PEACOCK D H LIMITED

GST Reg No 97918708 email: dave2mar@gmail.com Mob: 021 02465899

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MAKARIKA STREAM MEAN BED LEVEL TRENDS; 1958 TO 2017.

1.0 Introduction:

This is one of a series of reports on river bed level trends in the Waiapu catchment, Ruatoria, 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 1958. Trends have been assessed starting at the most upstream cross section, EC518, approximately 21 kilometres upstream of the confluence with the Mata River. "*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. While long term trends in mean bed levels are reasonably reliable indicators of bed level change, shorter term trends (ie; from surveys over ten years or less) are not reliable and it would be unwise to rely on these surveys alone.

2.0 The Makarika stream catchment:

The Makarika stream runs approximately parallel to SH35 from Te Puia to its confluence with the Mata River, a short distance west of Ruatoria; see figure 1. The stream is approximately 28 kilometres in length, and has a catchment area of 80.9 square kilometres.

3.0 Executive Summary:

River bed aggradation rates at the two cross sections has been "moderate" up until circa 1988, and since then the rate has slowed; this slowing of the aggradation rate is likely attributable to reforestation of many of the smaller gully systems from which sediment supply has all but ceased within a period of one rotation of forest.

Extensive gullying in the headwaters of an unnamed tributary stream, which joins the Makarika stream left bank about 5 kilometres upstream of EC524, is the largest of the untreated gully systems and is currently the most significant source of sediment input into the Makarika stream channel.
This and other active gullying systems which have yet to be reforested provide sediment input to the Makarika stream, and for this reason monitoring of mean bed levels should continue;

Shingle extraction totalling some 10,000 m3 has taken place near Ihungia Road Bridge between 2006 and 2012, but is most unlikely to have had any significant impact on mean bed levels. However, if the Ihungia Road bridge site is to be used regularly in the future for shingle extraction the impact on the stream mean bed levels could best be monitored from new cross sections upstream and downstream of the site.

Because of the poor quality of the bed load material downstream of Makarika Road bridge, no shingle has been extracted here in the past and it is most unlikely that shingle will be extracted from this reach of the river in the future.

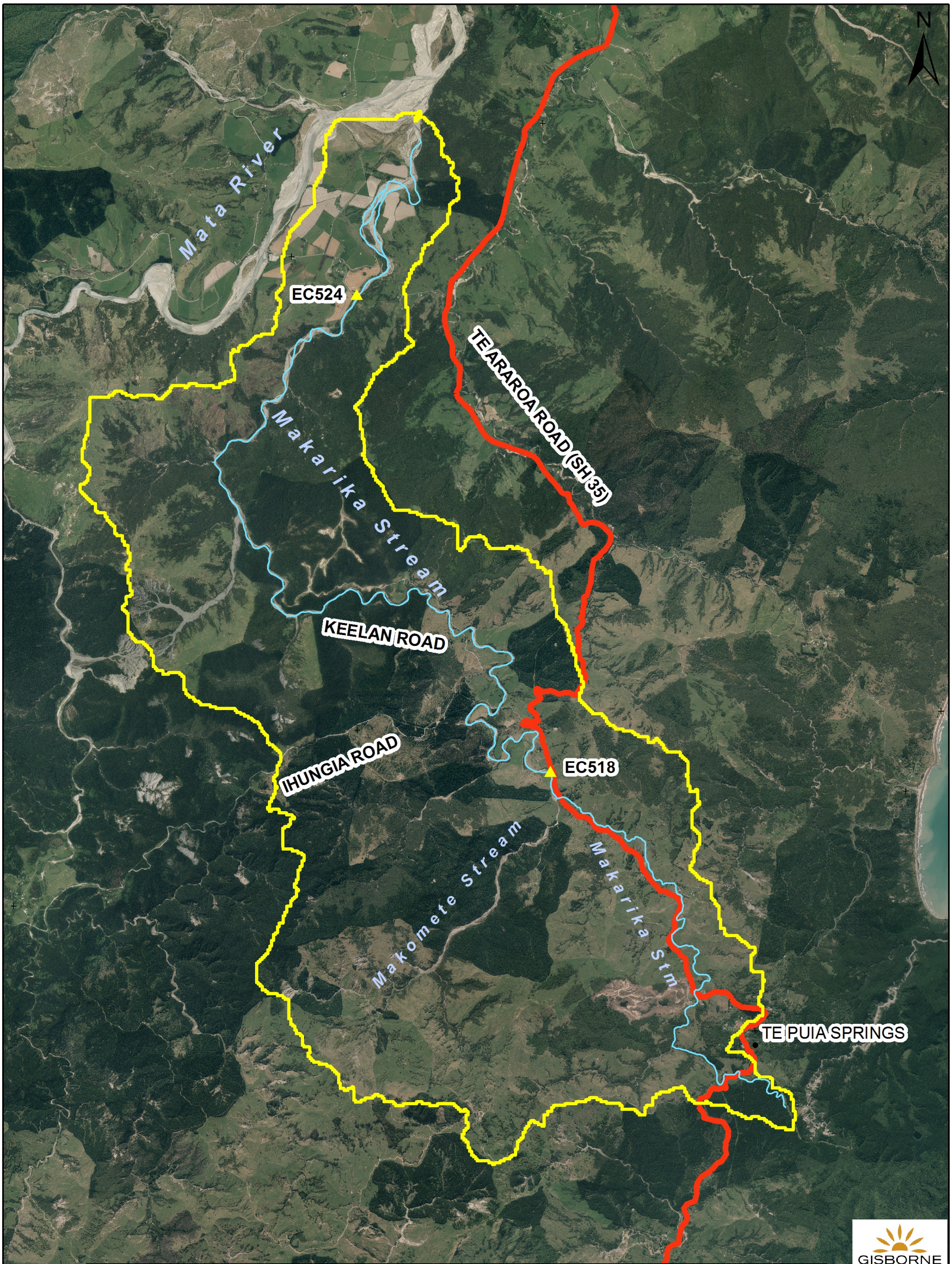


Fig 1. Makarika Stream Catchment

Land Information

Name: makarika
Path: X:\Projects\makarika.mxd
Date: 25/05/2017
User: mdc

Scale 1:75,000

4.0 River bed load material grading:

The Makarika stream has a much finer bed load grain size than the much larger Mata River which is in the adjacent catchment to the west; see Figures 2 and 3. The reason for this lies in the different lithologies of the two catchments, as described by Dr M Marden in item 5 of the Addendum.

Fig. 2: *Makarika stream bed downstream of Makarika Road bridge;
Photo: I Hughes.*

Fig. 3: *Makarika stream bed downstream of Ihungia Road bridge
Photo: D Peacock; 15th March 2017.*

5.0 Shingle extraction operations:
The only shingle extraction records available from the Gisborne District Council were for the years shown in Table 1:

Table 1: GDC Shingle Extraction records; 2001 to 2016.

Year	Shingle Permit No.	Location of Permit	Volume Extracted (m3)
2006	RS202008	100 to 200m upstream of Ihungia Rd bridge	700
2007	RS202008	100 to 200m upstream of Ihungia Rd bridge	4040
2009	RS207006	100 to 200m upstream of Ihungia Rd bridge	1525
2012	RS207006	100 to 200m upstream of Ihungia Rd bridge	3404
2013	LS106043	300 to 400m upstream of EC518	700
			Total: 10,369 m3

Some 9,700 m3 of shingle has been extracted over the seven year period between 2006 and 2012 from the site 100 to 200 metres upstream of Ihungia Road bridge, with a maximum annual volume of 4040 m3 in 2007. It may be tempting to explain the flat MBL curves at both EC518 and EC524 between 2002 and 2012 as being the result of the shingle extractions. However there have not been enough surveys over this period to confirm whether this is the case, and the relatively modest quantities of shingle removed and the distance of the Ihungia bridge shingle extraction site from either EC518 (4.2 km) or EC524 (13.3 km) make this possibility unlikely.

Even if there was no additional bedload input into the stream channel upstream of Ihungia Road bridge, given the normal frequency of floods and freshes the excavated area would rapidly infill with reworked bedload material from the channel upstream. Based on the 4.2 km channel length between Ihungia Road bridge and EC518 and an average channel width of 25 metres, the infilling of the 4040 m3 excavation would lower the channel by only 38 mms if it is averaged over this distance. However the drop in mean bed level would be a maximum at the shingle extraction site, and would taper off upstream. In the opinion of the author the drop in mean bed level would be insignificant at EC518.

If however the Ihungia Road bridge site is to be used regularly in the future for shingle extraction, the the impact on the stream mean bed levels could best be monitored from new cross sections upstream and downstream of the site.

No shingle has been extracted downstream of Makarika Road bridge in the past, according to GDC records since 2001. This is undoubtedly because of the smaller grain size and poor quality of the bedload material; see Chapt. 4.

6.0 Mean bed level plots:

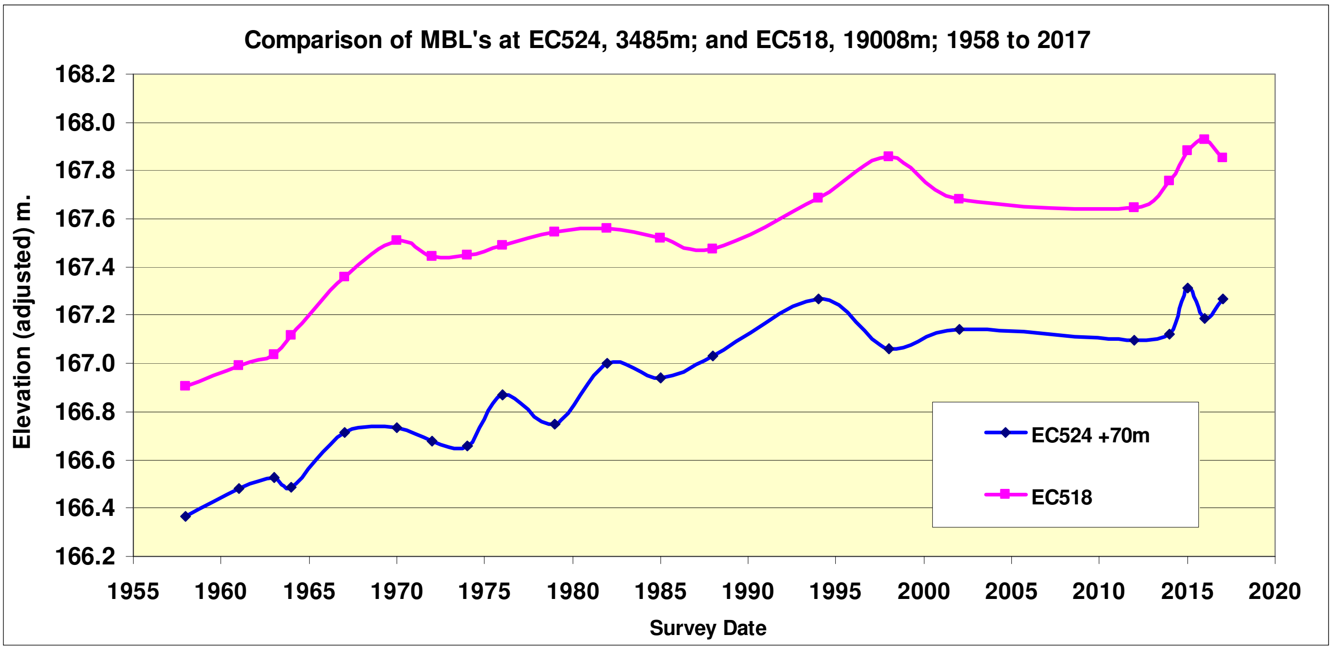


Fig. 4

Figure 4 above, shows mean bed levels for the two cross sections plotted together. The plot for EC518 is at the correct elevation, but the plot at EC524 has been adjusted upwards 70 metres, so that the curves can be conveniently compared.

The distance between EC524 and EC518 has been measured as 17.5 kms on Google Earth aerial photography (dated January 2015). If the 3485m distance of EC524 from the confluence with the Mata River is correct (which it appears to be), then EC518 would be at a distance of 20,985m, not 19008m as in the survey records. This discrepancy of about 2 kilometres may be due in part to increasing sinuosity of the upper stream course, or may be an error in the early channel length measurements, or both.

Despite the two cross sections being a distance of 17.5 kilometres apart, the two plots are remarkably similar in shape.

Mean bed levels at **EC518** have risen between 1958 and 1970, at a (moderate) average rate of 50.5 mm/year. Dr M Marden explains as follows: *This rise in mean bed level is likely a result of storm events in 1957 and during the 1960s which initiated gullies and reactivated earthflow movement producing significant quantities of sediment. Thereafter the main channel stabilised and remained almost unchanged until 1988. Cyclone Bola once again reactivated earthflows, initiated new gullies, and enlarged existing gullies which at this time remained unforested. The result was an injection of new sediment to the riverbed to produce a peak in mean bed level at around year 1998.*

The changes in mean bed levels since 1998 are not large, or sustained over long periods, and are therefore more difficult to attribute to any specific cause/s. The impact floods/freshes may have had on mean bed levels over this period is also unknown. However Dr Marden explains the likely reasons for these changes as follows; *Reforestation in the catchment upstream of EC518 occurred after Cyclone Bola (~year 2000), and together with scrub reversion in many of the smaller gullies likely slowed the rate of sediment supply over the next 10-year period, and allowed the main stream bed to degrade by about 200mm. The increased aggradation rate by 200 to 300mm at EC518 over the past five years is likely due to the combined effects of recent storms remobilising bedload generated during previous storm events, and temporarily stored in Makomete Stream, to the main Makarika Stream channel, and continued sediment input from three major gullies upstream of this cross section that remain untreated.*

Note that the extraction of some 10,000 m3 of shingle over the period 2006 to 2012 near Ihungia Road bridge is unlikely to have had any significant effect on bed levels at EC518; see Chapt. 5.

Mean bed levels at **EC524** generally follow the shape of the mean bed level plot at EC518; which suggests that the hydraulic regime and input from sediment sources from the much larger catchment downstream of EC518 are influenced by much the same factors as for the smaller catchment upstream of EC518. The main differences between the two plots are:

(i) The smoother mean bed level curve at EC518 between 1972 and 1988. The plot at EC524 shows mean bed levels alternately increasing and decreasing between successive surveys, probably because during storm events the influxes of sediment from the largest gullies present in this catchment (Fig. 5) would be more significant than that from the smaller gullies upstream of EC518. Alternatively, the fluctuations in mean bed level at EC524 between 1972 and 1988 may simply reflect the movement of bed load material in the stream channel as "waves" during floods and freshes.

(ii) The increase in mean bed level at EC524 had reversed post-1994, some four years earlier than at EC518. According to Dr Marden, this is because reforestation downstream of EC518 occurred earlier than in the upper catchment; it was more extensive, it enclosed more gullies, and thus the sediment generation rate decreased sooner than in the upper catchment.

Fig. 5; *Gullies in headwaters of tributary; October 2011. Makarika stream at top right of photo.*

Figure 5 shows extensive gullying in the headwaters of an unnamed tributary stream, which joins the Makarika stream left bank about 5 kilometres upstream of EC524.

According to Dr M Marden, this gully system is the largest of the untreated gully systems and is currently the most significant source of sediment input into the Makarika stream channel.

On the right bank, upstream of the confluence of the unnamed tributary and the Makarika stream, aerial photography shows that an area of some 3 to 4 square kilometres of exotic forest has been cut down between 2011 and 2015. Whether this area has been or will be replanted is unknown, and it is too early to tell whether there is likely to be any resultant impact from sediment and slash input into Makarika stream.

7.0 Conclusions:

- Despite the cross sections at EC518 and EC524 being a distance of 15.5 kilometres apart, the two plots are remarkably similar in shape;
- River bed aggradation rates at the two cross sections has been “moderate” up until circa 1988, and since then the rate has slowed; this slowing of the aggradation rate is likely attributable to reforestation of many of the smaller gully systems from which sediment supply has all but ceased within a period of one rotation of forest (~27 years).
- There remain extensive and active gullying systems providing sediment input to the Makarika stream which have yet to be reforested, and for this reason monitoring of mean bed levels should continue;
- Shingle extraction totalling some 10,000 m3 has taken place near Ihungia Road Bridge between 2006 and 2012, but is unlikely to have had any significant impact on mean bed levels 4.2 kms upstream at cross section EC518, and even less likely 13.3 kms downstream at EC524;
- If the Ihungia Road bridge site is to be used regularly in the future for shingle extraction the impact on the stream mean bed levels could best be monitored from new cross sections upstream and downstream of the site;
- Because of the poor quality of the bed load material downstream of EC524, no shingle has been extracted here in the past and it is most unlikely that shingle will be extracted from this reach of the river in the future;
- Whilst the long term mean bed level trends are reasonably accurate, shorter term trends ie; over 10 years or less, are not considered as reliable.

Recommendations:
It is recommended that:

1. Cross section surveys are carried out in the future at the same sites at two yearly intervals**;**
2. If the Ihungia Road bridge site is likely to be used regularly in the future for shingle extraction new cross sections upstream and downstream of the site should be established.

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 Waiapu catchment rivers.*

Acknowledgements:

- Ian Hughes and Brian Currie; for providing a continuous high quality survey record for the past 59 years;
- Mark Cockburn for the preparation of Figure 1;
- Dr. M Marden, for comments on the effect of reforestation, and for item 5 in the addendum.
- Paul Murphy for checking and commenting on the draft reports;
- Dr. J Tunnicliffe, Environmental Science Dept; University of Auckland; for preparation of items 1 to 3 in the addendum;

Prepared by:
D H Peacock;
29th May 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.

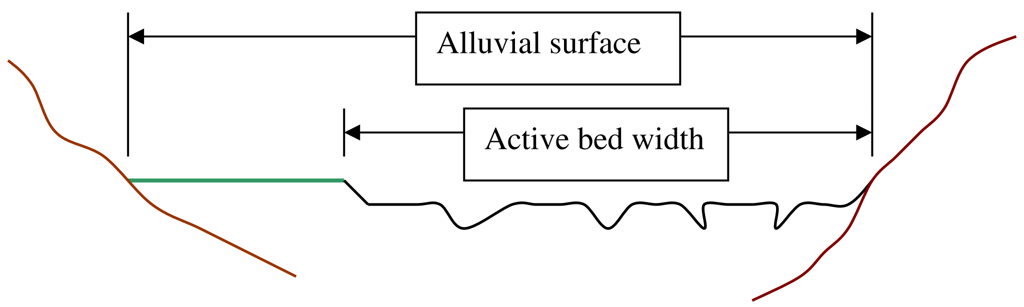
1. Mean river bed level:

"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. Makarika catchment lithologies:

The following explanation has been kindly prepared by Dr M Marden, Landcare Research, Gisborne:

The bedrock underlying the majority of the Makarika catchment is collectively called the Mokoiwi Formation. It consists of thin bedded (centimetre to meter thick beds) of alternating mid-grey sandstone and dark blue to black mudstone, typically highly tectonised. These are interspersed with slivers of in-faulted lithologies belonging to the Tikihore and Whangai Formations of similarly fine-grained sandstones and mudstones, and melange (Mazengarb and Speden, 2000). All these lithologies have been locally folded and faulted resulting in disrupted bedding and loss of coherence which makes them susceptible to erosion, particularly to gullying.

The fine-grained texture of the bedload (pebble, sand and silt-sized particles) in this catchment is in keeping with other rivers that drain the same mix of fine-grained, disaggregated lithologies with similar high rates of attrition and downstream fining. This contrasts with the bedload of the Mata River which drains a significant area of thicker-bedded, younger-aged and therefore less tectonically disrupted lithologies, thus the bedload is coarser (cobble to boulder-sized). The coarser bedload is also less mobile and attrition rates are lower, thus downstream fining is less evident.