Hope for the best, plan for the worst: Managing sediment input in the upper catchment whilst preparing for avulsion at the mouth.

Michael D Cheetham[1], Julian C Martin[1]

1 *Water Technology, West End, QLD, Australia. michael.cheetham@watertech.com.au*

Key Points

- High sediment loads in the George River due to granitic catchment, historic mining and ongoing erosion.
- Sediment slug at the mouth of the river will likely lead to avulsion in the short to medium term.
- Controlling sediment production and transport in the upper catchment will take decades.
- Avulsion management must happen in the short term through sediment extraction or controlled avulsion.

Abstract

The George River in north east Tasmania runs from west of Pyengana to St Helens, where it flows out onto a large delta within Georges Bay. Previous research shows the delta, on which the township of St Helens is built, is Holocene in age. The George River and the Golden Fleece Rivulet to the south have both contributed to delta progradation during the Holocene and the George River has occupied several courses on the delta over that time. Currently, the George River occupies a course at the northern boundary of the delta; however, increased sediment accumulation in this section of the channel is causing rapid infill and avulsion to a new course on the floodplain is becoming imminent.

Sitting in a granitic catchment, the George River is naturally subject to high sediment loads. However, historic hydraulic mining and land clearing have increased sediment loads substantially. The George River consists of alternating floodplain and gorge sections. As such, eroded sediment is forced rapidly through gorge sections and stored temporarily in the valley expansions, either as splays on the floodplain or sand slugs in the channel. Increased bank erosion due to a lack of vegetation or willow outflanking is leading to a substantially increased rate of sediment moving to the mouth, instead of being stored in these sections. Combined with substantial willow infestations in the lower reaches the river mouth is soon set to fill completely.

Management options to reduce sediment load include weed management, riparian revegetation and stock exclusion. However, the channel is very close to the threshold required for avulsion and the scale of bank stabilisation and revegetation required is vast. Whereas, managing sediment in the upper catchment is strongly recommended, preparing for avulsion at the mouth is essential to ensure a stable new course for the George River.

Keywords

Sediment extraction, Revegetation, Bank Erosion, Gullying, Mining Impacts, Sediment Slugs.

Introduction

In 2016, Tasmania was subject to widespread flooding. The flooding caused significant damage to many of Tasmania's waterways, including the George River system. The George River in north east Tasmania runs from west of Pyengana to St Helens, where it flows out onto a large delta within Georges Bay. Previous research shows the delta, on which the township of St Helens it built, is Holocene in age (Mazengarb, 2016).

The George River and the Golden Fleece Rivulet to the south have both contributed to delta progradation during the Holocene and the George River has occupied several courses on the delta over that time. Currently, the George River occupies a course at the northern boundary of the delta; however, increased sediment accumulation in this section of the channel is causing rapid infill and avulsion to a new course on the floodplain is becoming imminent.

Sand slugs are evident in the channel, at the bridge near the mouth of the George River and in the form of a large delta at the mouth of the river. This project investigates the sources of this sediment and proposes management options to mitigate the sediment influx and prepare for potential system changes in the future.

Catchment Description

The George River catchment drains to the north east coast of Tasmania at St Helens, south of the Bay of Fires. The catchment is approximately 616 km^2 in size, including several major tributaries such as the Ransom River, Groom River, Powers Creek, Kohls Creek and Factory Creek (Sprod, 2003). In the upper catchment near Pyengana the river splits in to the North and South George Rivers (Figure 1).

The George River and Ransom River consist of alternating sections of open floodplains/terrace and confined gorge sections. Much of the catchment is very steep. The channel, in many of the floodplain sections, is almost completely devoid of vegetation and channel erosion both on the bed and banks is evident in almost all these locations. Willows are present in patches along most of the upstream floodplain channel areas.

Land use on the floodplain areas is predominantly grazing. Logging activities are also evident within the catchment and most headwater streams and tributaries run through state or forest reserve. The gorge sections of the Rivers are also usually flanked by state or forest reserve.

Figure 1. Map of the George River Catchment with key locations identified.

The Lower George River

The lower George River is situated immediately downstream of a steep gorge section (Figure 2) and runs through a large Holocene delta complex out to Georges Bay. The channel has clearly occupied various locations on the delta surface over the past 10,000 years. Currently, the channel runs along the northern boundary of the delta, flanked by terraces on the left bank and a levee along the right bank.

As can be seen in Figure 2, the channel immediately downstream of the gorge section is unvegetated on the right bank. The channel is then lined with willows for almost its entire length of the reach all the way to its mouth. Recent and historic flooding has led to large volumes of sand deposited as splays across the floodplain (Figure 2) and as sand slugs within the channel. Aggradation along this reach has led to the channel being infilled and, due to the levee, the channel bed is now higher than the adjacent floodplain in some locations.

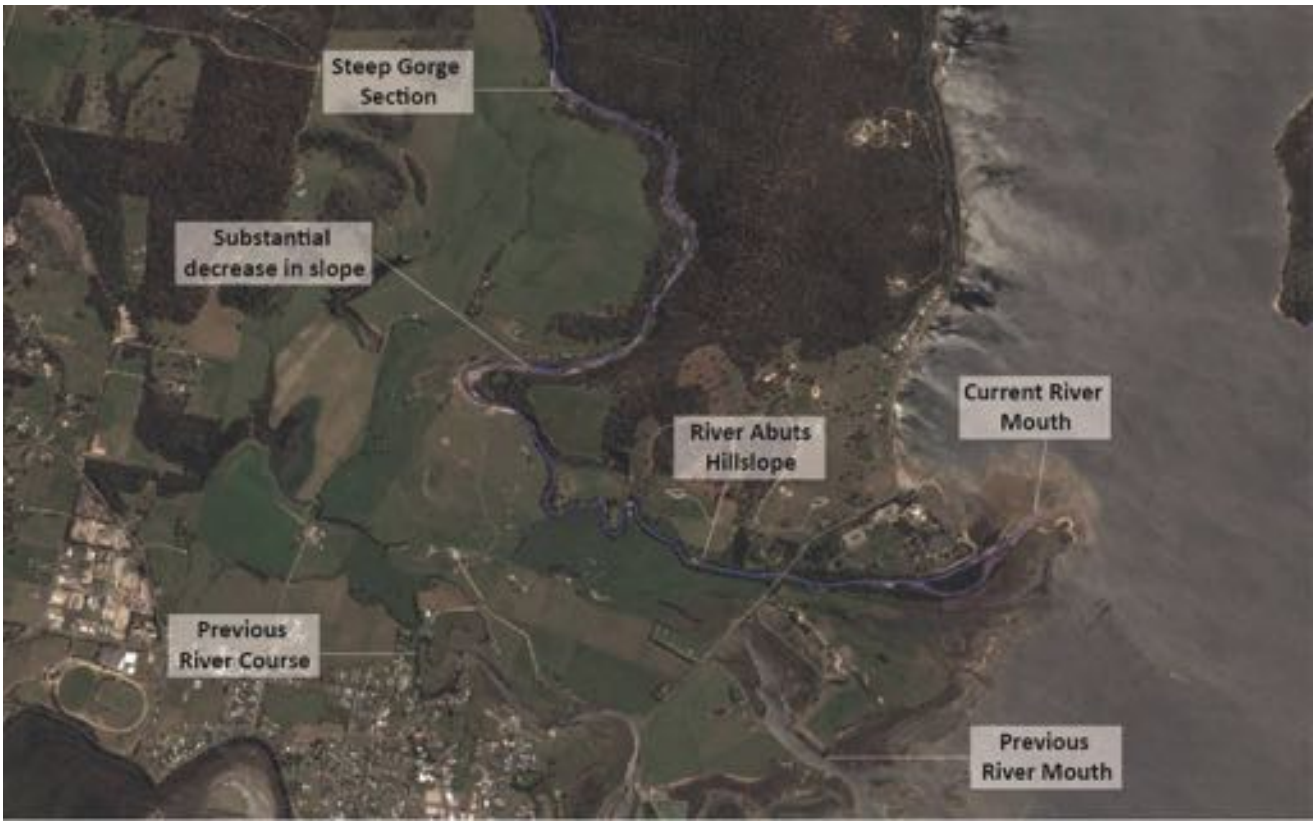

Figure 2. Map of the Lower George River with key locations identified.

Sediment Sources

Bed and Bank Erosion

The George River catchment is predominantly Devonian granite and is therefore naturally subject to high sandy sediment loads. However, historic hydraulic mining and land clearing have increased sediment loads substantially. Bed deepening has been reported since 2003 (Sprod, 2003) and is observable in historic aerial photography.

Bank erosion and developing avulsions are occurring on a large scale along much of the upstream river reaches. This is particularly evident at Priory, approximately 16 km upstream of the mouth. Figure 3 shows erosion along a secondary flow path (avulsion) along the George River at Priory. Erosion at this scale is extensive and is observable for approximately 6 km along this reach (Figure 5). Whereas bed deepening may have been initially responsible for bank collapse, a majority of the ongoing erosion can be attributed to a lack of riparian vegetation. The channel is now widening along much of its length.

The George River consists of alternating floodplain and gorge sections. As such, eroded sediment is forced rapidly through gorge sections and stored temporarily in the valley expansions, either as splays on the floodplain or sand slugs in the channel. Increased bank erosion due to a lack of vegetation or willow outflanking is leading to a substantially increased rate of sediment moving to the mouth, instead of being stored in these sections. Land clearing also results in increased sediment making its way rapidly to the channel.

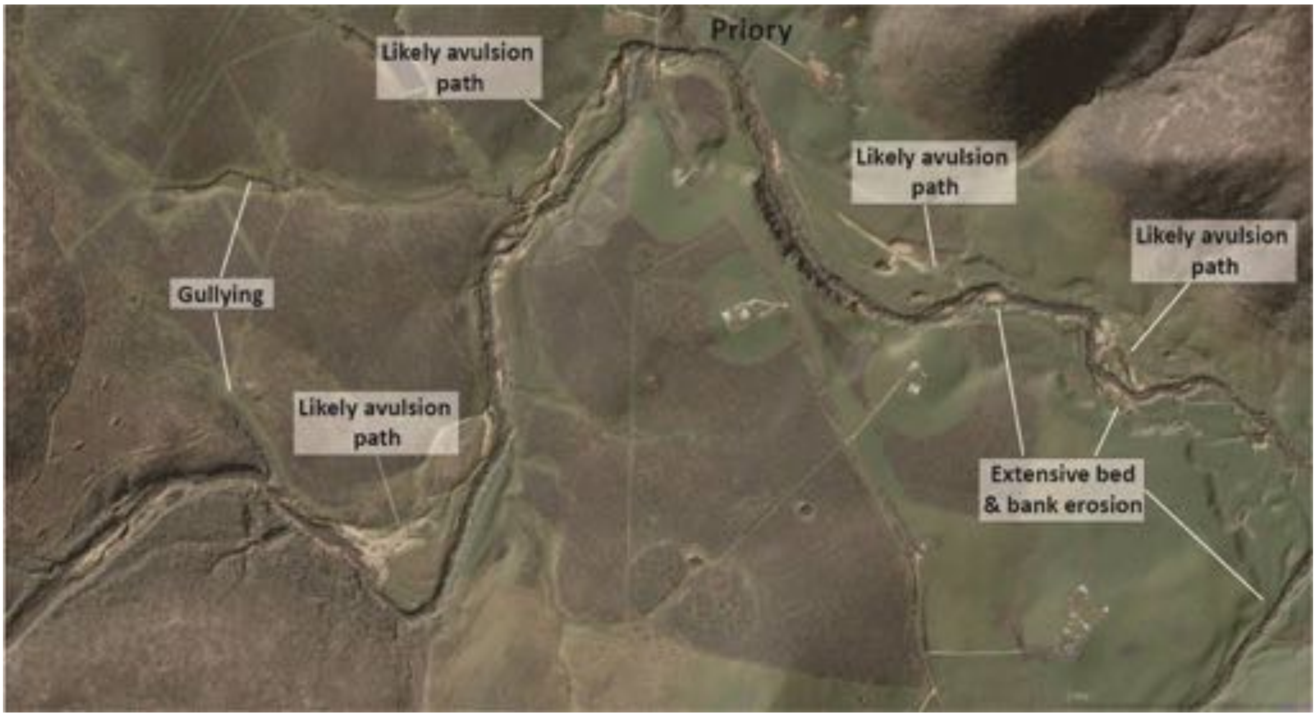

Figure 5. LiDAR topography overlain on aerial imagery showing extent of bank erosion.

Figure 6. Extensive bank erosion approximately 8m high 15m of retreat over 400m (Left). Erosion along an avulsion path near Priory (Right).

Mining

Historic mining in the upper reaches of the George River is well documented, commencing from the 1880's. Tin mining on the Ransom and Groom Rivers through bucket dredging, sluicing, open cut and underground excavations is said to have generated up to 1.6 million cubic metres of sand (Sprod, 2003). The majority of the sand tailings were added straight to the channel. The Anchor Mine operated continuously between 1885 and 1945, and then intermittently until 1995. All sand tailings from this operation were added straight to the river system. This mining activity has contributed to large sand slugs moving downstream within the George River system.

Almost all these mining areas have since been reforested. However, evidence of the hydraulic mining can be seen easily in the LiDAR topography (Figrue7).

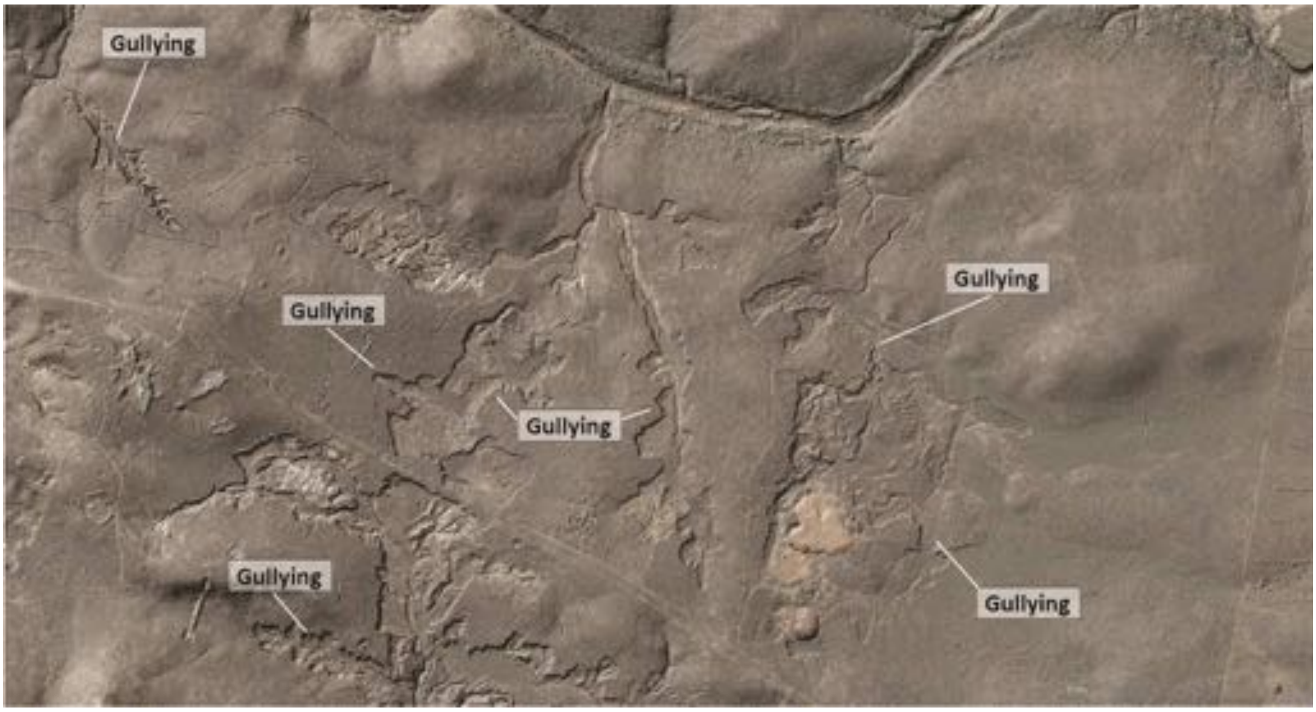

Figure 7. LiDAR topography showing effect of historic sluice mining and ongoing gullying.

Topographic Assessment

An assessment of previous flood hazard mapping (Pitt & Sherry, 2013) and floodplain/delta topography adjacent to the lower George channel was conducted to predict likely breakout points and a future preferred channel course. The current course of the Lower George is, in planform, the shortest path to George Bay. However, an inlet to the south (likely a previous mouth of the George River) is only slightly longer and, as it is not full of sand, represents a steeper path to the bay.

Several potential breach locations exist along the lower George River, based on topography and channel planform. However only three are confirmed by photographic and anecdotal evidence. Of the two confirmed locations, only one is considered a likely avulsion path due to the downstream channel length and thus grade increase (Figure 8).

Figure 8. LiDAR topography showing previous courses of the George River along with potential future courses and breakout points.

Trajectory for Change

The George River is undergoing substantial change in terms bank collapse in response to bed deepening. Much of this change is associated a lack of riparian vegetation along the banks and floodplain. This bank erosion is leading to significant quantities of sand being added to the channel. In addition, it is likely that gullying within the old mining areas is also continuing to add sediment to the channel. These sediment sources are likely to continue and even worsen in the short to medium term.

Floodplain topography of the George River delta shows that the lower George River channel has changed course many times in the past. Combined with substantial willow infestations in the lower reaches the river mouth is soon set to fill completely. Ongoing infilling of the George River with sand, indicates an approaching threshold change for the Lower George River, at which, it will change course again. Certainly, if sediment continues to accumulate in the channel at this location breaching of the levee during floods is increasingly likely.

Discussion

Monitoring of the area over the last 15 years indicates that sedimentation within the lower George River is an ongoing problem. Like most deltas the lower George delta represents a substantial reduction in grade to that of its immediately upstream reach. It is therefore an area naturally prone to sediment accumulation and anthropogenic influences such as mining and tree clearing have accelerated this process. Sediment delivery to the channel upstream does not appear to be slowing and avulsion is likely in the coming years. As such, intervention is required to address excess sediment in the channel and it associated impacts.

The objective of this project is to reduce sediment with the express intention of a) reducing the likelihood of avulsion in the lower George delta; and b) reducing the volume of sand deposited on the floodplain during floods. Management options for excess sediment include: reducing the ***sediment supply*** at the source, promoting ***sediment storage*** in the channel, accelerating ***sediment transport*** through the system or directly ***extracting sediment*** from the channel (Sims and Rutherford, 2017). Sims and Rutherford (2017) go on to point out that these are not necessarily mutually exclusive. With avulsion as the ultimate result in this scenario, a fifth option of planning for a ***controlled avulsion*** is added to the list, particularly as this is a natural and common process in the formation of alluvial deltas.

Reducing the sediment supply at the source and promoting storage on the floodplain are considered appropriate in this location it is likely that these options will require a substantial investment of both time and money. Revegetating the riparian zone along the eroding areas and re-establishing vegetation on the floodplain (including likely avulsion paths) will assist in both reducing erosion and increasing storage. However, the areas requiring treatment are large and considerable time will be required to get funding and buy in from landholders. It could be decades before for the works achieve the desired response at the bottom end of the catchment. Given the degree to which the channel is infilled in its lower reaches it is likely that any future flood will breach and damage the levee and catastrophic flooding, like that seen in 2016, has the potential to carve a new course through the landscape.

Trapping sediment in the George River channel is unlikely to be an option due its steepness in the reach immediately upstream and degraded (incised) nature of the channel upstream of that. However, trapping sediment along tributaries affected by mining is an option and may reduce sediment loads substantially if undertaken on a wide scale. This could be achieved in a number of ways, including revegetation and cross channel log or weir structures.

Rutherfurd and Budahazy (1996), recommended sediment extraction from the main channel on the Glenelg River in Victoria and discuss the potential for improved condition when compared to the existing. In this affected reach of the George River, a near complete lack of geomorphic diversity suggests that may also be the case in this scenario. The common detrimental effect of channel sand extraction, incision through knickpoint migration is unlikely progress far due to bedrock bars in the gorge section. As such extracting sediment from the channel at this location is a potential option to address the potential avulsion. Sand extraction at this location could be accompanied by the replacement of willows with native vegetation. This approach would increase channel capacity and allow for enhanced sediment transport through this reach, particularly if the levee was maintained. The costs of sand extraction are ideally offset with the sale of the sand to the construction industry; however, A cursory glance suggests that the sand is unsuitable for use in construction.

Analysis of topography and previously conducted hydraulic modelling (flood hazard results available only) shows the likely and most achievable path for an avulsion when the channel fills past the critical flow conveyance threshold. The path is slightly longer than the current channel but steeper due to its lack of infilling. The path also has the additional advantage of an existing bridge on Binalong Bay Road. Currently the channel is protected from deepening through knickpoint migration by a concrete weir structure. This structure could be removed and to promote the formation of a new channel and redirection of the George River. This would also require replacement of willows with native vegetation and revegetation efforts along the new channel. A controlled avulsion also comes with risks and analysis would be required to assess and mitigate these risks.

Conclusions

The solution to sedimentation along the George river is likely to be an all-of-the-above approach. Revegetating the riparian zone along the eroding areas and re-establishing vegetation on the floodplain (including likely avulsion paths) will assist in both reducing erosion and increasing storage. Trapping sediment along tributaries affected by mining will reduce sediment loads substantially if undertaken on a wide scale through revegetation and cross channel log or weir structures. These two actions will eventually reduce sedimentation on the floodplain (agricultural land); however, realistically, neither of these approaches could be undertaken rapidly enough to counter sedimentation and potential avulsion in the Lower George River channel. Particularly, given the degree to which the channel is already filled and the amount of sediment already in the upstream reaches. Therefore, planning a controlled avulsion or extracting sediment from the channel combined with revegetation are the only feasible options left to mitigate or stop the likely avulsion.

Further studies (such as hydraulic modelling) are required to understand the advantages and disadvantages of the two techniques including their costs and impacts. Hydraulic modelling would assist in reducing the uncertainty associated with allowing a controlled avulsion. High-resolution topographic analysis and geotechnical studies would assist with determining the amount and quality of sand with in the lower George River channel and as such the costs of its extraction and likely destination.

Acknowledgments

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