

Supplementary Materials for
**Coseismic river avulsion on surface rupturing faults: Assessing
earthquake-induced flood hazard**

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Sci. Adv. **9**, eadd2932 (2023)
DOI: 10.1126/sciadv.add2932

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Fig. S1. NIWA depth survey point data of the Waiau Toa | Clarence River. RTK GNSS Survey was completed on the 21st of December 2016. Depth points are overlain atop pre-earthquake aerial imagery taken by Environment Canterbury, sourced from an unpublished survey report. Absolute elevation and positional accuracy is accurate to ~10 m.

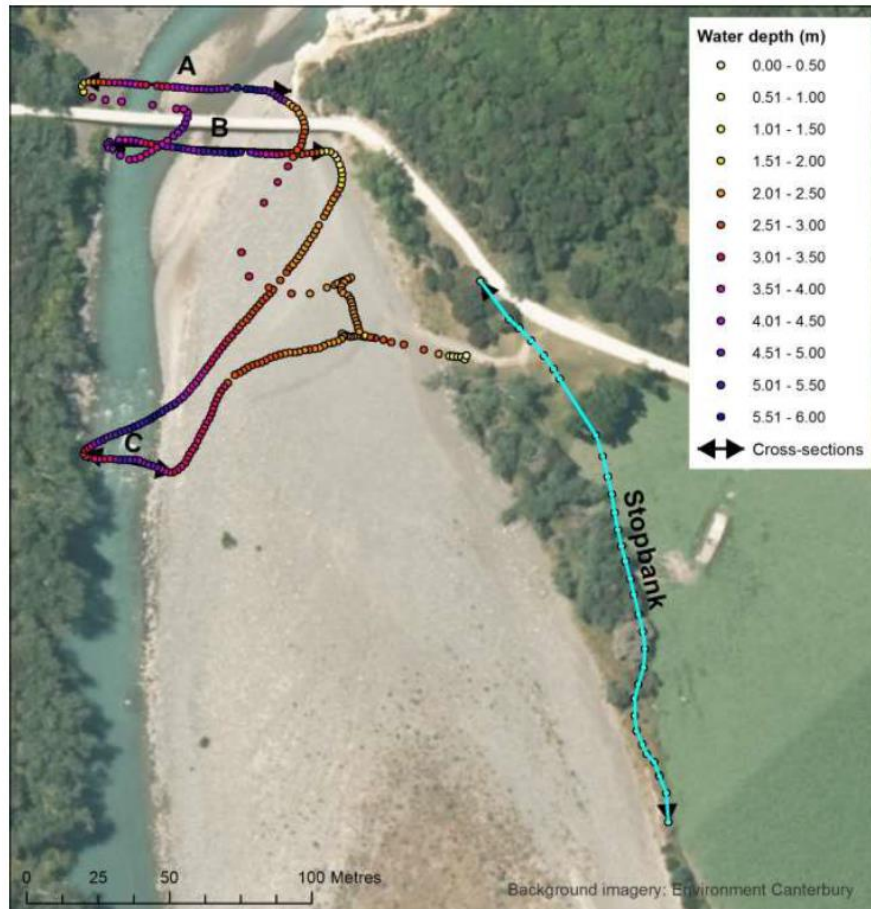


Fig. S2. Comparisons between HEC-RAS model results and NIWA depth survey data.

NIWA depth data overlain upon the benchmark and calibration HEC-RAS model results. Flow conditions are the time of the survey were unspecified, and a stopbank was in place across the avulsion node (yellow dots), however the measured depth values provide a useful benchmark to compare HEC-RAS model outputs. **(A)** NIWA data overlain atop the 2016 benchmark model, run in flow conditions of $187 \text{ m}^3\text{s}^{-1}$. Modelled depth values are consistent within the main channel and across the fault-scarp. The absence of the Papatea Fault scarp within the main river channel likely drives such uniformity. The scarp may have been obscured by water at the time of the 2016 lidar collection, or removed during lidar data hydroprocessing **(B)** NIWA data overlying the 2012 DEM calibration model, modified with a 6.5 m high synthetic fault-scarp and run with the same flow regime as the benchmark. The synthetic scarp creates an obstacle within the main channel, facilitating pooling and depth increases upstream of the scarp. Resultant depth values and spatial allocation are more consistent with the profiles obtained by NIWA in late 2016.

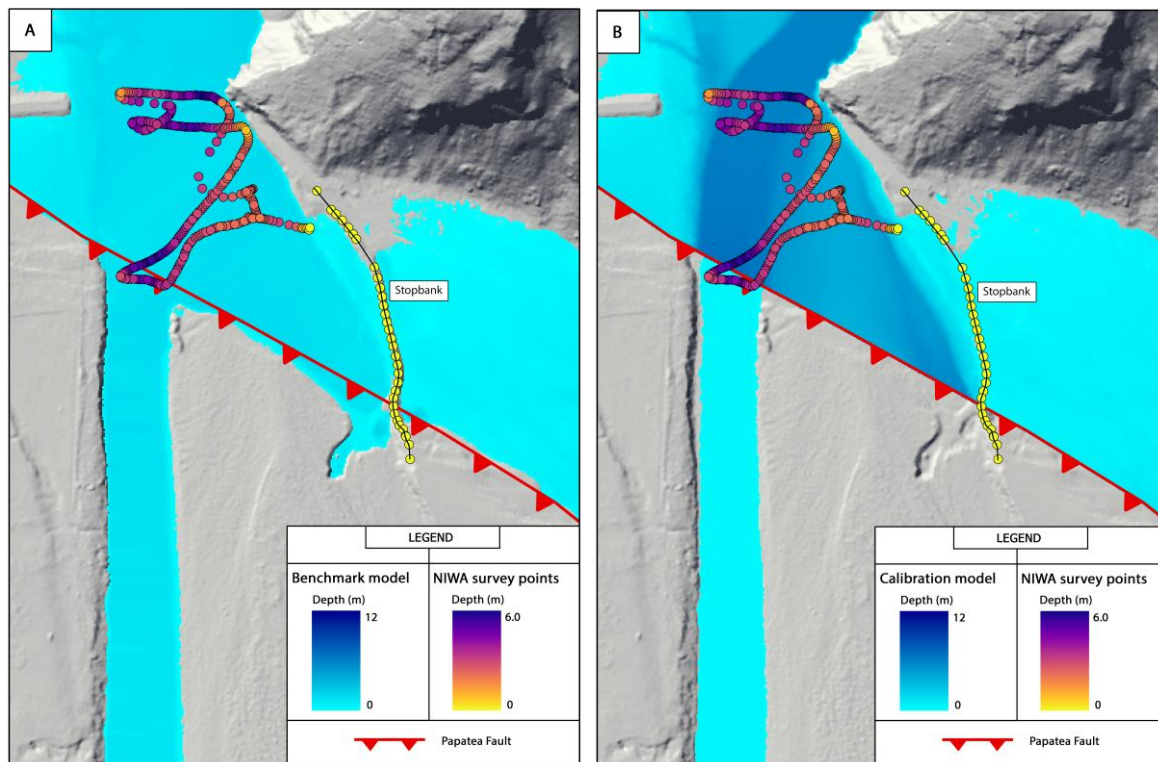


Fig. S3. Manning's 'n' values set for the Waiau Toa | Clarence River valley model area.
 Values are spatially allocated using the Land Resource Information System (LRIS) land-cover database version 5.0.

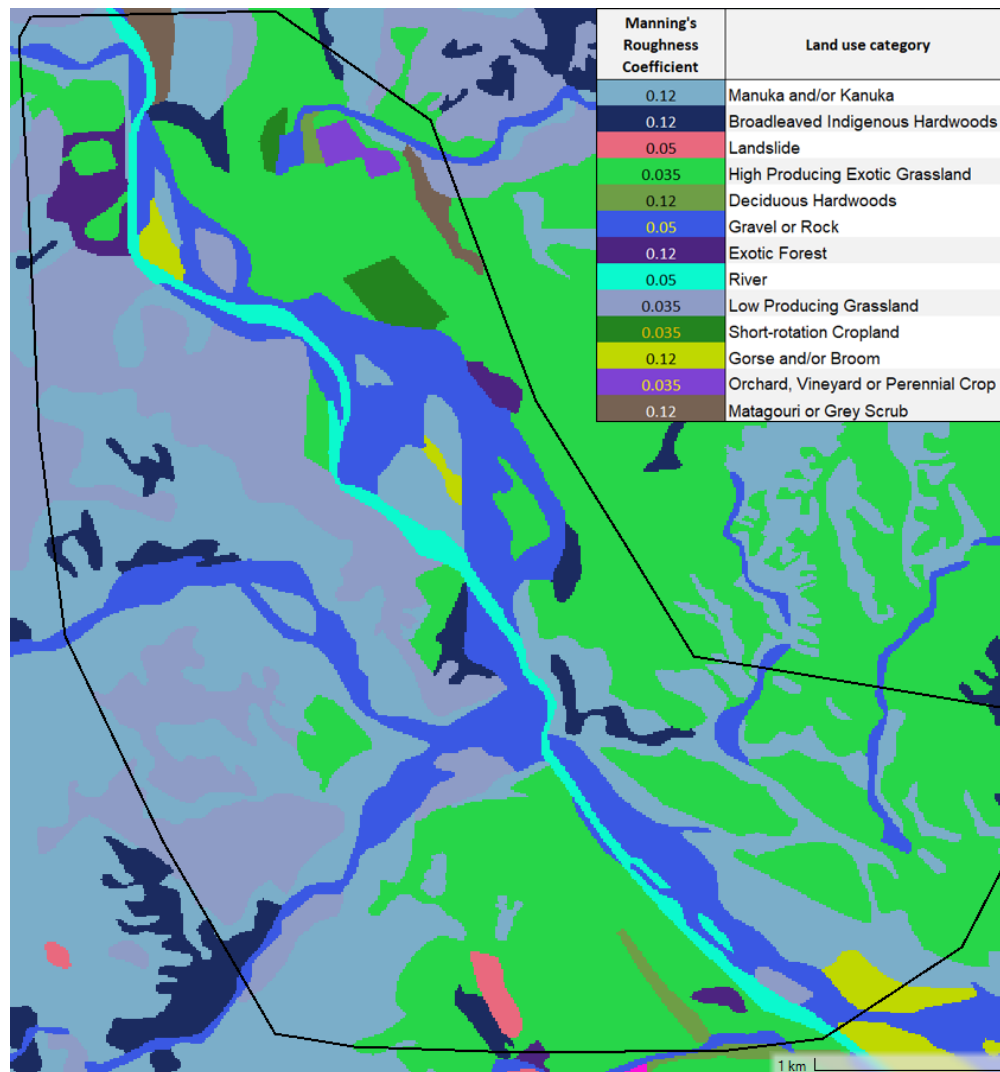
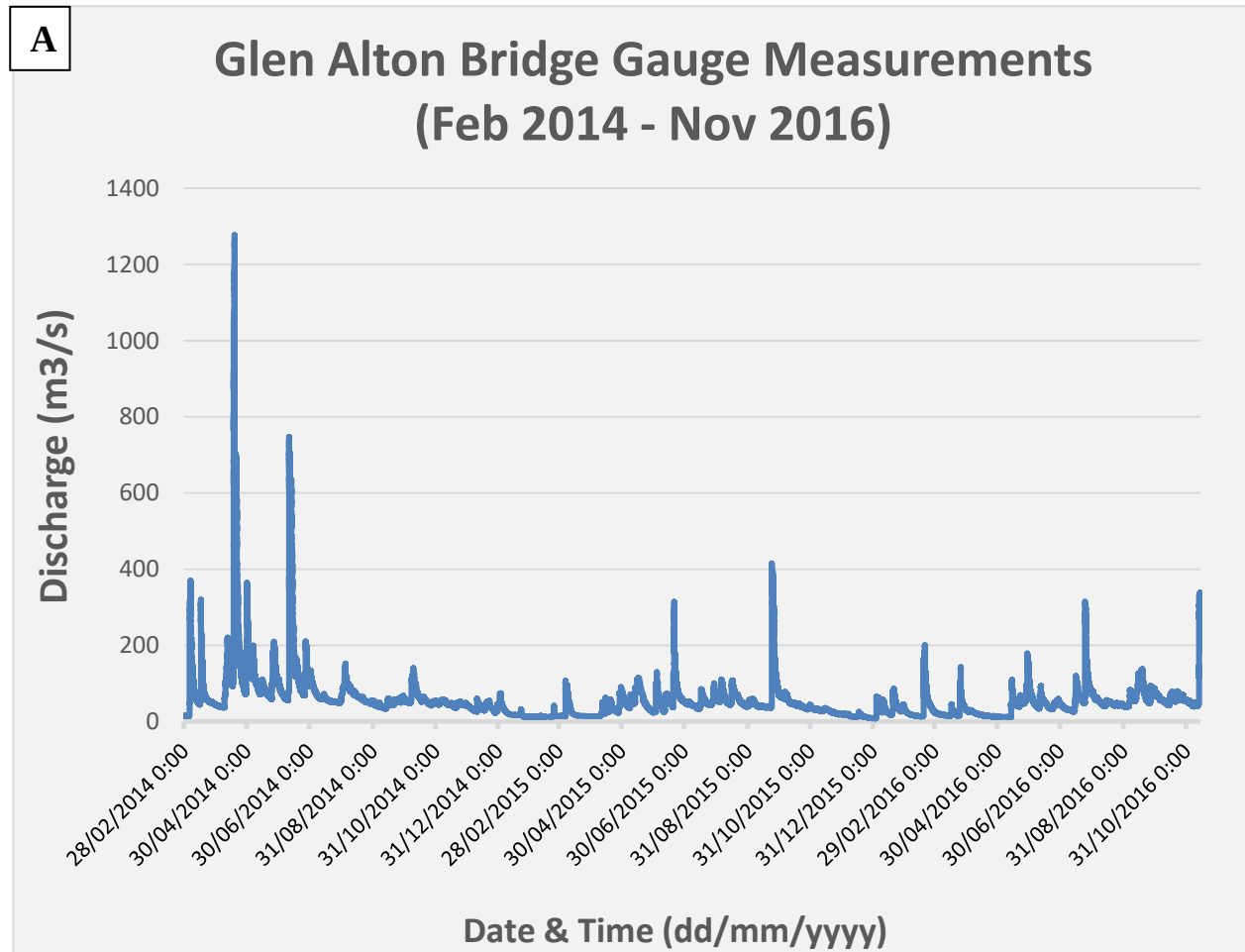
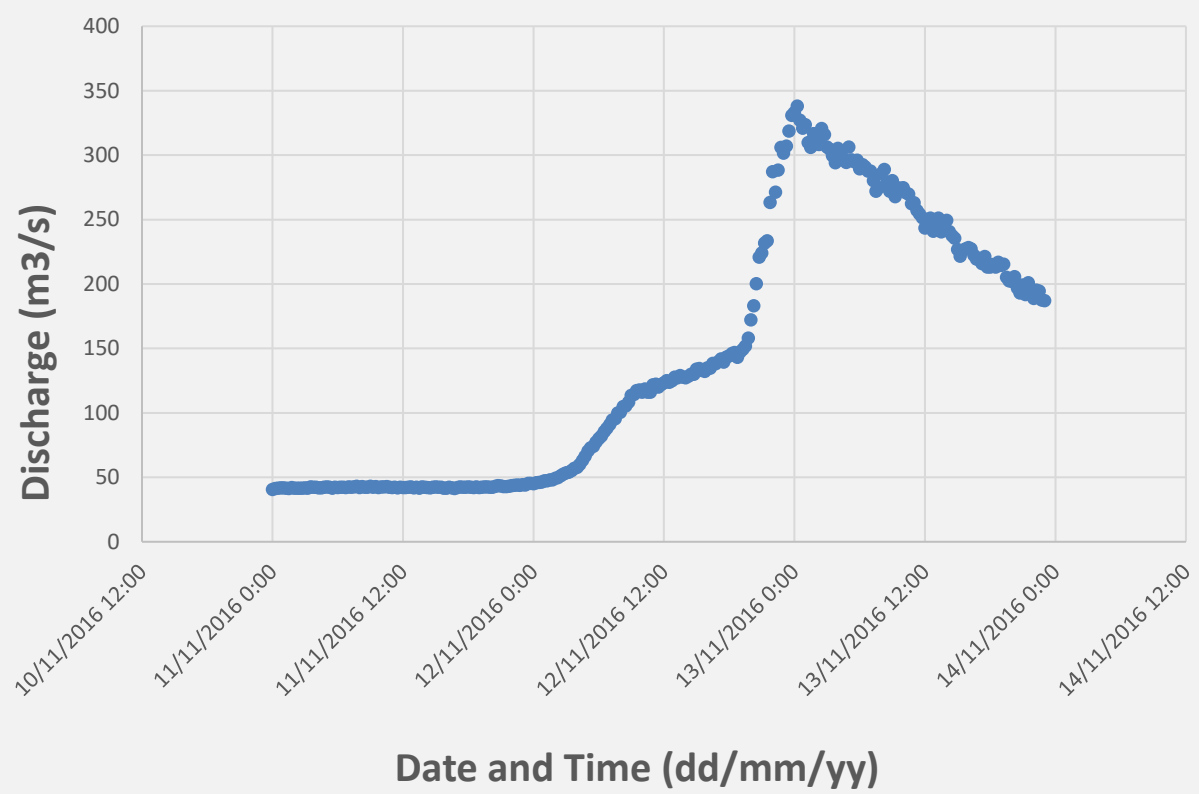


Fig. S4. Glen Alton Bridge Gauge data (Feb 2014 – Nov 2016). Measurements were taken at the Environment Canterbury (ECAN) Glen Alton bridge gauge every 15 minutes. **(A)** The full dataset of bridge gauge measurements, ranging from February 2014, through until 1 hour prior to the Papatea Fault rupture. The only year with a complete dataset of measurements is 2015, and as such, annual average, and annual lowest flow values from 2015 were used in the Waiau Toa | Clarence River scenario modelling. **(B)** Flow conditions over the two days preceding the 2016 Papatea fault rupture.



B

2016 Glen Alton Bridge Gauge Measurements between the 11th and 13th of November



Supplemental Text

Determination of D_Q values used in the calculation of F

Five scenario model flow regimes were run in HEC-RAS on a pre-quake undeformed (2012) DEM. Normal depth (D_Q) for each flow regime was established by measuring a section of the channel (located immediately upstream of where the fault would emerge) where the slope of the bed and water surface elevation were parallel. The difference between water surface elevation and bed elevation along this section provides the D_Q value for each model run, and the D_Q value each discharge could then be used to establish the non-dimensional F , calculated as $T + D_Q / D_N$, wherein D_N is the bankfull normal depth (defined as the mean annual flood depth). An issue arises in that the 2012 DEM channel geometry is analogous to the water surface elevation at the time of lidar collection, rather than the true elevation of the channel base. To determine the influence of water surface elevation on our depth estimates, D_Q values determined using the 2012 (pre-event) DEM were compared with an RTK GPS elevation profile taken in 2021 across the abandoned parent channel. The cross-sectional profile of the parent channel was taken immediately downstream of where D_Q was derived in the pre-event DEM. The RTK cross-sectional profile suggests that the mid-channel elevation is ~ 70.5 m, which roughly aligns with the predicted bathymetric elevation in the 2012 (pre-event) DEM of 66 m when accounting for vertical fault offset of ~ 6.5 m. The difference of ~ 2.0 m can be attributed to a number of factors including; 1) the 2012 water surface elevation is higher than the underlying channel elevation; 2) post-event human modification of the parent channel occurred, including using vehicles and machinery in the area where the profile was obtained; 3) there was a component of subsidence along the footwall of the fault, and; 4) post-event erosion of the parent channel may have occurred when the flow of the Waiau Toa | Clarence river was rerouted into the parent channel for ~ 4 months when a stopbank was constructed across the avulsion node. All of these factors may contribute the ~ 2.0 m difference in channel elevation (when accounting for ~ 6.5 m of throw), which may influence our depth calculations to a small degree. While our D_Q calculation may be slightly different than actual, the relative difference between different discharges should yield the same relationship displayed in Fig. 7.