Appendix H: Stormwater Modelling Report

REPORT

Tonkin+Taylor

Pohara Stormwater Modelling

Drainage Network Improvement Options

Prepared for
Tasman District Council

Prepared by
Tonkin & Taylor Ltd

Date
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Job Number
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Exceptional thinking together

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16/09/2016	2	Second draft for TDC review	DNV
15/11/2016	3	Final version	DNV

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1 Introduction

This report presents a summary of flood modelling results for the Pohara Township, considering the existing situation and the impact of a proposed development. Results and conclusions are presented in the context of flood assessments carried out by Tasman District Council (TDC) over recent years.

1.1 Background – previous assessments

A summary timeline of flood assessments and relevant reports by TDC is set out below. Note that additional assessment has been carried out by private parties in support of various subdivision applications; the summary below focuses on assessment and reporting commissioned by TDC.

1 July 2009 – Pohara Subdivision Flooding Investigation (MWH)

Assessment and reporting following reports of flooding on farmland behind 734 to 762 Abel Tasman Drive;

2 June 2012 – Pohara Catchment Stormwater – Issues and Options Assessment (MWH)

Assessment and reporting following December 2011 storm event, focusing on issues relating to the capacity of the existing network and presenting a range of mitigation options that could be considered;

3 February 2014 - Ellis Creek Modelling – Model build and flood hazard mapping (T+T)

Detailed hydrological and hydraulic modelling of the Pohara catchments and floodplain, to assess the existing stormwater network for present day and future design storm events, allowing for the effects of climate change. The model was subsequently used to assess the existing network under a range of storm scenarios, and to undertake preliminary assessment of the effectiveness and impact of various possible flood mitigation measures.

1.2 Current assessment

In December 2015, following use of the model to assess a range of flood mitigation options, TDC refined the list of potential flood mitigation measures to be pursued further, and commissioned Tonkin & Taylor Ltd (T+T) to use the 2014 model to assess the effectiveness and impact of these various measures within the floodplain. TDC were interested in obtaining flood mapping that would help to prioritise flood mitigation measures, and enable discarding of any options that the model indicated would have a high cost benefit ratio. TDC are seeking a reduction in flood damages. A key objective for TDC for any mitigation measure is a reduction in the number of flooded floors and sections in design storm events.

Whereas previous modelling was focused on the future 2100 1% Annual Exceedance Probability (AEP) event, this current assessment considers both 10% and 1% AEP (1 in 10 year and 1 in 100 year) events, and both present day and 2100 planning horizons.

The reason for the two sets of modelling is to provide data to support primary flow level of service considerations (10% AEP) and resource consent considerations that are based on 1% AEP assessments.

2 Previous assessments

Over the last few years a range of potential flood mitigation measures have been assessed using the hydraulic model as the primary assessment tool. Modelling results have been presented in reports and/or meetings to TDC, and options discarded or refined after review of the modelled likely change to inundation extents and depths.

The findings of assessments made prior to T+T involvement are summarised as follows:

- Various network improvements options are presented in MWH 2009, with a view to reducing flooding of farmland behind properties at 734 to 762 Abel Tasman Drive. These include:
  - Improving drainage from this area towards the east by works on the channel and culverts;
  - Increasing the Abel Tasman Drive culvert (Bartlett Creek) and local bunding to allow flows to discharge west rather than ponding behind Abel Tasman drive properties;
  - Increase farm culvert sizes to limit outbreak flows.
- Recommendation for development of a strategy for flood mitigation on land currently zoned for residential development (MWH, 2009);
- The overall stormwater drainage network is constrained by the presence of foredunes to the north, the very flat nature of the floodplain, channel and culvert capacities within the floodplain, partial blockage of the beach outfall culvert to the east and tide level effects in the Motupipi estuary in the west (MWH, 2012);
- Given the experience of recent large storm events (e.g. December 2011 event) and more moderate events, more detailed modelling in order to allow a refined assessment of network capacity issues and development of flood mitigations is recommended. This would also allow consideration of the impact of any development and/or land use changes within the contributing catchments (MWH, 2012);

Following the acquisition of LiDAR and other ground survey data, T+T developed an uncalibrated hydrological and hydraulic model for use in the assessment of stormwater network performance. The December 2011 event was used as a basis for assessing the validity of the model results. The report detailed model build details and presented flood maps based on modelling of the existing drainage network. Modelling was undertaken for present day 5%, 2% and 1% AEP events. The modelling also considered the effect of 0.8 m sea level rise for a 1% AEP event (T+T 2014).

The T+T model was subsequently used to assess existing network performance for a range of storm scenarios:

- Specified flow events, including approximate "channel full" flow modelling to assess the impact of various improvement works on flow events not leading to floodplain storage;
- Rainfall events, including present day and future year 2100 rainfall;
- Tidal events, including sunny day tidal inundation and the impacts of anticipated sea level rise of up to 1 m by 2100;
- Full blockage of all culverts;
- Zero, partial and complete blockage of the existing sinkholes/tomos in Catchment F.

The T+T model was also used to assess the impact of various flood improvement measures, including:

a Increasing the size of Kohikiko Place culvert from the existing 25 mm diameter to a 750 mm diameter. This option serves to pass flows from west to east of Kohikiko Place more effectively, thereby reducing the peak flood depth and inundation duration west of Kohikiko Place, and increasing inundation in parts of the eastern floodplain;

b Installing a flapgate on the downstream end of the existing 1350 mm diameter Abel Tasman Drive culvert. This option is designed to prevent flooding from Ellis Creek west of SH60 from backing up through the existing culvert and into property east of SH60. Without the flapgate (as per the existing situation), modelling indicates that for certain flood levels this is likely;

c Increasing the floodplain width at the confluence of Clifton and Ellis Creeks (i.e. minor earthworks). A spur of an existing small ridge currently terminates close to the top of the existing bank, resulting in a relatively narrow floodway at this point. This could be widened, allowing flood flows to move westward more freely;

d Improving the capacity of the Boyle Street culvert. The existing culvert is a twin barrelled culvert, approximately 900-1000 mm diameter each. The modelling has assessed the case where these are replaced with a new 4 m wide by 2 m high culvert and local road raising (earlier modelling assessed culvert widths up to 10 m, but it was found that beyond a 4 m width there was very little change observed in modelled flooding. The existing Boyle Street embankment is approximately 300 mm higher than the top of the culverts, forming a heading area behind in which flood flows may be impounded during extreme events. The culvert is low-lying, and allows salt water to back up within the Bartlett Creek drain during high tide events;

e Removal of the Boyle Street Culvert and embankments. This option considered removal of the Boyle Street culverts and road embankment, such that flood flows could move freely into and out of the Motupipi Estuary. Costing of this option includes the construction of a new access to the Golf Course club house from Selwyn Street, along the foredunes;

f Bunding within RPH property along the northern edge of Bartlett Creek upstream of Abel Tasman Drive to reduce flooding of residential property east of Abel Tasman Drive. This option should be used in conjunction with local reprofiling of SH60 to ensure that flood water during extreme events is not able to flow along the road carriageway toward Totally Roasted Café and into other private property, but is directed into the western floodplain;

g Bunding behind properties at 1 to 7 Selwyn Street, to isolate selected Selwyn Street properties from the wider floodplain, and to prevent western flooding from circulating across Selwyn Street and into Totally Roasted and other Abel Tasman Drive properties. There is likely to the need for a flapgated outlet pipe to allow water impounded due to pluvial flooding with 1-7 Selwyn Street to discharge into the western floodplain;

h Bunding to isolate dwellings and garages within 59b and 59c Selwyn Street properties from the wider floodplain. Again, there is likely to the need for a flapgated outlet pipe to allow water impounded due to pluvial flooding with 59b and 59c Selwyn Street to discharge into the western floodplain;

i Diversion of catchment F into an existing flood detention dam and piping of flows from dam directly to coast. Modelling of this option did not result in significant change to flooding within catchment F, nor did it result in appreciable changes to flood levels in the floodplain below the existing detention dam. These results, combined with the high cost and potential consenting issues involved with piping to a coastal discharge point, resulted in this option being discarded. It was briefly considered whether instead of piping dam outflows to the coast, these outflows could be captured into a pipe through an intake where the gully opens out into the floodplain, immediately south-east of 16 Kohikiko Place. This would shorten the length of piping required, but may still encounter consenting difficulties, and for extreme year 2100 scenarios, modelling indicates only minimal changes to downstream flooding. This option has therefore not been pursued further at this stage;

j Diversion of catchment F into an existing flood detention dam and piping of flows from the dam to the top of eastern drain. Widening of eastern drain and Richmond Road and SH6 culverts (if necessary) to accommodate the additional flow (assuming maximum probable development (MPD) within the catchment). As per option (i) above, modelling of this option did not result in significant change to flooding within catchment F, nor did it result in appreciable benefits to flood levels in the floodplain below the existing detention dam. On the other hand, preliminary modelling of this option showed an increase in flooding around the eastern drain and Richmond Road. On this basis, this option was not pursued further;

k New flood retention dam above existing detention dam to assess the feasibility of retaining the excess runoff volume from fully-developed catchment with controlled release following recession of downstream inundation. Comprehensive modelling of this option indicated a reduction in peak flows out of Catchment E, but no appreciable change in modelled flood levels and extents in the downstream floodplain.

The above range of network improvement options were modelled for the 2100 10% and 1% AEP event, and flood maps and a table of resulting flood levels for residential properties prepared and presented to TDC for discussion. The preliminary results showed that some options reduced flood levels and extents, and a number of other options made very little or negligible impact on the extent and depth of modelled flooding within residential property during design flood events. These latter mitigation options were those involving diversion of flows from Catchment F into the dam, and establishment of a new flood retention dam above the existing dam. In addition, it was found that upgrade of the Boyle Street culvert to even a 10 m wide by 2 m high box culvert only resulted in local reductions in flood levels, and not to an extent that alleviated flooding near any existing dwellings. It was agreed that these options would not be pursued further for consideration in relation to consent planning.

The refined list of options to be modelled and assessed in terms of benefits and costs is discussed in the next section.

A log of modelled simulations is presented in Appendix O.

3 Current assessment

3.1 Model updates

Full model build details for the original modelling are set out in the 2014 T+T report. A schematic of the modelled catchments, including three new 'F' sub-catchments is presented in Figure 3.1 below.

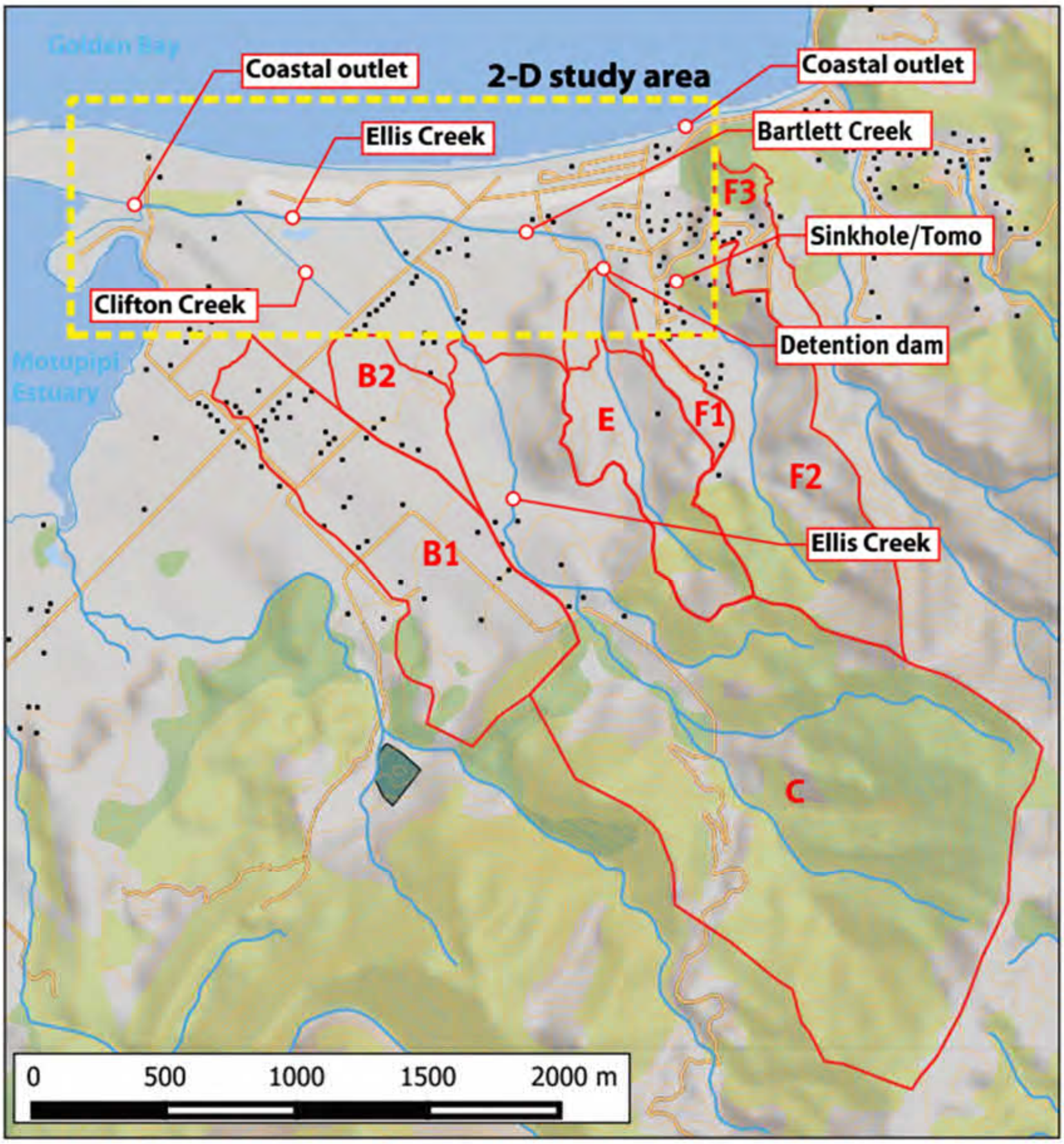

Figure 3.1: Study area extends from Motupipi Estuary to forested hill catchments. Catchment boundaries and labels shown in red.

As requested by TDC, the following changes have been made to the base (2014) model before using the model to assess mitigation options in the current assessment:

- Addition of Catchment F (split into three sub-catchments) to the east of Richmond Road, to enable assessment of flood depths within the residential area at the east end of the Pohara township;
- Present Day and Year 2100 design storms to be based on 10% and 1% annual exceedance probabilities (AEP);

- Design storms based on 12 hour duration with two-hour minimum duration storm nested within. This storm profile was adopted after sensitivity analysis on shorter and longer duration storms, and peakier storms (i.e. shorter duration storms nested within);
- Times of concentration have been adjusted to ensure that peak flows used in the modelling match reasonably well with peak flow estimates derived by other hydrological assessment approaches. Previously, times of concentration for sub-catchments were adopted by averaging estimates derived by a number of methods; a brief re-assessment of peak flow estimates indicates that the SCS method for time of concentration (as outlined in Auckland's TP108 guidelines) yields peak flow estimates that compare well with other methods. Hence, times of concentration for all sub-catchments are now based on this method;
- The Ellis Creek floodplain below Abel Tasman Drive (State Highway 60) has been selectively raised by 250 mm to account for siltation following the December 2011 storm event. The extent over which this is applied is based on aerial photography showing siltation after the event. The average siltation depth was supplied by TDC. We recommend that when updated LiDAR data becomes available, this data be used to update the modelled floodplain surface;
- The tidal boundary for both 10% and 1% AEP modelling now allows for 1 m sea level rise (SLR) between present day values and year 2100. The tidal boundary now oscillates sinusoidally up to a maximum value of RL 3.27 m (present day mean high water springs (MHWS) tide plus 1 m SLR);
- An existing sinkhole (tomo) above Bay Vista Drive below Catchment F2 was previously modelled as completely blocked. In the current modelling, unless specified otherwise, a tomo capacity up to 3 m^3/s has been adopted, as advised by TDC.

No changes were made to the channel cross sections or the floodplain topography, as no new survey data was available at the time of modelling.

3.2 Modelled drainage network improvement options

The refined range of scenarios and inundation mitigation options requested by RPH and TDC is presented in Table 3.1 below.

Table 3.1: Modelled option sets

Scenario	Description
Existing	Existing network (no network improvements, or "do nothing" option)
RPH	Proposed Richmond Pohara Holdings Ltd (RPH) development including the following catchment and network changes: • Stage 1 residential development (34 lots) within RPH land in Catchment E; • Use of an existing stormwater detention basin to attenuate flows during extreme rainfall events; • A stopbank along the northern (true right) bank of Bartlett Creek above Abel Tasman Drive (State Highway 60), and local road reprofiling. The purpose of this bund would be to prevent flows from Ellis Creek and Bartlett Creek (Catchments C and E) from contributing to inundation of Abel Tasman Drive properties eastward of (and including) Totally Roasted Café.
TDC Option Set 1	TDC improvements including; • Install flapgate on the 1350mm diameter Bartlett Creek culvert under Abel Tasman Drive; • Upgrade an existing culvert under Kohikiko Place to a 750 mm diameter culvert;

Scenario	Description
	• Confluence widening downstream of confluence of the farm drain; • A bund running along the back (south-west) boundaries of properties at 1, 3 and 7 Selwyn Street. Previously modelling indicated that during extreme events flows from the floodplain west of Abel Tasman Drive are able to flow through the property at 1 Selwyn Street and back across Abel Tasman Drive into the eastern floodplain. The model indicates that this backflow flowpath worsens flooding of Abel Tasman Drive properties. Therefore the purpose of this bund would be to cut off this flowpath; • A bund around two low lying properties at 59b and 59c Selwyn Street. The purpose of this bund would be to isolate the dwellings on these properties from the main floodplain during extreme events; • Boyle Street upgrade: Replace double culverts under Boyle Street with a 4 m wide by 2 m high box culvert.
TDC Option Set 2	As per Option Set 1 except: • Boyle Street upgrade: Remove double culverts and section of Boyle Street road embankment to allow “free flow” between floodplain and Motupipi Estuary and install alternate road access to golf clubhouse.
TDC Option Set 3	The following network improvement, considered in isolation of any other improvements: • Boyle Street upgrade: Remove double culverts and section of Boyle Street road embankment to allow “free flow” between floodplain and Motupipi Estuary and install alternate road access to golf clubhouse.
TDC Option Set 4	As per Option Set 1 with the additional improvement: • Combined with the proposed RPH bund along the northern (true right) bank of Bartlett Creek above Abel Tasman Drive (State Highway 60), and local road reprofiling.

These configurations have been run for each of the four design storm events (present day and year 2100 design horizons and 10% and 1% AEP storms at each horizon).

4 Model results

Flood depth maps were generated, showing the maximum flood depths across the floodplain, and differences between the “improved” and “existing” flooding maps. These flood maps are presented in Appendices B through G.

In order to illustrate (in spatial terms) the impact of each modelled network change, “difference maps” have also been prepared, presenting the change (±) in modelled flood levels using the “existing” scenario as the basis for comparison. These flood maps are presented in Appendices H through L.

Flood depth and difference maps are numbered as presented in Table 4.1 below.

Table 4.1: Modelled network upgrade options

Network scenario ID (appendix numbering)	Description	Design horizon	Design storm event (AEP)	Depth map figure	Difference map figure
B	Existing	Present day	10%	B1	n/a
			1%	B2	n/a
		Year 2100	10%	B3	n/a
			1%	B4	n/a
C	Proposed RPH development (Stage 1 development (34 lots), Bartlett Creek bund)	Present day	10%	C1	H1
			1%	C2	H2
		Year 2100	10%	C3	H3
			1%	C4	H4
D	TDC network improvement Option Set 1, with box culvert upgrade option for Boyle Street culvert	Present day	10%	D1	I1
			1%	D2	I2
		Year 2100	10%	D3	I3
			1%	D4	I4
E	TDC network improvement Option Set 2, with removal of Boyle Street culvert and lowering of local road embankment	Present day	10%	E1	J1
			1%	E2	J2
		Year 2100	10%	E3	J3
			1%	E4	J4
F	TDC network improvement Option Set 3, removal of Boyle Street culvert only	Present day	10%	F1	K1
			1%	F2	K2
		Year 2100	10%	F3	K3
			1%	F4	K4
G	TDC network improvement Option Set 4, as per Option 1 but in combination with RPH Bartlett Bund	Present day	10%	G1	L1
			1%	G2	L2
		Year 2100	10%	G3	L3
			1%	G4	L4

In addition to these flood depth maps, a GIS exercise was undertaken to determine the impact that any mitigation measure (or combination of measures) was modelled to have to number of flooded floor levels and number of flooded properties. The analysis of flooded floor levels was necessarily limited to those properties for which surveyed floor levels exist in the TDC database. The assessment of flooded properties considered properties with flooding of greater than 20 % of the total property area flooded to a depth greater than 50 mm.

5 Assessment of benefits and costs

In order to assess whether a particular flood mitigation option has merit, it must be demonstrated that the cost of implementing that option is at the very least offset by a reduction in recovery and reinstatement costs, i.e. that over the expected lifetime of the proposed mitigation option, the cost per benefit ratio (CBR) exceeds an adopted minimum threshold (usually at least 1.0). Putting aside non-cost drivers, a particular option may be preferred over others when it is demonstrated to have a lower cost per benefit ratio.

TDC have established a stormwater project prioritisation system to assist in decision making with respect to stormwater network upgrades. The system is based on a benefit valuing (scoring) system as presented in Table 5.1.

Table 5.1: TDC benefit-valuing scorecard

Benefit	Score	Unit
Reduction in number of flooded sections	1	per section
Reduction in number of floors flooded once	5	per floor
Reduction in number of floors flooded more than once	10	per floor
Increase in number of "growth sections"[1]	3	per section

[1] Previously undevelopable sections now able to be developed due to mitigation of flooding – at TDC request, not considered in current assessment

It is noted that the scoring system does not take into consideration any change (increase or decrease) in flooding that does not meet the criteria in Table 5.1. For example, bunding on the north bank of Bartlett Creek may divert catchment to the western floodplain, but this effect does not affect the scoring system unless it results in an increase in the number of flooded sections and/or floors in the western floodplain.

In the absence of a database of flood damages associated with historic flood events, TDC have requested modification of the scorecard. In the scorecard above, modelling results are compared with historic flood data (i.e. flooded floors and sections, and whether floors have been flooded once or more than once in the past). In the modified scorecard, flood modelling results are compared to the modelled "existing" case, and the "flooded more than once" scoring category is ignored.

Floor level survey data has been provided by TDC for properties where data is available. A spreadsheet detailing the floors expected to be flooded for each modelled event in the existing situation, and the reduction in flooded floors expected for each improvement option is presented in Appendix M.

5.1 Cost/benefit analysis

The tables below present a summary of the costs and benefits associated with each modelled option, for each of the four design events (present day and year 2100 design horizons and 10% and 1% AEP storms at each horizon).

Rough order costs for each network improvement option have been developed assuming cut to waste and borrow to fill for all earthworks, and rates are based on recent experience in the Nelson/Tasman regions. Costs are indicative only, but considered suitable for the purpose of options comparison. Cost schedules for each option are included in Appendix N.

Table 5.2: Flood mitigation option prioritisation – 10 year (present day)

Option Set	Cost ($000)	Reduction in no. sections flooded	Scoring multiplier	Reduction in no. floors flooded	Scoring multiplier	Total benefit	Cost/benefit	Priority
RPH	107	0	1	1	5	5	$21,400	3
TDC 1	125	2	1	1	5	7	$17,857	2
TDC 2	219	2	1	1	5	7	$31,286	4
TDC 3	206	2	1	0	5	2	$103,000	5
TDC 4	146	8	1	2	5	18	$8,111	1

Table 5.3: Flood mitigation option prioritisation - 100 year (present day)

Option	Cost ($000)	Reduction in no. sections flooded	Scoring multiplier	Reduction in no. floors flooded	Scoring multiplier	Total benefit	Cost/benefit	Priority
RPH	107	22	1	6	5	52	$2,058	2
TDC 1	125	7	1	2	5	17	$7,353	3
TDC 2	219	7	1	2	5	17	$12,882	4
TDC 3	206	0	1	0	5	0		5
TDC 4	146	32	1	9	5	77	$1,896	1

Table 5.4: Flood mitigation option prioritisation – 10 year (Year 2100)

Option	Cost ($000)	Reduction in no. sections flooded	Scoring multiplier	Reduction in no. floors flooded	Scoring multiplier	Total benefit	Cost/benefit	Priority
RPH	107	14	1	5	5	39	$2,744	1
TDC 1	125	5	1	3	5	20	$6,250	3
TDC 2	219	3	1	3	5	18	$12,167	4
TDC 3	206	0	1	0	5	0		5
TDC 4	146	19	1	6	5	49	$2,980	2

Table 5.5: Flood mitigation option prioritisation - 100 year (Year 2100)

Option	Cost ($000)	Reduction in no. sections flooded	Scoring multiplier	Reduction in no. floors flooded	Scoring multiplier	Total benefit	Cost/benefit	Priority
RPH	107	16	1	4	5	36	$2,972	2
TDC 1	125	2	1	0	5	2	$62,500	3
TDC 2	219	2	1	0	5	2	$109,500	5
TDC 3	206	2	1	0	5	2	$103,000	4
TDC 4	146	25	1	11	5	80	$1,825	1

6 Conclusions and recommendations

Scope for improving the long term flood vulnerability of land within the Pohara floodplain is limited by topography, tidal influence and the adverse effects of anticipated climate change on rainfall and sea level over the next 100 years. Nevertheless, there are network drainage improvements that can be made that have a low cost to benefit ratio. These improvements are shown by the modelling to reduce anticipated damages in terms of flooding impacts in 10% and 1% AEP flood events between present day and 2100.

Modelling of Option Sets and assessing benefits using the TDC scoring system indicates that selection of the "best" Option Set is largely independent of which design storm event is being considered, as shown in the tables in Section 5.

The ranking of options under the TDC scoring system is as follows (in order of lowest to highest cost to benefit ratio – i.e. from most cost-effective to least):

1. TDC improvement option 4 / RPH improvement option
2. TDC improvement option 1
3. TDC improvement option 2
4. TDC improvement option 3

We note that the TDC scoring system does not differentiate between a large rural section and a smaller residential section, and that if this was considered, the scores may change. For example, the Boyle Street embankment removal, resulting in a reduction of two flooded rural sections, scores well due to its relatively low cost. However, there may be little reduction in actual damages associated with increased flooding in these two rural sections.

The drainage network improvement delivering the greatest effect on floodplain flood levels is the construction of a new stopbank along the northern (true right) bank of Bartlett Creek upstream of Abel Tasman Drive. This option, proposed by RPH as part of their Stage 1 development, serves to divert catchment runoff from the Ellis Creek and Bartlett Creek catchments towards the west, and significantly reduces flood depths within residential property in the floodplain east of Abel Tasman Drive. There is a corresponding increase in modelled flood depths in the floodplain west of Abel Tasman Drive, resulting in increased flood depths on farmland but no increase in the number of flooded sections or building floors. Thus, while the additional development within Catchment E would result in greater total volume of runoff, the Bartlett Creek stopbank proposed as part of Stage 1 development would mean that the net effect of allowing this development within Catchment E would be to reduce flooding in Abel Tasman Drive properties to the east of Abel Tasman Drive. This is shown clearly in the attached difference maps (refer Appendix H).

It is noted that the modelling detailed in this report assumes that the peak flows during a heavy rainfall event coincide with a high tide. This is a sensible and commonly used assumption, as extreme flows are likely to have durations long enough that coincidence with a high tide is more than a remote possibility. However, it is noted that in any particular real-world event, the peak runoff may coincide with (say) a mid or low tide. In such events, the effect of implementing an option like the Boyle Street culvert, which is influenced to a large degree by tidal levels, may be greater than that modelled to date.

Once preferred mitigation options are identified, it is recommended that the model be used to confirm detailed design arrangements. This is particularly important with respect to confirming the height and extent of any new stopbanks.

7 Applicability

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

Tonkin & Taylor Ltd

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DNV
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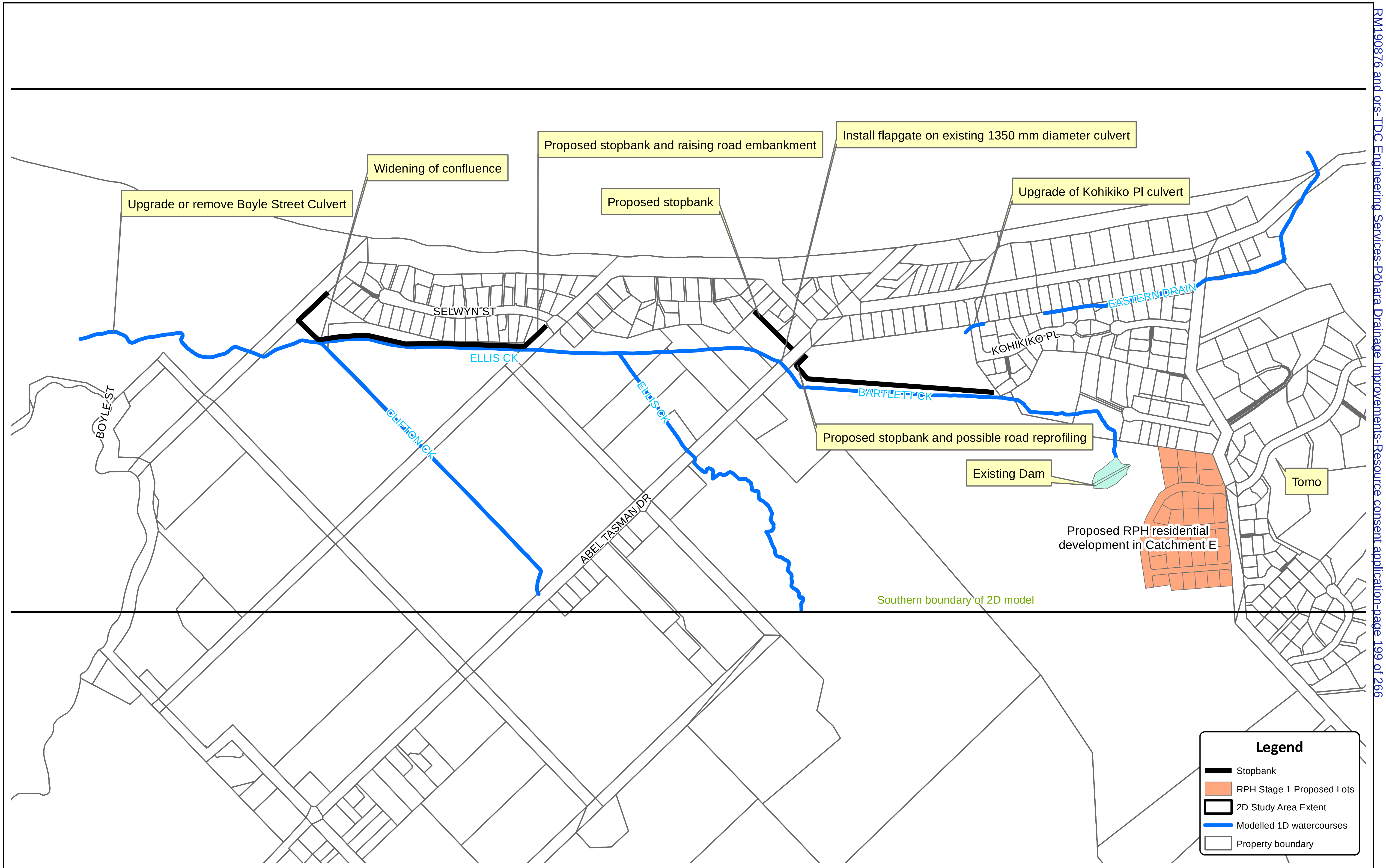
Appendix A: Improvement Option Location Map

- Figure A – Model Schematisation and Modelling Improvements



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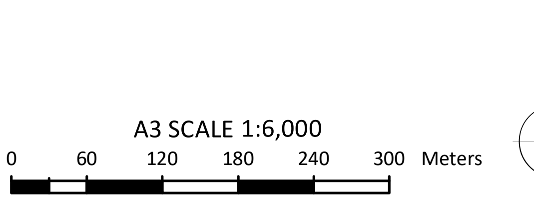

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TASMAN DISTRICT COUNCIL
POHARA STORMWATER OPTIONS ASSESSMENT

Model Schematisation and Modelled Improvements

FIGURE No. Figure A
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