sites managed by TDC are:

- Upper Motueka at Gorge (records available from 1987 to 2020).
- Motupiko at Christies (records available from 1990 to 2020).
- Tadmor at Mudstone (records available from 1977 to 2020).

The hourly rainfall records are available for those three sites.

NIWA has rainfall record in Tapawera (records available from 1993 to 2020), however, it only contains daily rainfall. No other actual rainfall records are available within the floodplain area.

2.2.3 Flow Data

The three relevant flow gauging sites managed by TDC are:

- Upper Motueka at Gorge (records available from 1965 to 2020).
- Motupiko at Christies (records available from 1990 to 2020).
- Tadmor at Mudstone (records available from 1978 to 2020).

2.2.4 Aerial Photographs

The historic aerial photography that covers the area of interest collected are:

- the 2016-2017 data set.
- the 2006-2007 data set.

- the 2001-2002 data set.
- the 1940-1949 data set.

It can be observed that the main river channel bed in the 2016-2017 data set changes from the 2006 - 2007 data set but not significantly. Approximately seven new cutbanks were formed.

2.2.5 Historic Flood Pattern

Relevant historic flood extents that are available and obtained are as follows:

- 1967 August flood extent covers part of the Upper Motueka Catchment.
  The only historical record available for this event is the flow record at Upper Motueka Gorge gauging site. The peak flow recorded is 321 m^3/s, which makes it equivalent to a 20% AEP flood.

- 1974 April flood extent covers part of the Upper Motueka, Tadmor and Motupiko catchments.
  The only historical record available for this event is the flow record at Upper Motueka Gorge gauging site. The peak flow recorded is 563 m^3/s, which makes it equivalent to a 5% AEP flood.

- 1976 December flood extent covers part of the Upper Motueka Catchment.
  The only historical record available for this event is the flow record at Upper Motueka Gorge gauging site. The peak flow recorded is 192 m^3/s, which makes it equivalent to a 100% AEP flood.

- 1983 July flood extent covers part of the Upper Motueka, Tadmor and Motupiko catchments.
  The peak flow recorded at Upper Motueka Gorge gauging site is 356 m^3/s, which makes it equivalent to a 10% AEP flood. The peak flow recorded at Tadmor Mudstone gauging site is 109 m^3/s, which makes it equivalent to a 3.33% (1 in 30) AEP flood. No flow data is available in the Motupiko catchment.

- 1986 March flood extent covers part of the Mill Stream Catchment.
  No rainfall or flow records are available for this site.

- 1990 August flood extent only covers part of the downstream area in the Upper Motueka Catchment.
  The peak flow recorded at Upper Motueka Gorge gauging site is 241 m^3/s, which makes it equivalent to a 100% AEP flood. The peak flow recorded at Motupiko Christies gauging site is 74 m^3/s, which makes it equivalent to a 10% AEP flood. The peak flow recorded at Tadmor Mudstone gauging site is 102 m^3/s, which makes it equivalent to a 5% AEP flood.

2.2.6 Land use Type

The existing land use type data was available and obtained from IRIS "Land Cover Database Version 5.0".

2.2.7 Soil Drainage

The soil drainage map was available and obtained from IRIS "S-map Soil Drainage Aug 2019".

2.2.8 Stormwater System in Tapawera

The stormwater network data in Tapawera were downloaded from the Top of the South Maps webpage. Three layers were downloaded: Stormwater Features, Stormwater Pipes and Stormwater Drains. The Stormwater Features layer contains the location of the stormwater features such and manholes and sumps, but it does not provide invert or lid levels. The Stormwater Pipes layer provides the location of the pipes as well the material and diameters of the pipes. The Stormwater Drains layer provides the location of the open drains and the asset ID.

3 MODEL LOG AND FILE NAMING

3.1 Model Log

A model log for this modelling exercise has been developed and provided as an additional spreadsheet file. The model log documents the model naming and simulation log sheet. The simulation log sheet documents all relevant elements of model development process. The model log should be read together with this documents and other documents referenced in the model log spreadsheet.

A print of the model log that displays all the important simulation files is attached in Appendix B.

3.2 Naming Convention

A naming convention in accordance with the TDC modelling guideline was used. The model log spreadsheet "01_SimNaming" Tab contains the information that should be included in the simulation/result file. They are:

1. A numbering identifier (Counter)
2. River name
3. Land use type
4. Rainfall scenario (AEP)
5. Rainfall duration
6. Downstream boundary condition
7. Climate change
8. Simulation type (base, certainty, hydrology, calibration etc.)

4 CATCHMENT DESCRIPTION

4.1 Hydrology Model

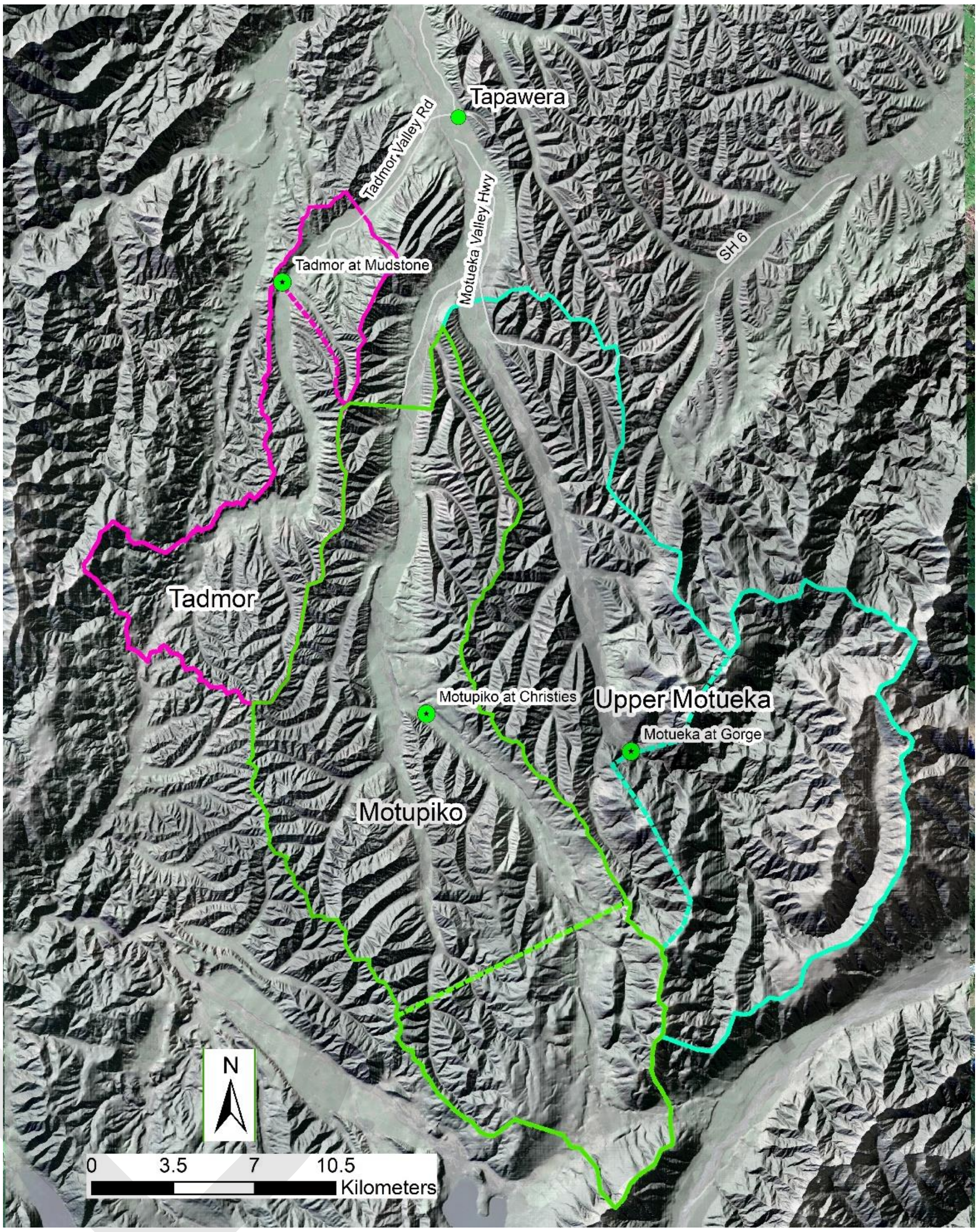
4.1.1 Location and Topography

The hydrology model is comprised of three catchments: Upper Motueka, Motupiko and Tadmor catchments. The solid lines in Figure 2 shows the outlines of the three catchments. The sizes of the catchments are 324 km², 324 km² and 106 km² for the Upper Motueka, Motupiko and Tadmor catchments respectively.

In the Upper Motueka catchment, the terrain above the Motueka Gorge is relatively steep. The majority of the slope is greater than 30%. The hillside slope in the rest of the catchment is mostly between 20% to 30%. In the Motupiko catchment, the hillside slope generally ranges from 20% to 30%. In the Tadmor catchment, the hillside slope is mostly between 10% to 25%.

In combination of relatively poor drained soil, some rocky surface, greater slope and more intensive rainfall above the Upper Motueka Gorge, the Upper Motueka Catchment generates a much greater amount of runoff in comparison to the Motupiko catchment even though the two catchments are similar in size.

Figure 2 – The solid lines show the model extents for the Upper Motueka, Motupiko and Tadmor catchments.



4.1.2 Soil Infiltration

TDC and GNS Science have conducted groundwater modelling in the Upper Motueka Catchment that covers the area of interest. However, no comprehensive study on the soil filtration that is relevant to the flood modelling has been studied.

In this modelling exercise, S-Map Soil Drainage Map was used to categorise the soil drainage from well drained to poor drained. Figure 3 shows the soil drainage within the catchments. The drainage in the area that is not covered by the Soil Drainage Map is assumed to be the same as the adjacent ground that has a category assigned. Table 1 summarised the percentage of the catchment area for each drainage category.

Figure 3 – The S-Map Soil Drainage Map for the Upper Motueka, Motupiko and Tadmor catchments.

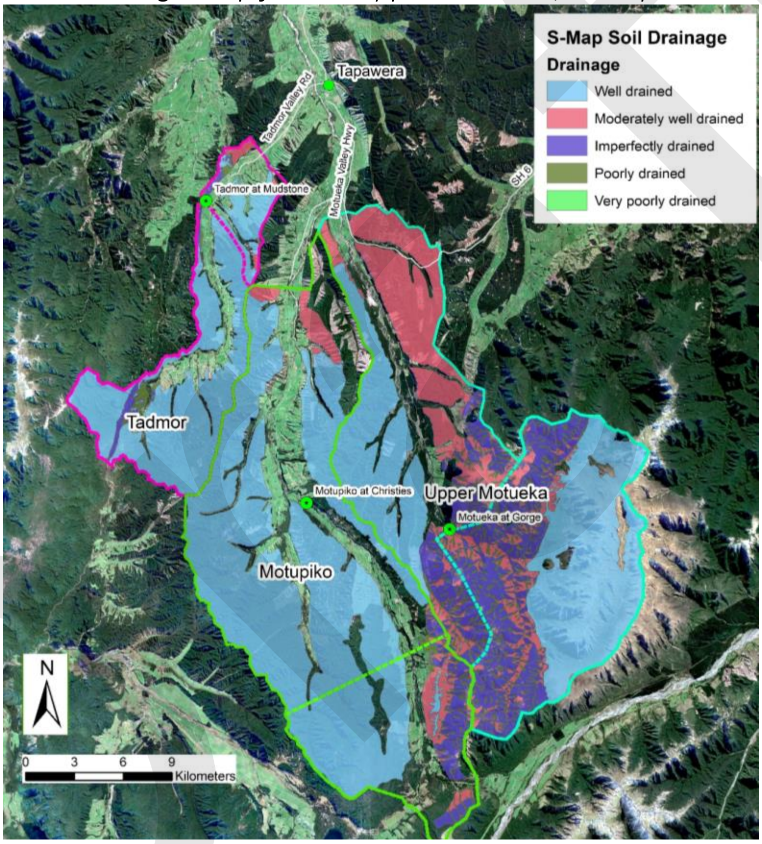


Table 1. Percent of the catchment area for each soil drainage category based on S-Map.

Catchment	% Well Drained	% Moderately Well Drained	% Imperfectly Drained	% Poorly Drained	% Very Poorly Drained
Upper Motueka	52%	22%	20%	6%	0%
Motupiko	91%	5%	3%	1%	0%
Tadmor	93%	2%	3%	2%	0%

In general, the soils in the three catchments have good drainage. The Upper Motueka catchment is covered by 74% well to moderately well drained soil, the Motupiko catchment is covered by 96%, and the Tadmor catchment is covered by 95%.

4.1.3 Land use and Vegetation Cover

Figure 4 displays the vegetation cover for the Upper Motueka, Motupiko and Tadmor catchments. Table 2 summaries the percentage cover for each vegetation category. The majority of the vegetation cover in the Upper Motueka catchment are exotic forest (35%), indigenous forest (30%) and tall tussock grassland (16.5%). The majority of the vegetation cover in the Motupiko catchment are indigenous forest (42.9%) exotic forest (25.1%), and high producing exotic grassland (18.4%). The majority of the vegetation cover in the Tadmor catchment are exotic forest (33.9%), indigenous forest (27.1%) and high producing exotic grassland (27.5%).

Figure 4 – Land Cover Database Version 5.0 for the Upper Motueka, Motupiko and Tadmor catchments.

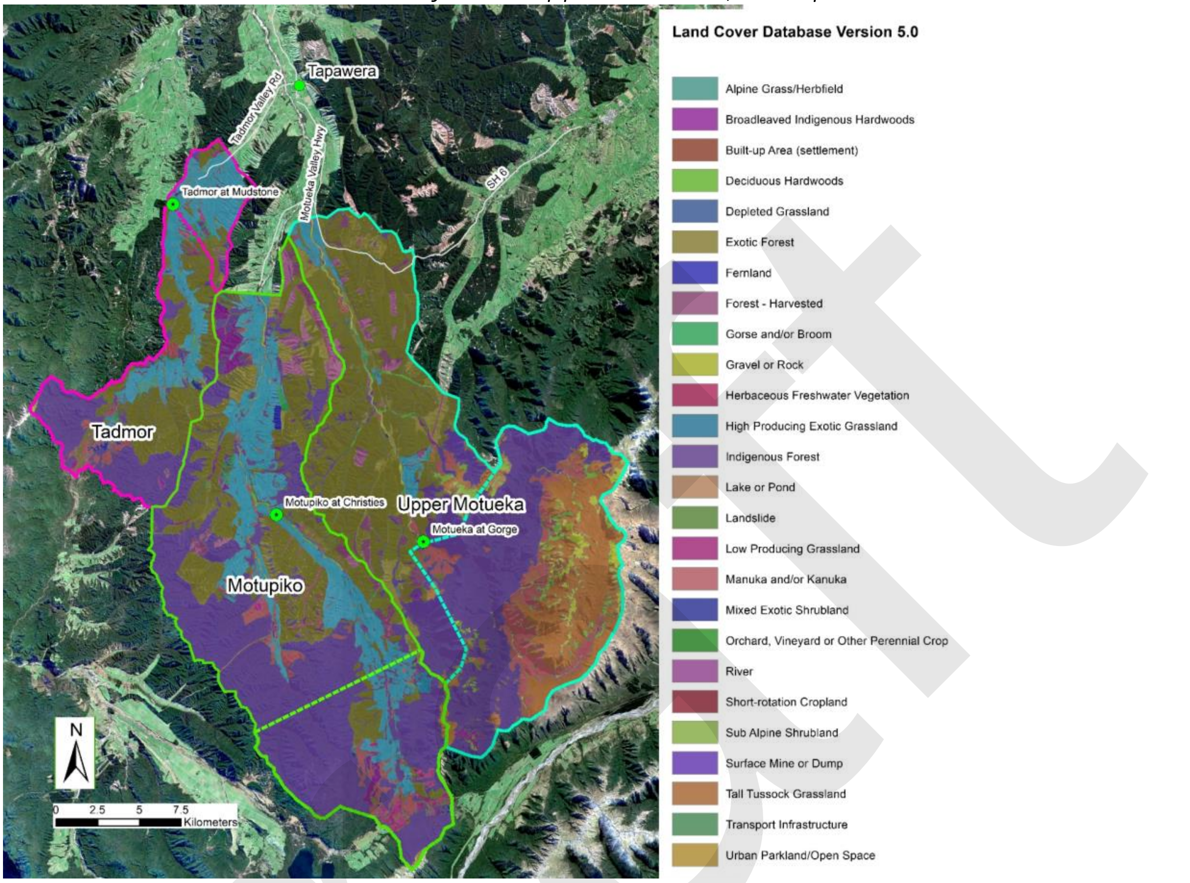


Table 2. Percent of the catchment area for each vegetation category.

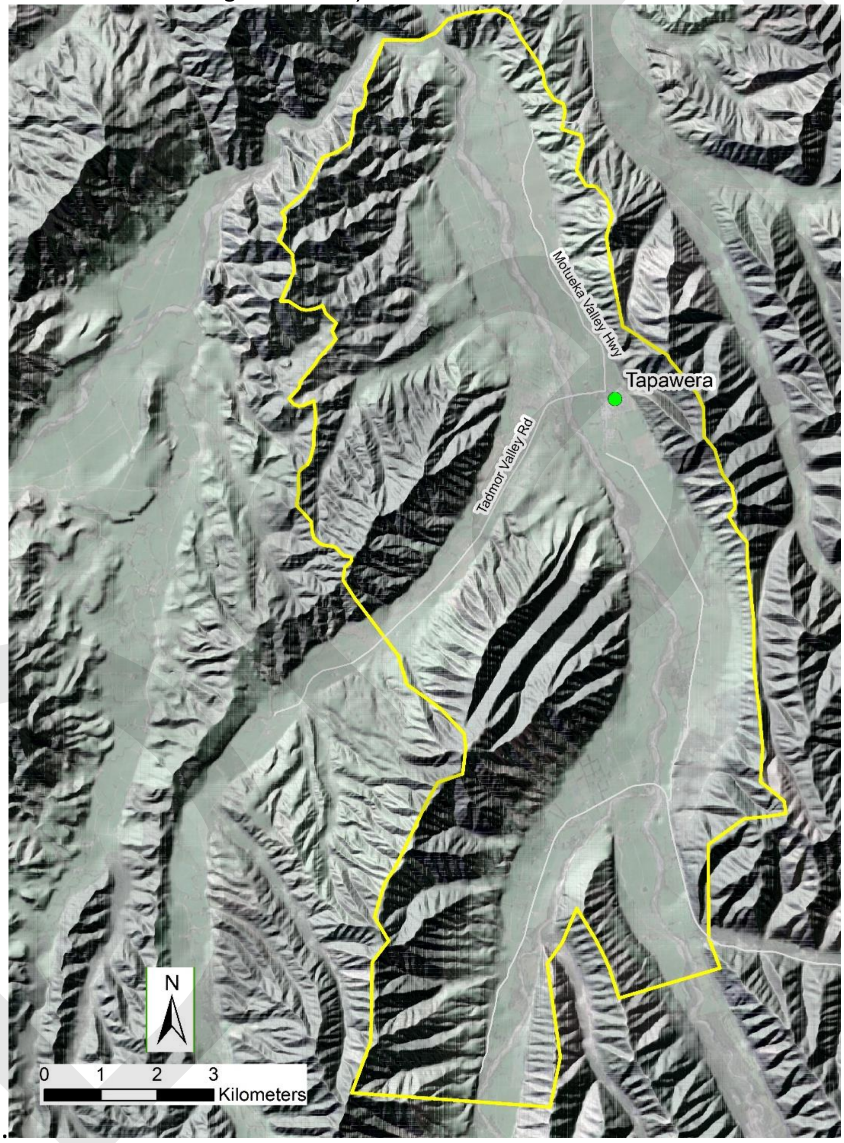
			Upper Motueka	Motupiko	Tadmor
Land Use Type 2018	Manning's n in the Guideline	Manning's n Used in the Model	% Cover	% Cover	% Cover
Exotic Forest	0.150	0.17	35.0%	25.1%	33.9%
Indigenous Forest	0.150	0.165	30.0%	42.9%	27.1%
Deciduous Hardwoods	0.125	0.138	0.4%	0.3%	0.3%
Alpine Grass/Herbfield	0.100	0.110	0.0%	0.0%	0.0%
Broadleaved Indigenous Hardwoods	0.100	0.110	0.7%	2.3%	1.1%
Fernland*	0.100	0.110	0.0%	0.3%	0.5%
Manuka and/or Kanuka*	0.100	0.110	6.7%	4.2%	4.7%
Tall Tussock Grassland*	0.100	0.110	16.5%	0.4%	0.0%
Low Producing Grassland	0.090	0.099	0.2%	1.4%	0.8%
Sub Alpine Shrubland*	0.090	0.099	2.1%	0.0%	0.1%
Forest - Harvested*	0.075	0.083	2.7%	3.7%	1.0%
Mixed Exotic Shrubland*	0.075	0.083	0.0%	0.0%	0.3%
Gorse and/or Broom*	0.070	0.077	0.2%	0.5%	2.2%
High Producing Exotic Grassland	0.050	0.055	2.1%	18.4%	27.5%
Orchard, Vineyard or Other Perennial Crop	0.050	0.055	0.0%	0.0%	0.1%
Surface Mine or Dump	0.050	0.055	0.0%	0.0%	0.0%
Landslide*	0.040	0.044	0.1%	0.0%	0.0%
Built-up Area (settlement)	0.030	0.033	0.1%	0.0%	0.0%
Gravel or Rock	0.025	0.028	3.3%	0.4%	0.1%
Lake or Pond	0.020	0.022	0.0%	0.0%	0.0%
Transport Infrastructure	0.020	0.022	0.0%	0.0%	0.0%
*The value of n is not provided in the TDC Modelling Guideline 2019					

4.2 Hydraulic Model

4.2.1 Location and Topography

The hydraulic model covers the primary area of interest and its adjacent hill catchments. Figure 5 shows the extent of the hydraulic model. The total size is 104.5 km², and the floodplain covers approximately 38.7 km². The length of the river from the most upstream extent of the model to the downstream end is approximately 22 km dropping from 228m to 112.5m (an average slope of 0.5%).

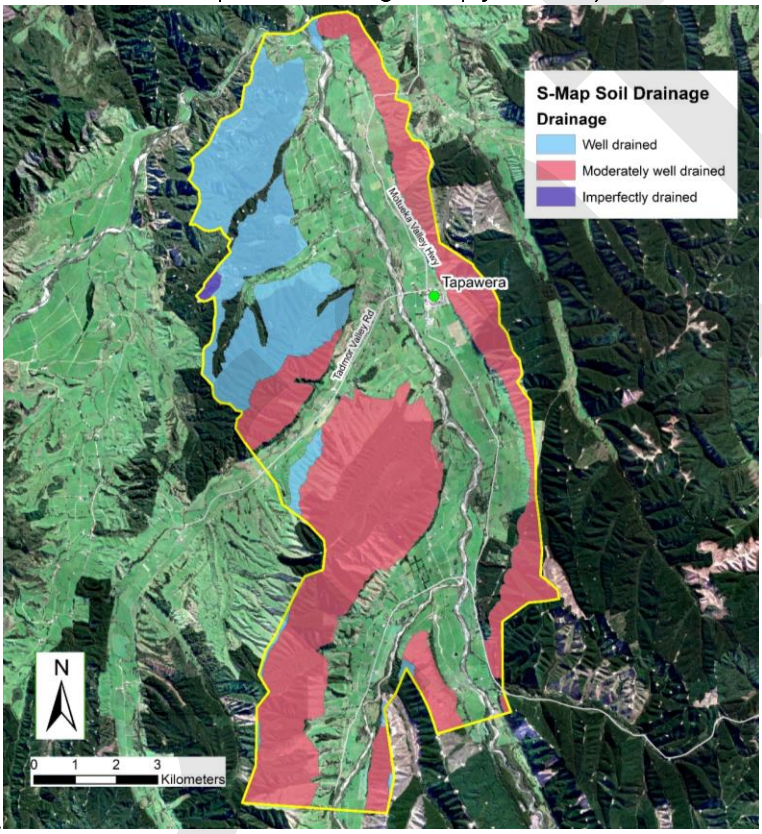
Figure 5 – Hydraulic model extent.



4.2.2 Soil Infiltration

Figure 6 shows the S-MAP soil drainage category for the hydraulic model extent. The S-Map Soil Drainage Map does not cover the area of floodplain. Based on GNS' ground modelling report, (*Three-Dimensional Finite-Element Transient Groundwater-River Interaction model in a Narrow Valley Aquifer System of the Upper Motueka Catchment*, Report 2010/2011) the most common soil in the area is Tapawera loam, which is well drained soil. In combination with the soil drainage in the adjacent area, it was assumed that the soil drainage within the floodplain area is well drained. The well drained, moderately well drained and imperfectly drained soil cover 21%, 40.1% and 0.2% of the model extent respectively. 38.8% of the area has no data and was assumed to be well drained.

Figure 6 – The S-Map Soil Drainage Map for the hydraulic model.



4.2.3 Land use and Vegetation Cover

Figure 7 displays the vegetation cover for the hydraulic model extent. Table 3 summaries the percentage cover for each vegetation category. The majority of the vegetation cover in the floodplain and its adjacent hillside catchment are high producing exotic grassland (44%) and exotic forest (34%) respectively. 5% of the total land area is orchard, vineyard or other perennial crops. The current vegetation in the near-future hop industry area (8. In Figure 7), which covers an area of approximately 422.7 ha, is entirely covered by high producing exotic grassland.

Figure 7 – Land Cover Database Version 5.0 for the hydraulic model extent.

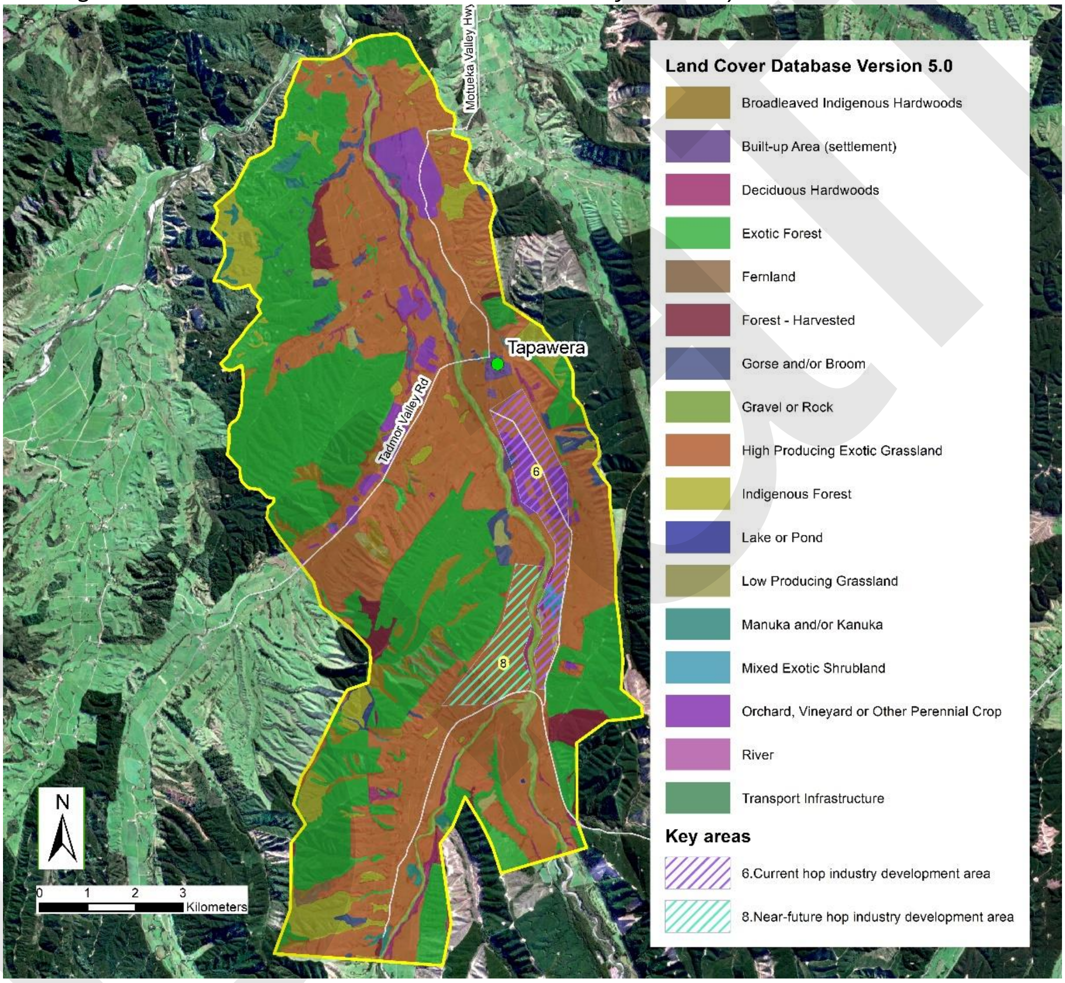


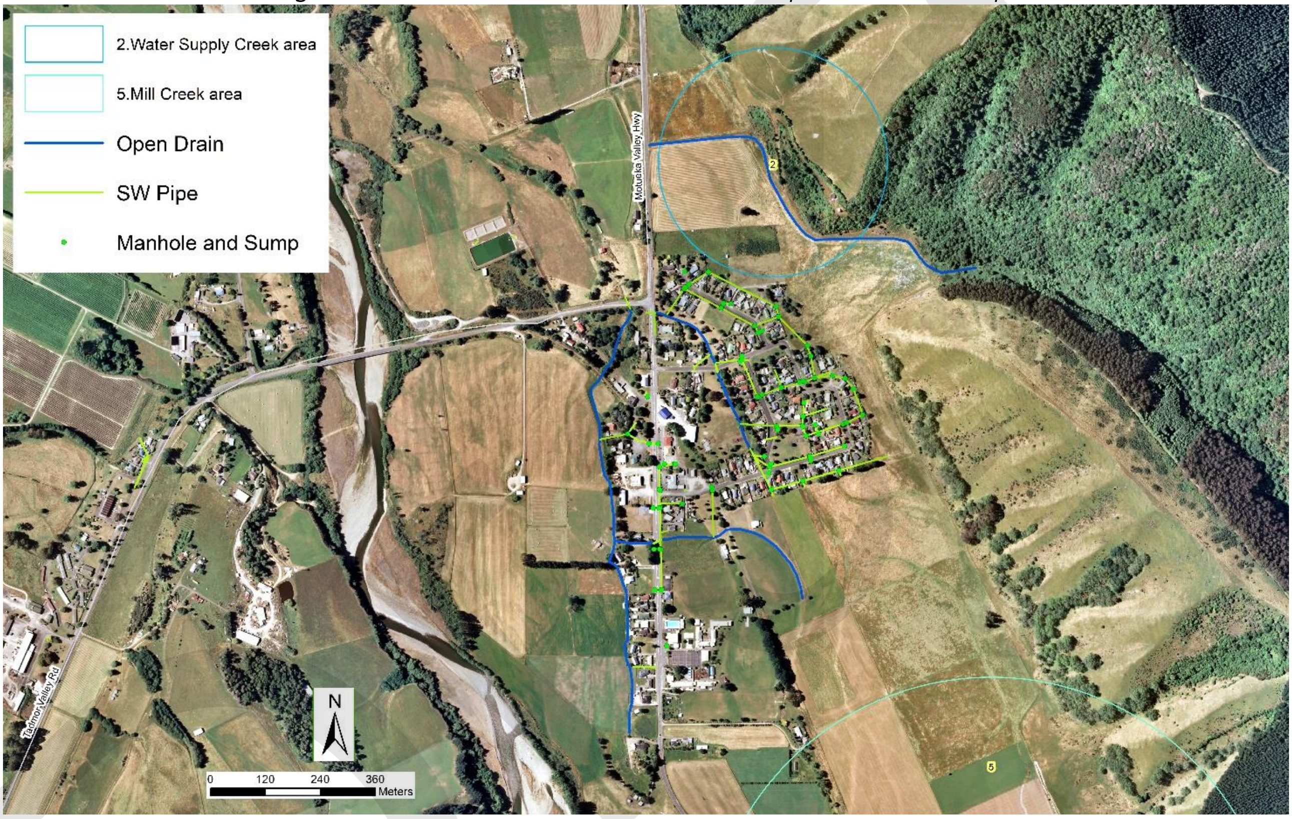
Table 3. Percent of the catchment area for each vegetation category in the hydraulic model.

			Floodplain
Land Use Type 2018	Manning's n in the Guideline	Manning's n Used in the Model	% Cover
High Producing Exotic Grassland	0.050	0.055	44.3%
Exotic Forest	0.150	0.165	33.6%
Indigenous Forest	0.150	0.165	4.8%
Orchard, Vineyard or Other Perennial Crop	0.050	0.055	3.7%
Gravel or Rock	0.025	0.028	2.6%
Broadleaved Indigenous Hardwoods	0.100	0.110	2.5%
Forest - Harvested*	0.075	0.083	2.0%
Deciduous Hardwoods	0.125	0.138	1.9%
Gorse and/or Broom*	0.070	0.077	1.8%
Manuka and/or Kanuka*	0.100	0.110	1.0%
Low Producing Grassland	0.090	0.099	0.9%
Fernland*	0.100	0.110	0.4%
Built-up Area (settlement)	0.030	0.033	0.3%
Mixed Exotic Shrubland*	0.075	0.083	0.2%
Transport Infrastructure	0.020	0.022	0.1%
Lake or Pond	0.020	0.022	0.0%
Alpine Grass/Herbfield	0.100	0.110	0.0%
Landslide*	0.040	0.044	0.0%
Sub Alpine Shrubland*	0.090	0.099	0.0%
Surface Mine or Dump	0.050	0.055	0.0%
Tall Tussock Grassland*	0.100	0.110	0.0%
*The value of n is not provided in the TDC Modelling Guideline 2019			

4.2.4 Stormwater Drainage System

Figure 8 displays the stormwater system in Tapawera. There are a limited number of piped stormwater network (a total length of 3.6 km) within the urban drainage area. The pipes discharge into a series of open channels (a total length of 5.4 km) which eventually flow into the Upper Motueka River. A cut-off drain was constructed at the bottom of the hill in the Water Supply Creek area to divert the flow into the Upper Motueka River.

Figure 8 – Stormwater network in the Tapawera township.



5 MODEL BUILD

5.1 Modelling Software

The hydrology and hydraulic models were simulated using GPU processed DHI MIKE 21 software package released in 2016 (Service Pack 3).

5.2 Coordinate System

All geospatial files are in terms of the New Zealand Transverse Mercator 2000 (NZTM2000) Coordinate reference system. The vertical datum used is New Zealand Vertical Datum 2016 (NZVD2016).

5.3 Two-dimensional Only Model

In consultation with TDC, a two-dimensional only approach was applied to both of the hydrology and hydraulic modelling. During the discussion in Phase 1, it was decided that it is not necessary to have a model that couples the one-dimensional river channels or urban stormwater networks with the two-dimensional floodplain. The main reason is that the river system in the area is highly dynamic. The river morphology changes constantly with the input of rainfall, which means that the cross-section survey is outdated almost immediately after it was conducted. A two-dimensional only model allows the model to be updated efficiently as new topographic data (i.e. LiDAR) become available. Another reason is that TDC do not intend to obtain detailed flood outputs in the Tapawera township from this model, so a one-dimensional model that represents the stormwater piped network within the Tapawera township is not necessary.

5.4 Direct Rainfall Method (DRM)

The direct rainfall method (sometimes referred to as "rain on grid" (RoG) method) was used in both of the hydrology and hydraulic models. The rainfall was applied directly to the 2D mesh elements, and the infiltration loss was setup as the only losses in the model. The runoff was routed through the catchment with shallow water equations. The major factors that affect the amount of runoff calculated include: the mesh size, rainfall depth, surface roughness, slope between neighbouring meshes, and rainfall losses.

In theory, a single model could be developed to cover the area of interest as well as all of its contributing catchments using the DRM. However, this means that the model extent would have to cover an area of 859 km^2. To generate accurate enough results while maintaining practical model runtime, the model was divided into two parts: the hydrology and hydraulic models. The hydraulic model covers the area of interest and its immediate hillside catchments. The hydrology model was further divided into three individual models. Each model covers one of the three major catchments that contribute runoff into the area of interest. The hydrographs derived from the hydrology modelling results were used as the inflow boundary conditions for the hydraulic models.

5.5 Hydrology Model

5.5.1 Topographic Data Source

LINZ Data Service “NZ 8m Digital Elevation Model 2012” was used to interpolate the 2D surface elevation in the hydrology model.

5.5.2 Mesh Size Optimisation

An initial modelling exercise was conducted to estimate the optimal mesh size that will generate the most accurate result without unpractical extended modelling runtime. The analysis concludes that the most optimal mesh file is the one that has an average size of 321 m².

The final models for the Upper Motueka and Motupiko catchments have approximately one million mesh elements each. By comparison, the Tadmor catchment model has approximately one third at 0.36 million mesh elements.

5.5.3 Critical Duration

Another initial investigation was conducted to establish the storm duration that will generate the highest peak flow at the inflow boundaries of the hydraulic model. The test was conducted on the 1% AEP storm events. The results show that the critical duration is 12 hours for the Upper Motueka and Motupiko catchments and 24 hours for the Tadmor catchment.

5.5.4 Flood Frequency Analysis

TDC provided the most current flood frequency analysis – conducted in May 2020. The result gives flood peak at the three gauging sites in the Upper Motueka (Gorge), Motupiko (Christies) and Tadmor (Mudstone) catchments up to 1% AEP flood event. The confidence in the values for the 1% AEP for the Motupiko and Tadmor catchments is lower because they were extrapolated a long way beyond the original observation range. The values to estimate the 0.4% (1 in 250) AEP peak flow were further extrapolated. Table 4 summaries the result of the flood frequency analysis. The confidence is lower in the values that are greyed out.

Table 4. The result of the flood freq

Gauging Site	Data Start	Data End	Years of Records	1 Exceedance per Year	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	1 in 250 AEP
				Flow (m³/s)						
Motueka at Gorge	1965	2019	55	271	341	432	536	702	853	989
Motupiko at Christies	1990	2020	31	48.3	56	71	90	124	159	183
Tadmor at Mudstone	1978	2019	42	60.6	76	89	101	117	129	145

5.5.5 Review of the Historical Flood Records

The historical records at the relevant gauging sites were reviewed. As mentioned in Section 2.2.3, the three relevant flow gauging sites managed by TDC are:

- Upper Motueka at Gorge (records available from 1965 to 2020).

- Motupiko at Christies (records available from 1990 to 2020).
- Tadmor at Mudstone (records available from 1978 to 2020).

The largest peak flow recorded at the Upper Motueka Gorge site occurred on 1995 February 23. The peak flow was 800 m^3/s, which is equivalent to a 1.25% (1 in 80) AEP event. The event had an extremely intense rainfall in the catchment upstream of the gauging site, which washed away the water level recorder. The peak flow was confirmed by survey flood marks. No recession record was available for this event at the Gorge site. At the same period of time, the peak flows recorded at Motupiko Christies and Tadmor Mudstone gauging sites were very small. The peak flow at Motupiko Christies was 20 m^2/s, which is equivalent to a less than a 1 Exceedance per Year event. The peak flow at Tadmor Mudstone was 8 m^3/s, which also is equivalent to less than a 1 Exceedance per Year event. In terms of rainfall records, all recordings were less than 50% AEP. Table 5 summaries the flow and rainfall records for the 1995 February event.

Table 5. Summary of the 1995 February event.

1995 February Event

Site	Flow Peak (m^3/s)	Flow AEP	Rainfall AEP
Motueka at Gorge	800	1 in 80	< 50%
Motupiko at Christies	20	< 1 Execeedance per Year	< 50%
Tadmor at Mudstone	8	< 1 Execeedance per Year	< 50%

The largest peak flow recorded at the Motupiko Christies site occurred on 2005 March 25. The peak flow was 169.7 m^3/s, which is equivalent to a 0.833% (1 in 120) AEP event. The recorder was damaged during the storm, and the peak flow was again confirmed by survey marks. There was no recession record available for this site. The rainfall record at the Christies site was only equivalent to a 5% AEP storm event. The peak flow recorded at Motueka Gorge site was large: 789 m^3/s, which is equivalent to a 1.43% (1 in 70) AEP flood. The rainfall recorded at Motueka Gorge was equivalent to a 0.5% (1 in 200) AEP storm event. The peak flow and rainfall recorded at Tadmor Mudstone site were relatively small. The peak flow was equivalent to a less than a 1 Exceedance per Year event, and the rainfall was less than 20% AEP. Table 6 summaries the flow and rainfall records for the 2005 March event.

Table 6. Summary of the 2005 March event.

2005 March Event

Site	Flow Peak (m^3/s)	Flow AEP	Rainfall AEP
Motueka at Gorge	789	1 in 70	1 in 200
Motupiko at Christies	169	1 in 120	5%
Tadmor at Mudstone	19	< 1 Execeedance per Year	50% - 20%

The largest peak flow recorded at the Tadmor Mudstone site occurred on 1983 July 10. The peak flow was 109.6 m^3/s, which is equivalent to a 3.13% (1 in 32) AEP event. The peak flow at Motueka Gorge site was 361 m^3/s, which is close to a 20% AEP event. No record was available at the Motupiko Christies site. Table 7 summaries the flow and rainfall records for the 1983 July event.

Table 7. Summary of the 1983 July event.

1983 July Event

Site	Flow Peak (m^3/s)	Flow AEP	Rainfall AEP
Motueka at Gorge	361	20%	No Record
Motupiko at Christies	No Record	No Record	No Record
Tadmor at Mudstone	109.6	1 in 32	53hr, 50% - 20% AEP

The comparison between the rainfall and flow records shows that the rainfall recorded at the gauging site usually had a smaller annual exceedance probability (AEP) than the AEP of the flow. This indicates that the rainfall intensity further upstream of the gauging sites could have been much higher than the rainfall intensity at the gauging sites. This implies that it would be more appropriate to apply spatially varied rainfall in the hydrology model domain.

5.5.6 Treatment of Joint Probability

The primary objective of this modelling exercise is to assess the flood risk in the area of interest for the 5%, 2%, 1% and 1 in 250 AEP storm events. Various combinations of the flow probabilities from the three upstream catchments can generate those flood AEPs in the area of interest. The historic flood record was examined and a Monte Carlo simulation was adopted to establish one representative combination of the flood probabilities from the three contributing catchments.

Firstly, the daily maximum flow records at the three gauging sites from March 1990 to May 2020 were examined. By focusing on one catchment at a time, the combination of flood probabilities in each historic event was established. For Upper Motueka and Motupiko catchment, all the events that were above 20% AEP were used. There are 19 records for the Upper Motueka catchment and 14 records for the Motupiko catchment. The overall historic rainfall intensity is lower in the Tadmor catchment, so all the records above 50% AEP were used. There are 16 records in the Tadmor catchment.

By focusing on one flood probability (either 5%, 2%, 1% or 1 in 250 AEP) in one focused catchment at a time, a range of flood probabilities that may occur in the other two catchments using Monte Carlo simulation was established. Figure 9 shows the result of the Monte Carlo simulation using Upper Motueka as the focused catchment.

The analysis shows that when using Upper Motueka catchment as the focused catchment, it is most likely to generate the worst combination of flood probabilities. Therefore, the analysis result that used Upper Motupiko catchment as the focused catchment was used. Table 8 summaries the combination.

Figure 9 – Monte Carlo simulation to generate a range of flood probabilities in the Motupiko catchment and Tadmor catchment using Upper Motueka catchment as the focused catchment.

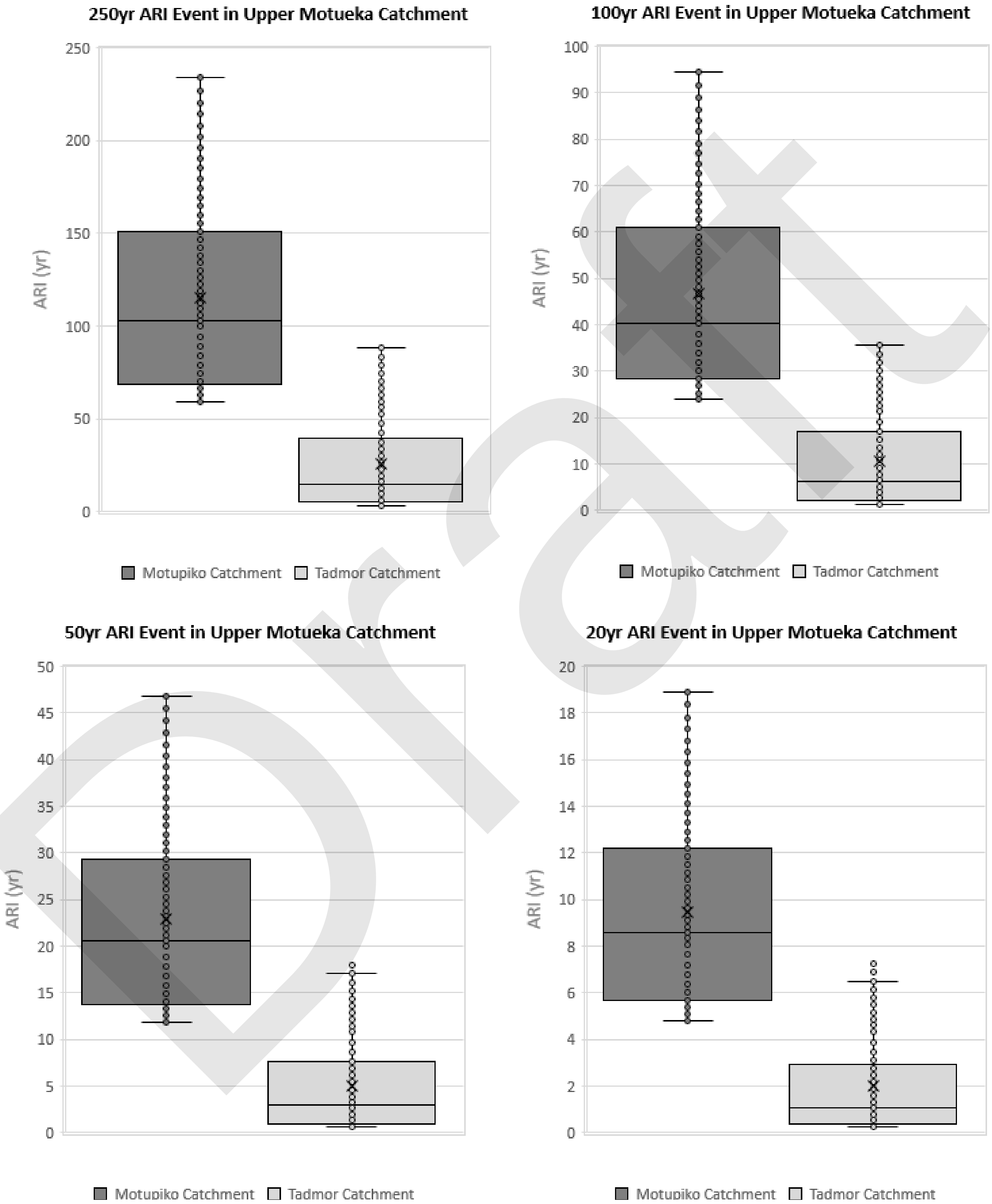


Table 8.Combination of AEP used in the hydraulic models.

AEP Combination

Floodplain - AEP	20%	50%	100%	1 in 250
Upper Motueka - AEP	20%	50%	100%	1 in 250
Motupiko - AEP	10%	1 in 30	2%	1 in 150
Tadmor- AEP	1 Exceedance per Year	10%	5%	2%

5.5.7 Rainfall

In accordance with TDC's modelling guideline, the rainfall depth from NIWA High Intensity Rainfall System (HIRDs V04) and NIWA HIRDs V4 "North of South Island" was used as the rainfall temporal pattern. Figure 10, Figure 11 and Figure 12 shows the hyetographs used for the Upper Motueka, Motupiko and Tadmor catchments respectively.

As discussed in Section 5.5.5, the analysis of the historical records indicates that the rainfall intensity upstream of the gauging sites may tend to be higher for rarer events. In addition, initial model simulations suggest that the hydrology models are sensitive to the rainfall depths applied. Rainfall data were retrieved from HIRDs V04 at several locations in each catchment. From the locations selected, the average rainfall depth in the upper catchment can increase 13%, 10% and 40% from the lower catchment for the Tadmor, Motupiko and Upper Motueka catchments respectively. Therefore, a simplified spatially varied rainfall was applied. Each catchment was divided into two zones: upstream (US) and downstream (DS). An estimated averaged rainfall depth was then applied to each zone. The dotted lines in Figure 2 on Page 9 show the division for each catchment.

Figure 10 – The hyetographs used in the Upper Motueka catchment.

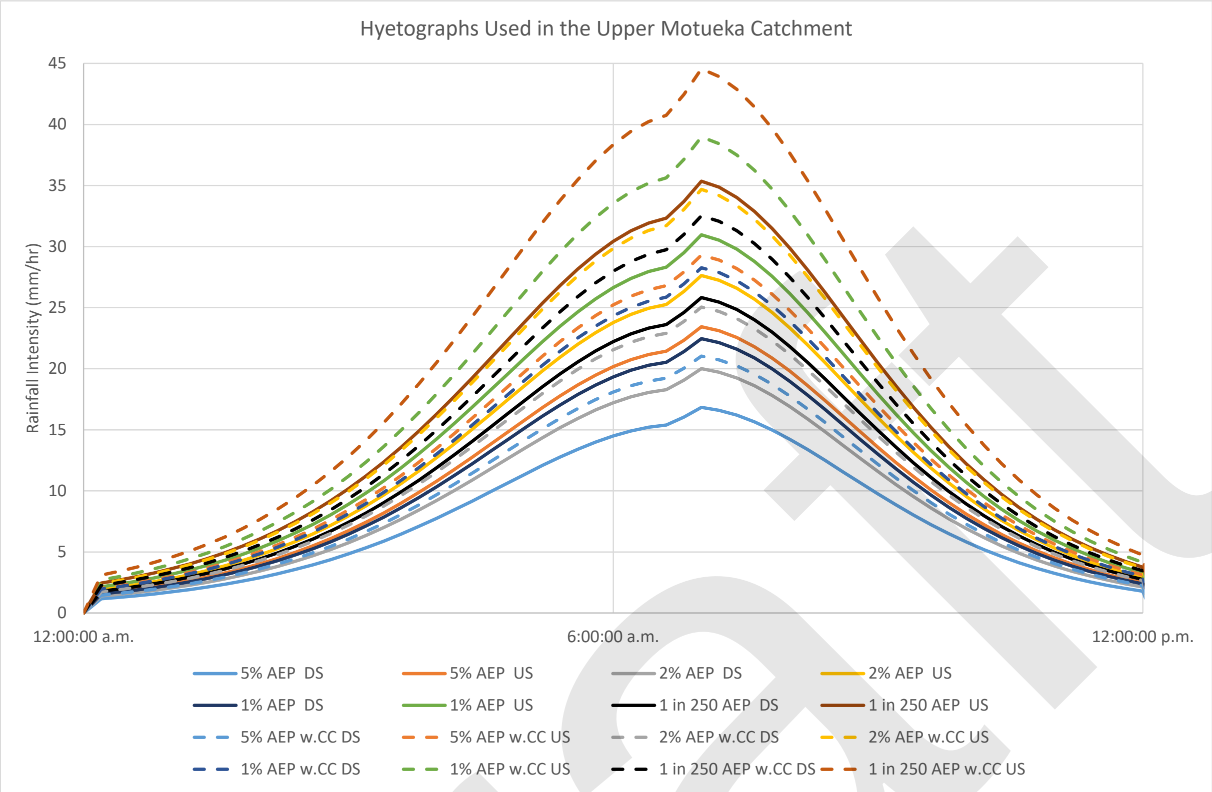


Figure 11 – The hyetographs used in the Motupiko catchment.

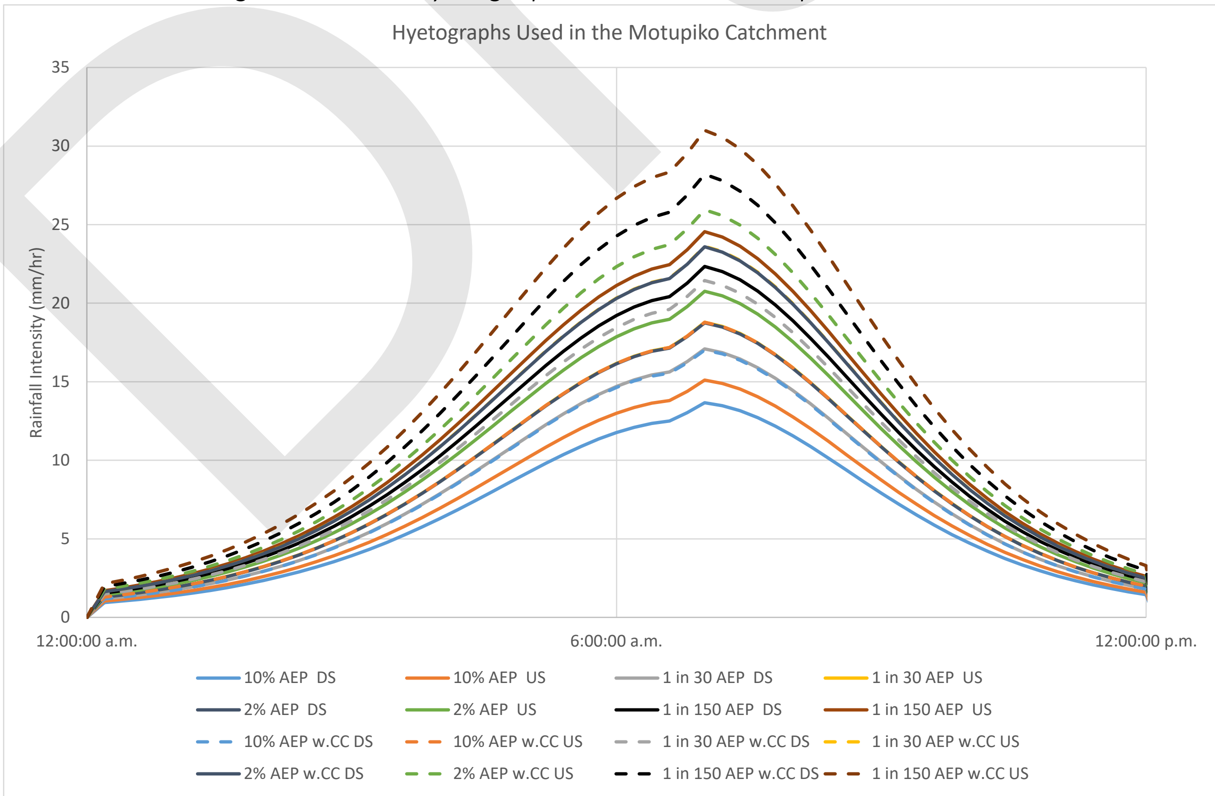
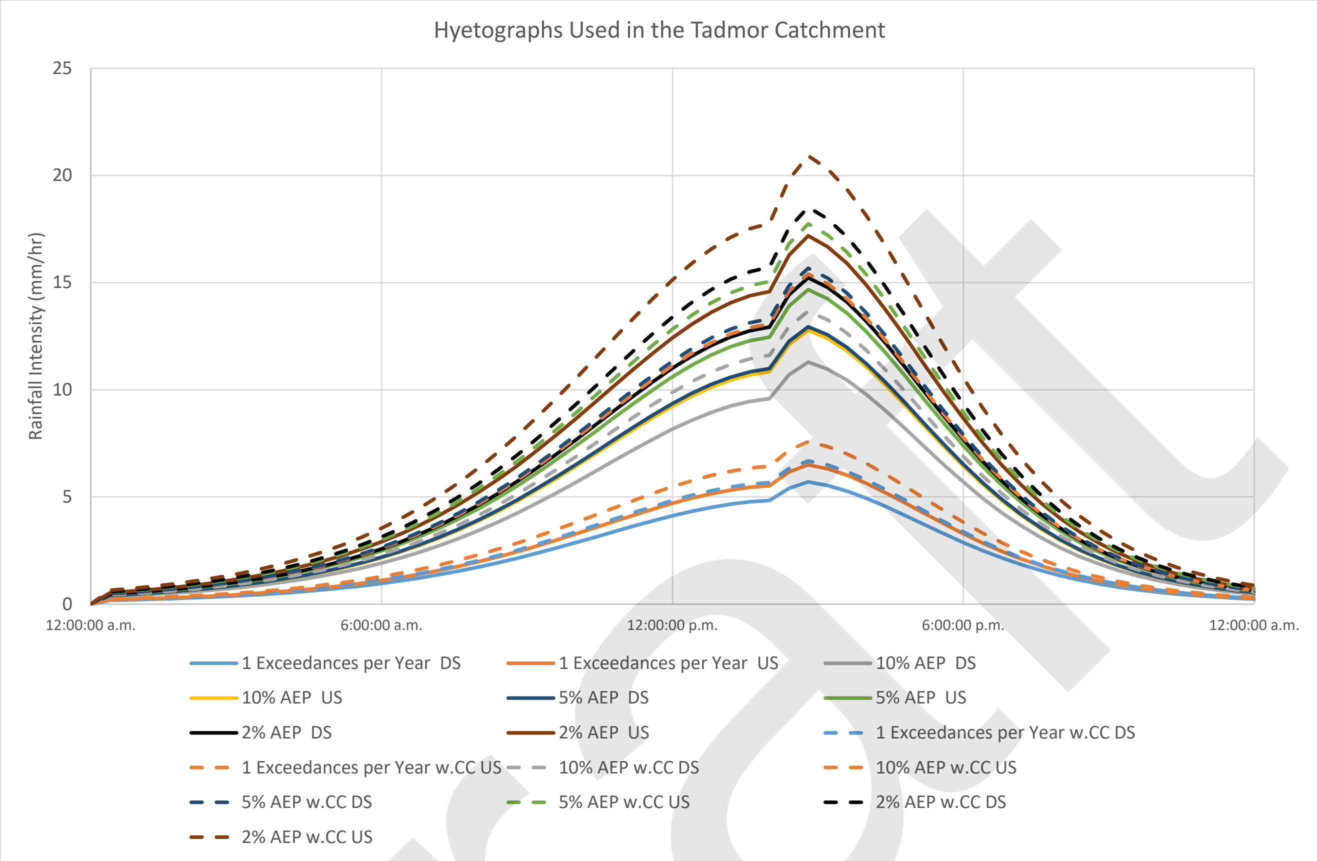


Figure 12 – The hyetographs used in the Tadmor catchment.



5.5.8 Climate Change

In accordance with the TDC modelling guideline, the RCP 8.5 for the period 2081 – 2100 rainfall data were used to assess climate change impacts.

5.5.9 Rainfall Losses

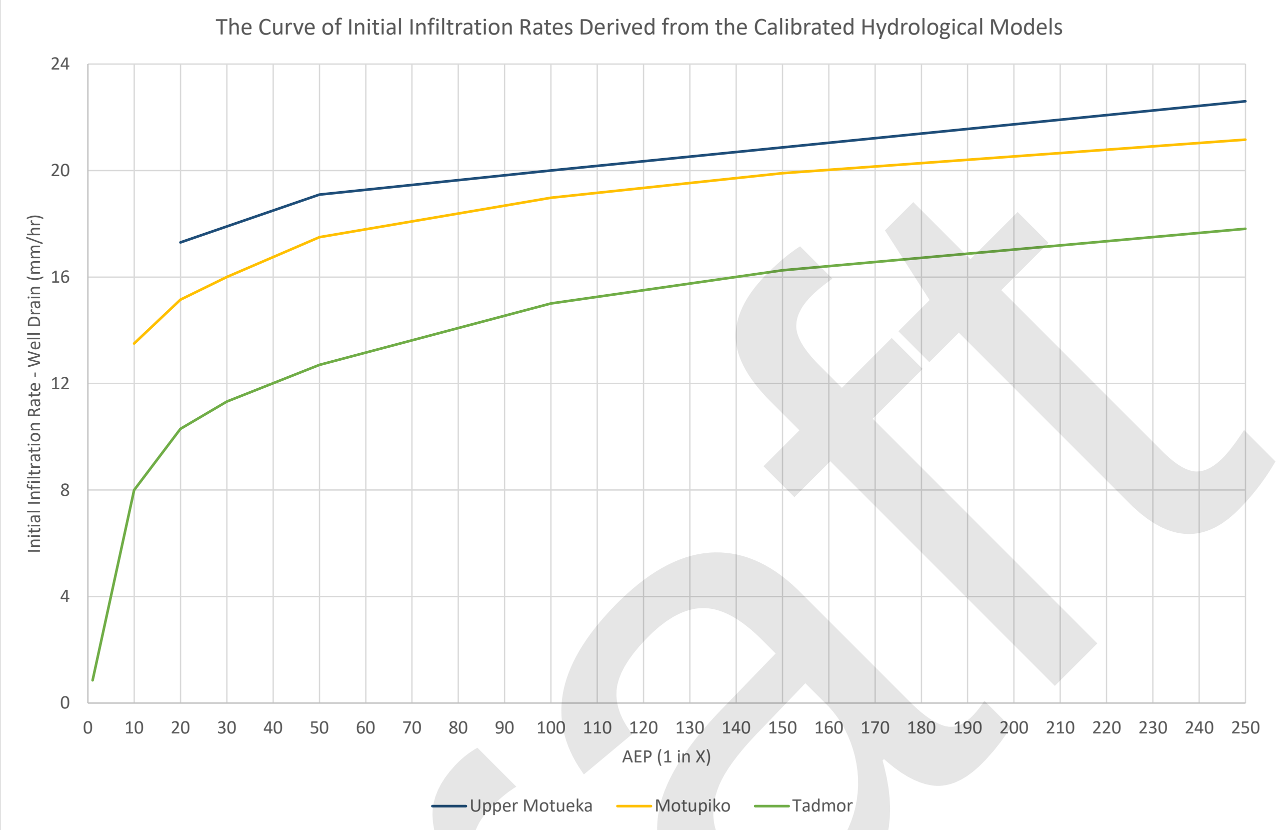
Estimate of rainfall loss (i. e. how much rainfall is absorbed by the environment as opposed to how much becomes runoff) is one of the flood modelling inputs to the design process (such as the critical storm duration, rainfall spatial pattern and rainfall temporal pattern) that can affect the magnitude of the design flood. Rainfall losses is attributed to the key processes such as interception by vegetation, infiltration into soil, depression storage and transmission loss through the stream bed and banks. In this modelling exercise, all the losses were assumed to be related to infiltration. The Horton's method was used, and it was assumed that the initial infiltration rate would decrease to half of its initial value over a 36 hours period.

S-Map Soil Drainage Map's soil category was used to assign three levels of infiltration rates. Figure 3 on Page 10 and Figure 6 on Page 14 shows the soil drainage classification for the hydrology and hydraulic model. The same infiltration rate was assigned for the well-drained and moderately well drained soil. A half of the well-drained infiltration values was assigned to the imperfectly drained soil. One third of the well-drained infiltration rates was applied to the poorly and very poorly drained soil.

The hydrology models were simulated using design rainfalls and the models were calibrated by adjusting the infiltration rates so that the peak flows at the gauging sites match the flood frequency analysis. Figure 13 shows the curve of infiltration rate derived from the calibrated hydrology models.

The infiltration rate for the Upper Motueka is similar to the rate for the Motupiko catchment. The infiltration rate for the Tadmor catchment is relatively lower, which may be partly due to longer rainfall duration and lower rainfall intensity.

Figure 13 – The curve of initial infiltration rates derived from the calibrated hydrology models.



5.5.10 Energy Losses – Roughness

In accordance with the TDC's modelling guideline, the method described in the guideline was used to determine the two-dimensional surface roughness. The guideline provides a list of roughness values based on the categories of the Landcare Research's Land Cover Database (LCDB). It was noted that the roughness values for several land use categories (the most updated version of the LCDB, v5.0) that fall within the area of interest were not given in the guideline. The gap was filled with commonly accepted values based on experience and industry. Table 2 in Page 12 provides the roughness values used for each vegetation and land use cover type.

The roughness values (Manning's n) were increased by a factor of 1.1 and then applied in the model. The reason for the increase was to counteract for the large mesh size, which in effect smooths the 2D surface.

In the high country in the Upper Motueka catchment, an area of 861 ha (2.7% of the total catchment area) is covered by outcrop. The steep terrain combined with low Manning's n value (0.025) created abnormal model result. To stabilise the model, the roughness value in this area was increased to 0.1.

5.5.11 Energy Losses – Eddy Viscosity

Turbulence losses are usually modelled in a two-dimensional model through a viscosity term. The Eddy viscosity is generally unimportant because the friction forces at the base of the water body dominates in shallow overland flow condition. In addition, activating the Eddy viscosity term in the model significantly increased the model runtime. Therefore, the Eddy viscosity term was not included in the model.

However, a sensitivity simulation with the Eddy viscosity parameter was run to assess the impact of activating Eddy viscosity in the model. The sensitivity result demonstrates that the effect is minimal. See Section 7 of the report for the description of the sensitivity testing.

5.5.12 Downstream Boundary Condition

A constant water level was set at the downstream boundaries of the hydrology models. The downstream boundaries were located further away from the area of interest to minimise potential artificial effects on the model in the area of interest.

5.5.13 Antecedent Condition

Soil moisture can have great influences on the rainfall-runoff responses. In this modelling exercise the model was simulated without initial water depth.

5.5.14 Baseflow

In this modelling exercise, baseflows were not explicitly applied. However, when generating the 2D mesh in the channel, the water surface elevation would have been sampled as bed level. Therefore, the baseflow was in a way taken into consideration.

5.5.15 Control Structures

No control structures were explicitly schematised in the hydrology model.

5.5.16 Building Representation

A number of buildings are scattered within the hydrology model extent. However, no buildings were explicitly represented in the hydrology model.

5.5.17 Hydrology Model Calibration

The roughness values, infiltration rates and rainfall depth and distribution are the obvious inputs to be adjusted in the model calibration process. Initial investigation shows that the hydrology model is relatively sensitive to the rainfall and infiltration inputs while varying the roughness values has little impacts on the flood results. Since the rainfall depth and distribution were well established by NIWA's research, this leaves the infiltration rate being the most uncertain variables in this modelling exercise. During the calibration process, the infiltration values were adjusted so that the peak discharges at the gauging sites match the flood frequency analysis.

5.6 Hydraulic Model

5.6.1 Topographic Data Source

Two sets of topographic data were used in the development of the hydraulic model. The "Nelson and Tasman LiDAR 1m DEM (2008-2015)" data set is most accurate and has a higher resolution, but it only covers the floodplain area. Therefore, the "NZ 8m Digital Elevation Model 2012" data set was used for the adjacent hillside catchment.

It was noted that the "NZ 8m Digital Elevation Model 2012" data set generally gives a higher surface elevation than the "Nelson and Tasman LiDAR 1m DEM (2008-2015)" data set. To minimise the effects of a sudden elevation change at the interface of the two data set, a 100 m wide buffer zone was created. The ground level within the buffer zone was then interpolated between the two data sets. The flood maps in the appendices show the buffer zone.

5.6.2 Flexible Mesh

The flexible mesh has 1.7 million mesh elements ranging from 2.2 m^2 to 166.9 m^2. The average mesh size is 61.1 m^2. Instead of resorting to very small mesh elements, dyke structures were set up in the model to represent the important features such as certain road centrelines and embankments. The Dyke structure is a tool in DHI's MIKE 21 software, which allows for easy representation of barrier type infrastructure with functional overtopping levels.

5.6.3 Tapawera Township

The mesh elements were densified in the Tapawera township to incorporate more detailed resolution. The average mesh size within the township is 17 m^2. The mesh was created in a way so that the open drains (Figure 8) are well represented. In consultation with TDC, it was decided not to include the piped stormwater system. The main reason is that the piped system is small and unlikely to have significant impact on the flood result for the high intensity events. Also, the piped system can be easily incorporated into the model if required in the future.

A fictitious sink was set-up at the northern end of the Totara Street to drain off the runoff that would realistically discharge into an open drain via a 525 mm diameter pipe. This setup was to prevent the runoff from unrealistically flowing into, and accumulating in, the area north west of the cul-de-sac.

5.6.4 Building Representation

The majority of the buildings are clustered in Tapawera, and some are scattered across the floodplain. The “NZ Building Outlines 2020 August 24” from LINZ was used to raise the elevation of the buildings within the hydraulic model extent by 5 m so that water cannot flow over the buildings.

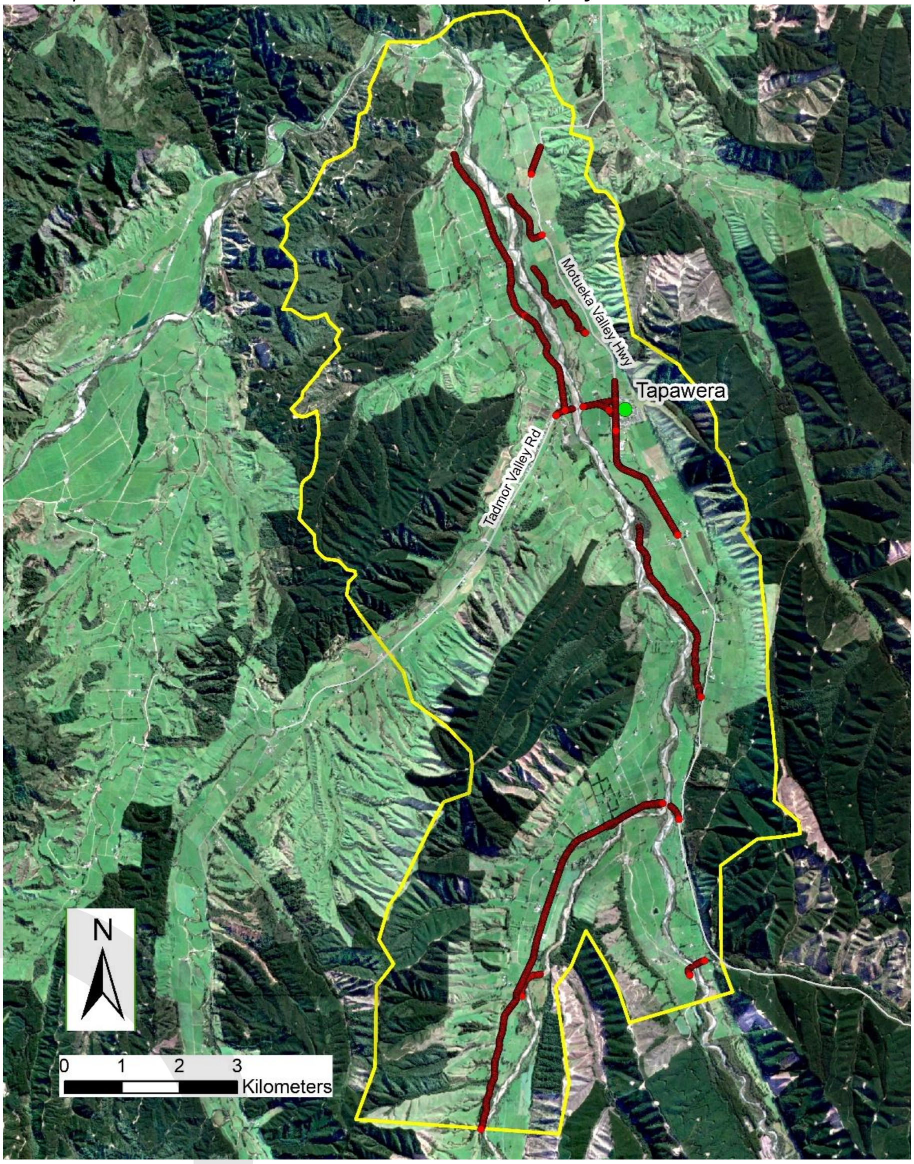
5.6.5 Road Representation

The topographic data were investigated and the results were examined from the initial trial simulations to determine locations where it may be important to have the road centrelines better represented. Those road centrelines were then represented as dyke structures in the model so that the need for very small mesh elements was eliminated, hence save model runtime.

5.6.6 Embankment Representation

The known stopbanks (see Figure 1 in Page 2 #7.Post 83 Flood Catchment Board Stopbank and #9.State Highway 6 Banking and Overflow Area) were incorporated as dyke structures in the model to capture the top of the banks. The topographic data were investigated and the results were examined from the initial trial simulations to determine a number of additional locations where it may be helpful to have the embankments represented. The red dotted lines in Figure 14 illustrate the places where dyke structures were used in the model.

Figure 14 – The locations where the surface elevation was represented as dyke structures in the hydraulic model to represent the road centrelines or the top of the embankments.



5.6.7 Bridge Representation

Denser mesh elements were used at the location of the three main bridges (the Norths, Kohatu, and Tapawera-Tadmor bridges) within the hydraulic model extent. The average mesh size is approximately 30 m^2. The topographic data set used (the "Nelson and Tasman LiDAR 1m DEM (2008-2015)") has already removed the bridges from the surface so that the river channels are continuous at the bridge locations.

The bridge piers were not represented in the model. In MIKE 21, the effect of bridge piers can be modelled as sub-grid structures using a simple drag-law to capture the increasing resistance imposed by the piers as the flow speed increases. A testing simulation was conducted to evaluate the effect of the pier structure set-up in the model. The testing result shows that the set-up of the bridge piers in the model has minimal impact on the overall flood level.

The bridge decks were not represented in the model as survey data were not available for the bridge decks to be accurately represented. The model results show that the water levels at the three bridges are all below the embankment level based on the "Nelson and Tasman LiDAR 1m DEM (2008-2015)" data set.

5.6.8 Culvert Representation

The topographic data used (the "Nelson and Tasman LiDAR 1m DEM (2008-2015)") treated the culverts as ground. The stream channels break at culvert locations leaving the roadway over the culvert intact. The results were examined from the initial trial simulations, and it was determined that it may be helpful to allow the runoff to flow under the road in a number of locations in the Glen Rae Stream Overflow area and Tapawera area. In those area the surface elevations were manually lowered to match the upstream and downstream channel bed levels.

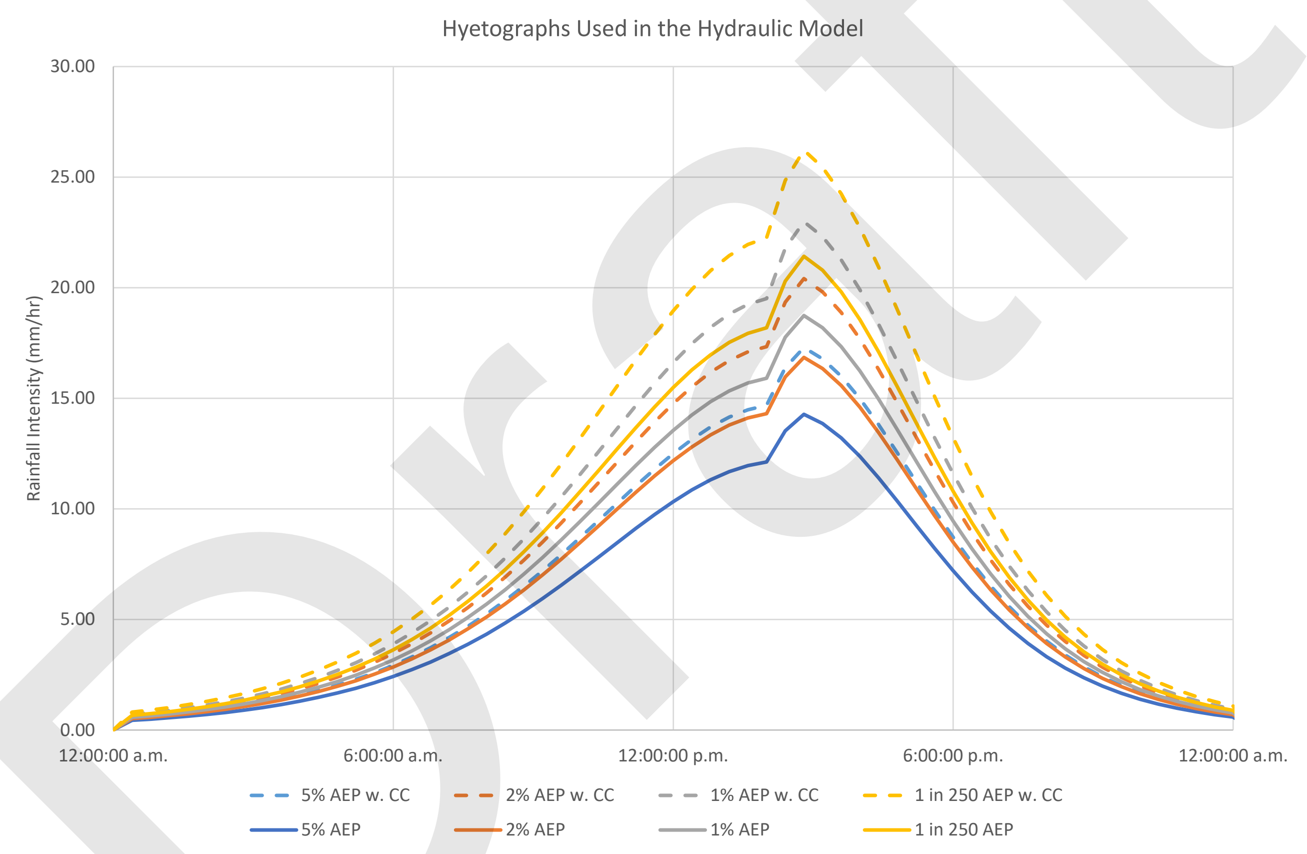
5.6.9 Critical Duration

A number of simulations were conducted to establish the critical storm duration. The results show that a 24 hours storm event generates the largest flow and highest water level in the Upper Motueka River.

5.6.10 Rainfall

The rainfall intensity at several locations across the hydraulic model extent was examined. The variations from the centre of the model extent are within 10% for the 24 hours events. In addition, the hydraulic model is less sensitive to the rainfall inputs than the hydrology models. Therefore, only one rainfall input was applied for the entire model extent. The rainfall data used was extracted from the centre of the model extent, which is approximately 3.8 km south of Tapawera. Figure 15 illustrates the hyetographs used in the hydraulic model.

Figure 15 – The hyetographs used in the hydraulic model.



5.6.11 Climate Change

In accordance with the TDC modelling guideline, the RCP 8.5 for the period 2081 – 2100 rainfall was used to assess effects of climate change.

5.6.12 Rainfall Losses

The infiltration rates were derived from the calibrated Tadmor model. This is because the critical duration in the hydraulic model is 24 hours, which is the same as the Tadmor model. Also, the Tadmor model has the lowest infiltration rates which provide the most conservative values. Sensitivity testing was conducted on increasing and decreasing infiltration rates to ascertain the model confidence. See Figure 13 in Page 28 for the curve of the initial infiltration rates derived from the Tadmor model.

5.6.13 Energy Losses

The same approaches used in the hydrology model for the roughness (see Section 5.5.10) and Eddy viscosity (See Section 5.5.11) were used in the hydraulic model.

5.6.14 Inflow Boundary Conditions

The hydraulic model has three inflow boundary conditions that introduce runoff from the Upper Motueka, Motupiko and Tadmor catchments. See Figure 16 for the locations of the inflow boundaries and their relation to the gauging sites.

Figure 17 to Figure 24 provides the combinations of the inflow hydrographs for the 1 in 250 AEP, 1% AEP, 2% AEP and 5% AEP storm events with climate change and no climate change scenarios.

Figure 16 – The location of the inflow boundaries from the Upper Motueka, Motupiko and Tadmor catchments and the gauging sites.

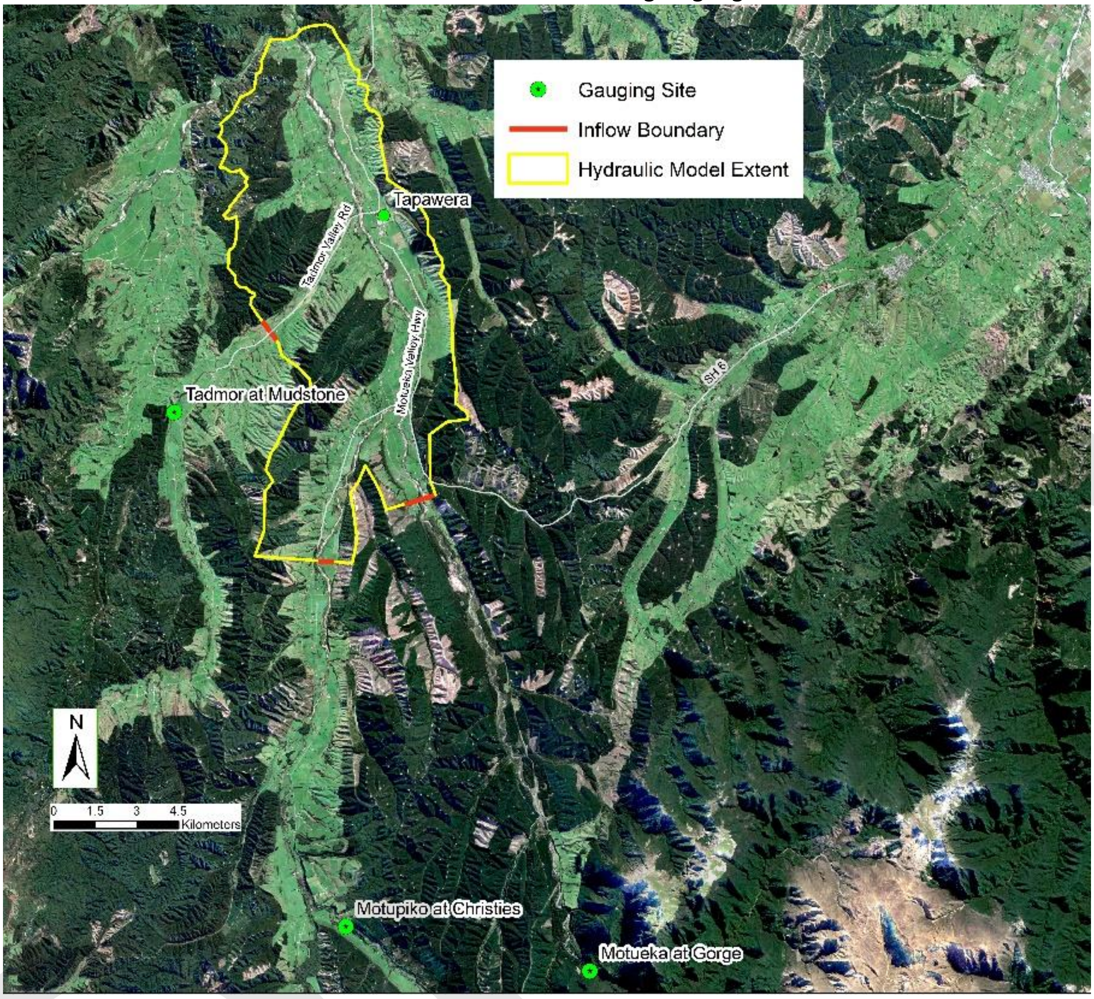


Figure 17 – Inflow hydrographs for the 1 in 250 AEP event with climate change.

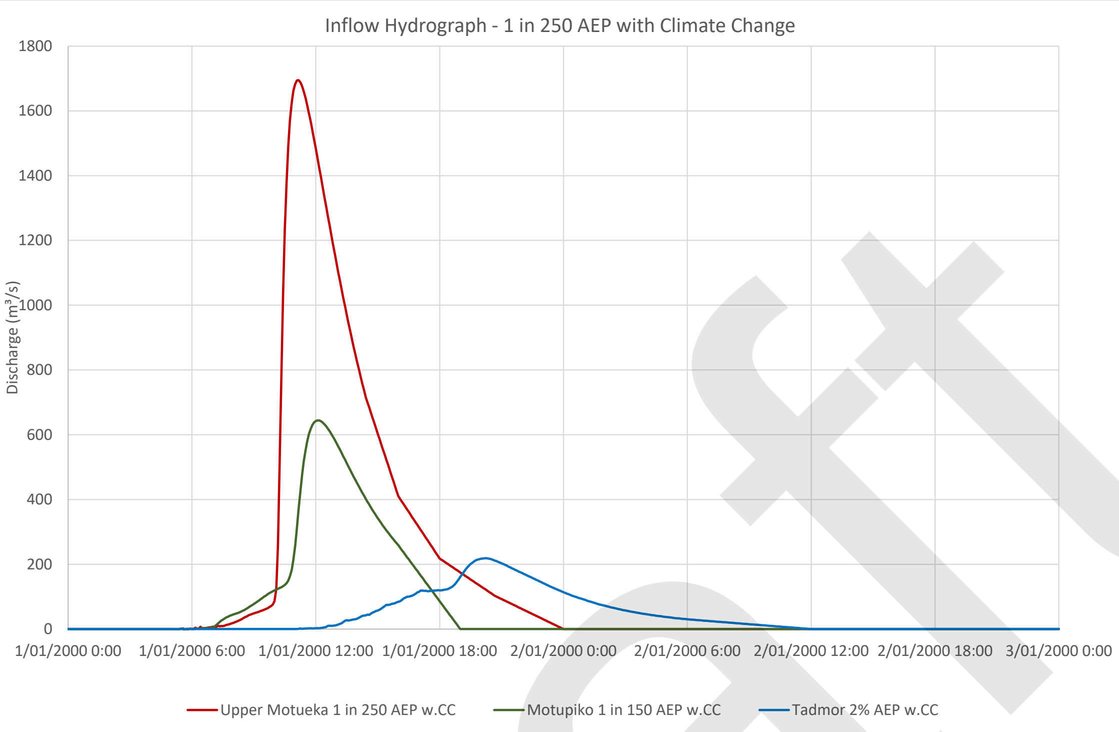


Figure 18 –Inflow hydrographs for the 1% AEP event with climate change.

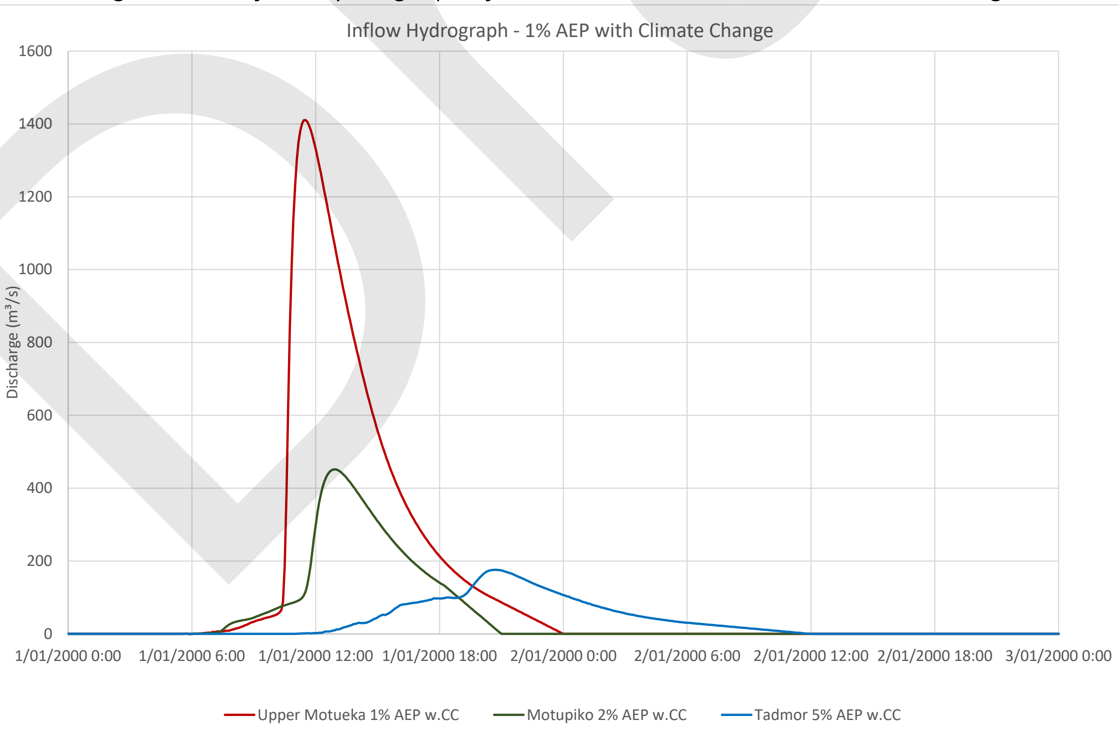


Figure 19 –Inflow hydrographs for the 2% AEP event with climate change.

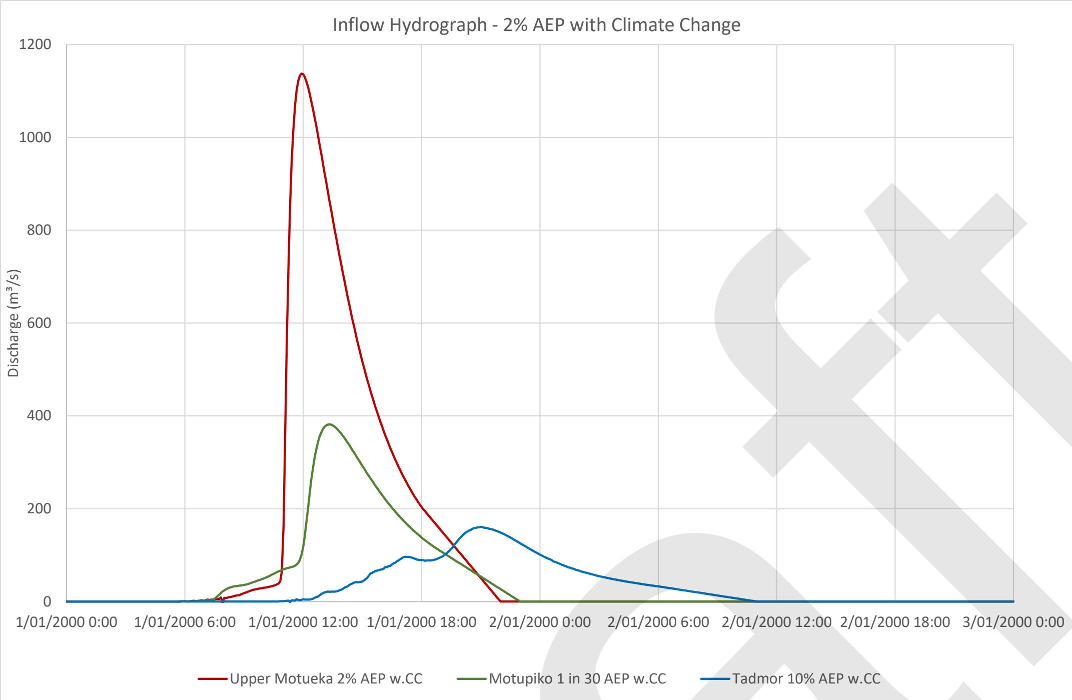


Figure 20 –Inflow hydrographs for the 5% AEP event with climate change.

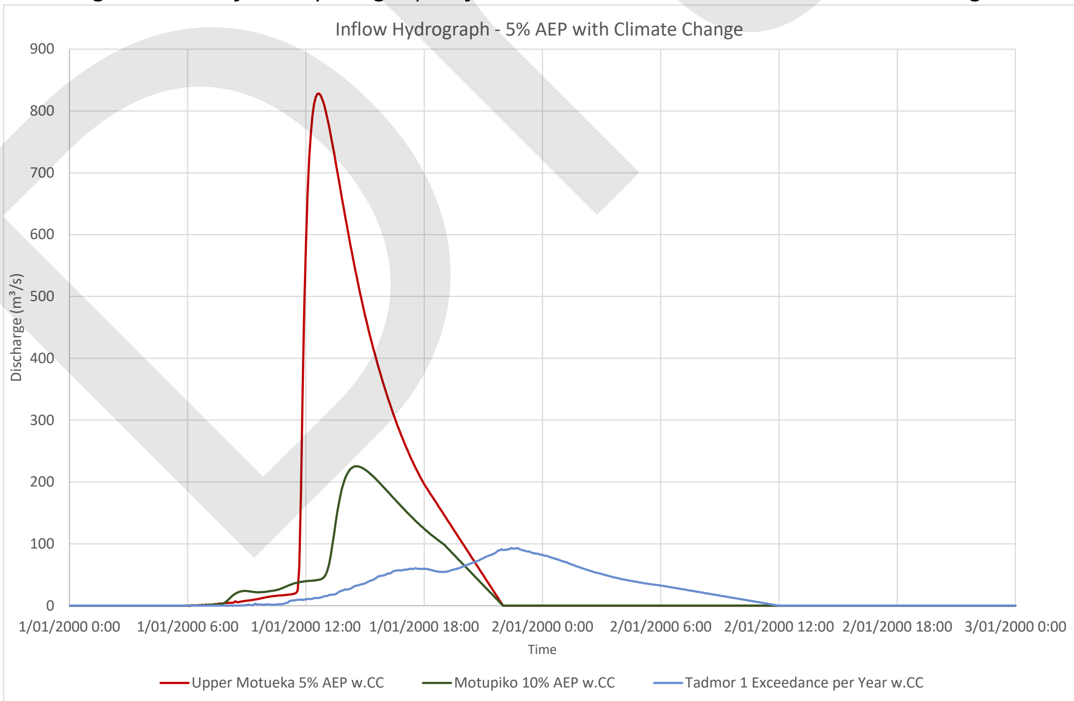


Figure 21 –Inflow hydrographs for the 1in 250 AEP event without climate change.

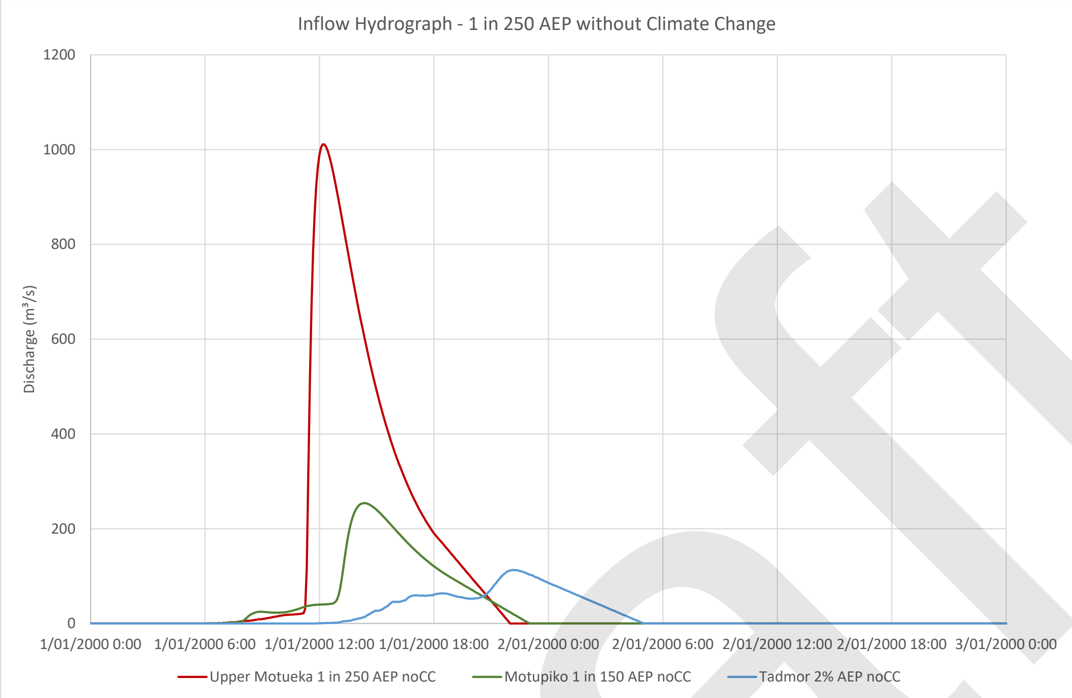


Figure 22 –Inflow hydrographs for the 1% AEP event without climate change.

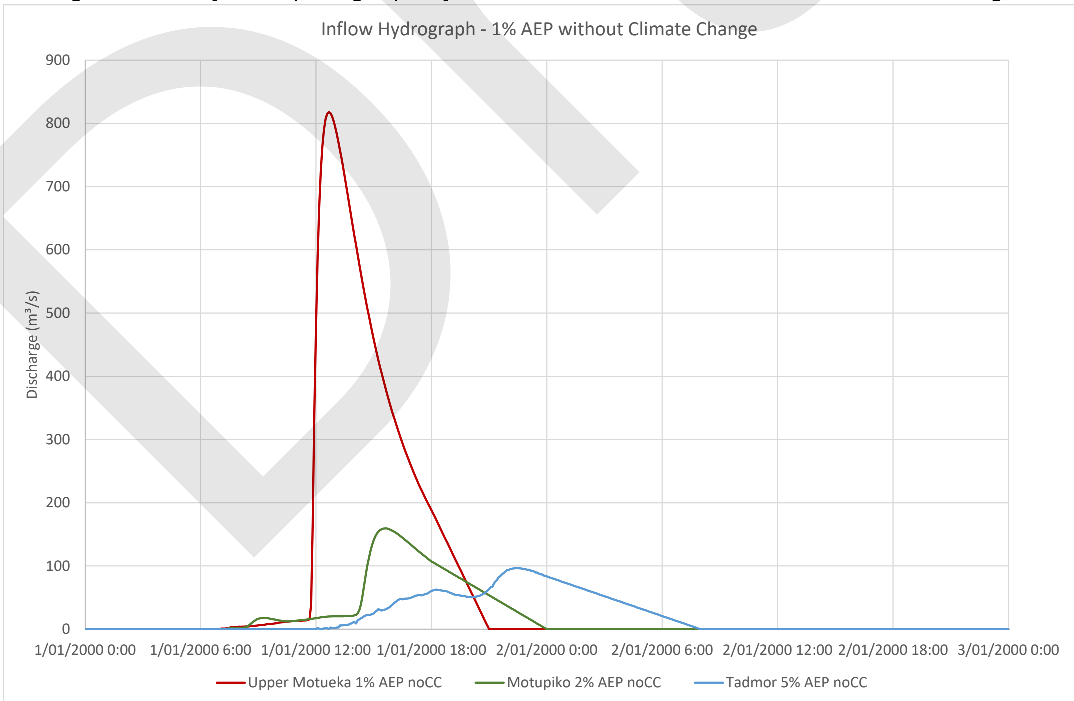


Figure 23 –Inflow hydrographs for the 2% AEP event without climate change.

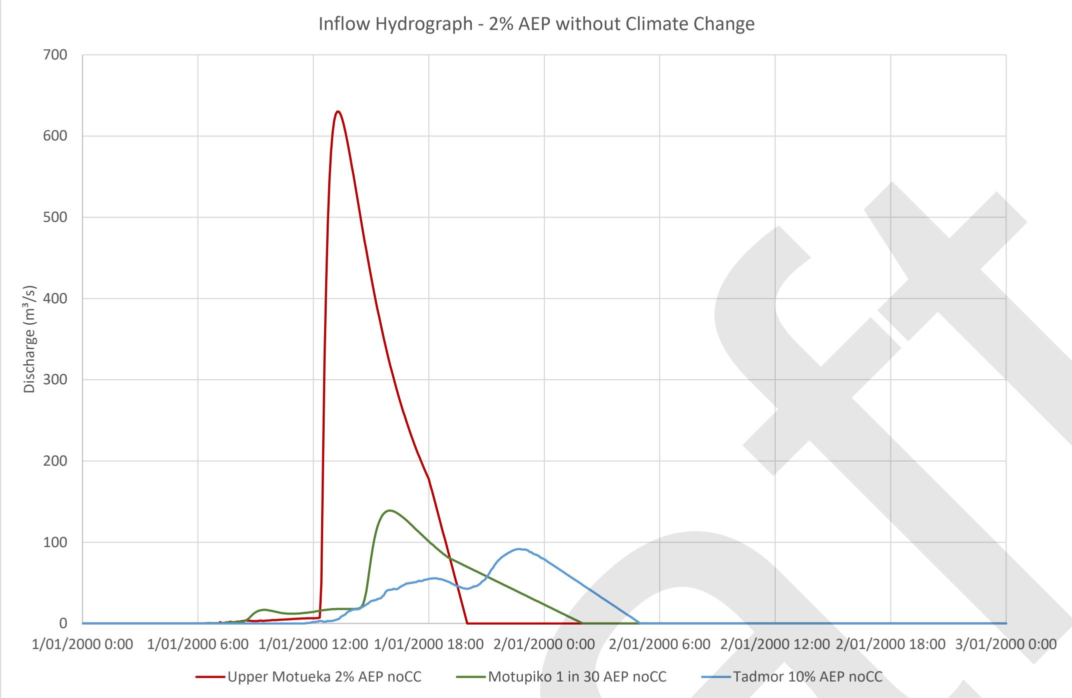
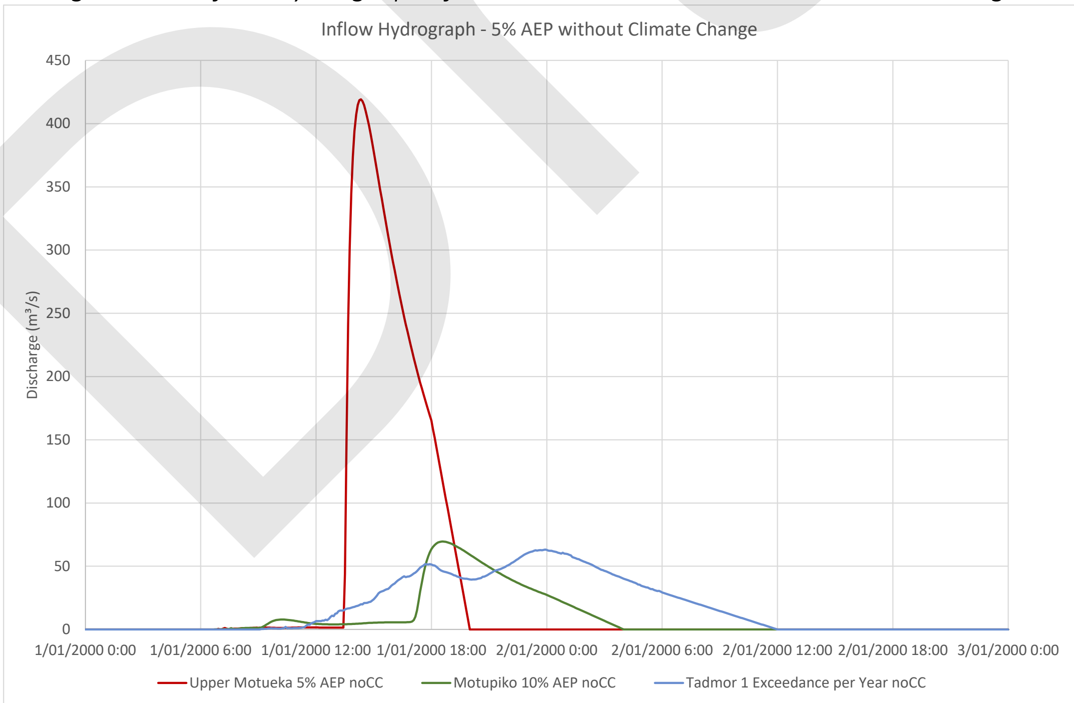


Figure 24 –Inflow hydrographs for the 5% AEP event without climate change.



5.6.15 Downstream Boundary Condition

The downstream boundary condition was set at the location where the Upper Motueka River meets the Wangapeka River. A constant water level of 113.7 m at the downstream boundary was assumed. Because of this assumed boundary condition the model result in the area approximately 2 km from the downstream boundary is not accurate. This area was excluded from the presentation of the 2D model results.

5.6.16 Baseflow

As discussed in the hydrology modelling section, baseflows were not explicitly applied. However, when generating the 2D mesh in the channel the water surface elevation was sampled as bed level. Therefore, the baseflow was in a way taken into consideration.

6 SIMULATION SCENARIOS

6.1 Hydrology Modelling

A number of model simulations were conducted to investigate various aspects of the modelling process. The model log attached in Appendix B provides the list of the final simulations. In summary, the following final 24 scenarios were simulated in the hydrology modelling exercise:

1-4 The Upper Motueka catchment without climate change, 12hr duration for 1 in 250 AEP, 1% AEP, 2% AEP and 5% AEP storm events.

5-8 The Upper Motueka catchment with climate change, 12hr duration for 1 in 250 AEP, 1% AEP, 2% AEP and 5% AEP storm events.

9-12 The Motupiko catchment without climate change, 12hr duration for 1 in 150 AEP, 2% AEP, 1 in 30 AEP and 10% AEP storm events.

13-16 The Motupiko catchment with climate change, 12hr duration for 1 in 150 AEP, 2% AEP, 1 in 30 AEP and 10% AEP storm events.

17-20 The Tadmor catchment without climate change, 24hr duration for 2% AEP, 5% AEP, 10% AEP and 1 Exceedance per Year storm events.

20-24 The Tadmor catchment with climate change, 24hr duration for 2% AEP, 5% AEP, 10% AEP and 1 Exceedance per Year storm events.

6.2 Hydraulic Modelling

A number of model simulations were conducted to investigate various aspects of the modelling process. The model log attached in Appendix B only provides a list of the critical simulations. In summary, the following final 12 scenarios were simulated in the hydraulic modelling exercise:

1-4 Existing land use condition without climate change, 1 in 250 AEP, 1% AEP, 2% AEP and 5% AEP storm events.

5-8 Future land use condition without climate change, 1 in 250 AEP, 1% AEP, 2% AEP and 5% AEP storm events.

9-12 Future land use condition with climate change, 1 in 250 AEP, 1% AEP, 2% AEP and 5% AEP storm events.

7 ASSESSMENT OF MODEL CONFIDENCE

7.1 Sensitivity Testing

In the hydraulic modelling exercise, sensitivity testing was conducted on a selection of inputs that include: Manning's roughness values, infiltration rates, rainfall depth and Eddy viscosity. The exercise was performed on the "Existing land use condition, 1% AEP 24hr, with climate change" condition. The following scenarios were tested:

- Increase bed roughness by a factor of 1.1
- Decrease bed roughness by a factor of 0.9
- Increase infiltration rate by a factor of 1.1
- Decrease infiltration rate by a factor of 0.9
- Increase rainfall depth by a factor of 1.1
- Decrease rainfall depth by a factor of 0.9
- Activate Eddy viscosity

7.2 Sensitivity Testing Results

7.2.1 Discharge in the River Channel

Figure 25, Figure 26 and Figure 27 compare the sensitivity testing result hydrographs with the base model at the Norths, Kohatu and Tapawera-Tadmor Bridges respectively. The results show that varying the values of the input parameters or activating Eddy viscosity only result in a minor change of the shape of the hydrographs.

Figure 25 –Sensitivity testing results: hydrographs at the Norths Bridge.

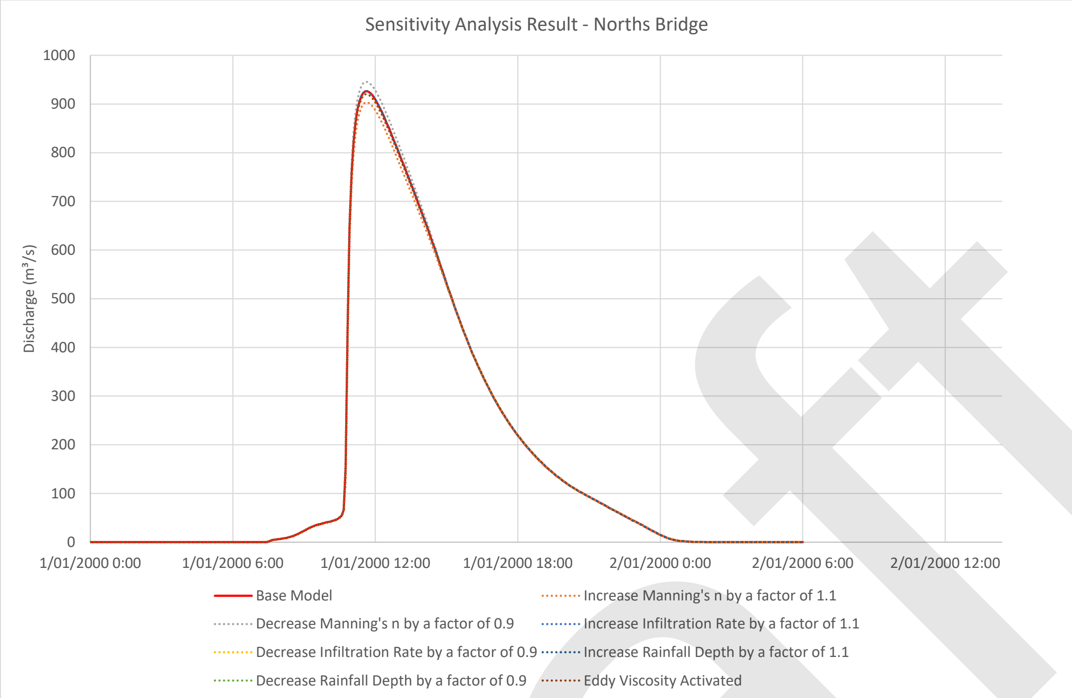


Figure 26 – Sensitivity testing results: hydrographs at the Kohatu Bridge.

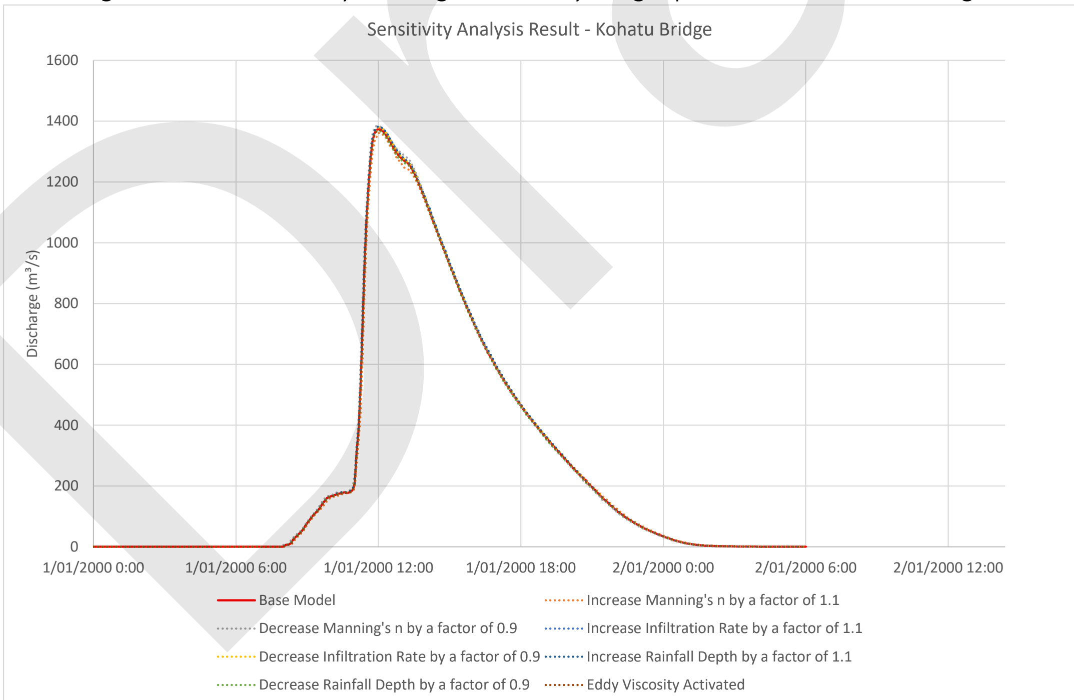


Figure 27 – Sensitivity testing results: hydrographs at the Tapawera-Tadmor Bridge.

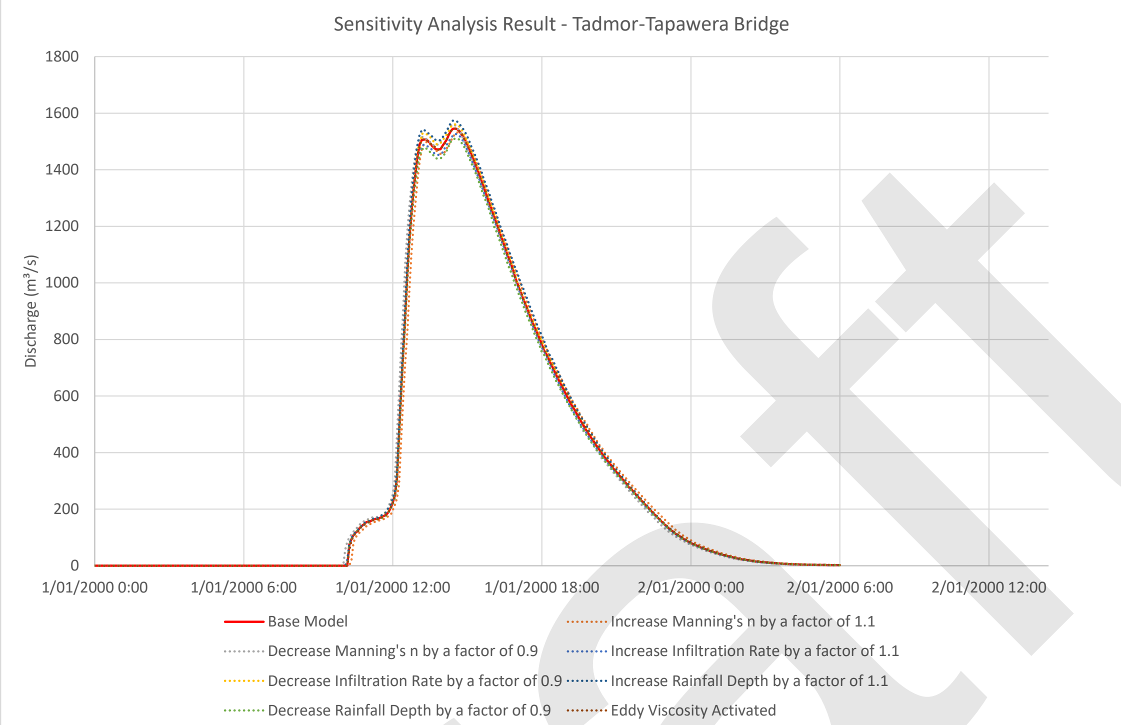


Table 9 provides the percent changes of the peak discharges from the base model at the three bridges. An increase in bed roughness by a factor of 1.1 results in reduction of the peak flow. The reductions are 2.48%, 0.98% and 0.9% at the Norths, Kohatu and Tapawera-Tadmor bridges respectively. A decrease in bed roughness by a factor of 0.9 results in increase of the peak flow. The increases are 2.1%, 0.72% and 1% at the Norths, Kohatu and Tapawera-Tadmor bridges respectively.

An increase in bed infiltration rate by a factor of 1.1 results in reduction of the peak flow. The reductions are -0.0002%, -0.34% and -1.22% at the Norths, Kohatu and Tapawera-Tadmor bridges respectively. A decrease in infiltration rate by a factor of 0.9 results in increase of the peak flow. The increases are 0.0049%, 0.34% and 0.94% at the Norths, Kohatu and Tapawera-Tadmor bridges respectively.

An increase in rainfall depth by a factor of 1.1 results in an increase of the peak flow. The increases are 0.02%, 0.6% and 1.84% at the Norths, Kohatu and Tapawera-Tadmor bridges respectively. A decrease in rainfall depth by a factor of 0.9 results in a reduction of the peak flow. The reductions are 0.02%, 0.41% and 2.25% at the Norths, Kohatu and Tapawera-Tadmor bridges respectively.

When the Eddy viscosity was activated, the peak flow decreased 0.6% and 0.33% at the Norths and Kohatu bridges. The peak flow increased 0.03% at the Tapawera-Tadmor Bridge.

Table 9.Sensitivity testing results: peak flows at the Norths, Kohatu and Tapawera-Tadmor Bridges.

	Base Model	Increase Manning's n by a factor of 1.1	Decrease Manning's n by a factor of 0.9	Increase Infiltration Rate by a factor of 1.1	Decrease Infiltration Rate by a factor of 0.9	Increase Rainfall Depth by a factor of 1.1	Decrease Rainfall Depth by a factor of 0.9	Eddy Viscosity Activated
Peak Flow at Norths Bridge (m^3/s)	926	903	946	926	926	926	926	920
% Change from the Base Model		-2.48%	2.10%	-0.0002%	0.0049%	0.02%	-0.02%	-0.68%
Peak Flow at Kohatu Bridge (m^3/s)	1375	1361	1384	1370	1379	1383	1369	1370
% Change from the Base Model		-0.98%	0.72%	-0.34%	0.34%	0.60%	-0.41%	-0.33%
Peak Flow at Tadmor-Tapawera Bridge (m^3/s)	1546	1532	1561	1527	1560	1574	1511	1546
% Change from the Base Model		-0.90%	1.00%	-1.22%	0.94%	1.84%	-2.25%	0.03%

7.2.2 Flood Depth

Appendix C provides the flood maps showing the changes of the flood level from the base model. The most significant changes were observed when varying the bed roughness values. An increase in bed roughness results in an increase of water level in the majority of the river channel and its adjacent floodplain. The increase ranges primarily between 20 mm to 110 mm. A decrease in bed roughness results in a reduction in water level in the majority of the river channel and the adjacent floodplain. The reduction ranges primarily between 10 mm to 110 mm.

An increase in infiltration rate results in a decrease of water level in the majority of the river channel and the adjacent floodplain. The reduction ranges primarily between 8 mm to 30 mm. A decrease in infiltration rate results in an increase in water level in the majority of the river channel and the adjacent floodplain. The increase ranges primarily between 10 mm to 20 mm.

An increase in rainfall depth results in an increase of water level in the majority of the river channel and the adjacent floodplain. The increase ranges primarily between 10 mm to 40 mm. A decrease in rainfall depth results in a decrease of water level in the majority of the river channel and the adjacent floodplain. The increase ranges primarily between 10 mm to 70 mm.

When the Eddy viscosity was activated, a slight increase in flood depth in the majority of the river channel and the adjacent floodplain was observed. The increase ranges typically between 10 mm to 20 mm.

In summary, the sensitivity testing results demonstrate that the maximum flood depth across the floodplain and the peak discharge at the three bridge locations have little variation when activating the Eddy viscosity or altering the bed roughness values, infiltration rates and rainfall depth by +/- 10%. This sensitivity analysis provides a level of certainty in all the model results presented throughout this study.

8 RESULTS

8.1 Hydrology Model

8.1.1 Historical Events Comparison

The purpose of this modelling exercise is not to estimate an actual or historic flood from a specific rainfall event. Rather, the purpose is to estimate design flood with flood and rainfall data derived from statistical analysis. The comparison here is just to get a sense of the difference between a modelled design flow and historical records.

The historical flood events were already reviewed in depth in Section 5.5.5. The 2005 March flood event is equivalent to a 1 in 80 AEP flood at the Upper Motueka Gorge gauging site. The rainfall recorded is equivalent to a 1 in 200 AEP storm that lasted for 20 hours. Figure 28 compares the model result from a 1% AEP 12 hr design rainfall without climate change scenario to the flow record. Note that the flow record in the receding phase was not available.

The 2005 March flood event is equivalent to a 1 in 120 AEP flood at the Motupiko Christies gauging site. The rainfall recorded is equivalent to 5% AEP storm that lasted for 24 hours. Figure 29 compares the model result from a 1 in 120 AEP 24 hr design rainfall without climate change to the flow record.

The 1883 July flood event is equivalent to a 1 in 32 AEP flood at the Tadmor Mudstone gauging site. The rainfall recorded is equivalent to a 50% to 20% AEP rainfall that lasted 53 hours. Figure 30 compares the model result from a 5% AEP 24 hr design rainfall without climate change to the flow record.

Figure 28 – Comparison of the model result (1% AEP 12hr storm without climate change) and 2005 March flood event at the Upper Motueka Gorge gauging site.

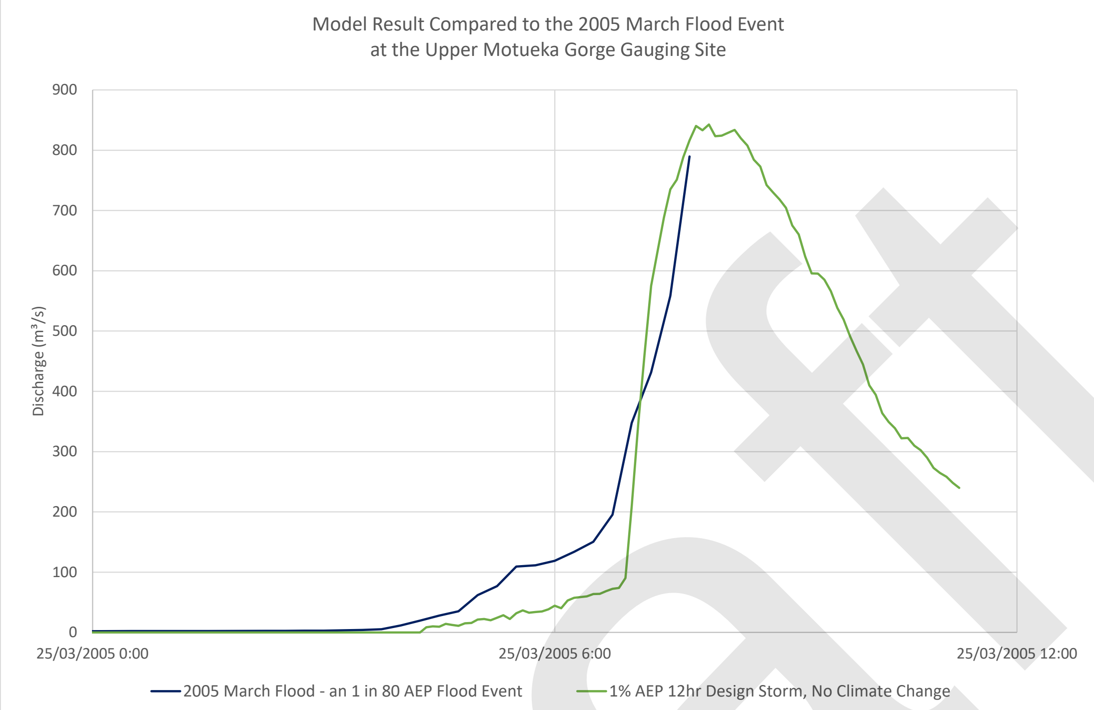


Figure 29 – Comparison of the model result (1 in 120 AEP 24hr storm without climate change) and 2005 March flood event at Motupiko Christies gauged site.

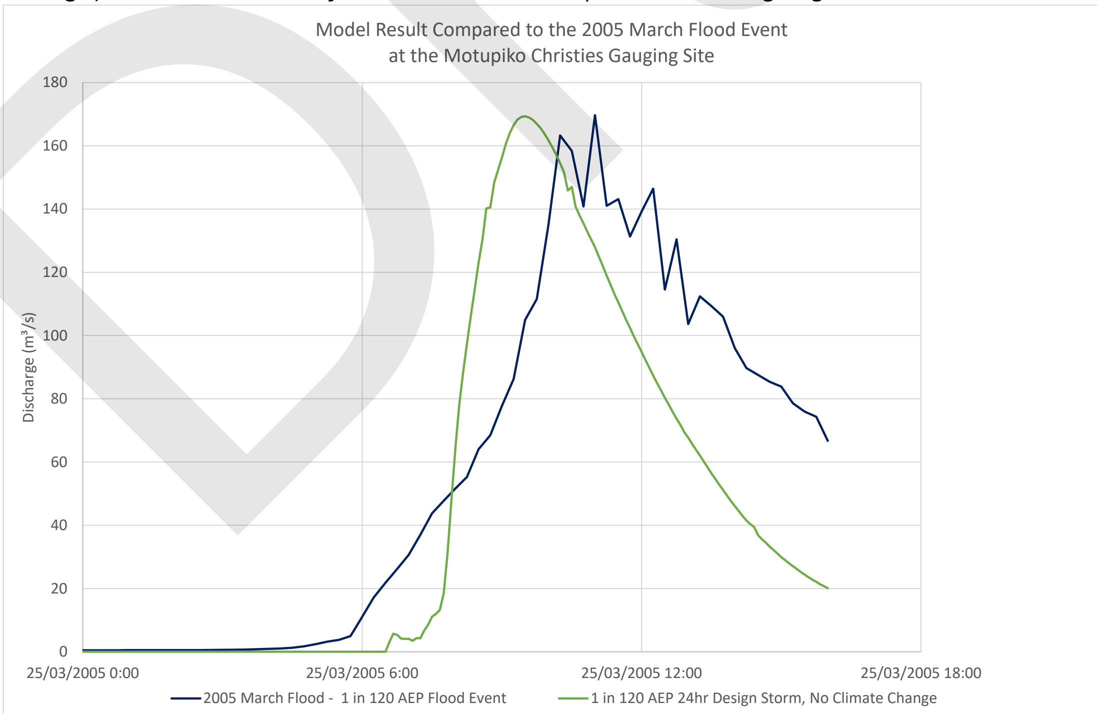
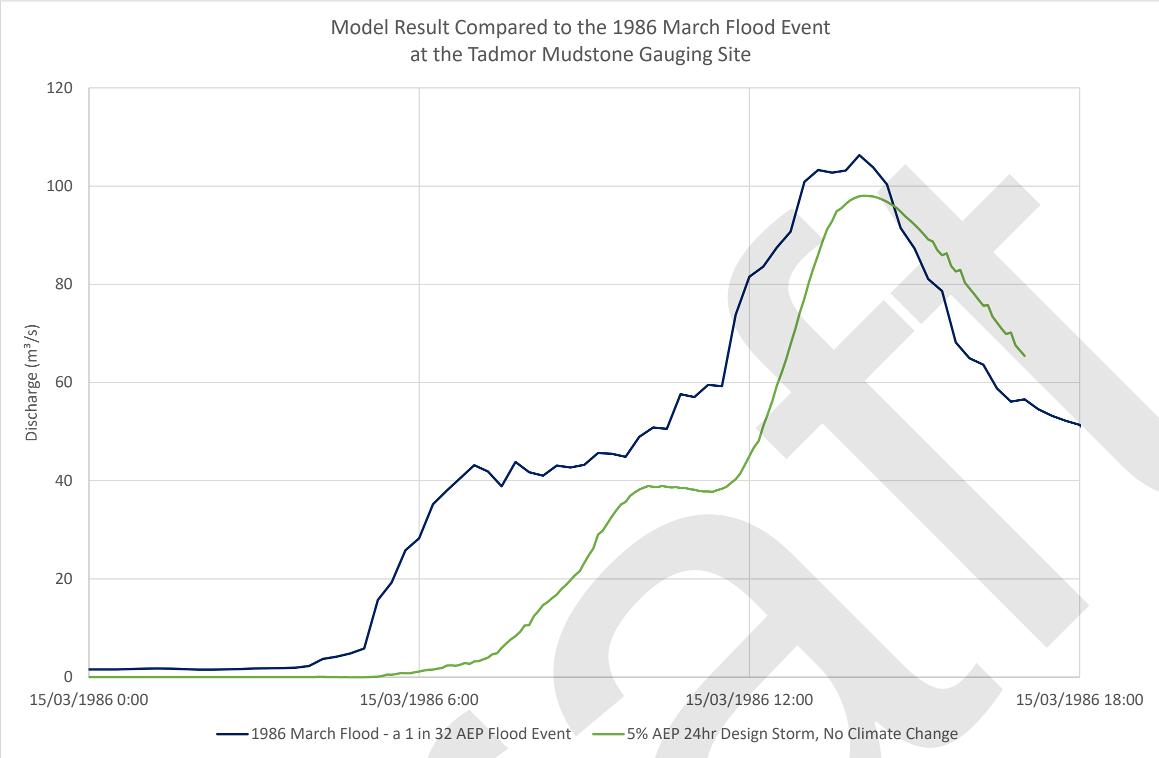


Figure 30 - Comparison of the model result (5% AEP 24hr storm without climate change) and 1986 March flood event at the Tadmor Mudstone gauging site.



8.1.2 Climate Change Impacts

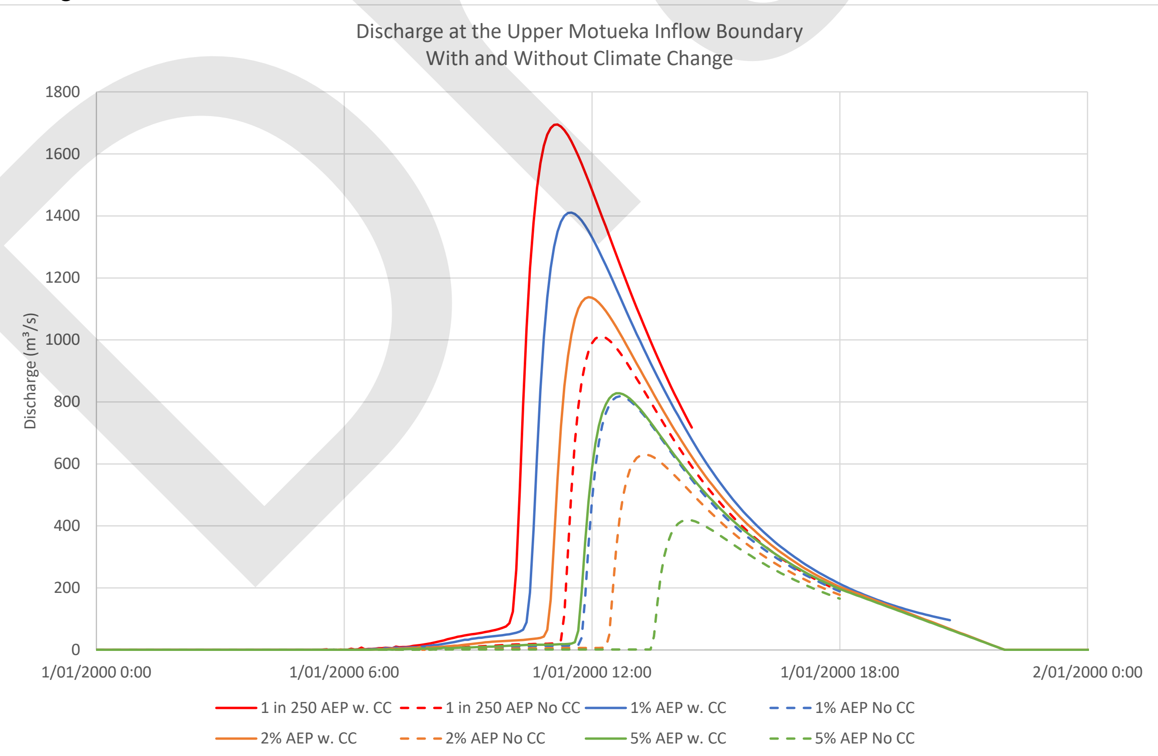
The model results show that the impact of climate change becomes greater further downstream in the hydrology models. The greatest impact from climate change condition was observed in the Motupiko model.

In all climate change scenarios, the average rainfall depths used in the Upper Motueka model increase by a factor of 1.3. The peak flows at the Gorge gauging site increase by a factor of 1.6, 1.5, 1.4 and 1.4 for the 5% AEP, 2% AEP, 1% AEP and 1 in 250 AEP storm events respectively. The peak flows at the hydraulic model inflow boundary increase by a factor of 2, 1.8, 1.7 and 1.7 for the 5% AEP, 2% AEP, 1% AEP and 1 in 250 AEP storm events respectively. Refer to Table 10 for the summary. Figure 31 displays the hydrographs for the climate change and no climate change conditions at the Upper Motueka inflow boundary.

Table 10. The average rainfall depths used and climate change impacts on the peak flow in the Upper Motueka model.

	Average Rainfall Depth Used in the Model			Peak Flow at the Gorge Site			Peak Flow at the Hydraulic Model Inflow Boundary		
Upper Motueka	No CC (mm)	CC (mm)	Factor increase	No CC (m³/s)	CC (m³/s)	Factor increase	No CC (m³/s)	CC (m³/s)	Factor increase
5% AEP	113	141	1.3	536	865	1.6	419	828	2.0
2% AEP	133	167	1.3	702	1068	1.5	630	1138	1.8
1% AEP	149	188	1.3	853	1229	1.4	818	1411	1.7
1 in 250 AEP	171	215	1.3	989	1424	1.4	1011	1695	1.7

Figure 31 – Discharge at the Upper Motueka inflow boundary with and without climate change conditions.

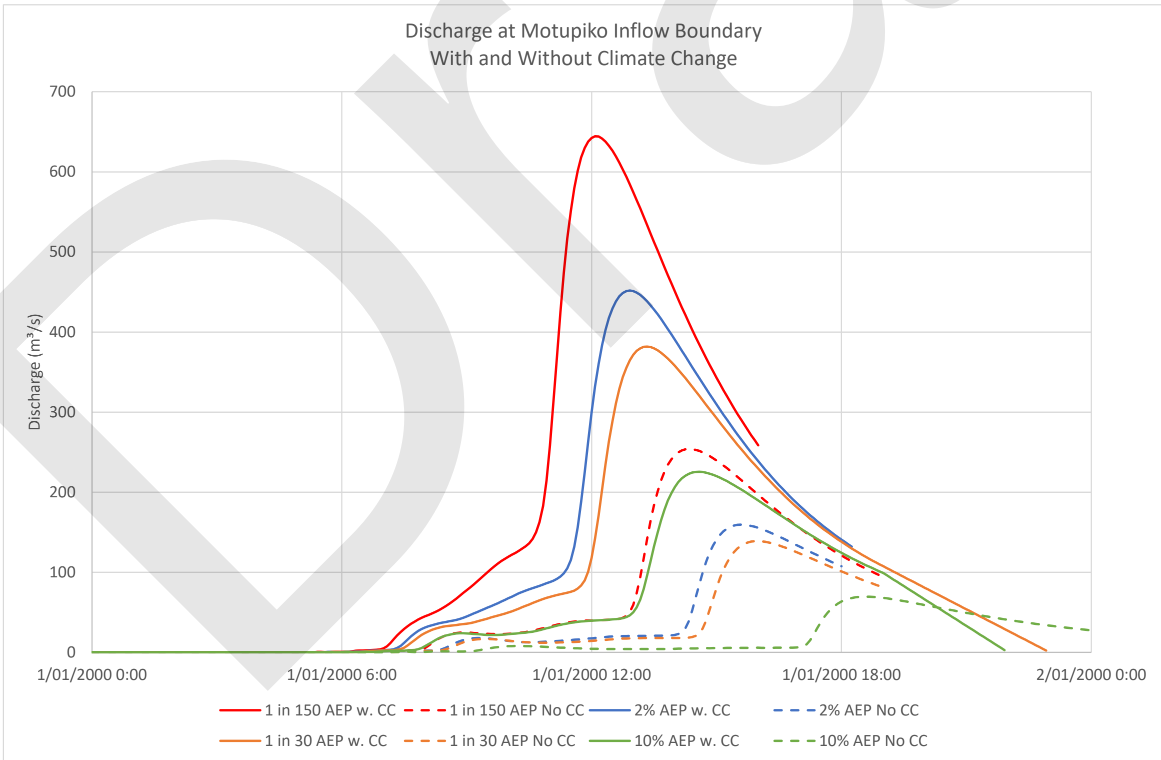


In all climate change scenarios, the average rainfall depths used in the Motupiko model increase by a factor of 1.2. The peak flows at the Christies gauging site increase by a factor of 1.9, 1.9, 1.9 and 2 for the 10% AEP, 1 in 30 AEP, 2% AEP and 1 in 150 AEP storm events respectively. The peak flows at the hydraulic model inflow boundary increase by a factor of 3.2, 2.7, 2.8 and 2.5 for the 10% AEP, 1 in 30 AEP, 2% AEP and 1 in 150 AEP storm events respectively. See Table 11 for the summary. Figure 32 displays the hydrographs for the climate change and no climate change conditions at the Motupiko inflow boundary.

Table 11.The average rainfall depths used and climate change impacts on the peak flow in the Upper Motueka model.

	Average Rainfall Depth			Peak Flow at the Christies Site			Peak Flow at the Hydraulic Model Inflow Boundary		
Motupiko	No CC (mm)	CC (mm)	Factor increase	No CC (m^3/s)	CC (m^3/s)	Factor increase	No CC (m^3/s)	CC (m^3/s)	Factor increase
10% AEP	55	64	1.2	71	137	1.9	70	226	3.2
1 in 30 AEP	108	130	1.2	111	208	1.9	139	382	2.7
2% AEP	124	150	1.2	124	241	1.9	159	452	2.8
1 in 150 AEP	145	177	1.2	166	332	2.0	254	644	2.5

Figure 32 – Discharge at the Motupiko inflow boundary with and without climate change conditions.

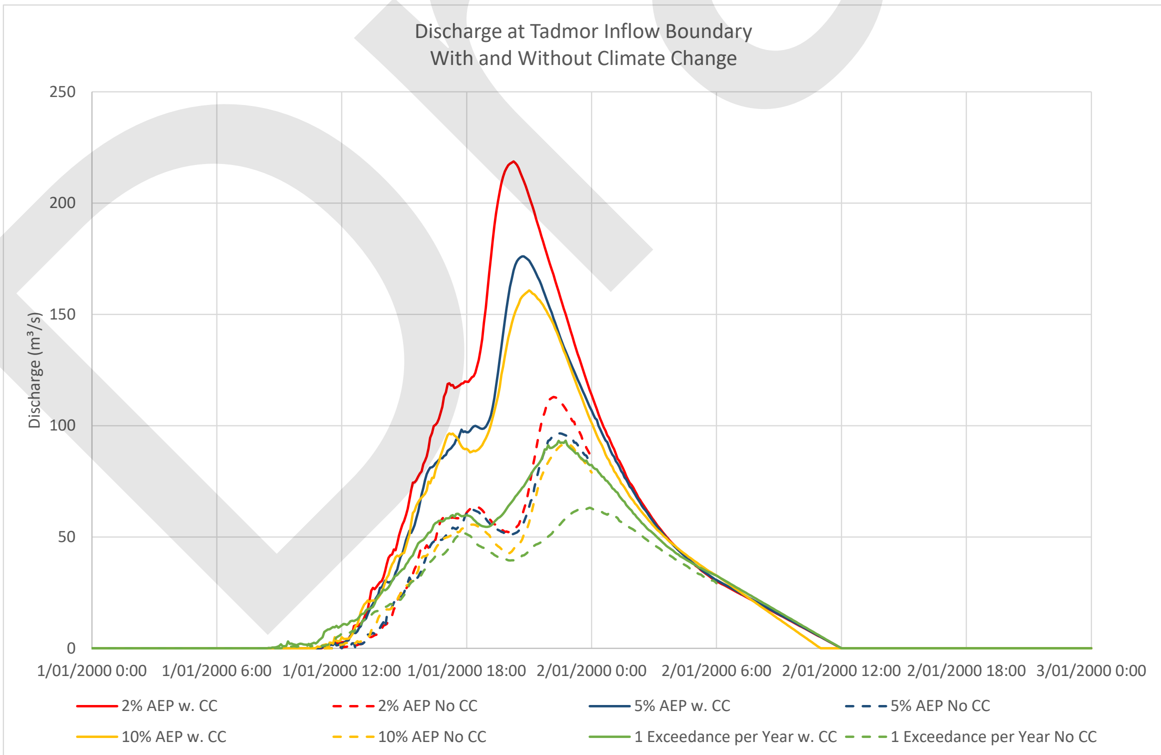


In all climate change scenarios, the average rainfall depths used in the Tadmor model increase by a factor of 1.2. The peak flows at the Christies gauging site increase by a factor of 1.4, 1.7, 1.7 and 1.8 for the 1 Exceedance per Year, 10% AEP, 5% AEP and 2% AEP storm events respectively. The peak flows at the hydraulic model inflow boundary increase by a factor of 1.5, 1.8, 1.8 and 1.9 for the 1 Exceedance per Year, 10% AEP, 5% AEP and 2% AEP storm events respectively. See Table 12 for the summary. Figure 33 displays the hydrographs for the climate change and no climate change conditions at the Tadmor inflow boundary.

Table 12.The average rainfall depths used and climate change impacts on the peak flow in the Tadmor model.

	Average Rainfall Depth			Peak Flow at Mudstone Site			Peak Flow at the Hydraulic Model Inflow Boundary		
Tadmor	No CC (mm)	CC (mm)	Factor increase	No CC (m^3/s)	CC (m^3/s)	Factor increase	No CC (m^3/s)	CC (m^3/s)	Factor increase
1 Exceedance per Year	55	64	1.2	61	85	1.4	63	93	1.5
10% AEP	108	130	1.2	89	151	1.7	92	161	1.8
5% AEP	124	150	1.2	101	171	1.7	97	176	1.8
2% AEP	145	177	1.2	117	212	1.8	113	219	1.9

Figure 33 – Discharge at the Tadmor inflow boundary with and without climate change conditions.



8.2 Hydraulic Model

8.2.1 Comparison to the Historical Flood Pattern

Among the flood events that have the historic flood pattern available, 1974 flood event provides the most intense flood recorded at the Upper Motueka Gorge gauging site. The peak flow recorded at the Upper Motueka Gorge gauging site was 563 m^3/s, which is approximately a 5% AEP flood event. There are no flood records available for the Motupiko and Tadmor catchments for this event.

Appendix D compares the 1974 historic flood pattern to the model result for the 5% AEP existing land use condition with no climate change. The combination of the flood frequency at the inflow boundaries for this scenario are 5% AEP, 10% AEP and 1 Exceedance per Year for the Upper Motueka, Motupiko and Tadmor catchments. The comparison shows that:

- Generally, the model result in the Motueka floodplain matches well with the 1974 flood pattern, except that the 1974 event overtopped the 1983 stopbank and SH 6 bank area. This is expected as the stopbanks were installed after the 1974 flood.
- The 1974 event may have a more intense flood in the Motupiko catchment than what has been modelled, which was a 10% AEP event.
- The model result in the Tadmor catchment does not match well with the historic flood extent. This is partially because the Tadmor catchment is largely located in the area where the surface elevation was interpolated from the DEM with lower resolution. Therefore, the Tadmor river channel and floodplain were not represented as accurate as those in the Motueka and Motupiko catchments. The blue line on the flood map indicates where the two DEM data sets intersect.

8.2.2 Existing Land use without Climate Change Scenario

Appendix E provides the results of the flood depth for the existing land use condition without climate change scenarios for the 5%, 2%, 1% and 1 in 250 AEP storm events. Figure 34, Figure 35 and Figure 36 show the hydrographs at the Norths, Kohatu and Tapawera-Tadmor Bridge respectively. Table 13 provides the summary of the model results in the key areas.

Figure 34 – Discharge at the Norths Bridge for the existing land use without climate change scenarios.

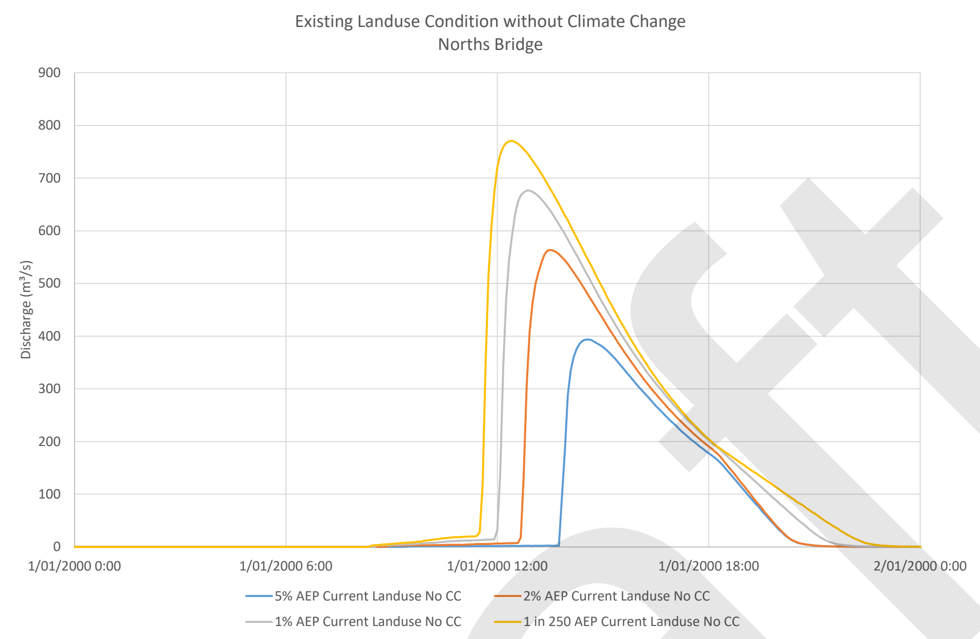


Figure 35 – Discharge at the Kohatu Bridge for the existing land use without climate change scenarios.

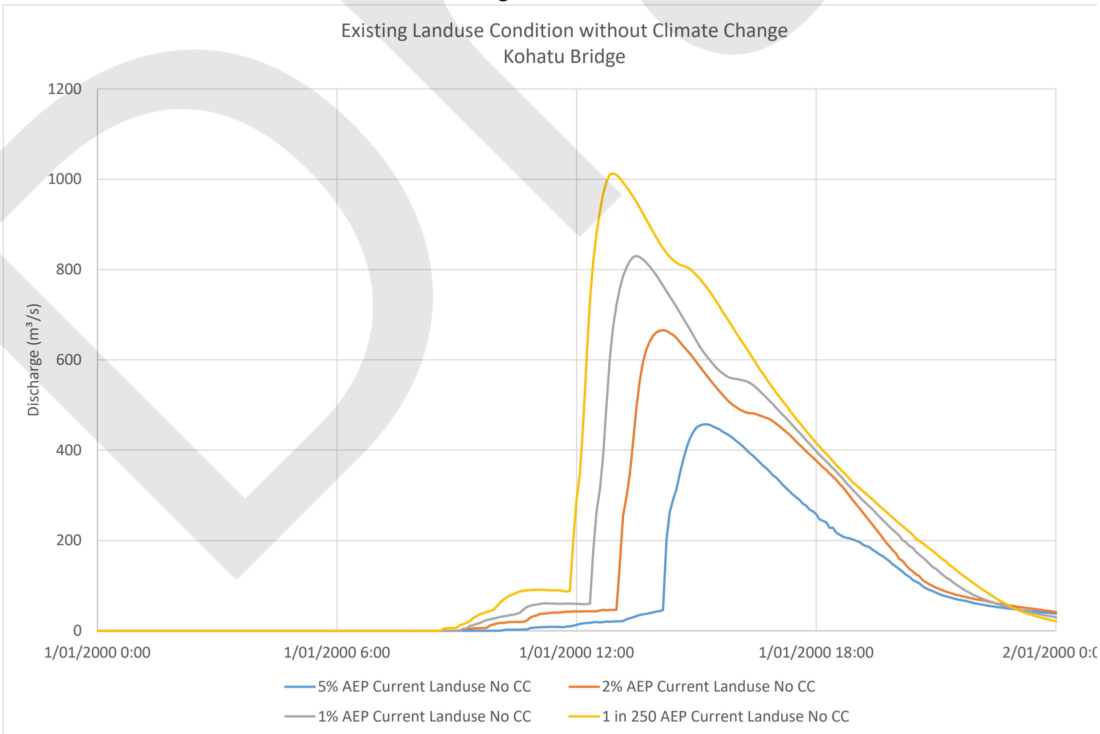


Figure 36 – Discharge at the Tapawera-Tadmor Bridge for the existing land use without climate change scenarios.

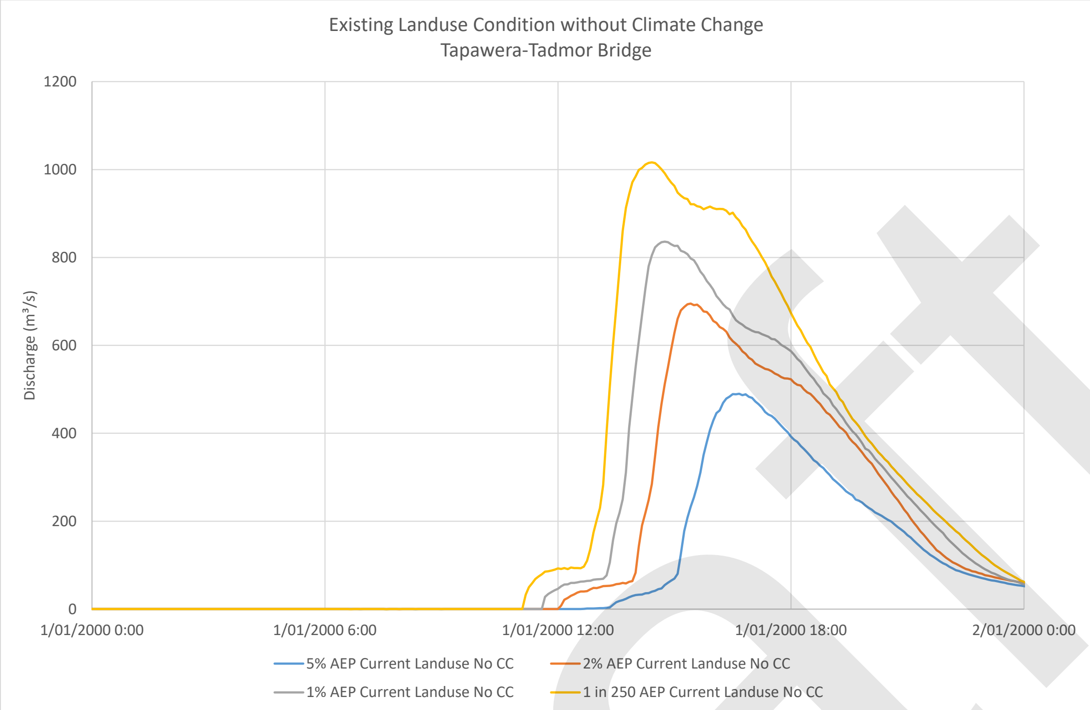


Table 13.Summary of the modelling results in the key areas for the existing and future land use without climate change scenarios.

Key Area	Summary
1.Glen Rae Stream overflow area	The flood extents are similar for the 5%, 2%, 1% and 1 in 250 AEP storm events, however the flood depth deepens as the storm intensity increases.
2.Water Supply Creek area	No Significant flooding risk is observed in this area for all simulated events.
3.Tapawera township	Flood flows across from the west side of the Motueka Highway in the south of the township (Milk Creek Area) near the Motueka Valley Highway road bent to the east side for the 2%, 1% and 1 in 250 AEP events.
4.Tapawera-Tadmor Bridge	The flood does not overflow over the bridge or the road for all the simulated events.
5.Mill Creek area	The Mill Creek catchment contributes to the flooding in the southern part of the Tapawera township.
6.Current hop industry development area	The area in the west of the Motueka Highway and the south of the Post 83 stopbank is severely flooded for all the simulated events.
7.Post 83 flood Catchment Board stopbank	Breakout of 83 Stopbank is observed from the southern section for the 1% and 1 in 250 AEP events.
8.Near-future hop industry development area	The lower land is flooded for all the events.
9.State Highway 6 banking and overflow area	Breakout near the Kohatu Bridge for the 2%, 1% and 1 in 250 AEP events.
10.Norths Bridge	The flood flows over North Road on the eastern side of the bridge for all the simulated events.
11.Kohatu Bridge	Breakout over the State Highway 6 on the western side of the Kohatu Bridge for the 2%, 1% and 1 in 250 AEP events.
12.Quinney's Bush	Quinney's Bush is flooded for all the simulated events.

8.2.3 Future Land use without Climate Change Scenario

Appendix F provides the results of the flood depth for the future land use condition without climate change scenarios for the 5%, 2%, 1% and 1 in 250 AEP storm events. Figure 37, Figure 38 and Figure 39 show the hydrographs at the Norths, Kohatu and Tapawera-Tadmor Bridge respectively. The model results in the key areas is similar to results of the existing land use without climate change scenarios, which are described in Table 13.

See Section 8.2.5 for the discussion of the impact of land use change.

Figure 37 – Discharge at the Norths Bridge for the future land use without climate change scenarios.

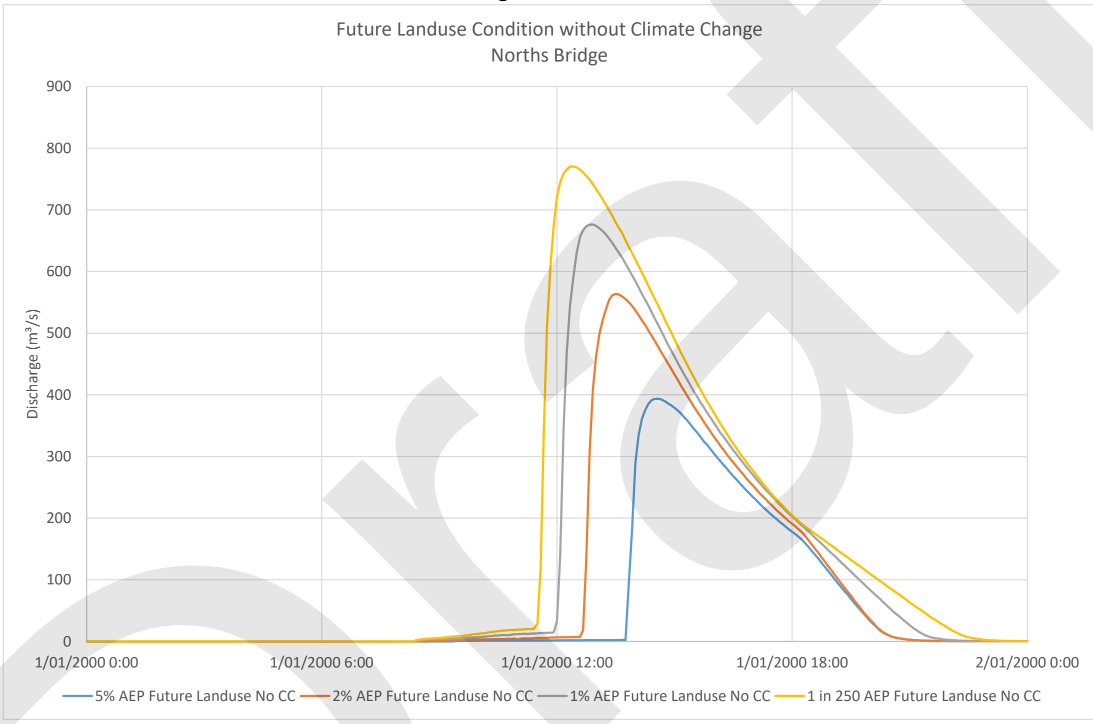


Figure 38 – Discharge at the Kohatu Bridge for the future land use without climate change scenarios.

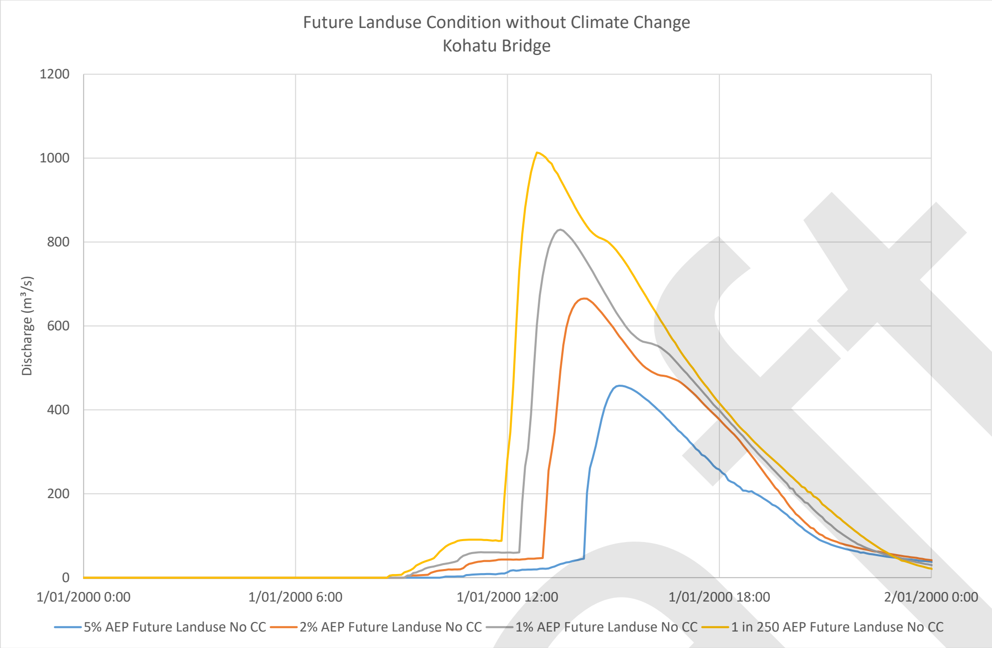
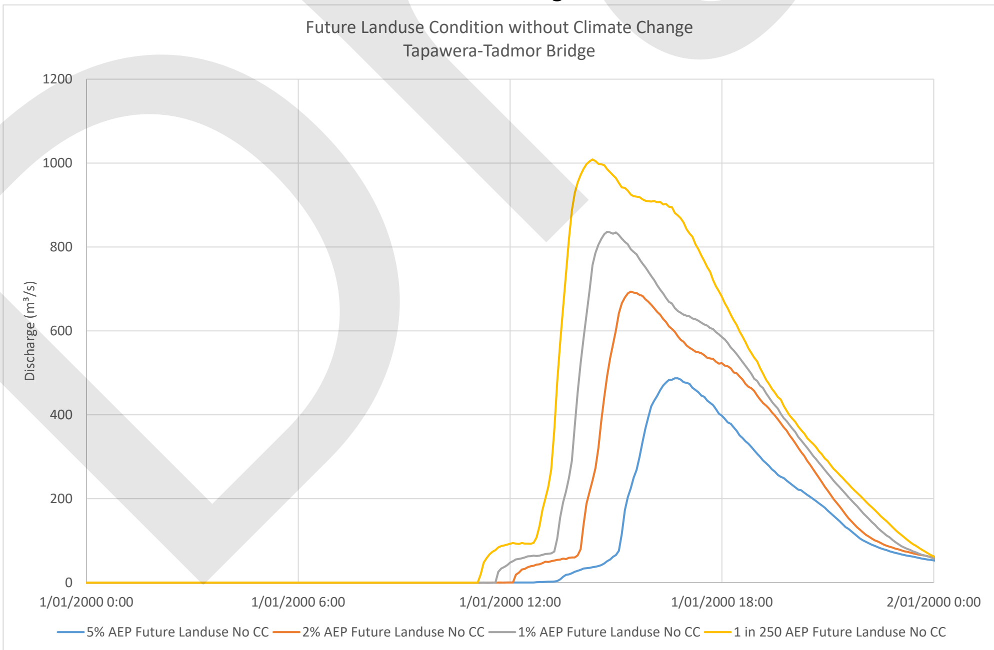


Figure 39 – Discharge at the Tapawera-Tadmor Bridge for the future land use without climate change scenarios.



8.2.4 Future Land use with Climate Change Scenario

Appendix G provides the results of the flood depth for the future land use condition with climate change scenarios for the 5%, 2%, 1% and 1 in 250 AEP storm events. Figure 40, Figure 41 and Figure 42 show the hydrographs at the Norths, Kohatu and Tapawera-Tadmor Bridges respectively. Table 13 summaries the model results in the key areas. In the climate change scenarios, both the Post 83 flood Catchment Board stopbank and State Highway 6 stopbank are overtopped for all the simulated events.

See Section 8.2.4 for the discussion of the impact of climate change.

Figure 40 – Discharge at the Norths Bridge for the future land use with climate change scenarios.

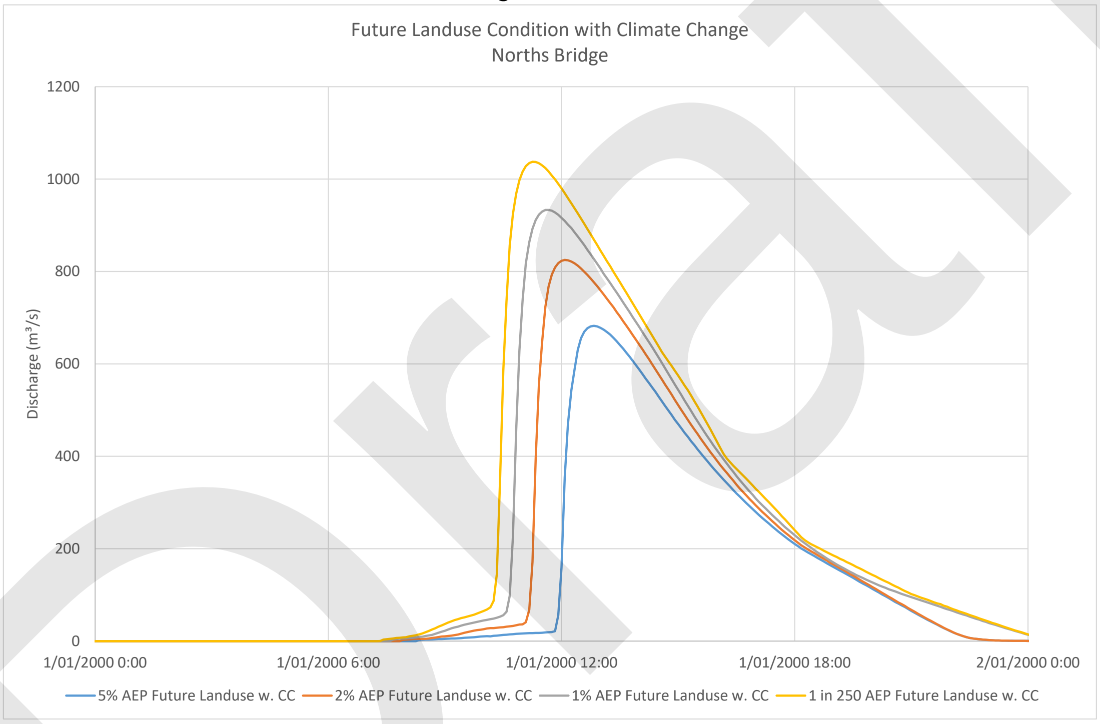


Figure 41 – Discharge at the Kohatu Bridge for the future land use with climate change scenarios.

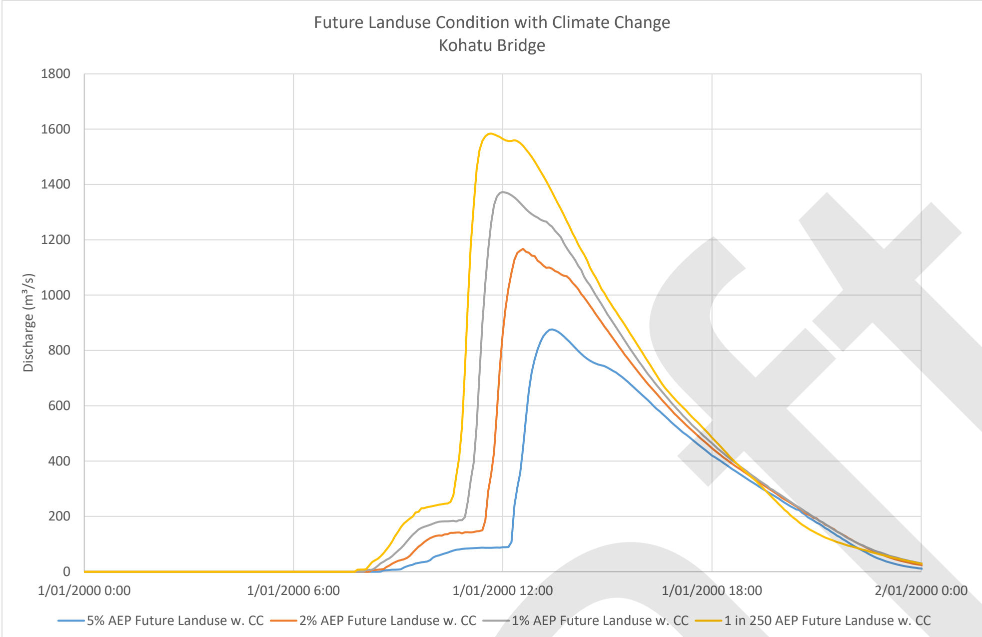


Figure 42 – Discharge at the Tapawera-Tadmor Bridge for the existing land use without climate change scenarios.

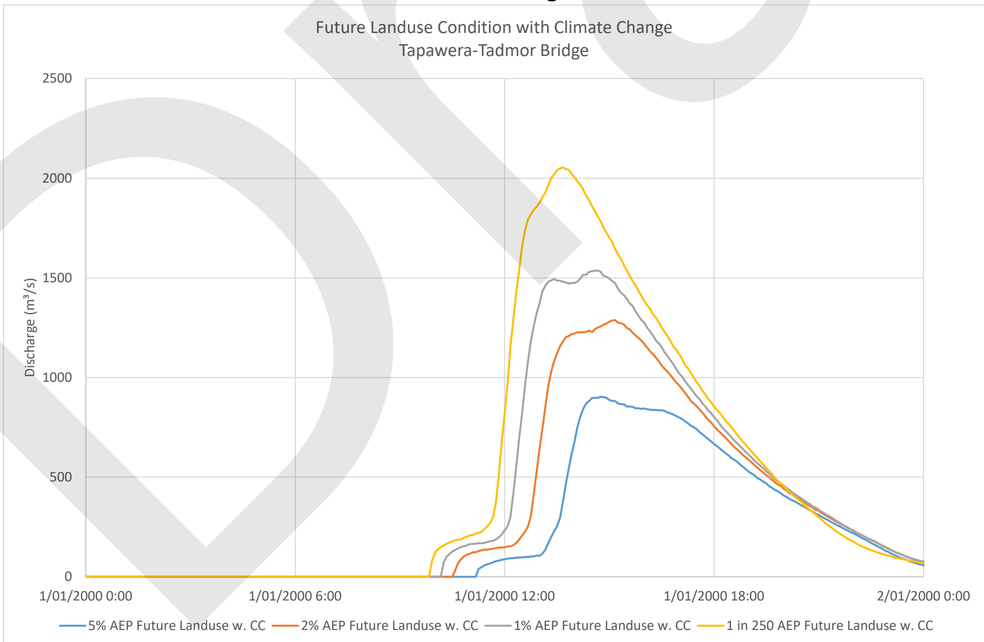


Table 14.Summary of the modelling results in the key areas for future land use with climate change scenarios.

Key Area	Summary
1.Glen Rae Stream overflow area	The flood extents are similar for the 5%, 2%, 1% and 1 in 250 AEP storm events, however the flood depth deepens as the storm intensity increases.
2.Water Supply Creek area	No Significant flooding risk is observed in this area for all the simulated events.
3.Tapawera township	Flood flows across from the west side of the Motueka Highway in the south of the township (Milk Creek Area) near the road bent and the south of the road bent to the east side for all the simulated events.
4.Tadmor-Tapawera Bridge	The flood does not overflow over the bridge or the road for all the simulated events.
5.Mill Creek area	The Mill Creek catchment contributes to the flooding in the southern part of the Tapawera township. However, the major contributor of the flooding is from the Motueka River.
6.Current hop industry development area	The area in the west of the Motueka Highway and south of the Post 83 stopbank is severely flooded for all the simulated events.
7.Post 83 flood Catchment Board stopbank	Breakout of 83 Stopbank is observed from the southern section for all the simulated events.
8.Near-future hop industry development area	The lower land is flooded for all the simulated events.
9.State Highway 6 banking and overflow area	Breakout near the Kohatu Bridge for all the simulated events.
10.Norths Bridge	The flood flows over North Road on the eastern side of the bridge for all the simulated events.
11.Kohatu Bridge	Breakout over the State Highway 6 on the western side of the Kohatu Bridge for all the simulated events.
12.Quinney's Bush	Quinney's Bush is flooded for all the simulated events.

8.2.5 Land use Change Impact

Appendix H compares the impact on the flood hazard as a result of the land use change. The results show that the change in the flood level from the future land use without climate change scenarios to the existing land use without climate change scenarios.

The majority of the "Near-future hop industry development area", the southern part of the "Current hop industry development area" and the area immediately south of the Tapawera township have an increase in flood depth as a result of land use change. The increase mostly ranges between 50 mm and 100 mm.

The area immediately north of the "Near-future hop industry development area", the flow path in the "Current hop industry development area" and the area west of the Tapawera township have a decrease in flood depth. The reduction ranges mostly between 20 mm and 150 mm.

Figure 43, Figure 44 and Figure 45 compare the discharges at the Norths Bridge, Kohatu Bridge and Tapawera-Tadmor bridges respectively. Table 16 summaries the peak discharge at the bridges. The results show that the land use change has very little impact on the discharge at those locations.

Figure 43 – Comparison of the discharge at the Norths Bridge for the existing and future land use condition without climate change scenarios.

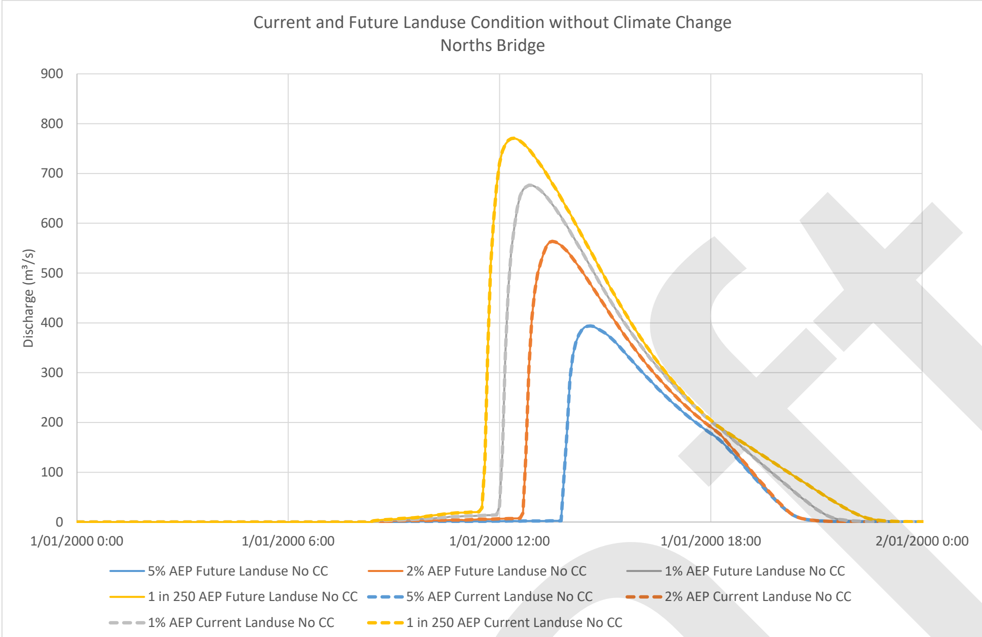


Figure 44 – Comparison of the discharge at the Kohatu Bridge for the existing and future land use condition without climate change scenarios.

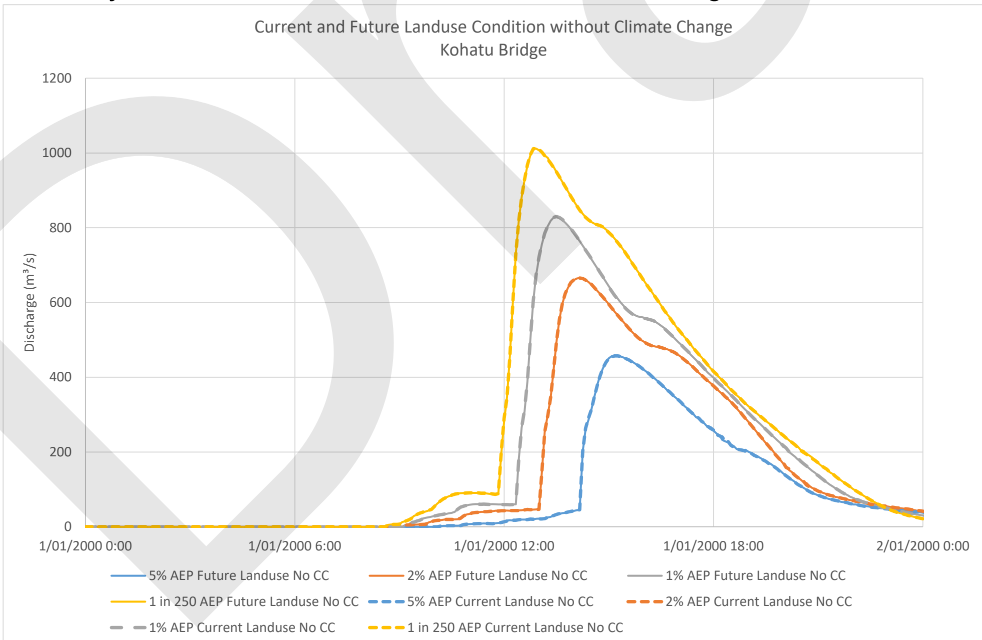


Figure 45 – Comparison of the discharge at the Tapawera-Tadmor Bridge for the existing and future land use condition without climate change scenarios.

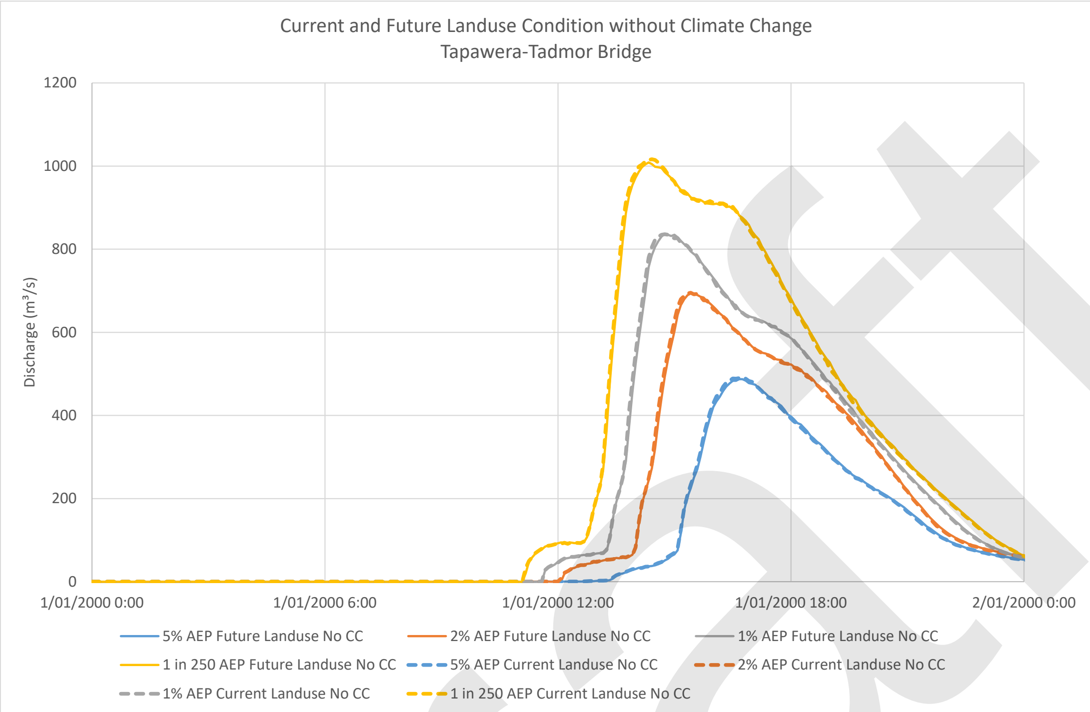


Table 15 Summary of the modelling results at the Norths Bridge, Kohatu Bridge and Tapawera-Tadmor Bridge for the existing and future land use conditions without climate change.

Norths Bridge	Peak Discharge			
	5% AEP	2% AEP	1% AEP	1 in 250 AEP
Existing Landuse (m^3/s)	394	564	676	771
Future Landuse (m^3/s)	394	564	676	771
Factor Increase	1.00	1.00	1.00	1.00

Kohatu Bridge	Peak Discharge			
	5% AEP	2% AEP	1% AEP	1 in 250 AEP
Existing Landuse (m^3/s)	457	666	830	1013
Future Landuse (m^3/s)	458	666	830	1014
Factor Increase	1.00	1.00	1.00	1.00

Tapawera-Tadmor Bridge	Peak Discharge			
	5% AEP	2% AEP	1% AEP	1 in 250 AEP
Existing Landuse (m^3/s)	490	695	836	1016
Future Landuse (m^3/s)	487	694	837	1009
Factor Increase	0.99	1.00	1.00	0.99

8.2.6 Climate Change Impact

Appendix I compares the impact on the flood hazard as a result of climate change. The model results show that the flood extents are similar, but the flood depth is higher for the climate change scenarios. The flood maps display the amount of increase in the flood level from the future land use with climate change scenarios to the future land use without climate change scenarios. The results show that the climate change scenarios significantly increase the flood level in the river channel and its adjacent floodplain. The amount of increases becomes greater as the rainfall intensity increases. For the 5% AEP event, the increase is mostly between 200 mm to 400 mm. For the 2% AEP event, the increase is mostly between 300 mm to 600 mm. For the 1% AEP event, the increase is mostly between 300 mm to 700 mm. For the 1 in 250 AEP event, the increase is mostly between 400 mm to 1 m.

Figure 46, Figure 47 and Figure 48 show the discharge at the Norths Bridge, Kohatu Bridge and Tapawera-Tadmor Bridge respectively. Table 16 summaries the peak discharge at the bridge for the future land use without climate change and with climate change scenarios. The peak discharges at the Norths bridge increase by a factor of 1.7, 1.5, 1.4 and 1.3 for the 5% AEP, 2% AEP, 1% AEP and 1 in 250 AEP storm events respectively. The peak discharges at the Kohatu bridge increase by a factor of 1.9, 1.8, 1.7 and 1.6 for the 5% AEP, 2% AEP, 1% AEP and 1 in 250 AEP storm events respectively. The peak discharges at the Tapawera-Tadmor bridge increase by a factor of 1.9, 1.9, 1.8 and 2.0 for the 5% AEP, 2% AEP, 1% AEP and 1 in 250 AEP storm events respectively.

Figure 46 – Comparison of the discharge at the Norths Bridge for the future land use with and without climate change scenarios.

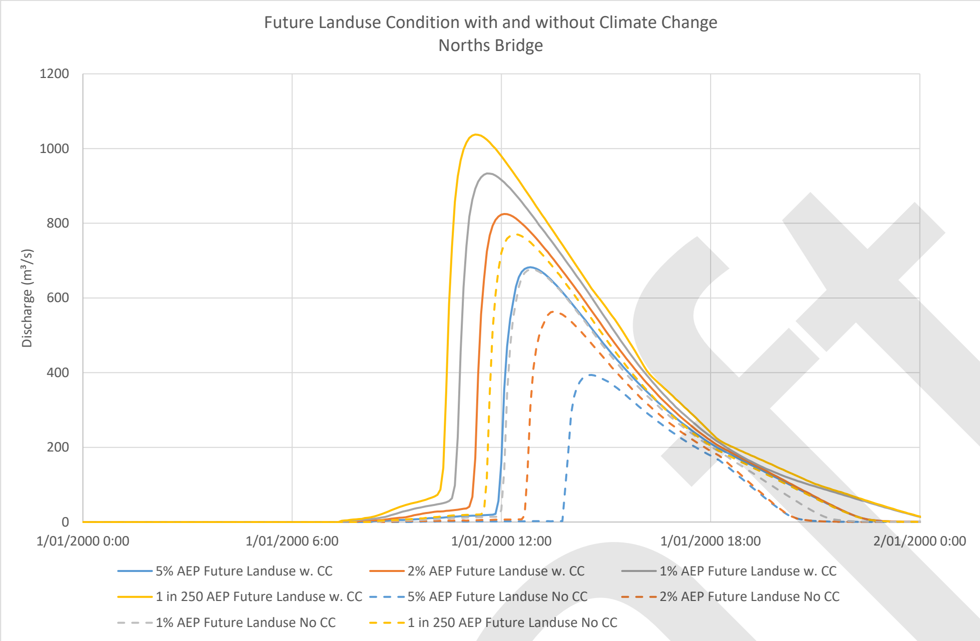


Figure 47 – Comparison of the discharge at the Kohatu Bridge for the future land use with and without climate change scenarios.

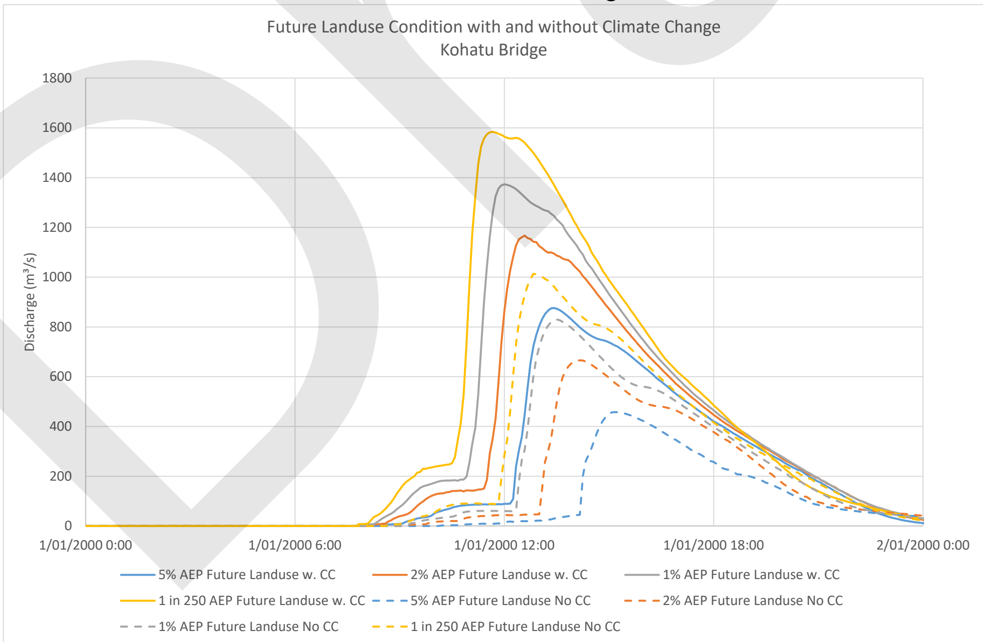


Figure 48 – Comparison of the discharge at the Bridge for the existing and future land use condition without climate change scenarios.

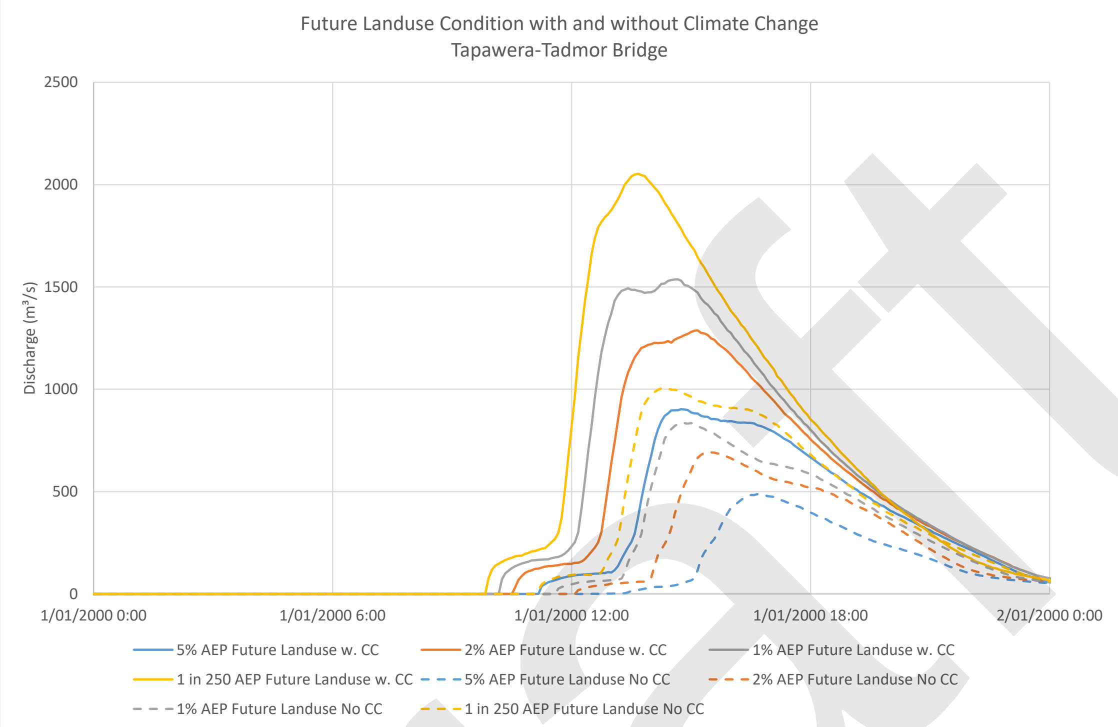


Table 16 Summary of the modelling results at the Norths Bridge, Kohatu Bridge and Tapawera-Tadmor Bridge for the future land use condition with and without climate change.

Norths Bridge	Peak Discharge			
	5% AEP	2% AEP	1% AEP	1 in 250 AEP
Without Climate Change (m³/s)	394	564	676	771
With Climate Change (m³/s)	682	825	933	1038
Factor Increase	1.7	1.5	1.4	1.3

Kohatu Bridge	Peak Discharge			
	5% AEP	2% AEP	1% AEP	1 in 250 AEP
Without Climate Change (m³/s)	458	666	830	1014
With Climate Change (m³/s)	876	1167	1373	1584
Factor Increase	1.9	1.8	1.7	1.6

Tapawera-Tadmor Bridge	Peak Discharge			
	5% AEP	2% AEP	1% AEP	1 in 250 AEP
Without Climate Change (m³/s)	487	694	837	1009
With Climate Change (m³/s)	903	1288	1537	2053
Factor Increase	1.9	1.9	1.8	2.0

9 CONCLUSION

e2Environmental Ltd. (e2) conducted a flood modelling exercise to assess the flood risk on the Upper Motueka River and its floodplain of 5% AEP, 2% AEP, 1% AEP and 1 in 250 AEP storm events for the existing land use, future land use and climate change (RCP 8.5 for the period 2081 - 2100) scenarios.

A number of two-dimensional models using DHI MIKE 21 software package were developed:

- direct rainfall method (DRM) was adopted.
- the flood model was divided into two components: the hydrology model and the hydraulic model to achieve a balance between model resolution and runtime.
- the hydrology models were calibrated so that the model results at the gauging sites match the TDC's flood frequency analysis.
- a number of sensitivity tests on a selection of model input parameters for the hydraulic model including bed roughness values, infiltration rates, rainfall depths and activation of Eddy viscosity were conducted to confirm a level of certainty in all the modelling results presented in the study.
- the modelling results were compared to the historic flood records and flood patterns.
- the impacts of land use change and climate change were analysed.

The study shows that:

- the flood depth in the floodplain and discharge in the river channel vary little when the Eddy viscosity is activated and the bed roughness values, rainfall depth and infiltration rate change by ±10 %.
- the comparison between the model result and 1974 historic flood pattern result show that the flood extent in the Motueka floodplain matches well with the 1974 flood pattern, except that the 1974 event flooded out of the 1983 stopbank and SH 6 bank area. This is expected as the stopbanks were installed after the 1974 flood.
- the land use change has relatively small impact on flood depth. The increase mostly ranges between 50 mm and 100 mm in the hop development area.
- climate change has a relatively larger impact on flood hydraulics in study area. The amount of increases in flood depth increases as the rainfall intensity increases. The increase ranges between 200 mm to 1 m.

APPENDICES

APPENDIX A – List of the Data Collected

APPENDIX B – Model Log

APPENDIX C – Sensitivity Testing Results

APPENDIX D – Comparison between the Historic Flood Pattern and Model Result

APPENDIX E – Flood Maps for the Existing Land use Condition without Climate Change

APPENDIX F – Flood Maps for the Future Land use Condition without Climate Change

APPENDIX G – Flood Maps for the Future Land use Condition with Climate Change

APPENDIX H – Impacts of Land use Change

APPENDIX I – Impacts of Climate Change

APPENDIX A – List of the Data Collected

Data Type	Source	Received Date	Review
Topographic Data			
LiDAR data, Nelson and Tasman LiDAR 1m DEM, 2008-2015	Nelson and Tasman LiDAR 1m DEM, 2008-2015	8/04/2008	This data only cover about 2km from the river centreline. Lakes and large rivers were hydroflattened in the Bare Earth Digital Elevation Model. This layer contains the DEM for LiDAR data from the Nelson and Tasman region captured between 2008 and 2015.
LiDAR data, NZ 8m Digital Elevation Model, 2012	NZ 8m Digital Elevation Model, 2012	18/02/2020	This data cover the whole study area. This 8m DEM was originally created by Geographx (http://geographx.co.nz) and was primarily derived from January 2012 LINZ Topo50 20m contours (https://data.linz.govt.nz/layer/768). Spatial accuracy is nominally the same as for the LINZ source data: 90% of well-defined points are within ±22 metres horizontally and within ±10 metres vertically.
Vector contour data, NZ Contour Topo 1:50k	NZ Contour Topo 1:50k	8/04/2020	This contour was what NZ 8m Digital Elevation Model 2012 was based on.
Rainfall and Flow Data			
Upper Motueka (at Gorge) - rainfall (1987-2020)	TDC, Hilltop	12/05/2020	The record covers from 1987 Oct to 2020 May. The highest daily rainfall occurred on 2005 March 25, which equates to a 1 in 200 AEP event
Upper Motueka (At Gorge) - flow (1965-2020)	TDC, Hilltop	12/05/2020	The record covers from 1965 Jan to 2020 May. The 2005 March event, the peak reaches 788 m^3/s. The largest peak occurred on 1995 Feb 23 at 799 m^3/s, however, this flow correponds to an event with low intensity (61-hr rainfall event, <50% AEP). There was no flow record after this for three months.
Upper Motueka - catchment size	GNS 2010 - 2011 Upper Motueka catchment Transient Model Final	12/05/2020	419 km^2.
Tadmor (at Mudstone) - rainfall (1977-2020)	TDC, Hilltop	12/05/2020	The record covers from 1977 Jun to 2020 May. The highest flow occurred on 1983 July 10, 109 m^3/s. The second largest peak occurred on 1986 March 15, 108m^3/s. The third peak flow occurred on 2012 July 15, 104 m^3/s. The 2005 March 25 event only produced a peak of 19 m^3/s.
Tadmor (at Mudstone) - flow (1978-2020)	TDC, Hilltop	12/05/2020	The record covers from 1978 Mar to 2020 May. The 1983 July event corresponds to 53-hr duration 20-50% AEP event. The 1986 March event corresponds to 26-hr 20% AEP event. The 2012 July event corresponds to 35-hr 20%-50% AEP event. The 2005 March 25 event only corresponds to 21-hr 50% - 20% AEP event.
Tadmor - catchment size	GNS 2010 - 2011 Upper Motueka catchment Transient Model Final	12/05/2020	124 km^2.
Motupiko (at Christies) - rainfall (1990-2020)	TDC, Hilltop	12/05/2020	The record covers from 1990 Mar to 2020 May.
Motupiko (at Christies) - flow (1990-2020)	TDC, Hilltop	12/05/2020	The record covers from 1990 May to 2020 May.
Motupiko - catchment size	GNS 2010 - 2011 Upper Motueka catchment Transient Model Final	12/05/2020	334 km^2.
Flood Frequency Analysis from TDC	TDC's Flood Frequency Analysis 2020 May	26/05/2020	TDC's most updated flood frequency analysis (conducted in May 2020).
Rainfall HIRDs V4 Data - Tapawera	Rainfall HIRDs V4 Data - Tapawera	15/04/2020	Data collected the NIWA's Tapawera gauging site G12383.
Rainfall HIRDs V4 Data - Motueka At Gorge	Rainfall HIRDs V4 Data - Motueka At Gorge	18/05/2020	Rainfall depth and intensity.
Rainfall HIRDs V4 Data - Motupiko at Christies	Rainfall HIRDs V4 Data - Motupiko at Christies	18/05/2020	Rainfall depth and intensity.
Rainfall HIRDs V4 Data - Tadmor at Mudstone	Rainfall HIRDs V4 Data - Tadmor at Mudstone	18/05/2020	Rainfall depth and intensity.
Tapawera Rainfall - Daily rainfall only (1993-2020)	NIWA Cliflo Daily Rainfall	20/05/2020	At this site, only daily rainfall depth record is available. The largest daily rainfall depth occurs on 2005 March 28.
Aerial Photography			
Aerial photography, 2019	Tasman 0.3m Rural Aerial Photos (2018-2019)	20/02/2020	This data set does not cover the area of our interest.
Aerial photography, 2017	NZ 10 Satellite Imagert (2017) from LINZ	17/02/2020	The imagery was captured by the European Space Agency Sentinel-2 satellites between December 2016 - December 2017.
Aerial Photography, 2016-2017	Tasman 0.3m Rural Aerial Photos (2016-2017)	5/05/2020	This is the most recent and detailed data set that covers the area of interests. The main river channel bed changes from the 2006 - 2007 data set but not significantly. Approximately seven new cutbanks were formed. Orthophotography for the Tasman region taken in the flying season (summer period) of 2016-2017.
Aerial Photography, 2006 - 2007	Tasman 1m Rural Aerial Photos (2006-2007)	5/05/2020	Orthophotography for the Tasman region taken in the flying season (summer period) of 2006-2007.
Aerial Photography, 2001 - 2002	Tasman 1m Rural Aerial Photos (2001-2002)	5/05/2020	Orthophotography for the Tasman region taken in the flying season (summer period) of 2001-2002.
Aerial Photography 1940-1949	Aerial_1940_1949 on Top of the South Maps	5/05/2020	The oldest data set available.
Historic Flood Patterns			
Historic flood patterns (1967, 1974, 1976, 1986, 1990)	TDC Historic Flood Patterns	30/04/2020	Data receievd from TDC, which include: polygons for the historic flood extent and rectify flood maps.
Others			
Land use type, LCDB v5.0 - Land Cover Database version 5.0	LCDB v5.0 - Land Cover Database version 5.0	26/02/2020	Several landuse types fall with the area of interest.
Land use type, prediction	Key Areas of Interest	15/04/2020	TDC provided the key areas.

Data Type	Source	Received Date	Review
Soil Drainage, Smap Soil Drainage Aug 2019	Smap Soil Drainage Aug 2019	9/04/2020	It didn't cover the floodplains.
Control structures - Bridges: Kohata Bridge, Norths Bridge and Tapawera Bridge	Bridges As-build Drawings	22/05/2022	As-built drawings provding information for the bridge abutments and piers.
Relevant data to establish infiltration rate for the loss model	GNS 2010 - 2011 Upper Motueka catchment Transient Model Final	30/04/2020	Ch4.4 in this model, if the daily rainfal total exceeds 2mm, 10% of the total daily rainfall is assumed to be drained through macropores. Soil drainage takes place only if the irrigation plus any rainfall exceeds the soil moisture deficit.
NZ Building Outlines	NZ Building Outlines	16/12/2019	The building footprint is a 2D representation of the roof outline of a building.
Annual rainfall isohyets - 2011	GNS 2010 - 2011 Upper Motueka catchment Transient Model Final	30/04/2020	GNS 2010 - 2011 Upper Motueka catchment Transient Model Final mentioned that TDC provide them the data (Figure 3).
Tapawera Stormwater Systems	Top of the South Maps	8/09/2020	Three layers were downloaded: Stormwater Features, Stormwater Pipes and Stormwater Drains. The Stormwater Features layer contains the location of the stormwater features such and manholes and sumps, but it does not provide invert or lid levels. The Stormwater Pipes layer provides the location of the pipes as well the material and diameters of the pipes. The Stormwater Drains layer provides the location of the drains and the asset ID. The total length of the open drains is 5.4km. The total length of the pipes is 3.6km.

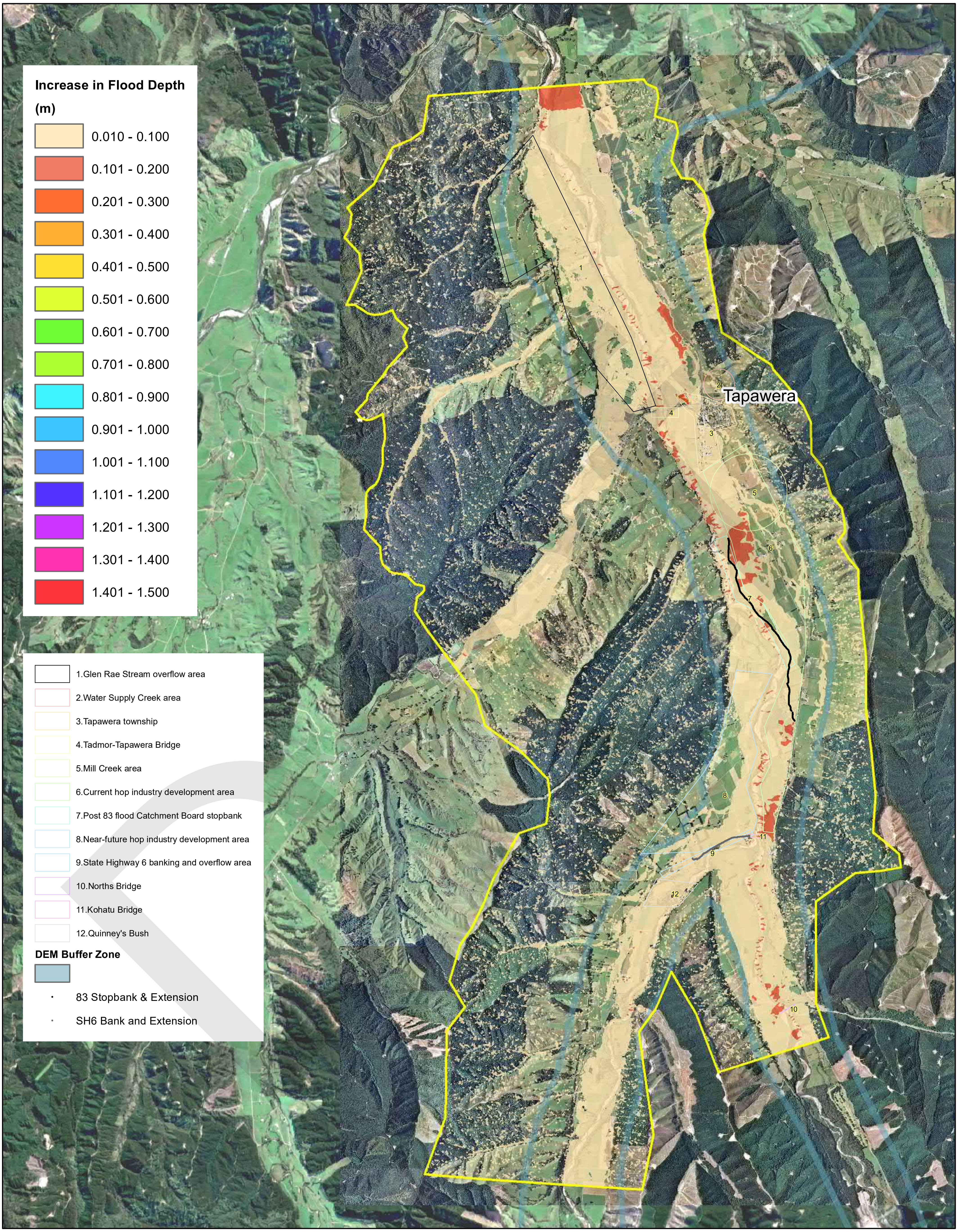
APPENDIX B – Model Log

					Model Build							Rainfall								Losses			Boundary Source		Simulation	Mesh
Counter	Simulation Name	Run Period (hr)	Simulation Purpose	Status	DEM Soource	DEM Date	Land Use	Vertical Datum	Cooridnate Reference	2D Roughness Data Source	Eddy Viscosity	Rainfall Data Source	AEP	Temporal Profile	Rainfall Duration	Climate Scenario	Spatial Distribution	Areal Reduction Factor	Approach	Loss Model	Routing Model	Loss Parameter Source	DS Boundary Condition	2D Boundary Condition	Solition Technique	Max. Mesh Size
237	237_105v01_Floodplain_Existing_20y_24h_WL_113p7m_CC_Base	30	Base Model	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	5%	NIWA NSI	24h	RCP8.5 2081-2100	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
239	239_107v01_Floodplain_Existing_50y_24h_WL_113p7m_CC_Base	30	Base Model	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	2%	NIWA NSI	24h	RCP8.5 2081-2100	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
240	240_103v06_Floodplain_Existing_100y_24h_WL_113p7m_CC_Base	30	Base Model	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	1%	NIWA NSI	24h	RCP8.5 2081-2100	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
241	241_109v01_Floodplain_Existing_250y_24h_WL_113p7m_CC_Base	30	Base Model	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	1 in 250	NIWA NSI	24h	RCP8.5 2081-2100	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
260	260_205v01_Floodplain_Existing_20y_24h_WL_113p7m_noCC_Base	30	Base Model	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	5%	NIWA NSI	24h	no CC	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
261	261_207v01_Floodplain_Existing_50y_24h_WL_113p7m_noCC_Base	30	Base Model	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	2%	NIWA NSI	24h	no CC	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
262	262_203v01_Floodplain_Existing_100y_24h_WL_113p7m_noCC_Base	30	Base Model	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	1%	NIWA NSI	24h	no CC	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
263	263_209v01_Floodplain_Existing_250y_24h_WL_113p7m_noCC_Base	30	Base Model	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	1 in 250	NIWA NSI	24h	no CC	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
264	264_309v01_Floodplain_Future01_250y_24h_WL_113p7m_CC_Base	30	Base Model	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Future_1	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	1 in 250	NIWA NSI	24h	RCP8.5 2081-2100	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
265	265_305v01_Floodplain_Future01_20y_24h_WL_113p7m_CC_Base	30	Base Model	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Future_1	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	5%	NIWA NSI	24h	RCP8.5 2081-2100	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
266	266_307v01_Floodplain_Future01_50y_24h_WL_113p7m_CC_Base	30	Base Model	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Future_1	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	2%	NIWA NSI	24h	RCP8.5 2081-2100	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
267	267_303v01_Floodplain_Future01_100y_24h_WL_113p7m_CC_Base	30	Base Model	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Future_1	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	1%	NIWA NSI	24h	RCP8.5 2081-2100	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
268	268_405v01_Floodplain_Future01_20y_24h_WL_113p7m_noCC_Base	30	Base Model	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Future_1	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	5%	NIWA NSI	24h	no CC	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
269	269_407v01_Floodplain_Future01_50y_24h_WL_113p7m_noCC_Base	30	Base Model	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Future_1	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	2%	NIWA NSI	24h	no CC	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
270	270_403v01_Floodplain_Future01_100y_24h_WL_113p7m_noCC_Base	30	Base Model	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Future_1	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	1%	NIWA NSI	24h	no CC	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
271	271_409v01_Floodplain_Future01_250y_24h_WL_113p7m_noCC_Base	30	Base Model	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Future_1	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	1 in 250	NIWA NSI	24h	no CC	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
184	184_204v02_Motupiko_Existing_10y_12h_WL_223m_noCC_Calibration	24	Calibration	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline Adjusted	noEddyV	Motupiko NIWA HIRDs V4 Spatially Varied Rainfall	10%	NIWA NSI	12h	no CC	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_199m	No Inflow BD	High Order	500
208	208_104v03_Tadmor_Existing_10y_24h_WL171m_noCC_Calibration	24	Calibration	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Tadmor NIWA HIRDs V4 Spatially Varied Rainfall	10%	NIWA NSI	24h	no CC	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL_171m	No Inflow BD	High Order	500
187	187_105v25_Tadmor_Existing_20y_24h_WL171m_noCC_Calibration	24	Calibration, Historic Event Comparison	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Tadmor NIWA HIRDs V4 Spatially Varied Rainfall	5%	NIWA NSI	24h	no CC	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL_171m	No Inflow BD	High Order	500
195	195_308v04_UpM_Existing_100y_12h_WL_198p5m_CC_InflowBD	18	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline Adjusted	noEddyV	Upper Motueka NIWA HIRDs V4 Spatially Varied Rainfall	1%	NIWA NSI	12h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_198p5m	No Inflow BD	High Order	500
197	197_307v02_UpM_Existing_50y_12h_WL_198p5m_CC_InflowBD	18	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline Adjusted	noEddyV	Upper Motueka NIWA HIRDs V4 Spatially Varied Rainfall	2%	NIWA NSI	12h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_198p5m	No Inflow BD	High Order	500
198	198_309v02_UpM_Existing_250y_12h_WL_198p5m_CC_InflowBD	18	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline Adjusted	noEddyV	Upper Motueka NIWA HIRDs V4 Spatially Varied Rainfall	1 in 250	NIWA NSI	12h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_198p5m	No Inflow BD	High Order	500
199	199_207v08_Motupiko_Existing_50y_12h_WL_223m_CC_InflowBD	24	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Motupiko NIWA HIRDs V4 Spatially Varied Rainfall	2%	NIWA NSI	12h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_199m	No Inflow BD	High Order	500

200	200_204v03_Motupiko_Existing_10y_12h_WL_223m_CC_InflowBD	24	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Motupiko NIWA HIRDs V4 Spatially Varied Rainfall	10%	NIWA NSI	12h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_199m	No Inflow BD	High Order	500
201	201_210v02_Motupiko_Existing_150y_12h_WL_223m_CC_InflowBD	24	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Motupiko NIWA HIRDs V4 Spatially Varied Rainfall	1 in 150	NIWA NSI	12h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_199m	No Inflow BD	High Order	500
202	202_206v02_Motupiko_Existing_30y_12h_WL_223m_CC_InflowBD	24	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Motupiko NIWA HIRDs V4 Spatially Varied Rainfall	1 in 30	NIWA NSI	12h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_199m	No Inflow BD	High Order	500
211	211_106v26_Tadmor_Existing_20y_24h_WL171m__CC_InflowBD	30	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Tadmor NIWA HIRDs V4 Spatially Varied Rainfall	5%	NIWA NSI	24h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL_171m	No Inflow BD	High Order	500
213	213_107v07_Tadmor_Existing_50y_24h_WL171m__CC_InflowBD	30	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Tadmor NIWA HIRDs V4 Spatially Varied Rainfall	2%	NIWA NSI	24h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL_171m	No Inflow BD	High Order	500
214	214_104v04_Tadmor_Existing_10y_24h_WL171m__CC_InflowBD	30	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Tadmor NIWA HIRDs V4 Spatially Varied Rainfall	10%	NIWA NSI	24h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL_171m	No Inflow BD	High Order	500
224	224_305v16_UpM_Existing_20y_12h_WL_198p5m_CC_InflowBD	18	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline Adjusted	noEddyV	Upper Motueka NIWA HIRDs V4 Spatially Varied Rainfall	5%	NIWA NSI	12h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_198p5m	No Inflow BD	High Order	500
229	229_111v03_Tadmor_Existing_1y_24h_WL171m__CC_InflowBD	30	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Tadmor NIWA HIRDs V4 Spatially Varied Rainfall	1 EY	NIWA NSI	24h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL_171m	No Inflow BD	High Order	500
243	243_308v04_UpM_Existing_100y_12h_WL_198p5mnoCC_InflowBD	18	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline Adjusted	noEddyV	Upper Motueka NIWA HIRDs V4 Spatially Varied Rainfall	1%	NIWA NSI	12h	no CC	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_198p5m	No Inflow BD	High Order	500
244	244_307v03_UpM_Existing_50y_12h_WL_198p5mnoCC_InflowBD	18	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline Adjusted	noEddyV	Upper Motueka NIWA HIRDs V4 Spatially Varied Rainfall	2%	NIWA NSI	12h	no CC	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_198p5m	No Inflow BD	High Order	500
245	245_309v03_UpM_Existing_250y_12h_WL_198p5mnoCC_InflowBD	18	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline Adjusted	noEddyV	Upper Motueka NIWA HIRDs V4 Spatially Varied Rainfall	1 in 250	NIWA NSI	12h	no CC	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_198p5m	No Inflow BD	High Order	500
246	246_305v16_UpM_Existing_20y_12h_WL_198p5mnoCC_InflowBD	18	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline Adjusted	noEddyV	Upper Motueka NIWA HIRDs V4 Spatially Varied Rainfall	5%	NIWA NSI	12h	no CC	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_198p5m	No Inflow BD	High Order	500
247	247_207v09_Motupiko_Existing_50y_12h_WL_223m_noCC_InflowBD	18	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Motupiko NIWA HIRDs V4 Spatially Varied Rainfall	2%	NIWA NSI	12h	no CC	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_199m	No Inflow BD	High Order	500
248	248_210v03_Motupiko_Existing_150y_12h_WL_223m_noCC_InflowBD	18	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Motupiko NIWA HIRDs V4 Spatially Varied Rainfall	1 in 150	NIWA NSI	12h	no CC	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_199m	No Inflow BD	High Order	500
249	249_206v03_Motupiko_Existing_30y_12h_WL_223m_noCC_InflowBD	18	Derive Inflow BD Hydrograph	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Motupiko NIWA HIRDs V4 Spatially Varied Rainfall	1 in 30	NIWA NSI	12h	no CC	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_199m	No Inflow BD	High Order	500
250	250_107v08_Tadmor_Existing_50y_24h_WL171m_noCC_InflowBD	24	Derive Inflow BD Hydrograph, Calibration	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Tadmor NIWA HIRDs V4 Spatially Varied Rainfall	2%	NIWA NSI	24h	no CC	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL_171m	No Inflow BD	High Order	500
251	251_111v07_Tadmor_Existing_1y_24h_WL171m_noCC_InflowBD	30	Derive Inflow BD Hydrograph, Calibration	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Tadmor NIWA HIRDs V4 Spatially Varied Rainfall	1 EY	NIWA NSI	24h	no CC	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL_171m	No Inflow BD	High Order	500
253	253_308v05_UpM_Existing_100y_12h_WL_198p5m_CC_SensitivityIncNby0p1	18	Roughness Sensitivity Testing	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*0.9*M TDC Guideline Adjusted	noEddyV	Upper Motueka NIWA HIRDs V4 Spatially Varied Rainfall	1%	NIWA NSI	12h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_198p5m	No Inflow BD	High Order	500
254	254_308v06_UpM_Existing_100y_12h_WL_198p5m_CC_SensitivityDecNby0p1	24	Roughness Sensitivity Testing	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	1.1*0.9*M TDC Guideline Adjusted	noEddyV	Upper Motueka NIWA HIRDs V4 Spatially Varied Rainfall	1%	NIWA NSI	12h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_198p5m	No Inflow BD	High Order	500
255	255_207v09_Motupiko_Existing_50y_12h_WL_223m_CC_SensitivityIncNby0p1	24	Roughness Sensitivity Testing	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*0.9*M TDC Guideline Adjusted	noEddyV	Motupiko NIWA HIRDs V4 Spatially Varied Rainfall	2%	NIWA NSI	12h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_199m	No Inflow BD	High Order	500
256	256_207v10_Motupiko_Existing_50y_12h_WL_223m_CC_SensitivityDecNby0p1	24	Roughness Sensitivity Testing	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	1.1*0.9*M TDC Guideline Adjusted	noEddyV	Motupiko NIWA HIRDs V4 Spatially Varied Rainfall	2%	NIWA NSI	12h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant_WL_199m	No Inflow BD	High Order	500
257	257_107v08_Tadmor_Existing_50y_24h_WL171m__CC_SensitivityIncNby0p1	30	Roughness Sensitivity Testing	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	0.9*0.9*M TDC Guideline Adjusted	noEddyV	Tadmor NIWA HIRDs V4 Spatially Varied Rainfall	2%	NIWA NSI	24h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL_171m	No Inflow BD	High Order	500
258	258_107v09_Tadmor_Existing_50y_24h_WL171m__CC_SensitivityDecNby0p1	30	Roughness Sensitivity Testing	Final	NZ 8m Digital Elevation Model 2012	2012	Existing	NZVD2016	NZTM2000	1.1*0.9*M TDC Guideline Adjusted	noEddyV	Tadmor NIWA HIRDs V4 Spatially Varied Rainfall	2%	NIWA NSI	24h	RCP8.5 2081-2100	with Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL_171m	No Inflow BD	High Order	500
230	230_203Av01_Floodplain_Existing_100y_24h_WL_113p7m_CC_SensitivityIncNby0p1	30	Sensitivity Testing	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Existing	NZVD2016	NZTM2000	0.9*0.9*M TDC Guideline Adjusted	noEddyV	Hirds V4 Average	1%	NIWA NSI	24h	RCP8.5 2081-2100	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
231	231_203Bv01_Floodplain_Existing_100y_24h_WL_113p7m_CC_SensitivityDecNby0p1	30	Sensitivity Testing	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Existing	NZVD2016	NZTM2000	1.1*0.9*M TDC Guideline Adjusted	noEddyV	Hirds V4 Average	1%	NIWA NSI	24h	RCP8.5 2081-2100	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
232	232_303Av01_Floodplain_Existing_100y_24h_WL_113p7m_CC_SensitivityIncInfilby0p1	30	Sensitivity Testing	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	1%	NIWA NSI	24h	RCP8.5 2081-2100	no Spatial Distribution	no ARF	DRM	1.1*Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
233	233_303Bv01_Floodplain_Existing_100y_24h_WL_113p7m_CC_SensitivityDecInfilby0p1	30	Sensitivity Testing	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	Hirds V4 Average	1%	NIWA NSI	24h	RCP8.5 2081-2100	no Spatial Distribution	no ARF	DRM	0.9*Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
234	234_403Av01_Floodplain_Existing_100y_24h_WL_113p7m_CC_SensitivityIncRainby0p1	30	Sensitivity Testing	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	1.1*Hirds V4 Average	1%	NIWA NSI	24h	RCP8.5 2081-2100	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500
235	235_403Bv02_Floodplain_Existing_100y_24h_WL_113p7m_CC_SensitivityDecRainby0p1	30	Sensitivity Testing	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	noEddyV	0.9*Hirds V4 Average	1%	NIWA NSI	24h	RCP8.5 2081-2100	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500

252	252_503v02_Floodplain_Existing_100y_24h_WL_113p7m_CC_SensitivityEddyViscosity	30	Sensitivity Testing	Final	Combined 2008-15 and 2012 DEM	Combined 2008-15 and 2012	Existing	NZVD2016	NZTM2000	0.9*M TDC Guideline	withEddyV	Hirds V4 Average	1%	NIWA NSI	12h	RCP8.5 2081-2100	no Spatial Distribution	no ARF	DRM	Spatially Varied Horton	Hydrodynamics	Calibration	Constant WL at 113p7m	Inflow Hydrograph derived from the sub-catchment models	High Order	500

APPENDIX C –Sensitivity Testing Results



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Paper Size: A3

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Coordinate System: NZGD 2000 New Zealand Transverse Mercator
Projection: Transverse Mercator
Datum: NZGD 2000

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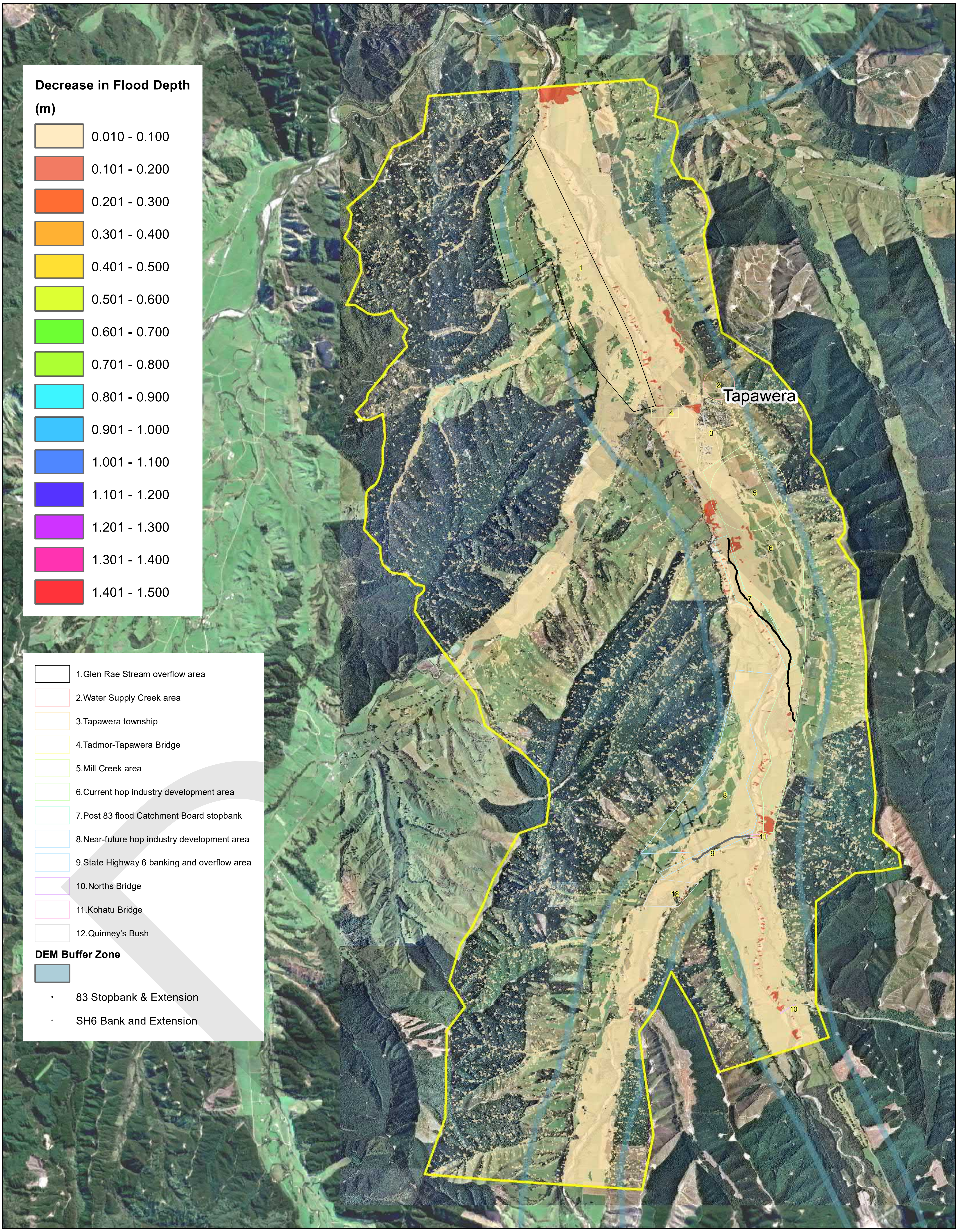
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 15

Sensitivity Testing Result - Increase in Flood Level
Increased Bed Roughness by a Factor of 1.1

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_Sensitivity_InN_v03.mxd



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Datum: NZGD 2000

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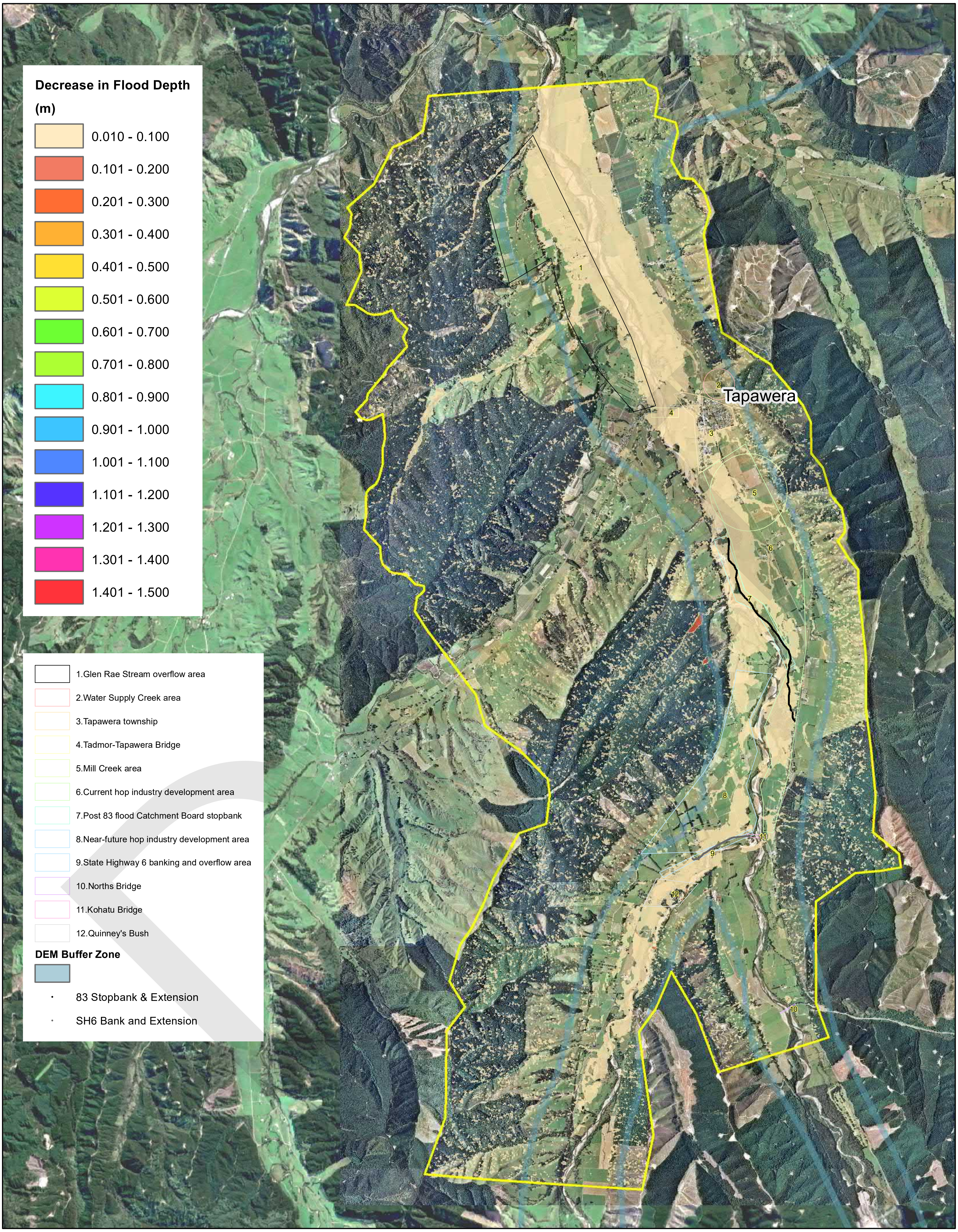
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 15

Sensitivity Testing Result - Decrease in Flood Level
Decreased Bed Roughness by a Factor of 0.9

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_Sensitivity_DecN_v03.mxd



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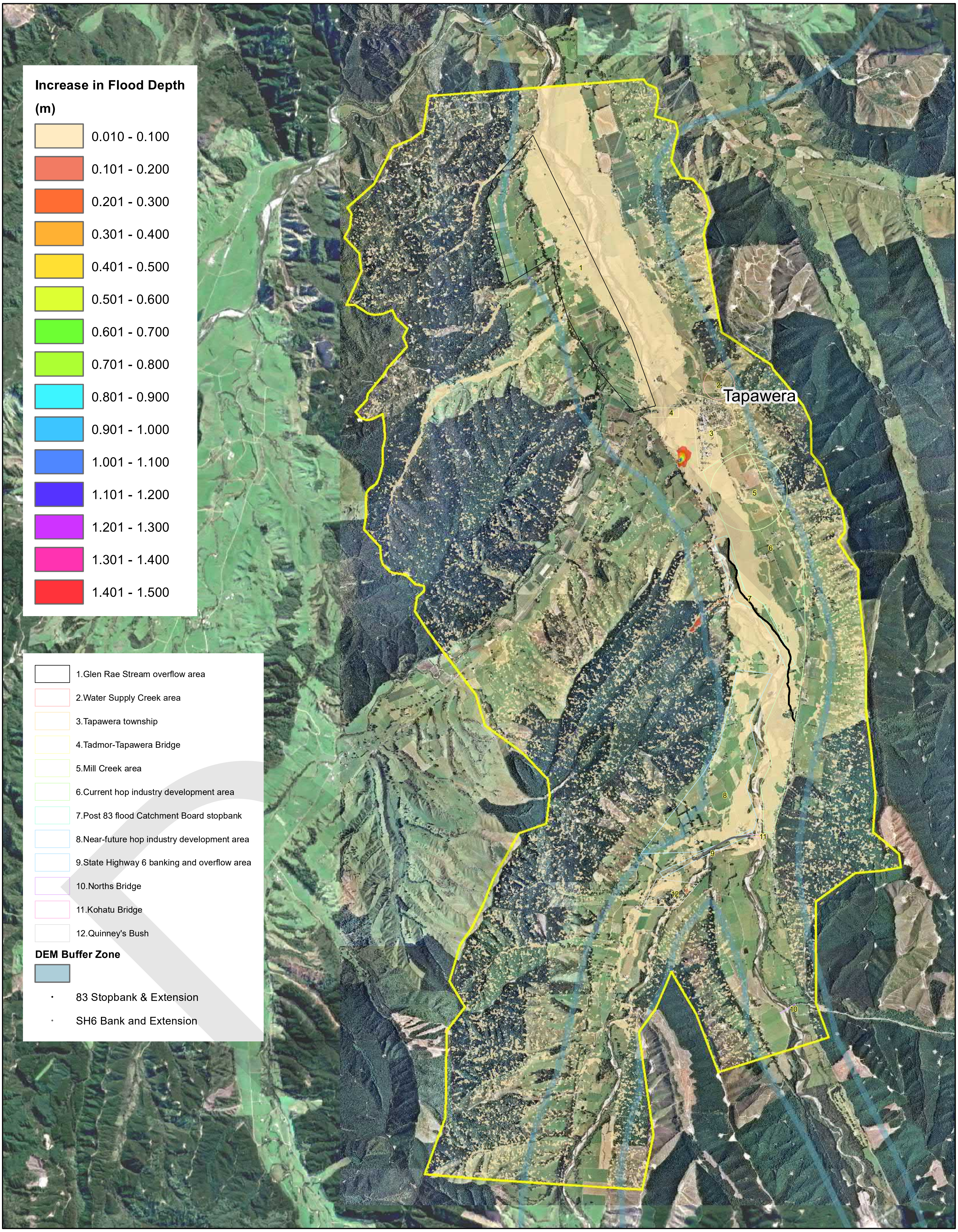
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 15

Sensitivity Testing Result - Decrease in Flood Level
Increased Infiltration Rate by a Factor of 1.1

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_Sensitivity_IncInfil_v03.mxd



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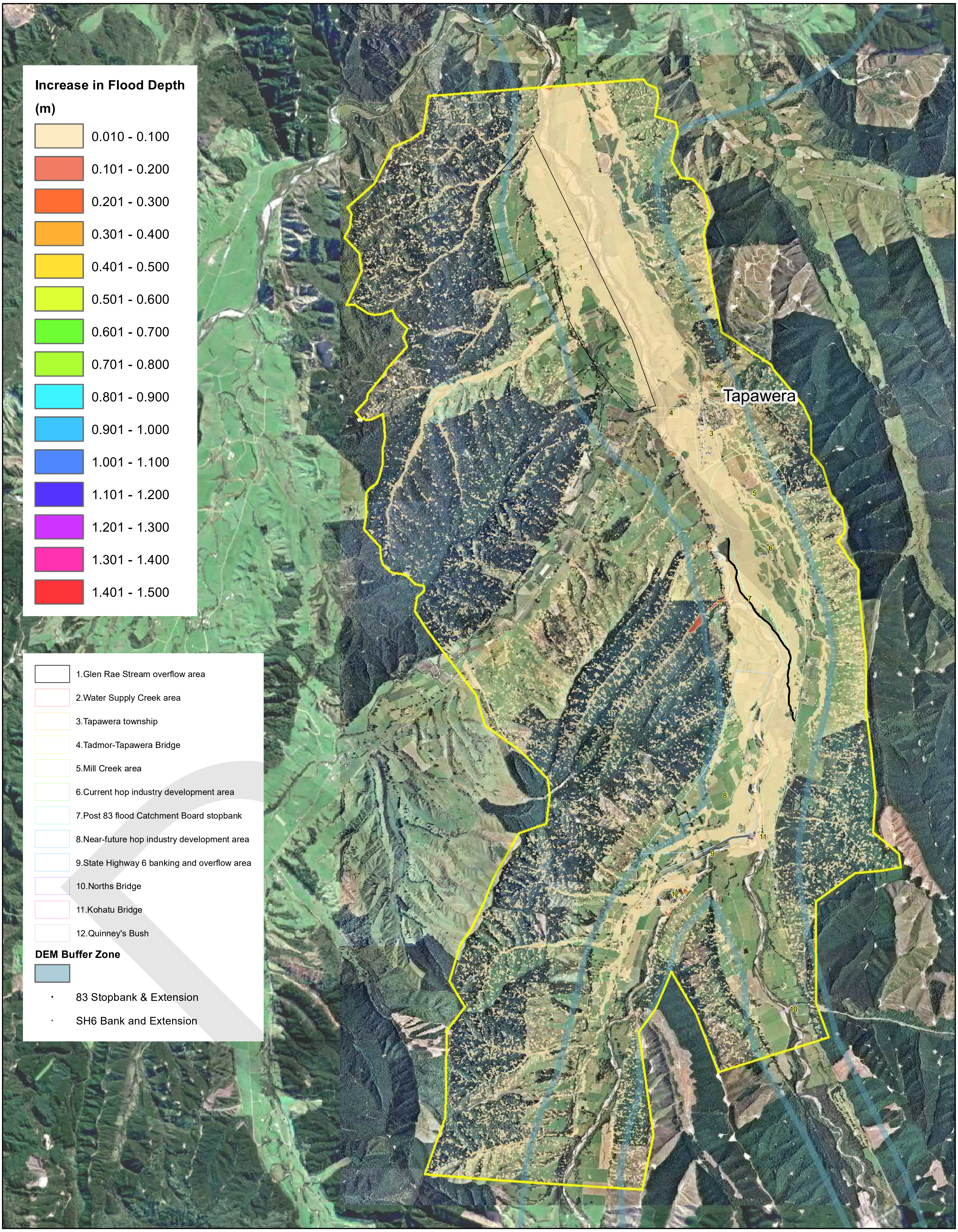
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 15

Sensitivity Testing Result - Increase in Flood Level
Decreased Infiltration Rate by a Factor of 0.9

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_Sensitivity_DecInfil_v03.mxd



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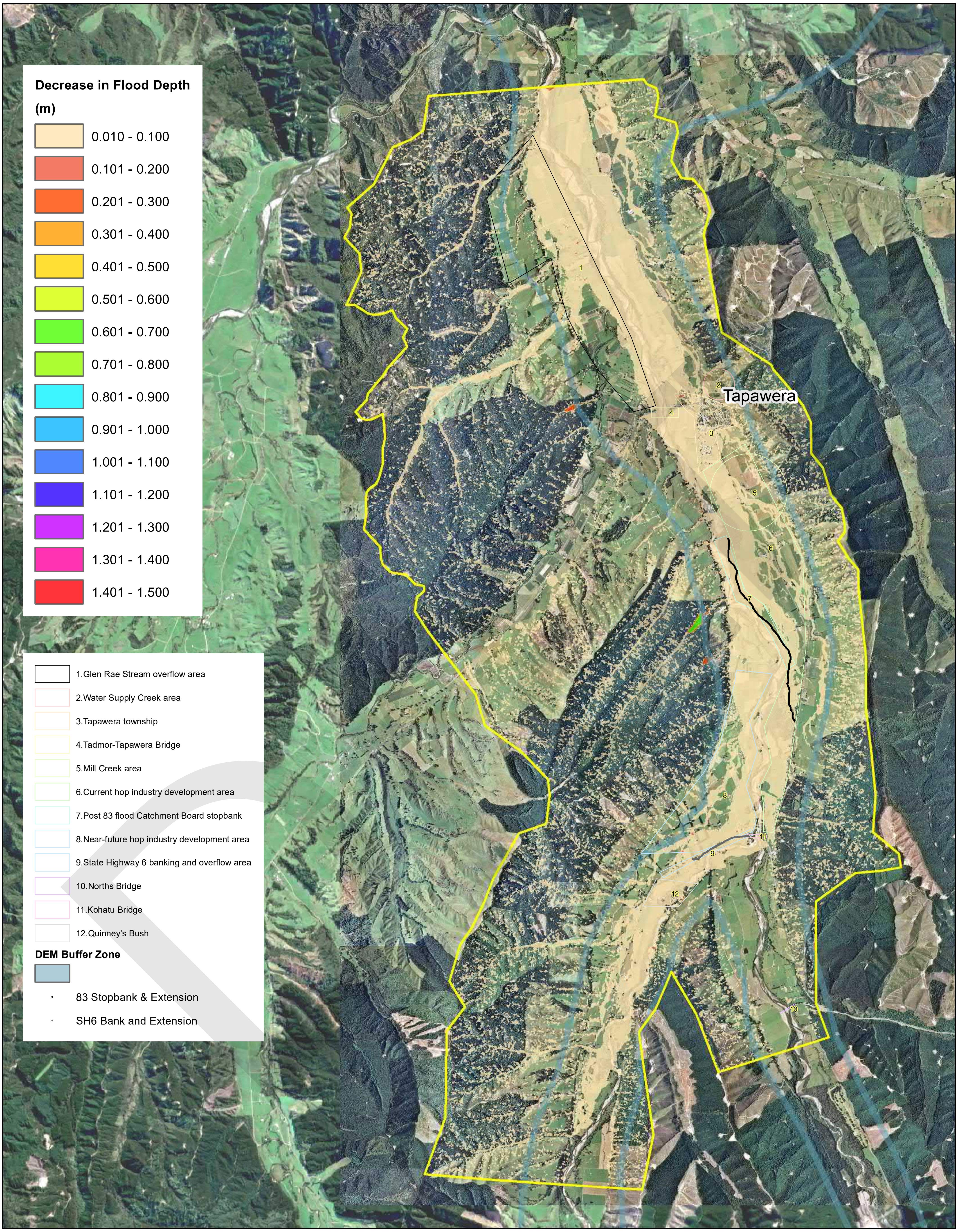
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 15

Sensitivity Testing Result - Increase in Flood Level
Increased Rainfall Depth by a Factor of 1.1

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_Sensitivity_IncRain_v03.mxd



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Datum: NZGD 2000

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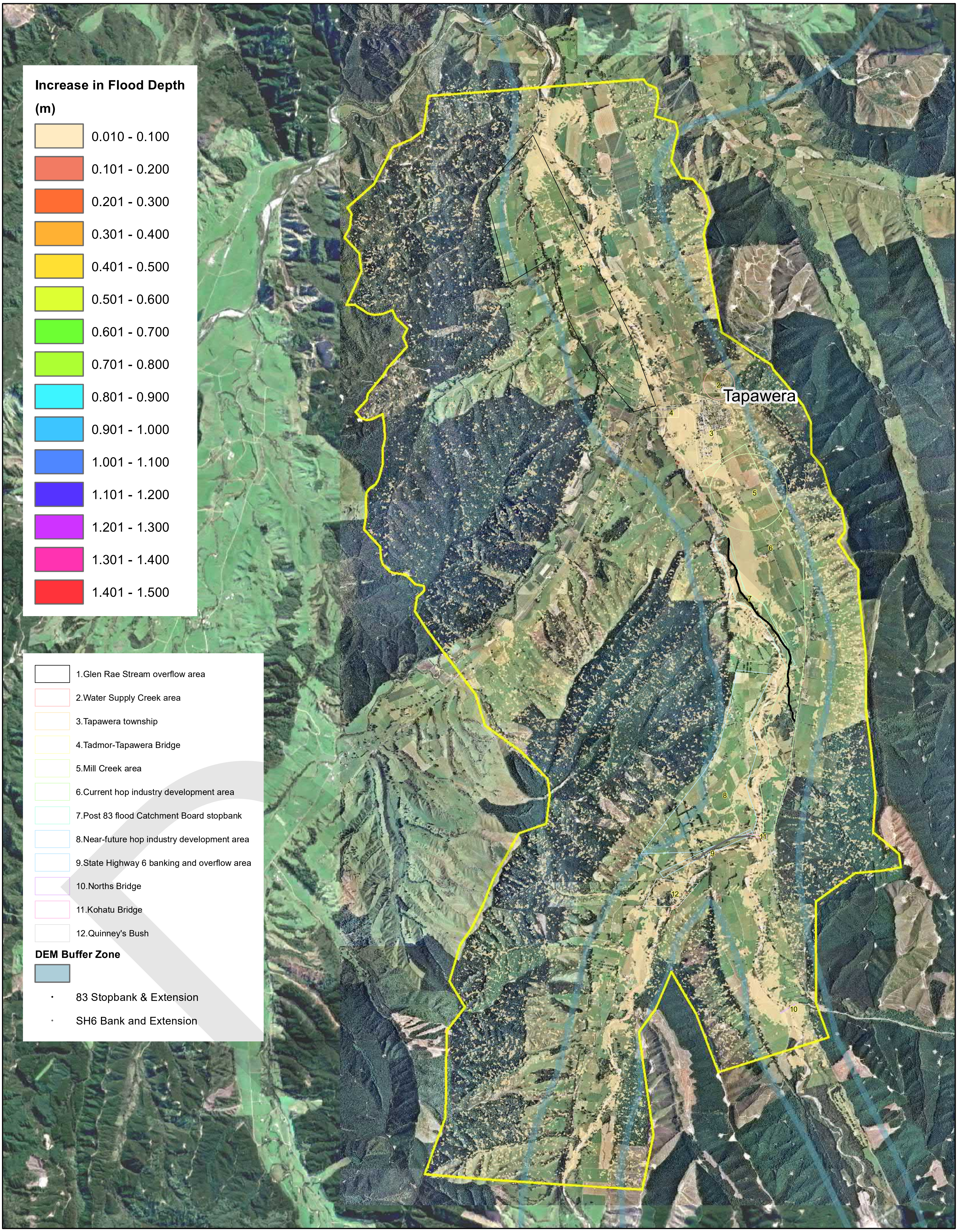
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 15

Sensitivity Testing Result - Decrease in Flood Level
Decreased Rainfall Depth by a Factor of 0.9

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_Sensitivity_DecRain_v03.mxd



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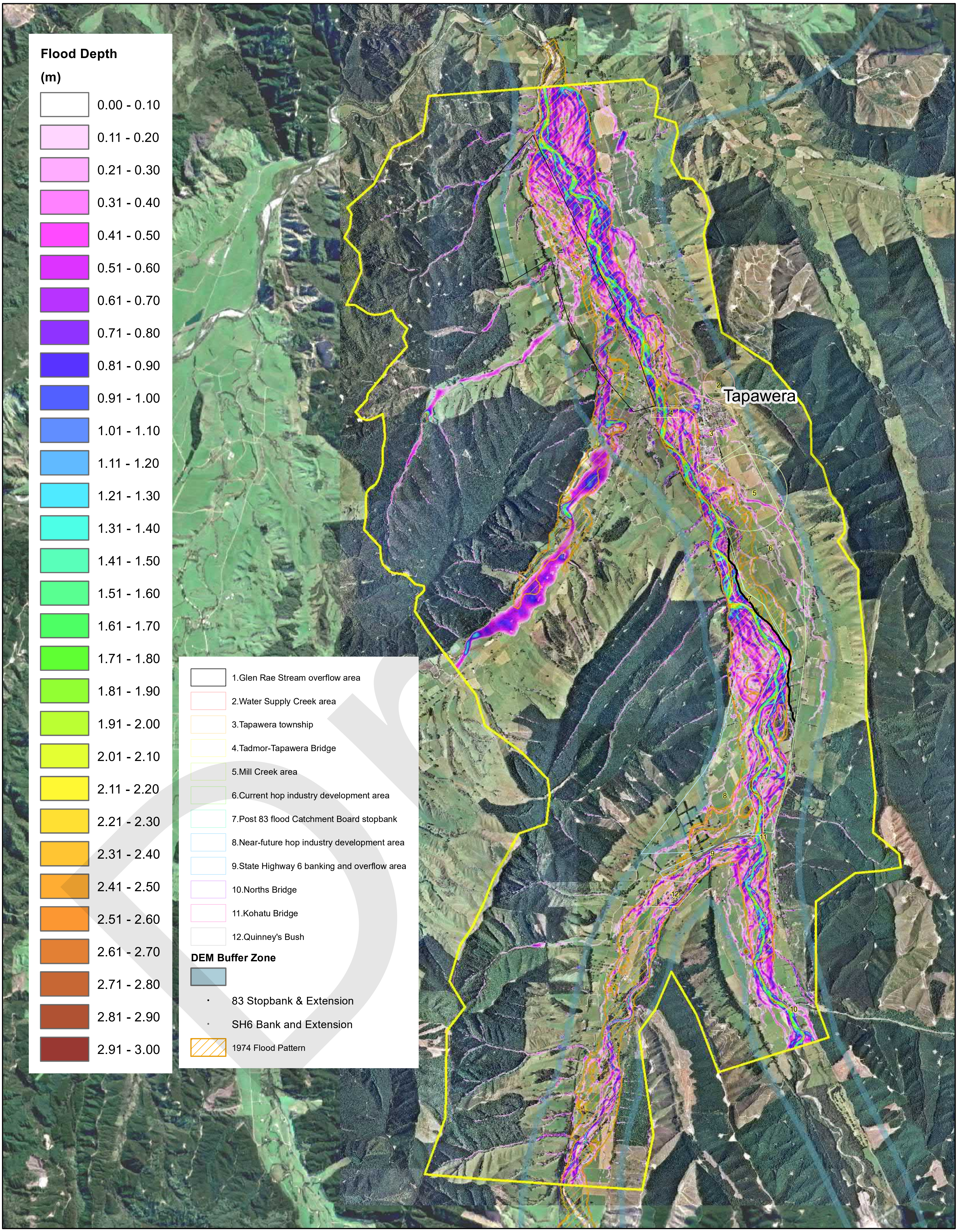
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 15

Sensitivity Testing Result - Increase in Flood Level Activated Eddy Viscosity

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_Sensitivity_Eddy_v03.mxd

APPENDIX D – Comparison between the Historic Flood Pattern and Model Result



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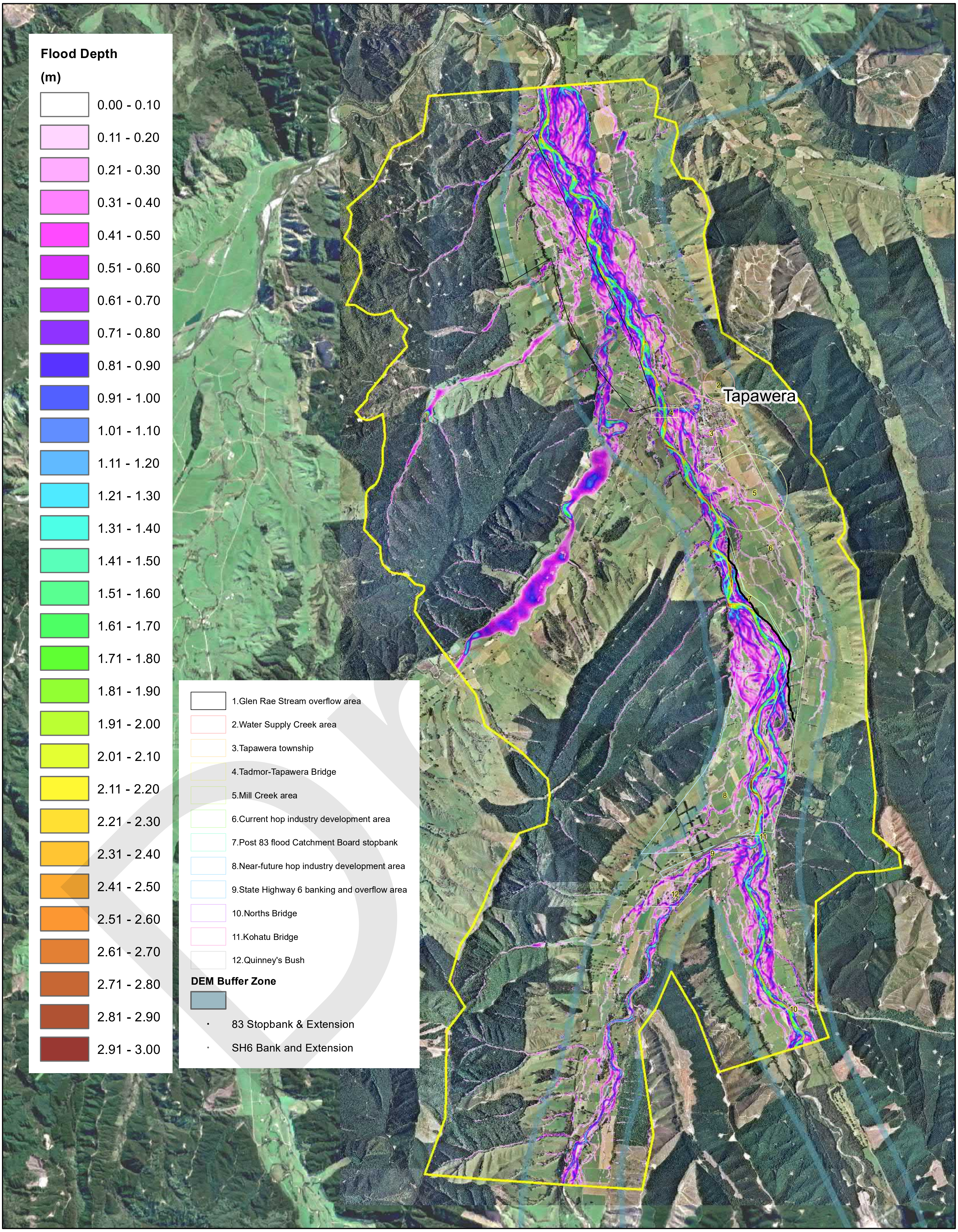
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 21

Flood Depth for the 5% AEP Existing Landuse without Climate Change Scenario and 1974 Flood Extent

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016TDCUpperMotueka_HistoricPattern_v03.mxd

APPENDIX E – Flood Maps for the Existing Landuse Condition without Climate Change



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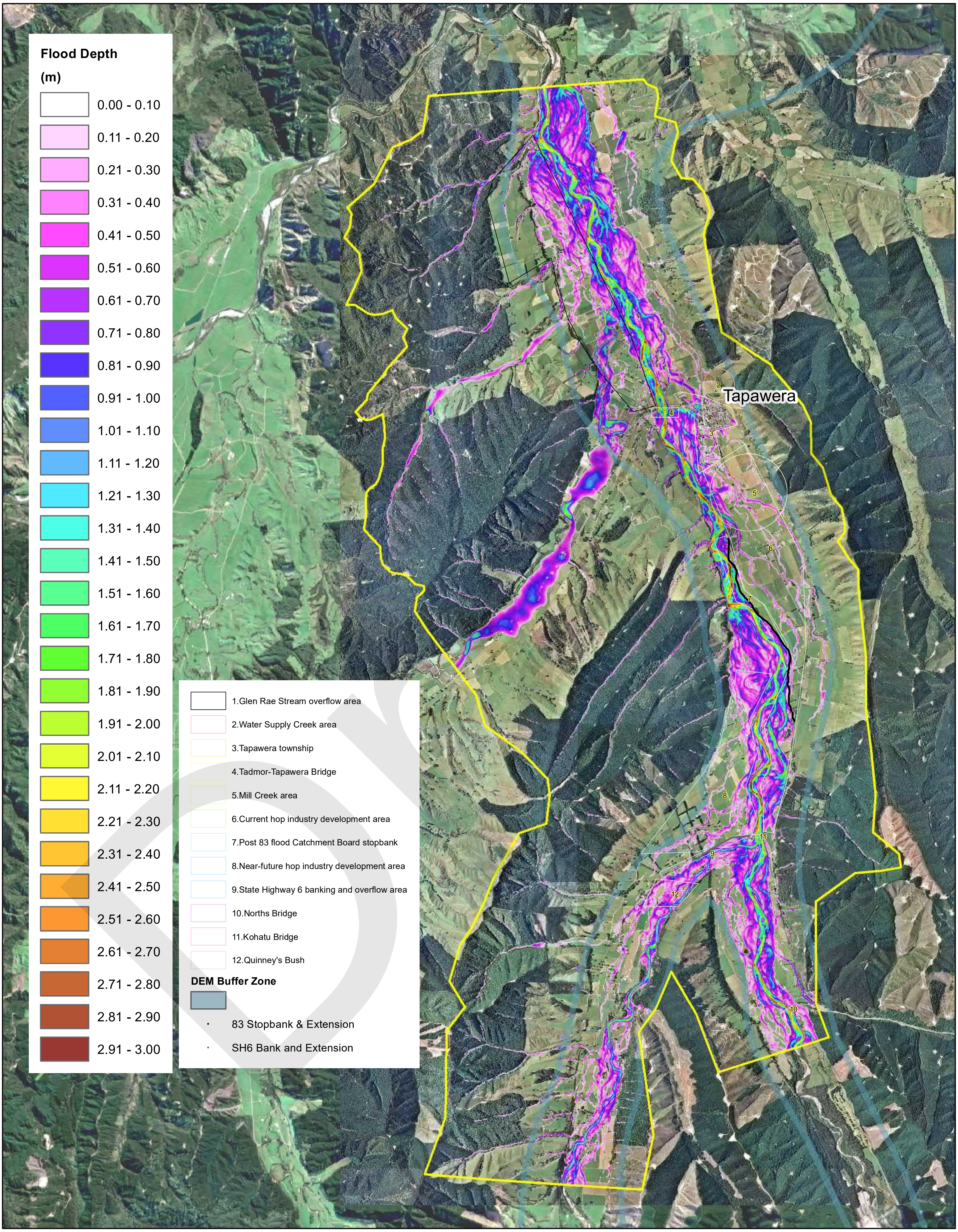
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 19

Model Result - Flood Depth
Existing Landuse without Climate Change
5% AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_ExistingLand_NoCC_20y_v02.mxd



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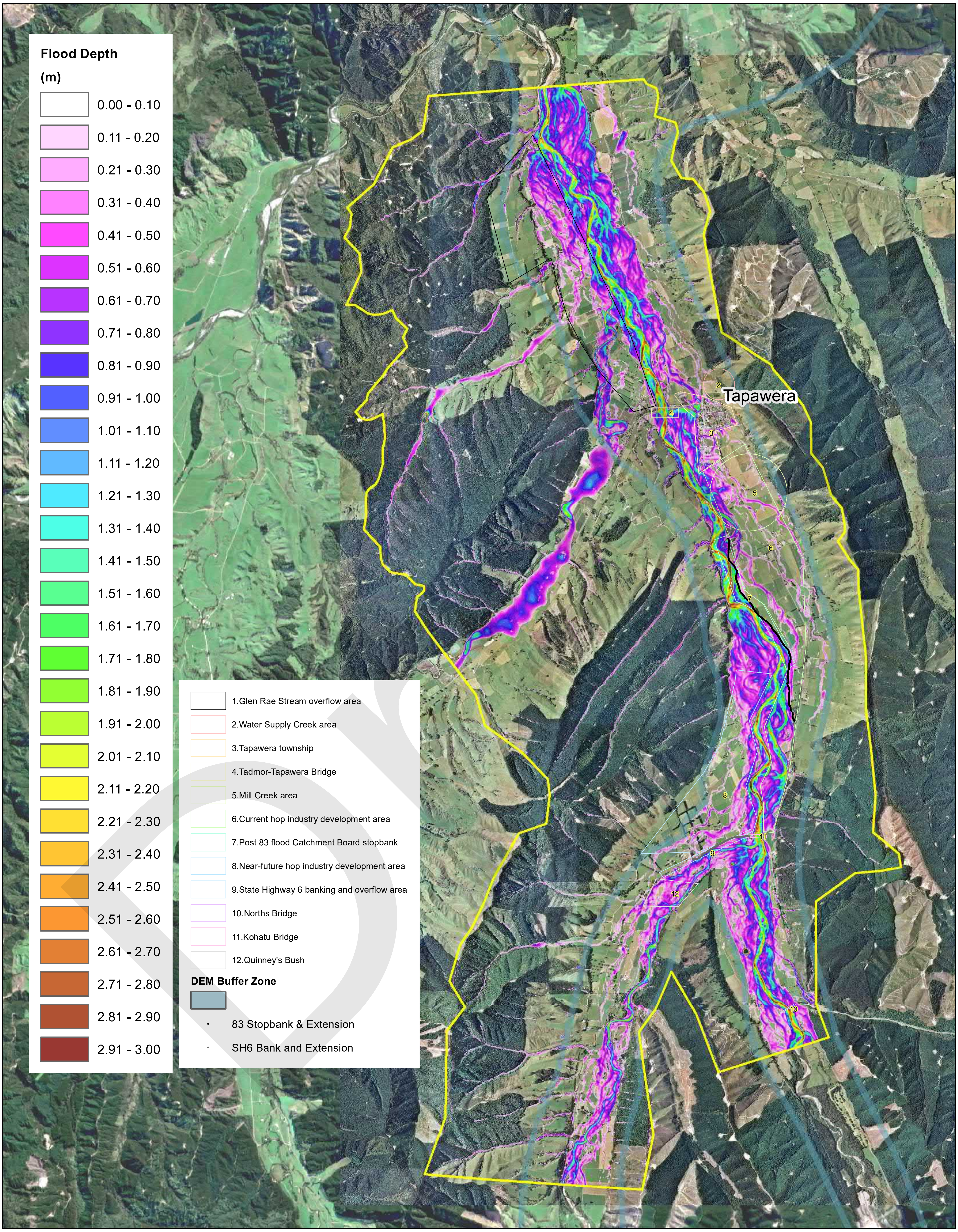
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 19

Model Result - Flood Depth
Existing Landuse without Climate Change
2% AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_ExistingLand_NoCC_50y_v02.mxd



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Projection: Transverse Mercator
Datum: NZGD 2000

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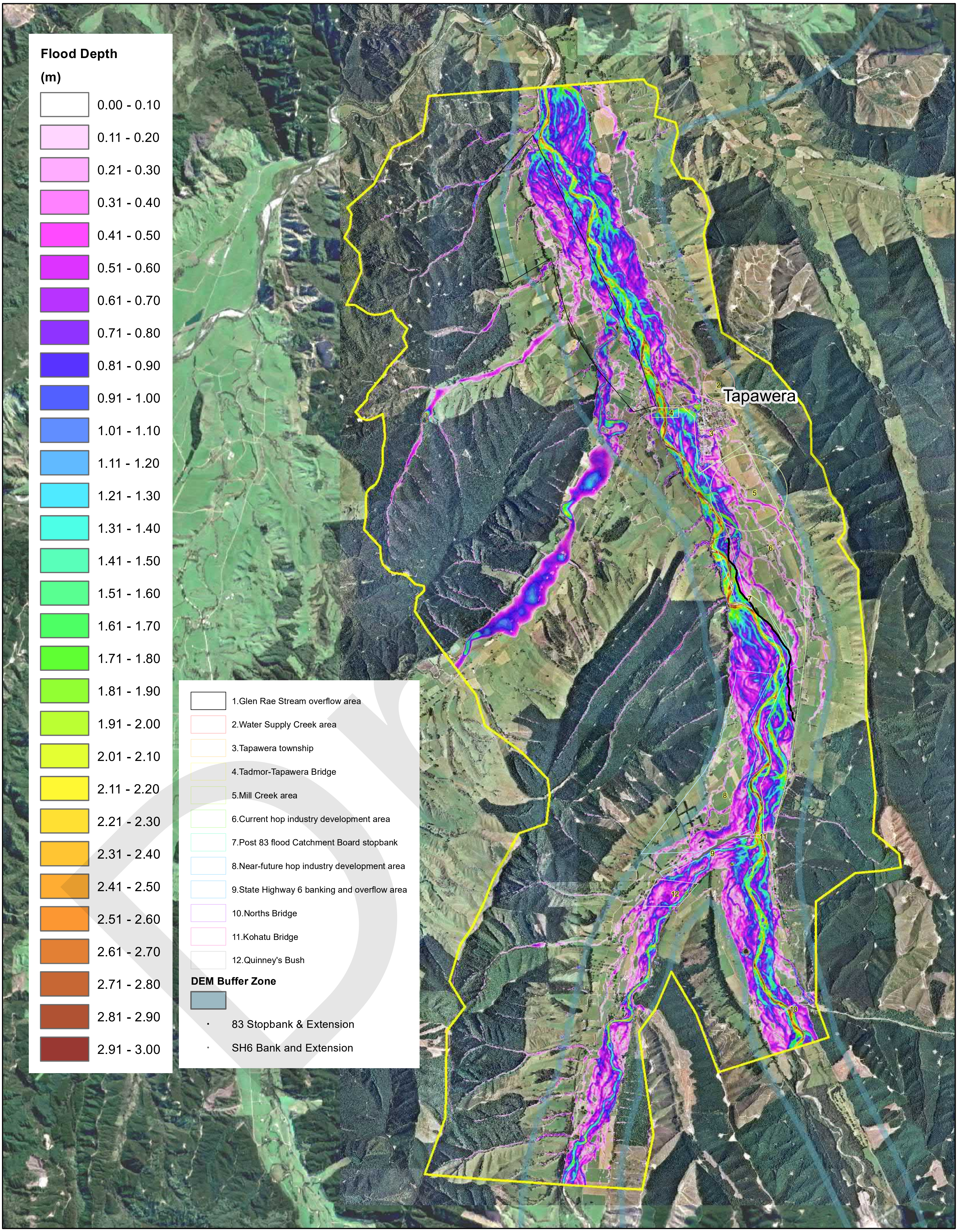
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 19

Model Result - Flood Depth
Existing Landuse without Climate Change
1% AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_ExistingLand_NoCC_100y_v02.mxd



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Paper Size: A3

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Coordinate System: NZGD 2000 New Zealand Transverse Mercator
Projection: Transverse Mercator
Datum: NZGD 2000

N

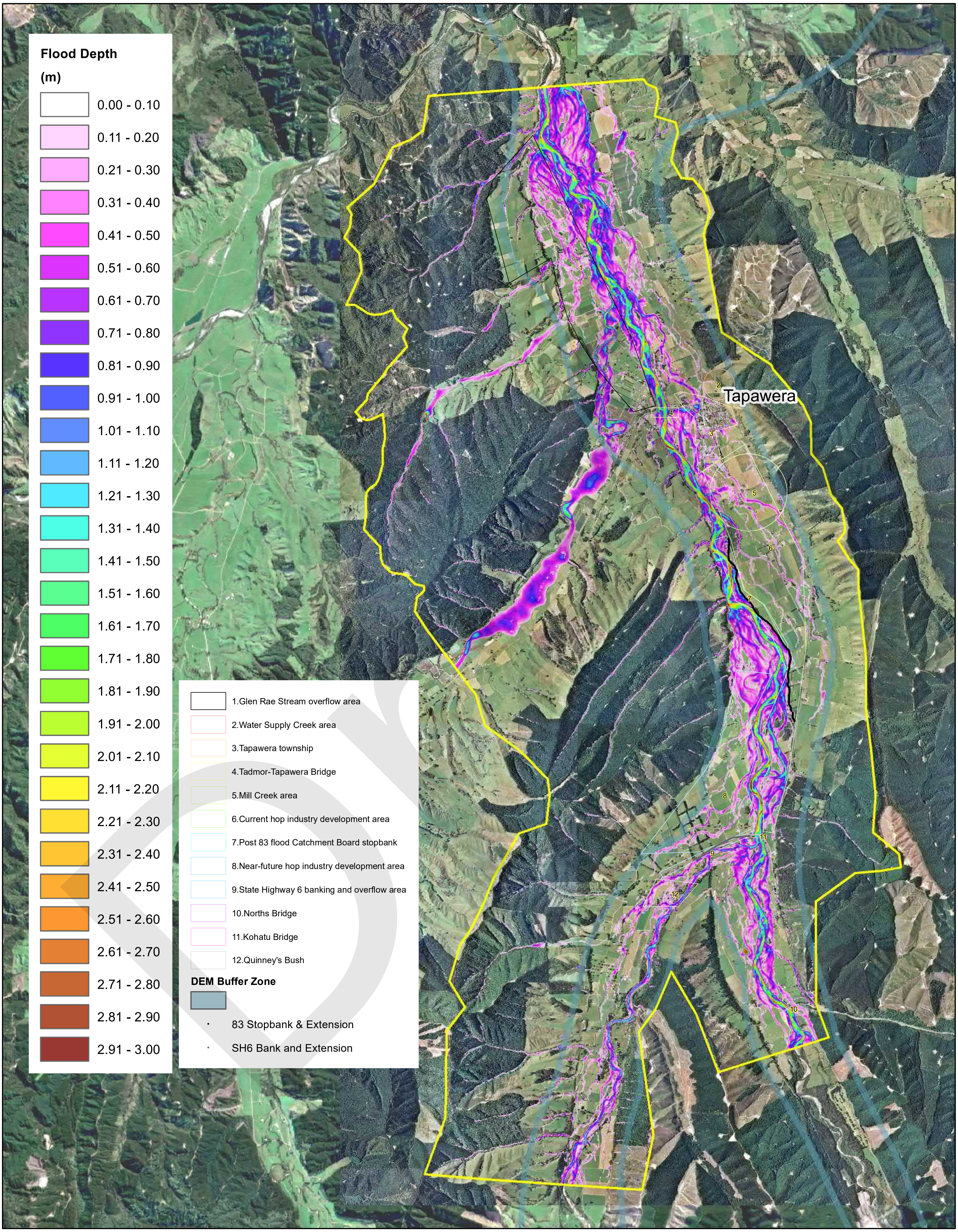
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 19

Model Result - Flood Depth
Existing Landuse without Climate Change
1 in 250 AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_ExistingLand_NoCC_250y_v02.mxd

APPENDIX F – Flood Maps for the Future Landuse Condition without Climate Change



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Paper Size: A3

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Coordinate System: NZGD 2000 New Zealand Transverse Mercator
Projection: Transverse Mercator
Datum: NZGD 2000

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Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 21

Model Result - Flood Depth
Future Landuse without Climate Change
5% AEP

Author: Ting Powell
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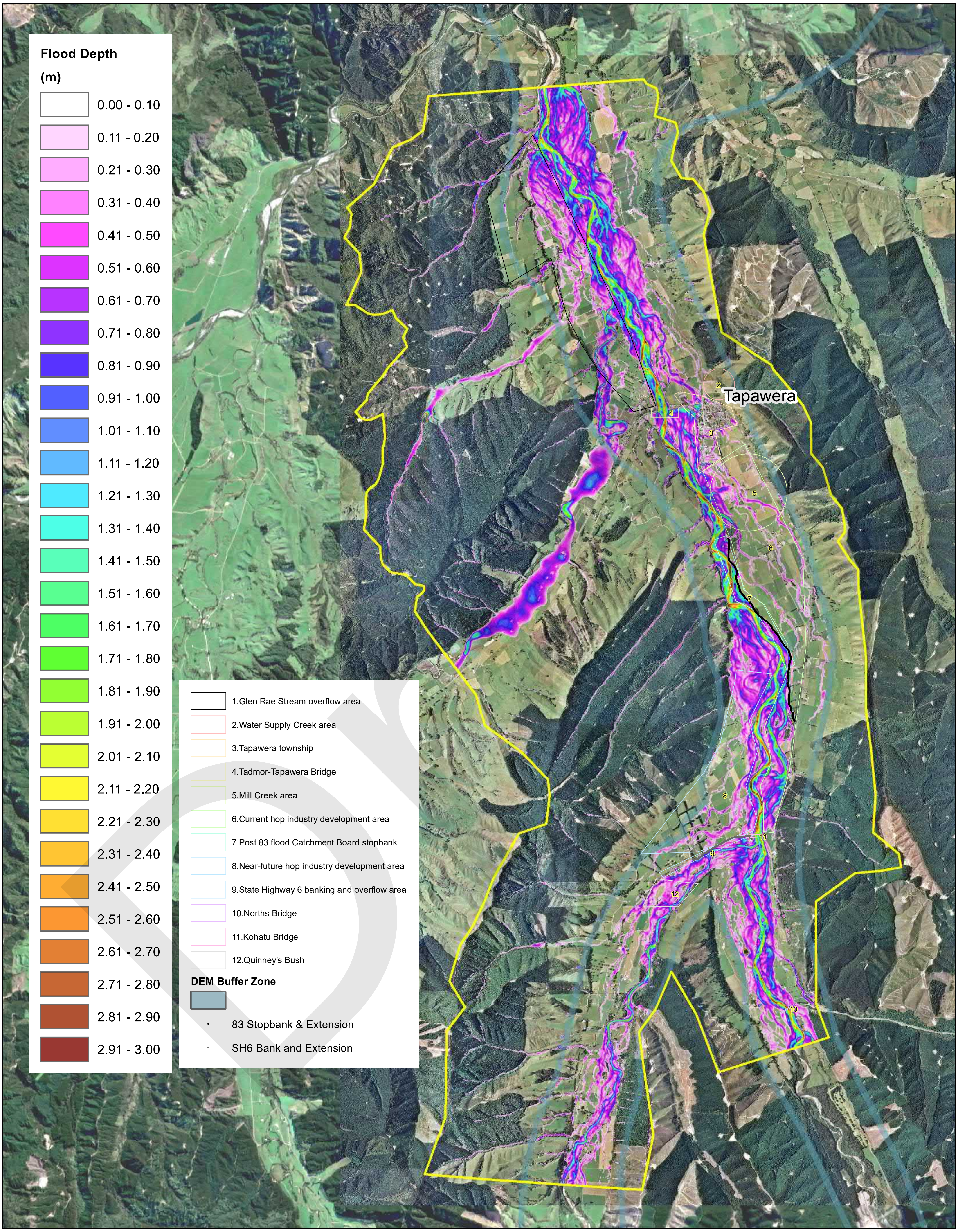

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Paper Size: A3

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Coordinate System: NZGD 2000 New Zealand Transverse Mercator
Projection: Transverse Mercator
Datum: NZGD 2000

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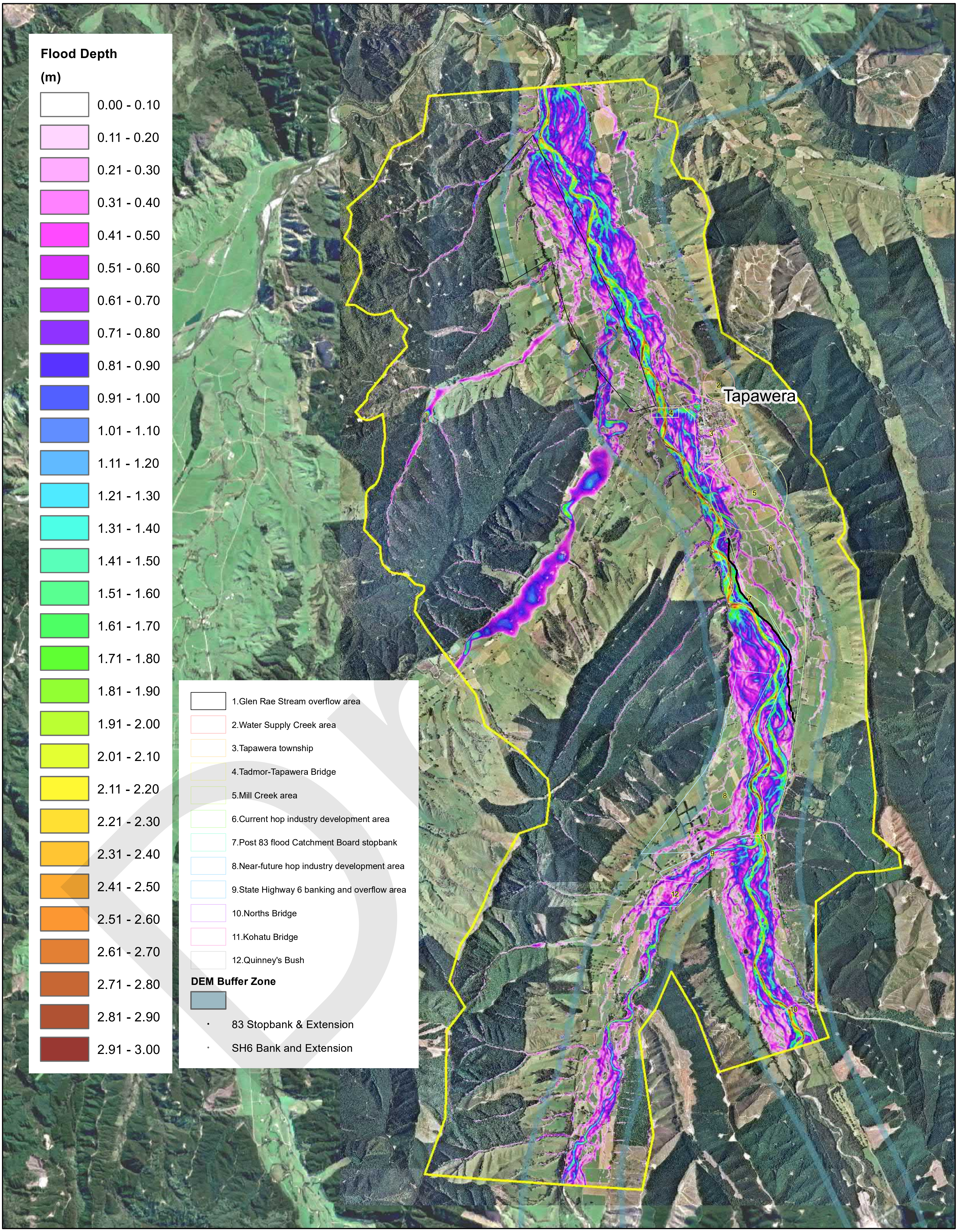
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 21

Model Result - Flood Depth
Future Landuse without Climate Change
2% AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_FutureLand_NoCC_50y_v02.mxd



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Coordinate System: NZGD 2000 New Zealand Transverse Mercator
Projection: Transverse Mercator
Datum: NZGD 2000

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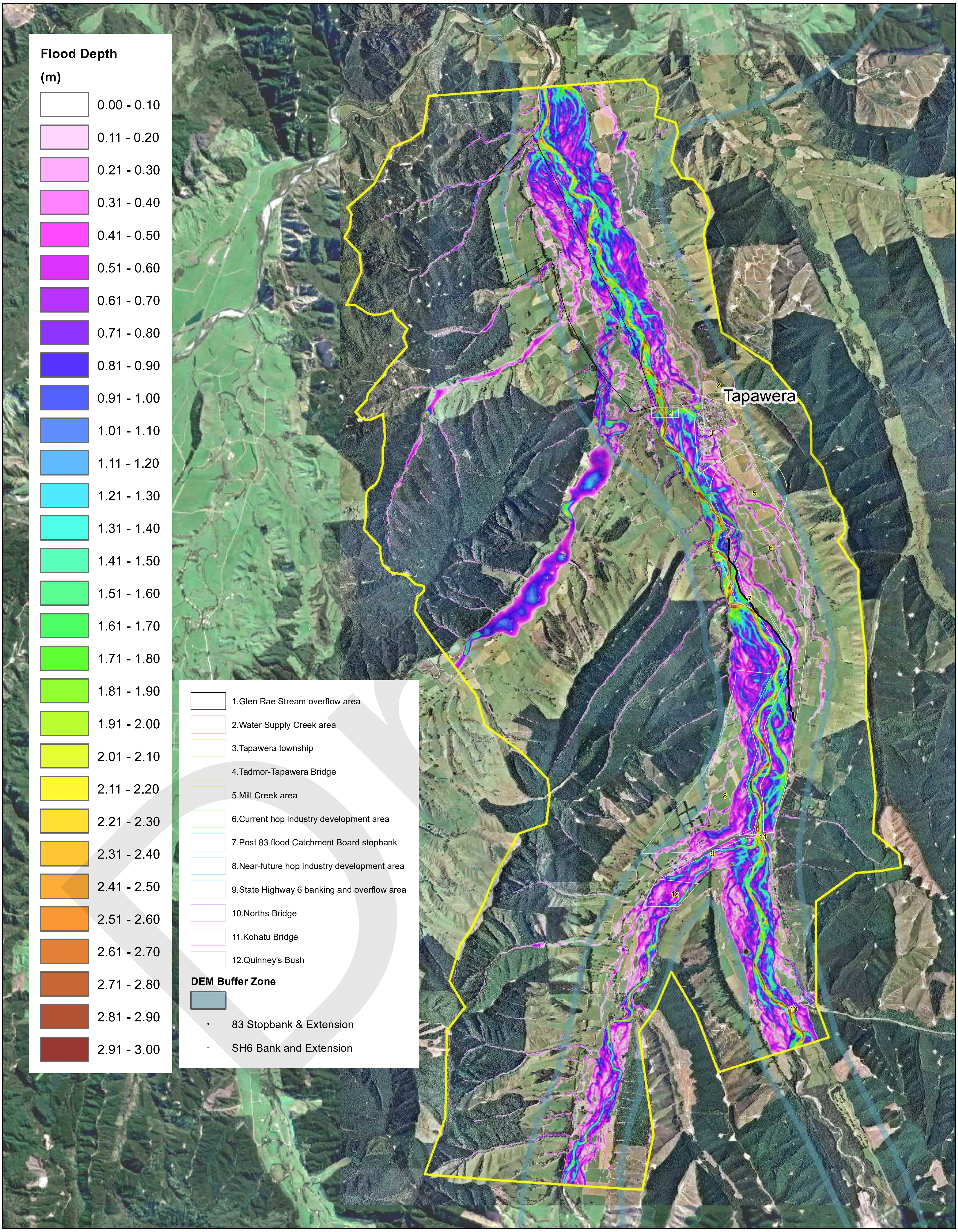
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 21

Model Result - Flood Depth
Future Landuse without Climate Change
1% AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_FutureLand_NoCC_100y_v02.mxd



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Paper Size: A3

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Meters

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Coordinate System: NZGD 2000 New Zealand Transverse Mercator
Projection: Transverse Mercator
Datum: NZGD 2000

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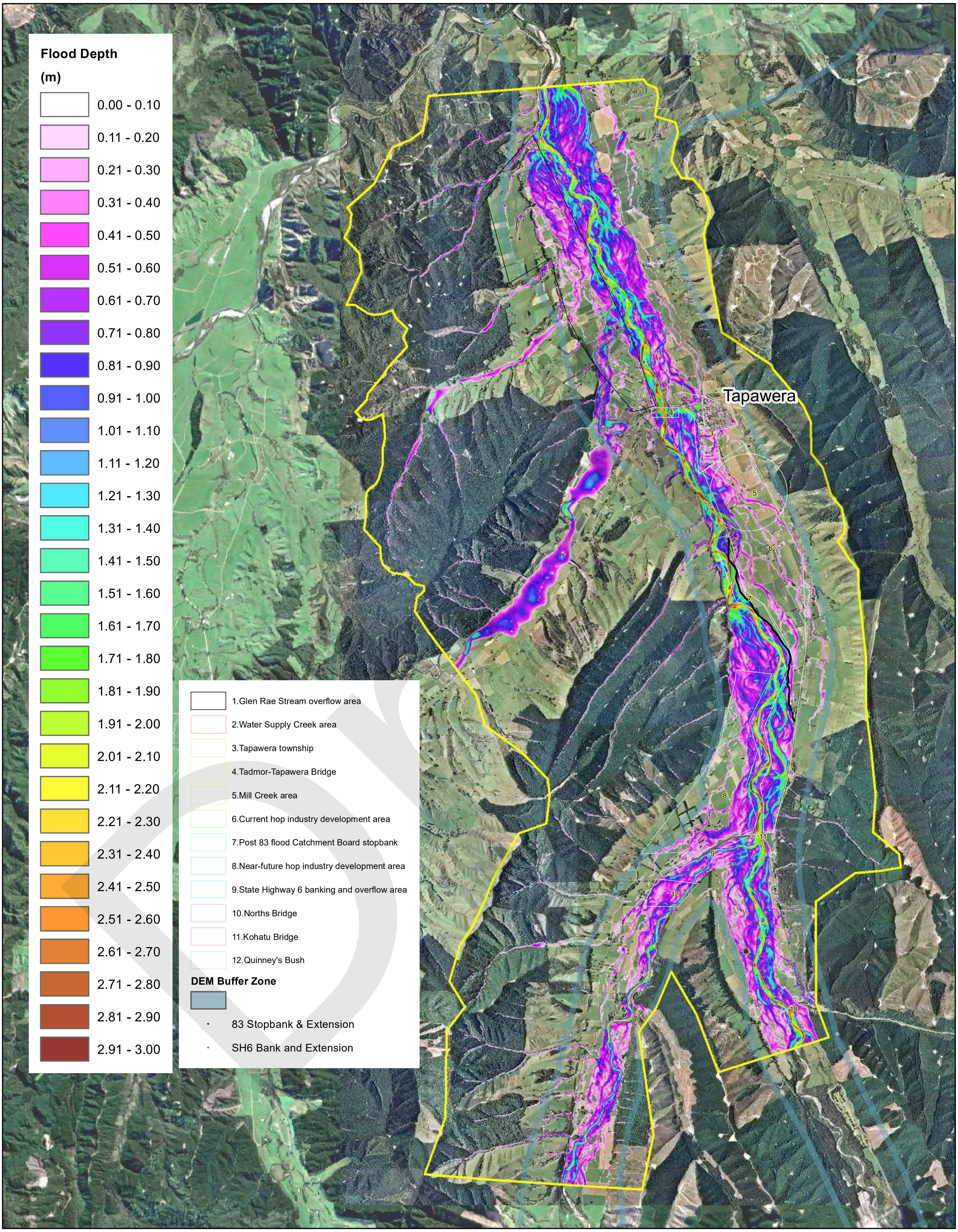
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 21

Model Result - Flood Depth
Future Landuse without Climate Change
1 in 250 AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_FutureLand_NoCC_250y_v02.mxd

APPENDIX G – Flood Maps for the Future Landuse Condition with Climate Change



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Coordinate System: NZGD 2000 New Zealand Transverse Mercator
Projection: Transverse Mercator
Datum: NZGD 2000

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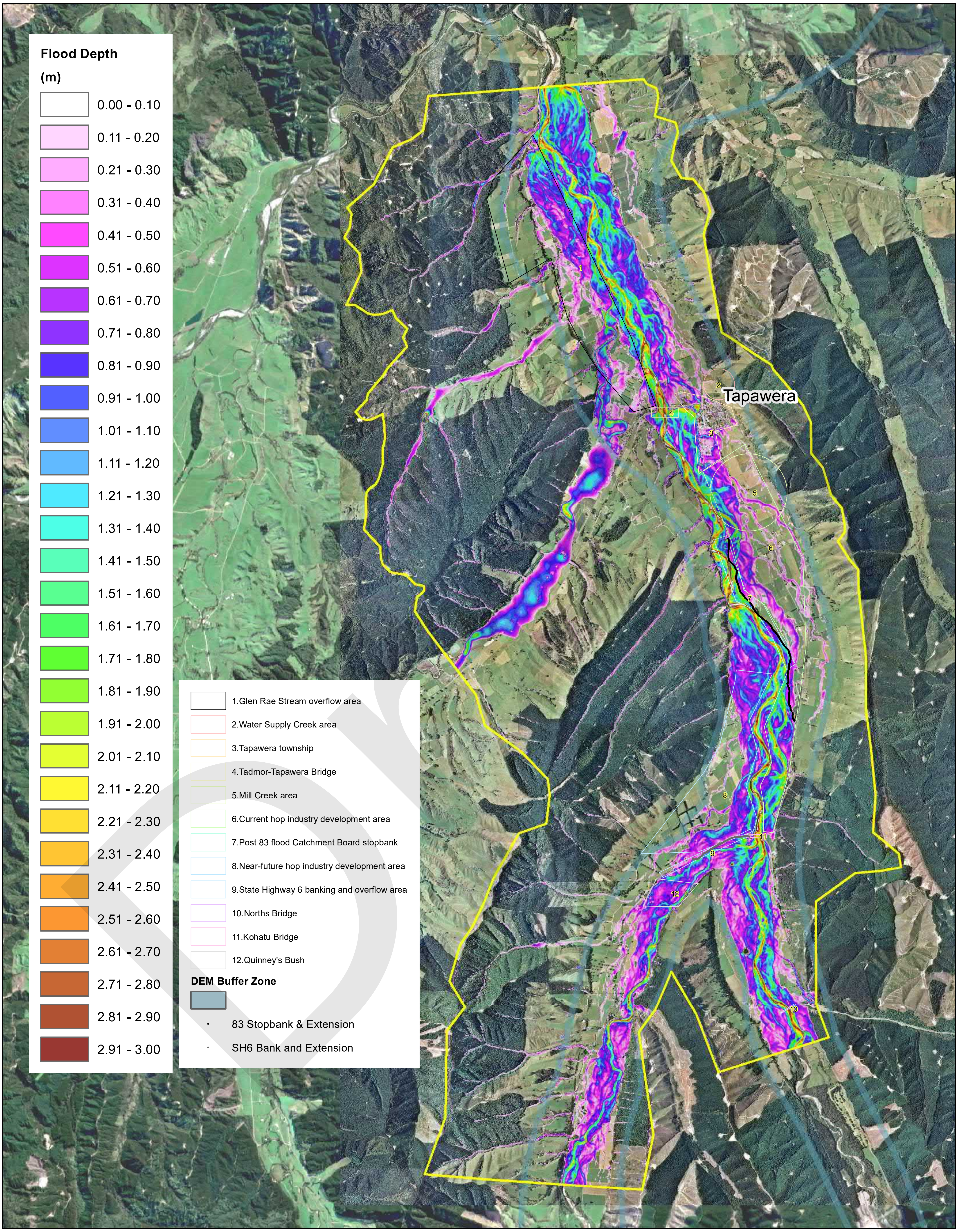
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 19

Model Result - Flood Depth
Future Landuse with Climate Change
5% AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_FutureLand_CC_20y_v02.mxd



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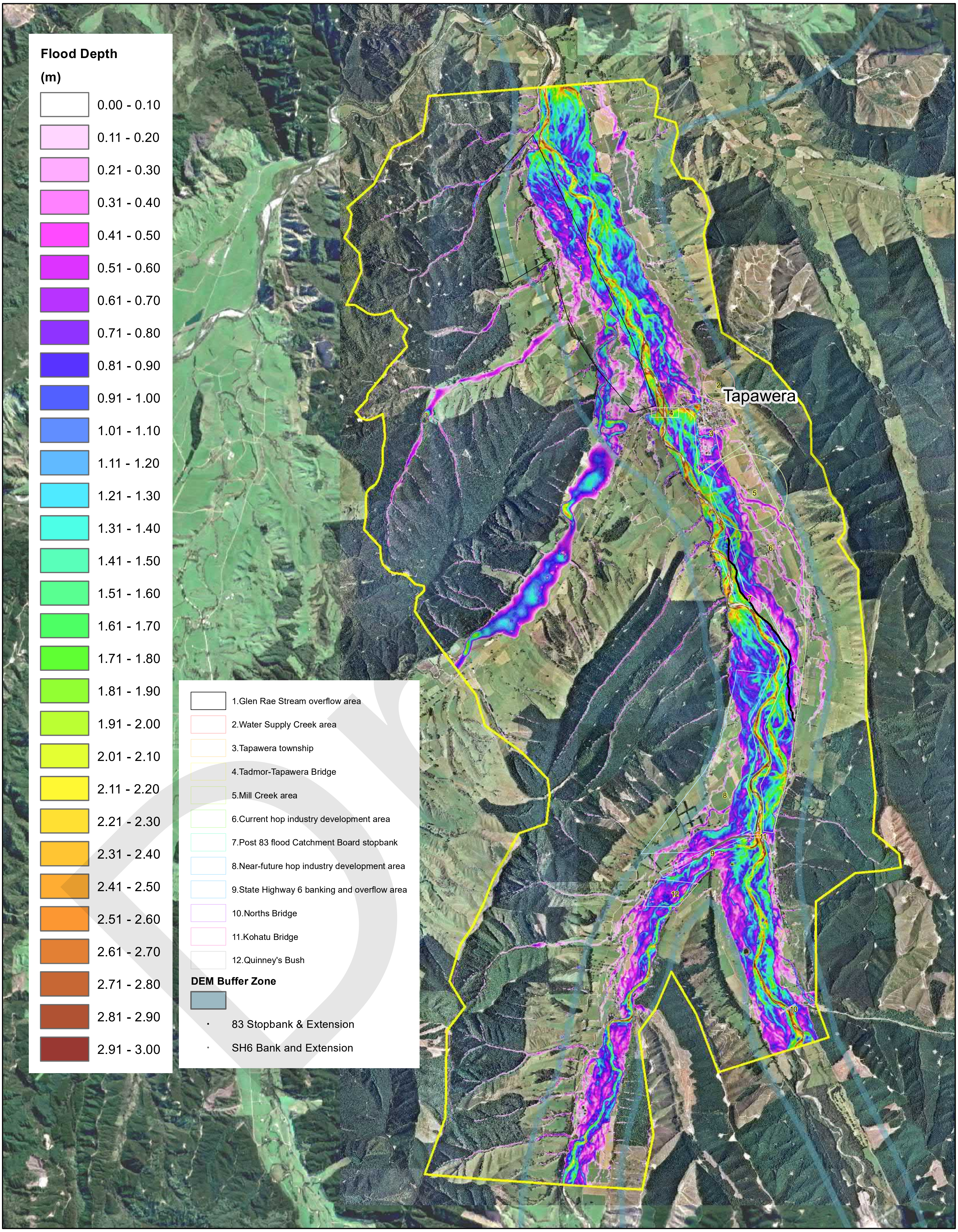
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 19

Model Result - Flood Depth
Future Landuse with Climate Change
2% AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_FutureLand_CC_50y_v02.mxd



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Paper Size: A3

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Projection: Transverse Mercator
Datum: NZGD 2000

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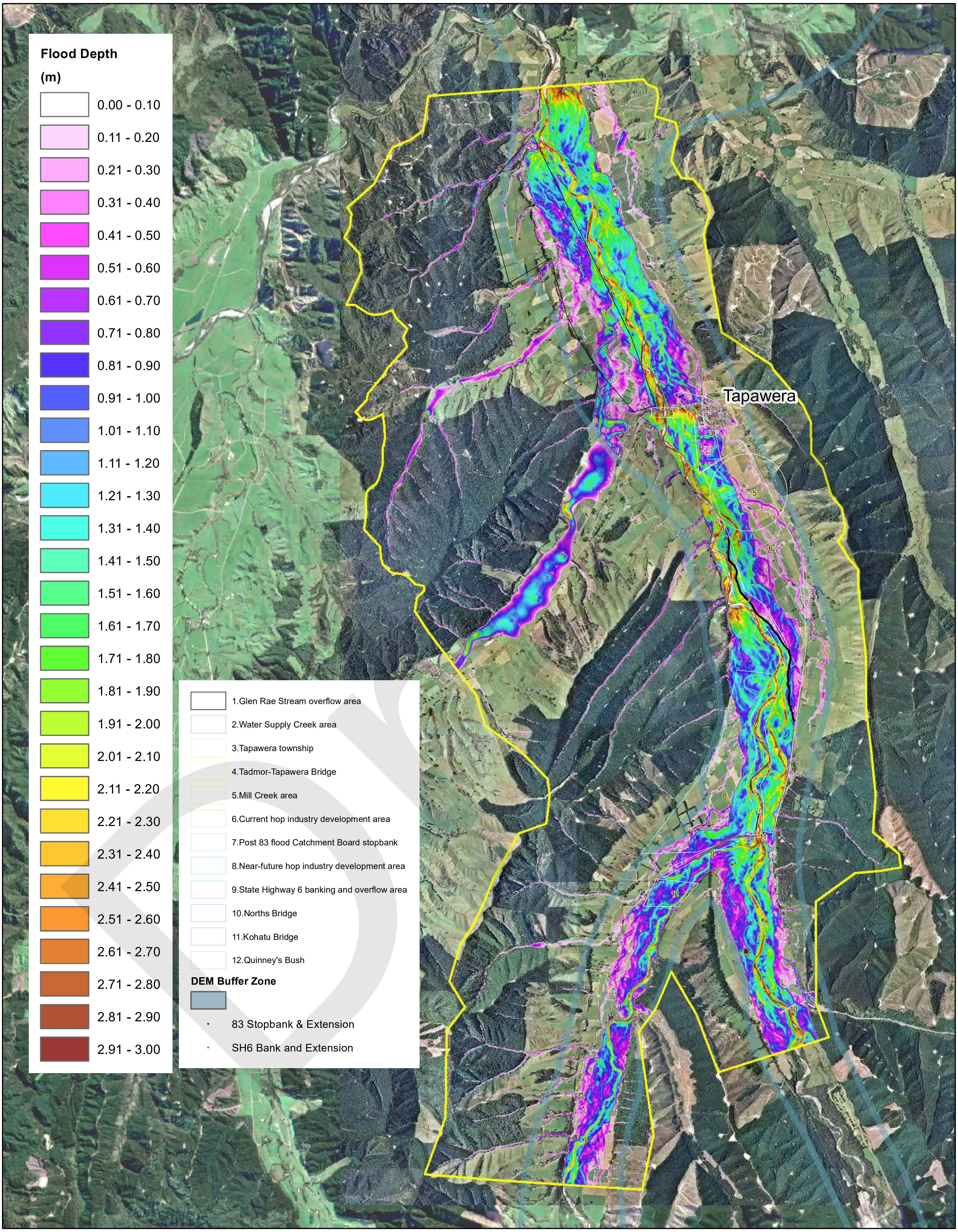
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 19

Model Result - Flood Depth
Future Landuse with Climate Change
1% AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_FutureLand_CC_100y_v02.mxd



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Paper Size: A3

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Coordinate System: NZGD 2000 New Zealand Transverse Mercator
Projection: Transverse Mercator
Datum: NZGD 2000

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Tasman District Council
Upper Motueka Flood Modelling

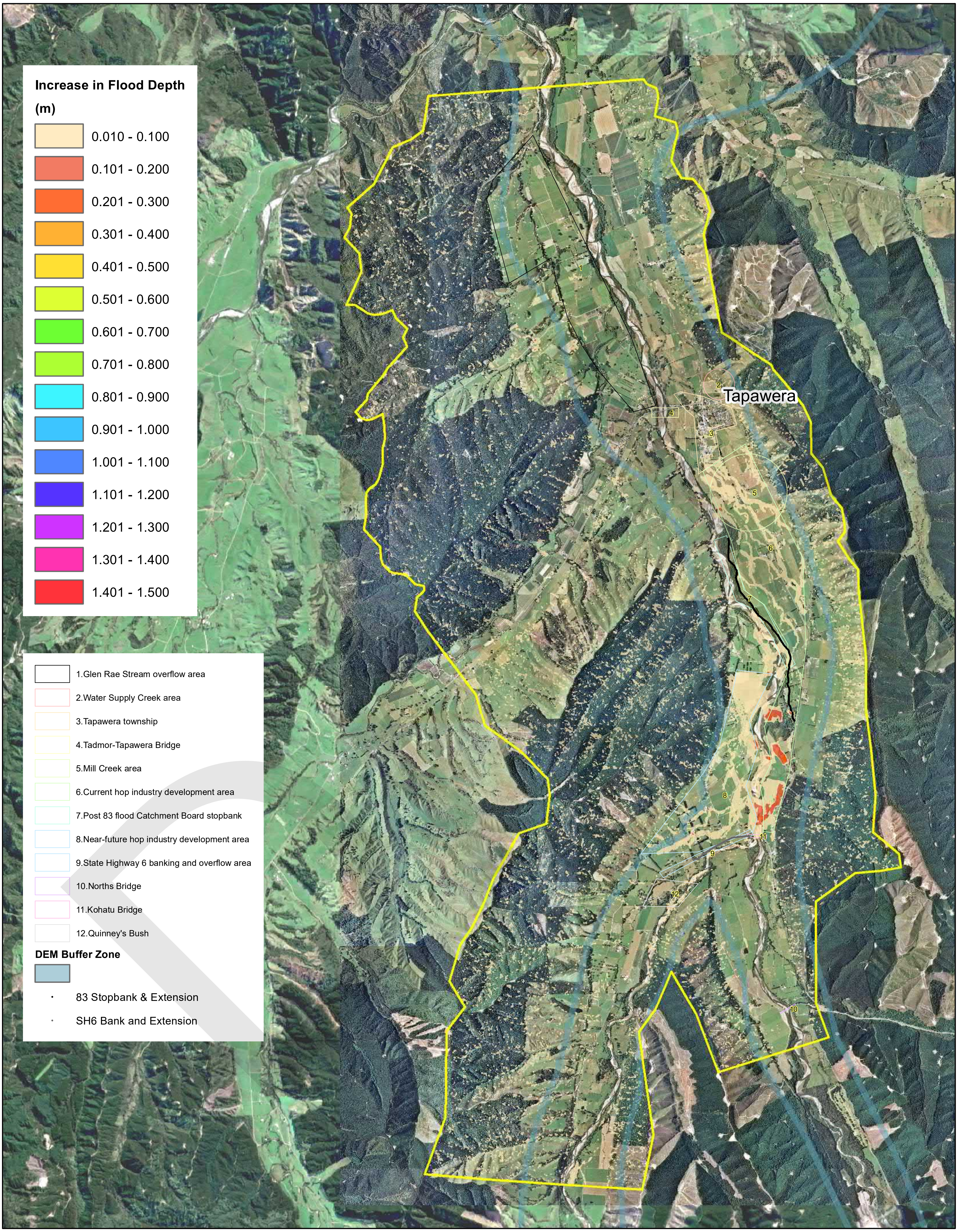
Job Number	20016
Revision	A
Date	2020 October 19

Model Result - Flood Depth
Future Landuse with Climate Change
1 in 250 AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_FutureLand_CC_250y_v02.mxd

Upper Motueka River Model Development
Tasman District Council

APPENDIX H – Impacts of Landuse Change



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Projection: Transverse Mercator
Datum: NZGD 2000

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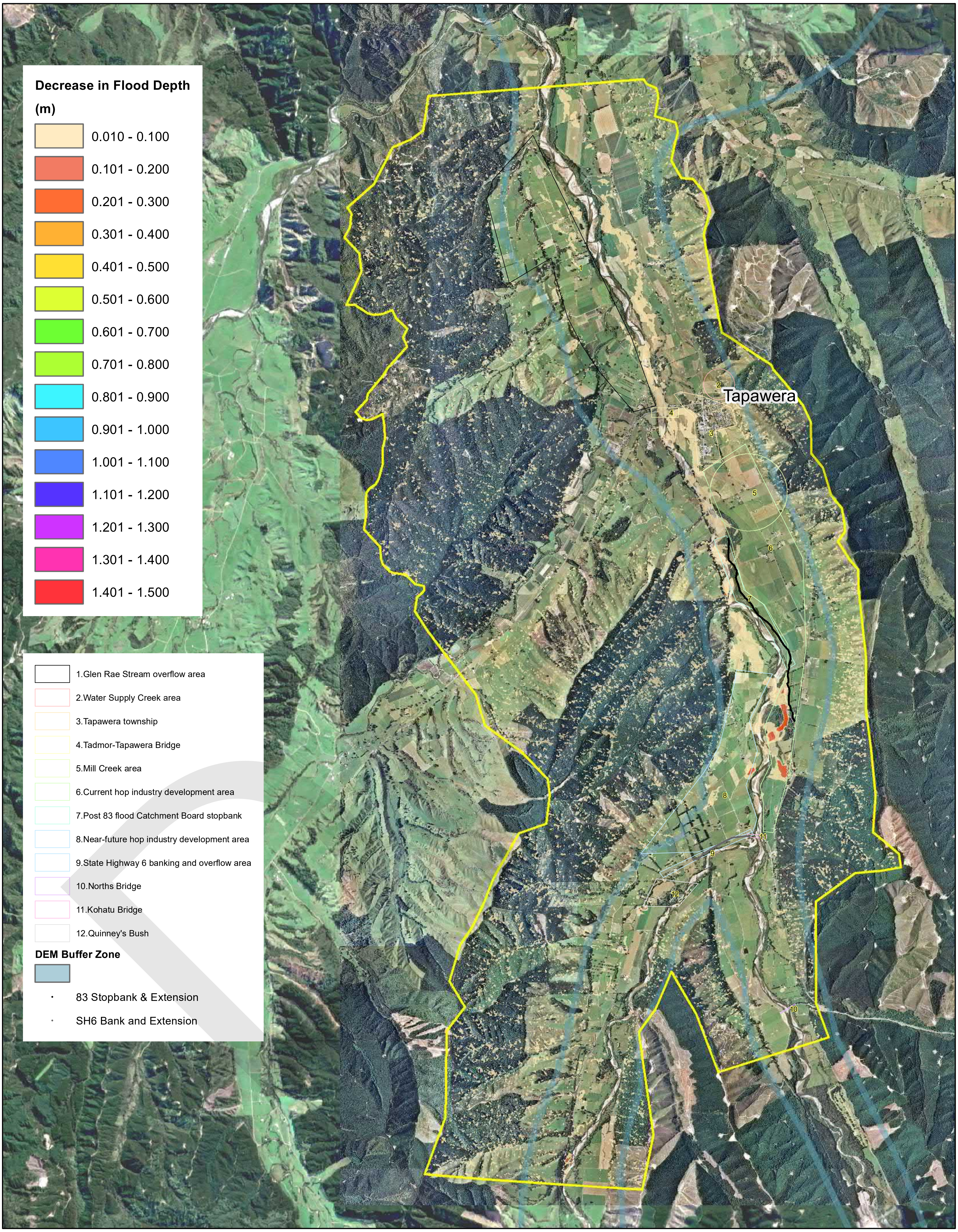
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 19

Landuse Change Impact - Increase in Flood Depth From Future Landuse without Climate Change to Existing Landuse without Climate Change 5% AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_LanduseImpact_20y_v02.mxd



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Projection: Transverse Mercator
Datum: NZGD 2000

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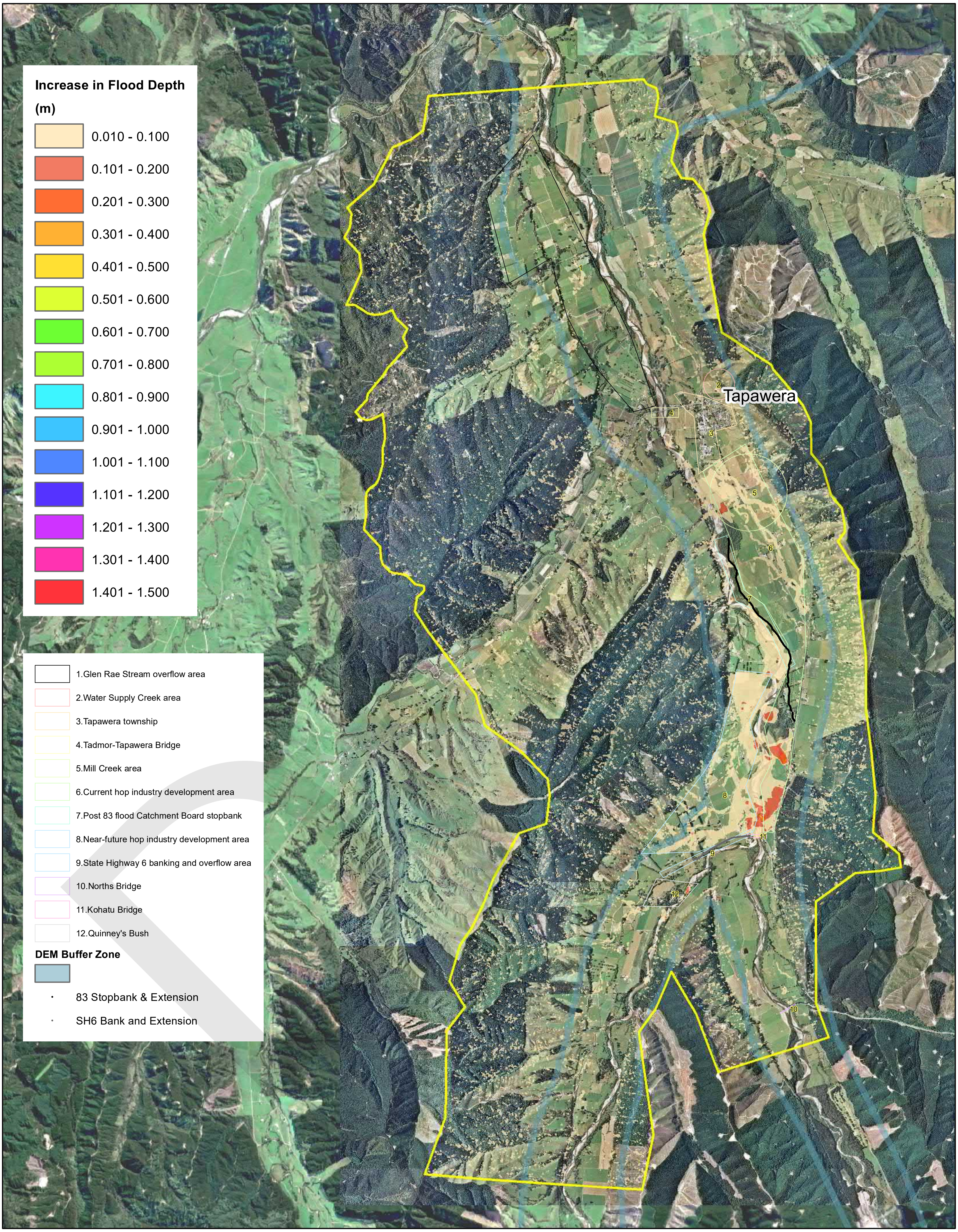
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 19

Landuse Change Impact - Decrease in Flood Depth From Future Landuse without Climate Change to Existing Landuse without Climate Change
5% AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_LanduseImpact_20y_Reducedv02.mxd



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Coordinate System: NZGD 2000 New Zealand Transverse Mercator
Projection: Transverse Mercator
Datum: NZGD 2000

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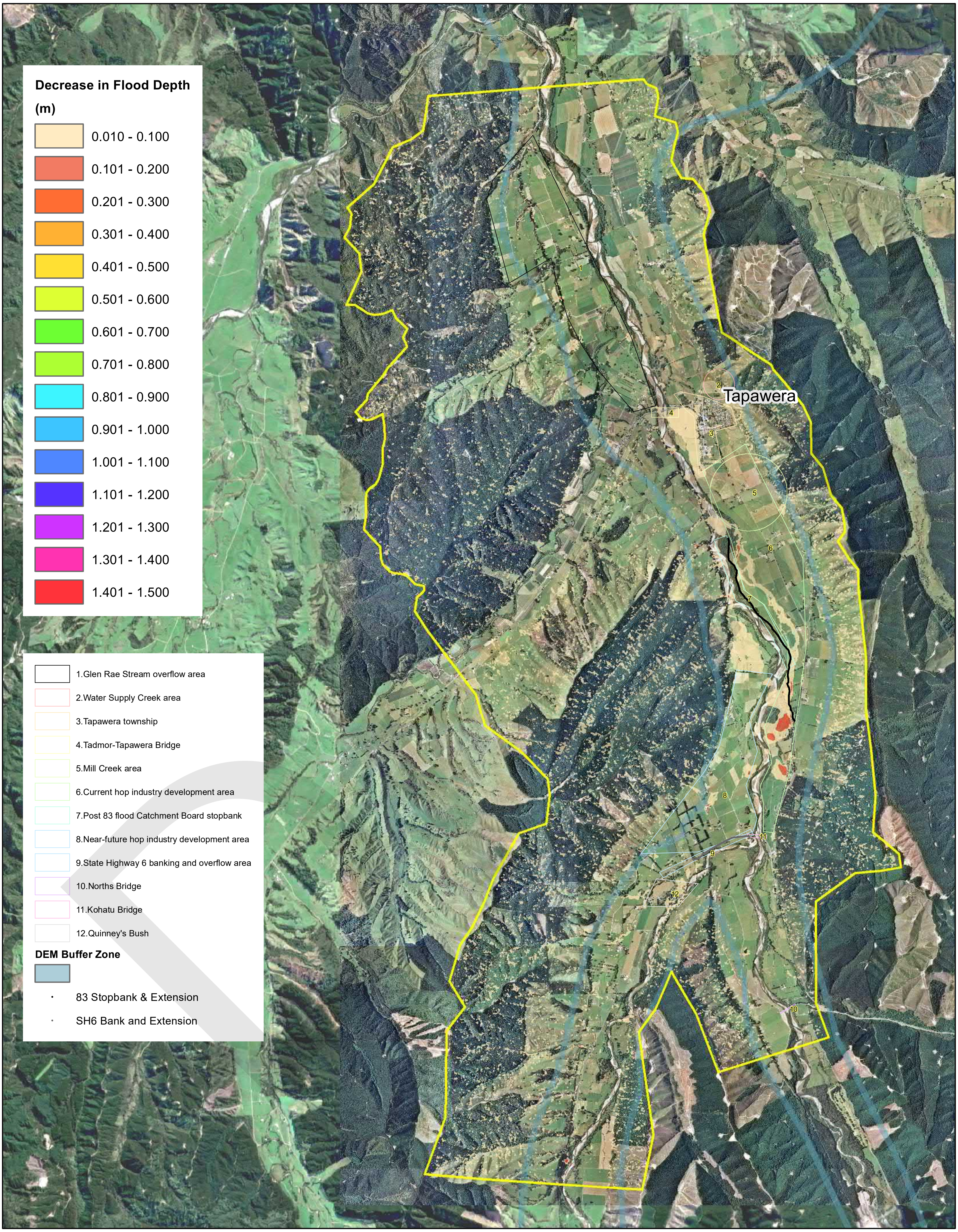
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 19

Landuse Change Impact - Increase in Flood Depth From Future Landuse without Climate Change to Existing Landuse without Climate Change 2% AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_LanduseImpact_50y_v02.mxd



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Datum: NZGD 2000

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Tasman District Council
Upper Motueka Flood Modelling

Landuse Change Impact - Decrease in Flood Depth From Future Landuse without Climate Change to Existing Landuse without Climate Change 2% AEP

Job Number	20016
Revision	A
Date	2020 October 19

Author: Ting Powell
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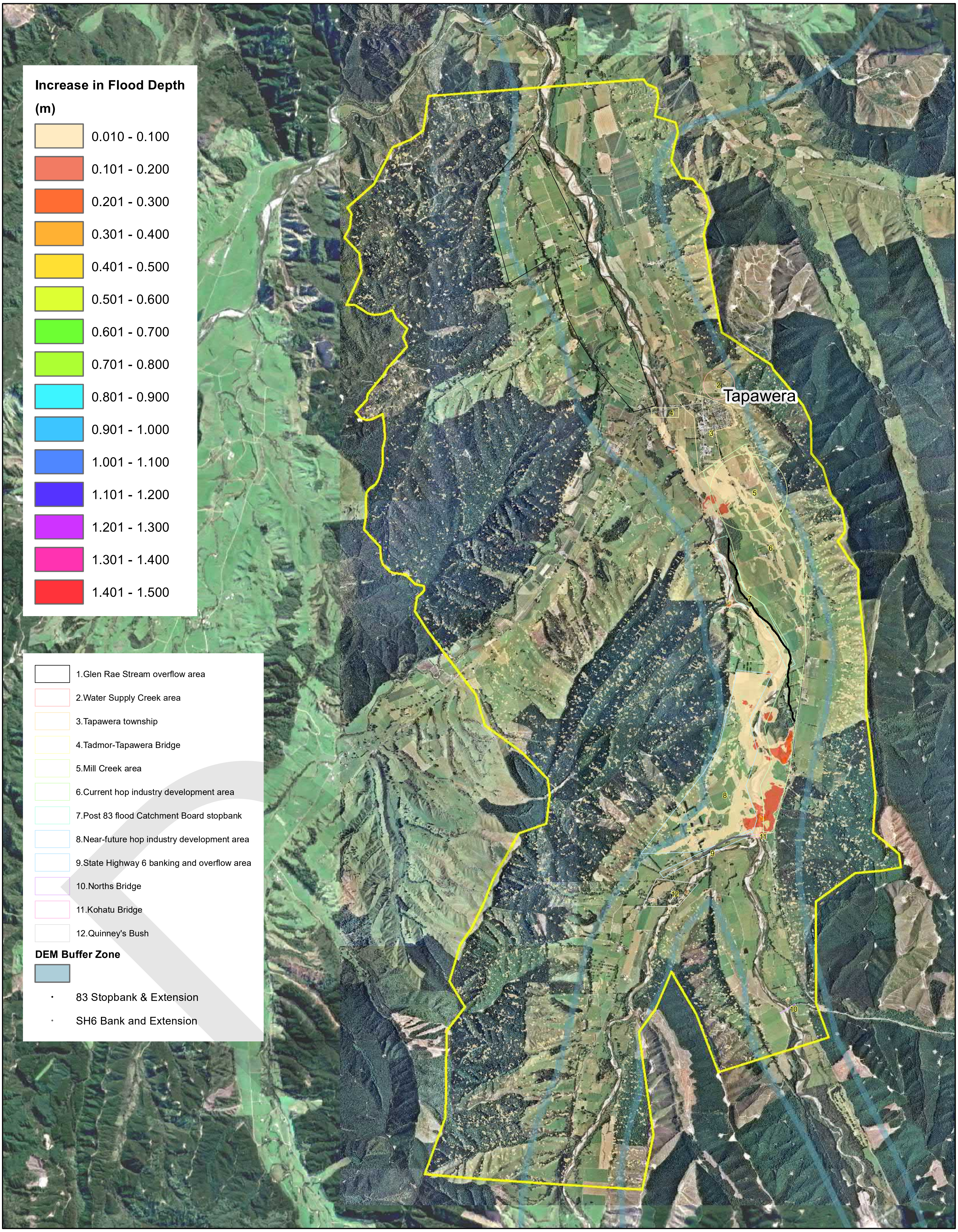

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Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 19

Landuse Change Impact - Increase in Flood Depth From Future Landuse without Climate Change to Existing Landuse without Climate Change 1% AEP

Author: Ting Powell
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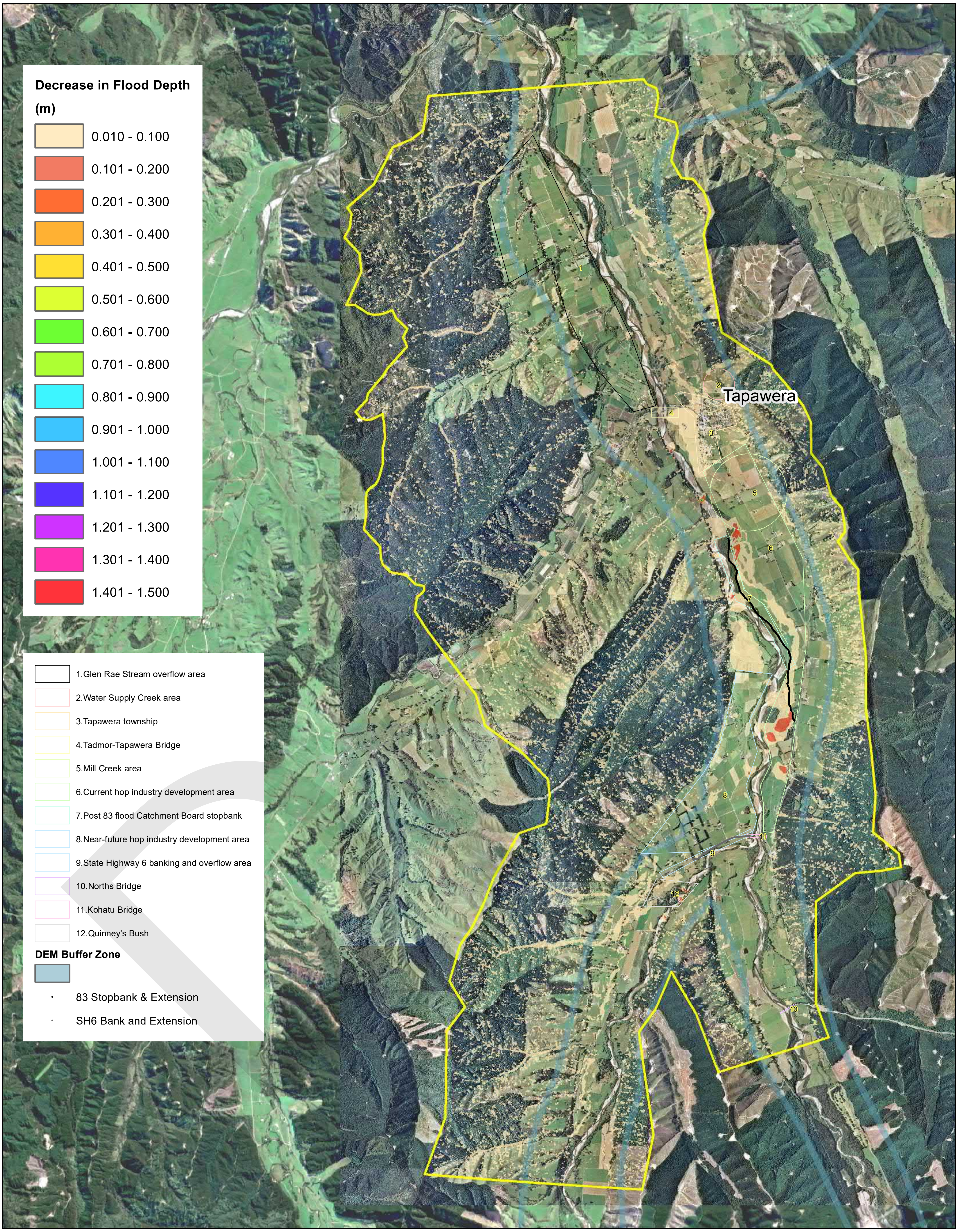

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Coordinate System: NZGD 2000 New Zealand Transverse Mercator
Projection: Transverse Mercator
Datum: NZGD 2000

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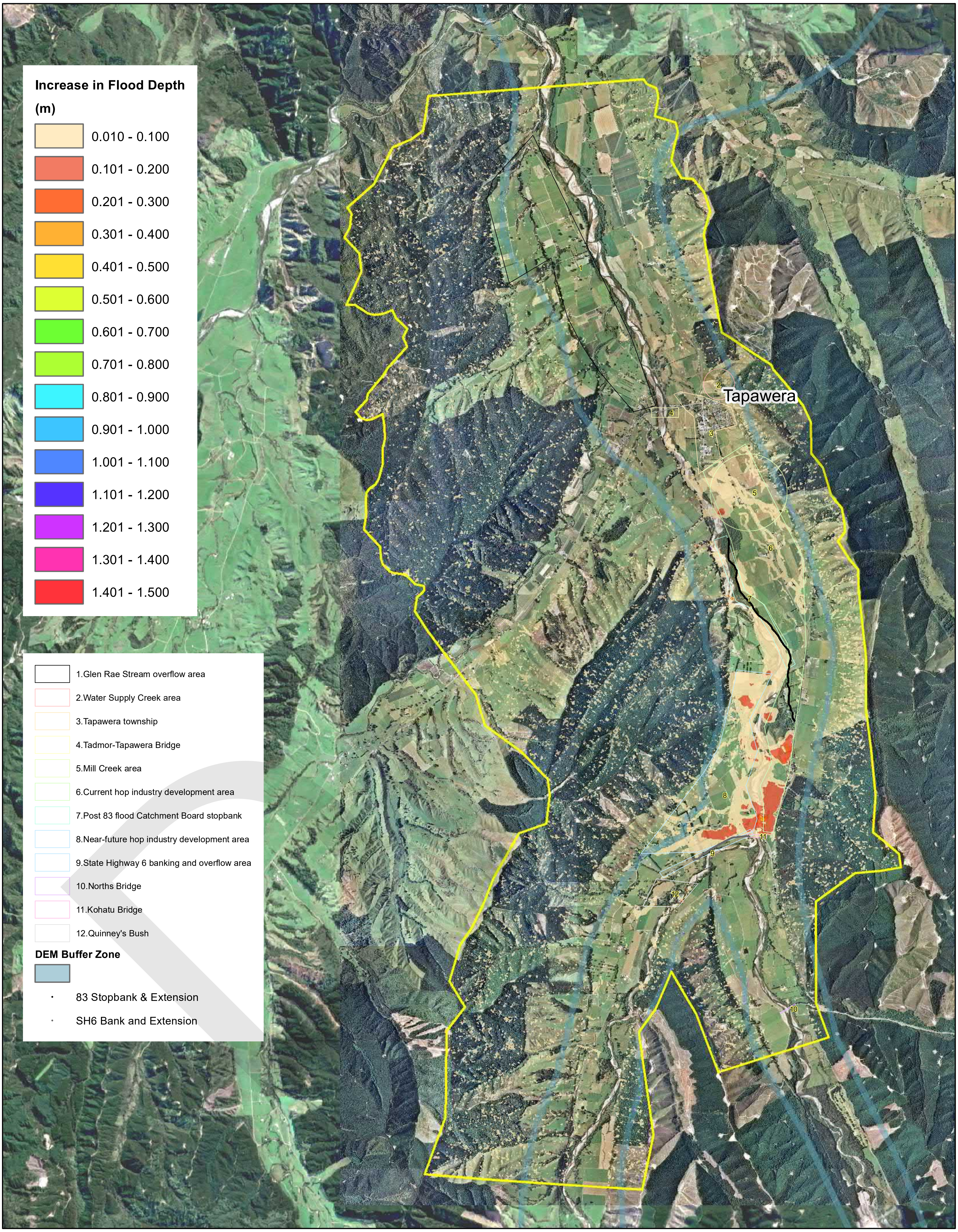
Tasman District Council
Upper Motueka Flood Modelling

Landuse Change Impact - Decrease in Flood Depth From Future Landuse without Climate Change to Existing Landuse without Climate Change
1% AEP

Job Number	20016
Revision	A
Date	2020 October 19

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_LanduseImpact_100y_Reducedv02.mxd



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Projection: Transverse Mercator
Datum: NZGD 2000

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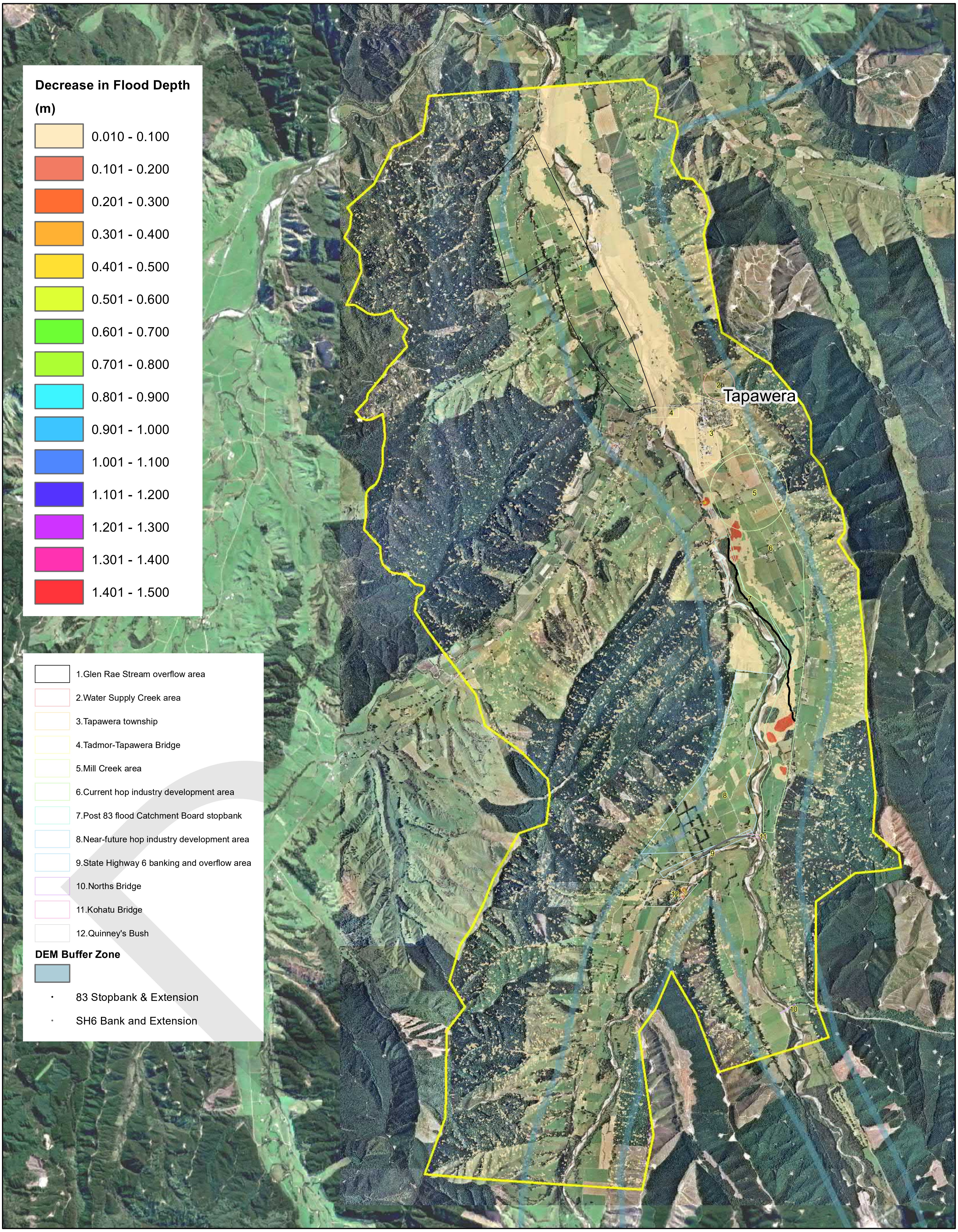
Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 19

Landuse Change Impact - Increase in Flood Depth From Future Landuse without Climate Change to Existing Landuse without Climate Change
1 in 250 AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_LanduseImpact_250y_v02.mxd



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Paper Size: A3

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Projection: Transverse Mercator
Datum: NZGD 2000

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Tasman District Council
Upper Motueka Flood Modelling

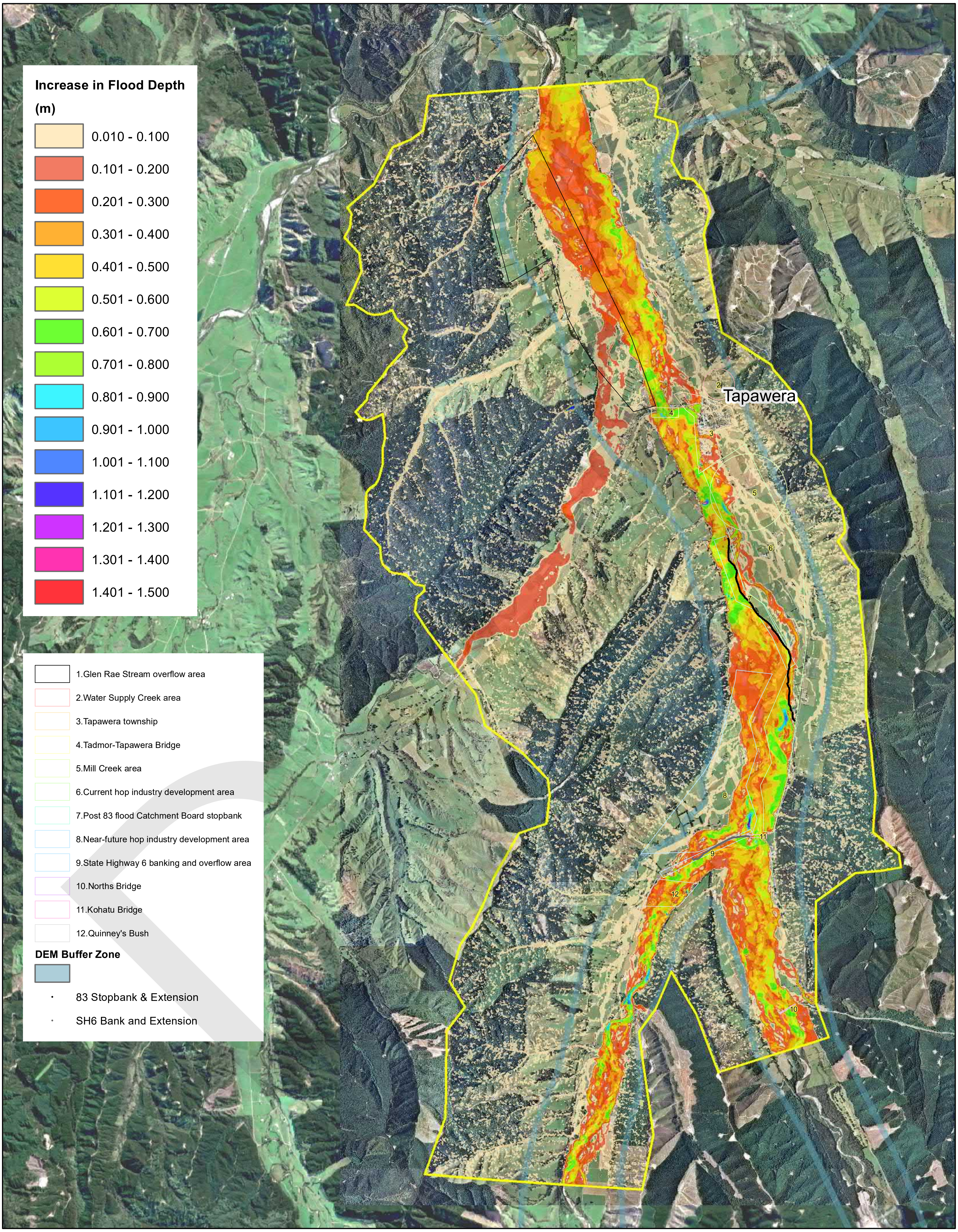
Job Number	20016
Revision	A
Date	2020 October 19

Landuse Change Impact - Decrease in Flood Depth From Future Landuse without Climate Change to Existing Landuse without Climate Change
1 in 250 AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_LanduseImpact_250y_Reducedv02.mxd

Upper Motueka River Model Development
Tasman District Council

APPENDIX I – Impacts of Climate Change



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Datum: NZGD 2000

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Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 19

Climate Change Impact - Increase in Flood Depth From Future Landuse with Climate Change to Future Landuse without Climate Change
5% AEP

Author: Ting Powell
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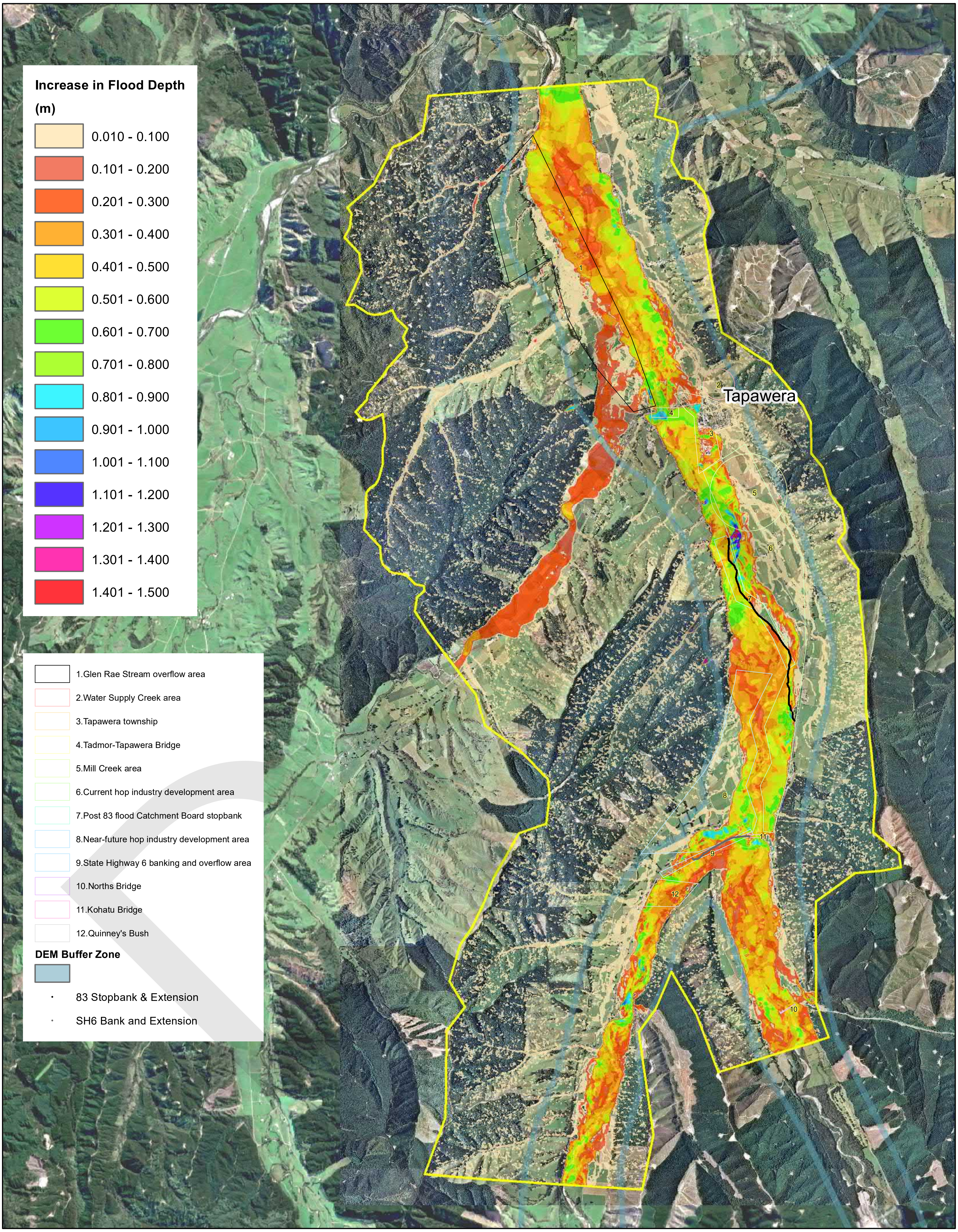

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Coordinate System: NZGD 2000 New Zealand Transverse Mercator
Projection: Transverse Mercator
Datum: NZGD 2000

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Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 19

Climate Change Impact - Increase in Flood Depth From Future Landuse with Climate Change to Future Landuse without Climate Change 2% AEP

Author: Ting Powell
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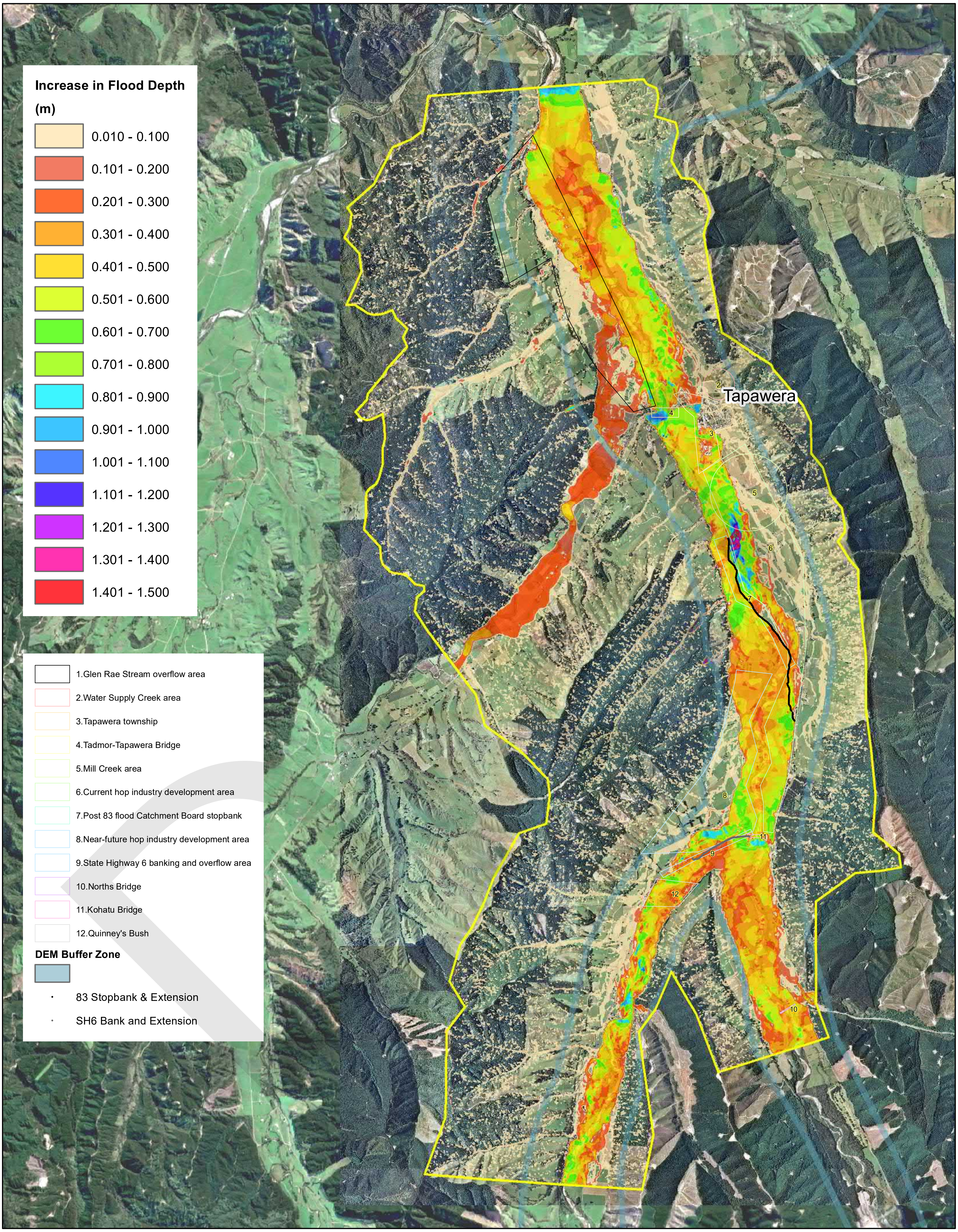

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Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 16

Climate Change Impact - Increase in Flood Depth From Future Landuse with Climate Change to Future Landuse without Climate Change 1% AEP

Author: Ting Powell
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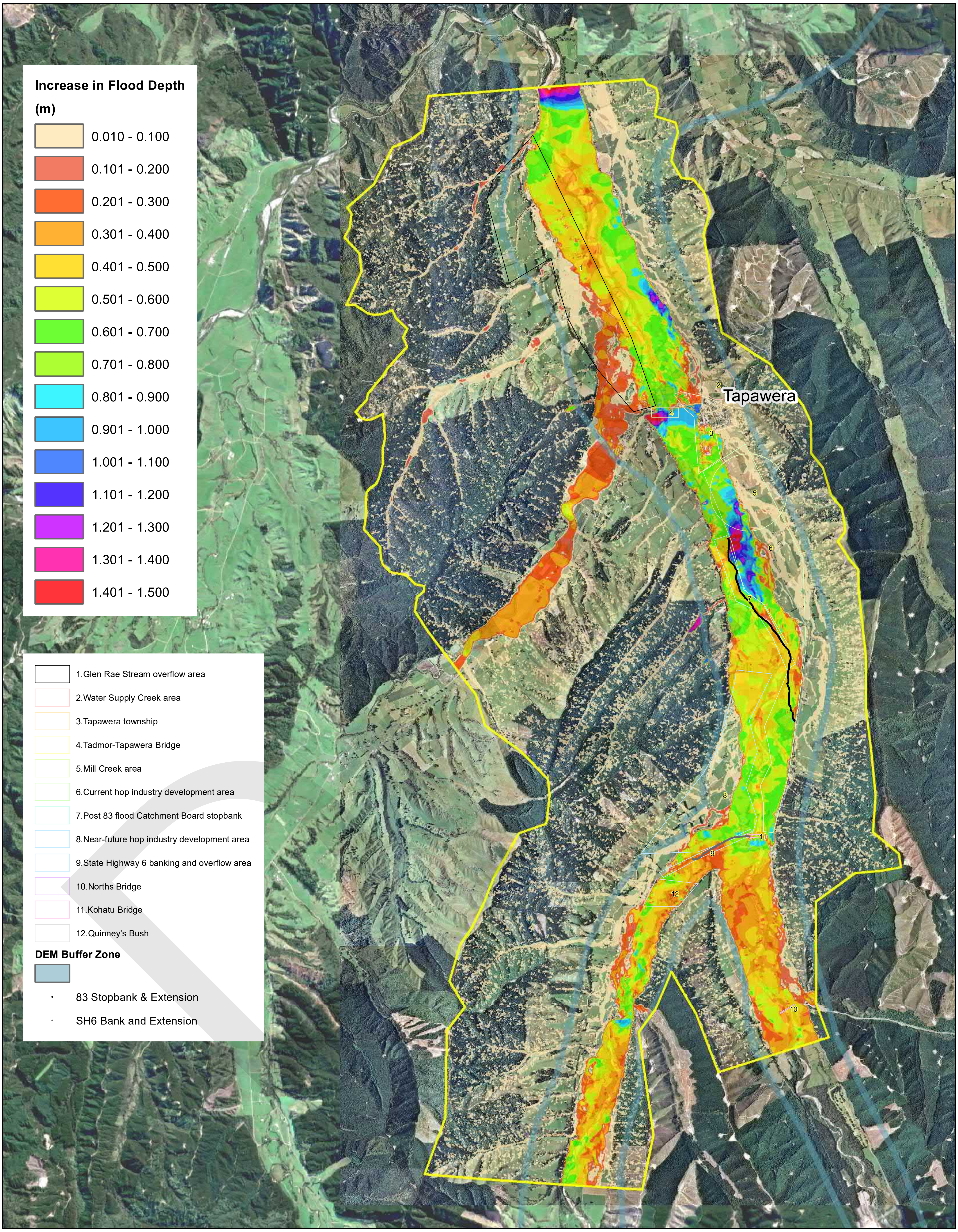

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Tasman District Council
Upper Motueka Flood Modelling

Job Number	20016
Revision	A
Date	2020 October 16

Climate Change Impact - Increase in Flood Depth From Future Landuse with Climate Change to Future Landuse without Climate Change
1 in 250 AEP

Author: Ting Powell
Document Path: M:\GIS\Projects\20016 TDC Upper Motueka Modelling GIS\rpt_20016 TDC Upper Motueka_ClimateImpact_250y.mxd

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