

# Harvesting water on a Victorian colonial goldfield

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*Water was vital to almost every aspect of gold mining in the colonial period, but many areas had limited access to reliable water supplies. Miners responded by building substantial reservoirs and lengthy races to capture, store and distribute water to mining claims. In this paper we present a case study of the archaeology of water management on the Creswick alluvial goldfield in central Victoria. During the 1850s and 1860s, miners at Creswick constructed numerous dams and several hundred kilometres of races, many of which are well preserved on the goldfield today. The remains indicate the ways in which miners came to terms with environmental limits and created landscapes of water management. The integration of archaeological evidence with a range of historical sources into a GIS system reveals the rapid development of water networks and the complex relationships between water users.*

## INTRODUCTION

Miners on Victoria's colonial goldfields needed substantial quantities of water to wash gold from the earth. Variable rainfall and limited supplies in creeks and rivers, however, meant that miners often had to construct storage dams and lengthy races to bring water from where it was available to where it was needed. On the Creswick alluvial goldfield, located 18km north of Ballarat in central Victoria, the archaeological remains of these water management systems are generally well preserved, and reveal the ways in which miners came to terms with the possibilities and limits of the natural world. As part of an Australian Research Council-funded project, 'Cultural Landscapes of Colonial Water Management in Victoria's Central Highlands', we have mapped over 160 kilometres of races which carried water into and from storage dams to the various claim areas. Some of these races no longer exist, however the vast majority of major channels are extant with some long sections substantially intact. GIS mapping is a vital component of this ongoing research, permitting the integration of diverse historical sources and archaeological remains, and the analysis of relationships between water networks.

Robert Brough Smyth, Secretary for Mines in Victoria from 1860 to 1876, calculated that 2434 miles (3916km) of water races were in operation in 1868, by which time the early alluvial rush was waning and many races had already been abandoned (Smyth 1980 [1869]:547). These races, dams and other elements of water infrastructure took months and often years to build, dug with pick and shovel through clay, gravel and rock. They demonstrate a commitment to local mining areas that defies the mobile, migratory reputation of the early gold rush populations (Goodman 1994; Lawrence 2000). Races are also important evidence for the commercialisation of water, where a natural resource came to be measured and traded as so many 'sluice-heads' to be leased and sold. In addition, the miners' use of water was instrumental in the development of water law, where competing users in Victoria looked to government and the courts to arbitrate disputes over water access and entitlements. By the mid-1860s a system had evolved to regulate flows of water for mining purposes, creating a legal framework that the other colonies soon followed (Armstrong 1901:220; Davies and Lawrence in press).

In this paper we present the results of archaeological and historical research carried out on the Creswick goldfield, focusing on the remains of races and dams built during the shallow alluvial phase of mining in the 1850s and 1860s. We begin with a brief review of previous archaeological research into water management in Australia, and outline the history of

the study area and our approach to the sources. We note the development of permits and licenses for water diversion, and then describe the operations of a number of prominent mining parties in the area, including the Humbug Hill Sluicing Company, Charles and Benjamin Eaton, James Robertson and the St. George's Sluicing Company, and William and George Russell. Alongside the activities of these partnerships were groups of Chinese miners who preferred to lease water for their operations, while the Creswick local council built a town supply that gradually incorporated many of the water resources of the larger mining parties. As surface alluvial mining faded from the Creswick goldfield during the 1860s, the legacy of the miners included extensive networks of races and dams that were often integrated into complex systems of water management.

## PREVIOUS RESEARCH

Water management has been an important focus of Australian archaeological research in both Indigenous and European contexts. Much of the archaeological focus on water in the colonial period has been on the exploitation of water as a source of industrial energy. Water mills, for example, were an important source of power in nineteenth-century Australia, with hundreds used for flour-milling and ore processing (Godwin 1983; Pearson 1998). Examples of hydraulic power (Baird 1986) and hydro-electricity (Gojak 1988) were also developed in New South Wales during the later nineteenth century. Water was also vital for agriculture. Detailed archaeological research in the Adelaide Hills has revealed that settlers in the area relied heavily on creeks and permanent springs for water, bringing traditional techniques from their homelands and adapting them to local conditions. Farmers used races, pipes, dams and cisterns, along with terracing and waterwheels, to grow irrigated crops in the fertile creek valleys (Smith 2006, 2007).

Market gardens and water systems were also developed by Chinese settlers, who became successful growers of European foods for a largely European market. At Yong Kit's garden settlement on the Loddon River in central Victoria, archaeological survey revealed a complex system of terraces, vegetation, paths and household debris, dating from the late nineteenth and early twentieth century (Stanin 2004). Crops were planted in straight, parallel rows and furrows dug to the very edge of the property. There were also shallow rectangular wells placed along the furrows, indicating the use of manual watering techniques. There were, however, no internal fences or divisions to show individual ownership by separate

leaseholders, only specific areas devoted to different crops. The remains suggest dependence on traditional agricultural methods, frugality and co-operative labour, similar to the pattern documented for market gardens in suburban Sydney, Perth and Melbourne (Morris 2001).

Several archaeological studies of mining have also identified races and storage dams associated with water management. Coroneos' (1993) study of the Lisle-Denison goldfields in Tasmania, for example, documents the archaeological remains of water races and reservoirs associated with the various forms of alluvial mining employed in the area. Barry McGowan (1992, 2001) has reviewed the use of water and its environmental effects in the Shoalhaven goldfields of New South Wales, while the archaeology of water management has also been studied in many areas of New Zealand, especially in central Otago (eg McCraw 2009; Ritchie 1981; Stephenson *et al.* 2004).

Several themes run through much of this research on water management in colonial Australia. One is the issue of technology transfer, where capital, skills and equipment were transplanted from other countries to the Australian colonies and modified according to local economic, social and environmental conditions (Casella 2006; Jack and Cremin 1994). This was a vital element of the colonising process, and water management played an important role in creating and sustaining non-Aboriginal settlement. Archaeologists have also identified, however, the related problem of obsolescence, where new technologies replaced old and finance was re-directed to more profitable enterprises, often creating historic cultural landscapes in the process. While water's role in industry has been acknowledged, archaeologists have been less explicit about how environmental constraints also affected the use of water for industry and agriculture. The limits of climate, terrain and water could rarely be ignored and it is apparent that industry had to accommodate itself to the available water, either by selecting locations close to reliable sources, or by diverting water from miles away.

## STUDY AREA AND APPROACH

Creswick lies about 18km north of Ballarat in central Victoria, on the northern side of the Great Dividing Range. The town lies at the boundary of two major landforms. To the north, basalt flows of recent geological age (6–1 mya) cover gold-bearing deep leads and quartz reefs at considerable depth, which were mined from the 1860s onward. The gentle hill country to the south is characterised by shallow rises and ridges cut by numerous creeks and gullies. The terrain is of Ordovician age (490–450 mya), characterised by deep sedimentary horizons of slate and sandstone. The gold-bearing matrix consists of iron sulphide cemented quartz boulders in a quartz silt or clay matrix, from which gold flakes and nuggets have eroded by alluvial pressure (Taylor 2000). This area was a primary focus of shallow alluvial mining in the 1850s and 1860s.

Watercourses on the Creswick goldfield generally rise in the hills south-east of the township, starting at around 600 m above sea level. Creswick Creek itself is fed by numerous tributary gullies, including Adekate (or Atticott) Creek, Ashwells Gully, Lincoln Gully and Slaty Creek, all of which were associated with extensive water race systems and sluicing. Long-term average rainfall in the area is around 720mm per annum, but this obscures substantial variability from year to year. Major droughts in the area were recorded in 1865–1866, 1876, 1881 and 1888, while flood years included 1863 and 1870 (Lawrence and Davies 2012:49).

The focus of our investigation here is a small area of forest

regrowth (about 16km<sup>2</sup>) located several kilometres south-east of the Creswick township. The area, bound by Slaty Creek to the west and south, Creswick Creek to the north and the Melbourne road to the east, includes numerous examples of lengthy water races, storage dams and deep scarring from ground sluicing (Figure 1). Archaeological evidence for water management is well preserved, with relatively little disturbance following the shift from mining to forestry and small allotments later in the nineteenth century. Features date from the beginning of the gold rush in the early 1850s and remained in use, in some cases, until the 1930s and later. Controlled burning of the area in recent years also means that surface visibility is generally very good.

Gold was first discovered in the Creswick Creek area in September 1851 (Flett 1970:407–416). Miners focused on shallow auriferous leads around the site of the present town and adjoining ground to the north and east. In 1854, the mining population expanded dramatically when a series of shallow leads was opened to the west and south of town. These areas proved to be very profitable for ground sluicing, being covered by up to 10m of gold-bearing washdirt. Important areas included Humbug Hill, Cabbage Tree Flat, Mopoke, Creswick Creek, Lincoln Gully, Long Gully and Slaty Creek, where up to 4000 miners arrived to work these fields (Flett 1970:416). Working these claims by ground sluicing required substantial volumes of water, and small companies formed to build storage dams in the higher catchments and bring water along open races which wound through the hills and gullies. Most races in the 1850s and early 1860s were surveyed by the miners themselves using line of sight and water flow. They demonstrate an intimate knowledge of topography and highly skilled bush engineering. These networks of water management are the principal focus of our present research.

One of the main techniques of working the alluvial deposits involved directing a flow of water over a deep working face, which was typically 20 to 30 feet (6 to 10m) high, with miners standing at the base to rake and pick the loosened washdirt into a sluice channel. Stones or blocks placed in the sluice assisted the break-up of the washdirt, permitting the deposition of the heavier gold particles (Smyth 1980 [1869]:128). The sluice emptied into a tailrace that was constructed with a steeper fall to allow for the rapid flushing of water into the channel. This technique could, however, be very dangerous. Working faces sometimes fell in slabs, bringing down tons of earth, rock and clay onto the miners below. At Humbug Hill, for example, at least seven men were killed by earth falls during the 1860s and 1870s, including Richard Martin (1860), Fun Wagh (1861), Yung Lan (1863), Ah Hik (1866), Ah Luke (1877) and Fun Gwan (1879) (Chin and Scott 2010).

Puddling was also widespread on the Creswick field. Although puddlers could only process a fraction of the ground that could be worked by sluice parties, they required much less water than sluicing and could generally be used all year round. The local Mining Surveyor reported 159 of these machines at work in August 1859, and this number remained fairly constant until drought in the mid-1860s forced many puddlers out of business (Bannear 1996; Mining Surveyor 1859).

The shallow alluvial claims at Creswick began to be worked out by the 1860s, and many miners departed to goldfields elsewhere in Victoria or joined the rush to New Zealand. Drought in 1865 exacerbated the trend and by the 1870s it was mainly Chinese miners who persevered with sluicing shallow alluvial claims and working old ground. By this stage the main focus of mining in the Creswick Division had shifted to the deep leads and quartz reefs located north of

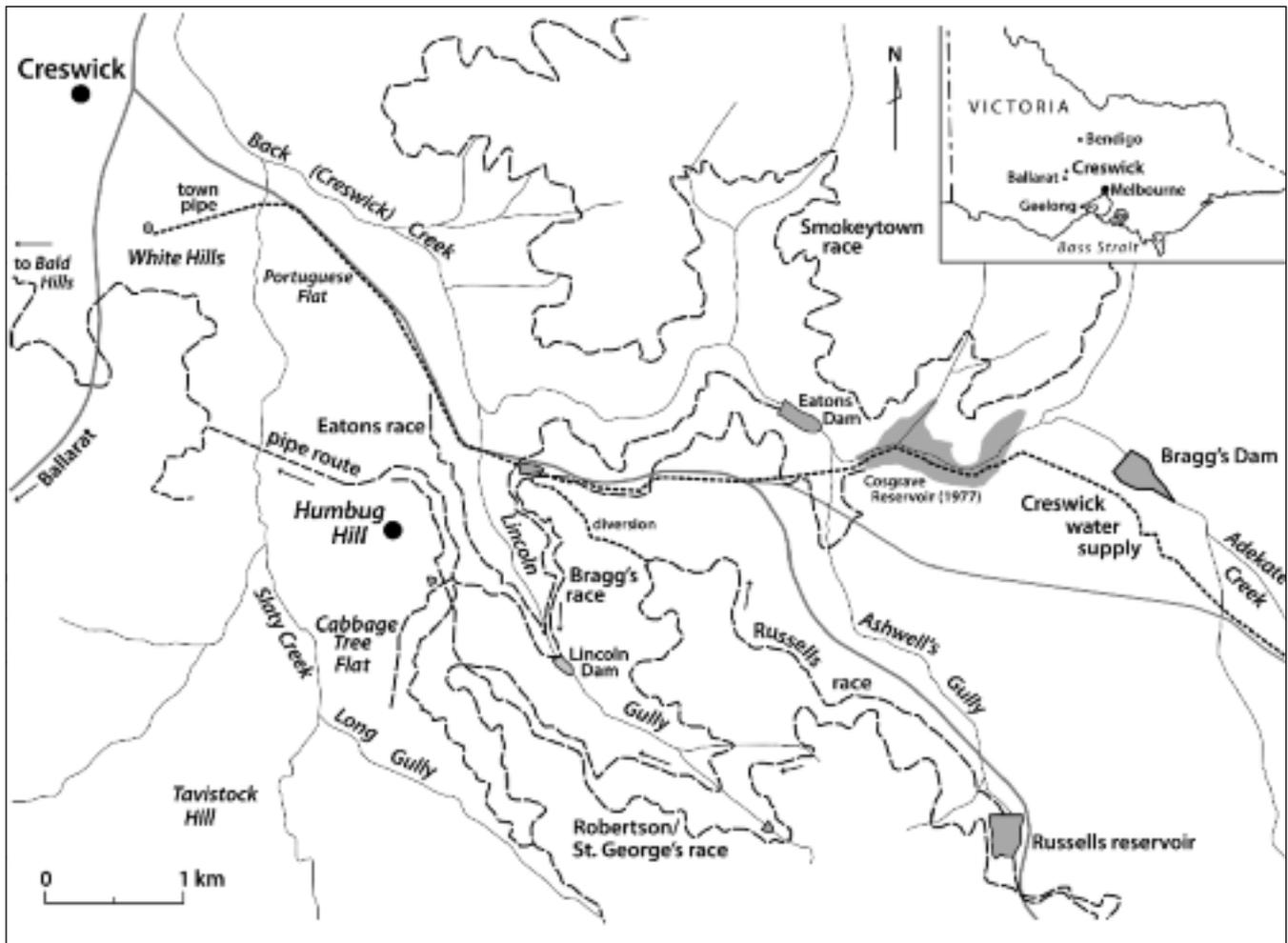


Figure 1: Map showing major water creek races on the Creswick alluvial goldfield.

town, and many of these yielded great wealth in gold. By the 1880s only a few hundred people remained in the forested ranges south of Creswick. Most eked out a living as miners or fossickers, wood-cutters, charcoal burners and small farmers. Many occupied a hut and an acre or two on a miner's right, while several dozen Chinese men cultivated gardens at Creswick Creek, Slaty Creek and Mopoke (La Gerche 1885). The area was incorporated into the Ballarat-Creswick State Forest in 1872, and in the 1880s and 1890s local forester John La Gerche worked to reclaim the forest for trees, and removed much of the physical evidence of housing and gardens as occupants died or moved away (Taylor 1998:111-112). In 1910, a School of Forestry opened at Creswick, and the area became a training ground for generations of forest workers. Today most of the area remains public land, which is managed by Parks Victoria as part of the Creswick Regional Park.

Our research has focused on the integration of diverse sources of evidence relating to water management on the Creswick alluvial goldfield, with field survey to check and identify races, dams and other archaeological features. Historical sources include nineteenth-century geological maps (eg Krause 1880), historical survey maps, mining lease plans and parish plans, along with Council Minute Books and Mining Warden's Registers, which provide important evidence for the development of dams and races by mining parties and the location of alluvial claims. Further details can be gleaned from newspapers including the *Ballarat Star* and the *Creswick Advertiser*. Many of the water races have also been mapped in considerable detail by orienteering groups, revealing the survival of these features over 150 years.

We have incorporated evidence of these water management features into MapInfo© GIS software to analyse a range of spatial relationships, including the position of races and dams in relation to hydrology, geology, mining claims, water licences and land ownership. GIS mapping also permits analysis of changes to race ownership and management through time, and the identification of physical links between water networks which created extensive water systems. Field surveys have also benefited from the use of an iPad©, which combines digital historical and modern map layers with MapInfo-generated spatial data. This greatly facilitates the ability to locate, verify and interpret relationships between features on the ground in this complex mining landscape.

## PERMITS AND WATER LAW

The first permits to divert water for mining were simple verbal statements from goldfields commissioners, sometimes with a notice posted on nearby trees authorising the water permit (Report 1862-63:341). Although vaguely defined, such permits were often exchanged for thousands of pounds, in the belief that they gave good legal title to the available water (Report 1860-61:1-2). In 1857, however, laws began to catch up with the needs of the miners, when the *Goldfields Amendment Act* (21 Vict. 32) extended the provisions of the miner's right to allow miners to build races and dams on Crown land on payment of a rent or royalty. Water-rights licenses were introduced in 1862, valid for up to 15 years, which recognised races and dams as a 'chattel interest'

(articles of property) which could be leased, bought and sold. These laws were clarified in the 1865 *Mining Statute* (29 Vict. 291) and adopted in similar ways on the other colonial goldfields.

The amount of water miners could legally extract, however, varied considerably from place to place. While in New Zealand a 'Government sluice head' consisted of one cubic foot of water flowing per second (McCraw 2009:10), in Victoria local by-laws determined the amount that could be diverted. Volumes were measured by 'sluice-heads', which consisted of a wooden box of specified dimensions and incline inserted in the head of a race, through which water flowed at a certain pressure. Different dimensions and flow rates, however, gave rise to anomalies in the delivery of water. Up to 2.3 million gallons (10.5ML), for example, were available per sluice-head each day in the Ararat District, but only 211,500 gallons (0.96ML) at Ballarat (Figure 2). British engineer Richard Sankey, who inspected progress on the Coliban Scheme of water supply to Bendigo in 1871, concluded in exasperation that he was 'wholly at a loss to know what the term "sluice-head" may imply (Sankey 1871:107). Miners at Creswick also found the term to be very vague, with sluice heads ranging widely different between claims (*Ballarat Star* 11 August 1858:2). The cost of such water, if provided by a water merchant or company, also varied substantially from place to place (Smyth 1980 [1869]:406-7).

In spite of variations among local by-laws, legislation relating to water diversion for mining in Victoria was fairly well established and widely understood by the mid 1860s, and remained in place largely unchanged for the next few decades (Armstrong 1901:220-7). The Crown issued licenses for the private construction and maintenance of races and reservoirs for mining purposes, while retaining notional ownership of the water as a resource. A water-right remained analogous to an easement, and the license-holder was expected to construct and maintain the race with sufficient skill and efficiency so that no overflow or percolation should affect a neighbour's land. In the 1880s, new legislation for irrigation effectively nationalized State ownership of Victoria's surface water,

creating rights of access for private supply while abolishing previously recognised riparian rights in order to assert State management (Powell 1989:113-14).

## WATER COMPANIES

The first generation of water managers on the Creswick alluvial goldfield came from a wide range of places and backgrounds, and few had previous experience of mining and sluicing. In this section we describe the operations of several pioneers in the development of water resources at Creswick. These include George and William Russell, John Bragg and the Humbug Hill Sluicing Company, James Robertson and the St. George's Sluicing Company, and Charles and Benjamin Eaton. Careful study of the historical evidence and the archaeological remains associated with these groups reveals important patterns in the development of dams and water races, as well as the disputes that emerged over water rights and privileges. As the early period of alluvial mining at Creswick faded in the 1860s and 1870s, the water networks created by these mining parties were taken up by the municipal council and integrated into the town water supply.

The brothers Benjamin Franklin and Charles Lafayette Eaton began their gold mining career in Australia on the Turon goldfield near Bathurst in New South Wales, after migrating from California around 1853 (Potts and Potts 1974:55). After early success their fortunes declined and the brothers took themselves off to Victoria in 1855. The Eatons soon became active participants on the Creswick alluvial goldfield, entering into partnerships with local miners John Roycraft and William and George Russell, and disputing with John Bragg and the Humbug Hill Sluicing Company.

The Eaton brothers may have encountered James William Robertson during their early days on the Turon goldfield. Robertson was born in 1823, in New Brunswick in Canada, and worked in both farming and the timber industry as a young man. He arrived in Australia in the early 1850s, and for the next few years pursued opportunities on the Turon goldfield and around Melbourne, Hobart, Ballarat, Creswick and Bendigo. Later he moved to Otago in New Zealand, where he made a fortune in flour and sawmilling and became the first mayor of Queenstown (Scholefield 1940:246-7). Robertson spent the years 1855 to 1861 at Creswick, from where he wrote a series of letters to his family which reveal important details of the water races and sluicing operations he developed (Wynn 1979).

The brothers George and William Russell were among the first builders of water races at Creswick, and they developed mining and water interests on numerous creeks and gullies in the area. They were born in Dublin in 1815 and 1817 respectively, and both were apprenticed as blacksmiths. In 1835, however, William Russell was transported to Sydney as a convict after a conviction for burglary, while George came to Victoria via South Australia in 1855 with his wife and their six children (Clarke 1994:30). In later

SIZE OF SLUICE-HEADS IN THE SEVERAL MINING DISTRICTS.

District.	Division.	Sluice-boxes.				Number of gallons per twenty-four hours.
		Length.	Width.	Depth inside.	Opening across bottom.	
BALLARAT (a)	All divisions	—	16 ins.	1 in.	—	211,500
BURCHWORTH (b)	All divisions	12 feet	12 ins.	6 ins.	1½ in.	178,500
	except					
	Buckland	12 feet	12 ins.	6 ins.	3 ins.	476,000
	Goulburn					
	Mitta-Mitta					
	Woolshed					
	Yackandandah (for bank water-rights)	12 feet	12 ins.	3½ ins.	3 ins.	362,500
	Yackandandah (for creek water-rights)	12 feet	12 ins.	7½ ins.	7 ins.	1,240,500
SANDHURST (c)	All divisions	6 feet	12 ins.	6 ins.	3 ins.	476,000
MARYBOROUGH (d)	All divisions	12 feet	20 ins.	3 ins.	—	1,875,500
CASTLEMARINE (e)	All divisions	6 feet	10 ins.	3½ ins.	2 ins.	202,000
ARARAT (f)	All divisions	6 feet	12 ins.	3½ ins.	—	2,341,000
GIFFELAND (g)	All divisions	—	16 ins.	1 in.	—	211,500
	except					
	Kobana East	—	16 ins.	2½ ins.	—	476,000
	Tarraville					

Figure 2: Variations in sluice-heads in Victoria's seven mining districts (Smyth 1980 [1869]:405).

years the sons of both men continued the family's involvement in sluicing and water management.

The Humbug Hill Sluicing Company began in 1856 under the management of Irish-American John Boadle Bragg. Partners in the multi-national group included Jacinto de Lima from the Azores islands, and Domingo Francisco, a Philippine sailor who had jumped ship in Sydney in 1853. Bragg himself was a naturalised American who had worked as a tanner in New Orleans before arriving in Melbourne in the early 1850s. The company soon became one of the most prominent water parties in the Creswick area, and notwithstanding Bragg's death in 1865, at the age of 42, it remained a going concern for more than 20 years.

One of the first steps in developing an alluvial mining claim was to secure a supply of water, in both legal and practical terms. Numbered Water Privileges or Rights had begun to be issued in 1857 under the *Goldfields Amendment Act* (21 Vict. 32), although disputes emerged over priority of access and the ongoing validity of earlier verbal permits. Water-Rights Licenses were issued from 1862 in a single running sequence for the entire colony, and some of the first licenses were issued to miners at Creswick. These rapid changes in law and regulation meant that mining parties had to be ready to defend their water interests, both on the ground and in the courts. The resulting tangle of water rights and privileges was the source of conflict and dispute on the Creswick goldfield for years to come.

William Russell purchased a share in the first water permit or privilege on Back (Creswick) Creek from Davis and Co in 1854, and in the following years he and his brother worked a claim downstream from the Eaton brothers. James Robertson, in partnership with William Mitchell, held the second privilege on Creswick Creek, which was sold to the Eaton brothers in 1857. John Bragg obtained water privilege No. 3 for Adekate Creek, a tributary of Creswick Creek, on behalf of the Humbug Hill Sluicing Company in 1856. These mining groups were to spend the next few years in and out of court arguing over which had proper legal access to the available water (eg *Ballarat Star* 7 September 1858, 16 September 1858).

Conflict over water could also erupt within parties. In 1860, the eight partners of the Humbug Hill Sluicing Company came to blows over plans to extend the group's operations. Construction of a race from Slaty Creek westward to the Bald Hills was well advanced by April 1860, but the members argued about whether this was the best approach. After a dispute over water supplies ended in a fist fight, the case was argued in the Creswick Court of Mines. Bragg and three supporters agreed to buy out the interests of the other four partners for £480 and continued extending the race (*Creswick Advertiser* 10 August 1860:4).

Creeks and gullies around Creswick generally provided limited and often unreliable flows of water. This meant that construction of storage dams was often necessary to provide a consistent supply to mining claims. The Humbug Company constructed a large dam on Adekate Creek, which could hold 15 to 20 million gallons (68 to 91ML) of water (*Creswick Advertiser* 3 June 1862:2). The dam wall is well preserved, although the reservoir has silted up and today holds little water. The wall is made from clay and extends for 110m in length. It has a gently sloping profile of 32 degrees, unlike other dams in the study area which were often built at a steep angle in narrow gullies. The wall stands around 4.7m in height, and contains approximately 3650m<sup>3</sup> of fill.

The Russell brothers expanded their mining enterprise in 1861 by building Russell's Dam in Ashwells Gully, another tributary of Creswick Creek. A race from the dam brought water 7km westward to the family's alluvial mining claims at

Humbug Hill, where they had another dam for sluicing. Russell's Dam had a wall 18 feet (5.5m) high, covered five acres (2.02ha) and had a capacity of 11 million gallons (50ML), with a daily inflow of around 2 million gallons (9ML) (*Creswick Advertiser* 2 December 1864:3). As well as sluicing their own claims, the brothers were willing to sell their excess water to other miners in the area. In the 1930s the dam was upgraded to a larger reservoir and today it still forms part of the town supply.

Charles and Benjamin Eaton developed their claim on Creswick Creek in 1857, with the purchase of a small reservoir known as Yankee Dam and an associated water race for £500 (*Ballarat Star* 14 November 1857:2). In 1862, the Eatons began to dismantle Yankee dam in order to wash for gold in the bed of the creek (*Argus* 8 April 1863:6). At the same time they began construction of a new dam further upstream with a much larger capacity. The remains of Eaton's dam are among the most striking and best preserved archaeological features on the Creswick goldfields. The dam wall is unusual in the district for having been built with a substantial stone facing and a clay embankment on the upstream (water) side, when most other mining dams in the area were simple mounds of clay quarried from the adjacent creek banks. The dam wall is approximately 70m long, about 8 m wide at the base and generally 4–5m in height (Figure 3). The top of the dam wall is 1.5m wide and was originally secured with a frame of heavy timbers (*Ballarat Star* 2 July 1862:4). The lowest courses of stone protrude outward slightly from the base, while above these the masonry consists of large schist slabs laid horizontally with a small rock infill. The central section of the wall features a steep sloping buttress on the downstream side about 4m in height.

In 1863, the dam was still under construction when it was damaged by floods, but when completed the following year it held up to 15 million gallons, or 68ML (*Ballarat Star* 19 October 1863:2; Dicker 1864:180). In 1869, the dam was flooded again, while the smaller Yankee dam was destroyed entirely. By the late nineteenth century Eatons dam was still a source of mining water but it had also become a popular place for picnics, bird watching, shooting parties and fishing (Graham 1987:124; Lindsay 1965:24). In 1933, however, heavy rain flooded the creek again and partially destroyed the dam wall (*Creswick Advertiser* 5 December 1933).

Water was conveyed from storage dams to sluicing claims by simple open cut channels or races. More than 100km of races are preserved on the Creswick alluvial goldfield, including substantial sections associated with the mining parties described here. Most races were excavated on a slight gradient across a gentle slope, with a simple u-shaped profile.



Figure 3: North section of Eatons Dam, breached by flooding in 1933 (Davies 2011).

They range from narrow 20cm trenches to more substantial races up to 2m wide. Many of the races change dimensions over their length as a result of terrain, but also to regulate flow. Silts from the flowing water helped seal the channel and reduce leakage. Junctions, diversions, intakes and outlets to and from water races have also been observed on the Creswick goldfield races, indicating the complex connections made to link water networks into larger water systems.

James Robertson spent several years developing a substantial race network to bring water from the Bullarook forest south-east of Creswick to the headwaters of Slaty Creek and from there to Humbug Hill. In 1857, the race was costing £50 per mile to build, with 40 men at work. At the terminus of the race his men had built an 800-foot (244m) wooden flume to span a saddle between two low spurs, bringing water across to Humbug Hill for sluicing. The upper section of the race was completed in the following year, by which time it stretched 14 miles (22km) to the south-east. This section had ‘... been cut mostly by chinamen they are satisfied with 6 or 7 shillings per day and very steady men to work’ (Wynn 1979:264-5).

The race started at 610m above sea level, and was high enough to divert southward over the Dividing Range to Ballarat. The upper section of the race is not well understood, but the lower section, from the hillside adjacent to Russell’s Reservoir and along to Humbug Hill, is well preserved. It extended for five miles (8km) and may have drawn water from a small reservoir on the upper part of Slaty Creek, passing through the head of Lincoln Gully on the way to Humbug Hill (Dicker 1864:180). No sign of the wooden flume, however, has been identified.

By 1861, Robertson’s interest in gold and waterworks had begun to fade, and he sold his interests in water races to associates and soon after left for New Zealand (Scholefield 1940:246). The race from Slaty Creek that Robertson had developed now belonged to the St. George’s Sluicing Company, whose partners focused much of their work on Humbug Hill. In 1862, they replaced the wooden flume to Humbug Hill with 560 yards (512m) of 6-inch bitumenized paper pipes (*Creswick Advertiser* 16 September 1862:2). In spite of leaks in the pipe, the company still yielded a dividend of £1 per man per week (*Creswick Advertiser* 24 October 1862:2).

The Eaton brothers built a water race which extended two miles (169 chains, or 3.4km) downstream from their large dam along the south side of Creswick Creek to Portuguese Flat via Lincoln Gully. Much of the area has been extremely disturbed by surface working over the years, which has destroyed some sections of the race. The race was held as Water-Rights License No. 2, the second issued in Victoria, and appears to have been leased jointly by Benjamin Eaton and John Roycraft. The pair applied successfully for another license (No. 30) to the race and reservoir in 1865 (Government Gazette 16 April 1866:818-819). In 1879, Roycraft obtained another 15-year license (No. 414), this time without the Eatons’ involvement. The license specified a total quantity of water to be diverted of 2 million gallons per day (Secretary of Mines 1884:54). Roycraft continued renewing the license until it expired in 1924, by which time the race appears to have been in operation for almost 70 years.

The race built by the Humbug Hill Sluicing Company from Bragg’s Dam to Humbug Hill remains in an excellent



Figure 4: Section of race built by Humbug Hill Sluicing Company (Davies 2011).

state of preservation, despite disturbance in several small sections by road construction and logging (Figure 4). In addition, construction of Cosgrove Reservoir in 1977 inundated a one-kilometre section of the race below Bragg’s Dam. The race is generally about one metre wide and up to 1.2m deep, curving around Ashwell’s Gully and Lincoln Gully en route to Humbug Hill. Extensions of the race westward to the White Hills, and beyond to Long Point and the Bald Hills, are more disturbed and difficult to identify.

In 1859, the District Mining Surveyor, James Stephenson, reported the activities of the Humbug Hill Sluicing Company:

The Ground was washed from the surface to the bottom – a depth of 30 feet, the lower 10 of which were a soft clayey red reef, and had to be thrown up into the sluice streams. The mode of working adopted was first to cut a face on the ground, and then to turn on the water along its base. Thus the water assisted in cutting down the ground, and frequently blocks of from 20–50 tons were so taken down. The shifts were 6 hours on and 12 hours off, and the work was kept going night and day.

In this way the party moved 8½ cubic yards (6.5m<sup>3</sup>) per man per day, using 300 gallons (1364 l) of water per minute, with a gold yield of 245 ounces (Mining Surveyor 1859:8). The scars of the sluicing work carried out by the Humbug Company and various other groups remain highly visible on the southern and western slopes of Humbug Hill today, and



Figure 5: Deep sluicing gullies on the southern slopes of Humbug Hill (Lawrence 2011).

indicate the scale of landscape change brought about by the manipulation of water by miners (Figure 5).

The Humbug Hill Sluicing Company was also responsible for a remarkable piece of water engineering, when the group built half a mile of elevated pipe in 1862. For some time the main barrier to completing the group's water system was Slaty Creek, where the broad creek flats were more than 20m below the group's lowest operation on Humbug Hill. Eight hundred yards (730m) of piping were needed to convey the water across by gravity at sufficient pressure. The company contracted with the Patent Bitumenized Pipe Company of Melbourne and Bendigo to lay eight-inch pipes across Slaty Creek in an inverted siphon carried on braces or trestles that began 114 feet (34 metres) above the height of the creek, and discharged into an open race on the other side.. The pipes, made from paper sealed with bitumen, were cheaper and much lighter than iron pipes, and were used on the goldfields for fluming, draining and pumping. Manufacture involved passing a roll of paper through a vat of molten bitumen, and then coiling the paper tightly around a mandrel to form a tube (Argus 27 Aug. 1860:5). The walls of the pipe were 22mm thick. Pipes used by the Humbug Company featured flanged joints and a T-piece at the lowest point for blowing out any accumulated sediment. They were supported in iron-braced wooden boxes, and relied on gravity, rather than steam engines, for water pressure. The entire outlay for the company amounted to £3000 (Creswick Advertiser 3 June 1862:2; 12 September 1862:2).

Water was laid through the pipes and across the creek for the first time on Wednesday, 10 September 1862. The event caused great excitement, with the *Creswick Advertiser* reporting that:

'The operation began at Humbug Hill at 4 p.m., and 35 minutes afterwards the water made its appearance on the White Hills, and intelligence which was transmitted through the firing of a gun and received with cheers at the starting point. A great many strangers were present on this interesting occasion and the whole company enjoyed themselves heartily to celebrate the event' (Creswick Advertiser 12 September, 1862:2).

With this connection made, the Humbug Hill Sluicing Company had succeeded in delivering water from its reservoir on Adekate Creek all the way westward to Long Point and the Bald Hills, a distance of approximately 14 miles (22.5km). In

the following days, however, there were reports that some of the pipes had burst under the pressure of water, and repairs with thicker pipes were needed in some sections (Creswick Advertiser 7 October 1862:2). In spite of these efforts, the 'paper and pitch' pipes do not appear to have been very successful, and by 1864 the company had replaced them with conventional iron pipes (Dicker 1864:180). The route of the pipe is still clear today as a long straight clearing through the forest, while fragments of the bitumen pipe are preserved in a vehicle track. This feature was identified with the aid of real time positioning over geo-referenced historical maps during field survey.

At this time, the Creswick Council was finalising construction of a domestic water supply scheme, conveying water from a reservoir 7 miles (11.3km) south-east of the town. In 1864, the Council also began to draw on water supplied by the Humbug Hill Sluicing Company's race and dam on Adekate Creek. The Council used the extra water to fill a small service reservoir at Lincoln Gully, using a sluice gate and brick-lined channel to divert water from Bragg's race (Figure 6). This small reservoir, of about 5ML in volume, was built on the side of a hill and is well preserved today, and appears to have been constructed to take advantage of the reliable flow from the Humbug Hill Company.

The Council was also eager to acquire rights to the upper section of the race built by James Robertson and held by the St. George's Sluicing Company, as a way of augmenting municipal supplies. In 1864, the St. George's Company applied for a new 15-year license to the lower five miles (8km) of race to Humbug Hill, which delivered 800,000 gallons (3.6ML) of water per day (Creswick Advertiser 2



Figure 6: Brick-lined sluice from Humbug race into Lincoln Gully Reservoir (Davies 2012).

December 1864:3). By 1873, however, the company was being run by a party of Chinese miners, who complained of interference by European competitors. In 1879, the Council compulsorily acquired the lower section of the St. George's race, and in the following year leased the water right to Chinese miner Ha Son for three years (VPRS 3730, 19 April 1880).

In 1873, the Council also acquired Russell's Dam, and a narrow diversion channel was excavated down a spur to link Russells' race to the Council service reservoir built on the slope above Lincoln Gully. By this period, sluicing claims in the Creswick hills were gradually being abandoned, and the Council sought to consolidate its water resources by acquiring the water rights of mining parties. Surplus water from these sources was sold at times to groups of Chinese miners (VPRS 3730, 13 December 1880).

## CONCLUSION

There were many more miles of water races constructed on the Creswick goldfields during this period. Those presented here, however, are important for the insight they provide into the processes of water management during the alluvial mining era. GIS has enabled historical maps, documentary research, and detailed on-ground mapping from a variety of sources to be integrated in a way that reveals more completely the extent of what the miners achieved within a few short years. Gold miners were pioneers in the capture and manipulation of water sources, demonstrating the reliability of local supplies and the measures needed to manage this most vital of natural resources. While the technology used was simple, it represents an enormous investment in time and labour *before* mining could even begin. The extant remains of races, pipes and dams, and the even larger extent of former races seen in the GIS mapping, reveal the scale of water diversions and the very substantial effort needed to direct water to mining claims, as well as the integration of water networks into wide-ranging systems of water management.

Miners co-operated to use water when it was in their interests to do so, but otherwise jealously guarded their water privileges. Newspapers of the time are filled with the legal battles of stolen water, cut races, over-sized sluice boxes, 'abandoned' races, sludge flows and other disputes. Some miners became water merchants, developing and trading the water resources they controlled, and making substantial profits in the process. Chinese parties also became water traders, asserting their rights to full water entitlements and often selling water at high prices.

The races and dams built by the miners represent a rapid coming-to-terms with environmental constraints. Washing gold from the earth typically demanded substantial volumes of water, which had to be diverted to claims at a fixed location. While Creswick lies in a zone of good, if variable rainfall, there are no major rivers nearby and creek and gully flows are usually seasonal and erratic. Dams and ditches were a simple but labour-intensive response to diverting water from where it was available to where it was needed. The manipulation of water supplies by the miners created an extensive cultural network of water management that overlaid and modified flows in the natural environment.

As the early alluvial rush declined in the 1860s and 1870s, the water networks created by the miners were reused for domestic supply. Local councillors, many with close connections to the mining industry, sought to acquire for public benefit both the legal rights and the physical infrastructure of races, dams, pipes and other elements to augment town supplies. By the 1880s the Creswick Council had purchased water rights from the Humbug Hill Sluicing

Company, St George's Sluicing Company and the Russell family, using these to increase domestic supply. As water systems expanded in the following years, dams and races originally built by the miners were upgraded or abandoned, creating a history of water management etched in the landscape today.

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