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POROPORO RIVER MEAN BED LEVEL TRENDS; 1958 TO 2016.

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 20 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 is not possible from the available cross section data to calculate reliable volumetric data for the various reaches (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.

2.0 The Poroporo River catchment:

The headwaters of the Poroporo River are on the southern flank of Whakaangiangi (alt. 539m) in the Ruatoria State Forest. The headwater stream runs in a southerly direction, and then as the Poroporo River, turns in an easterly direction and some 18 kilometres to the east passes under SH35 just north of Tikitiki. After a further 7 kilometres the Poroporo river discharges into the Waiapu River near its mouth. The last 16 kilometres of the river has a meandering single thread channel.

The Poroporo River catchment (68.75 sq. km), shares its southern boundary with the northern boundaries of the Mangaoporo River and Paoruku Stream catchments.

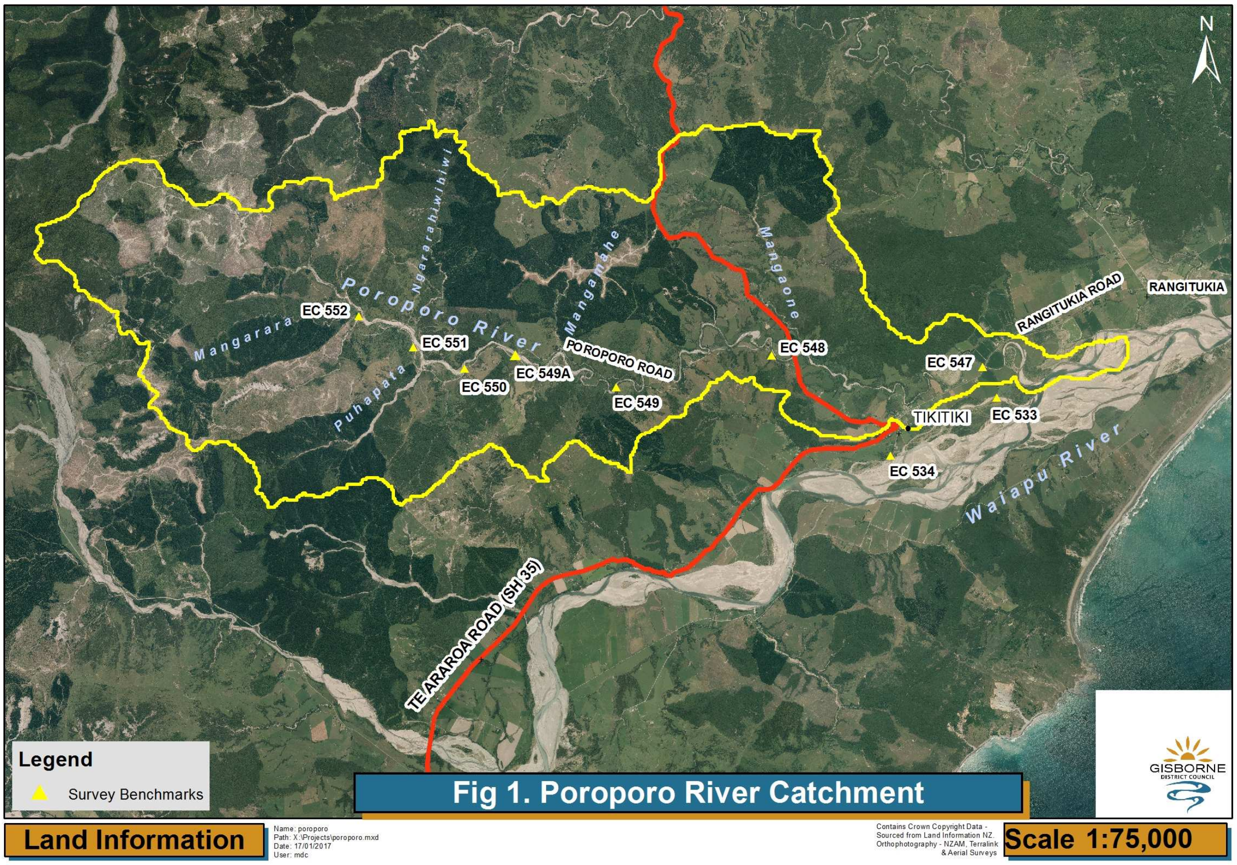

Fig 1. Poroporo River Catchment

3.0 Executive Summary:

This river is uniquely different to its neighbours to the south, the Mangaoporo, Tapuaeroa and Waiorongomai, in that the bed load material in the middle and lower reaches has a much finer grain size. This is because the river cuts through a sheared matrix of smectitic (swelling clay) material and sheared mélange (crush zone). This finer material makes the middle and lower reaches unattractive for shingle extraction, and only a relatively small quantity of shingle has been excavated (and not since 1988) in the vicinity of the most upstream cross section.

River bed aggradation rates at the three upstream cross sections has been “moderate” up until circa 1988, and since then the rate has slowed; this slowing of the aggradation rate likely to be attributed to reforestation of the upper catchment.

The 4.1 kilometre reach of river from EC550 to EC549 changes in characteristics from a braided channel upstream of EC550, to a sinuous single thread channel downstream. At EC549 the river has aggraded at a moderate rate up until 2003, after which the aggradation rate has slowed;
At the two most downstream cross sections, EC547 and EC548, mean bed levels have been virtually static compared to the upstream cross sections, as have the active bed widths. This meandering, and in places swampy downstream reach of the river, appears to be in equilibrium with respect to its bed load.

The Poroporo River bed profiles have been examined, and using the original river distances the 1958 profile appeared to show a sudden change in slope at or about EC550**.** At first it was thought that there could be a “nick point” near EC550, or a fault which could account for the anomaly. However, subsequent measurements of the 2014 river channel are substantially different from the original survey distances. A re-plot of the 1958 profile using the 2104 river distances bore a close resemblance to the smooth 2016 plot which strongly suggests that some of the original river reach lengths have been scaled incorrectly. However this does not necessarily discount the possibility that the river course upstream of EC550 was substantially longer in 1958 than it is now. An examination of the Poroporo river aerials with a cadastral boundaries overlay and examination of historic aerial photographs shows that the river course has meandered substantially since the early 20th century.

Without knowledge of the date in which the original river distances were measured and the exact course of the river, it is not possible to confirm the original river distances between the bench marks. Unless further evidence turns up it would seem reasonable to accept the 2104 river distances rather than the original survey distances.

4.0 River Bed Profiles:

The Poroporo River bed profiles have been examined, and using the original river distances the 1958 profile appeared to show a sudden change in slope at or about EC550, (Fig. 2), contrary to the normal steepening of grade proceeding upstream in most rivers and streams. In the reach upstream of EC550 (16,070m to 18,460m) the mean bed level gradient (in 1958) is 2.94 m/km, while downstream the grade between 11,900m to 16,070m is a much steeper 4.62 m/km; Fig. 2.

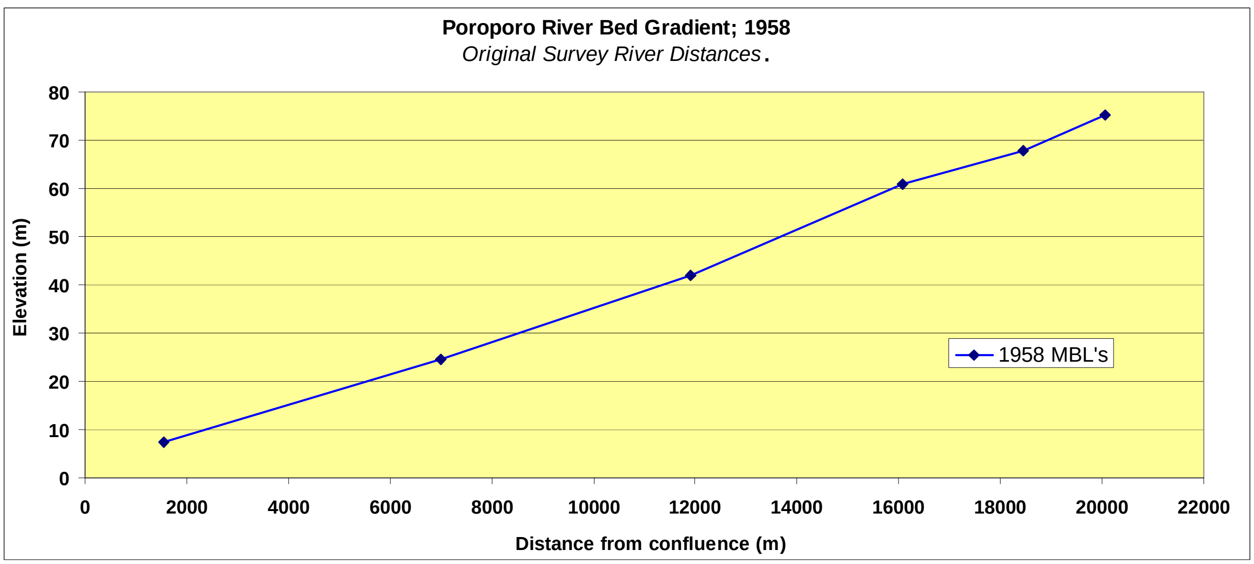

Fig. 2

At first it was thought that there could be a “nick point” near EC550, or a fault which could account for the anomaly. However, subsequent measurements of the river channel (scaled off Google Earth aerial photos dated October 2104), are substantially different from the original survey distances. The original and revised distances are shown in the following table:

BM No.	1958 Survey Distance	Reach	1958 Reach Length	2014 Reach length	2014 Survey Distance
	m		m	m	m
EC547	1550	0-EC547	1550	1550	1550
EC548	7000	EC547-548	5450	5700	7250
EC549	11900	EC548-549	4900	5400	12650
EC549A	14890	EC549-549A	2990	2960	15610
EC550	16070	EC549A-550	1180	1180	16790
EC551	18460	EC550-551	2390	1240	18030
EC552	20060	EC551-552	1600	1200	19230

The 1958 reach lengths were scaled off early aerial photographs, but this may not have been done until sometime after 1958, *pers. com; Brian Currie*. The 2014 reach lengths were scaled by the author off October 2014 Google Earth aerial photographs.

When the 1958 bed gradient is re-plotted using the 2014 scaled distances, it follows a typical concave upwards river bed profile close to the 2016 plot, see Fig 3.

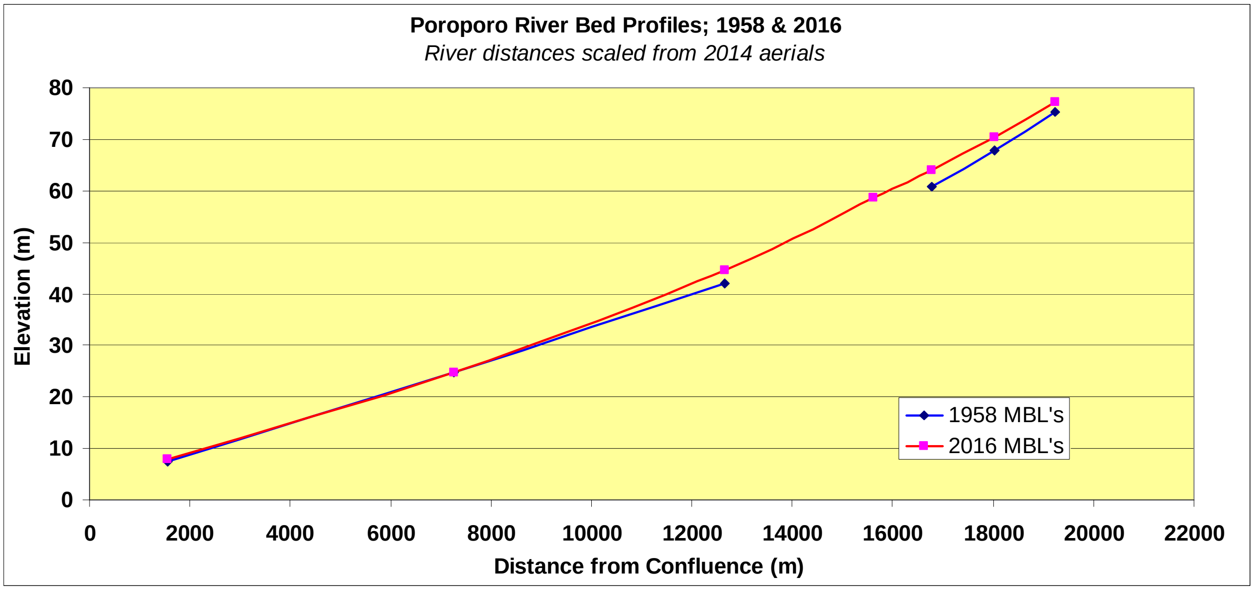

Fig. 3.

The close resemblance between the 1958 and 2016 plots in figure 3 strongly suggests that some of the original river reach lengths have been scaled incorrectly, however this does not necessarily discount the possibility that the river course upstream of EC550 was substantially longer in 1958 than it is now. An examination of the Poroporo river aerials with a cadastral boundaries overlay, (Fig. 4), shows that the river course has meandered substantially since the early 20th century.

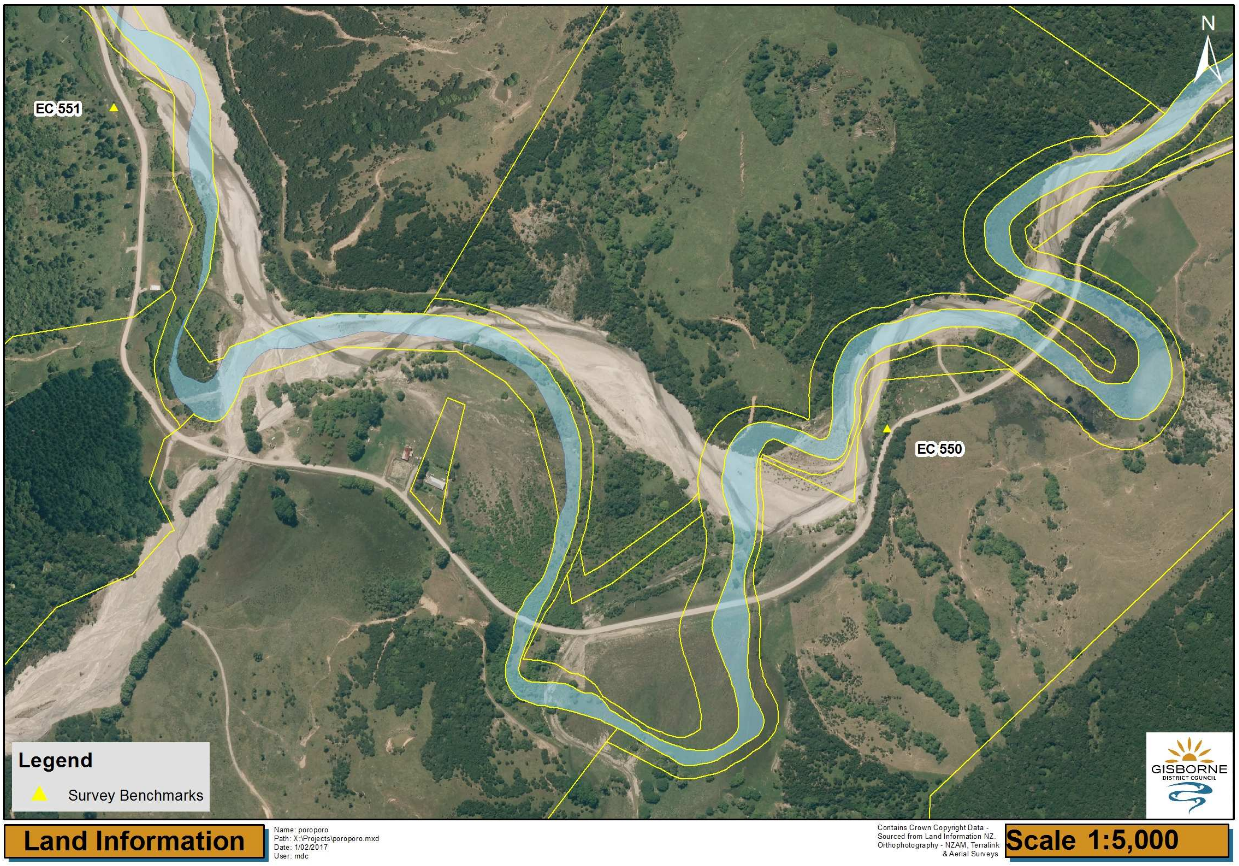

Fig. 4: *Historic river course between EC550 and EC551.*

The distance between EC550 and EC551 measured along the centre of the historic river course (shaded blue in Fig. 4), is approximately 1870m, compared to 2390m for the original 1958 measurement and 1240m for the 2014 course (scaled from Google Earth).

Early aerial photos belonging to Landcare Research show that the 1939 river course was very similar to the historic course in this area, while a 1961 photo shows a course similar to the present day course. Without knowledge of the date in which the original river distances were measured and the exact course of the river, it is not possible to confirm the original river distances between the bench marks. Unless further evidence turns up it would seem reasonable to use the 2104 river distances for all surveys.

5.0 River bed load material grading:

Unlike the neighbouring rivers, the Mangaoporo, the Wairongomai and the Tapuaeroa; the Poroporo River has a much smaller bed load grain size particularly in the lower reaches. According to Dr M Marden, the Poroporo River cuts through a sheared matrix of smectitic (swelling clay) material and sheared malange (crush zone), and explains that…. *"These units are not cut by the Mangaoporo thus given that there is much more mudstone plus the presence of smectitic material and sheared mélange this could explain the overall smaller grain size of the bedload in the Poroporo cf the Mangaoporo"*.

Further explanation by Dr. Marden of the effect of the lithologies on the Poroporo River bed load material, is available in the Addendum.

6.0 Mean bed level plots and active bed widths:

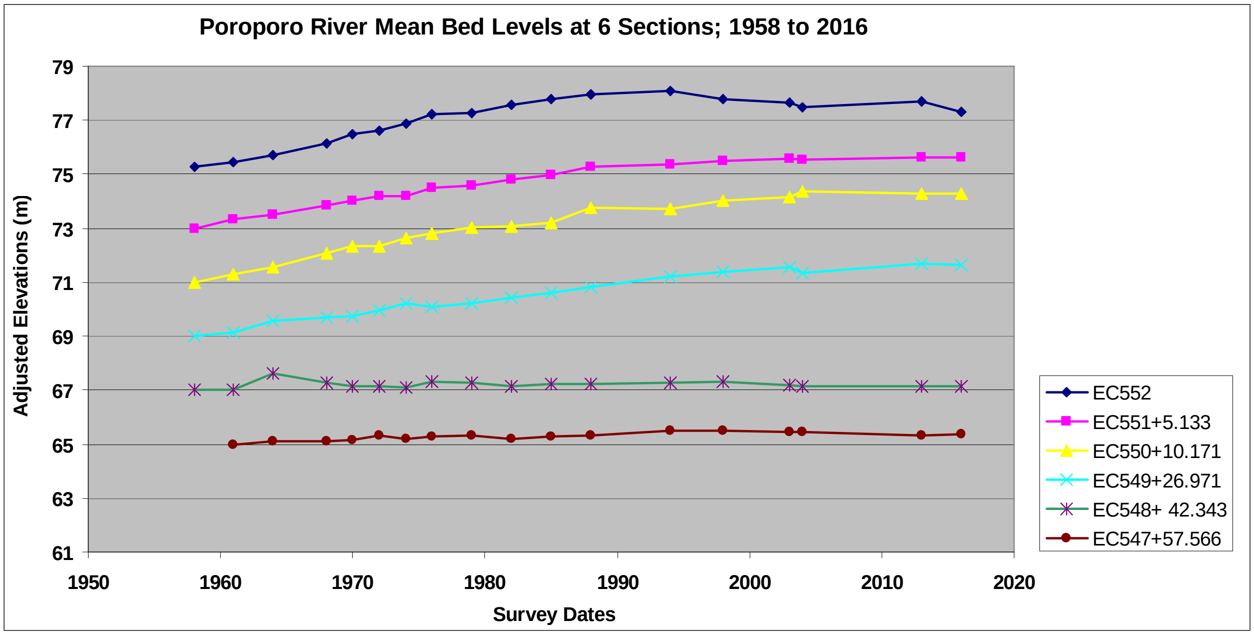

Fig. 5

Figure 5 above shows mean bed levels for all the cross sections plotted together. The plot for EC552 is at the correct elevation, but the other five plots have been adjusted upwards (by the amounts shown in the legend) so that the curves can be conveniently compared.

Mean bed level plots for the three most upstream cross sections (EC550, 551 & 552) show a distinct similarity, with "moderate" aggradation, 76 to 92 mm/yr over the 40 year period from 1958 to 1988, followed by a gradual decline in mean bed level from 1994 at EC552, and a slowing of the aggradation rate since 1988 at EC550 and EC551. This slowing of the aggradation rate is likely to be attributed to the reforestation of the upper catchment during the mid to late 1970s; *pers com*, Dr M Marden.

The active bed widths at these three cross sections (Figure 6), also generally increase over the first 30 to 40 years, then decrease to about half of their original (1958) widths by 2016.

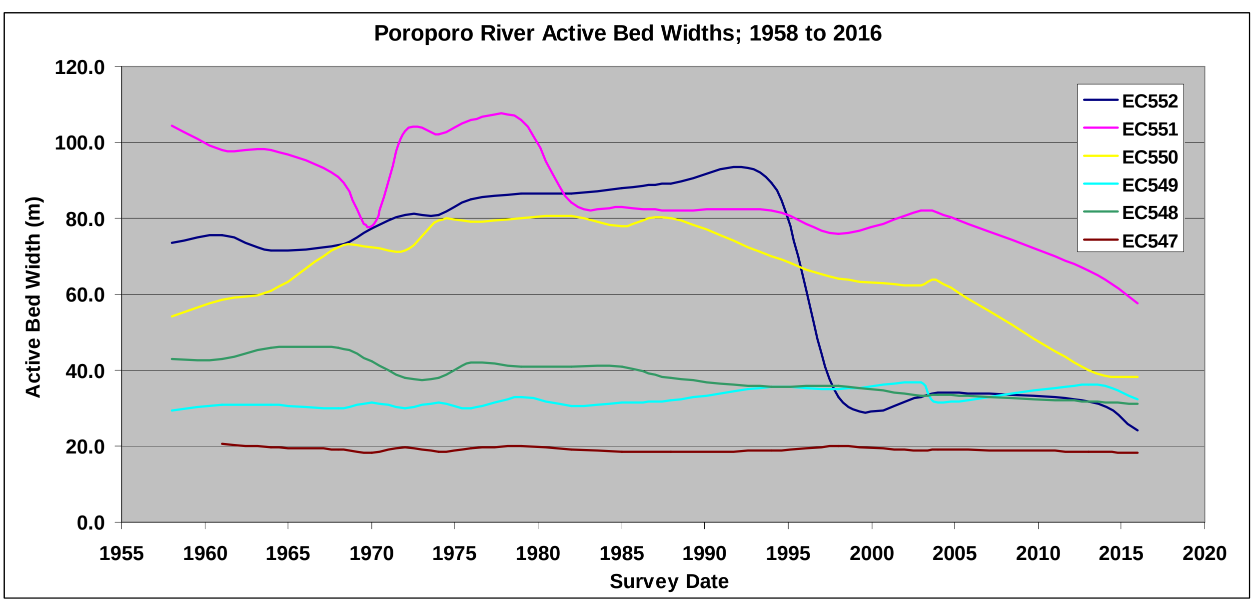

Fig. 6

The 4.1 kilometre reach of river from EC550 to EC549 changes in characteristics from a braided channel upstream of EC550, to a sinuous single thread channel. The active bed widths for the three cross sections at EC547, 548 and 549 are significantly narrower than for the three upstream sections, as shown in Fig. 6.

At EC549 the rate of aggradation is a moderate 56 mm/yr until 2003, after which the rate decreases, while the active bed width also reaches a maximum in 2003.

At the two most downstream cross sections, EC547 and EC548, mean bed levels have been virtually static compared to the upstream cross sections, as have the active bed widths, (Figs. 5 & 6). This meandering, and in places swampy, downstream reach of the river appears to be in equilibrium with respect to its bed load.

7.0 Mean bed level changes at individual cross sections:
For ease of comparison the following mean bed level plots have been charted to the same vertical and horizontal scale.

EC552:

This is the most upstream of the six cross sections, and is situated a short distance upstream of the Mangarata stream confluence. The mean bed level plot in Fig. 7 shows an almost linear increase in mean bed level up to 1988, with a peak level in 1994 and a gradual decline in level to 2016.
Over the 30 year period 1958 to 1988 the river bed has aggraded 2.72 metres, at a “moderate” average aggradation rate of 90.5 mm/yr. *Note the term “moderate” is a subjective term with respect to other rivers/streams within the Waiapu catchment*; *and that a table showing these terms is provided in the Addendum.*

The “active” river bed width has increased from 73.5m in 1958 to 89.5m in 1994, and decreased to only 24.2m in 2016. This reduction in bed width together with the decrease in mean bed level since 1994 confirms that river bed degradation is now underway at this cross section.

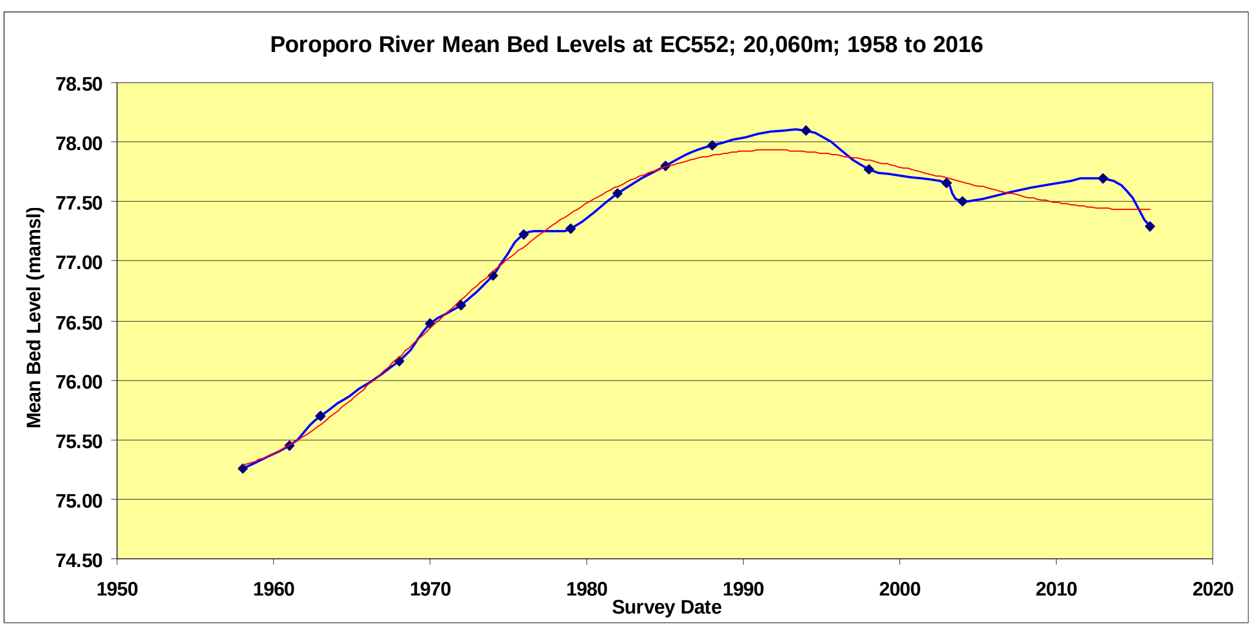

Fig. 7

EC551:
The mean bed level plot in Fig. 8 again shows an almost linear increase in mean bed level up to 1988, with a slower rate of rise until 2003, and almost flat in level to 2016. Over the 30 year period 1958 to 1988, the river bed has risen by 2.29 metres at an average aggradation rate of 76.3 mm/yr.

The active bed width has increased from 104.5m in 1958 to 106m in 1976/79, then decreased to 82m in 1988 and to 58m in 2016. It would appear that the river bed at its current width, slope and sediment supply is close to equilibrium at this cross section, and that the river bed degradation which is now underway upstream at EC552 should, all other factors being equal, reach EC551 in the near future.

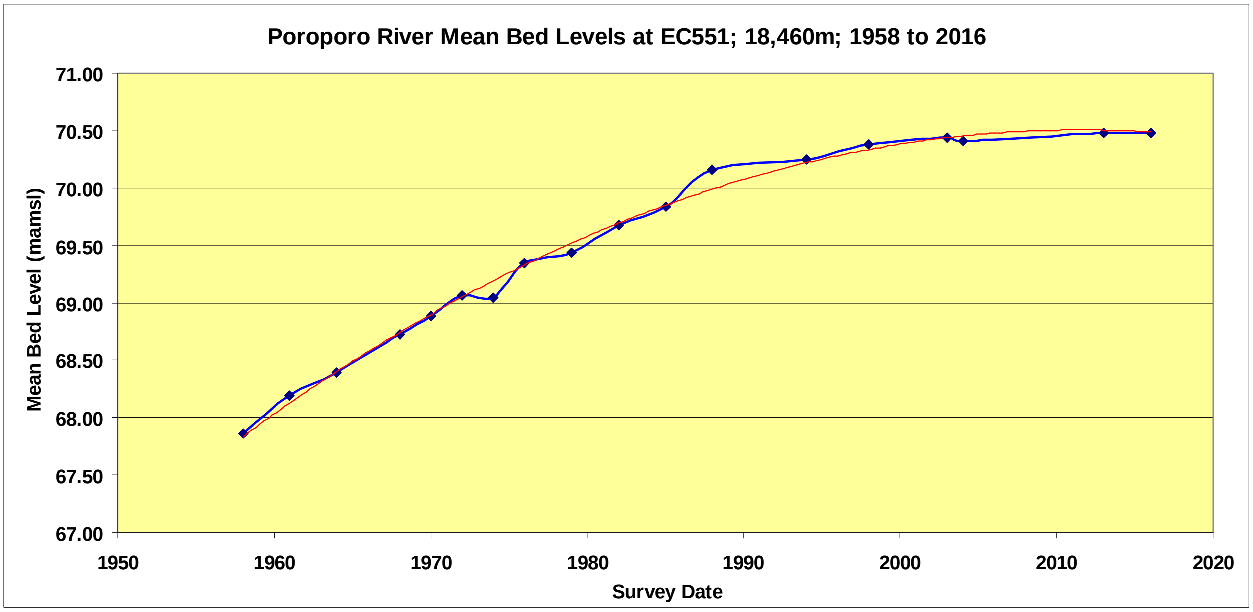

Fig. 8

EC550:
This plot being very similar to that for EC551 is not shown.
However there is an almost linear increase in mean bed level up to 1988, with a gradual slowing of the rate of aggradation to 2016.
Over the 30 year period 1958 to 1988, the river bed has risen by 2.75 metres at an average aggradation rate of 91.6 mm/yr.

The active bed width has increased from 54m in 1958, to 78m to 80m in 1974-1980, then decreased to 38m in 2016. This follows a similar trend as for EC551.

The river bed gradient changes markedly at or about EC550, as can be seen in Figure 4. This is contrary to the normal steepening of grade proceeding upstream in most rivers and streams; and signals the change from a wide braided channel to a narrower, more steeply sloping single thread channel.

EC549A:
This is a recently established cross section adjacent to the second Poroporo Road bridge upstream of SH35. Surveys are only available for the years 2004, 2013 and 2016. These show relatively steady mean bed levels over that period.

EC549; 11,900m:
The 4.1 kilometre reach of river from EC550 to EC549 changes in characteristic from a braided channel upstream of EC550, to a sinuous single thread channel.

The mean bed level plot in Fig. 9 again shows an almost linear increase in mean bed level up to 2003, with a slower rate of rise until 2016. Over the 45 year period 1958 to 2003, the river bed has risen by 2.54 metres at a more moderate average aggradation rate of 56 mm/yr.

The active bed width has increased from 29.5m in 1958 to reach a maximum of 36.6m in 2003, then decreased to 32.5m in 2016.

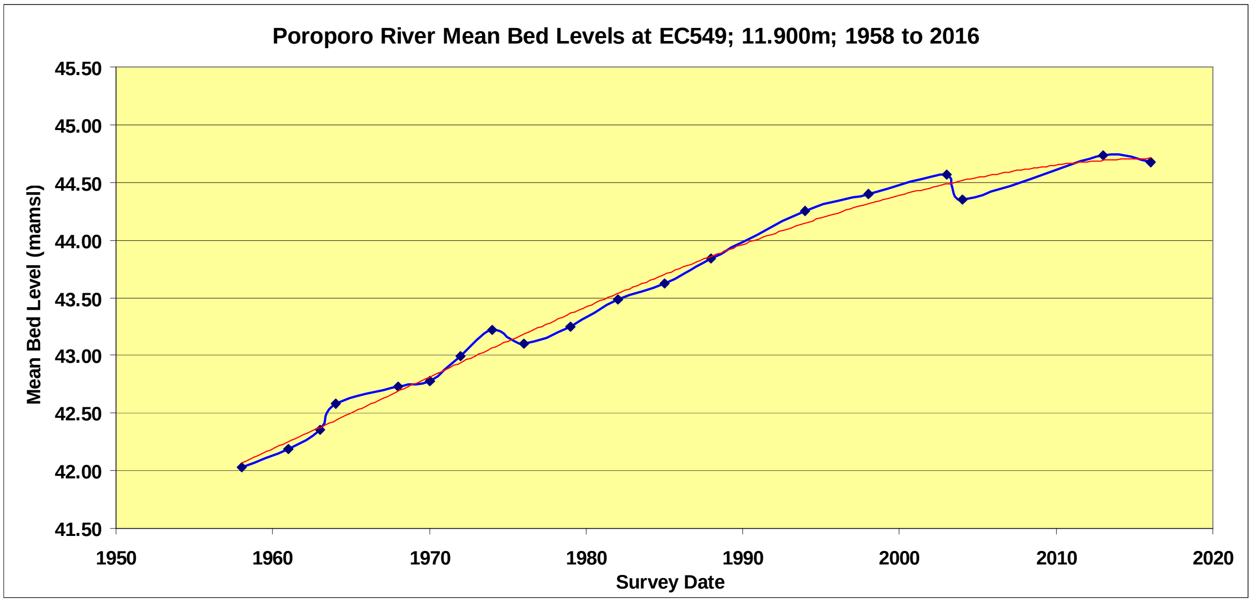

Fig. 9

EC548; 7000m:
This plot being very similar to that for EC547 is not shown.
The rate of mean bed level rise reduces substantially, to an average of only 8 mm/yr over the 40 year period from 1958 to 1998.

The active bed width has increased from 43m in 1958, to 64m in 1964 & 1967, then decreased to 31m in 2016.

EC547; 1550m:
The plot in Fig.10 shows a gradual rise in mean bed level from 1961 to 1994, and then a gradual decline to 2016. Over the 33 year period 1961 to 1994, the river bed has risen by 0.52 metres at a gradual average aggradation rate of 15.7 mm/yr.
The changes at this cross section have been gradual, with very small fluctuations in level**.**

Variations to the active bed widths have likewise been small, from 20.6m in 1961 to 18.2m in 2016**.**

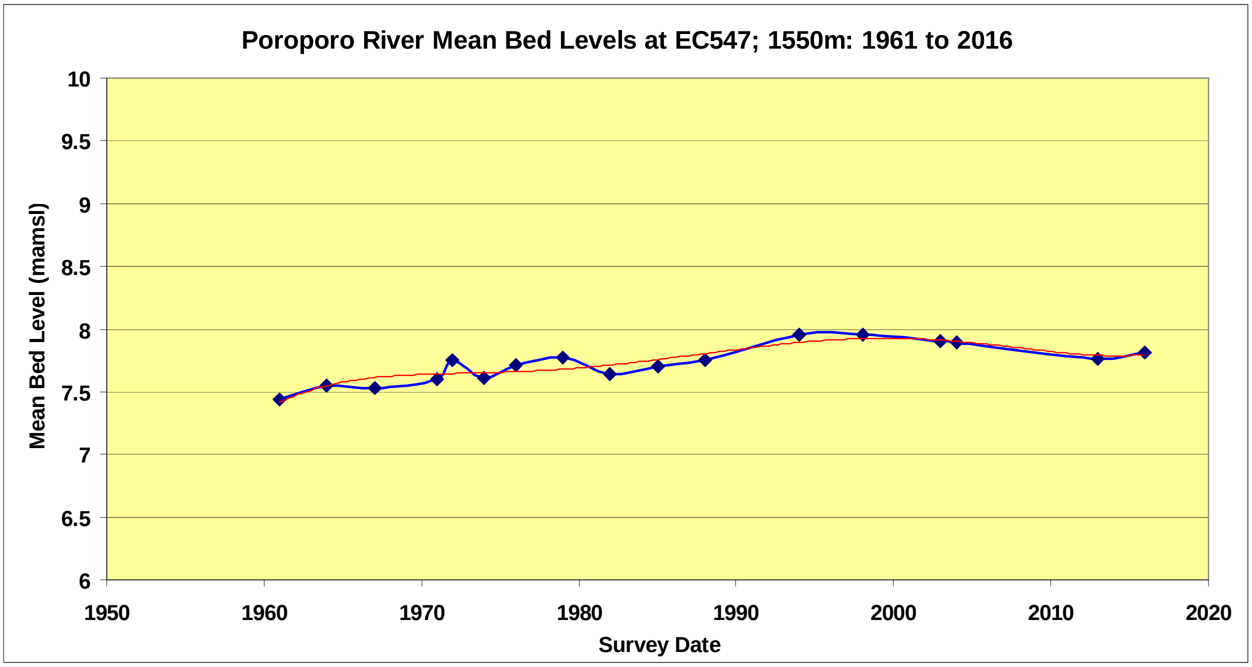

Fig. 10

8.0 Shingle extraction operations:
The only shingle extraction records available from the Gisborne District Council were for the years 1984 to 1988, as follows in the table:

Year	Volume of Shingle extracted (m3)
1984	5603
1985	1770
1986	195
1987	195
1988	343
Total:	**8106m3**

This shingle was excavated from the GDC permit sites RS 19807 and RS 201003, a short distance downstream of EC552. Removal of these relatively small quantities of shingle would not be considered by the author to have had any significant impact on the river shingle budget, but could have had an effect locally on specific survey results (viz; at EC552 and/or EC551). However an examination of the mean bed levels in the plots for EC552 and EC551 show these are very close to, if not right on, the trend lines and therefore it is highly unlikely that there have been any effects on the survey results.

According to GDC records, no shingle has been extracted downstream of EC551 in the past. This is undoubtably because of the smaller grain size and poor quality of the bedload material; see chapt. 5.

9.0 Conclusions:

- This river is unique compared to neighbouring rivers to the south, and for this reason (amongst others) monitoring of mean bed levels should continue;
- River bed aggradation rates at the three upstream cross sections has been “rapid” up until circa 1988, and since then the rate has slowed; this slowing of the aggradation rate likely to be attributable to the increasing age and influence of extensive reforestation of the upper catchment;

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- Mean bed levels at EC552 reached a peak in 1994 and gradually declined in level to 2016. This river bed degradation which is now underway at EC552 should, all other factors being equal, reach EC551 in the near future;
- The meandering reach of the river downstream of EC548, appears to be in equilibrium with respect to its bed load;
- Without knowledge of the date in which the original river distances were measured and the exact course of the river, it is not possible to confirm the original river distances between the bench marks. Unless further evidence turns up it would seem reasonable to accept the 2104 river distances rather than the original survey distances;
- A relatively small amount of shingle extraction has taken place near the most upstream cross section, but this is not considered to have had a significant impact on mean bed levels;
- Because of the poor quality of the bed load material downstream of EC551, 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.

10.0 Recommendations:
It is recommended that:

1. Cross section surveys are carried out in the future at the same sites at two to three yearly intervals**;**
2. The 2014 river distances are adopted for use in river gradient calculations, unless future changes in the river course or further evidence proves otherwise.

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 35 years;
- Mark Cockburn for the preparation of Figures 1 and 4;
- Paul Murphy for checking and commenting on the draft reports;
- Dr. J Tunnicliffe, Environmental Science Dept; University of Auckland; for preparation of terms in the addendum;
- Dr. M Marden, for comments on the effect of reforestation, and for item 5 in the addendum.

Prepared by:
D H Peacock;
7th February 2017**.**

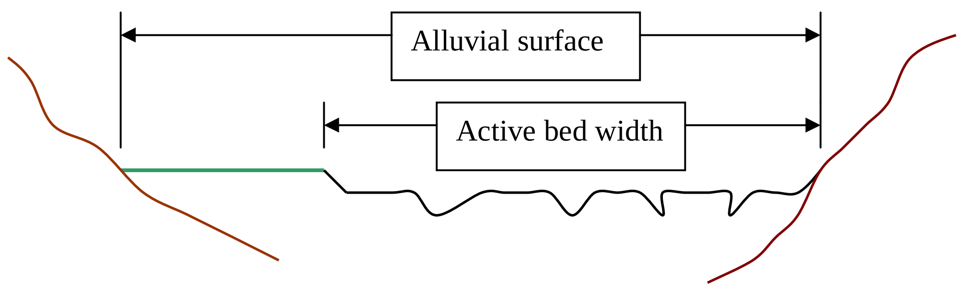
ADDENDUM

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 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. 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. Poroporo catchment lithologies:

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

Approximately 15km upstream from the junction of Poroporo with the Waiapu, the Poroporo cuts through a 2.5km section of bedrock (shown as MI and MIm on Mazengarb and Speden map). These units are described as undifferentiated mudstone with minor sandstone and tuff. There is also a thin sliver of EGW (Wanstead Formation) which is described as pale grey-green, calcareous and non-calcareous smectitic mudstone, in placed with intercalated red-brown and white smectitic mudstone and thin glauconitic sandstone beds. Minor conglomerate and pebbly mudstone are also present. There is also a thin sliver of melange (mel) of mixed Early Cretaceous to Early Miocene lithologies in a sheared matrix of smectitic mudstone similar to that which outcrops in Mangatu Forest. These units are not cut by the Mangaoporo thus given that there is much more mudstone plus the presence of smectitic material and sheared melange this could explain the overall smaller grain size of the bedload in the Poroporo cf the Mangaoporo. That is, there is likely to be a higher sand and silt component in the Poroporo. The coarser bedload material will also be distinctive from that in the Mangaoporo in that there will be a minor component of coloured rocks (red, green) which you shouldn't find in the Mangaoporo.

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.