

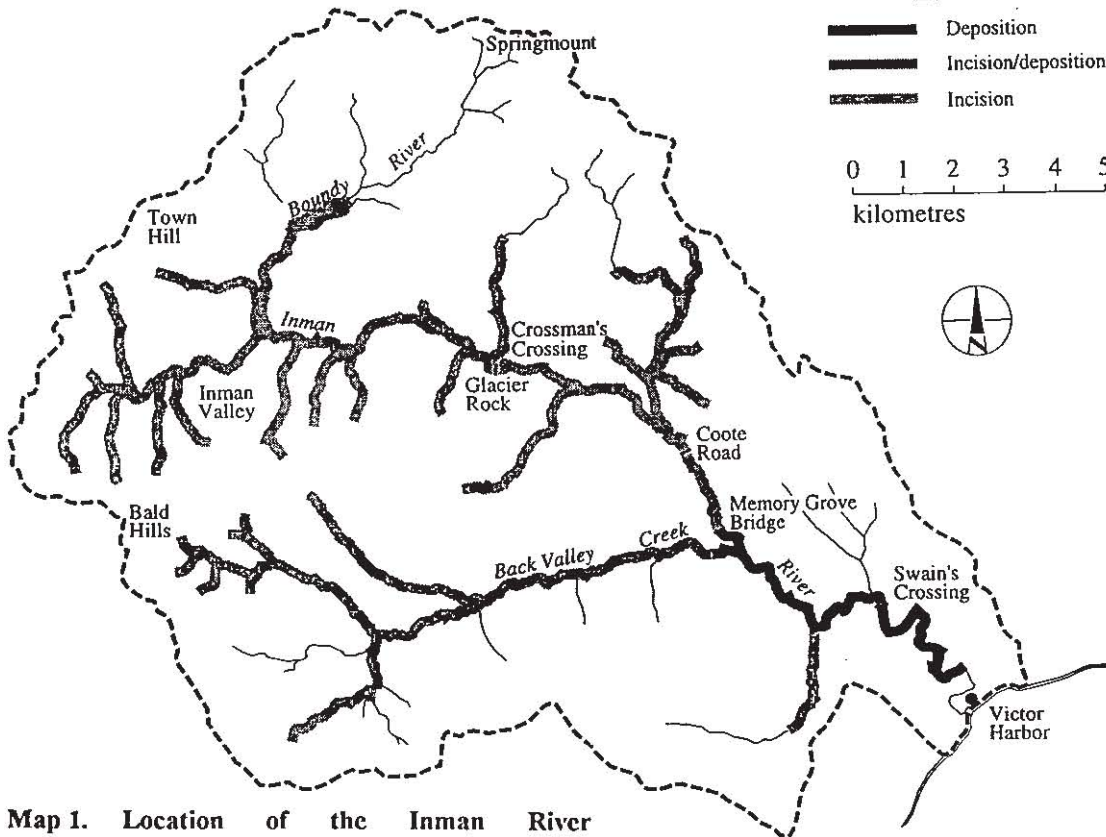
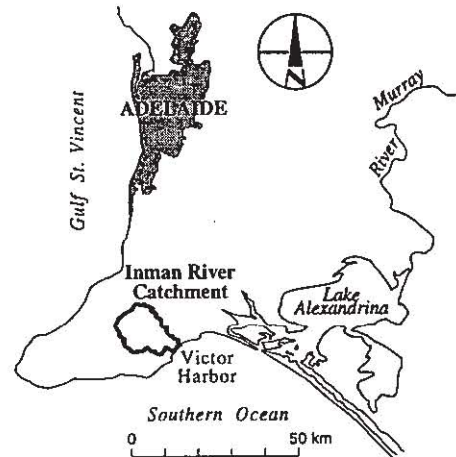
# THE IMPACT OF EUROPEAN SETTLEMENT ON EROSION AND SEDIMENTATION IN THE INMAN RIVER CATCHMENT, SOUTH AUSTRALIA

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**ABSTRACT:** *The onset of European settlement of the Inman River catchment, breached a geomorphic threshold, unleashing a dramatic cycle of erosion. Evidence of severe stream erosion can be traced back to 1854. This paper analyses the impacts of channelization, swamp drainage, vegetation clearance, sand extraction and unrestricted stock access. Approximately 13.4 million m<sup>3</sup> of sediment has been liberated since European settlement. Rates of migration of nick points of 2,100 metres pa. and 82 metres pa. have been recorded. Rates of erosion have declined during the last 40 years. Given the intermittent nature of the majority of watercourses in the catchment, comprehensive revegetation of watercourses is the best long term management option. The approach taken to erosion control is that of "minimalist" intervention, with "hard" engineered structures considered as last resort.*

## 1.0 INTRODUCTION

The Inman River catchment is located approximately 70 kilometres south of Adelaide (refer to Map 1, below) and has an area of 195.3 km<sup>2</sup>. Rainfall varies from less than 520 mm at Victor Harbor to in excess of 900 mm at Spring Mount (the highest point in the catchment).



Map 1. Location of the Inman River Catchment.

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The major watercourses of the catchment are believed to follow an ancient valley or basin, cut into the underlying Precambrian basement rocks, prior to the Permian glaciation. Permian glaciation deepened these ancient valleys, but left in its wake considerable depths (up to 300 m) of glacial and fluvio-glacial deposits (Bourman 1969). The following 200 million years was a period of erosion, reducing the region to an area of low relief. Tectonic uplift in the Tertiary period rejuvenated the watercourses (Bourman 1969), re-opening this ancient valley. This has resulted in an undulating to rolling landscape in the valley floor, quite distinctive from the steeper and higher hills of the surrounding hard rock landscapes that enclose the catchment.

The majority of the soils of the valley floor (Quaternary alluvium) are derived from the Permian glacial sediments. The undulating rises and low hills are formed on soft unconsolidated clay or sandy clay. The clays are sodic (ie contain a high level of sodium, thus are highly dispersive), therefore the region is prone to landslip and erosion.

Like many of the watercourses of eastern Australia at the time of European settlement, most of the watercourses of the Inman River catchment were marshy wetlands, with no defined channel, or formed small chain-of-ponds (Bird 1980 & 1982, Eyles 1977, Lush 1971, Starr 1989). These sites were believed to be dominated by dense stands of woolly tea-tree (*Leptospermum lanigerum*) and prickly tea-tree (*L. continentale*) (G. Ellers pers comm).

The Inman valley was settled by Europeans in 1837. As was the case elsewhere in Australia (Recher *et al* 1993), initial settlement and clearance of the catchment focussed on the river flats and open woodlands / grasslands. Governor Gawler, when visiting the region in 1839, described the valley as "...a lovely valley, varying from two to six miles in width, well watered and a rich soil for agriculture and herbage for pasture", (Lush 1971, p19). Since European settlement livestock grazing and dairying have been the mainstay of the valley.

## 2.0 STREAM EROSION

The erosion that followed European settlement has been primarily nick point migration, followed by lateral migration and bank collapse. There have been eras of rapid, episodic incision, rather than gradual, progressive erosion.

The initiation and development of stream bed erosion was generally associated with intense rainfall

events, particularly during the summer months. In January 1941, the area known as Back Valley (refer to Map 1) received 205 mm of rain in less than 48 hours. The ensuing floodwaters destroyed the Back Valley bridge and Keen's Road bridge (L. Keen pers comm).

The rates of erosion have declined since the late 1950s. This coincides with the eradication of rabbits, the sowing of "improved" pastures and the use of superphosphate. Most of the watercourses of the catchment have passed through the phase of maximum instability as they adjust to the hydrological changes and channel disturbances brought about by European settlement.

### 2.1 "It Was Once All Swamp"

According to long time residents Adrian Lush and Eric Ashby, stories passed down by family members, stated that, at the time of European settlement, the river had no clearly defined course. Rather, it spread out over the river flats. The grandmother of Eric Ashby clearly remembered the Inman River (downstream of the junction of the Boundy River - a distance of approximately 16 km) as being "all swamp and marsh". At the Inman Valley township (refer to Map 1), it was once possible to leap from one bank to the other (Lush 1971). Today, the river has incised to a depth of more than 5m and widened to approximately 20 m (Burston & Good 1995).

In 1844, the Boundy River (refer to Map 1), upstream from the confluence of the Boundy and Inman Rivers, was described as having no defined channel. It was possible for a bullock team to cross at any point (Lush 1971). Today, this reach of the Boundy River, where it joins with the Inman River, has incised over 5m and widened to approximately 50-60 m (Burston & Good 1995).

In 1850, a writer employed by the South Australian Register described areas of the catchment, near "Glacier Rock" (refer to Map 1), as marshy and undrained (Lush 1971). Yet in 1854, Professor Selwyn drew attention to the glacial grooves and polishing in the Kanmantoo bed rock now exposed in the channel of the Inman River (Selwyn 1859). Thus, in less than 4 years, the level of the stream bed had dropped by approximately 4 metres. Either a catastrophic erosion event occurred *in situ* or a large knick point travelled up-stream and "uncovered" Glacier Rock. The trigger that initiated this bed deepening event is unknown.

### 2.2 Gullying

The development of commercial grain farming in the district in the 1840s (Lush 1971) resulted in

spectacular landform changes. The fields were cultivated by single furrow ploughs, drawn by bullocks. A particular practice of ploughing, known as the "lands" (ie. patterns of ridge and furrow), was done by ploughing up and down the slope of the land (Twidale *et al.* 1971). The technique was a disaster in the highly erodible, sodic soils of the catchment, initiating severe gully erosion.

Gullying has been most severe in the headwaters (ie. 1<sup>st</sup> and 2<sup>nd</sup> Order streams - as determined from 1:50000 map sheet, following Strahler 1964) of the Inman River in the region of Bald Hills (refer to Map 1). The initiation and development of these gullies were associated with intense rainfall events falling on the ploughed "lands". One gully, Welch's Washout, measuring 100 m long and 1-2 m wide, developed in a single downpour in 1906 (Bourman 1974).

With the abandonment of cereal cropping at the turn of the century, the growth rate of the erosion gullies slowed. The introduction of pasture improvement and the elimination of rabbits in the late 1950's, accelerated the process of gully stabilisation. Since then, the majority of the gullies have battered back, although some are still actively eroding. Much of the sediment mobilised by this process has not entered the river. Rather, it has been stored on alluvial fans or flood-outs, at the break of slope at the bottom of the gully.

### 2.3 Bed Deepening

It has been estimated that approximately 13.4 million m<sup>3</sup> of sediment has been eroded from watercourses of the catchment (of magnitude 3<sup>rd</sup> Order or greater) since European settlement (Burston and Good, 1995). The location and size of all knick points on all watercourses of magnitude 3<sup>rd</sup> Order or greater have also been identified (Burston and Good 1995). For some reaches, the process of bed deepening is occurring as a series of clusters of minor knick points, rather than as one large event. The implication of this habit is not fully understood. Channels have become deeply incised, to the point where more than 60% of watercourses surveyed have now incised to a depth of more than 2 metres (Burston and Good 1995).

Owing to its glacial history, very few natural control points (ie. rock reefs) are present within the catchment. Thus, nick points have the potential to travel long distances. Many of the small bridges and culverts built on the roads that traverse the catchment are acting as *quasi* control points. At several locations, erosion heads have worked up to these structures, where they have been "locked up",

in the form of a concrete drop structure on the downstream side of the bridge or culvert.

#### 2.3.1 Swamp Drainage

Swamp drainage is a familiar trademark in the history of land clearance in Australia (Erskine 1994, Recher *et al.* 1993, Bird 1980 & 1982). European settlers perceived wetlands as unproductive wastelands that could be converted to agriculture via drainage. Undoubtedly, the drainage of wetlands triggered many episodes of stream bed deepening across the catchment. As the main channel became more incised, so too did its tributaries. The practice of draining "unproductive" wetland continues to this day. In 1994, a 400m drain was cut (to a depth of 1.2 m) through a waterlogged paddock in order to improve drainage. Given the sandy-loam soil type, within a couple of months, bank collapse and bed deepening were severe. The security of a large farm dam is now threatened.

Drains were also cut in order to alleviate problems of sedimentation that were associated with gully erosion. Large volumes of sediment, transported by tributary streams, were being deposited on the flood plain of the Inman River. In one particular case, in the 1940's, a farmer, frustrated by the repeated flooding and sedimentation, cut a small drain from the bottom of the gully to the Inman River, a distance of approximately 250m. In a matter of 3-4 years, the whole channel had incised to depth of 3 m and a width of 8 m (D. Lush pers comm). The banks have now, of their own accord, battered back and revegetated.

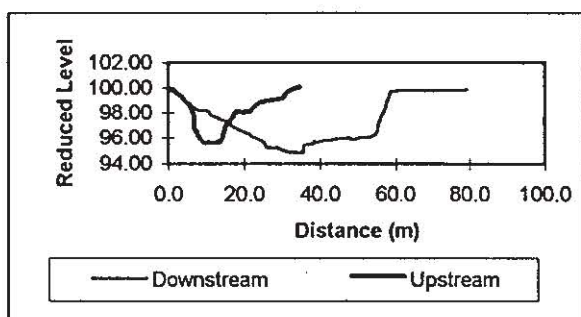
#### 2.3.3 Channelization

The main area of channelization in the catchment has been along Back Valley Creek, up-stream from its confluence with the Inman River. It was done by the District Council of Victor Harbor during the 1940's (R. Brown, pers comm) to "protect" two bridges from being outflanked by a meander. The old watercourse channel is still evident, lying approximately 2 m above the present bed of the watercourse.

### 2.4 Sand Extraction

In recent years, the most severe degradation in the catchment has occurred as a result of sand extraction in the reach of river known as Memory Grove - Swains Crossing (refer to Map 1). Extraction of "concrete sand" occurred for only one year, 1985, during which 6,700 m<sup>3</sup> of sand was mined from the river. As a result, there has been catastrophic erosion upstream and severe aggradation downstream of the mine site. In less than 2 years, a 2 m knick point had migrated 4.2 km upstream ( a mean rate of

migration of 2.1 km per year), and currently threatens the integrity of the Memory Grove Bridge. Although no photographs were taken at the time, landholders vividly recollect the "6 foot waterfall" that travelled rapidly upstream (C. Liston & R. Liston, pers comm). Burston and Good (1995) estimated that the resultant bed deepening released some 101,000 m<sup>3</sup> of sediment. Currently, the river is undergoing a very active phase of lateral migration, as it strives to attain a new balance. Thus, many more thousands of cubic metres of sediment are being released from the ensuing bank collapse. The affect on channel dimension is graphically illustrated in Figure 1, below.



**Figure 1.** Impact of sand extraction on channel dimension at Memory Grove bridge (cross-sections are taken at the first inflection point upstream and downstream of the bridge).

At a site below Swains' Crossing culvert, approximately 5,300 m<sup>3</sup> of "concrete sand" was removed from the site. As this site currently enjoys a high level of aggradation, there is no visible impact from the extraction.

Although the extent of commercial extraction has been limited (but with devastating impact), extraction by landholders for domestic uses has been widespread, often with grave consequences. In 1976, at a site 1.4 km downstream from Glacier Rock, a small volume (quantity unknown) of sand was extracted from the river (for building purposes and to create a water hole for domestic uses). By 1993, a 1.2 m knick point had travelled 1.4 km upstream (at a mean rate of 82 m per year), mobilising approximately 24,000m<sup>3</sup> of sediment (Burston and Good 1995).

## 2.5 Rabbits

Rabbit numbers built up rapidly in the catchment as the glacial and alluvial soils of the catchment afforded easy digging. In the 1940's there were "literally thousands, if not millions" (G & P. Stephens, E. Ashby, pers comm). The burrowing

activity of rabbits initiated many erosion gullies and exacerbated bank erosion.

The release of the myxomatosis virus did not make a significant in-road to the rabbit population. In 1959, the Inman Valley Rabbit Eradication committee was established to facilitate a community control program. The strategy of poisoning (using 1080) and warren ripping was very successful. Landholders involved in the program recall the stench of dead rabbits (P. Stephens, E. Ashby, pers comm).

Local residents believe that the control of rabbits, followed by pasture "improvement" and the use of superphosphate, was the most important factor in reducing the rate of both catchment erosion and bank erosion along watercourses of the catchment. With rabbits all but eliminated, vegetation, including native plants, began to re-establish along the banks of the Inman River and its tributaries.

## 2.6 Bank Erosion

The rapid incision of the main channel of the Inman River had a profound impact on bank stability. Adjusting to the "recent" incision and new hydrological regime, the watercourses began (and continue to this day) a process of lateral migration. The unconsolidated alluvial and glacial sediments offer little resistance to this process.

In the 1930's it was considered unwise to purchase property with river frontage, owing to the high rates of bank erosion. Many properties were abandoned or sold to neighbours as their owners feared the river would "sweep all the soil into the sea" (Bourman pers comm). Long time residents attest, that during years of above average rainfall, the sound of banks slumping into the river was a common occurrence, particularly on still nights (Bourman 1969). Poor bank stability (as defined by Ian Drummond & Assoc 1985) currently affects nearly 25% of all banks in the catchment. However, approximately 46% are in good-excellent condition (Burston and Good 1995).

## 3.0 AGGRADATION

One hundred and fifty years of erosion has released vast amounts of sediment into watercourses of the catchment. The majority of the sediment appears to be sourced from erosion of the channel, rather than from the catchment. The high rates of channel erosion released vast quantities of sediment, much of which has been deposited across the floodplain, as "Post-European Settlement Alluvium" (PESA). At points below Memory Grove bridge, PESA attains a depth of more than 1.5m. However, many streams are now incised to a depth where over-bank flow is no longer possible. Consequently, the mobilised sediment is confined to the channel trench. The

majority of watercourses show some degree of aggradation. Over 28% of the total stream length are affected by moderate to high levels of aggradation (Burstion and Good 1995).

The most pronounced sand slug occurs downstream of Memory Grove bridge. Comparison of early photographic records and aerial photographs from 1949 and 1993 indicate that the sand slug formed between 1922 and 1949. Downstream from Swain's Crossing culvert, for a distance of 1.5 km, the river is severely aggraded, consisting of a tangle of channels of varying width and depth. In the 1920's this reach was still navigable by small craft (Bourman 1969). Refer to Figure 2, below.

Bourman (1969,1974) provided evidence of fence posts, trees and ferry cables being buried by 4 metres of sediment. Furthermore, there are accounts of a house and flax mill being buried under the sediment (Lingard 1987). Near the site of the old Victor Harbor rubbish dump, two buried fences would indicate a rate of sedimentation in this area of approximately 1m per 25 years between the period c.1920-1969. A third fence has been built on top of the two buried fences (Bourman 1969).

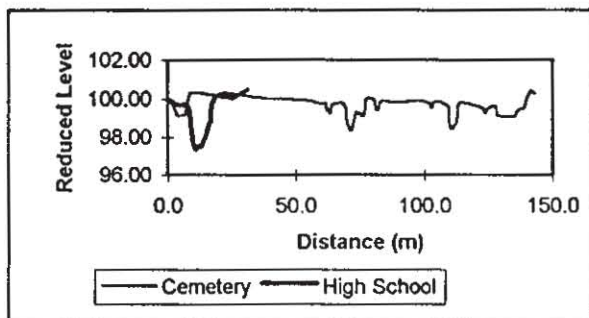


Figure 2. Impact of aggradation on channel cross-section between cemetery and High School.

Sedimentation is still occurring in this reach. Many young river red gums (ie estimated age < 30 years) are encased in sand. The rate of sedimentation is likely to be maintained in light of the large volume of sediment currently being released due to catastrophic erosion occurring in the reach Memory Grove bridge to Swain's Crossing culvert.

During the period 1949-1979, in the reach between Glacier Rock and Stephens Rock (a distance of 2.2 km) the stream bed was raised by approximately 1.2 m.(which has since undergone renewed incision - see Sn 2.4) This was as a result of the deposition of sediment from upstream sources and bank collapse *in situ*. During this time, the banks battered back to a point where vegetation could again grow.

#### 4.0 REHABILITATION

In their study of the Inman River catchment, Burstion and Good (1995) identified 185 watercourse management issues, across the catchment, that need redress. Implementation of improved management practices is likely to reduce erosion and sediment supply, with the potential to trigger renewed incision along some reaches.

It is important to recognise that the majority of landholders have inherited problems that were initiated many years ago. Improvements will not occur overnight, but they are certainly achievable within the medium term (ie. 5-10 years). The lack of resources (ie. time and money) and knowledge among landholders will be the most important constraint upon the full implementation of the on-ground works.

The control of erosion (bed and bank) is a fundamental pre-requisite to achieving improvements to the water quality and ecological health of watercourses in the catchment. In the vast majority of cases identified in the catchment, the erosion can be arrested by using the revegetation technique. That is, fence the watercourse to exclude stock access and then revegetate the site with indigenous plant species. At other sites in the Mount Lofty Ranges, direct seeding of local native plant species has shown the efficacy and cost effectiveness of this approach. Revegetation will do much to increase the roughness of the channel and provide physical protection to the bed and banks.

Given the intermittent nature of the majority of watercourses in the Inman River catchment, plus the excellent growing environment, the revegetation approach has a high probability of success. Unlike the large watercourses of the eastern states, the intermittent nature and relatively small discharge of watercourses in the catchment, favour the revegetation approach. However, in catastrophic events, the technique will be overwhelmed. The approach is based on risk management - the trade-off between the risk of an infrequent event and the cost of works. Furthermore, all in-stream disturbances should be avoided at all costs.

At sites where stock access has been restricted, the growth of reeds and rushes has been prolific. Reed, rushes and sedges will quickly re-establish from their rhizomatic root base (and from seed) and will generally stabilise the site within a couple of years. The most effective plants for this purpose are the common reed (*Phragmites australis*) and the bulrush (*Thypha domingensis*).

Given the highly erodible nature of the glacial and alluvial sediments, the reed beds appear to be playing a vital role in reducing the rate of movement of the knick points. In fact, many erosion heads identified by Burston and Good (1995) are presently located in macrophyte beds, which have dramatically slowed their progress. Common reed and bulrush also play an important role in trapping and storing sediment. In following the revegetation approach, however, knick points will continue to migrate upstream, but at a rate much slower than at present. The approach has significant cost advantages over a more interventionist approach based on engineered works.

For smaller watercourses (such as 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> Order), where knick points are likely to be beyond the scope of the revegetation approach, there are a range of "farmer friendly" grade control structures that can be installed to neutralise a knick point (Carter and Collingham 1995). Some of these structures are cheap and can be constructed by the landholder using materials readily available on the farm. For landholders to construct these structures, they must be cheap, "low tech", easy to construct, and use farm materials and equipment.

Fences should be placed at a suitable distance back from the edge of the bank in order to accommodate the gradual batter of the bank. The distance will be dependent on bank height, the nature of the bank material and one's position on the meander. For streams that appear to have a stable morphology, a rule of thumb is for the distances between the fences to be at least 10 times the low flow channel width (Rutherford pers comm). In reality, however, the fence will be placed back by whatever distance the landholder deems appropriate.

## 5.0 CONCLUSION

The dramatic cycle of erosion encountered in the Inman River catchment during the past 150 years can be added to the litany of similar studies of severe watercourse erosion that accompanied European settlement. The glacial history of the catchment, creating an environment of sodic, highly erodible soils, in which few natural control points exist, exacerbated the impact of European settlement. Since the late 1950's, the rate and extent of erosion has gradually declined. Factors attributed to this include natural stabilisation, the control of rabbits and the establishment of improved pasture base (ie vegetative cover). Fortunately, due to the intermittent nature of the watercourses, the solution to most erosion issues is very simple. Fence the watercourse to exclude stock access and revegetate with indigenous plant species.

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