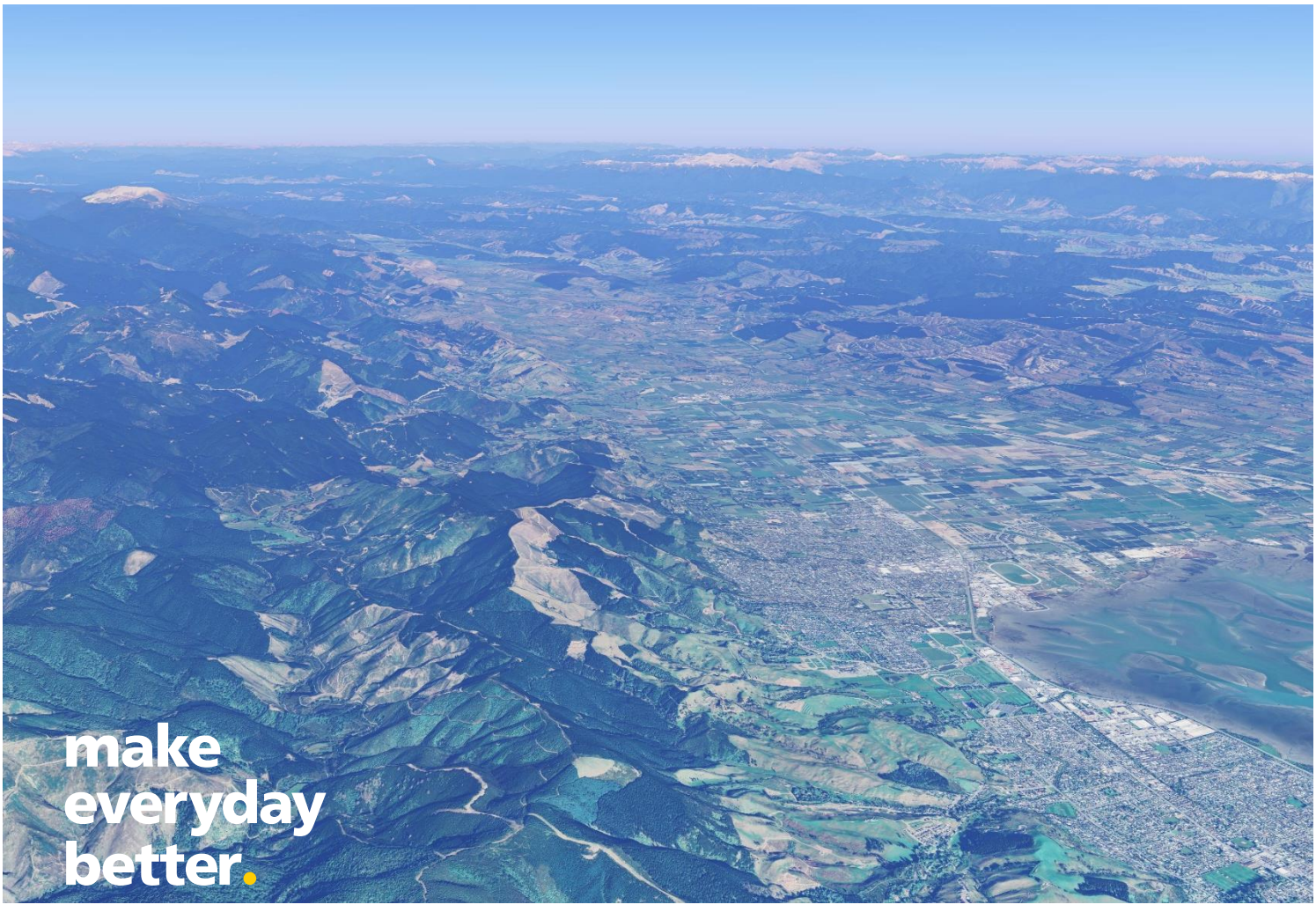
Review of Active Earthquake Faults in the Tasman District – Methodology Report

Prepared for Tasman District Council
Prepared by Beca Limited

15 November 2021



Revision History

Revision Nº	Prepared By	Description	Date
1	Dan Chamberose	DRAFT for client comment	3 September 2021
2	Dan Chamberose	Revision with changes requested by client	28 October 2021
3	Dan Chamberose	Final	15 November 2021

Document Acceptance

Action	Name	Signed	Date
Prepared by	Dan Chamberose, Paul Wopereis and Sarah Barrett		15 November 2021
Reviewed by	Paul Horrey		15 November 2021
Approved by	Paul Horrey		15 November 2021
on behalf of	Beca Limited		

Contents

Appendices

1 Introduction

Beca Ltd has been commissioned by the Tasman District Council (TDC) to develop a methodology that identifies active faults in the Tasman District which warrant consideration in the Tasman Environment Plan (TEP). This report covers the following aspects as outlined in the Project Agreement dated 15 July 2021:

- Identify all known onshore active faults in the district and summarise available information on rupture recurrence interval (desktop analysis). This is to include those active faults that are mapped in the Tasman Resource Management Plan (TRMP) as Fault Rupture Risk Areas (Waimea-Flaxmore, Wairau/Alpine, White Creek, Lyell); and other active fault lines including the Eighty-Eight and Kikiwa Faults. It should also comment on any other prominent but less active faults such as Ruby Bay, Pikikiruna and other faults in the northwest of the district (such as Wakamarama Fault).
- Set out a methodology to identify a threshold (based on rupture recurrence interval) to identify which faults should be included in the TEP for the purpose of planning controls. The methodology should be based on state of practice guidance, for example Ministry for Environment's (MfE) 'Planning for Development of Land on or Close to Active Faults' (Kerr et al. 2003).
- Using the methodology, the report will identify those faults within the district which should, or should not, be included within the TEP for the purpose of planning controls, including a short explanation for the rationale.

2 Review of existing data sources

There are a number of active, and many inactive, faults in Tasman District. The location, status (active or inactive) and recurrence interval of these faults are presented in various geospatial datasets, regional maps, and published reports.

Our review considered the following datasets in order to identify 'active' and potentially active (capable) faults in Tasman District. 'Active' faults are defined in New Zealand as faults with evidence for ground surface displacement and/or deformation in the past 125,000 years. 'Capable' faults are those that are considered to have the potential to be seismogenic (i.e., causing earthquakes).

2.1.1 New Zealand Active Fault Database

The New Zealand Active Faults Database (https://data.gns.cri.nz/af/; NZAFD, 2020) outlines the locations, recurrence interval, and expected earthquake magnitude of known active onshore faults in New Zealand. The database was produced by GNS Science and includes data from the latest published maps as compiled at a scale of 1:250,000. The assigned recurrence interval represents the last time the fault ruptured the ground surface based on mapped surface geology and/or the average time between ground surface ruptures inferred from paleo-seismic studies. Faults are assigned the recurrence interval classes listed in Table 2-1.

Table 2-1: Active Fault recurrence interval classes as identified in the NZAFD.

Recurrence interval class	Average fault recurrence interval of surface rupture
I	≤2000 years
II	>2000 years to ≤3500 years
III	>3500 years to ≤5000 years
IV	>5000 years to ≤10,000 years
V	>10,000 years to ≤20,000 years
VI	>20,000 years to ≤125,000 years

2.1.2 New Zealand Community Fault Model

The New Zealand Community Fault Model (NZCFM) will be a new 3D model of active and capable faults in New Zealand and is due for public release in late 2021. An overview of the NZCFM is presented in van Dissen et al. (2021).

The NZCFM will include the most recent data on active and capable faults that has been developed from a review of the previous New Zealand Active Faults Database, published literature and geologic maps, and local working groups facilitated by GNS Science. The model defines 'Capable' faults as those not proven to be 'active', however are '*considered potentially capable of being seismogenic'* (i.e., active) based on the following four favourable factors:

- the orientation of a fault aligns with current stress field.
- there is geomorphic expression of the fault in surface topography.
- similarity of the fault with nearby faults that are known to be active.
- the proximity of the fault to historical moderate to large earthquakes epicentres.

2.1.3 Published regional and local geologic maps

Geologic maps outline the locations of mapped faults and include surface features that identify whether the fault warrants consideration as 'active'. Local maps include more detail on the mapped geology than regional maps as they are produced at a finer resolution. The following regional and local maps were reviewed to identify if any local faults, not included in the New Zealand datasets, warranted consideration in the TEP.

- 1:250,000 Geology of the Nelson Area (QMap) (Rattenbury et al., 1998)
- 1:31,250 revised Nelson Geology Map (Johnston, Ghisetti & Wopereis, 2021)
- 1:25,000 Geology of the St Arnaud district (Johnston, 1990)
- 1:63,360 scale map of Takaka (Grindley, 1971).

2.1.4 Published paleo-seismic studies

Published paleo-seismic studies provide more detail on the recurrence intervals of specific active faults from site-specific fault trenching and dating techniques. Specific studies included in our review include:

- Berryman (1980): 'Late Quaternary movement on White Creek Fault, South Island, New Zealand'
- Fraser (2005): 'Paleoseismic Investigation of the Waimea - Flaxmore Fault System'
- Johnston and Nicol (2013): 'Assessment of the location and paleo-earthquake history of the Waimea-Flaxmore Fault System in the Nelson-Richmond area with recommendations to mitigate the hazard arising from fault rupture of the ground surface'
- Ghisetti, Johnston, and Wopereis (2019): 'Structural evolution of the active Waimea-Flaxmore Fault System in the Nelson-Richmond urban area, South Island, New Zealand'
- Ghisetti, Johnston, Wopereis, and Sibson (2018): 'Structural and morpho-tectonic evidence of Quaternary faulting within the Moutere Depression, South Island, New Zealand'
- Nicol, and van Dissen (2018): 'A 6000-year record of surface rupturing paleo-earthquakes of the Wairau Fault'

3 Guidance on development adjacent to faults

The MfE "'Planning for development of land on or close to active faults" guidelines (MfE, 2003) presents a risk-based approach for land-use planning on and near active onshore faults in accordance with the risk management standard AS/NZS 4360:1999. The guidance considers the fault recurrence interval, as identified in the NZAFD, along with fault complexity, and the building importance category (BIC) of the proposed structure to establish whether the risk of damage is 'sufficiently low to be generally accepted in land use planning'. Separate approaches are provided for greenfield and previously developed sites. These approaches do not guarantee that the building will not suffer damage from fault rupture.

The guidance provides recommendations on the Building Importance Categories that are considered 'allowable' based on the fault recurrence interval class (see Table 3-1). Separate recommendations are provided for previously subdivided or developed sites and greenfield sites. 'Allowable' buildings are those where the level of risk is considered ''sufficiently low to be generally accepted in land use planning'. Descriptions of the structures under each Building Importance Categories are listed in Table 3-2.

Table 3-1 indicates that structures with post-disaster function (BIC 4) are not considered 'allowable' when associated with faults with a recurrence interval of V or greater. 'Normal structures' (BIC 2b) are not considered 'allowable' where the fault with recurrence intervals less than IV. The limitations recommended by the guidance are intended to be applied to a set-back or buffer zone around active faults which is to be defined by the regional authority (i.e., TDC).

Table 3-1: Relationship between fault recurrence interval and allowable building importance categories as per MfE (2003)

Recurrence interval class	Fault recurrence interval	Building importance category (BIC) limitations* (allowable buildings)	
		Previously subdivided or developed sites	"Greenfield" sites
I	≤2000 years	BIC 1	BIC 1
II	>2000 years to ≤3500 years	BIC 1 and 2a	
III	>3500 years to ≤5000 years	BIC 1, 2a and 2b	BIC 1 and 2a
IV	>5000 years to ≤10,000 years	BIC 1, 2a, 2b and 3	BIC 1, 2a, and 2b
V	>10,000 years to ≤20,000 years		BIC 1, 2a, 2b and 3
VI	>20,000 years to ≤125,000 years	BI Category 1, 2a, 2b, 3 and 4	

Table 3-2: Building Importance Categories: a modified version of New Zealand Loading Standard classifications as per MfE (2003)

Building Importance Category	Description	Examples
1	**Temporary structures** with low hazard to life and other property	• Structures with a floor area of <30m^2 • Farm buildings, fences • Towers in rural situations
2a	**Timber-framed** residential construction	• Timber framed single-story dwellings
2b	**Normal structures** and structures not in other categories	• Timber framed houses with area >300 m^2 • Houses outside the scope of NZS 3604 "Timber Framed Buildings" • Multi-occupancy residential, commercial, and industrial buildings accommodating <5000 people and <10,000 m^2 • Public assembly buildings, theatres and cinemas <1000 m^2 • Car parking buildings
3	**Important structures** that may contain people in crowds or contents of high value to the community or pose risks to people in crowds	• Emergency medical and other emergency facilities not designated as critical post disaster facilities • Airport terminals, principal railway stations, schools • Structures accommodating >5000 people • Public assembly buildings >1000 m^2 • Covered malls >10,000 m^2 • Museums and art galleries >1000 m^2 • Municipal buildings • Grandstands >10,000 people • Service stations • Chemical storage facilities >500m^2
4	**Critical structures** with special post disaster functions	• Major infrastructure facilities • Air traffic control installations • Designated civilian emergency centres, medical emergency facilities, emergency vehicle garages, fire and police stations

4 Identification of faults warranting inclusion in TEP

Our review of available datasets and relevant guidance (MfE, 2003) indicates that mapped ‘active’ and ‘capable’ onshore faults in the Tasman District that meet any of the criteria outlined below warrant inclusion in the TEP with associated planning controls.

1. Faults with an assigned recurrence interval class of V or less in the NZAFD, in which recommendations on the allowable BIC are applied.
2. Faults that show evidence of existing ground surface deformation based on published literature, local geologic maps, and/or local knowledge. The presence of existing surface deformation provides evidence of previous fault movement and suggests that the fault may be active.
3. Faults identified as ‘Active’ or ‘Capable’ in the NZCFM with an assigned recurrence interval class of V or less (to be reassessed once the NZCFM is publicly released).

Active faults were identified in the Tasman Region from a review of the NZAFD and published reports. This list may wish to be updated when the NZCFM is publicly released. The assigned recurrence interval class and recommendations on whether the fault warrants inclusion in the TEP based on Criteria 1-2 are listed in Table 4-1 and shown in Appendix A. Offshore faults were not considered in our review which includes the offshore sections of those faults listed in Table 4-1, along with the Kahurangi, Farewell and Kongahau Faults.

Table 4-1: Summary of Active and Capable faults identified in the Tasman Region from the NZAFD and published literature and recommendations for inclusion in the TEP

Fault Name	Fault Status	Last Earthquake (years before present)	Recurrence Interval (Years)	Recurrence Interval Class	Evidence of ground surface deformation due to fault movement	Data Source for Recurrence Interval	Included in TRMP FRRA[1]	Recommended for inclusion in TEP according to Criteria 1, 2, 3
Waimea Central Fault	Active	5,600	5,000 -10,000	IV	Yes	Fraser, 2005 (fault trenching at Heslington Road, Brightwater)	Yes	Yes (Criteria 1, 2, and 3)
Waimea South Fault	Active	1,000	3,500 - 5,000	III	Yes	Nicol pers. comm. (fault trenching at Motueka River Gorge)	Yes	Yes (Criteria 1, 2, and 3)
Eighty-Eight Fault	Active	Unknown	3,500 - 5,000	III	Yes	NZAFD (mapped fault scarp above Hart Road, Richmond)	Yes	Yes (Criteria 1 and 2)
Whangamoa Fault	Active	Unknown	5,000 -10,000	IV	Yes	NZAFD, fault scarp mapping and trenching at Whangamoa Valley, fault scarp at Beeby Range, Johnston 1990)	No	Yes (Criteria 1,2, and 3)
White Creek Fault[2]	Active	92	10,000–20,000	V	Yes	NZAFD, Berryman 1980	Yes	Yes (Criteria 1,2, and 3)
Lyell Fault	Active	Unknown	5,000 -10,000	IV	Yes	NZAFD (fault scrap at Lyell Terrace offsets last glaciation outwash terrace)	Yes	Yes (Criteria 1,2, and 3)
Kikiwa Fault	Active	Unknown	10,000–20,000	V	Yes	Johnston, 1990 (scarp at Kikiwa offsets glacial outwash surface)	No	Yes (Criteria 1 and 2)

Fault Name		Last Earthquake Event (years before present)	Recurrence Interval (Years)	Recurrence Interval Class	Evidence of ground surface deformation due to fault movement	Data Source for Recurrence Interval	Included in TRMP FRRA[1]	Recommended for inclusion in TEP according to Criteria 1, 2, 3
Wairau	Active	Unknown	<2,000	I	Yes	Nicol et al. (2011)	Yes	Yes (Criteria 1 and 2)
Ruby Bay-Moutere Fault (extends south into Tutaki Fault and north into the Surville Fault)[3]	Active	Unknown	Unknown	VI	No	NZCFM and Ghisetti et al, 2018 (Ruby Bay-Moutere Fault does not appear to reach ground surface)	No	No (Does not meet Criteria 1, 2, or 3)
Pikikiruna Fault[3]	Capable	Unknown	Unknown	VI	Yes	Grindley, 1971 Rattenbury et al. (1998); Ghisetti and Sibson (2001)	No	No[3]
Wakamarama Fault[3,4]	Active	153	Unknown	V or VI	Yes	NZCFM Rattenbury et al. (1998)	No	Yes (Criteria 1,2, and 3)[3]
Alpine (Springs to Tophouse)	Active	1,750 - 970	1,000	I	Yes	Nicol and van Dissen,)2018)	Yes	Yes (Criteria 1,2, and 3)

[1] Fault Rupture Risk Areas (FFRA) included in the Tasman Resource Management Plan (TRMP).

[2]White Creek Fault ruptured in 1929 Murchison Earthquake M 7.8 with vertical offset 4.5m.

[3] Offshore section does not warrant consideration in TEP

[4] 1868 Cape Farewell M 7.0 earthquake ruptured ground near Puponga in vicinity of Wakamarama Fault.

NZAFD = NZ Active Faults Database (GNS Science).

NZCFM = NZ Community Fault Model, version 0.9 (Draft; van Dissen et al., 2021)

4.1 Consideration of other mapped faults

Faults listed in the NZAFD that do not meet the above criteria do not have sufficient evidence of activity to warrant consideration in the TEP. This includes faults where the recurrence interval class is 'VI' or greater and/or faults that do not exhibit evidence for existing ground surface deformation such as the Ruby Bay-Moutere Fault. TDC may consider identifying these other mapped faults for information only and/ or implement a different set of planning rules near these faults, such as restricting BIC 4 structures.

Buried faults and/ or areas where the fault location is poorly defined do not warrant inclusion in the TEP due to uncertainty in the fault location. TDC may consider applying a buffer zone around these faults and/or including these faults in a new 'fault awareness zone' such as that outlined by Barrell et al. (2015). Planning rule requirements in these areas may be reduced compared to areas where faults are well-defined.

5 Conclusions and Recommendations

We conclude that the existing faults within the FRRA being the Waimea, Eight-Eight, Wairau-Alpine, White Creek and Lyell should remain within the TEP.

In addition, we recommend that the Whangamoa, Wakamarama and Kikiwa faults be added to the TEP (Note: the Whangamoa and Kikiwa Faults are recognised as active faults in the NZAFD).

6 Assumptions of Assessment

The data used in this report are sourced from the published maps, published reports, and fault models listed in Section 2. Our assessment considered the draft version of the NZCFM (version 0.9) and our recommendations are based on the fault status listed in this version. Any updates to the final model may change the conclusions of our assessments.

There are some areas where the fault recurrence interval is unknown as no detailed fault studies have been completed on that fault. The recurrence intervals of these faults are listed as 'unknown' in Table 4-1.

7 Applicability

This report has been prepared by Beca on the specific instructions of our Client. It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Any use or reliance by any person contrary to the above, to which Beca has not given its prior written consent, is at that person's own risk.

Should you be in any doubt as to the applicability of this report and/or its recommendations for the proposed development as described herein, and/or encounter materials on site that differ from those described herein, it is essential that you discuss these issues with the authors before proceeding with any work based on this document.

8 References

Barrell D. J. A., Jack H., Gadsby M., 2015. Guidelines for using regional-scale earthquake fault information in Canterbury. *GNS Science consultancy report; 2014/211, 30p*, GNS Science, Lower Hutt, New Zealand.

Berryman, K. R., 1980. Late Quaternary movement on White Creek Fault, South Island, New Zealand*. New Zealand Journal of Geology and Geophysics*, 23(1): 93-101.

Fraser, J., 2005. *A Paleoseismic Investigation of the Waimea - Flaxmore Fault System, Nelson Region*. M.Sc. Thesis, University of Canterbury, Christchurch, New Zealand.

Ghisetti, F. C., Johnston M. R., Wopereis, P. & Sibson, R.H., 2018. Structural and morpho-tectonic evidence of Quaternary faulting within the Moutere Depression, South Island, *New Zealand, New Zealand Journal of Geology and Geophysics* 61(4): 461-479.

Ghisetti, F. C., Johnston M. R. & Wopereis, P. 2019. Structural evolution of the active Waimea-Flaxmore Fault System in the Nelson-Richmond urban area, South Island, New Zealand*, New Zealand Journal of Geology and Geophysics*, 63(2): 168-189.

Grindley, G.W., 1971. Sh*eet S8 Takaka.* Geological Map of New Zealand 1:63 360. New Zealand Department of Scientific and Industrial Research, Wellington, New Zealand

Johnston, M. R. 1990. *Geology of the St Arnaud District, Southeast Nelson* (*Sheet N29),* NZ Geological Survey Bulletin 99 (including geological map 1:50,000 scale), Lower Hutt, New Zealand.

Johnston, M. R and Nicol, A. 2013. Assessment of the location and paleoearthquake history of the Waimea-Flaxmore Fault System in the Nelson-Richmond area with recommendations to mitigate the hazard arising from fault rupture of the ground surface. *GNS Science Consultancy Report 2013/186*, Lower Hutt.

Johnston M. R., Ghisetti, F. C. & Wopereis, P. 2021. Revised Geological Map of the Nelson-Richmond Urban Area, https://nelson-richmond-geolmap.github.io/RGMap/, Accessed 15/02/2021.

Kerr, J., Nathan, S., Van Dissen, R., Webb, P., Brunsdon, D and King, A. 2003. Planning for Development of Land on or close to Active Faults. *Report prepared for the Ministry for the Environment by the Institute of Geological & Nuclear Sciences*. Institute of Geological & Nuclear Sciences Client report 2002/124 440W103301, GNS Science, Lower Hutt, New Zealand.

New Zealand Active Faults Database (NZAFD). 2020. https://data.gns.cri.nz/af/. Last accessed 29/07/2021.

Nicol, A., Van Dissen, R. 2018. A 6000-year record of surface rupturing paleo-earthquakes of the Wairau Fault, New Zealand. *New Zealand Journal of Geology and Geophysics*, 61(3): 341-358.

Rattenbury, M.S.; Cooper, R.A.; Johnston, M.R. (compilers) 1998. Geology of the Nelson area: scale 1:250,000. Lower Hutt: Institute of Geological & Nuclear Sciences Limited. Institute of Geological & Nuclear Sciences 1:250,000 geological map 9. 67 p. + 1 folded map. Lower Hutt, New Zealand.

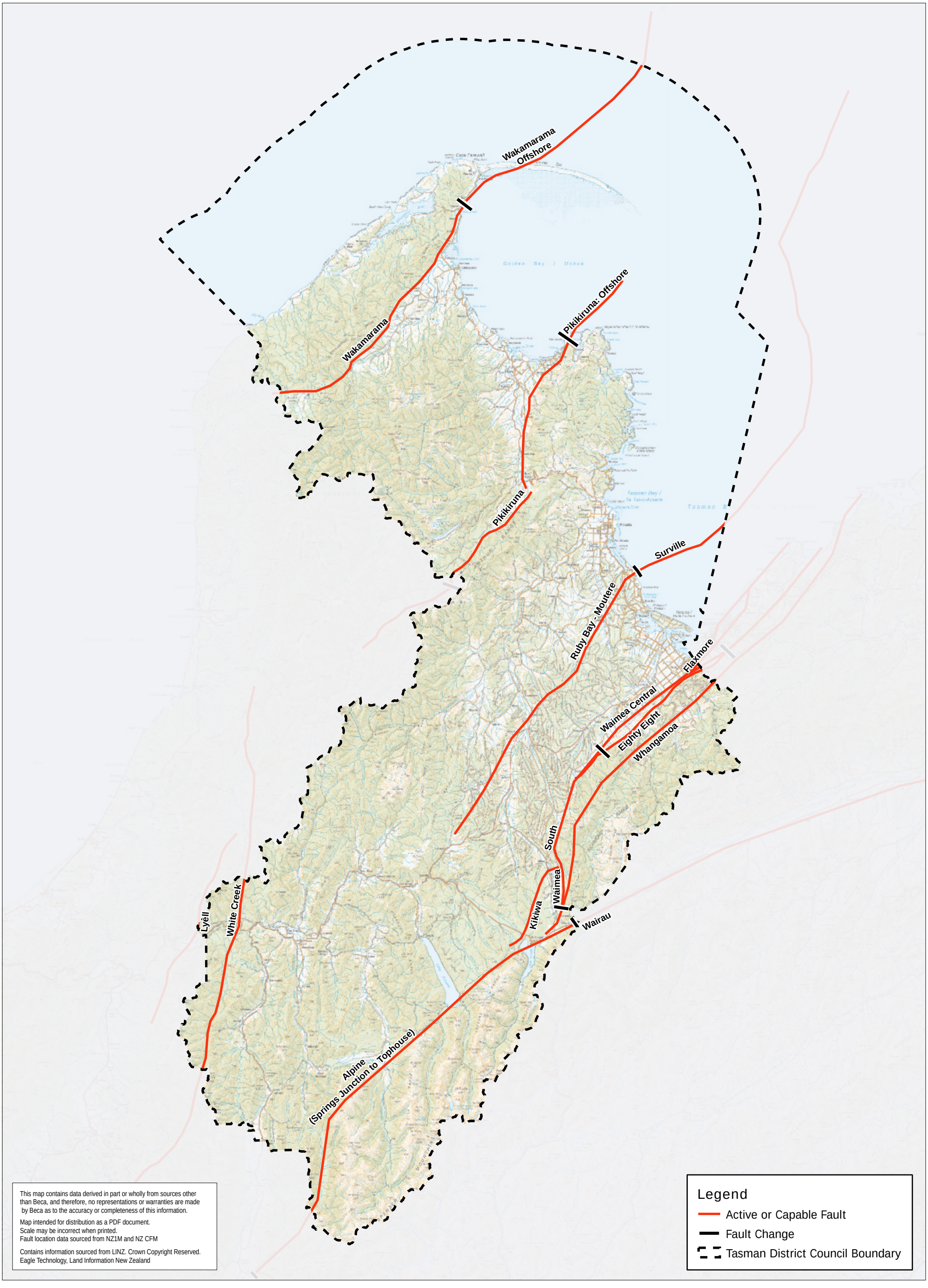
The Building Code. 1992. Schedule 1 of the New Zealand Building Regulations. (SR 1992/150). http://www.legislation.govt.nz/regulation/public/1992/0150/latest/DLM162570.html

van Dissen, R., Seebeck, H., Litchfield. N., Barnes, P., Nicol, A., Langridge, R., Barrell, D., Villamor, P., Ellis, S., Rattenbury, M., Bannister, S., Gerstenberger, M., Ghisetti, F., Sutherland, R., Fraser, J., Nodder, S., Stirling, M., Humphrey, J., Bland, K., Howell, A., Mountjoy, J., Moon, V., Stahl, T., Spinardi, F., Townsend, D., Clark, K., Hamling, I., Cox, S., de Lange, W., Wopereis, P., Johnston, M., Morgenstern, R., Eccles, J.D., Little, T., Fry, B., Griffin, J., Townend, J., Mortimer, N., Alcaraz, S., Massiot, C., Rowland, J., Muirhead, J., Upton, P., Hirschberg, H., Lee, J. 2021. Development of the New Zealand community fault model – version 1.0. in proceedings, NZSEE 2021 Annual Conference, New Zealand Society for Earthquake Engineering. Christchurch, New Zealand, 14-16 April 2021: Paper No. 92: 9 p.

A

Appendix A – Active and Capable Faults in the Tasman District

GIS@beca.com



This map contains data derived in part or wholly from sources other than Beca, and therefore, no representations or warranties are made by Beca as to the accuracy or completeness of this information.

Map intended for distribution as a PDF document.
Scale may be incorrect when printed.
Fault location data sourced from NZ1M and NZ CFM

Legend
- Active or Capable Fault
- Fault Change
- Tasman District Council Boundary

Map Scale @ A3: 1:630,000
0 10 20
Kilometers

Revision	Author	Verified	Approved	Date
3	BDJ2	JH133	Dan C	11/11/2021
2	SJF	Dan C	Paul W	20/10/2021
1	SJF	DRAFT	DRAFT	06/10/2021

Title: Fault Location Map
Active and Capable Faults
Within Tasman Region

Client: Tasman District Council

Project: TDC Fault Rupture Risk Area Review

Discipline: GIS

Drawing No: GIS-3160378-01

File: P:\3161316037\81-WIPWG-GIS\01-Map\TDC Fault Map\TDC Fault Map.aprx Author: BDJ2 Date: 11/11/2021