Lower Gordon River erosion monitoring

Update report for the period December 2018 to January 2020

Natural Values Science Section
Natural and Cultural Heritage Division DPIPWE
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Introduction

This is the fifth in a series of brief update reports since the last comprehensive documentation of the lower Gordon River erosion monitoring program (DPIPWE 2013). This update report contains only enough background information to understand the most recent monitoring results and updated time-series plots. For detailed landform description, methods, previous results and discussion of their significance please refer to the earlier comprehensive report. The monitoring documented here was conducted from 13 - 16 January 2020. While the erosion rates reported here may appear low, the lower Gordon River was a stable to actively depositional environment until the 1980s. It is the change in direction of landforming process rather than the absolute rate that is of concern.

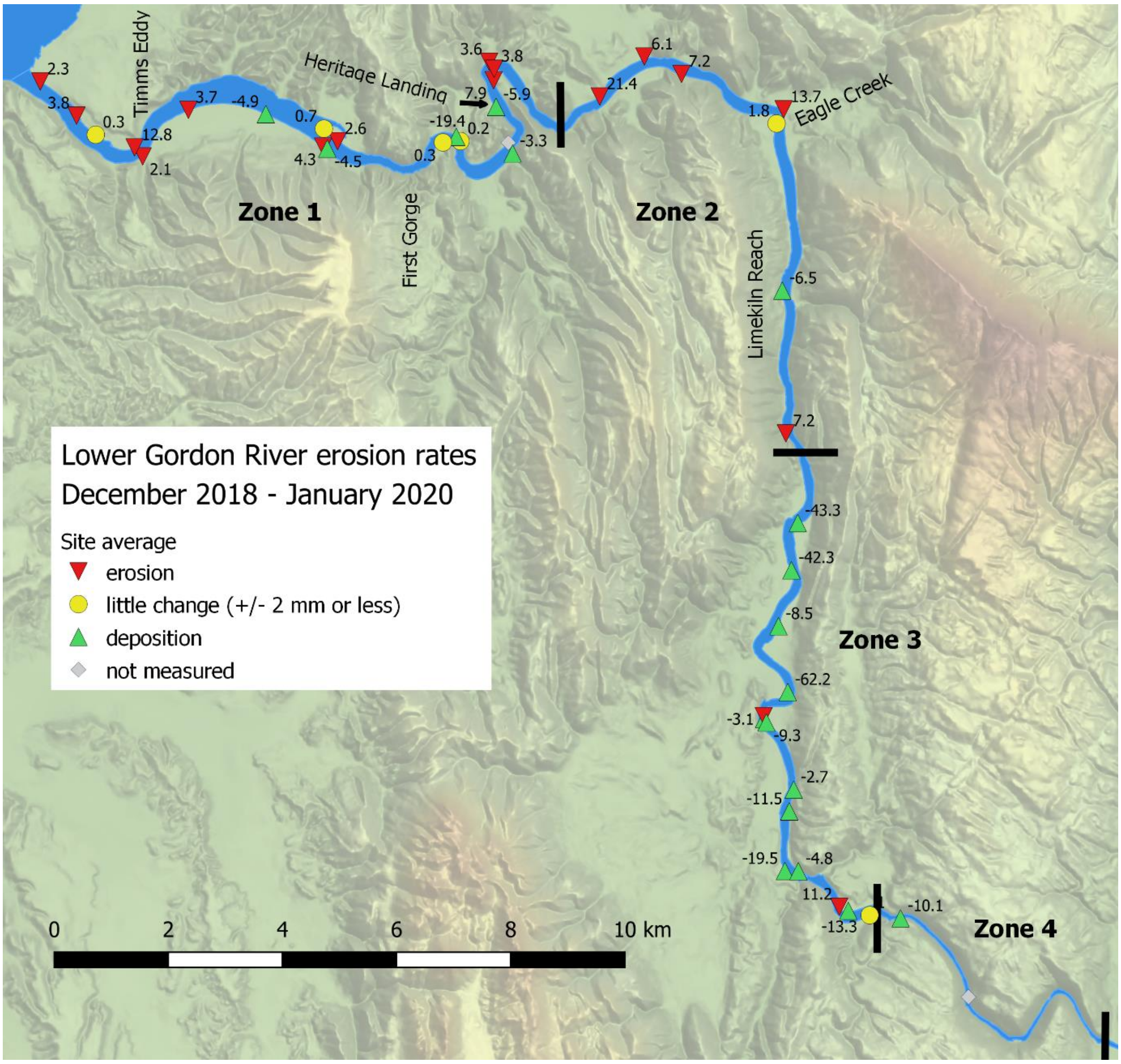

Figure 1: Map of the lower Gordon River area showing the mean rate of erosion of critical landforms (estuarine and alluvial scarps and lower levees) as recorded by multiple pins at each monitoring site. Numbers indicate the average rate of change at each site in mm/yr, zone boundaries are shown as thick black lines. Basmap ©TheLIST.

Methods

Erosion is measured using erosion pins, a well-established method of measuring the rate and magnitude of river bank change (Wolman 1959, Lawler 1993). Erosion rate is determined by repeated measurement of pins installed perpendicular to the bank face. Change in the exposed length of pins between measurements indicates the net amount of erosion or deposition that occurred during the monitoring period. By convention a positive measurement indicates erosion and negative numbers represent deposition. Measurements are normalised and reported as a rate in mm/year, thus allowing straightforward comparison of monitoring periods of varying length. Three distinct sedimentary bank types are recognised and their distribution is a key determinant of the management zoning. Heading upstream from the mouth these are in order estuarine, alluvial and levee banks. Pin monitoring results from each bank type are reported separately.

Instrumental monitoring of near bank turbidity at 15 second intervals has been operating intermittently since 2003 at two sites, one above and one below Heritage Landing. Greenspan TS 100 instruments have replaced the original Analite sensors, otherwise the installations and data analysis remain as described in DPIPWE (2013). The installations essentially act as boat counters, providing a record of each vessel pass that causes geomorphic activity. They do not however record vessel passage that does not cause nearshore sediment suspension. Battery power constraints limit data collection to approximately 180 days between services.

Erosion pin monitoring

Estuarine banks

Estuarine banks are the very low-lying banks consisting of organic rich mud and minor sand that occur between the mouth of the river and First Gorge. The general form of these banks is depicted in figure 2. Geomorphological evidence including radiocarbon dating (Bradbury et al. 1995) indicates that these banks were actively depositional until recent decades. Estuarine banks are low enough to expect inundation of the upper flat and possible deposition several times each year.

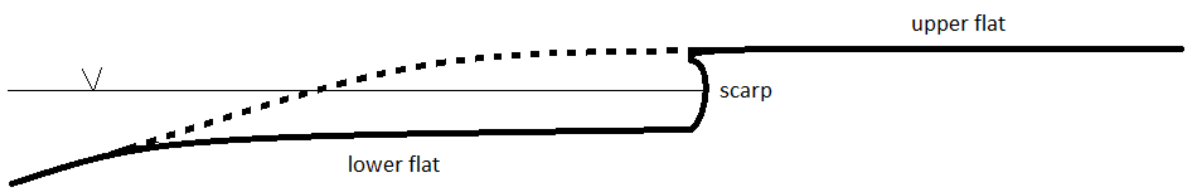

Figure 2: A generalised estuarine bank profile showing a near-vertical erosion scarp, typically 30 – 50 cm high, separating two sub-horizontal surfaces. The dashed line shows the pre-erosion profile, as preserved on similar banks in some relatively un-trafficked estuaries elsewhere in southwest Tasmania. The fine line indicates average water level.

Most erosion pins are installed sub-horizontally in the eroded scarp, to record the overall rate of bank retreat. A smaller number are installed vertically in either the permanently submerged shoal below or in the occasionally inundated, vegetated surface above. It is only on those flats where deposition can occur, although a few low scarp pins may record deposition burying the scarp foot. Due to the low angle between pin and depositional surface measurements from those pins overestimate the true rate of sediment accumulation. Estuarine bank erosion rates are summarised in table one and figure three. The graph shows the apparent effectiveness of successive management measures in reducing the rate of erosion of these banks.

Table one: summary estuarine bank erosion pin measurement statistics for the reporting period. All values except n are in mm/yr. Negative values indicate deposition.

	count (n)	min.	max.	mean	st. dev.	n < 0	n = 0
overall	68	-92.5	92.8	**0.2**	20.1	14	17
scarp	55	-92.5	92.8	**2.2**	21.3	5	16
lower flat	10	-34.2	3.6	**-8.6**	11.8	7	1
upper flat	3	-17.3	0.9	**-6.5**	9.5	2	0

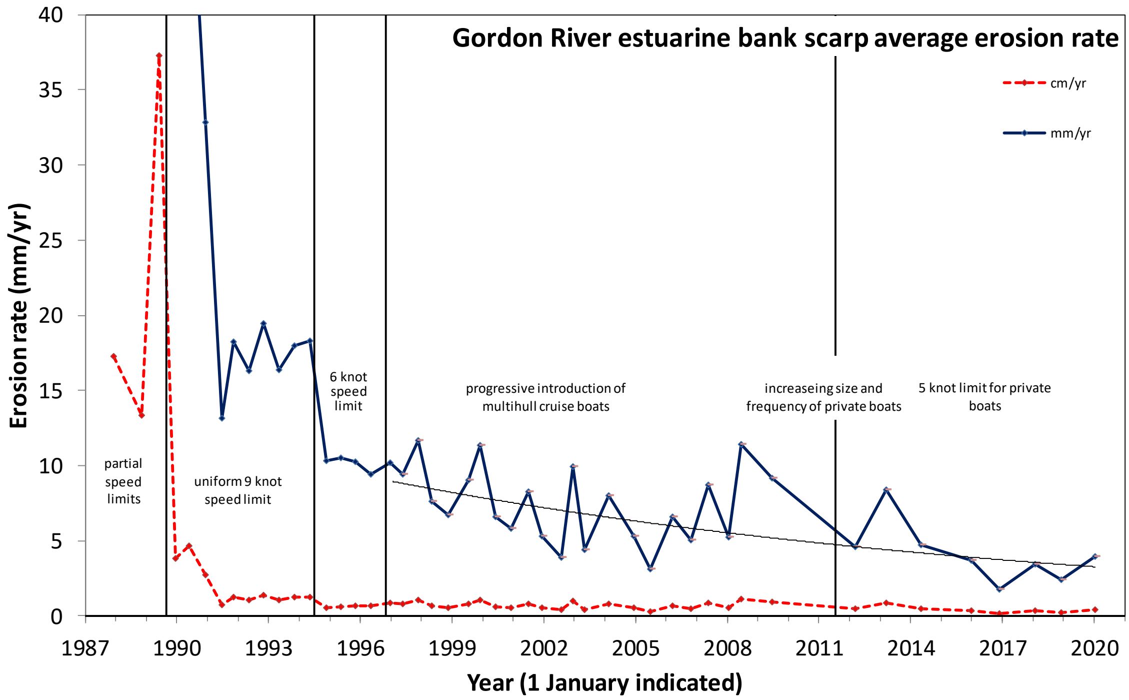

Figure 3: Mean rate of estuarine bank scarp erosion through time. In contrast to previous reports measurements from upper and lower flats are excluded, providing a better indication of bank retreat. The fine smoothed curve shows the best fit trend of the data since the first introduction of multi-hulled cruise vessels.

Alluvial banks

Alluvial banks consist of silt and fine sand and display a flat to subdued levee morphology with a crest typically about 0.3 - 1 m above mean water level. They occur in the floodplain areas between First Gorge and Eagle Creek, also sporadically in Limekiln Reach. These banks were stable, supporting millennia old Huon pines, until the 1980s. The general form of these banks is depicted in figure four. Again, most pins are installed in the eroded scarp, with a smaller number in the shoal below or vegetated surface above.

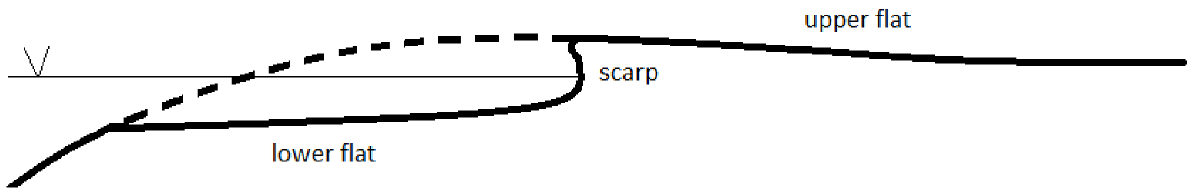

Figure 4: A generalised alluvial bank profile showing a near-vertical erosion scarp, typically 30 – 80 cm high, separating two sub-horizontal surfaces.

Alluvial bank erosion rates are summarised in table two and figure five. For reporting purposes zone 1 sites upstream of the present cruise limit at Heritage Landing are grouped with zone 2. In zone 1 six pins installed in the lower scarp recorded high rates of deposition (-20 to -44 mm/yr) due to mud accumulation on the lower flat. Those measurements have been excluded from calculation of scarp retreat. Furthermore, due to the high angle between pin and depositional surface those measurements are overestimates of the true rate of deposition.

Since 1989, when commercial cruises were excluded from zone two, the rate of alluvial bank erosion in that zone has typically (but not always) been lower than that in zone one (figure 5). That difference has been at times statistically significant and attributed to the effect of cruise boat wave wake. However for the past few years the difference has been reversed, largely due to anomalously high rates of erosion in Expectation Reach. A similar situation occurred in the mid-2000s, suggesting that the banks of Expectation Reach in particular may in fact be more erosion prone than otherwise comparable banks in zone 1.

Table two: summary alluvial bank erosion pin measurement statistics for the reporting period. All values except n in mm/yr. Negative values indicate deposition.

	count (n)	min.	max.	mean	st. dev.	n < 0	n = 0
Zone 1 alluvial banks							
overall	37	-87.2	12.3	**-8.0**	18.9	17	8
scarp	21	-5.4	12	**0.6**	3.4	5	7
lower flat	9	-87.2	9.9	**-17.0**	31.1	5	1
upper flat	2	-6.3	-3	**-4.5**	2.5	2	0
Zone 2 alluvial banks							
overall	52	-21.6	78	**6.4**	19.3	14	12
scarp	38	-19.8	76.6	**6.9**	16.8	7	10
lower flat	12	-21.6	77.5	**5.1**	28.0	7	2
upper flat	2	2.7	5.4	**4.0**	1.9	0	0

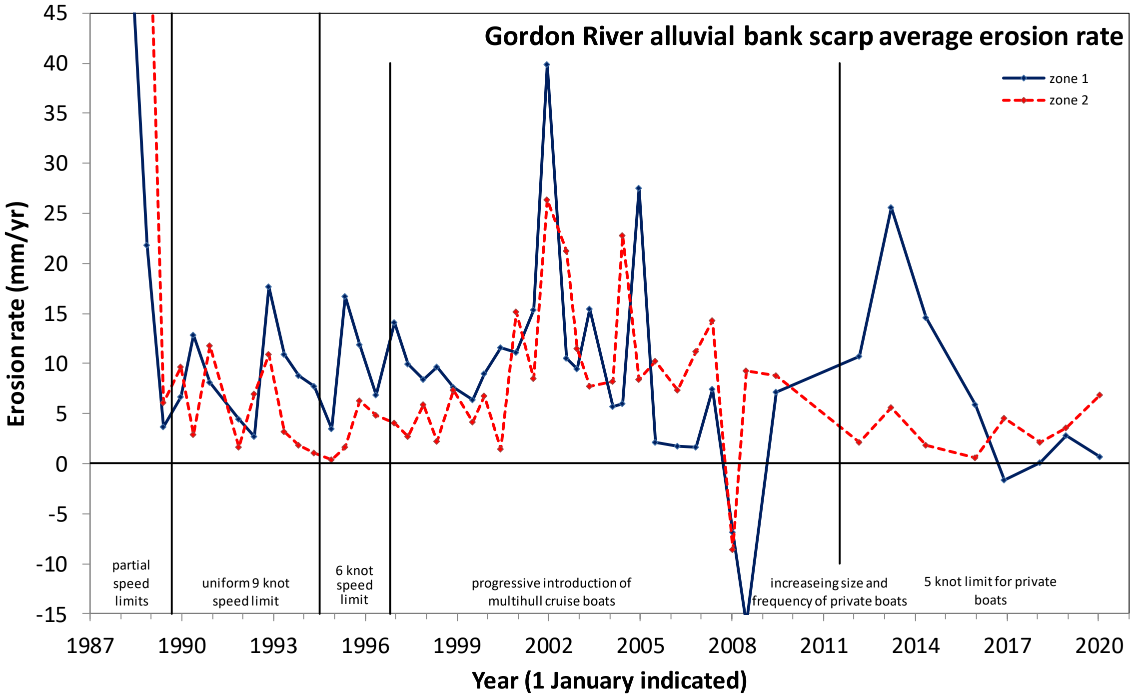

Figure 5: Mean rate of alluvial bank scarp erosion through time. In contrast to previous reports, measurements from upper and lower flats are excluded, providing a better indication of bank retreat.

Levee banks

The sandy levee banks of zone 3 and small areas of zone 4 are very susceptible to wake wave erosion and the formerly stable landforms were rapidly eroded in the 1980s after breaching of the protective surficial root mat. The monitoring program recognises three discrete landform subunits; an upper scarp, a mid-level debris apron and low sandy bars (figure 6). The latter consist of unconsolidated and unvegetated to sparsely colonised sand deposited since 1989; these represent partial recovery from a catastrophic event and are a fragile buffer against renewed levee retreat. In leveed reaches the lower levee is therefore the focus of the present monitoring program. Deposition on the lower levees is limited to periods of high flow, most notably having occurred during the floods of 1995 and 2007. Levee bank erosion rates are summarised in table three and figure seven.

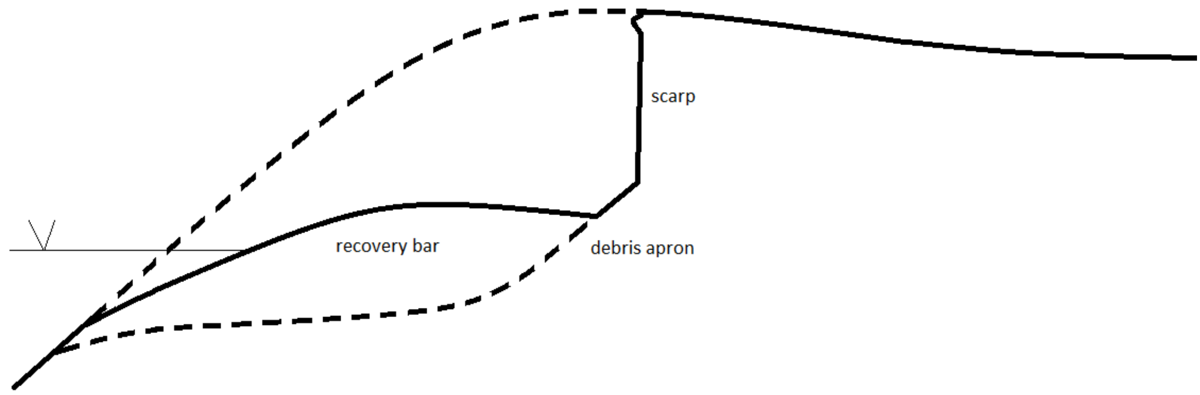

Figure 6: Generalised form of levee banks showing upper levee scarp, middle levee debris apron and lower levee recovery bar. The volume removed by erosion during the 1980s is shown between the dashed lines. The top of the scarp is typically 2 – 3.5 m above the normal water level shown.

Over the 2019 monitoring period only minor adjustments of the upper and middle levee landforms were recorded. The lower levees were considerably more active, with significant rates of both deposition and erosion being recorded, for an average of 19 mm/yr deposition. Since closure of the leveed reaches to commercial cruises in 1989 the lower levees have recorded an average of almost 200 mm of cumulative deposition. However, that is an underestimate of true deposition for two reasons:

- Backwater areas have recorded only mud deposition even in the larger floods. These areas may never again receive sand due to diminution of flood peaks by the Gordon dam.
- The 1995 and especially the 2007 event buried some lower levee pins, meaning that in the areas of greatest deposition the accumulation could not be quantified.

A qualitative estimate based on size and form of the scarp foot bars would be that on the order of 1 m of sand has accumulated since 1989.

Table three: summary levee bank erosion pin measurement statistics for the reporting period. All values except n in mm/yr. Negative values indicate deposition.

	count (n)	min.	max.	mean	st. dev.	n < 0	n = 0
upper levee	26	-0.9	34.2	**1.3**	6.7	1	23
middle levee	27	-15.3	8.1	**-1.8**	5.6	9	10
lower levee	89	-131.3	77.3	**-18.6**	37.4	62	3

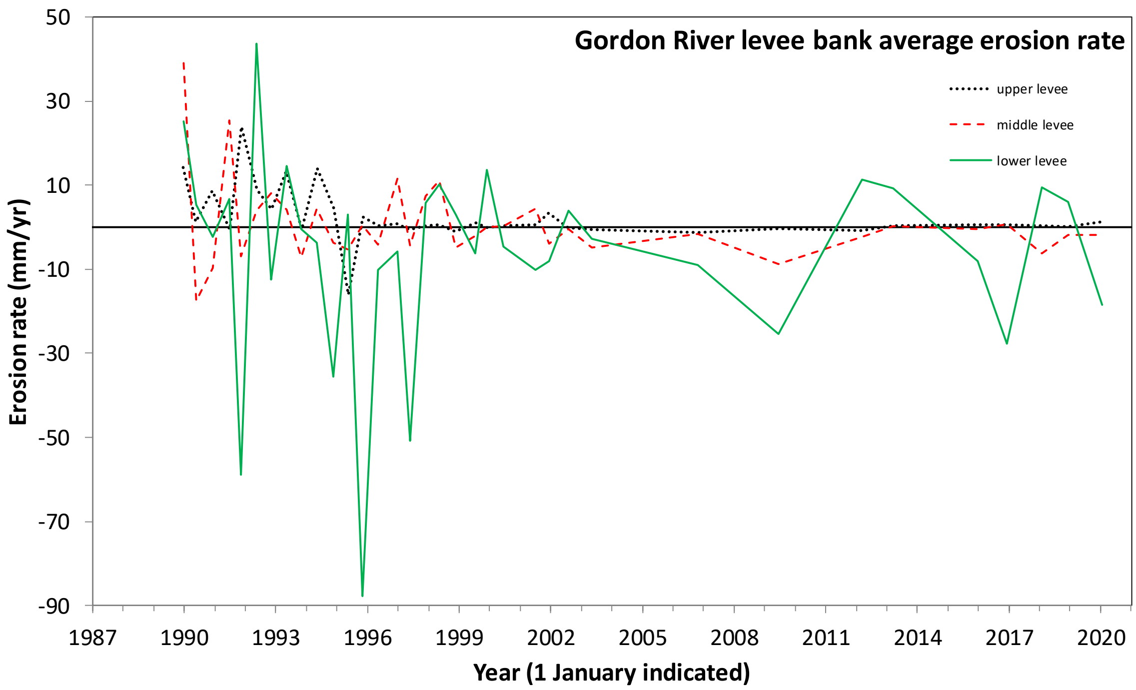

Figure 7: Mean rate of levee bank erosion through time. Prior to 1989, when the erosion rate was much greater before cruise vessels were excluded from these reaches, no distinction was made between upper, middle and lower levee.

Turbidity monitoring

The monitoring period 7 December 2018 to 16 January 2020 contained 405 days. Of those the upstream site recorded data for 313 days while the downstream site only recorded 56 days of data. In addition, time and date stamps for the August 2019 data from the downstream logger are suspect. Data loss was mostly due to datalogger malfunction, with an additional 24 days loss from the upstream site due to excessively noisy signal of unknown cause. The malfunctioning and by now obsolescent devices were replaced with new Unidata Neon 3004A loggers in January 2020.

At the downstream site a total of 251 turbidity events characteristic of wave wake impact were recorded, for an average of 4.48 per day over the 56 days of operation. The upstream site recorded 211 events, an average of 0.73 per day. The daily event counts at both sites are shown in figure 8 and are consistent with previous tallies. Note that due to the difference in bank type (estuarine vs. alluvial) and water depth the two sites are not directly comparable, with the upstream site being less sensitive to vessel effects.

Historically, the timing of turbidity events (figure 9) has shown that near bank geomorphic activity at the downstream site is dominated by scheduled cruises, which pass the site shortly after 10:00 am (upstream), noon (upstream and downstream) and about 2:00 pm (downstream). While that remained the case for the December 2018 data, the August 2019 data shows a similar pattern but approximately an hour earlier. It is not clear whether that represents a true pattern of use or corrupt time and date stamping as a by-product of logger failure.

Given the large gaps in the turbidity data time-series no further analysis is warranted here.

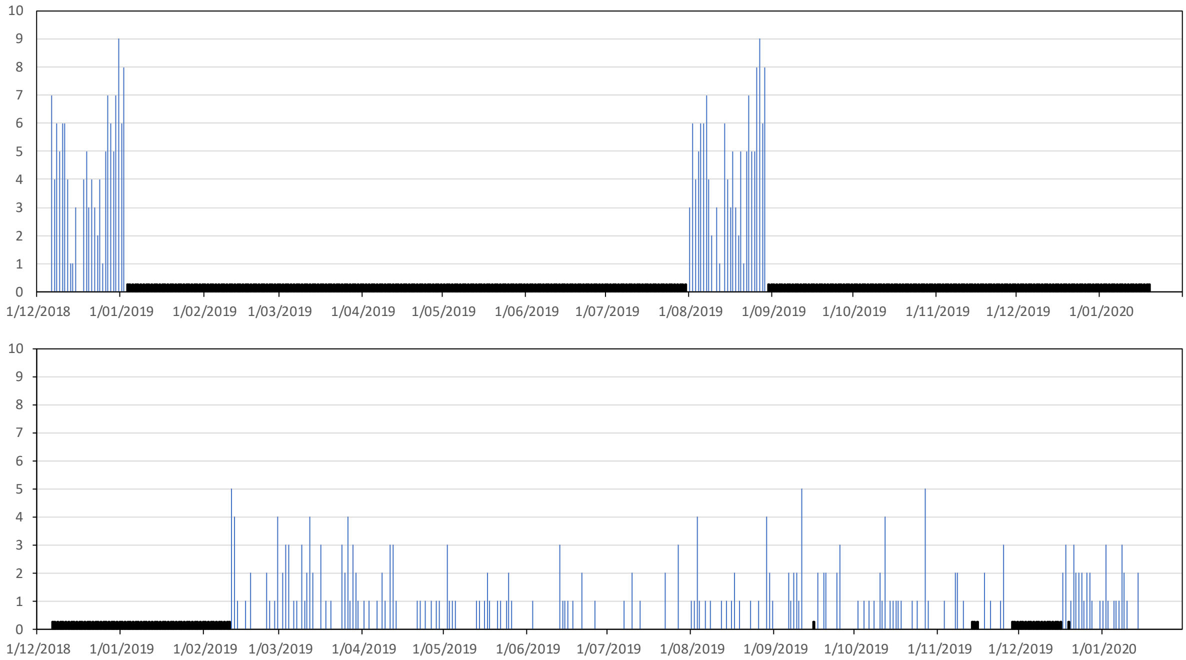

Figure 8: Histograms showing daily event counts at the two turbidity monitoring sites during the monitoring period, downstream top and upstream bottom. Thick black bars indicate periods of data loss.

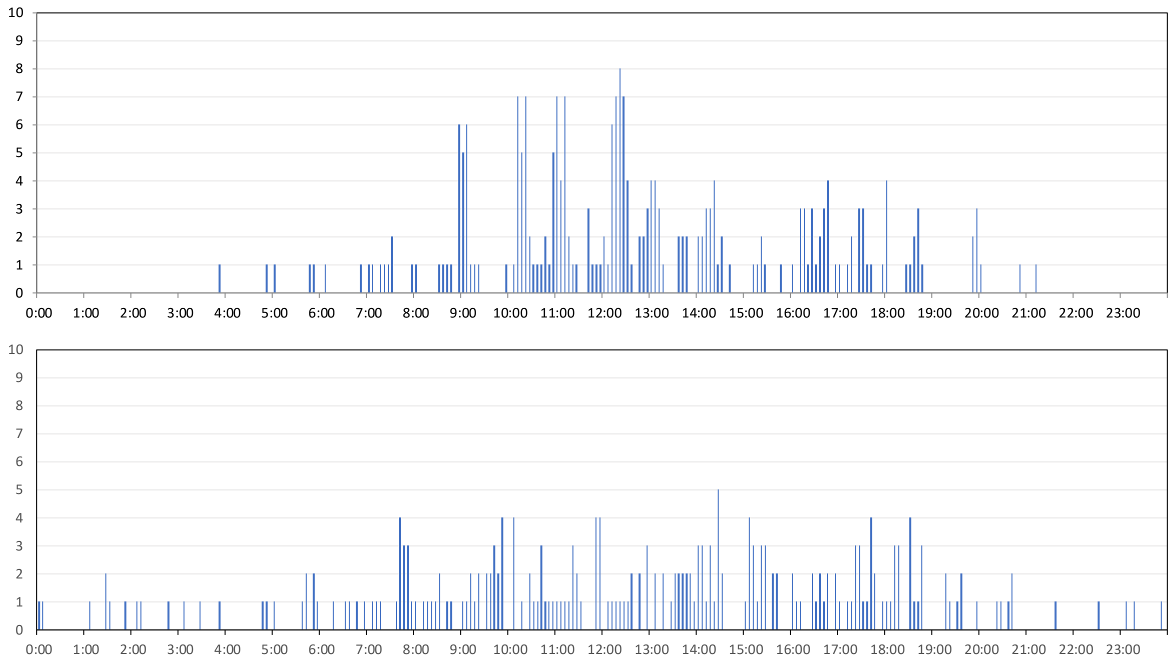

Figure 9: Histograms showing timing of turbidity events in 5-minute bins during the monitoring period, downstream top and upstream bottom.

Summary and conclusions

The formerly depositional estuarine banks recorded a slight increase in scarp erosion rate compared to the previous monitoring period. However, despite some flattening the long-term trend continues as one of declining erosion rate.

Formerly stable alluvial banks in zone 1 recorded near zero average scarp erosion and deposition on both upper and lower flats. However similar banks in zone 2 showed the highest average rate of scarp retreat in a decade and recorded erosion of both upper and lower flats. The long-term data suggests that the banks of Expectation Reach in particular may in fact be more erosion prone than otherwise comparable banks in zone 1.

Levee bank scarps and debris aprons showed little activity, as might be expected. In contrast to the previous year the scarp foot recovery bars recorded deposition of up to 131 mm/yr for an average of 19 mm/yr. These banks continue their slow recovery from the catastrophic erosion of the 1980s but do not yet show any evidence for the development of a protective surficial root mat.

Despite some recovery in the form of deposition on estuarine and alluvial flats and on the levee foot bars, all bank types in all zones remain susceptible to wave erosion.

Turbidity monitoring was affected by logger failures that resulted in significant data loss. Those loggers have now been replaced. The available data indicates that most geomorphic activity at the site downstream of Heritage Landing still occurs at the times of scheduled cruises. The daily average turbidity event count attributable to river traffic remained comparable to that of previous years in both zones 1 and 2.

When erosion pin and turbidity monitoring data are considered together and in conjunction with overall trends, no new erosion problems are revealed. However, some erosion remains attributable to cruise vessels. That is counter to the Lower Gordon River Recreation Zone Plan (PWS 1998) management target of zero wash induced erosion. Theoretical considerations, centered on an energy threshold that must be exceeded before erosion can occur, suggest that continued erosion by cruise vessel wave wake could be avoided by a slight (0.5 kt) reduction in speed. It is anticipated that this issue will be addressed in more detail in upcoming review of the Recreation Zone Plan.

In order to inform on-going adaptive management of the lower Gordon River it is recommended that erosion pin and turbidity monitoring be continued at the present frequency.

References

Bradbury, J., Cullen, P., Dixon, G. and Pemberton, M. 1995. Streambank erosion, revegetation and management of the lower Gordon River, Tasmanian Wilderness World Heritage Area. *Environmental Management* 19: 259 – 272

DPIPWE 2013 *Lower Gordon River erosion monitoring, Tasmanian Wilderness World Heritage Area-report for the period February 2004 to March 2013.* http://dpipwe.tas.gov.au/Documents/LGR%20Monitoring-2013-14.pdf

Lawler, D.M. 1993. The measurement of river bank erosion and lateral channel change: a review. *Earth Surface Processes and Landforms* 18: 777 - 821.

PWS 1998 *Lower Gordon River Recreation Zone Plan*. Parks and Wildlife Service, Hobart. http://www.parks.tas.gov.au/file.aspx?id=6604

Wolman, M.G. 1959. Factors influencing erosion of a cohesive river bank. *American Journal of Science* 257: 204 - 216.