REVISED GEOLOGICAL MAP OF THE NELSON-RICHMOND URBAN AREA

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Fault geometry and seismotectonic implications

The total stripping of cover sequence from the hanging wall of the Eighty-Eight and Waimea faults, the preserved Bishopdale Conglomerate in the hanging wall of the West Flaxmore Fault, and the concealment of the Tahunanui Fault beneath the late Quaternary clastic alluvium may be interpreted in terms of larger amounts of vertical separation along the Waimea Fault (and associated splays) relative to the Flaxmore, West Flaxmore and Tahunanui faults, together with progressive propagation of fault splays towards the NW.

The sub-parallel strike of the faults of the W-FFS, their close spacing, and the presence of obliquely cross-cutting splays suggests that all faults branch from a common basement fault and propagated across the Cenozoic cover sequence during reverse reactivation. Contemporaneous activity of splays rooted into a common, deeper fault is also suggested by the presence of the E-W Bishopdale Fault (Bruce 1962; Johnston 1979) between the Flaxmore and Waimea faults (Figure 3). The sub-orthogonal orientation of the Bishopdale Fault relative to the dominant NE-SW structural fabric and its strike-slip components are consistent with its role as a lateral ramp (cf. Fraser 2005). The Grampian Fault has perhaps a similar role, but we have no evidence for any strike-slip component along it. Both faults can be interpreted as inherited basement structures, reactivated to accommodate differential shortening of the sedimentary cover during activity of the Waimea and Flaxmore faults at different slip rates.

Reactivation of several interconnected fault splays and eventual late propagation of basement beneath the present-day coastal plain has relevant implications for seismotectonic hazard in Nelson and Richmond. In the urban area, late Quaternary displacements have been documented for the Eighty-Eight, Waimea, Flaxmore and Bishopdale faults, some of which have been connected to earthquake ruptures (Fraser 2005; Fraser et al. 2006; Johnston and Nicol 2013). The morphological scarp interpreted as part of the Flaxmore Fault between Stoke and Richmond (Supplemental file S1) requires further assessment to validate its interpretation as a fault scarp. Late Quaternary activity for the E-W

Bishopdale Fault (Johnston and Nicol 2013) may be related to contemporaneous reactivation of the Waimea and Flaxmore Fault, as documented by the coeval age of the most recent ruptures for both faults (Fraser 2005).

The Magnitude of the largest earthquakes on the W-FFS has been derived from estimates of the rupture area (Fraser 2005; Fraser et al. 2006; Johnston and Nicol 2013) and evaluated to be in the range **M** 6.5-7.4. In the current National Seismic Hazard Model of New Zealand (Stirling et al. 2012) the W-FFS is considered to be able to generate **M**7 earthquakes with average recurrence intervals of c. 6 kyrs.

The rupture length for earthquakes of **M**~7 along a reverse fault system should be of several km (Wesnouski 2008; Wells and Coppersmith 1994) In the Nelson-Richmond area the longest late Quaternary fault scarp preserved along a NE-SW fault has been recognised for a length < 3 km along the Eighty-Eight Fault (Johnston and Nicol 2013), with a normal (up-slope down) sense of slip. Complex arrays of coseismic surface ruptures have been documented for reverse fault earthquakes (e.g. Philip and Megharoui 1983) and the lack of preserved reverse fault scarps in the mapped area can be ascribed to poor exposure and slope instability of the hanging wall. However, it is also feasible that activity along the W-FFS increases southwards, i.e. in proximity of the Alpine Fault.

The Waimea and Flaxmore faults display similar orientation and kinematics and – possibly – a similar structural evolution. However, the largest total separation accrued on the Waimea Fault testifies to its preferential reactivation since the Miocene, though not necessarily excluding coeval late stages of slip on the Flaxmore Fault, as well as on the sub-parallel Tahunanui Fault. If this is the case, many splays of the W-FFS sharing similar geometry and kinematics can be reactivated in the present-day stress field, and the lack of known surface ruptures does not necessarily imply inactivity, as was the case of the previously undetected Greendale Fault that ruptured to the surface during the 2010 Darfield earthquake (Quigley et al. 2012).