KARAKATUWHERO RIVER MEAN BED LEVEL TRENDS; 1968 TO 2015.

1.0 Introduction:

This is one of a series of reports on East Coast river/stream bed level trends, commissioned by the Environmental section and the (former) Roading section of the Gisborne District Council.

The following trends in mean bed levels have been derived from cross section surveys by the former East Cape Catchment Board and the Gisborne District Council, commencing in 1968.
"*Mean bed levels*" has a specific meaning in relation to braided rivers on the east coast, and a full definition is provided in the Addendum.

Cross section surveys are only a "snapshot" of the river bed levels at a specific location on a particular day. Because of the movement of bed load material in "waves" during floods and freshes, there are frequent naturally occurring fluctuations in mean bed levels. This report does not investigate the impact of individual storms on the catchment.

The active bed limits for the Karakatuwhero River surveyed before 2003 have not been recorded in the survey notes and have had to be assessed. Some of the apparent "instability" in the MBL plots may be due to inaccuracies in the active bed limit measurements, which limits the interpretation of these plots.

2.0 The Karakatuwhero River catchment:

The Karakatuwhero River has a catchment area of 83.5 square kilometres and is some 16.5 kilometres long, excluding the two tributary steams, the Tapatu and the Onematariki; see Figure 1. The highest peak in this rugged catchment, Pukeamaru, is 990m above mean sea level.

There are three distinctively different lithological associations within this catchment. To the south of the Karakatuwhero River and west of Onematariki Stream channel the geology consists of sedimentary lithologies comprising the Tapuwaeroa and Tikihore Formations of Cretaceous age. To the north of the Karakatuwhero River and east of Onematariki Stream channel the underlying lithology consists of undifferentiated volcanics referred to as the Matakoa Volcanics. Separating these contrasting lithologies is a thin zone of melange containing a mixture of Cretaceous and Early Miocene aged lithologies. The alignment of the Onematariki Stream and Karakatuwhero River channels coincides with the outcropping melange.

3.0 Executive Summary:

The Karakatuwhero River catchment differs from all other East Coast river systems in that a significant proportion of its watershed is underlain with volcanic, as opposed to sedimentary lithologies. Nonetheless, most of the sediment has been derived from the eroding upper part of the catchment underlain by sedimentary lithologies thus the composition of the sandstone-dominated bedload reflects this. Additionally, a fault contact separating these contrasting lithologies has essentially dictated the alignment of the Onematariki Stream and main channel of the Karakatuwhero River.

At the most upstream cross section, EC612, bed levels changed significantly between 1968 and 1980, with a sudden increase of about 400mm from 1975 to 1976, dropping down again to approximate the bed level as at 1980. Since 1980 mean bed levels have risen at the moderate average rate of 51mms per year up to 2003.
Storms in 1980, 1982 (Cyclone Bernie), 1988 (Cyclone Bola) and in 1991 likely resulted in a major and ongoing influx of sediment resulting in aggradation in the main channel.

Mean bed levels at EC608, EC609 and EC612 all trend upwards between 1982 and 1993, while the trend at the most downstream cross section, EC607, over this period is gradually downward.

Over the last period, 2003 to 2015, mean bed levels at all cross sections (with the exception of EC610) show that the river bed appears to be degrading. In the absence of more recent sediment-generating storms the channel in both the upper EC612 and lower reaches EC607-609 are showing signs of sediment exhaustion and thus degradation.

The impact of shingle extraction on mean bed levels is difficult to quantify, however with mean bed levels degrading at four of the five cross sections over the last period (2003 to 2015), and an average 8600 m3 being excavated annually between 2002 and 2011, shingle extraction is likely to be having an impact, at least at EC607.

Because of the harder lithology of much of the Karakatuwhero River catchment, the volume of bed load material transported is expected to be substantially less than in another catchment of similar area in a mudstone lithology, hence this shingle resource should be carefully monitored and excavation limited.

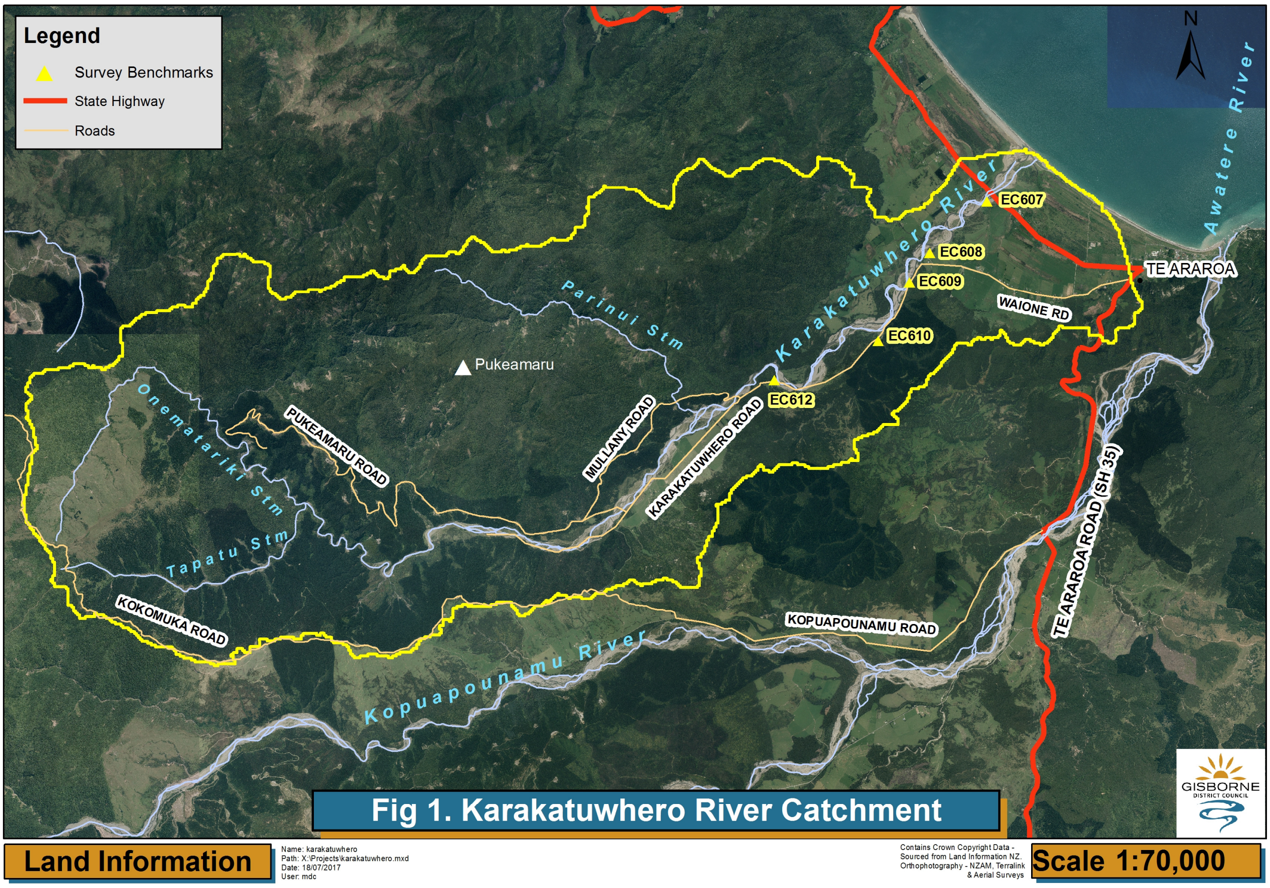


Fig 1. Karakatuwhero River Catchment

4.0 River bed load material grading:

Figure 2 shows a reach of the upper Karakatuwhero River, some 10 kilometres from the mouth. The river bed material in this steeply graded reach consists mainly of quite angular cobbles and small boulders, although there is finer bed load material deposited in side beaches and backwaters. Compare this with the much finer bed material visible in Figure 3.

The bedload of the Karakatuwhero River channel should comprise predominantly sedimentary sandstone while the more resistant and less erodible basaltic lithologies are likely to be a minor component of the bedload. The fines will have been derived by attrition of the less resistant sedimentary mudstones, and from the fine-grained melange; see also chapter 5.0.

Fig. 2: *P. Murphy next to the upper Karakatuwhero River; approx. 4kms upstream of EC612. Photo: D Peacock, 15th March 2017.*

Fig. 3: *Lower Karakatuwhero River; view upstream of SH35 bridge, in the vicinity of EC607. Photo; D Peacock, 15th March 2017.*

5.0 Shingle Extraction:

The following table shows the recorded annual volumes of shingle extracted from various sites on the Karakatuwhero River since 2001:

Year	Volume Extracted m3 at Permit Site No/s:	Volume Extracted m3 at Permit Site No/s:	Volume Extracted m3 at Permit Site No/s:
	LS 106047 & LS 106067	RS 197007 & RS 206017	LS 107162
2001			
2002		6,500	
2003		9,000	
2004		7,700	
2005		12,000	
2006		7,000	
2007		7,000	
2008		13,885	
2009		14,931	
2010			
2011		8,208	
2012			
2013			
2014	496		
2015	1300		
2016	168		1,671
TOTALS:	**1,964 m3**	**86,224 m3**	**1,671 m3**

Permit sites LS 106047 and LS 106067 are close together and approximately 4.6 kms upstream of EC612. Because of the distance and the relatively small quantities excavated, in the opinion of the author it is unlikely to have had much impact on mean bed levels at cross section EC612.

Permit sites RS 197007 and RS 206017 appear to be on the same gravel beach, about 400 to 500 metres upstream of EC607. The average quantity of shingle extracted over the ten year period, 2002 to 2011 inclusive, is 8,622 m3 per annum. This could be expected to have lowered mean bed levels at cross section EC607, particularly between 2005 and 2009.

Permit site LS 107162 is located in the same reach/bend as cross section EC608.
This could potentially have an impact on the results of the next survey at this site.

Dr M Marden has provided a full description of the lithology that the stream transverses in item 5 of the Addendum.

5.0 Karakatuwhero River Mean Bed Level Plots:

EC612 is the most upstream bench mark, some 6.25 kms from the sea. The total river length is 16.5 kms, (excluding the upstream tributaries), so the five cross sections are all in the lower Karakatuwhero River.

The plot of mean bed levels at EC612 in Figure 4 is the only plot which covers the whole period from 1968 to 2015. Bed levels change significantly between 1968 and 1980, with a sudden increase of about 400mm from 1975 to 1976, dropping down again to 1980. Since 1980 mean bed levels have risen at the moderate average rate of 51mms per year up to 2003.

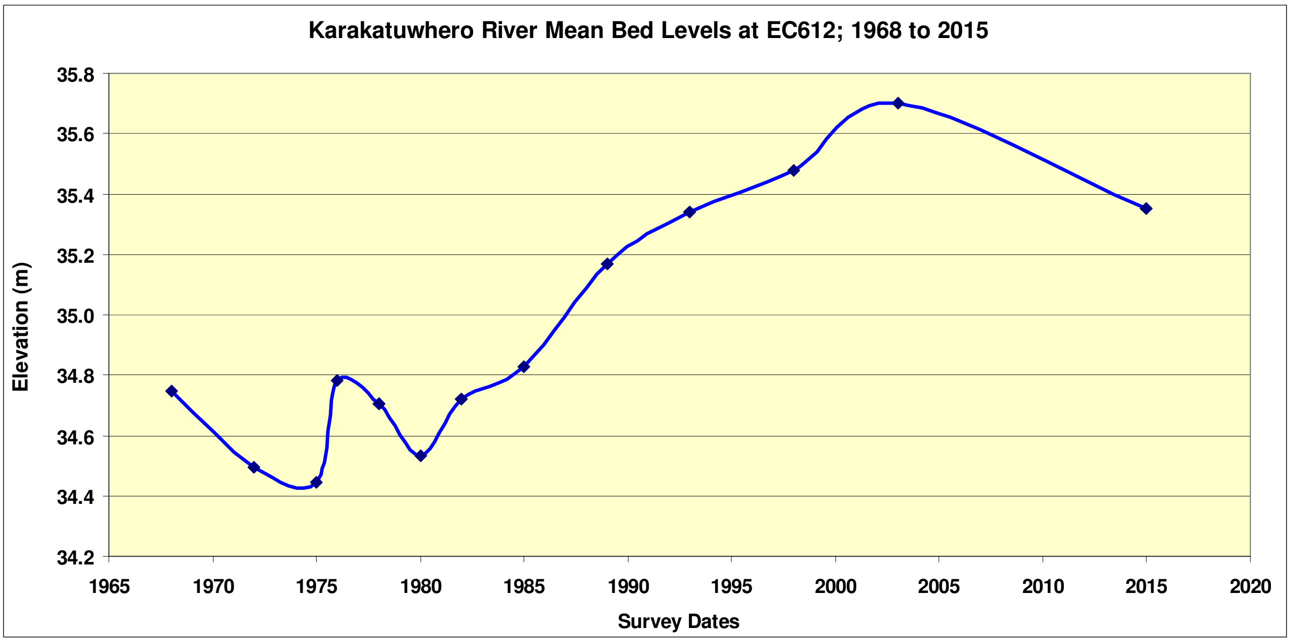


Fig. 4

Most sediment generated during storms was likely derived from the indigenous forest areas in the steeper upper catchment, and from the unforested Tapatu sub-catchment (not planted until about 2000) within which there were numerous linear gullies generating sediment and resulting in significant bedload widening rather than from the exotic forest areas much of which is on the lower and less steep slopes. Additionally, most of the sediment was derived from the Onematariki and Tapatu sub-catchments underlain with the more easily erodible sedimentary sandstones and mudstones, and where there are significant areas of visible bare eroding slopes.

While numerous landslide scars are also apparent in the Parinui sub-catchment draining the Pukeamaru Range, the volumes of sediment generated appear to be small. Thus the bedload of the Karakatuwhero River channel should comprise predominantly sedimentary sandstone while the more resistant and less erodible basaltic lithologies eroded from the Pukeamaru Range are likely to be a minor component of the bedload. The fines will have been derived by attrition of the less resistant sedimentary mudstones, and from the fine-grained melange.

Between 2003 and 2015 men bed levels have decreased by some 350 mms. Some 1300 m^3 of bedload material has been excavated from a beach 4.6 kms upstream of EC612 in January 2015, which may have interrupted the transport of bed load material downstream. The 2015 cross section survey was carried out in December 2015, but in the opinion of the author this is not likely to have affected the survey results significantly.

Figure 5 is a plot of all five cross section mean bed levels. The plot at EC612 is at the correct elevation, but the remaining four plots have been adjusted upward in elevation so that they can be conveniently compared.

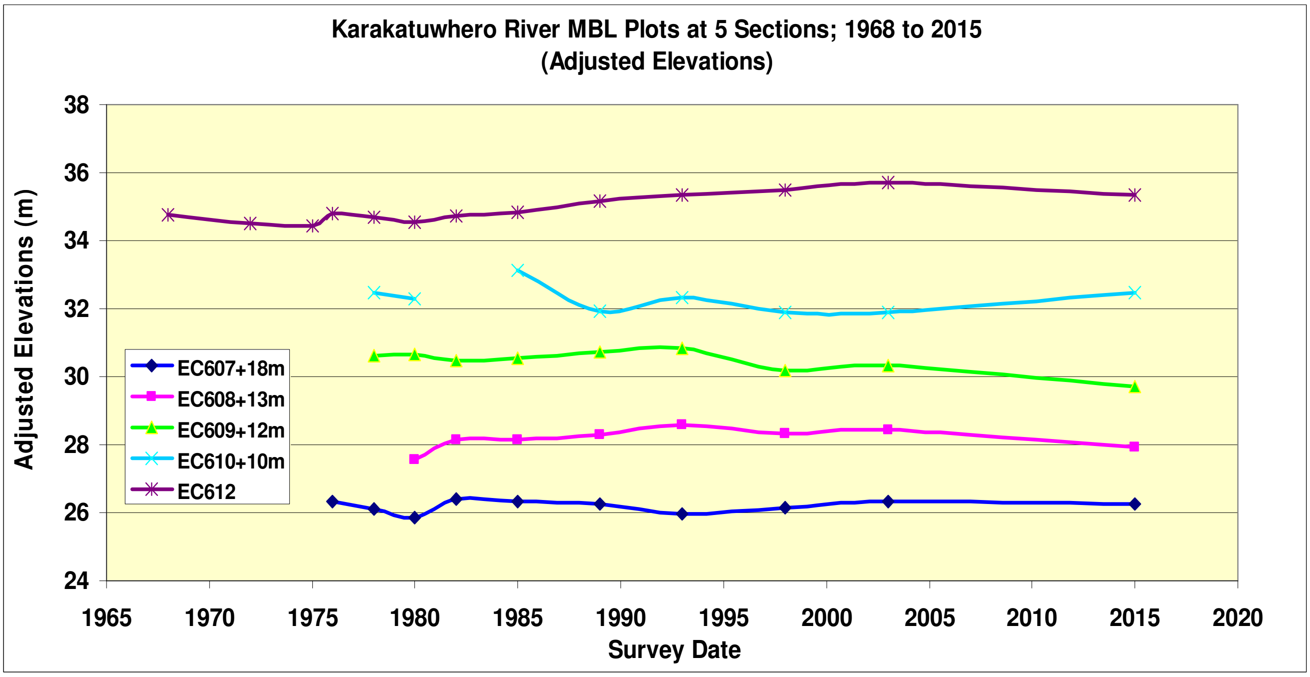


Fig. 5

The sudden aggradation of the river bed at EC612 between 1976 and 1977 may have been reflected somewhat later (1980 to 1982) further downstream at EC608 and EC607, however EC609 and 610 do not follow this trend. Mean bed levels at EC608, EC609 and EC612 all trend upwards between 1982 and 1993, while the trend at the most downstream cross section, EC607, over this period is gradually downward. The author is aware of an intense localised storm in 1991, which together with earlier storms, caused significant damage to this catchment and may well have contributed to an increase in bed load material reaching the river channel.

There is evidence that the storms in 1988 (Bola) and 1991 clearly resulted in a major and ongoing influx of sediment resulting in aggradation in the main channel. The most dramatic and earliest response shows up at the uppermost cross section, EC612 (mid catchment), but then a delay in time would be expected before the aggradation response shows up in the lower sections. Also, as sediment is constantly winnowed over time and exported as suspended sediment, and bedload sediment is stored as gravel beaches and in backwater swamps, then less bedload reached the downstream sections thus further downstream changes in bedload elevation are less dramatic.

The influence of reforestation (about 2000) in Tapatu sub-catchment likely helped slow the development and expansion of the linear gullies and thus slowed the rate of sediment generation following planting, however, as previously stated most of the sediment already in the channel at this time was likely generated by storms in 1988 and 1991, or earlier. The planting of areas of exotic forest along the base of the Pukeamaru Range is unlikely to have resulted in a significant decrease in sediment generation, and similarly the subsequent more recent harvesting of these areas is unlikely to have resulted in an increase in sediment generation, thus neither of these activities have had any influence on the behaviour of the Karakatuwhero River channel.

Over the last period, 2003 to 2015, the plot at EC610 appears to be somewhat different to the other plots, as the bed is aggrading; whereas bed levels at the other four cross sections are all degrading.

From an examination of Google Earth aerials, the main channel in 2002 and 2004 is wide and shows evidence of continued sediment working and accumulation down to section EC610 (the toe of the gravel wave), whereas in the 2016 imagery a lot of the gravel beaches have become backwater areas and have vegetated-over, thus the active channel has narrowed considerably. This possibly reflects the diminishing supply of sediment from the headwaters, the locking up of large quantities of sediment in numerous storage areas (backwater swamps) all the way down the main channel, and in the absence of more recent sediment-generating storms the channel at EC612 is showing signs of sediment exhaustion. Additionally, in the absence of the replenishment of coarse bedload reaching the lower reaches EC607-609, and as a result of the rapid attrition of the bedload (downstream-fining), the finer-grained bedload is readily transported through these reaches. With minimal deposition, more so on the berms, the channel is able to degrade.

6.0 Conclusions:

- Some of the apparent "instability" in the MBL plots may be due to inaccuracies in the active bed limit measurements, which limits the reliability of these mean bed level trends.
- The impact of shingle extraction on mean bed levels is difficult to quantify, however with mean bed levels degrading at four of the five cross sections over the last period (2003 to 2015), and an average 8600 m3 being excavated annually between 2002 and 2011, shingle extraction is likely to be having an impact, at least at EC607;
- Because of the harder lithology of much of the Karakatuwhero River catchment, the volume of bed load material transported is expected to be substantially less than in another catchments of similar area in a mudstone lithology, hence this shingle resource should be carefully monitored and excavation limited.

9.0 Recommendations:
It is recommended that:

1. Cross section surveys are carried out in the future at the same sites over the 2017/18 summer and thereafter at two yearly intervals**;**
2. Shingle extraction operations must be kept well clear of cross section bench marks.

NB: *Recommendation 1 should be subject to further review when survey methods using the latest available technology; ie drone surveys and DEM's, have been appraised for use on all of the East coast rivers.*

Acknowledgements:

- Ian Hughes and Brian Currie; for providing a continuous high quality survey record for the past 48 years;
- Mark Cockburn for the preparation of Figure 1;
- Paul Murphy for checking and commenting on the draft report;
- Dr. J Tunnicliffe, Environmental Science Dept; University of Auckland; for preparation of items 1 to 3 in the addendum;

Prepared by:
D Peacock and Dr M Marden;
2nd September 2017**.**

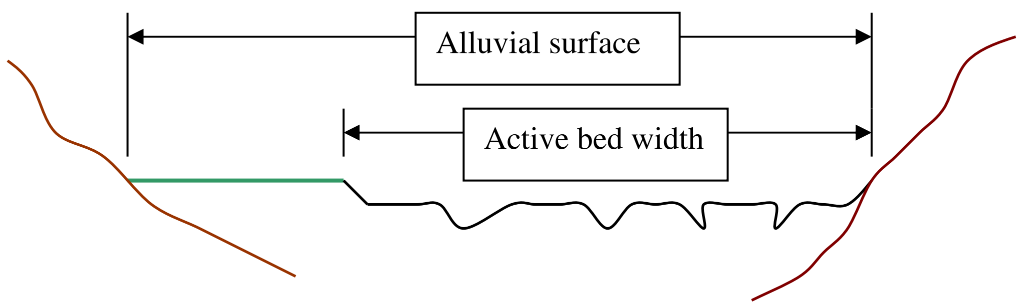
ADDENDUM

The following definitions and explanations have been provided to clarify the terms used in this report. Items 1 & 2 have been kindly provided by Dr Jon Tunicliffe; while item 5 has been prepared by Dr Mike Marden.

1. Mean river bed level:
"In the context of actively braiding or anabranching rivers found in the East Cape, ***mean river bed level*** refers to the average topographic elevation across multiple channels (including bed and banks) and the actively reworked (non-vegetated) alluvial surfaces, such as bars and braidplains. Changes to the mean bed elevation across this active transport corridor reflects adjustments to reach-wide sediment storage over time.

2. Reach:
A ***reach*** is length of river, typically constituting several meander wavelengths, with relatively homogenous governing conditions, e.g. discharge, channel geometry and floodplain extent."

3. Alluvial surface and active bed width:



The above diagram (not to scale), shows the ***alluvial surface*** for a braided river bed and the ***active bed width*** as measured by the cross section surveys. The green coloured terrace on the left of the diagram represents a terrace with vegetation at least one year old which is no longer considered to be part of the active river bed. ***Mean bed levels*** are computed for each cross section from the mean of all the levels taken within the active bed width.

4. Aggradation rates chart:

The following chart applies only to rivers/streams in the Waiapu catchment or the upper Waipaoa catchment.

Aggradation Rate mm/yr	Descriptive term
0 to 9	Negligible
10 to 29	Gradual
30 to 99	Moderate
100 to 199	Rapid
200 to 499	Very rapid
>500	Extreme

5. Karakatuwhero River catchment lithologies:

The following explanation has been prepared by Dr M Marden, Marden Properties Ltd, Gisborne:

There are three distinctively different lithological associations within this catchment. To the south of Karakatuwhero River and west of Onematariki Stream channel the lithologies comprise fossiliferous, sandstone- dominated, alternating sandstone and mudstone with minor conglomerate and breccia (Tapuwaeroa Formation), and centimetre to metre-bedded sandstone and mudstone, minor red and green mudstones, breccia and rare basalts (Tikihore Formation) of Cretaceous age. To the north of the Karakatuwhero River and east of Onematariki Stream channel the underlying lithology consists of undifferentiated volcanics comprising mainly submarine basaltic lava, pillow lava, tuff with subvolcanic intrusives of basalt, dolerite and gabbro collectively referred to as the Matakoa Volcanics. Separating these contrasting lithologies is a thin zone of melange containing a mixture of Cretaceous and Early Miocene aged lithologies within a sheared matrix of smectitic mudstone probably formed due to diapirism in Late Miocene and Holocene times. The alignment of the Onematariki stream and Karakatuwhero River channels coincides with the outcropping melange.