

## Dredging up the past: does historic gold dredging impact the rivers of Victoria today?

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### Key Points

- Historical gold mining has dramatically modified rivers and floodplains in SE Australia, but the impact of bucket dredges has not been recorded.
- At least 115 bucket dredges were operating along nine Geofabric river regions in Victoria between 1899 and 1973, with a third of these along the Ovens River.
- This dredging completely changed the sediment structure of Victorian floodplains to depths between 8 and 40 m.
- Downstream impacts caused by sediment released from the bucket dredge sites are difficult to quantify but are likely to be an issue in catchments with minimal water storages.

### Abstract

The gold rush in SE Australia began in 1851 but it never really ended: the mining methods just changed and became more industrial. One of the most industrial of methods was bucket dredging, which was most prominent in Victoria between 1900 and 1915. Bucket dredges were machines up to 167 metres long that could work floodplain sediments to depths of 40 m. Over 100,000,000 m<sup>3</sup> of sediment was excavated by more than 115 bucket dredgers, mostly in the Ovens and Loddon catchments in northern Victoria. Gravels were mined and placed behind the dredge as it moved across the floodplain, but fine sludge was also released into the river. Floodplains were often turned upside down with coarse sediment left on or near the surface, and river channels relocated and sometime replaced back to their original position. The environmental legacy of this assault is evaluated in this paper, focusing on an understanding of the period of greatest activity, between 1900-1915. Little regulation of dredging existed from 1900 – 1905, with sediment from spoil-piles and pondages at these leases continuing to enter the river system for the period of the mining. Dredging did not affect a large area of floodplain (a minimum of 7625 ha, or an area 9 km by 9 km). The worked areas were often impounded sections of floodplain that floated dredge pontoons, usually in the partly confined reaches of rivers. The buckets dug down to a paleochannel deposit containing gold. Working back and forth linearly across the lease they excavated, sorted and treated the sediment (sometimes with mercury). Current LiDAR shows these linear features from the elevation differences in the spoil mounds. At the time of the dredging, the practice was considered a rehabilitation technique for mined floodplains. In some cases this was true. However, 45 % of dredged land in the Ovens valley is still only suitable for rough grazing and pine plantations. Preferential export of subsurface fines combined with settlement has caused sinkholes. Whilst other mining methods may have liberated more sediment, and associated contaminants, the legacy of dredging has been to create large areas of land near to rivers that are extremely difficult to rehabilitate. It is useful for catchment managers to know the location and history of dredged sites.

### Keywords

Bucket dredging, Gold mining, River, Floodplain, Sediment.

## **Introduction**

This paper examines the history and current impact of bucket dredging for gold along the rivers and floodplains of Victoria. Gold mining has disturbed many of Victoria's catchments since the 1850s (Davies et al., 2018). Dredging was the last major wave of gold mining which occurred as a result of technological change. Initially steam driven, and later electric powered, they minimised manpower and maximised the volumes of sediment that could be moved.

In Victoria, the term "dredge mining" was widely applied to processes including bucket dredging, hydraulic sluicing by centrifugal pump, and jet elevator sluicing/dredging. Good data for bucket dredges, hydraulic pump sluices, jet elevators and rotary hydraulic systems is provided in Annual Mining Reports between 1900-1915 (e.g. Sellars, 1904). Bucket dredging occurred both in the river and on the floodplain. From the outset there were concerns about the environmental and agricultural impact of this new form of mining (Victoria, 1914).

*"No more striking instance of what might be termed this industrial vandalism can be cited than has occurred in the Ovens Valley in the neighbourhood of Porepunkah and Eurobin, through which visitors from all Australia must pass to reach the Buffalo Mountains. This once beautiful valley is now largely a shingle waste, over which vehicles must be drawn towards the mountains, and, in the opinion of the Board, is beyond recovery. Much evil has been done here and elsewhere from this point of view; while it is certain that, under leases yet running, much more remains to be done if preventative steps be not taken."* (Victoria, 1914, p. 18)

We can consider environmental impacts both on site, such as the shingle wastes described; and off site, from the export of sediment. The latter is much more difficult to quantify, and the focus of this paper will be the onsite impacts, and whether dredging really degraded the land beyond recovery. The bucket dredging industry in Victoria is quite well described (e.g. Lloyd, 1982, 2006; McGeorge, 1964; Ralph, 2001; Supple, 1994). However, relatively little work has been undertaken to look at the current state of areas that were once bucket dredged (Cargill, 2005). Historical records will be combined with remotely sensed data to determine where and when dredging occurred in Victoria, and whether its impacts are still detectable on the landscape.

## **The operation of the dredges**

Bucket dredges were a floating factory up to 167 m in length. They either sat in the channel or had an artificial lake formed on the floodplain to house them. At the front of the dredge was a chain of steel buckets that could be maneuvered, and raised up and down, so that the sediment in front of the machine could be excavated (Figure 1 A and B). They did not operate well in stiff clays, as the buckets clogged, but they were able to excavate coarse sediment up to the size of cobbles. Clean, reliable and plentiful water was essential for dredging operations, firstly to enable the dredge to float, and secondly for the treatment of alluvium. Water from upstream or from bores was used and settling ponds both settled fine sediment and provided a clean source of water to be re-used.

The gold bearing sediment that was being sought was known as a placer deposit. This is a deposit of previously eroded gold, often now stored in paleo-river deposits. The largest dredges could dig down into these fluvial gravels to a depth of 40 m. During the excavation the dredge separated out coarse and fine sediment using a rotating cylindrical screen. The fines were passed over undulating riffles allowing the gold to settle out in the hollows. Mercury was sparingly used to amalgamate the gold; however, the full details of its use are unknown (Davies et al., 2015).



These reports document the mines that were operating, the volume of sediment processed and how much gold they produced. There is little spatial data except the mining district and the nearest township or river.

Spatial data was available from the 'VicProd' database, produced by Geoscience Victoria (Department of Primary Industries, c.2002). A derivative database of 'VicProd' is 'VicMine' that has better classifications of mining types. Both databases had point data of up to +/- 25 m in accuracy. VicProd was searched using the word 'dredge' in the company name or mine description. VicMine distinguished dredged sites using a separate classification.

The final set of spatial data used was Mineral Tenements 'MINTEN' (Department of Economic Development, Jobs, Transport and Resources, 2013). These data show mining lease areas, and those classified as gold leases and having 'dredging' in their name were selected. In all these datasets care had to be taken to separate bucket dredging from other forms of dredging or sluicing operations.

LiDAR and aerial data from 2009-2010 was used to examine the sites identified using the spatial data. The data were used to look for any evidence of dredging. Features included dredge pools, depressions or linear marks that indicated a dredge track (Figure 2B). The absence of floodplain features such as palaeo-channels was also indicative the dredging had occurred (Figure 2C). The 2010 landuse present at the dredge sites was identified using aerial (Figure 2A) and satellite imagery and was manually classified by the vegetation type and the presence of urban features.

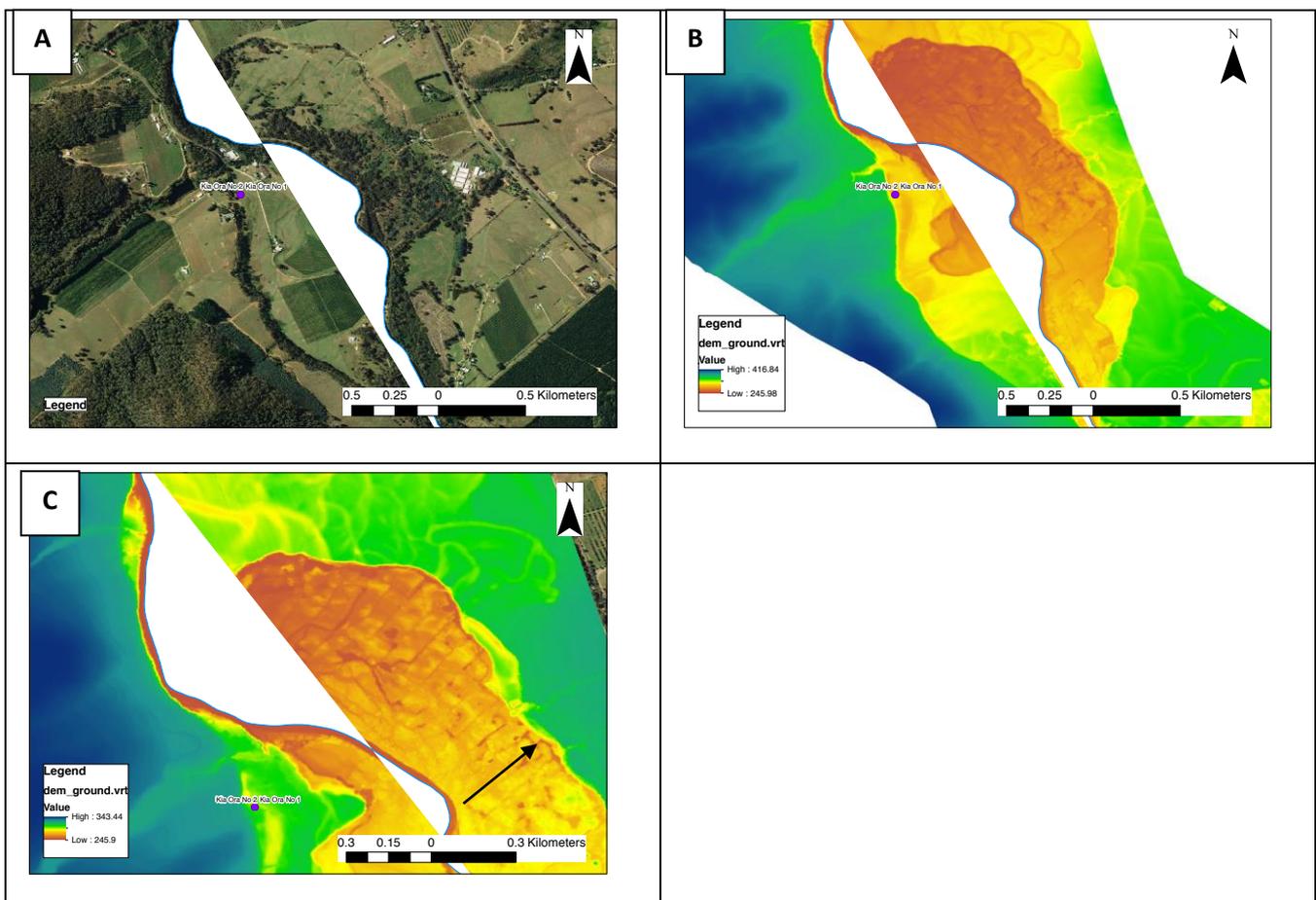


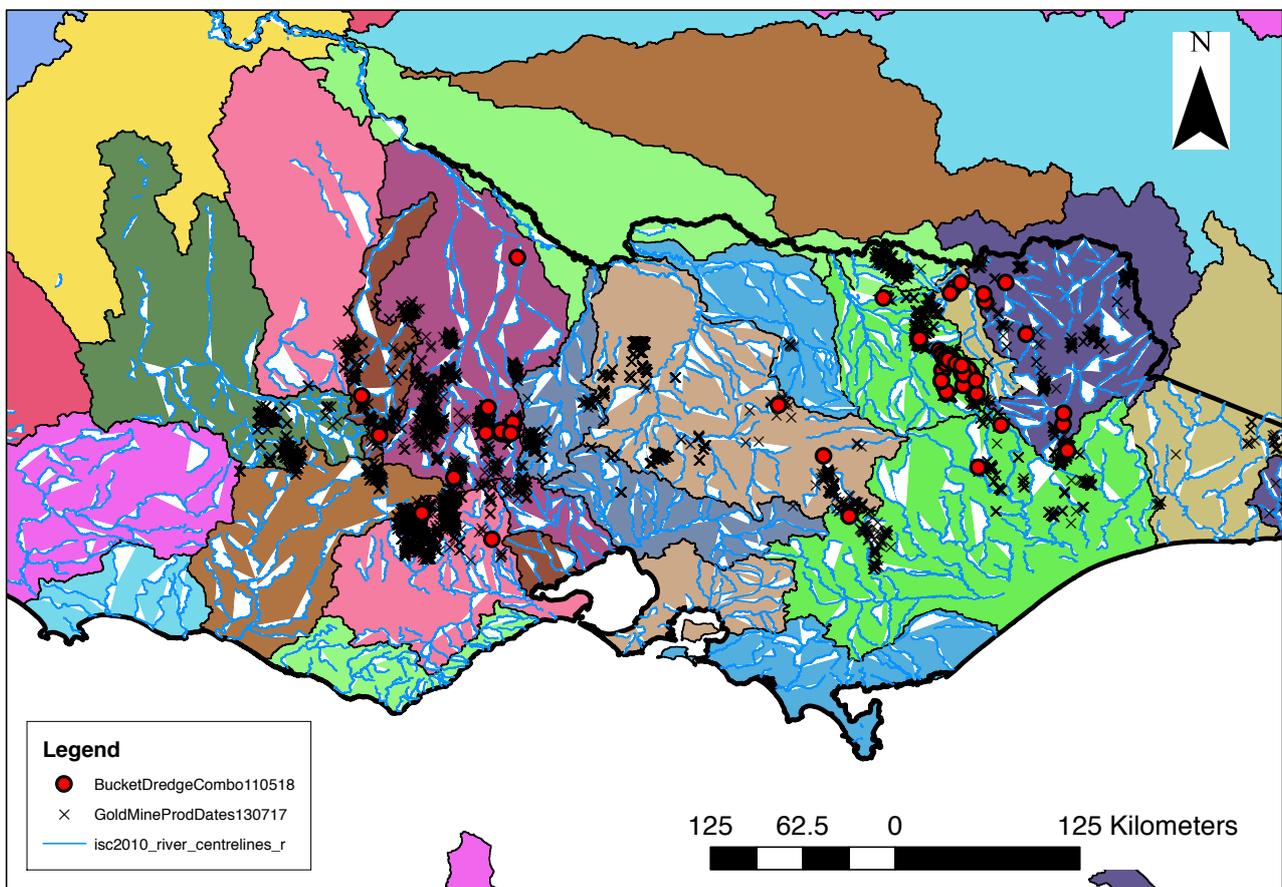
Figure 2. A) A bucket dredged site shown using 2010 aerial imagery, B) The same site shown using artificially coloured LiDAR elevation data, C) a close up of the LiDAR showing the absence of palaeochannels in the dredged area but the presence of linear dredge tracks perpendicular to the channel (the direction is highlighted by the arrow).

### Where did dredging occur?

115 different bucket dredging operations were formally recorded as operating between 1900 and 1984. This is likely to be an underestimate of the number as other dredging operations were not well documented and were sometimes listed incorrectly. 106 bucket dredging operations could be spatially located (Figure 3). At the dredging peak between 1908 and 1913 there were up to 50 dredges operating.

The dredges, not surprisingly, coincide with the regions of earlier mining efforts (Figure 3). In the west of the state the dredges are confined to the Avoca, Loddon and Barwon catchments. This may be due to the smaller area of placer deposits suitable for dredging operations. The majority of mines in this area were primary, often deep lead, mines such as those that occurred around areas like Bendigo.

The largest number of dredges operated in the Ovens River catchment (Figure 3). 37 dredges, 35% of the state total, operated on the Ovens River, Buckland River and Morses Creek. The second highest clustering was in the Loddon catchment, which contained 13 (12 %) dredges.



**Figure 3. Victorian bucket dredges (red circles) in each BOM Geofabric reporting catchment shown alongside other geolocated historic mining operations (black crosses).**

### What sort of rivers were dredged?

The typical dredge operated on confined floodplains, around 40 km from the catchment divide with catchment areas around 400 km<sup>2</sup>. The average level of valley confinement (as derived from the MRVBF (Gallant and Dowling, 2003)) was 92 % (from Stein 2011 data (based on Stein, Stein, & Nix, 2002)). This suggests that most of the dredges were operating in partially confined situations where there were valley flats, or floodplain pockets, that could be easily isolated for inundation and had a good supply of water.

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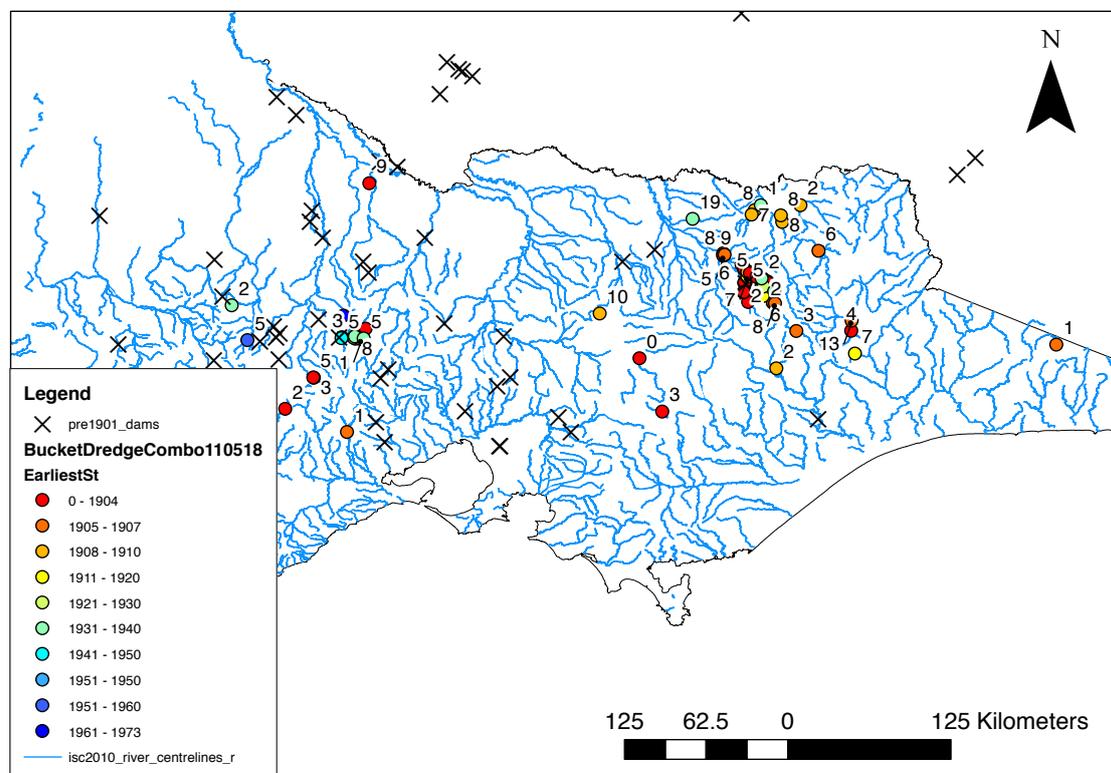
Catchment areas ranged from 1.5 km<sup>2</sup> up to 5,007 km<sup>2</sup>, with an average of 426 km<sup>2</sup>. The streams themselves were mainly 4<sup>th</sup> order using a Strahler classification. These streams were between 2.5-220 km, and on average 37 km, from the top of the catchment.

Dredges operated over 118 km of river length. Comparing this with the ISC3 stream network, which is 29,256 km in length, suggests that 0.5 % of the main streams in Victoria have been directly influenced by dredging. This is likely an underestimate because of our incomplete knowledge of the extent of dredging operations at each lease.

### The temporal history of dredging

Dredging technology was borrowed from technology developed in New Zealand in the 1860s. Bucket Dredges appeared in Australia in the late 1890s with Campbell's Creek dredge was the first to operate in Victoria in the 1899. The majority of early bucket dredge leases, those between 1901-1910, south of the Great Dividing Range, appear to have had short lifespans (Figure 4). Their distribution stretches from Craigie Bog in East Gippsland all the way to Smythe's Creek in the Yarrowee River near Corangamite. During the next two decades the dredges operated mainly in the north east, with operations down the extent of the Ovens River. The later dredges, between 1941 -1984, are to be found mostly in the west of the state.

Figure 4 shows the location of dredging compared to the location of pre-1900 dams and weirs (mapped from Geoscience Australia (2004)). The distribution of dams suggests that any offsite impacts from sediment mobilisation might be mitigated by storages north of the divide in the west of Victoria, but this was not the case in the rest of the state. In particular, in the Ovens River, where the majority of dredges operated no dams and weirs have been constructed. Thus, any disturbed sediment would be able to be transported throughout the Ovens River.



**Figure 4. The State of Victoria, showing start date of bucket dredging leases by colour and their lease length in years as a number. Dams and weirs present before 1901 are shown as crosses.**

### ***The current state of dredged lease areas***

The LiDAR was used where possible to look for surface elevation differences likely to be caused by bucket dredging. Most operations would require a dredge hole and a storage dam that would now be large holes on the floodplain.

Of the 115 sites in the database, only 52 record clear evidence that a dredge had been over the area. This could be due to poor spatial location in the data, so we do not know exactly where the dredge worked. It might also be that dredging has recovered so that it no longer leaves any visible trace. The former accounts for the majority of cases, as the spatial location from the yearly statistics is poor and other locations have proved to be inaccurate. To resolve this, we are currently compiling and mapping the original dredge leases to get an idea of the area that could have been dredged.

From the 52 sites where some surface expression of the dredging could be identified, the LiDAR revealed that 14 still had a dredge hole present, 30 had multiple stripes left by the dredge tracks (Figure 2). 60% of the areas that still have surface expression of the dredging are now scrub and woodland (Table 1). Only 9% are farmland.

**Table 1. Landuse on historically dredged sites identified using aerial imagery from 2010 and current satellite imagery.**

<b>Landuse</b>	<b>Number of sites</b>	<b>Percentage of identified sites (%)</b>
<b>Cropping</b>	7	13
<b>Grazing</b>	2	4
<b>Forestry</b>	8	15
<b>Scrub</b>	17	33
<b>Woodland</b>	14	27
<b>Urban</b>	4	8

### ***Discussion and Conclusions***

The onsite effects of dredging still persist in the landscape. The landuse identified sites is mainly scrub, this being patchy grass, small shrubs and often an abundance of bare soil. Some sites appear much more productive, and future work will investigate whether this is a consequence of the timing of dredging and the dredge type, such as the use of resoiling.

We do not have the resolution of data to specifically know the state of the land before the dredging, however, we are confident that most dredged areas had been subject to extensive alluvial mining in the 19<sup>th</sup> century. Previous mining efforts degraded the land (Davies, 2018). Further analysis is required to determine if these dredged sites are in poorer condition than those that were historically mined but undredged. Looking for evidence of the lease areas, both in LiDAR and aerial data, appears to support the case that the dredged areas were much less improved than adjacent undredged land.

The depth of dredging, combined with the stratification of the sediment, means that bucket dredging appears to have significantly altered the productivity of the land and will continue to do so for decades if not centuries. This has consequences for riparian rehabilitation programs, as there is little prospect that the original vegetation condition will be returned.

Bucket dredges followed 50 years of mining efforts by a range of methods. This makes it difficult to determine what offsite impacts might have been specifically caused by dredging. The Sludge Abatement Board reports that dredging sometimes, but not always, caused severe sedimentation downstream. What we do know is that the impact of dredging was highly variable, depending on the operator, the legislation in place during mining operations, and climatic events such as droughts and floods. The dredges operated in the upper floodplains of the catchments, and so their effect length could extend over large proportions of rivers

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and floodplains downstream. They also occur after previous mining has had the opportunity to fill rivers with sediment, increasing the connection with the floodplain.

These factors combine to suggest that any dredged sediment that made it offsite would have a significant impact on the population downstream, unless there was a storage downstream. Laanecoorie Reservoir, constructed on the Loddon River in 1895, lost much of its volume to sedimentation (Davis, Rutherford and Finlayson, 1999). We are currently seeking any chemical markers for dredging in this area to separate its impacts from other previous mining efforts and sediment that resulted from land clearance.

## Acknowledgments

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## References

- Cargill, D.D. (2005). *The Geomorphic Recovery of the Upper Ovens River Following Disturbances by Historical Gold Dredging*. BSc (Honours) thesis, University of Melbourne
- Davies, P., Lawrence, S., Turnbull, J., Rutherford, I., Grove, J., Silvester, E., ... & Macklin, M. (2018). Reconstruction of historical riverine sediment production on the goldfields of Victoria, Australia. *Anthropocene*, 21, 1-15.
- Davis, J. A., Rutherford, I. D., & Finlayson, B. L. (1999). The Eppalock Soil Conservation Project, Victoria, Australia: The Prevention of Reservoir Sedimentation and the Politics of Catchment Management. *Geographical Research*, 37(1), 37-49.
- DEDJTR. (2018). *MINSITE Mines and Mineral Occurrence Sites geodatabase*. ID ANZVI0803002225, Department of Economic Development, Jobs, Transport and Resources, Victoria
- DEDJTR. (2018). *MINTEN Mineral Tenements geodatabase*. ID ANZVI0803002840, Department of Economic Development, Jobs, Transport and Resources, Victoria.
- DEPI. (2002). *VICPROD geodatabase*. Department of Primary Industries, Victoria.
- Gallant, J. C., & Dowling, T. I. (2003). A multiresolution index of valley bottom flatness for mapping depositional areas. *Water resources research*, 39(12).
- Geoscience Australia (2004) *Dams and Water Storages 1990: Product User Guide*. National Mapping Division, Geoscience Australia, Canberra, Australia.
- Lawrence, S. and Davies, P. (2014) *The sludge question: the regulation of mine tailings in nineteenth-century Victoria*. *Environment and History*, 20(3), 385-410.
- Lloyd, B. (1982). *Gold at Harrierville*. (Wangaratta Vic: Shoestring Press).
- Lloyd, B. (2006). *Gold in the North-East* (Melbourne: Histec Publications).
- McGeorge, J.H.W. (1964). *Dredging for Gold: The history of two successful but contrasting enterprises* (Barwon Heads, Vic: the author).
- Ralph, G.M. (2001) *Gold Dredging in Central Victoria*. In P. Bertola and K. Miller eds. *Proceedings of the Australian Mining History Association Conferences 1997-2000* (Perth: Australian Mining History Association) pp. 97-109
- Stein, J. L., Stein, J. A., & Nix, H. A. (2002). Spatial analysis of anthropogenic river disturbance at regional and continental scales: identifying the wild rivers of Australia. *Landscape and Urban Planning*, 60(1), 1-25.
- Sellars, D.B (1904). *Dredge Mining and Hydraulic Sluicing*. In Annual Report of the Secretary for Mines and Water Supply for the Year 1903, (Melbourne: Parliament of Victoria), pp. 51-8.
- Stein, J. L., Stein, J. A., & Nix, H. A. (2002). Spatial analysis of anthropogenic river disturbance at regional and continental scales: identifying the wild rivers of Australia. *Landscape and Urban Planning*, 60(1), 1-25.
- Supple, R. (1994) *Cocks Eldorado Dredge*. In First Australasian Conference on Engineering

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Heritage 1994: *Old Ways in a New Land*; Preprints of Papers (Canberra: Institute of Engineers) pp. 155-60.

Swift, D. (1950) *Dredging for gold: The work of the past twelve years*. Mining and Geological Journal, 4 (2): 12-19.

Victoria (1914). *Dredging and Sluicing Inquiry Board*. Report Upon Complaints of Injury by Dredging and Sluicing (Melbourne: Parliament of Victoria).