Field Trip Guide 23rd January 2026

1855 Wairarapa Earthquake Commemoration

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Cover photo: A series of storm beach ridges at Turakirae Head and along the shoreline of western Palliser Bay that have were uplifted in the 1855 Wairarapa Earthquake and older large earthquakes. Credit: Lloyd Homer, Earth Sciences NZ.

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Introduction

The 23rd January 1855 magnitude 8.2 Wairarapa Earthquake occurred in one of the most complex active tectonic areas of Aotearoa New Zealand (Figure 1). Not surprisingly then, the earthquake ruptured several active faults (Grapes and Downes 1997; Schermer et al. 2004) and there have been several studies of these and other faults since the 1855 earthquake (https://www.itsourfault.org.nz/resources) to better understand their risk.

Recently, active faults in the western Wairarapa have been mapped using lidar data, and several previously-unidentified faults were found (Litchfield et al. 2022; Coffey et al. in press).

Beaches raised in past earthquakes (similar to the cover photo) east of Palliser Bay have also been studied to better understand the Hikurangi subduction zone earthquake and tsunami risk (Litchfield et al. 2021; Howell et al. 2022; Ninis et al. 2023).

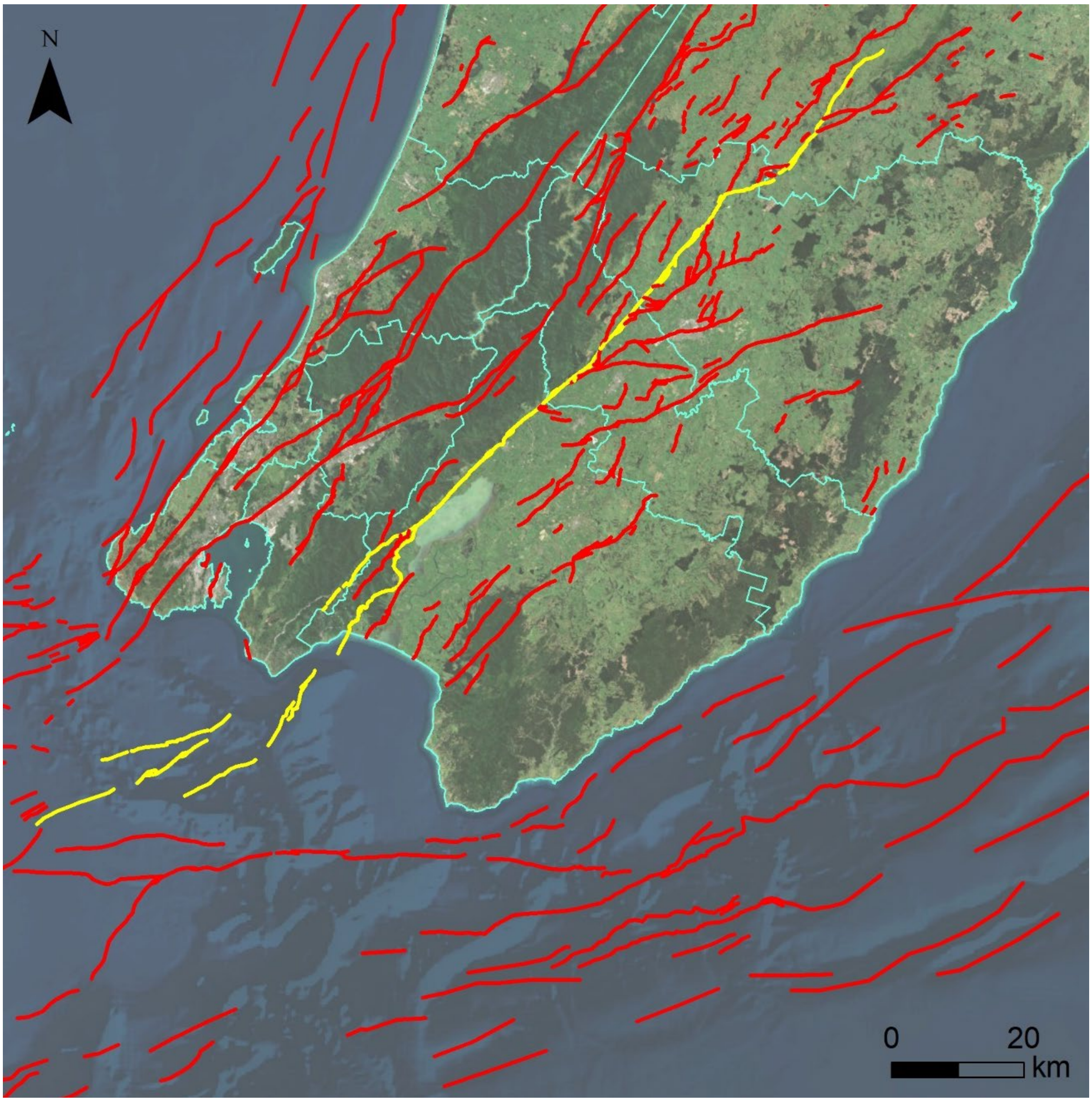

Figure 1. 1855 Wairarapa Earthquake fault ruptures (yellow) and other active faults in the Greater Wellington Region (red). The onshore active faults are from the 1:250,000 scale version of the New Zealand Active Faults Database (https://data.gns.cri.nz/af/; Langridge et al. 2016). The offshore faults are from Pondard and Barnes (2010) and Barnes et al. (2010).

Tectonic Setting

New Zealand straddles the complex Australian-Pacific plate boundary, with the major tectonic features being the Hikurangi Subduction Zone in the north, the Alpine Fault in the centre, and the Puysegur Subduction Zone in the south (Figure 2). These features are broken up into nearly 900 active faults that could could rupture in future earthquakes (Seebeck et al., 2024).

Figure 2. Schematic block diagram of the Hikurangi Subduction Zone and active faults in the Cook Strait area.

The Wairarapa is in the southern part of the Hikurangi Subduction Zone where the Pacific Plate is being pushed down (subducted) beneath the Australian Plate at ~41 millimetres per year (Figure 3).

The Hikurangi Subduction Zone fault (interface) lies 15-20 km beneath the Wairarapa and about 80% of the convergent plate motion occurs on the interface and the remainder on the faults above it, such as the Wellington and Wairarapa Faults (Wallace et al. 2009).

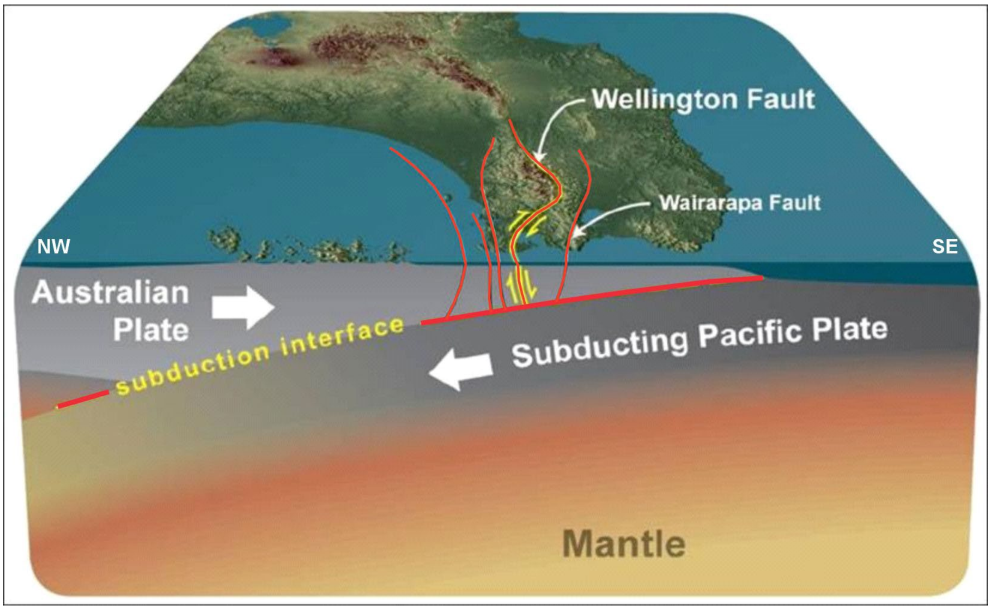

Figure 3. Schematic block diagram of the Hikurangi Subduction Zone and active faults in the Cook Strait area.

GeoNet Global Positioning System (GPS) data show that the Hikurangi Subduction Zone fault is currently largely locked beneath the Wellington Region (Figure 4) and is likely building strain to be released in a future earthquake. Part of the Hikurangi fault likely moved in the 1855 Wairarapa and 2016 Kaikōura earthquakes (Rodgers and Little, 2006; Hamling et al., 2017).

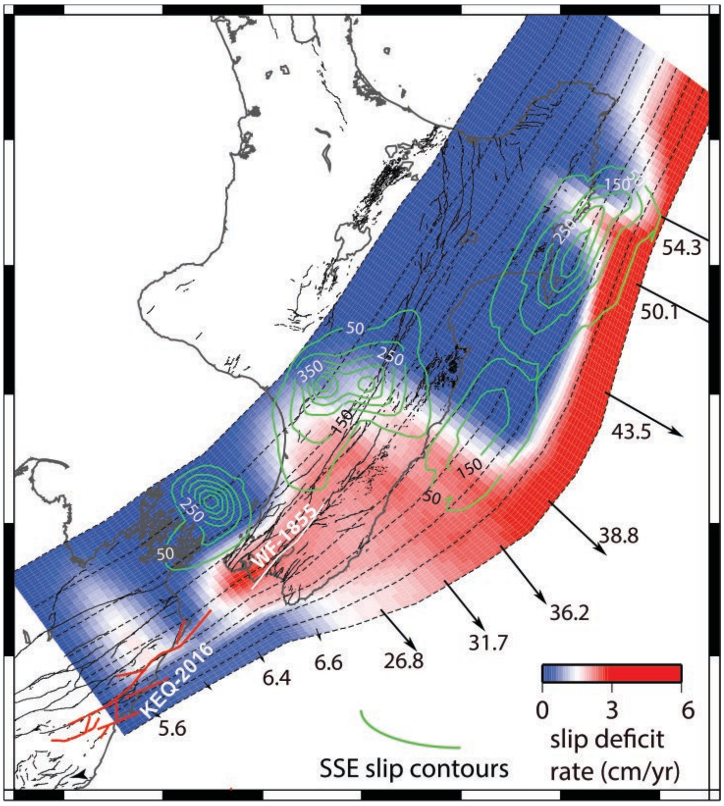

Figure 4. Current amount of locking on the Hikurangi Subduction Zone fault (interface) from GPS. Red is high, blue is low. Green lines are Slow Slip Events (SSEs) or slow earthquakes that periodically release some strain. From Wallace et al. (2018).

Fieldtrip Route

Starting and finishing at Featherston, we will drive in a general clockwise loop visiting the Wairarapa Fault, which ruptured in the 23rd January 1855 Wairarapa Earthquake, and other nearby active faults (Figure 5). The route will be adapted as needed, with some "stops" being "drive-by's" and a toilet stop is planned in Martinborough.

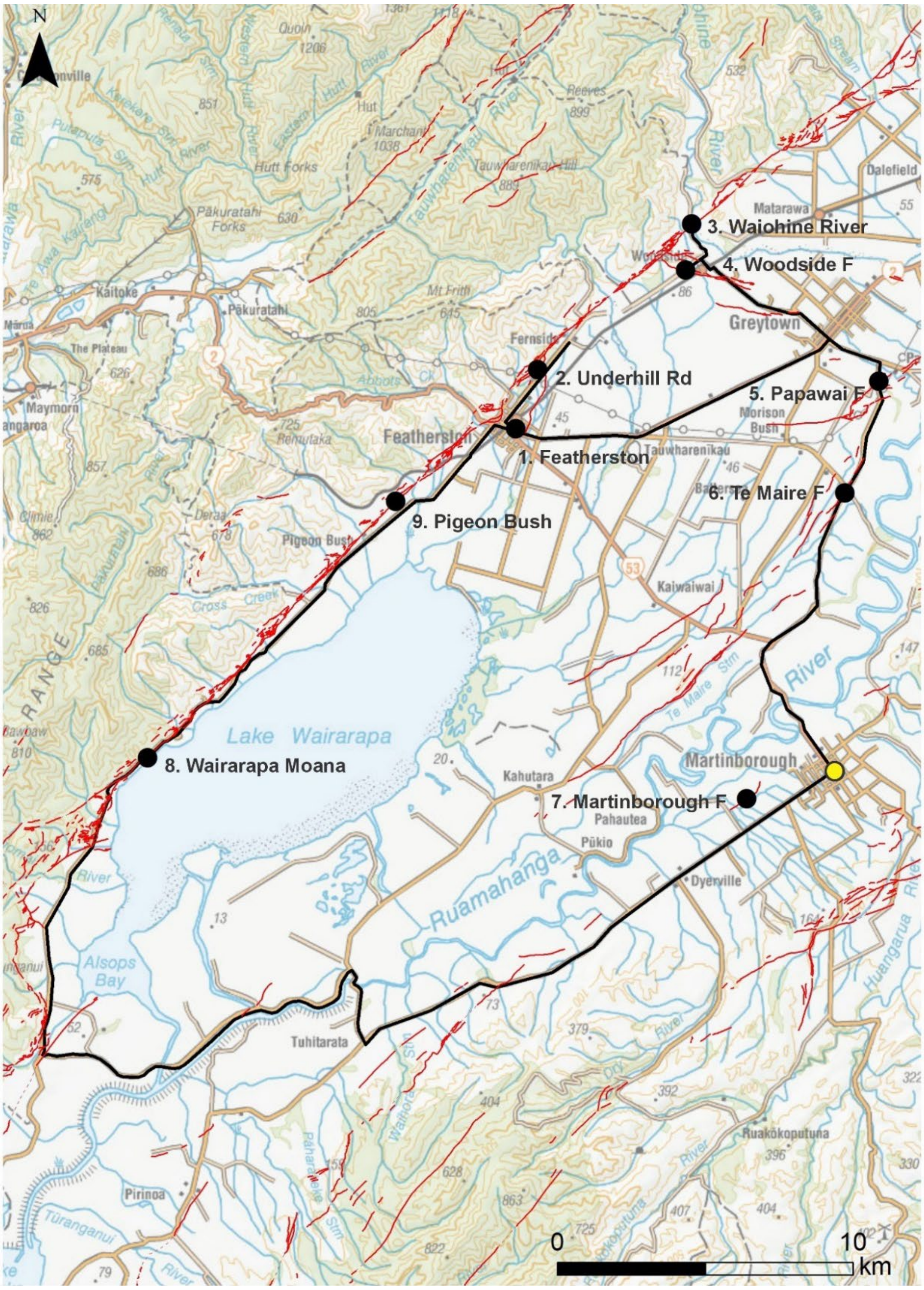

Figure 5. Fieldtrip route. Active faults in this and other maps are from the high-resolution version of the NZ Active Faults Database (Morgenstern et al. 2024) after Litchfield et al. (2022).

Stop 1. Wairarapa Fault, Featherston

The Wairarapa Fault is one of New Zealand's largest faults and extends from the middle of Cook Strait to near Mauriceville, a total distance of about 140 km. In the Wairarapa Valley it runs along the foot of the Remutaka Range and through Featherston (Figure 6). Key features of the Wairarapa Fault and other major Wairarapa active faults are summarised in Table 1.

Figure 6. The Wairarapa Fault running through Featherston. Photograph CN 1791 by Lloyd Homer, Earth Sciences NZ.

Table 1. Current information on major active faults in the Wairarapa.

	Wellington Fault	**Wairarapa Fault**	**Masterton Fault**	**Carterton Fault**	**Papawai Fault**	**Hikurangi Subduction Zone**
Timing of the last earthquake	110-310 years ago	1855 CE	<10,000 years ago	<2000 years ago	<10,000 years ago	~500 years ago
Recurrence Interval (average time between earthquakes)	715-1575 years	1230 ± 190 years	~2000-3500 years	~2000-3500 years	~2000-3500 years	~500 years
Slip rate (average rate of movement over time)	~6 mm/yr	~12 mm/yr	0.5-2 mm/yr	~2 mm/yr	~0.8 mm/yr	N/A
Average amount of movement in each earthquake	~5 m	~14-15 m horizontal, several m vertical	~1 m	1-6 m	1-2 m	several-10's m
Probability of rupture in the next 50 years	5%	1.2%	ND	ND	ND	26%

The 23rd January 1855 Wairarapa Earthquake ruptured the Wairarapa Fault as well as several faults to the north (Dreyers Rock, Alfredton, Saunders Road), a total length of about 175 km (Figure 1; Schermer et al. 2004). With an estimated magnitude of 8.2 the Wairarapa Earthquake is the largest earthquake since 1840 and shaking was felt throughout almost the whole of New Zealand (Grapes and Downes 1997). There was extensive damage to the young settlements in the southern North Island, with many landslides in the Remutaka and southern Tararua ranges, several metres of uplift of the coast (Cover photo) including Wellington Harbour, and a tsunami up to 12 m high at Te Kopi.

Recent active fault mapping has been undertaken using lidar (light detection and ranging data) data which provides very detailed maps of the bare earth – allowing us to "see through the trees" (Litchfield et al. 2022; Coffey et al. in press). The lidar data shows that the Wairarapa Fault in Featherston, like elsewhere, is not a single fault line, but is a series of lines that we call traces (Figure 7). The types and amounts of movement/slip/rupture on these traces in earthquakes likely differs, with most traces having mainly sideways movement (red lines in Figure 7), but a few having more up-down movement (blue lines). The ones with likely up-down movement were not recognised previously but are clearly visible in the lidar data.

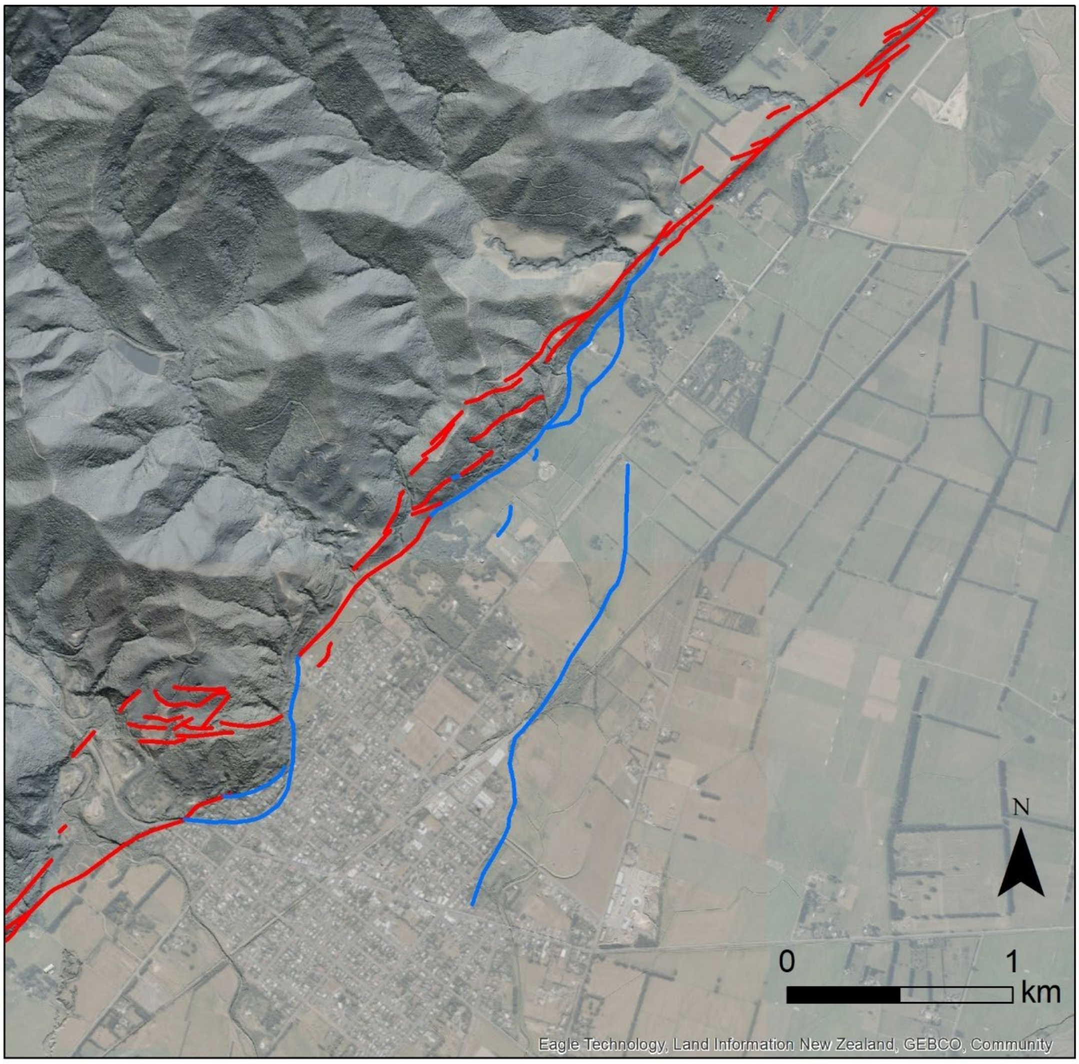

Figure 7. The Wairarapa Fault through Featherston and by Underhill Road. Red traces are expected to mainly have sideways movement, blue traces up-down movement (the northwest side uplifted) in future earthquakes.

Stop 2. Wairarapa Fault, Underhill Road

We will drive along Underhill Road and view the Wairarapa Fault out the bus window. Multiple traces are visible, most notably the newly-recognised ones with mainly up-down movement (Figure 7).

Stop 3. Wairarapa Fault, Waiohine River

We will stop on top of the Wairarapa Fault scarp and discuss the World-famous Waiohine River terraces site on the opposite, eastern side of the river (Figure 8). The terraces and channels formed by downcutting of the river over the last 11,000 years or so have been faulted in multiple Wairarapa Fault earthquakes. By matching up the youngest offset channel, an offset of 12.4 ± 0.8 m has been calculated and is attributed to the 1855 Wairarapa Earthquake (Carne et al. 2011).

From matching the oldest offset riverbank (marked by the yellow arrow), a slip rate of 11.9 ± 2.9 mm/y (horizontal) and 1.8 ± 0.2 mm/yr (vertical) has been calculated (Carne et al. 2011). This is the average rate of movement over 11,000 years, during which time there was likely about 9 earthquakes. This slip rate is the highest of any fault in the onshore North Island (Table 1).

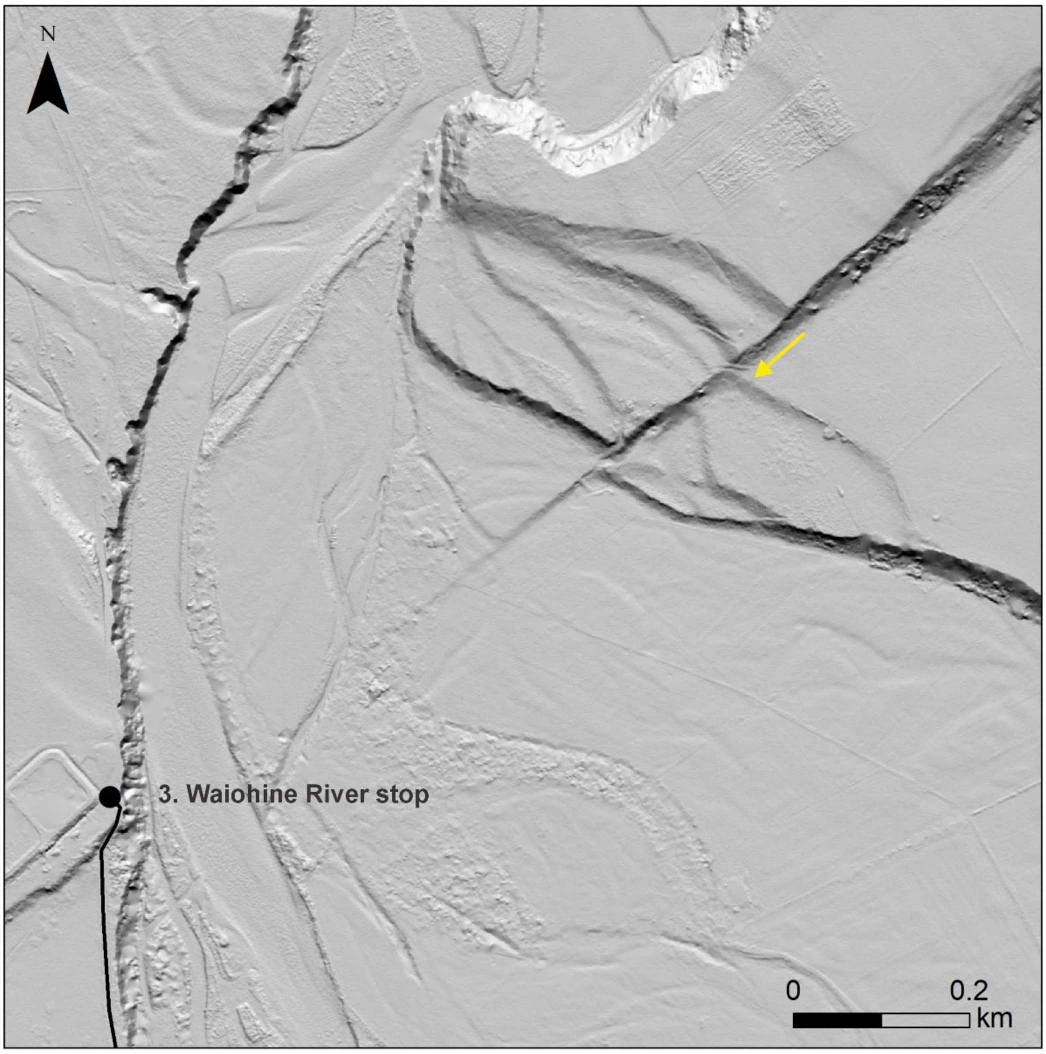

Figure 8. Lidar map showing the Waiohine River (eastern bank) terraces offset by the Wairarapa Fault.

Stop 4. Woodside Fault

The Woodside Fault was recently identified using the lidar data and although the traces are more subtle than the Wairarapa Fault, they are clearly visible cutting across the old channels and riverbanks of streams and rivers such as the Waiohine River (Figure 9). It is named after Woodside Railway Station and the movement is thought to be mainly sideways.

The Woodside Fault is the southernmost of a series of faults that branch off the Wairarapa Fault, such as the Carterton, Masterton and Mokonui faults (Figure 1). It is very short (about 5 km) though, and so we think that it most likely ruptures with the Wairarapa Fault (recurrence interval 1230 years).

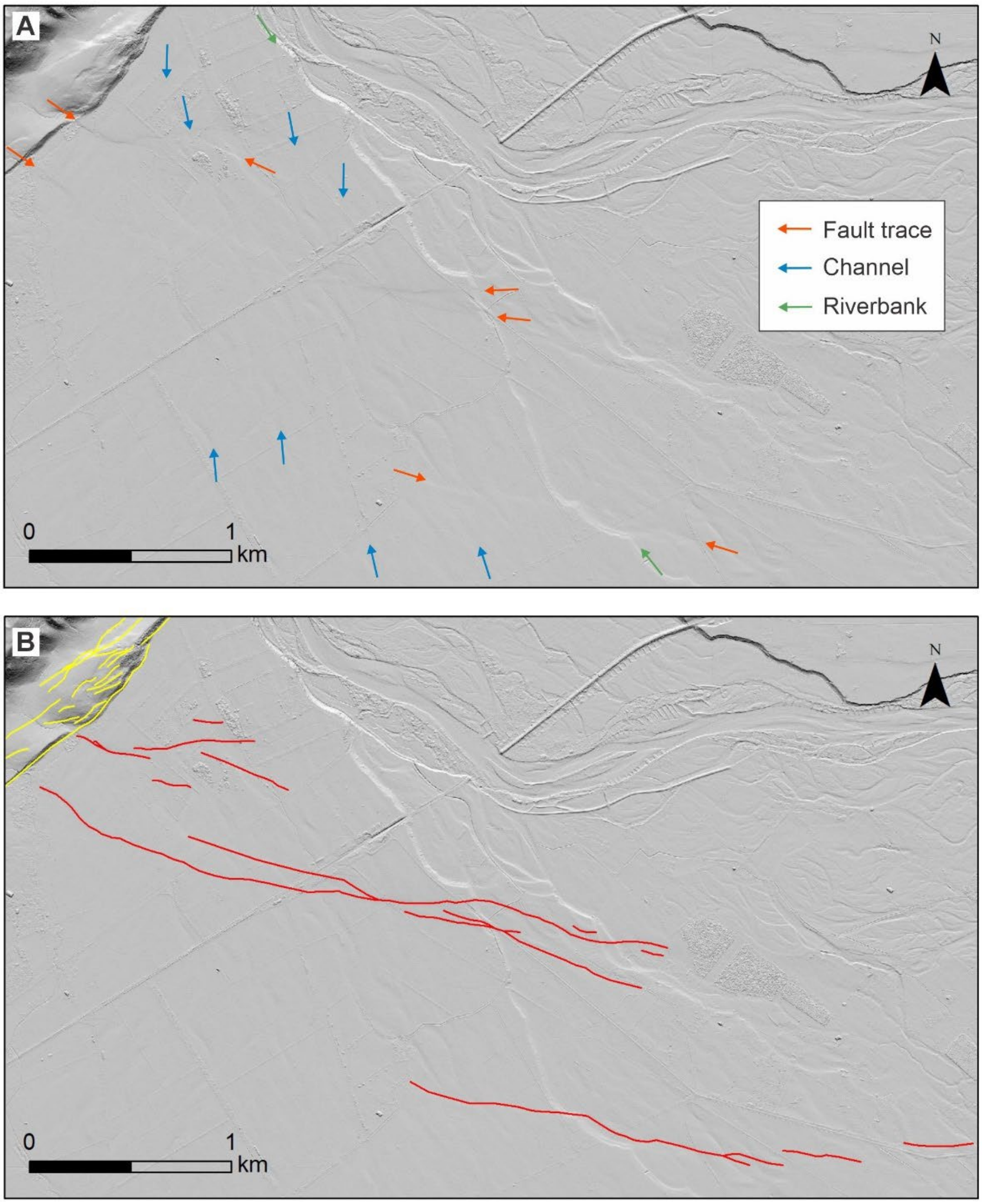

Figure 9. Lidar maps of the Woodside Fault area. A) River features are marked with blue and green arrows and fault traces with red. B) Mapped fault traces of the Woodside Fault in red (Wairarapa Fault in yellow). Adapted from Litchfield (2025).

Stop 5. Papawai Fault

The Papawai Fault is another active fault that was recently discovered using the lidar data and is named after the marae with permission from the haukāinga of Papawai. It is about 26 km long and extends from south of Greytown to northeast of Gladstone where it may join the Carterton Fault (Figure 10).

Like the Wairarapa Fault, movement on some traces (those oriented more easterly) is likely to be mainly sideways and some (those oriented more northerly) mainly up-down. The slip rate is about 0.8 millimetres per year and the recurrence interval is estimated to be 2000-3500 years (Coffey and Litchfield, 2023 and Coffey et al. in press). Further work is planned on the Papawai Fault this summer.

It is hard to spot on our route, but we will try to point out some Ruamahanga River terraces that have been uplifted and tilted to the northwest by multiple earthquakes on the Papawai Fault.

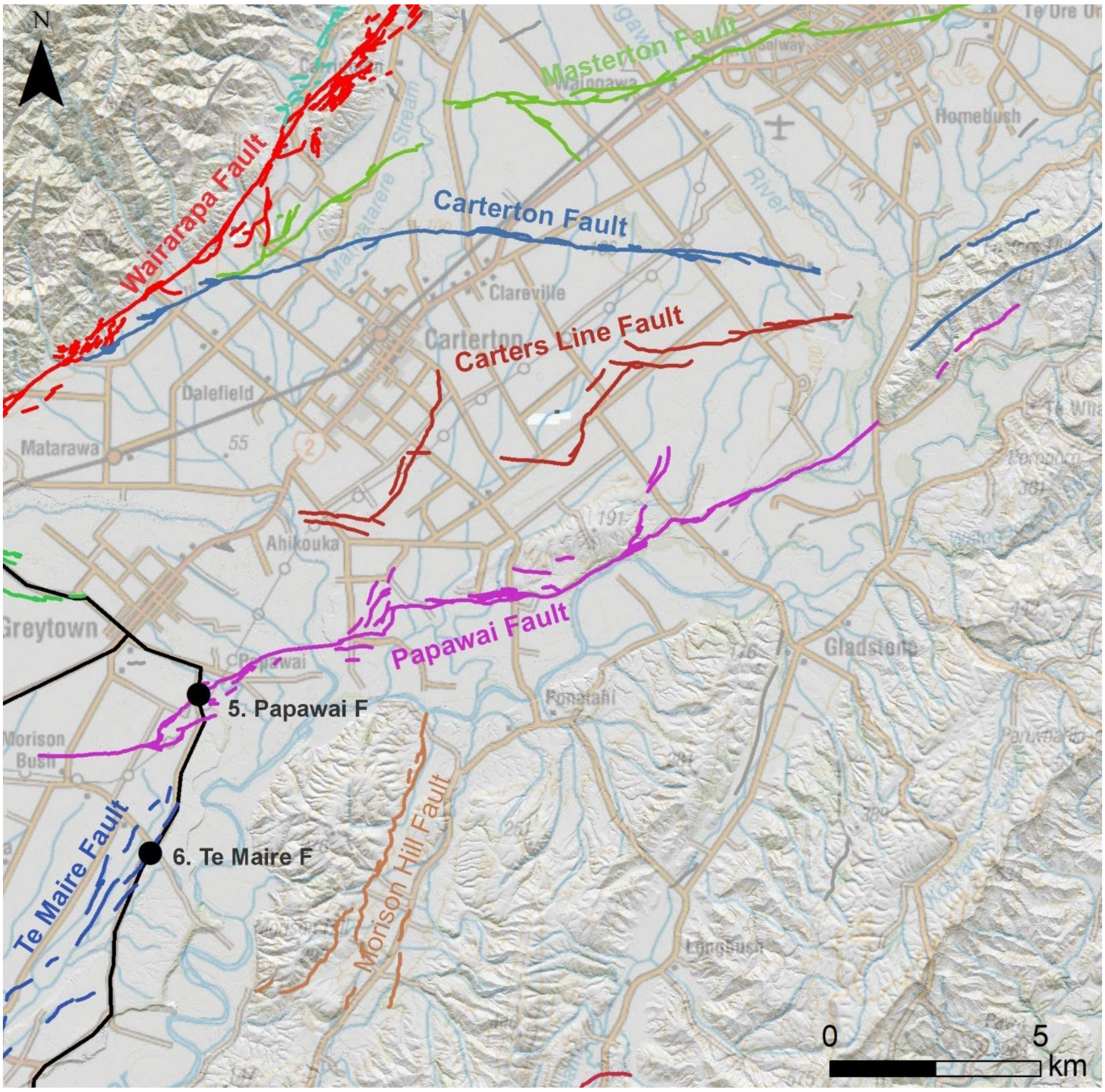

Figure 10. Active faults near Greytown, Carterton and Masterton, including the recently-identified Papawai Fault (and Carters Line Fault) and the northern end of the Te Maire Fault that we'll drive over.

Stop 6. Te Maire Fault

The Te Maire Fault had previously been mapped along the east side of Bidwill Hill ridge, but the lidar mapping found many traces on the west side (Figure 11).

The Te Maire Fault is about 17 km long and is thought to mainly have up-down movement (up to the northwest), and the recurrence interval is estimated to be 3500-5000 years (Litchfield et al. 2022).

Like the Papawai Fault, the Te Maire Fault is a hard to stop and view safely, but we will drive along the northern part of it on the way south (Figure 10).

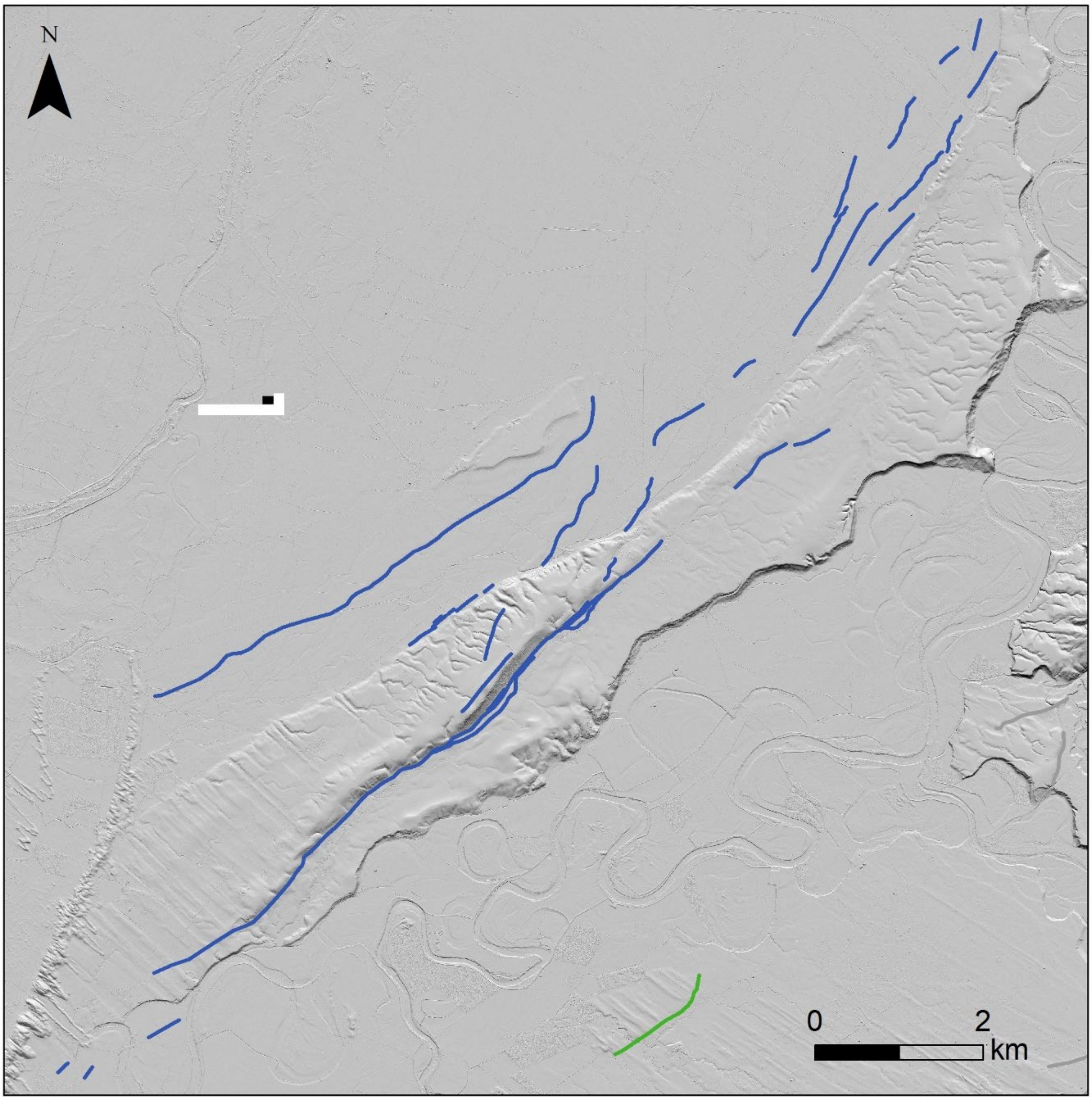

Figure 11. Lidar map of Te Maire Fault (blue) and the Martinborough Fault (green).

Stop 7. Martinborough Fault

The Martinborough Fault has been known about for a long time and was once an important geologic fault, but the trace in the lidar data is very short, about 1.4 km (Figure 11) suggesting it is not currently very active. The trace is subtle and crosses an old Ruamahanga River terrace (>55,000 years) (Litchfield et al., 2007), so it has a very low slip rate (0.1 mm/yr) and a long recurrence interval (10,000-20,000 years). The movement in earthquakes is expected to be mainly up-down (up to the northwest). We will point to it out of the bus window, but it is hard to spot.

Stop 8. Wairarapa Fault, Wairarapa Moana

The Wairarapa Moana Wetlands lookout is right beside the Wairarapa Fault (in the trees). Southwest of here the Wairarapa Fault is in the hills and becomes very distributed and hard to map, but it may run offshore at Mukamuka Rocks (south of Mt Matthews on Figure 12).

To the east are a series of active faults including the Wharekauhau Thrust, Wharekauhau East Fault and the Battery Hill Fault (Figure 12). Some, but not all, traces on these faults ruptured in the 1855 Wairarapa Earthquake and it is likely that the offshore part of the Wharekauhau Thrust was the main cause of uplift of Turakirae Head beach ridge by up to 6.4 m (Cover photo).

From here to Featherston the Wairarapa Fault is more concentrated along the foot of the Remutaka Range, although it is possible that there are some traces buried beneath Wairarapa Moana.

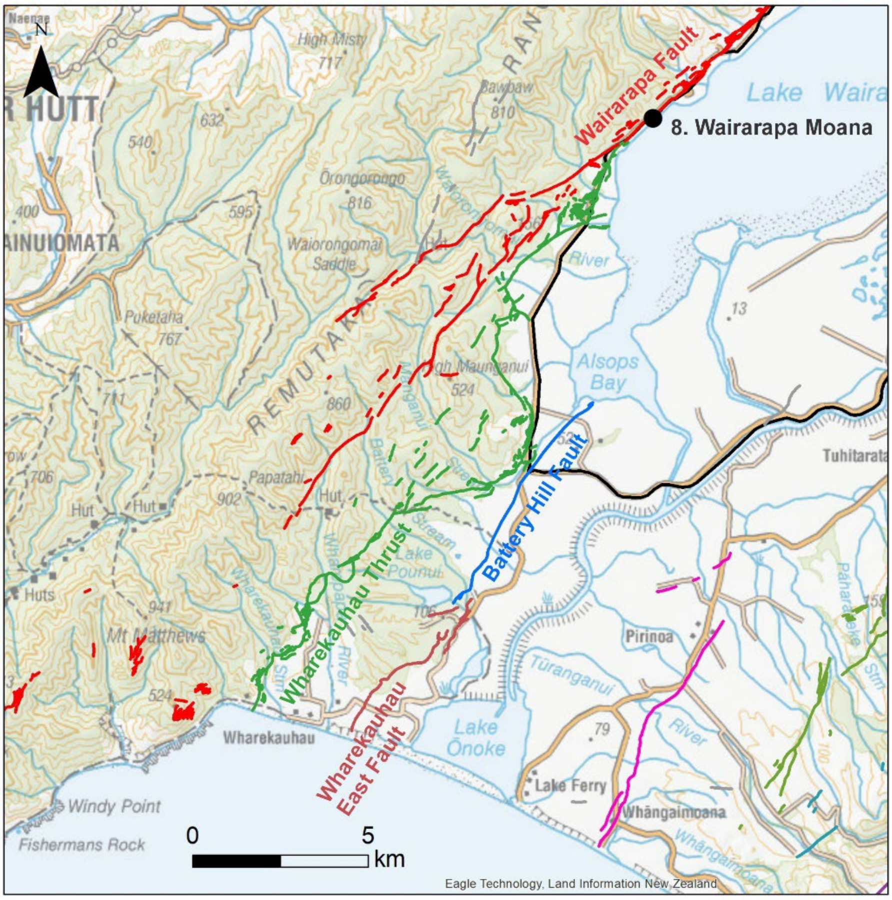

Figure 12. Active faults south of Wairarapa Moana.

Lidar mapping also made it possible to recognise secondary faults in the uplifted block of the Wairarapa Fault above Wairarapa Moana. One of these a couple of km north of here is very sharp (fresh-looking) and last summer a trench was dug (by hand) to look for evidence of recent earthquakes (Figure 13). From the very sharp nature of the scarp and several young charcoal dates it is interpreted that this trace ruptured in 1855, as well as previous earthquakes. This is an important observation for understanding secondary rupture hazards on faults throughout New Zealand.

Figure 13. Secondary trace of the Wairarapa Fault and digging of a trench which, along with it's sharpness, suggests that this trace ruptured in the 1855 Wairarapa Earthquake.

Stop 9. Wairarapa Fault, Pigeon Bush

The Pigeon Bush offset site is World-famous for being the site where the largest 1855 Wairarapa Earthquake offset on the Wairarapa Fault of 18.7 ± 1.0 m has been calculated (Rodgers and Little 2006) (Figure 14).

This is the largest fault offset in the world for an onland fault. Only offshore subduction faults have had larger offsets, such as the very large offsets – some estimates as much as 62 m – in the 2011 Tohoku-Oki earthquake (Japan).

The Pigeon Bush offset was calculated from measuring the distance between the small stream coming across the scarp and a channel that has now been abandoned but is assumed to have been continuous before the earthquake.

Another offset channel records a previous Wairarapa Fault earthquake of about 14 m.

Figure 14. Pigeon Bush 1855 Wairarapa Earthquake offset. From Te Ara Encyclopedia of New Zealand. https://teara.govt.nz/en/photograph/4400/wairarapa-fault-scarp-pigeon-bush. The earlier stream channel offset is c. 14 m (Rogers and Little 2006).

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