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MANGAOPORO RIVER MEAN BED LEVEL TRENDS; 1958 TO 2015.

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, approximately 13.3 kilometres upstream of the confluence with the Waiapu 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.

It has not been possible to calculate reliable volumetric data for the various reaches from the available cross section data (as has been done for the Raparapaririki and the Waiorongomai), as the cross sections are too far apart and there is a large variation in river bed width between sections.

Fig 1. Mangaoporo River Catchment

2.0 The Mangaoporo River catchment:

Figure 1 shows the 72.6 km2 Mangaoporo River catchment. The Mangaoporo River has its headwaters on the eastern flank of Raukumara, and flows in a south easterly direction some 23 kilometres to its confluence with the Waiapu River, where it disgorges its bed load into a massive shingle fan.

3.0 Executive Summary:

The mean bed level trends in this report cover only the lower half of the Mangaoporo river channel where the surveyed cross sections are located, as shown in Fig.1. This surveyed length of the river can be divided into three reaches, each with different characteristics. Firstly, the upstream reach between EC545 and EC 543 has a wide braided floodplain, followed by a narrow single thread reach between EC543 and EC542, and finally another (even wider) depositional zone and shingle fan between EC542 and the Waiapu river.

In the *upstream reach*, EC545 to EC543, aggradation of the river bed has been rapid (averaging 140 mm/yr) at the most upstream section EC545, and moderate (48 mm/yr) at the next downstream section EC544. However these two cross sections EC545 and EC544 do not include data since 1998 and 1988 respectively.

In the *narrow reach*, EC543 to EC542, the average aggradation rates from 1958 to 2015 have been in the “gradual” range, viz; 18 to 21 mm/yr, probably reflecting the fact that this is a bed load “transfer zone” rather than a depositional zone. Mean bed levels at EC543 have remained virtually the same since 2007; but mean bed levels at EC542 buck the trend however, with an average aggradation rate of 14 mm/yr since 2002.

Mean bed level data for this relatively narrow reach of the river show a curious phenomenon over the 30 year period between 1982 and 2012, in that for each 3 to 5 year period between surveys, the mean bed level has increased at one cross section while it has decreased at the other, or vice-versa. This suggests that the surveys are picking up peaks or troughs of waves of bed load material being transported downstream. These fluctuations in mean bed level demonstrate that the mean bed level trends over relatively short periods, eg; three surveys over the past ten years, are not reliable and it would be unwise to rely on them alone to inform Council policy.

In the *downstream reach*, EC541 to EC540, the average aggradation rates since 1958 have been gradual (18 to 23 mm/yr), however because the river bed is so wide here this represents a tremendous volume of bed load material being deposited in this reach of the Mangaoporo River, including a vast shingle fan at the confluence of the two rivers which measures up to 1.5 kilometres wide and extends into the Waiapu River by some 430 metres.

Figure 2, prepared by Dr J Tunnicliffe, shows diagrammatically the rate of aggradation at the six cross sections and the dramatic changes in the extent of the alluvial surface between the lower floodplain, the transfer zone and the upper floodplain.

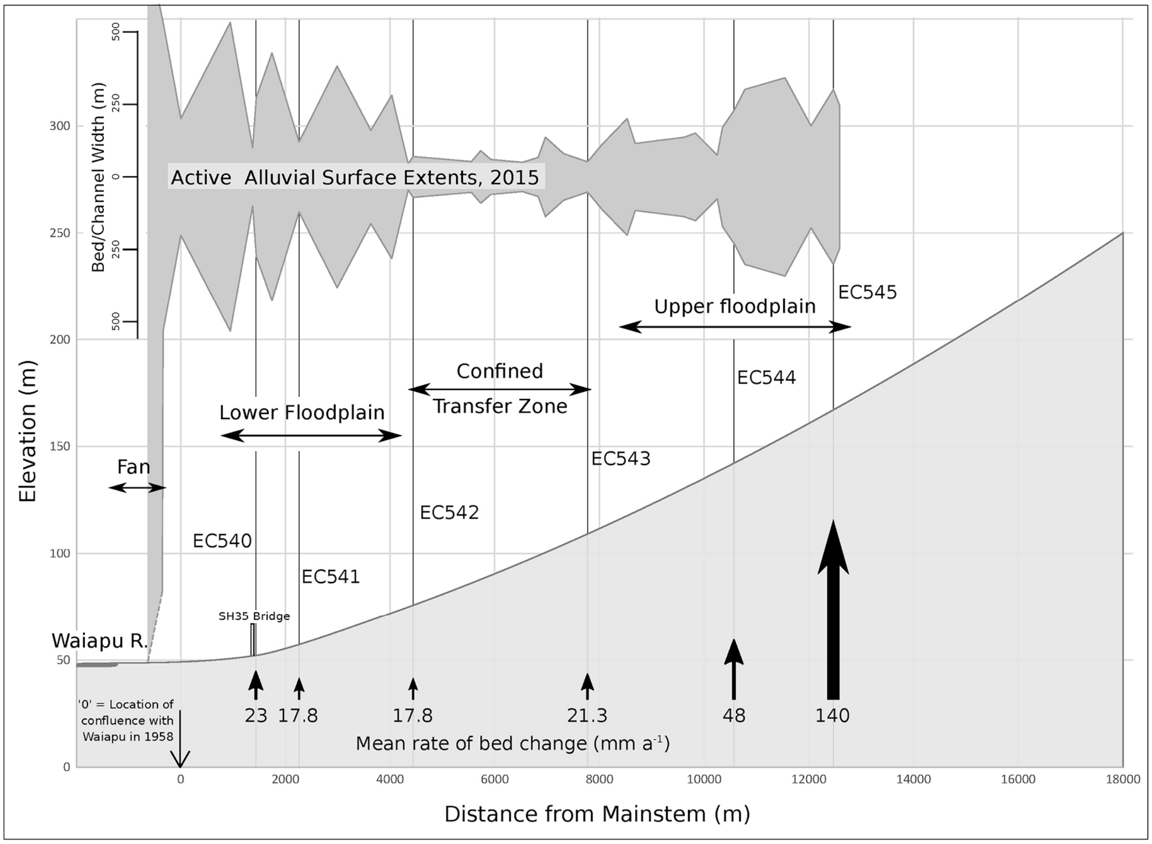


Figure 2: Longitudinal profile of the Mangaoporo River, showing cross-section locations and the planform extents of the active alluvial surface. The mean rate of bed-level change over the course of the survey record is indicated by arrows.

4.0 Mean bed levels at the cross sections:

EC545; 12,530m:

This is the most upstream cross section, 12.53 kilometres from the confluence with the Waiapu river, circa 1958; see Figure 1. Unfortunately the bench mark at this section was destroyed and the last available survey was in 1998. Over the 30 year period 1958 to 1998, mean bed levels rose by 4.21m at an average rate of 140 mm/yr. The (red) trend line in Fig. 3 shows that the rate of aggradation is gradually reducing with time. (This slightly convex trendline is a 2^{nd} order polynomial, and is virtually the same shape as a 3^{rd} order polynomial).

The width of the active river bed at this cross section has increased from 173 metres in 1958 to 226 metres in 1998.

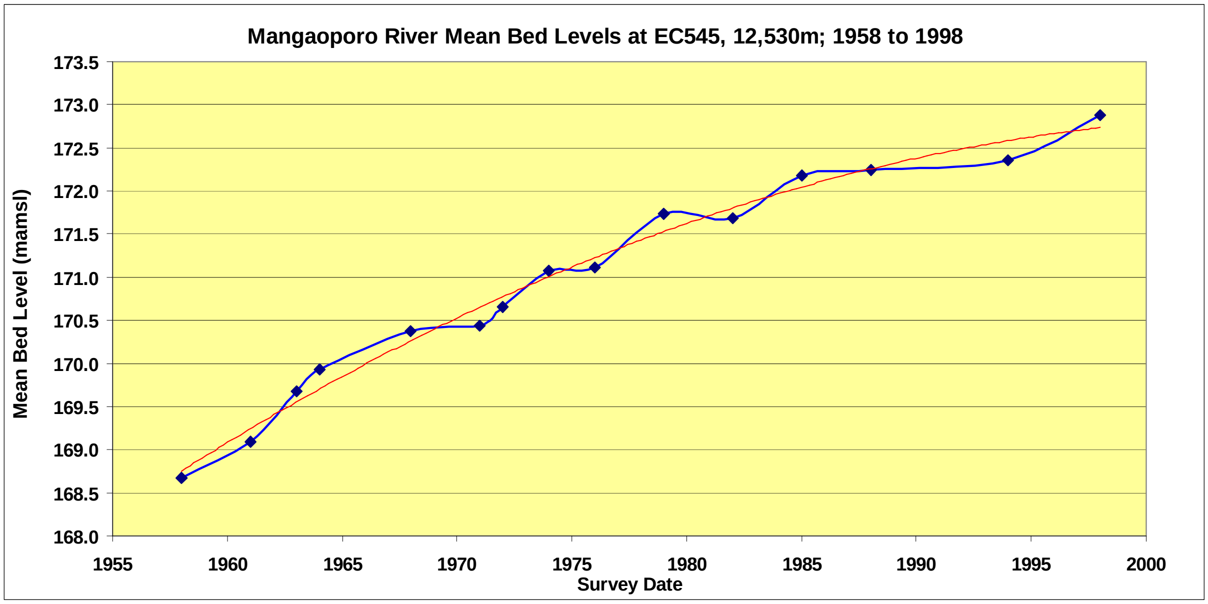


Fig. 3.

EC544; 10,630m:

The plot for EC544 is not shown here because over the past 10 to 20 years bed levels have been compromised to an increasing extent by the development of a shingle fan from a tributary a short distance upstream of the cross section. However, the average river bed aggradation rate for the first 30 years of surveys (1958 to 1988), has been a moderate 48 mm/year, followed by a ten year period when bed levels have been relatively steady. River bed levels have risen rapidly since then (1998), but have been increased by the shingle fan development.

The active bed width at EC544 was 205 and 220 metres in 1958 and 1998 respectively; while between EC545 and EC544 the river bed is now approximately 300 metres wide.

EC543; 7,850m:

The mean bed level plot in Fig. 4 shows fluctuating periods of shingle deposition and erosion superimposed on a net (gradual) rate of aggradation. Over the 57 year period 1958 to 2015, the trend line (shown in the figure as a second order polynomial) is a remarkably linear 21.3mm/yr.
The active bed width at EC543 increases from about 50m in 1958 to 62m in 2015.

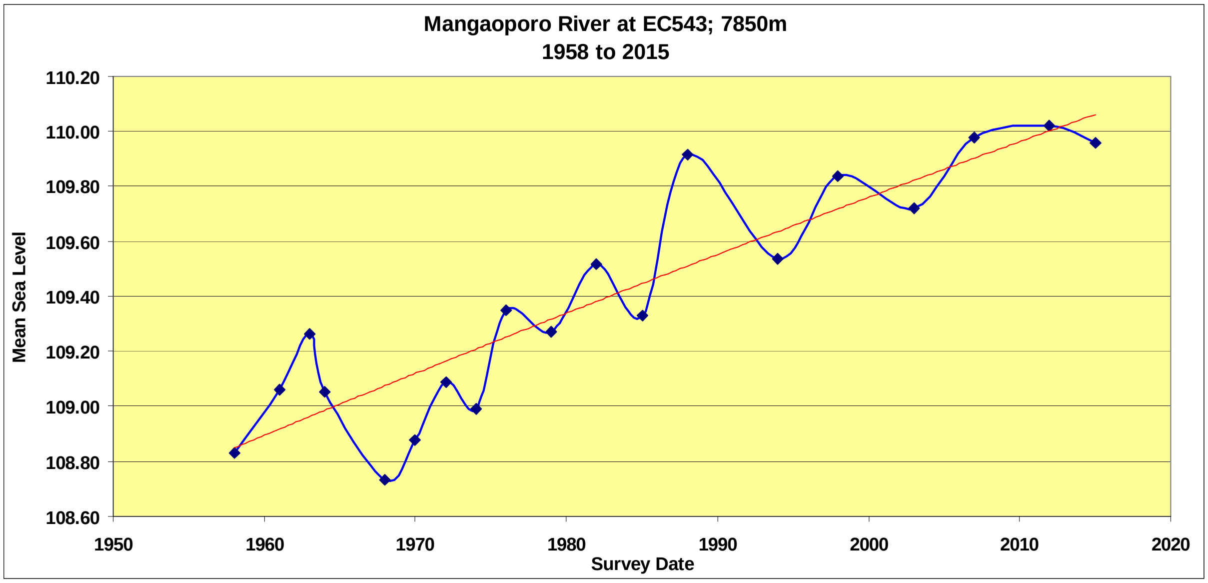


Fig. 4.

EC542; 4,460m:

At EC542 the active bed width increased from 60m in 1958 to 76m in 2015. Between EC543 and EC542 the river bed narrows substantially from 60 to 100m wide just downstream of EC543, to 30 to 50m wide over the last kilometre upstream of the bridge near EC542. In these “narrows” the river, especially during winter flow conditions, would most likely be more characteristic of a single thread channel rather than a braided channel.

The plot at EC542 (see Fig. 5), is similar to the plot at EC543 in that it shows fluctuations of deposition/erosion over time that depart from the (almost) linear trend; (slightly convex with the trend gradually reducing with time). The average aggradation rate over the 57 year period is 17.8 mm/yr.

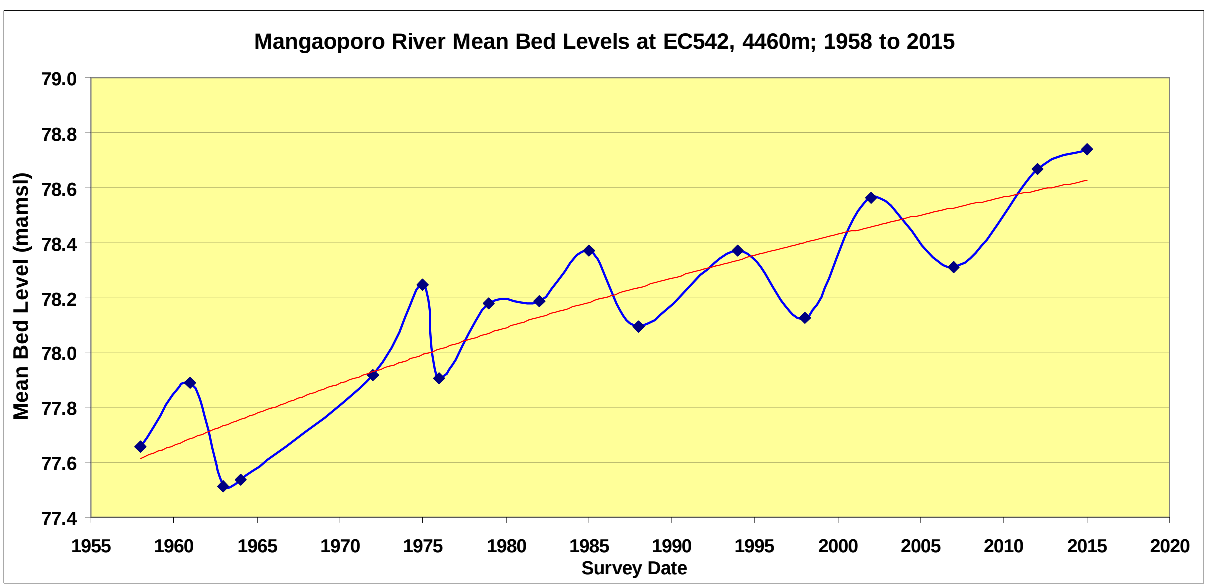


Fig. 5.

Comparison of EC543 and EC542:

These two similar plots have been charted together in Fig. 6, with 31.0 metres added to the MBL's at EC542 so that the two plots can conveniently be compared. All surveys plotted are for the same date in each year except for the survey plotted as 2002, which was surveyed in June 2002 for EC542 but surveyed in February 2003 for EC543.

This combined plot is remarkable for the 30 year period between 1982 and 2012 in that for each 3 to 5 year period between surveys, the mean bed level has increased at one cross section while it has decreased at the other, or vice-versa. So whilst (net) deposition has taken place over each period between surveys at one cross section, (net) erosion has taken place over the same period at the other cross section. This suggests a 6 to 10 year period between deposition/erosion cycles which are 3 to 5 years out of phase at each cross section.

This clearly discernable deposition/erosion cycle maybe just the result of a serendipitous aligning of natural bed level fluctuations with the survey dates. Other bed level fluctuations at widely different periods would no doubt exist and could have been revealed if the surveys had been at closer time intervals. It is widely known however that the transport of bed load in (at least single thread) rivers proceeds in "waves" as the material is transported downstream by floods and freshes, and hence the surveys pick up levels at the peaks or troughs or at any phase of such waves of material.

Just one fresh above the threshold of movement of the shingle bed load material would be enough to change the deposition/erosion phase at any one cross section.

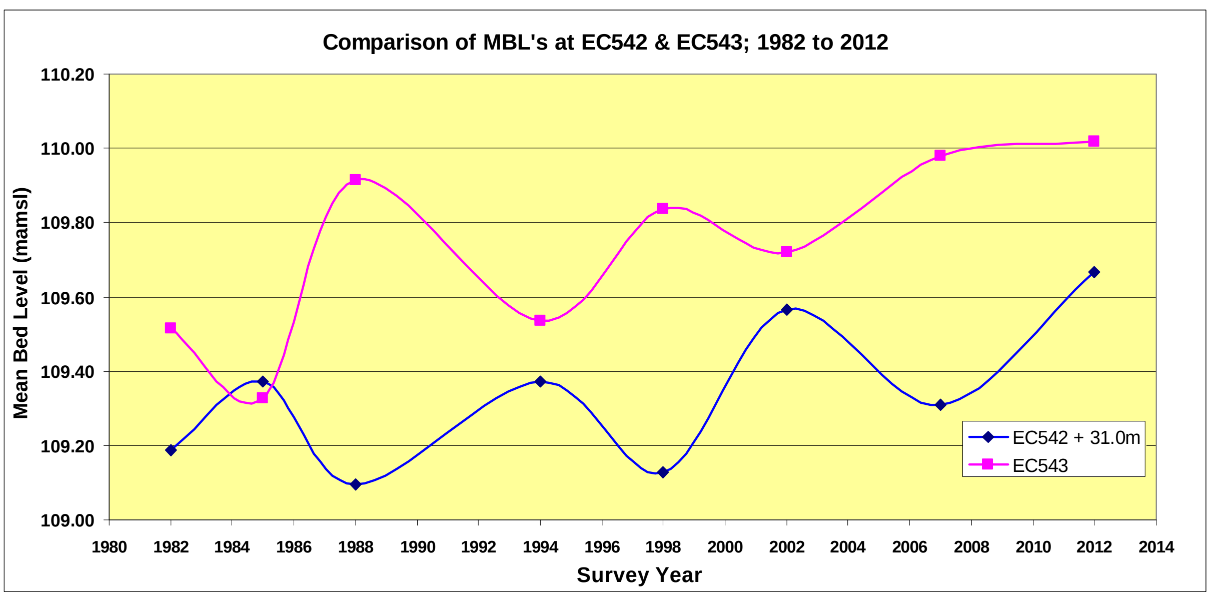


Fig. 6.

EC541; 2270m:

Figure 7 shows a slightly reducing trend in the rate of bed level rise with time at EC541, the average rate from 1958 to 1985 being a gradual 17.8 mm/yr, and almost no change over the past twenty years. There is a relatively large increase in mean bed level between 1985 and October 1988 which looks like an outlier but may have been a sudden input of bed load material as a result of the Cyclone Bola storm in March of 1988. However there is no evidence of this upstream at EC542, in fact the mean bed level for the October 1988 survey there is below the trend line. However it is possible that there was a sudden input of bed load from a tributary on the right bank between EC541 and EC542 during and after the Cyclone Bola storm .

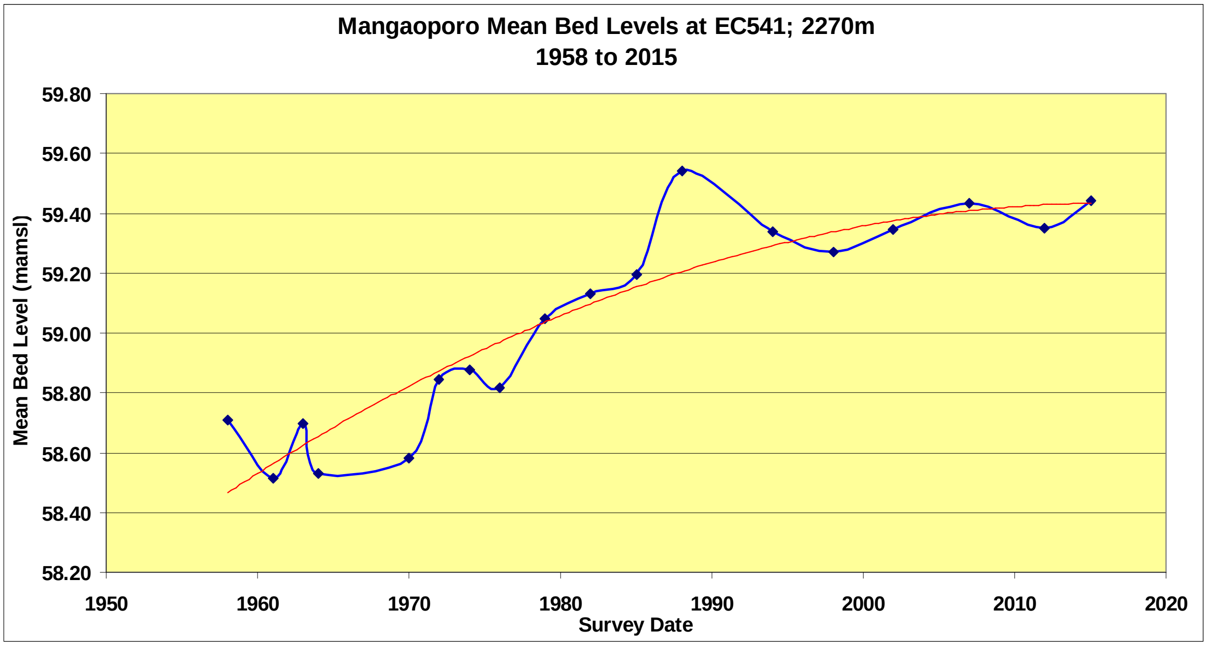


Fig. 7.

EC540; 1,450m; and the confluence with the Waiapu River:

This cross section, adjacent to the SH35 bridge, shows a gradual rise in mean bed level averaging 23 mm/yr between 1958 and 2015; see figure 8. The trend line shows this rate as gradually reducing with time, with the last four MBL's (since 2002), virtually the same.
The cross section at EC540 is at a narrower section of the river bed with a bed width of 100 to 130m, but the bed downstream of the SH35 bridge widens to some 550m. A tremendous volume of bed load material has obviously been deposited in this reach of the Mangaoporo River between the SH35 bridge and the Waiapu River.

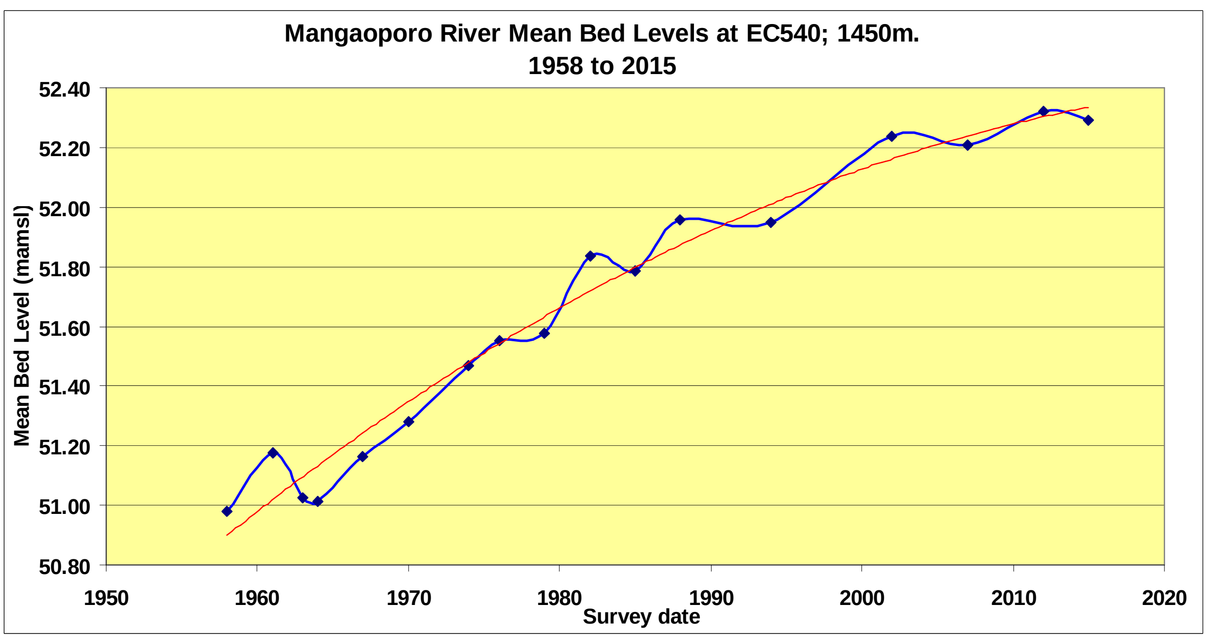


Fig. 8.

5.0 The Mangapaoro River shingle fan:

There is a vast shingle fan at the confluence of the two rivers which measures some 1.5 kilometres wide and extends into the Waiapu River by some 430 metres (see Fig. 9). This has forced the Waiapu River into the true right bank at Kaiinanga hill over many years. In the 1990's and early 2000's the Gisborne District Council constructed a series of rock groynes to prevent the erosion of the right bank and protect Waiomatatini Road.

Fig. 9. *Mangaoporo River shingle fan in the Waiapu River.*
Photo: G Swain, 30 May 2011.

Fig. 10. *Mangaoporo River fan showing historic river course (shaded blue) within cadastral boundaries.*

Figure 10 shows the cadastral boundaries of the Mangaoporo and Waiapu rivers in the vicinity of the shingle fan. The river boundaries were probably surveyed in the early 20th century. The original Waiomatatini Road legal boundaries are now in the active bed of the Waiapu River.

The narrow section of the Mangaoporo River, at left of the photo, was considered to be the “mouth” of the Mangaoporo in 1958 at the time the first river bench marks were established. This is the location of the “0” survey distance, as shown in Fig. 2.

6.0 Effect of Reforestation:

Unlike most of the other major tributaries of the Waiapu River, there is no easily discernable slowing down of the rate of river bed aggradation in the Mangaoporo attributable to reforestation. This rather surprising observation has been explained as follows by Dr M Marden,
“While in the upper Mangaoporo catchment there has been an enormous amount of landsliding and gullying, this was mainly in indigenous forest. Plantings of exotic forest in the upper catchment are small in area compared to the area of indigenous forest, therefore there has been no sudden reduction in sediment supply into the Mangaoporo due to afforestation like there has been in other catchments”.

7.0 Shingle Extraction:
Shingle extraction operations totalling 44,586 m3 have been undertaken by Ernslaw One Ltd in the Mangaoporo River bed between 2006 and 2011, as shown in the following table:

Year	Volume extracted (m3)	GDC Permit No.
2006	13,468	RS 204020
2007	2,100	RS 204020
2009	1,547	RS 204020
2010	21,312	RS 104356 (ex 204020)
2011	6,159	RS 104356 (ex 204020)
Total:	**44,586 m3**	

The shingle has been extracted from two areas, the first being between EC544 and EC545, and the second being between EC543 and EC544. It is possible that the changes captured in the 2007 and 2012 surveys at EC543 and EC544 are unduly influenced by shingle extractions upstream of these two cross sections but because of the large natural fluctuations in mean bed levels it is not possible to identify direct evidence of this from the survey data.

8.0 Conclusions:

- River bed aggradation rates over the full period of record at the cross sections are considered “rapid” at EC545, “moderate” at EC544, and “gradual” at the four downstream sites, EC543 to EC540. (*Note that the full period of record is 57 years for sites EC540 to EC543, 40 years for EC545 and 30 years of useful record for EC544).*
- There are large fluctuations in mean bed levels between surveys particularly in the narrow reach of the river between EC542 and EC543, considered to be due to the transport of bed load material downstream in “waves”;
- Whilst the long term mean bed level trends are reasonably accurate, shorter term trends ie; over less than 20 years, are not considered reliable because of the large natural fluctuations in these levels;
- It is possible that the changes captured in the 2007 and 2012 surveys at EC543 and EC544 could have been unduly influenced by shingle extractions upstream of these two cross sections, but because of the large natural fluctuations in mean bed levels it is not possible to identify direct evidence of this from the survey data.
- There has been no discernable reduction in the rate of aggradation of the Mangaoporo due to reforestation, because of the relatively small areas planted compared to the areas of indigenous forest.

9.0 Recommendations:

It is recommended that:

1. Cross section surveys are carried out in the future at the same sites (except at EC544), at two yearly intervals**;**
2. The location of shingle extraction sites be clearly identified in the future, and be kept as far away as possible from survey cross sections.

NB: *This recommendation 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.*

References:

Brierley, Gary J., and Kirstie A. Fryirs. *Geomorphology and river management: applications of the river styles framework*. John Wiley & Sons, 2013.

Acknowledgements:

- Ian Hughes and Brian Currie; for providing a continuous high quality survey record for the past 35 years;
- Mark Cockburn for the preparation of Figures 1 and 10;
- Paul Murphy for checking and commenting on the draft reports;
- Dr. J Tunnicliffe, Environmental Science Dept; University of Auckland; for preparation of Figure 2, terms in the addendum, and for very helpful comments on the draft report;
- Dr. M Marden, for comments on the effect of reforestation.

Prepared by:
D H Peacock;
2nd February 2017.

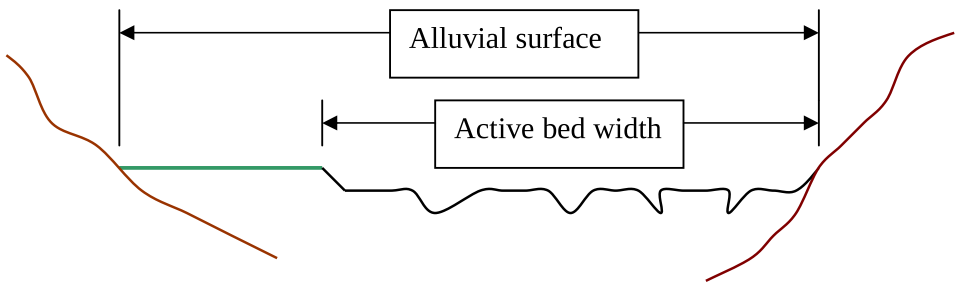
ADDENDUM

The following definitions have been provided to clarify the terms used in this report. Definitions 1, 2, and 4 have been kindly provided by Dr Jon Tunicliffe**.**

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 covered with vegetation which is no longer considered to be part of the active river bed. To be considered to be outside the active bed, a terrace (or island) has to be covered with established vegetation at least two years old, and which may be covered in water during floods but not be subject to scour or deposition of bed load material.

Mean bed levels are computed for each cross section from the mean of all the levels taken within the active bed width.

4. Transfer zone:
A ***transfer zone*** is a reach, or sequence of reaches, where a balance between sediment supply and sediment export is maintained, such that sediment is being conveyed downstream but is being supplemented by a roughly equivalent supply from upstream. These reaches characteristically have no major lateral sediment sources (e.g. tributaries, landslips) and typically exhibit a minimum of active sediment storage (e.g. bars, braidplains); Fryirs and Brierley, Chapter 3.

5. 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

APPENDIX 1

This appendix, which is available on request from the environmental section of the GDC, comprises all mean bed level and profile plots prepared for this report in electronic form.