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3. Tributary of Slab Hut Creek

3.1 SITE DESCRIPTION

The site is a small stream at map reference NZMS 260: K30 084938, draining a catchment of 7.9 km^2 (Fig. 1). In the 1980s the entire valley width was turned over for gold, and the stream diverted to the true right of the valley. The stream is believed to have formerly wandered to and fro across the valley.

Following the miner's insolvency, the site has been left unrestored. In places the stream appears to be in its original bed, but in other places it lies in a deep ditch formed in mining tailings. The stream bed in the surveyed region is higher than the mining tailings in the middle of the valley. It is possible, therefore, that the stream will break out to form a new bed. However, this had not occurred by 1994. This report therefore documents the relatively minor channel changes occurring in the existing bed.

The bed material was sampled using the Wolman (1954) method. The size distribution is shown in Fig. 6; d_{50} and d_{90}, are 47 mm and 145 mm, and the distribution is reasonably constant along the reach.

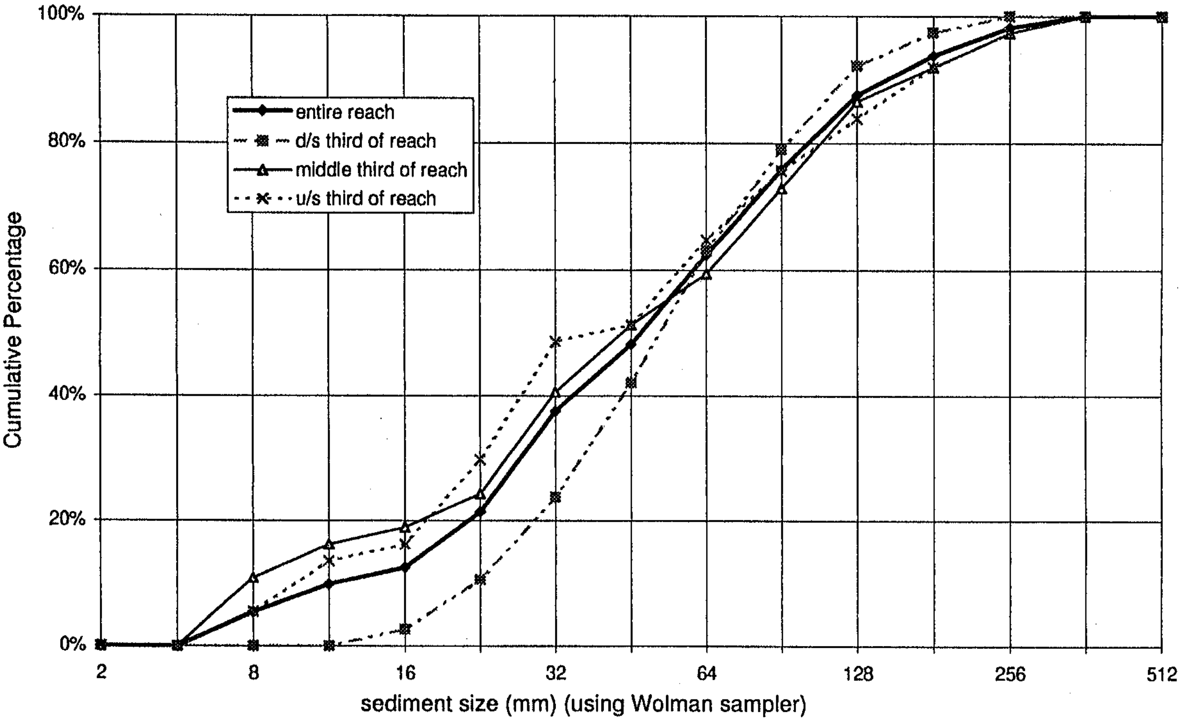

FIGURE 6. BED MATERIAL SIZE DISTRIBUTION FOR TRIBUTARY OF SLAB HUT CREEK.

3.2 SURVEY DATA AND PHOTOGRAPHS

Cross-sections were set out and measured in December 1990. Two cross-sections were re-surveyed in July 1991; comparison with the 1990 survey confirmed the visual evidence that no significant changes had occurred. The sections were re-surveyed in September 1994, when some changes were evident.

A plan of the surveyed cross-sections is shown in Fig. 7 and the three sets of measured cross-sections are plotted in Fig. 8, on which individual surveyed points are marked. The remarks for Giles Creek (2.2 above) about inferring bed changes are equally applicable to these sections.

On each survey visit photographs were taken looking upstream towards each surveyed cross-section. This was also done when the site was visited in January 1992 and March 1995.

3.3 OBSERVED CHANGES

The channel did not change measurably between December 1990 and January 1992. However, by September 1994 some of the cross-sections had widened considerably. The narrow ditch-like section 10 widened only slightly (Appendix Figs 11 and 12) but sections 11 and 12 widened with a drop in bed level (Appendix Figs 13 and 14).

Erosion occurred downstream at the outside of bends, at sections 3, 5–7 (Appendix Figs 15 and 16) and 9 (Fig. 8); at section 3 the bank has disappeared, with some overflow evident into the swampy region in the middle of the valley. Cross-sections 1–2 (Appendix Fig. 17) and 13, natural sections at the top and bottom of the reach, changed very little.

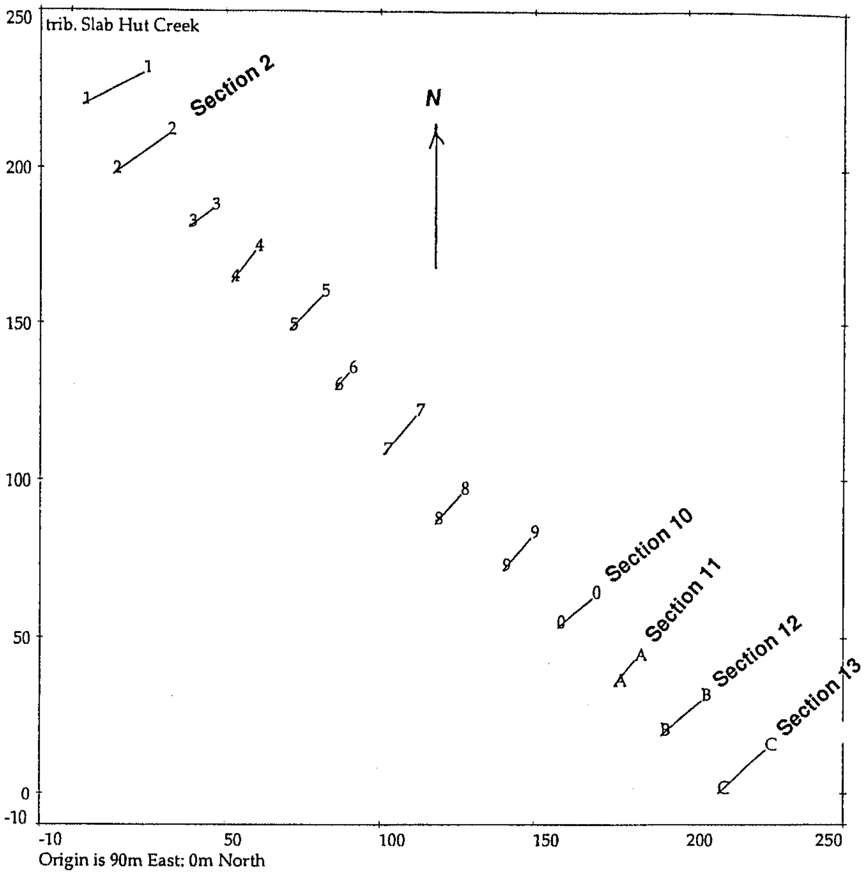

FIGURE 7. MAP OF SURVEYED CROSS-SECTIONS, TRIBUTARY OF SLAB HUT CREEK.

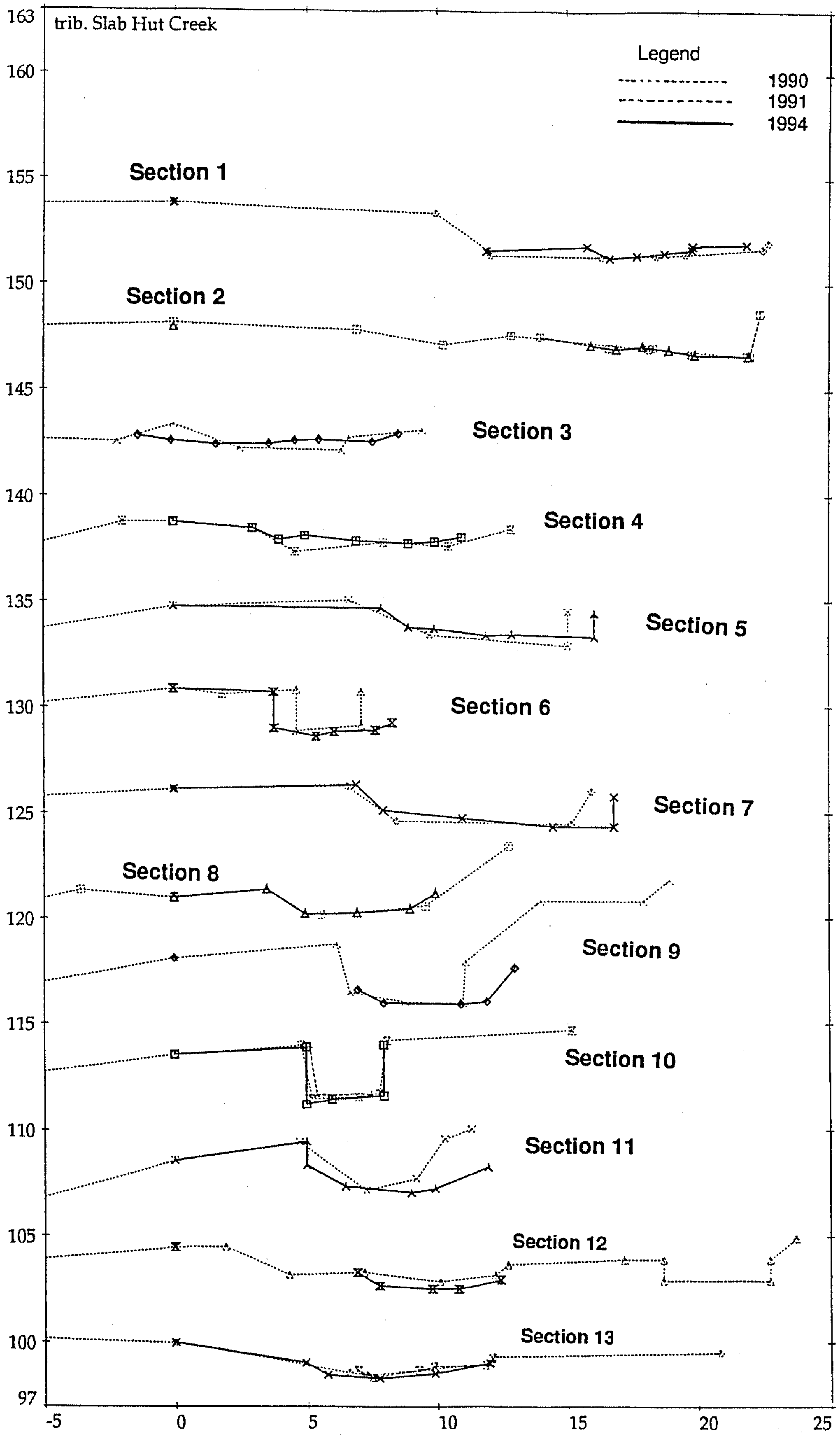

FIGURE 8. SURVEYED CROSS-SECTIONS, TRIBUTARY OF SLAB HUT CREEK.

4. Estimation of the regime channel form

For Giles Creek, cross-sections 1 and 17 of the survey data show a stream in an apparently stable regime with its width at 40 m and its gradient at 2%. During the fresh observed on 13 December 1990, the stream was just flowing bank-to-bank at cross-section 17 (Appendix Fig. 1), giving a maximum depth of 1.8 m (see Fig. 5).

This can be compared with theoretical estimates of the regime state. To make such estimates we need a value for the "channel-forming" discharge. This discharge is often assumed to have a return period of two years. Estimates of it were made using the method of McKerchar & Pearson (1989); the value obtained for Giles Greek was 129 m^3/s, and for the tributary of Slab Hut Creek, 10 m^3/s.

The most recent published theory for the width and depth of gravel-bed channels is by Ikeda et al. (1988) (Appendices, Section 8.1). Macky (in press) has found experimentally that these formulae predict wider, shallower channels than actually occur. The experimental data can be extrapolated to give approximate estimates of channel dimensions. Both estimates of width and depth are in Table 1.

TABLE 1. CALCULATIONS OF STABLE CHANNEL FORM.

	Giles Creek	Slab Hut Creek
Discharge Q (m^3/s)	129	10
Slope S	1.7%	2.4%
Sediment size d_{50} (mm)	85	47
Sediment size d_{90} (mm)	204	145
Width B predicted by Ikeda et al.	155	42
Depth D predicted by Ikeda et al.	0.45	0.20
Width B predicted by Macky	50	13
Depth D predicted by Macky	1.20	0.64

These calculated dimensions are applicable to straight, uniform channels where both banks and bed are formed from the same cohesionless material. If the banks are resistant to erosion, channels deeper and narrower than given in Table 1 would be expected. On the other hand, meandering or braiding results in wider channels than would otherwise occur.

The transition to braided channels has received a considerable research effort, but without a satisfactory resolution. In unpublished work, the writer has examined some Canterbury rivers and streams, from which it appears that a transition from a meandering channel to a braided one occurs according to a criterion suggested by Henderson (1961). Applying the same approach to Giles Creek and the tributary of Slab Hut Creek indicates that these streams might naturally braid (or at least adopt a form transitional between meandering and braiding) in the absence of bank resistance to erosion. Laboratory studies have shown that, in some circumstances, initially straight channels meander at first before ultimately changing to a braided form, and this progression would be possible for both sites if all bank resistance were removed.

5. Possible future changes

5.1 GILES CREEK

The stable channel shape for Giles Creek with erodible banks has a width of at least 40 m. The blocks of erosion-resistant material in the central gorge region should keep the width there under 40 m, but the erodible material in between will continue to be attacked by back-eddies.

When the protruding sandstone cliff on the left bank has been eroded away, the channel may become relatively stable and uniform. This ought to decrease the threat of erosion of the tailings on the true right bank at sections 7–10, but the new channel may be directed towards the right bank at section 6.

In the longer term, a channel not unlike that found further upstream is likely. There, a usually single-thread channel occasionally braids (to the extent of branching around an island). The stream is a series of straight reaches and bends, and changes are slow, most likely due to the restraining effect of forest vegetation.

5.2 TRIBUTARY OF SLAB HUT CREEK

The channel is in the process of forming meanders, and will continue to do so, resulting in a valley of (say) 30 m width within which meanders continually evolve and migrate. Unless bank vegetation prevents it, the meanders will eventually be replaced by braids. However, the stream has partly broken out at section 3, and should eventually also do so at section 8 or 11, as the sinuosity of the meanders increases. This part of the stream should therefore eventually lie in a new bed.

In the longer term, it is likely that the stream will adopt a roughly meandering form, with straight reaches and bends. Re-established vegetation should ensure that channel migration is slow and also prevent braiding.

5.3 RECOMMENDED FUTURE MONITORING

The 5 years of observations have determined the pattern of channel changes at both sites, and further intensive monitoring is not considered justified. However, it would be very useful to revisit both sites after some time to observe ongoing changes, assess the accuracy of the predictions made in this report, and reassess the likely 'final' channel form. A suitable date for this might be about the year 2000, although if there occurred a flood event more severe than those of 1990–95 it would be a good idea to immediately re-survey the sites.

6. Recommended practice for gravel-bed stream diversions

There is an existing theory, albeit approximate at present, which specifies channel dimensions in cohesionless material. If this theory is used to size stream diversions, the channel will be stable in that no significant general erosion will occur.

However, streams in all but the flattest terrain will tend to meander, and sufficient valley width should be allowed for this. Alternatively, the banks should be armoured to resist meandering.

The great majority of New Zealand channels are naturally narrower than they would be if both bed and banks were cohesionless material. If artificia1 channels are to retain these narrower widths, the necessary bank resistance to erosion must be provided. Where erosion-resistant bank material is absent, and until bank vegetation is fully re-established, artificial armouring (ideally by rip-rap rock) must be provided.

The two-year flood is often taken to be the “channel-forming discharge”, being both frequent enough and large enough to have a significant impact on channel evolution. It would be prudent to wait for one or two floods of this size before implementing revegetation and other restoration, both to allow major changes to occur and to better predict longer-term changes. Given that several of these channel-forming floods appear to be necessary to effect some changes, it seems reasonable to regard 10–15 years as an approximate time for a new river regime to become established. By this time, it would be desirable to have in place whatever bank protection - natural or artificial - is proposed for the future.

The question of what width should be reserved for the river channel is difficult to answer in general, given present knowledge. For straight channels, the lkeda et al. (1988) formula overestimates width significantly, but extrapolating using Macky’s (in press) experimental data is uncertain. Most streams will in time meander, and the meanders will migrate downstream, so that the complete width needed may be much more than the channel width. However, as long as the banks are reasonably well protected by vegetation or by artificial means, the timescale of meander development and migration will most often be slow enough to ignore. For this reason, and because erosion-resistant banks restrain channel width, it appears highly desirable to restore the pre-existing level of bank protection.

7. References

Henderson, F.M. 1961. Stability of alluvial channels. *Transactions of the American Society of Civil Engineers 87*: HY6: 109–138.

Ikeda, S., Parker, G., and Kimura, Y. 1988. Stable width and depth of straight gravel rivers with heterogeneous bed materials. *Water Resources Research 24(5)*: 713–722.

Ikeda, S. and Izumi, N. 1990. Width and depth of self-formed gravel rivers with bank vegetation. *Water Resources Research 26 (10)*: 2353–2364.

Macky, G.H. (in press) Large-flume experiments on the stable straight gravel-bed channel. *Water Resources Research*

McKerchar, A.I. and Pearson, C.P. 1989. Flood frequency in New Zealand. *Publication no. 20, Hydrology Centre, Christchurch.*

Ross, C.W., Mew, G., Jackson, R.J. and Payne, J.J. 1995. Land rehabilitation to indigenous forest species. *Science for conservation 17* 58 p.

Schumm, S.A., Mosley, M.P., and Weaver, W.E. 1987. *Experimental Fluvial Geomorphology.* John Wiley.

Wolman,M.G. 1954. A method of sampling coarse river-bed material. *American Geophysical Union Transactions 35(6)*: 951–956.

8. Appendices

8.1 CALCULATION OF REGIME CHANNEL WIDTH AND DEPTH

Ikeda et al. (1988) derive theoretical equations for the width B and depth D of gravel-bed channels with cohesionless banks formed of the bed material:

$$D = 0.0615\ (\rho_s/\rho - 1)(\log_{10} 19\sigma)^{-2}\ \sigma\ d_{50}\ S^{-1} \qquad (1)$$

$$B = Q/[D^{3/2} g^{1/2} S^{1/2}\ 2.5 \ln(11\ D/k)] + D[2.5710 + 2.066 / \ln(11\ D/k)] \qquad (2)$$

where k is the equivalent bed roughness, which they equated to 1.5 d_{90}, Q is discharge, g is acceleration due to gravity, d_{90} is the sediment size for which 90% of the bed material is finer, $\sigma = d_{90}/d_{50}$ and d_{50} is the sediment size for which 50% of the bed material is finer (i.e. the median sediment size) and ρ and ρ_s are the densities of water and sediment.