Heritage Assessment

Invincible Battery
NZAA Site No. E40/58

Invincible Concentrator
NZAA Site No. E40/59

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2014

Cover Photo: The Invincible water wheel in 2014.

Peer review statement

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1.0 Site Overview

AMIS Functional Location number: DS-38-105-5007
AMIS Equipment number: Water wheel 49570; Concentrator 49572; Berdans 49573.

The Invincible Mine and Battery and the associated Otago Pyrites Saving Company's buddle (also referred to as a 'rotating convex table' and a 'concentrator') are located on the western flank of the Richardson Mountains (which in turn defines the eastern side of the Rees Valley) about 17 kilometres north of Glenorchy. The gold mine opened in 1880, and operated intermittently until the mid-1890s, with sporadic prospecting continuing until about 1937. The sites are notable for the intact set of seven Berdans at the battery house, which is the largest surviving array of Berdans in New Zealand, and the buddle on the valley floor, which is the most intact gold-saving buddle in New Zealand. The sites are also set in a spectacular alpine landscape.

The Invincible Mine Historic Reserve is within the Wakatipu Area of the Department of Conservation. It is an actively managed site, which consists of overshot water wheel (1882), stamper battery (1882), concentrator (1884) and Invincible Berdans (1886). The Invincible Battery and associated sites have been recognised as significant by the creation of a historic reserve to protect them, and by inclusion in a number of lists and schedules of significant and/or protected features, which are described below.

The Invincible Mine and Battery and associated Otago Pyrites Saving Company buddle are situated within the Invincible Mine Historic Reserve (NZ Gazette 1979 p.570). This reserve in in two parts:

- Invincible Mine: Section 1 Block XII Earnslaw SD, S.O. 18563 (Invincible Mine Historic Reserve).
- Invincible Buddle: Section 2 Block XII Earnslaw SD, S.O. 18563 (Invincible Mine Historic Reserve).

However, during the preparation of this heritage assessment and the updating of the NZAA records, the GPS co-ordinates for the buddle appear to indicate that the surveyed boundaries of the lower section of the reserve (Section 2 Block XII Earnslaw) lie a considerable distance from the actual archaeological features (Figure 1). This will need to be checked by a qualified surveyor and the situation resolved if there is a problem.

The Invincible Mine and Battery and associated Otago Pyrites Company buddle are listed by Heritage New Zealand:

- Invincible Mine & Battery (List No, 5603) as a category 2 historic place.
- The Invincible Buddle (List No. 5604) as a category 2 historic place.

The Invincible Mine and Battery, Otago Pyrites Company buddle, and associated sites are recorded as archaeological sites on the New Zealand Archaeological Association Site Record File (Archsite) (Figure 2). These records have been updated as part of this Heritage Assessment:

- Battery NZAA Site No. E40/58 (S123/253).
- Buddle NZAA Site No. E40/59 (S123/254).
- Invincible Mine Machine Level drive Site No. E40/63.
- Invincible Mine upper workings Site No. E40/64.
- Hut ruin at start of Invincible track Site No. E40/65.
- Log hut beside Invincible track Site E40/66.

The Invincible Mine and Battery and associated buddle are listed in the Queenstown Lakes District Council District Plan in Appendix 3 Inventory of Protected features:

- Invincible Mine, Appendix 3, Item 34, QLDC category 3.
- Invincible Battery, Appendix 3, Item 703, QLDC category 2.
- Buddle, Appendix 3, Item 704, QLDC category 2.

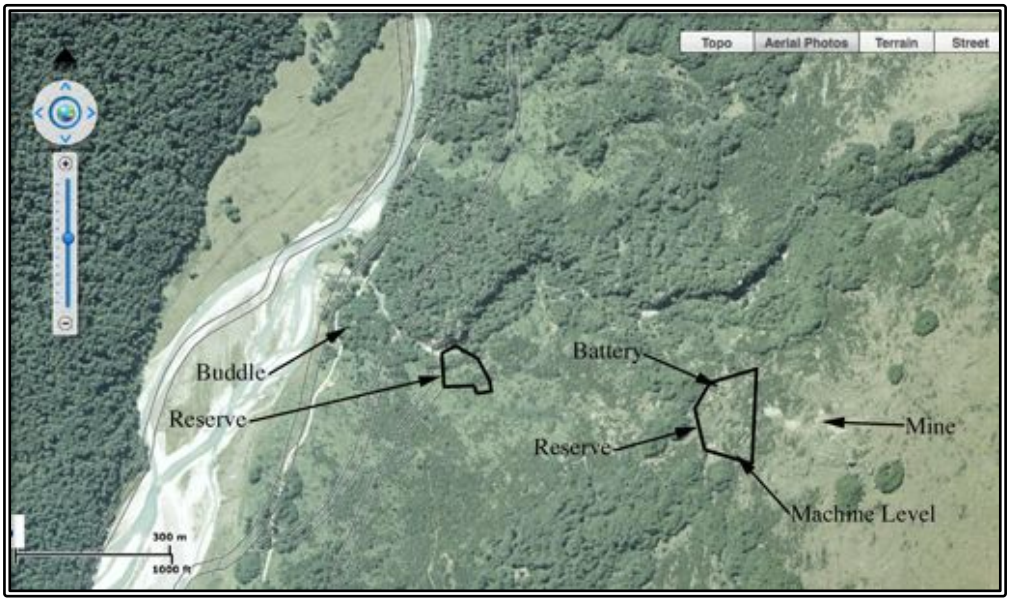

Figure 1
Annotated GIS map (QLDC online GIS), showing the location of the main features of the Invincible Mine complex and the current reserve boundaries.

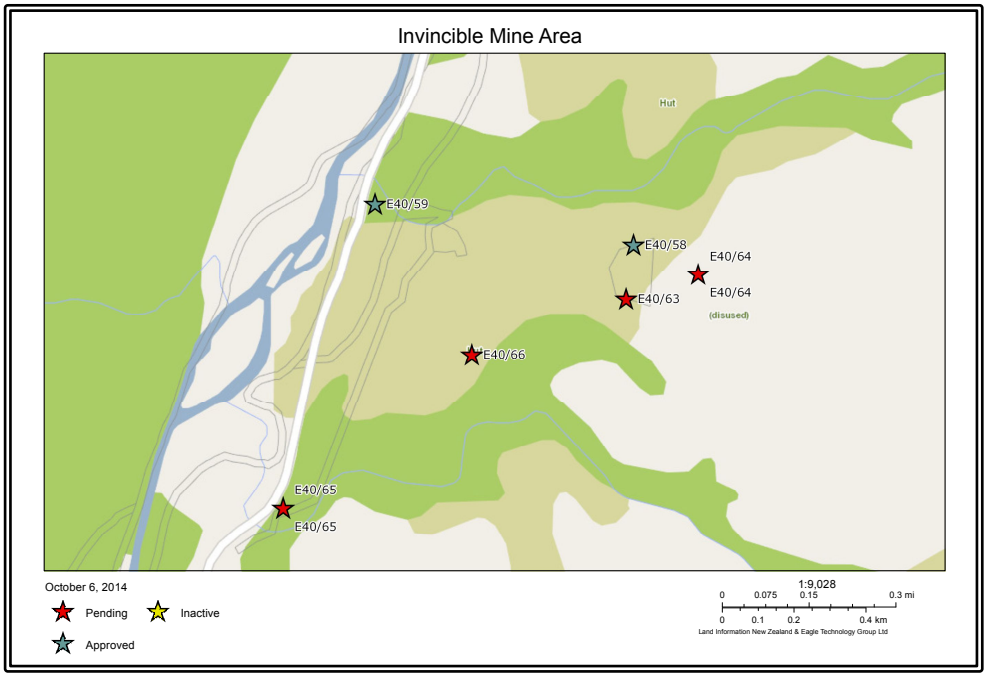

Figure 2
The Invincible Mine complex sites as recorded in the NZAA Archsite database (www.archsite.org.nz)

2.0 Setting

The Invincible Mine and Battery are located at about 820m asl on the western flank of the Richardson Mountains, above the valley of the Rees River, about 17 kilometres north of Glenorchy and the head of Lake Wakatipu (Figure 3). The associated buddle is found on the valley floor almost directly below the battery site. A Department of Conservation walking track follows the old mine track up from the valley floor. The return trip takes approximately 3 hours, and involves climbing and then descending approximately 400 metres. Table 1 gives the NZTM co-ordinates for the main features of the complex as recorded in the New Zealand Archaeological Association Site Record File (all updated in 2014 as part of this assessment).

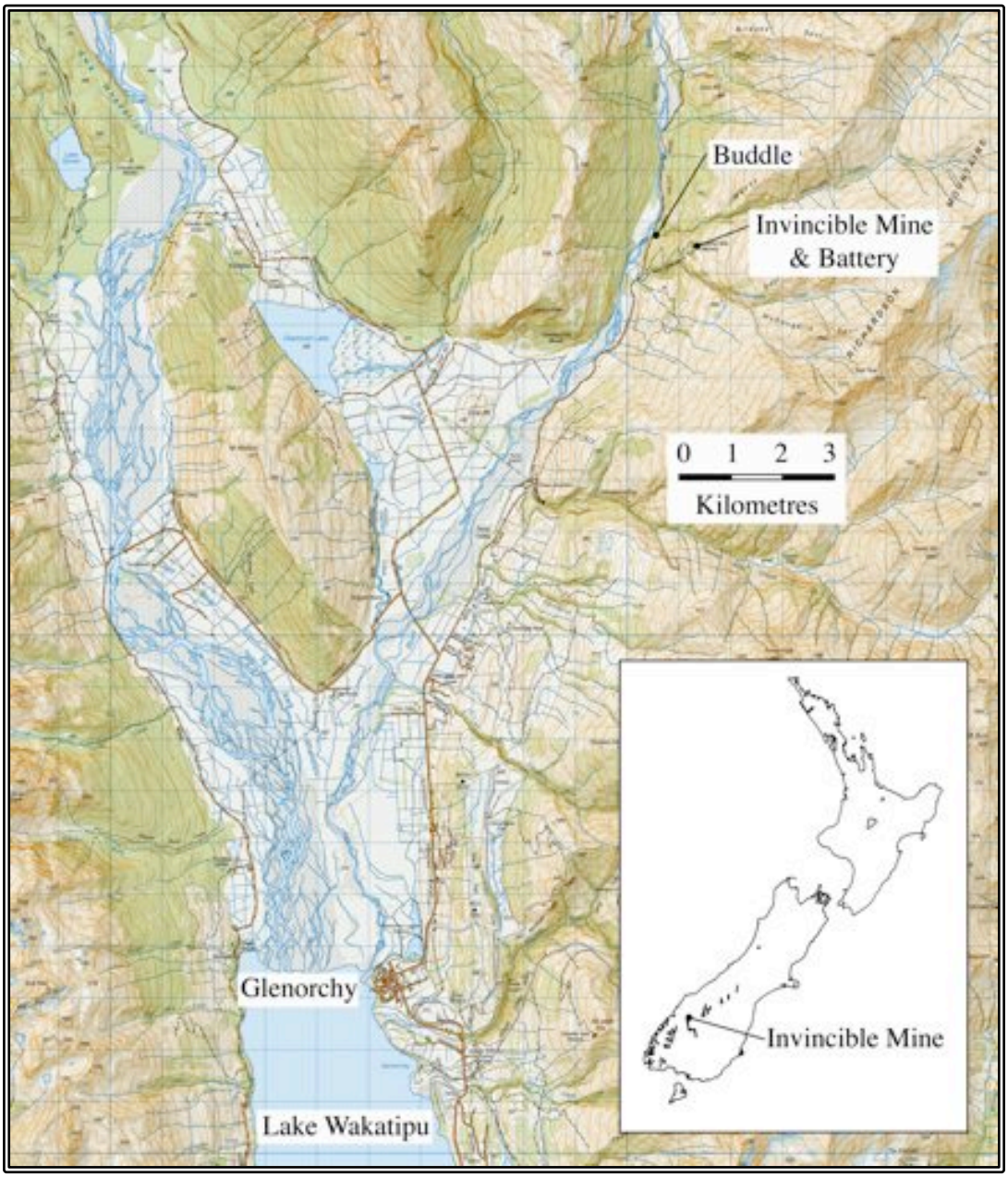

Figure 3
The location of the Invincible Mine, Battery and Buddle (NZTopo50 CB10 Glenorchy).

Table 1
Hand-held GPS co-ordinates for the recorded sites associated with the Invincible Mine (co-ordinates are in NZTM).

Description	NZAA No.	Easting	Northing
Invincible Battery	E40/58	1241258	5037661
Otago Pyrites Co. buddle	E40/59	1240540	5037774
Machine Level Drive	E40/63	1241238	5037510
Invincible Mine	E40/64	1241438	5037579
Hut at track start	E40/65	1240285	5036929
Log hut by track	E40/66	1240809	5037356

The walking track starts at the road in an area of mixed grassland and beech forest, and then climbs steeply in a zig zag up to the battery and mine site. On the way it passes through several areas of thick regenerating scrub and stands of beech forest. The battery and mine sites are in an area of mixed grassland with patchy scrub that is slowly encoraching on the entire area. The Berdans have been kept clear, and the main walking track to the site is clear, but other features such as the collapsed stamp mill are becoming increasingly overgrown. In several places along the walking track to the Invincible site, and from the battery and mine sites themselves, there are spectacular views up and down the Rees Valley (Figure 4).

Figure 4
View looking across the Invincibe Battery terrace and up the Rees Valley.

3.0 History of the Invincible Mine

Gold was first discovered in the Wakatipu region in 1862, and Mining Surveyor Wright commented in 1863 that "very few places have been prospected within this district that have not been found to contain some traces of gold" (AJHR 1863 D6:18). The Invincible Reef was discovered in 1879, but who exactly should have the credit is uncertain: Chandler (1984: 28) stated that local tradition had always credited a local shepherd, Tom Hope with the discovery; while Sutherland (1973: 1) stated that it was found by two shepherds, W.T. Campbell and W. Rainer. The Invincible Prospecting Company was soon formed to test the ore, and small quantities of ore were sent to Wellington in March 1880 for test crushing, which proved encouraging (AJHR 1880 H26: 27). The Invincible Quartz Mining Company (with a capital of £21,000) was formed in 1880 by W.L. Davis, C.C. Boyes, R. Williams, J.E. Davis, S.W. Wilson, W. Rainey and T. Hope, (AJHR 1888 C5: 44; Chandler 1984: 28; Sutherland 1974: 2).

In 1882 the Invincible Company erected a ten-stamp battery, each stamp weighing 8 cwt., driven by an overshot water wheel. Gold saving was by blanket tables, with the concentrates washed out from the blankets afterwards ground in a Berdan. No copper plates or mercury wells were used (AJHR 1885 C2: 11). The machinery was manufactured by Thompson & Co. of Castlemaine in Australia, and the total cost of the battery, water race and associated work was £1737 16s 8d (Otago Witness, 17 May 1884: 12; 14 June 1884: 9). Contemporary photographs show that the entire plant, including the water wheel, was housed inside weatherboard buildings (Figure 5). The first stone was crushed in December 1882, but this yielded only 325 oz. of gold from 1,350 tons of stone, and the reef appeared quite disjointed and broken (AJHR 1883 H5: 40). Although returns subsequently improved, (2,226 oz. from 3,173 tons in 1884), the company was losing a large amount of gold through the battery due to the high pyrites content of the lode. In order to quantify this loss Professor Black of the Otago School of Mines carried out an assay of the tailings that returned over 11 oz. to the ton from the pyrites.

In 1885 the Invincible Company entered into an agreement with George Watson of Dunedin (the Otago Pyrites Saving Company Ltd.) to allow him to work all of the tailings from the battery for a period of three years (or 4 or 5 years, depending on the source quoted) on consideration of 15 per cent of the gold that the pyrites contain (AJHR 1885 C2: 11; *Otago Witness* 4 April 1885: 22; 13 June 1885: 13). The Pyrites Company erected a new works on the floor of the valley, with a 2,200 ft. flume to carry the tailings down from the Invincible Battery above. The pyrites saving works consisted of two classifiers, three pyramidal boxes, two jiggers and a 26 feet diameter "rotating convex table," driven by a 10 inch diameter "Little Giant" turbine, all housed in a building that measured 45 feet by 90 feet (AJHR 1886 C4: 22; *Otago Witness*, 27 August 1886: 12). The machinery was imported from Germany, and was set up under the supervision of J.B. Neal, and the pyrites that were saved were shipped to the Sandhurst Pyrites Works in Victoria for smelting (*Otago Witness* 2 January 1886: 14; 27 August 1886: 12). An extremely detailed account of the plant and process was published in the *Otago Witness* (27th August 1886, p. 12), and this is reproduced here in Section 11.

However, to check Professor Black's assay the Invincible manager, Alfred Morrisby, collected 11 ½ tons of pyrites, ground it in a Berdan, and got 108 oz. of retorted gold. This return led the company to order six additional (to make a total of 7) 4 feet 6 inch Berdans from Kincaid McQueen & Co., at a cost of £1,230, to further process their tailings and recover the gold they were losing (AJHR 1886 C4: 22; C4A: 29). For the year from March 31 1885, the average yield per ton was 9 ¼ dwt. The following year the average yield was 14 dwt. per ton (AJHR 1887 C6: 37) (such figures are, of course, affected by the quality of stone

being crushed at the time). The improved processing of the ore by the Invincible Company left little for the Otago Pyrites Saving Company to recover, and it folded in 1886. The "Little Giant" turbine was later moved to power a battery in Butcher's Gully, Skippers (AJHR 1889 C2: 58).

Figure 5
The Invincible Battery (New Zealand Mining Handbook 1906).

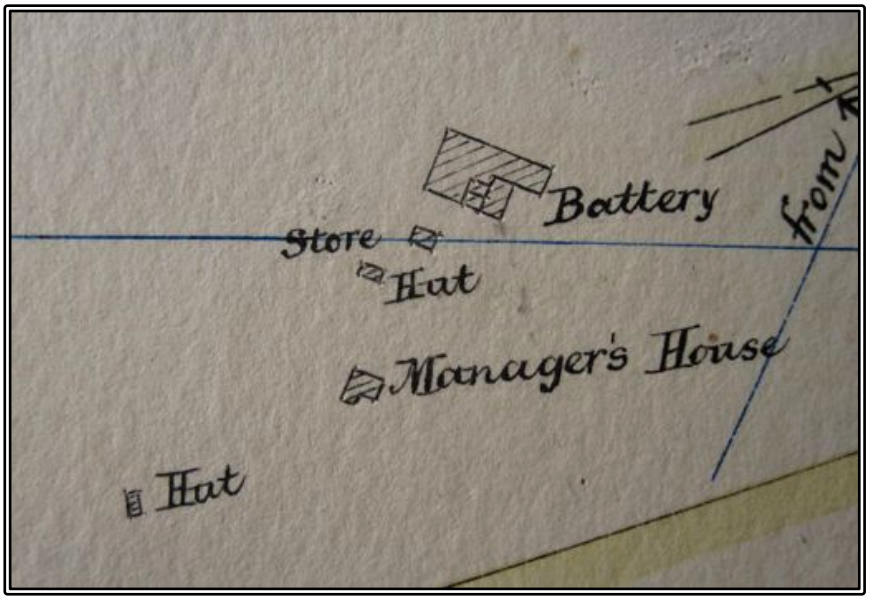

Figure 6
Detail from an 1896 survey plan showing the battery house and associated buildings at the Invincible Mine (Land Information New Zealand, SO 4147).

Figure 7
One of the Invincible Mine drives in the 1880s (Burton Bros. photo, Lakes District Museum EL 1226).

Although the Invincible Company had improved its gold saving, bad luck followed, and the reef was lost in August 1887. In February 1888 the mine was let on tribute for three years, the tributors to pay 16% of the gross yields (AJHR 1888 C6: 36; 1889 C2: 57). In the first year the results were encouraging and 500 oz. was extracted, but nothing was found subsequently. In 1891 the mine was sold to the Invincible Quartz Company (also named in the annual Mines Department reports as the Rees Valley Quartz-mining Company Ltd.) who proceeded to prospect the old claim and erect pumping machinery to enable them to test deeper levels (AJHR 1891 C4: 52, 182). But despite several years work on the part of the new company, the reef was not relocated.

The American mining expert T.A. Rickard visited the Invincible Battery in the 1890s, and commented unfavourably on the battery operation. Attempts to improve gold recovery by adding mercury to the mortar box had not been successful, but rather had apparently caused a loss of gold. Rickard was of the opinion that this was due to the design of the mortar boxes, which were "merely square iron boxes. He commented that they were "not designed of a shape adapting them for amalgamation inside, and there was no opportunity given to the amalgam to collect out of reach of the falling stamps, but, on the contrary, the quicksilver added was subjected to a violent agitation which caused it to be floured-that is, broken up into a myriad of small globules. These are readily borne away by the water, and escaping with the tailings, also take with them a certain amount of gold with which they may have come in contact' (Rickard 1898: 191).

A further attempt to re-process accumulated tailings was made using cyanide, and a treatment plant consisting of one solution tank, two 25 ton leaching vats, two extractors and two sumps was built in about 1896, but this also failed and was abandoned by 1897 (AJHR 1897 C3: 123; O.G.P. 1981). The battery, which was still standing but not in use at this date, was

described as a ten stamp mill, with 800 lb. stamps, seven 4ft. 6in. Berdans, an octagonal iron amalgamating barrel and a shaking table (AJHR 1897 C3: 123).

The claim was taken up again in 1903, when some more prospecting was done, and once again in 1913 by a Melbourne syndicate. Nothing came of either of these ventures (AJHR 1903 C3: 169; 1904 C3: 120, 1913 C2: 47; 1914 C: 63). In 1922 Thornton and Fitt again prospected the mine, putting in a drive to the south-west of the old workings (AJHR 1923 C2: 23). More attempts to reopen the mine were made during the Depression of the 1930s; in 1931 the Rees Valley Mining Syndicate received a £40 subsidy for driving (AJHR 1932-33 C2: 230); in 1934 a party of three men were subsidised to prospect for scheelite in the vicinity (AJHR 1935 C2: 40); and in 1937 prospecting operations were carried out to north of the old Invincible Mine (AJHR 1938 C2: 43). In the post-war period prospecting work continued, and a map held by the late Mines Inspectorate office in Dunedin showed the locations of Wathersonton's reef and a number of camp sites, adits and bulldozer excavations (Figure 8). The track up to the Invincible Battery was probably also recut using a bulldozer to improve access to the area (Sutherland 1973: 6).

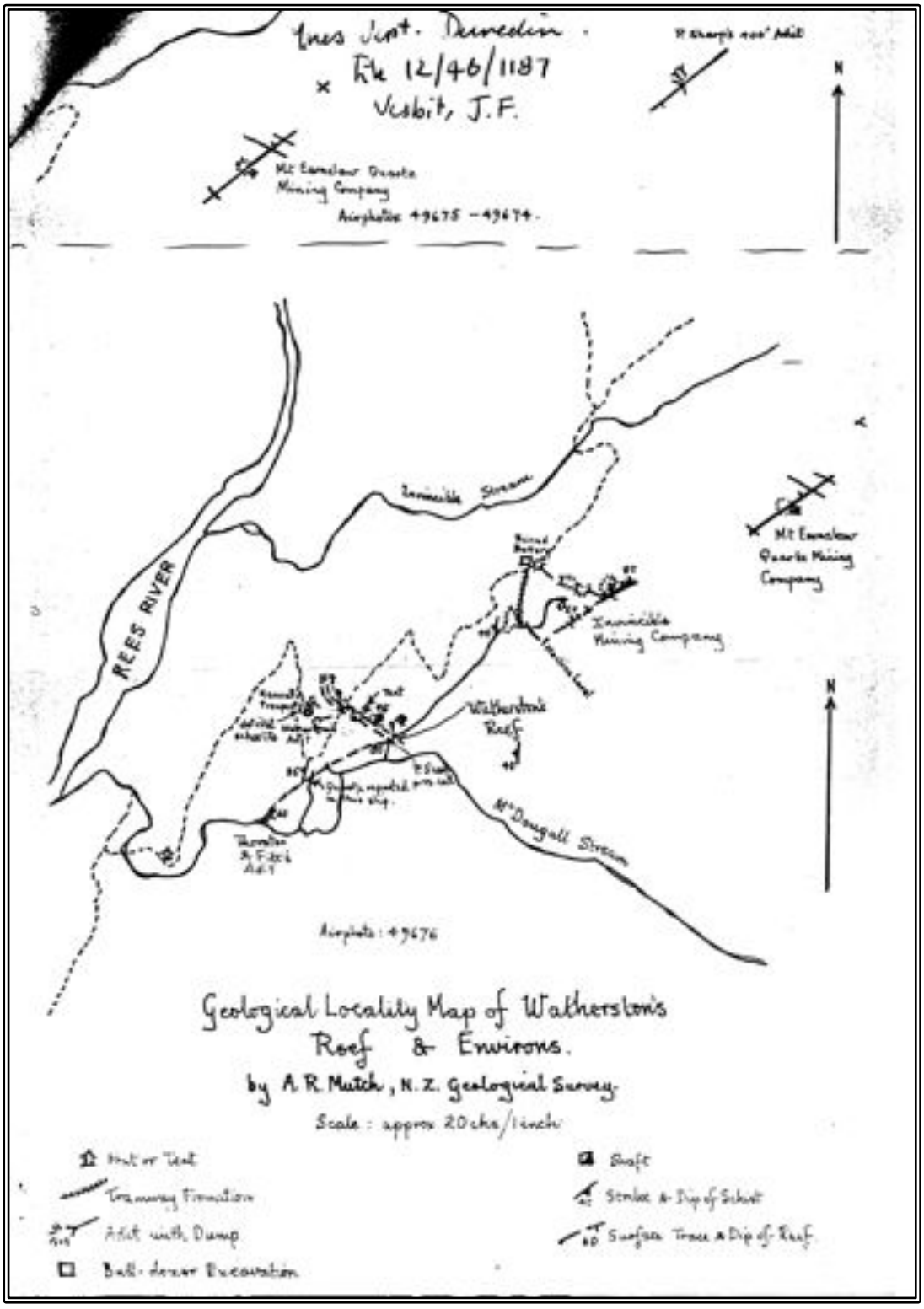

Figure 8
Map of Watherston's Reef & Environs, drawn by A.R. Mutch (not dated) (ex. Mines Inspectorate Office, Ministry of Commerce, File 12/46/1187).

When the Invincible Mine and Battery were closed much of the machinery was abandoned on site, and photographs from the 1930s onwards show the water wheel and Berdans still intact (but slowly decaying), and the battery frame standing with the camshaft in place, but the stamps, guides and mortar boxes were all missing (Figures 9 to 12). Down on the valley floor

the convex table was left in place, but all other machinery had been removed. In 1983 the Department of Lands & Survey replastered the table's convex upper surface. By the mid-1990s the water wheel had largely collapsed, and the Berdan framework was very decayed (Petchey 1995). In 2001 the Department of Conservation retimbered the Berdan framework using macrocarpa timber (Otago Daily Times 11 May 2001).

Figure 9
The Invincible Battery and Water Wheel, mid twentieth century (D. Sharpe, Lakes District Museum EL 5683).

Figure 10
The Invincible Battery in 1985 (Queenstown & District Historical Society, Lakes District Museum EL 6439 a).

Figure 11
The Invincible water wheel in 1985 (Queenstown & District Historical Society, Lakes District Museum EL 6439 c).

Figure 12
The Invincible Berdans in 1985 (Queenstown & District Historical Society, Lakes District Museum EL 6439 b).

The Rees Gorge Gold Mining Settlement

An industrial enterprise such as the Invincible Mine and Battery and associated pyrites saving works employed many men, some of whom had families. The Rees Gorge gold mining settlement was a somewhat scattered collection of houses and huts, and was the subject of Arthur Sutherland's research in 1973 (Sutherland 1973). His map (Figure 13) shows the location of the store/post office and generalised position of some of the hut sites.

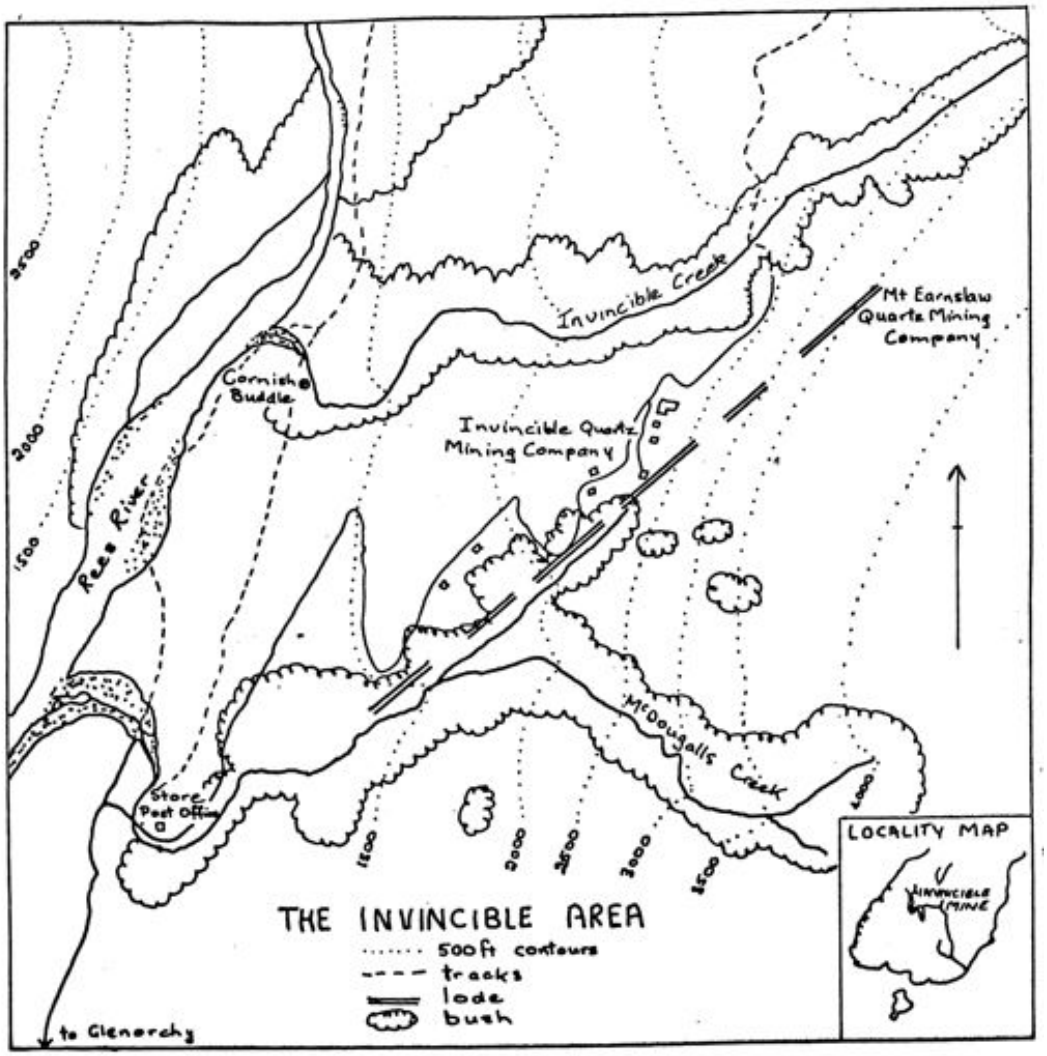

Figure 13
Map of the Invincible Area by Arthur Sutherland (Sutherland 1973). This shows the locations of some of the huts associated with the mining ventures in the area.

The Invincible Mine employed about six men in 1880, and reached a peak of about 30 to 35 in the mid-1880s, while the Pyrites Company employed 6 men, and census data shows that almost 60 people were living in the Rees Gorge area in 1891 (Table 2) (Sutherland 1973: 6). An 1896 plan of the mine (Figure 6 above) shows that the managers' house was close to the battery, and several huts were nearby. As the archaeological evidence (discussed below) shows, there were a number of other hut sites around the battery and mine, and Sutherland (1973: 7) has estimated that some 20 to 25 huts existed in the Rees Gorge settlement. Many miners would have lived there in the summer months, but during the harsh winters it is likely that most would have decamped to Glenorchy or further afield (Sutherland 1973: 7). A store was opened by John McDougall in about 1884 near the bottom of the Invincible Road, and

between 1885 and 1888 it also served as the Rees Gorge Post Office (AJHR 1886 F1: iv; 1889 F1: v; Sutherland 1973: 7). An undated photograph of the Invincible Mine (Figure 14) also shows a house close the battery together with another house on a spur to the north of the battery, in a location that has yet to be checked for archaeological evidence (although the NZTopo50 CB10 Glenorchy map shows a structure in this location).

Table 2
Census data for Rees Gorge (Sutherland 1973: 10).

Year	Total	Males	Females
1881	-	-	-
1886	48	44	4
1891	59	28	31

Figure 14
An undated images of the Invincible Battery (left mid ground) and the house on the ridge above the Invincible Creek (Lakes District Museum EL 5682). It is notable that the water wheel is in the open, meaning that this photo was taken either during the construction of the battery, or after its abandonment.

Chronology of the Invincible Mine Complex

1862 Gold discovered in the Wakatipu region.
1879 Gold-bearing reef found in the Richardson Range.
Invincible Prospecting Company formed.
1880 Invincible Quartz Mining Company formed to work the reef.
1882 Ten-stamp battery powered by overshot water wheel was erected.
First stone crushed for disappointing yield: 325 oz from 1350 tons of stone.
1885 Agreement with Otago Pyrites Saving Company to retreat the battery tailings.
1886 Pyrites Company erected saving plant including 'rotating convex table.'
1886 The Invincible Company installed 6 additional (to make total of 7) Berdans.
1886 Improved gold recovery left little for the Pyrites Company, and it folded.
1887 Reef lost.
1888 Invincible Mine let on tribute.
1891 Mine sold to the Invincible Quartz Company, which erected pumps and prospected.
1896 Cyanide plant erected to reprocess tailings. Failed and abandoned the following year.
1903 Claim was prospected.
1913 Claim was prospected by Melbourne syndicate.
1922 Thornton & Fitt prospected the mine and dug new drive.
1931 Rees Valley Mining Syndicate carried out subsidised work.
1934 Scheelite prospecting in the area.
1937 Prospecting.
1979 Invincible Mine Historic Reserve gazetted.
1983 Buddle replastered by NZ Lands & Survey.
1989 Detailed drawings of Berdans commissioned from Works Consultancy Services.
1995 Peter Petchey commissioned to produce conservation plan.
2001 Berdans retimbered by DOC.
2014 Peter Petchey commissioned to produce Heritage Assessment (this report).

4.0 Physical Description

As described above in **2.0 Setting**, the Invincible Mine and Battery are located on the mountainside, with the buddle on the valley floor below. The old Invincible track is now used as a walking track to the upper section of the historic reserve (Figure 15).

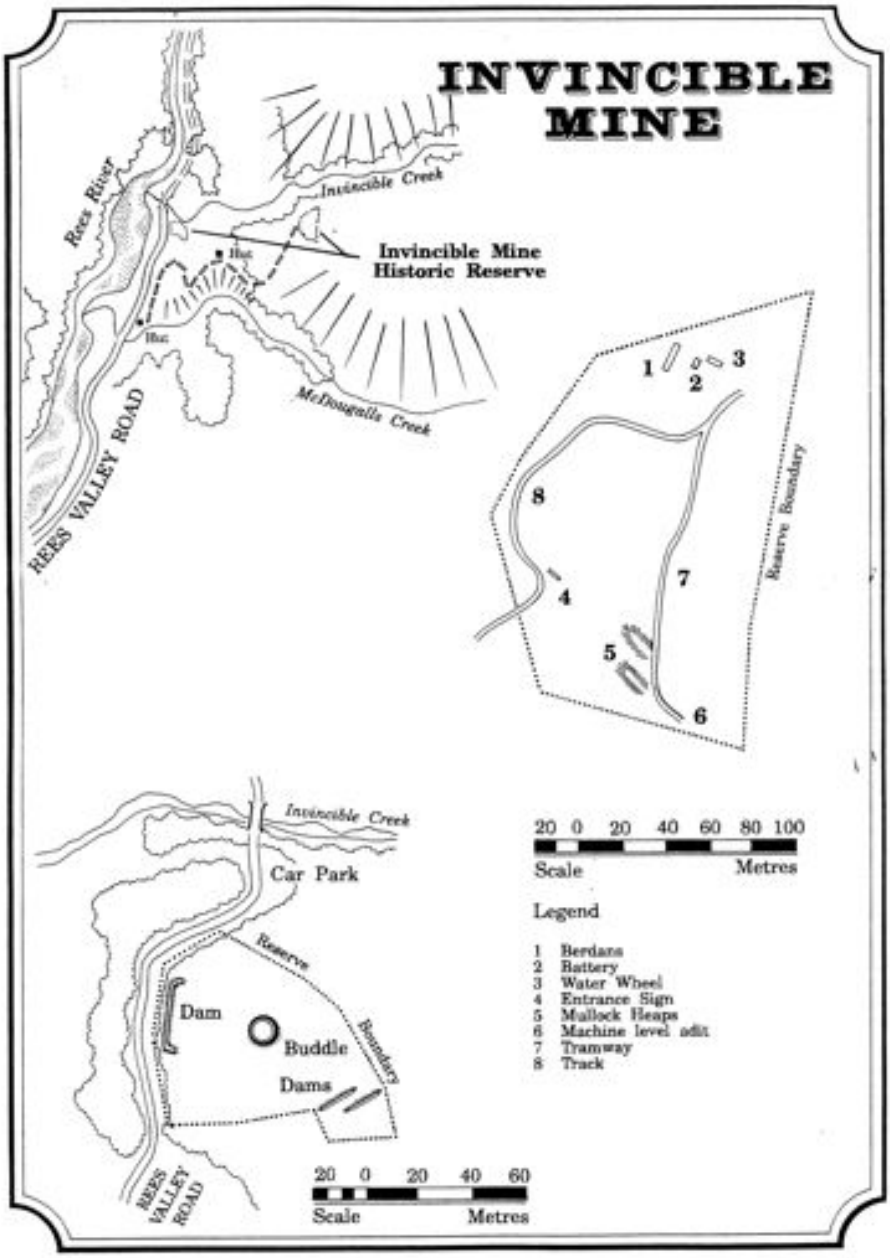

Figure 15
Otago Goldfields Park map of the Invincible Mine Historic Reserve. Note that this map does not show the upper mine workings (see Figure 16 below).

The Invincible Battery site and Otago Pyrites Saving Company Buddle have been visited and photographed by the present author on three occasions; in April 1993 as part of an MA research programme (Petchey 1996); in April 1995 for the preparation of a conservation plan

(Petchey 1995); and in October 2014 in order to update the site description for this heritage assessment. Between the two latter visits, in 2001, the Department of Conservation retimbered the framework for the row of seven Berdans (the work was actually carried out by Heenan Consulting Ltd.). A selection of 1995 photographs of the sites are included here in Section 10. The 2014 images are incorporated into the site description below. Detailed drawings of the Berdans were prepared by Works Consultancy Services in 1989.

However, no systematic survey has been done of the archaeological evidence of the Invincible Mine complex, and so there is no detailed map and no comprehensive description of the overall site and all of its components. The preparation of such a map was outside the brief of the present and past reports, but would considerably assist in the interpretation and management of the site. The map used here (Figure 16) is simply based on a Google Earth overlay, and is only a sketch plan showing the main features. Comparison of Figures 15 and 16 shows that the upper mine workings are not included in the Invincible Historic Reserve.

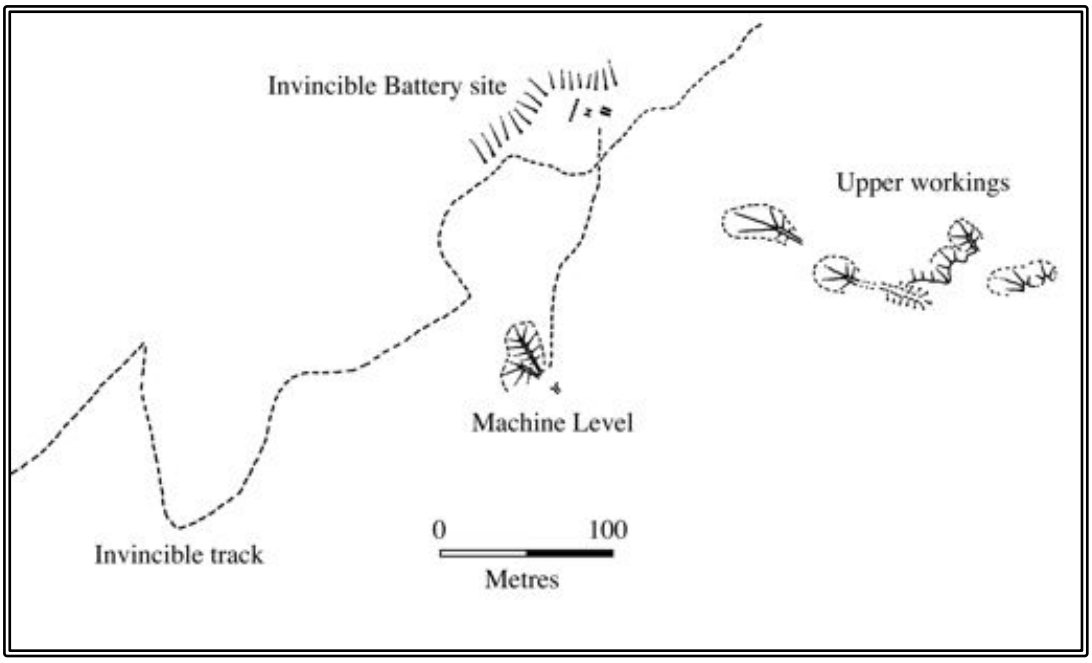

Figure 16
Map of the main features at the Invincible Mine and Battery. Based on Google Earth overlay.

Description of Main Features

The Invincible Company's mine and battery sites are located at an altitude of 820 metres asl on the east side of the Rees Valley, about 16 kilometres from the head of Lake Wakatipu. They are reached by walking up the Department of Conservation track that follows the old mine access road from the floor of the valley. The site of the Pyrites Company's works, which includes the circular buddle, is on the floor of the valley almost directly below the battery site. Associated with the mine complex are a number of huts sites and the mine road itself, together with a number of features associated with later attempts to mine the area. The sites are described below in geographical order, starting at the mine and heading downhill to finish at the Pyrite Company's works.

Invincible Mine

The upper workings of the Invincible Mine are located on mountainside above the battery site, and the Machine Level adit is located 150 metres to the south and just above the battery site. This archaeological evidence agrees with historical accounts that described 'upper and machine-site levels' (AJHR 1887 C6: 38). The most visible evidence of the mining activity are the numerous mullock heaps that mark where underground workings once existed (Figure 17), although with the exception of the Machine Level adit all of the drives have now collapsed. The Machine Level is still partially open, and has been gated to prevent anyone from entering the adit (allthough the drive is now completely collapsed only a feet feet from the entrance). Other surface features that still survive include a tramway cutting with stone revetment (Figure 18), the benched tramway formation between the Machine level and Battery, and the remains of a stone building beside the Machine Level adit.

Figure 17
Looking up to two of the main mullock heaps of the upper workings of the Invincible Mine in 2014.

Figure 18
Stone revetment along the tramway cutting to one of the upper Invincible Mine drives (collapsed) in 2014.

Figure 19
The entrance to the Machine Level drive in 2014. This level was driven in 1886 (AJHR 1886 C4: 22).

Invincible Battery

The Invincible Battery site is located on a terrace on the mountainside below the mine workings. The battery site itself consists of the the water wheel remains, the stamper remains and the row of seven Berdans (Figure 20), while the wider terrace also includes the Machine Level tramway and drive, and the sites of numerous huts and buildings (see Figure 30 below).

Figure 20
The Invincible Battery site in 2014, showing the Berdans to the right and the collapsed stamp mill to the upper left.

The layout of the battery site is conventional for a gravity-fed system, with the main components arranged down the slope. The ore was transported to the top of the site (either from the upper workings or the Machine Level via the Machine Level tramway), was crushed in the 10 stamp mill, passed over the tables, and then the concentrates were further ground in the Berdans. The water wheel was located above and to one side of the stamp mill, and drove the machinery through flat belts (as evidenced by the several wide pullies still on site).

The Stamp Mill

The collapsed timber frame and the camshaft of the stamp mill remains on site, together with a scatter of smaller items (Figure 21). There were originally ten stamps weighing 8 cwt. each (AJHR 1885 C2: 11). There is no evidence that this arrangement was modified during the life of the battery. Photographs of the abandoned battery taken throughout the twentieth century (Figures 9 and 10) show that the main stamper frame was left in place with the camshaft still mounted, but the stamps, guides and mortar boxes were all removed at or soon after abandonment. The frame had three vertical kingposts and two trestle frames (one on each end of the structure). The two outside camshaft bearings were carried on the horizontal beams of the trestle frames, while the centre bearing was mounted on the centre kingpost. The timber frame is still present, but has decayed badly and collapsed forward under the weight of the camshaft.

Figure 21
The Invincible stamp mill in 2014.

The camshaft is fitted with a large iron drive pulley at one end, and a smaller timber pulley at the other. The large pulley would have been the main drive from the water wheel (almost certainly via intermediate shafting), and the the small pulley would have then taken drive to ancillary equipment. The camshaft drive pulley is of an unusual design, with curved sheet iron spokes and a cast iron hub, and a larger pulley of exactly the same pattern is lying nearby (Figure 22). It is almost certain that both were made by the same company, most likely Thompson & Co. of Castlemaine who supplied the original battery equipment (*Otago Witness*, 17 May 1884: 12; 14 June 1884: 9), and they were both part of the original 1882 battery equipment.

The cams are of a conventional design, being reasonably heavy but without any strengthening webs, and are fixed with keys in a cut keyway. They show only moderate wear on their faces. They are set to give reciprocal drop orders: the left hand bank are set for 1-4-2-5-3, and the right hand bank are set for 1-3-5-2-4. This was a common drop order that was used in South Africa and the USA, and is the most common order found in surviving New Zealand stamp mills (Petchey 2013: 112, 225).

Figure 22
The large (54 ¾ inch diameter) pulley lying on the ground near the Berdans in 2014. It is exactly the same style as the camshaft drive pulley on the stamp mill, and was therefore probably part of the original battery equipment that was manufactured by Thompson & Co. of Castlemaine.

Scattered in front of the stamp mill are fragments of perforated iron sheet from the mortar box screens. The sheet is punched with 168 holes per square inch, each hole being approximately 1/32 inch diameter. This is very similar to the punched iron screen material found at the Premier/Maryborough Battery site (F41/471) at Macetown (Petchey 2013: 216), but is finer than the range that Gordon (1906: 386) stated was generally used in New Zealand. This would indicate that the battery was set to crush the ore quite finely. There were also some fragments of sheet iron with much larger ¼ inch (6.4mm) holes, the function of which is unknown; these holes are far too large to be used as mortar box screens under normal working arrangement.

Overall, the surviving evidence shows that the Invincible stamp mill was a mid-weight ten stamp mill with a timber trestle frame. The machinery was supplied from Castlemaine in Australia, and although slightly unusual in detail it was conventional in overall design and layout. The surviving screen fragments indicate that it was set for fairly fine crushing (although this evidence can only provide a single snapshot in time).

Berdans

The row of seven Berdans are the most notable feature of the battery site, as this is the largest set of Berdans to survive in New Zealand (Figures 23 and 24). They are mounted on timber framing set in a stone-lined pit in front of the stamp mill. There is a common drive from below, with an arrangement of dog clutches whereby individual Berdans could be engaged or disengaged. Each Berdan had (and most still have) a cast-iron trough mounted around the rim, which discharged at the low point (Berdans were always mounted on an angle) into a collection trough which is no longer present. When recorded in 1995 the Berdan framing timber (identified as local beech[1]) was badly decayed, and in 2001 it was replaced by the Department of Conservation. Macrocarpa (Monterey Cypress) was used in place of beech in the reconstruction (*Otago Daily Times* 11 May 2001).

[1] Identification carried out by R. Wallace, Auckland University.

Figure 23
The seven Invincible Berdans in 1995. This shows the Berdans with their original beech framing. This has since been replaced by the Department of Conservation.

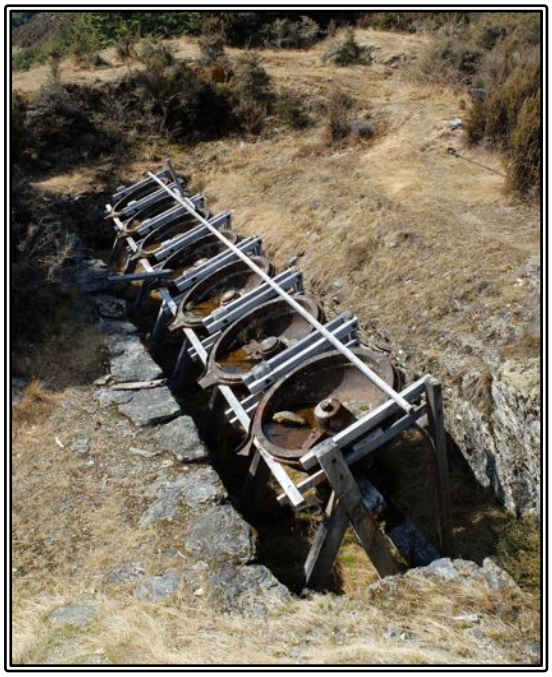

Figure 24
The Invincible Berdans in 2014. This shows the replacement macrocarpa framing that was constructed in 2001.

Figure 25
Detail of one Berdan in 2014.

The surviving archaeological evidence nationwide indicates that under-driven berdans were far less common that top-driven berdans, but other examples do exist, such as the pair at the Croesus Battery at Lyell (site L29/2). However, the number of Berdans at the Invincible site, and their intact state (albeit now with replaced framework) makes them unique in New Zealand.

Water Wheel

The water wheel was a wooden structure with iron axle and hub, fed by a water race from Invincible Creek. Photographs taken in the mid-twentieth century show the wheel standing intact (but with the ring gear removed), but by the 1980s the above-ground structure had largely collapsed. By 1995 only one spoke remained erect above the hub, and now (2014) no above-horizontal timbers remain in place (Figure 27). Down in the stone-lined wheel pit the lower section of the wheel survives in better condition (albeit covered with the debris from the upper half).

The wheel support walls and wheelpit are constructed from stacked schist, and remain in relatively good condition. Photographs of the intact wheel show that it was an overshot wheel, and as there is no ground-level tailrace to discharge used water, there must be a tailrace tunnel running from the base of the wheelpit. However, the route and condition of this tunnel is not known.

Figure 26
The Invincible water wheel in 1995 (P. Petchey). At this date only a few of the above-horizontal spokes remained in place.

Figure 27
The Invincible water wheel in 2014. Note how all of the spokes at or above horizontal have now collapsed.

Figure 28
Looking in to the Invincible water wheel wheelpit in 2014, where the lower section of the wheel remains partly intact.

The surviving water wheel fabric allows some measurements and observations to be made. The wheel was 24 feet 2 inches in diameter and 4 feet 9 inches wide (7.3m diameter, 1.4m wide), and had timber spokes, shroud, sole and buckets.[2] The spokes were internally braced with both diagonal cross-braces and straight braces. Timber sample were taken in 1995 and identified by Rod Wallace (University of Auckland), who found that the spokes were beech (*Nothofagus sp*.) and the sole was totara (*Podocarpus hallii*).

The wheel was a fairly robust timber structure of simple conventional design. Apart from the hub, ring gear and fittings it was constructed from local materials (beech, totara and schist). Its relatively simple design and construction did not allow for more advanced design features such as curved and ventilated buckets that were seen on contemporary iron and part-iron wheels (Petchey 1996).

Summary of Invincible Battery

The remains of the Invincible Battery suggest that it was conventional, with a timber knee-frame structure and key-mounted cams, powered by a wooden overshot water wheel. The processing technology used initially was similarly conventional. The contemporary Mines Inspectors' reports state that blanket tables were used for gold saving, without the use of amalgamating tables or mercury traps, and that a very high pyrites content in the ore meant that a lot of gold was lost. The buddle on the valley floor and the bank of seven Berdans at the battery site show how efforts were made to recover this lost gold. The period that this work was being carried out was one of rapid change in gold processing technology, when the introduction of the cyanide process would revolutionise the industry. The Berdans and buddle illustrate the immediately pre-cyanide approaches to improving gold recovery. Cyanide treatment was later tried at the Invincible mine, as was the addition of mercury to the mortar boxes, but the combination of high pyrites content and the ultimate loss of the reef meant that the mine failed.

[2] Shroud=the sides of the rim. Sole=the inside lining of the rim. Bucket=the board that held the water, mounted between the shrouds and against the sole.

Invincible Settlement

The Invincible settlement has not been the subject of an archaeological survey or any detailed research other than Sutherland's 1973 essay, and he estimated that 20 to 30 huts were present in the settlement. Smith (1990) also mentioned that dwelling remains were to be found around the mine and near Invincible Creek, and several of these are easily visible from the walking track (Figures 29 & 30). From these observations together with comparisons with other hard-rock mine site settlements, it is known that numerous hut sites are scattered around the general area, each likely to consist of a level terrace and the remains of a schist fireplace/chimney. The mine manager's house location is known from historic maps (Figure 6 above), but this has yet to be identified on the ground.

Figure 29
A stone chimney ruin surrounded by regrowth trees just below the Invincible track near where it enters the historic reserve in 2014.

Figure 30
Stone wall from a hut or other building on the Invincible terrace.

Invincible Mine Road & Huts

The track up to the Invincible battery site zig-zags up the mountainside from the valley floor. This track would have been cut in about 1881 in order to transport the heavy battery and mining machinery up to the battery and mine sites. According to Sutherland (1973: 6) the track was recut using a bulldozer in more recent years, but the road line is probably all the original 1880s route. The road is benched into the hillside for most of its length (Figure 31), apart from a few areas where it passes through shallow cuttings (Figure 32). In general the road is approximately 8 feet (2.4m) wide.

The road passes several hut sites as it climbs the mountainside. Near the start of the road there is a derelict stone hut with a sheet iron chimney and collapsed roof (Figure 33). The roof and chimney structure appear to be much younger than the stonework, and suggest that the ruin was refurbished for use, possibly in the 1950s or 1960s. It is probable that the original ruin was that of John McDougall's store and post office.

Half way up the mountainside the track passes the remains of a log hut (Figures 34 and 35). This was constructed in the (almost cliched) American style of stacked notched interlocked natural logs, and measured 15 feet by 14 feet (4.6m by 4.3m). It was roofed with sheets of white enamelled iron, covered with tarred material. The hut was possibly built in the 1930s (Smith 1990), while the scattered artefactual material (which includes a 2 ½ lb milk powder tin and rubber insulated electrical wire) suggests a 1950s or 1960s last period of occupation. The hut certainly post-dates the 1880s period of the Invincible Mine operation. There is another terrace below the hut terrace, and nearby is the remains of the long-drop latrine that had a square enamelled iron seat.

Figure 31
The Invincible track on a benched cutting as it climbs through regenerating scrub on the lower slopes of the Richardson Mountains in 2014.

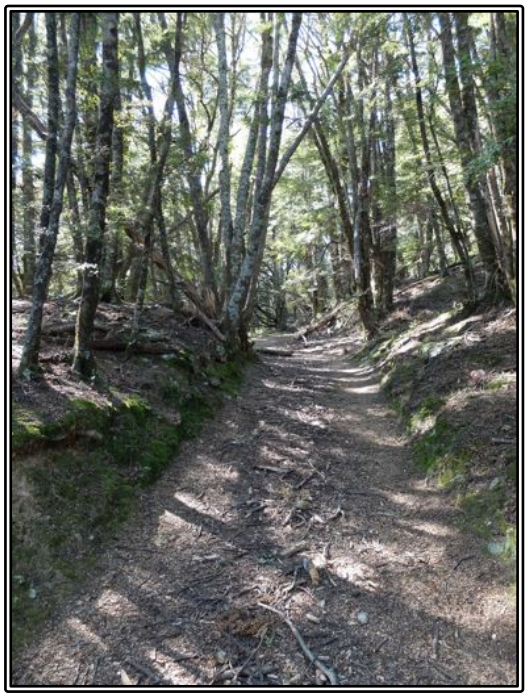

Figure 32
The upper section of the Invincible track as it passes through an 8 feet wide cutting in beech forest in 2014.

Figure 33
The stone ruin at the bottom of the Invincible track in 2014. This was probably originally the store and post office associated with the Invincible settlement.

Figure 34
The collapsed remains of the log hut in 2014, beside the Invincible track. This hut was possibly associated with Watherston's workings.

Figure 35
Detail of the most intact corner of the log hut in 2014, showing its construction method with notched and interlocked logs, together with a pile of the enamelled iron sheets that were used for the roof.

Otago Pyrite Saving Company's Works (Buddle)

The site of the Otago Pyrite Saving Company's works is on the valley floor beside the modern Rees Valley Road. The site is signposted. The most visible feature of the site is the convex table (also known as a 'buddle' or 'concentrator,' and often mistakenly called a 'Cornish buddle'), but there are also numerous other archaeological features in the vicinity including a large pond or reservoir and a stone ruin.

The rotating convex table (Figure 36) was variously described as being 24 feet or 26 feet in diameter, and was driven by a 10 inch diameter "Little Giant" turbine (AJHR 1886 C4: 22; *Otago Witness*, 27 August 1886: 12). The top was measured during the 2014 site visit, and is 26 feet 6 inches across. The cement surface that was relaid in the 1980s is still in reasonable condition, although moss growth and moisture retention due to leaf mould build up have begun to make the surface deteriorate. In the centre of the table is a cast iron pylon (Figure 38) that once supported the arms (sweeps) that fed water onto the table. The sands were fed into the distributing gutter at the table's high point, and washed down by the flow of water. Around the periphery of the table, and located under its 'drip nose,' is an iron gutter mounted on a series of jockey wheel that run on a circular rail (Figure 37). This revolving gutter was divided into four compartments, which passed the sand received off the table into the concrete gutters around the table (*Otago Witness* 27 August 1886: 12). These three cement channels are each six inches (150mm) wide (Figure 40), and are showing some deterioration (Figure 41). A cast iron arm that was once mounted radially to the table is lying on the ground (it was still mounted when recorded in 1995).

Looking down the centre of the table, past the pylon mount, it is possible to see some of the sub-surface concrete structure that lies beneath the table (Figure 39), and which gives a hint of how much sub-surface evidence must exist at the site.

Figure 36
The Otago Pyrites Saving Company's circular convex table in 2014.

Figure 37
The iron track and jockey wheels that support the revolving iron gutter under the 'drip nose' of the table.

Figure 38
The central pylon on the buddle in 2014.

Figure 39
A view down the opening below the central pylon of the buddle in 2014. This hints at the scale of the sub-surface pipework and infrastructure that probably exists at the Otago Pyrites Saving Company's site.

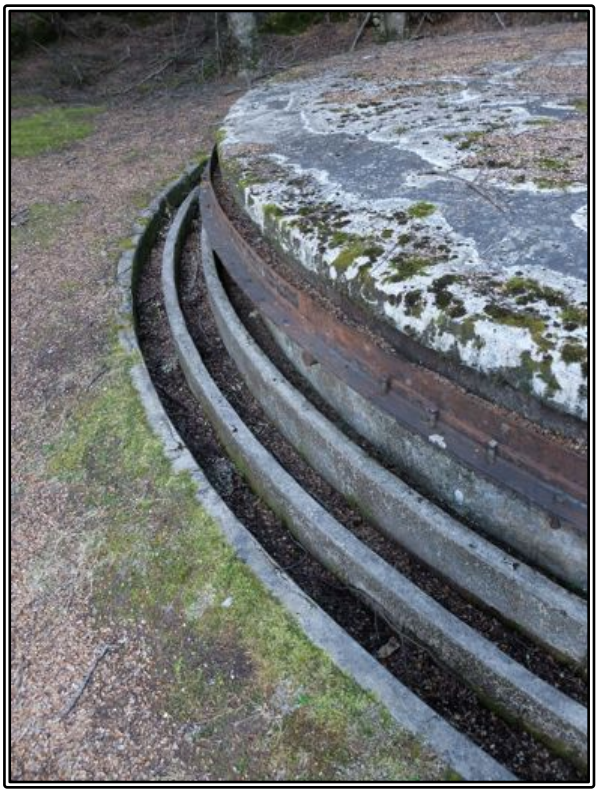

Figure 40
The series of 6 inch wide concentric cement channels around the periphery of the buddle in 2014.

Figure 41
Deterioration of the cement channels in 2014, showing a section that has broken away exposing the reinforcing bars.

Figure 42
The cast iron arm that used to be mounted beside the buddle, in 2014. It was in place when the site was visited in 1995.

Twelve metres to the west of the convex table is a large shallow pond or reservoir (Figure 43). This reservoir is dug into the slope on its east side, and has a stone and earth embankment on its west and north sides. It is rectangular, measuring approximately 87 feet by 31 feet (26.5m by 9.5m), but with a bank projecting into the middle from the east side, and a 'tail' off its north end.

Figure 43
The large pond on the Otago Pyrites Saving Company's site in 2014.

Beside the track in to the convex table from the road is a small stone ruin. It appears to be a stone ramp and a rectangular structure (Figure 44), but it would require closer investigation to confidently identify its function. Other features are scattered about the site, but once again no systematic archaeological survey has been carried out. Peter Chandler (1984: 28) thought that there was evidence that a cyanide plant had been used there as well, but it is not clear exactly what features he was referring to.

Figure 44
The stone ruin beside the entrance to the Otago Pyrites Saving Company's site in 2014.

The above section describes the Invincible Mine complex of sites as they are currently understood. However, this site requires a thorough archaeological survey to be fully understood. In particular the settlement sites around the mine and battery, and the Otago Pyrites Saving Company's site are not fully recorded. Not only does this mean that the full extent of the site can not be determined, but also that there is no base line data to identify deterioration or change in the sites, other than photographs such as those included here in Section 10.

5.0 Cultural Connections

The cultural significance of a place is not a static and easily defined concept, and can mean different things to different people. Cultural significance of a place can be considered with regard to one or more specific cultural groups, and/or with regard to its importance to the wider present population. A very good recent example of this is the management of the Christchurch Cathedral in the wake of the Canterbury earthquakes; the wider community has expressed considerable interest in the building as a cultural symbol of the city, resulting in enormous resistance to the Anglican Church's decision to deconstruct the building. The building has strong and variable meaning to different groups. The Invincible Mine complex can be regarded in a number of ways: as an historic technological site; as an historic site where people lived and worked; as a modern walkway and cultural heritage visitor attraction; and as a modern walkway that provides access to alpine scenery. Each of these attributes is of interest to different groups today.

The Invincible Mine complex can historically be associated with a number of identifiable people, groups and places. Nineteenth century gold mining was an international industry at all levels of its operation. International finance (especially after the 1880s), technology (in the form of both designs and actual items of machinery) and people all moved around the world's main goldfields (Petchey 2013: 302-314). The Invincible Mine is not unusual in that a number of these international influences can be identified from both historical and archaeological sources. The origins of the technology and equipment used in both the Invincible Battery and Otago Pyrites Saving Company's plant are discussed in detail in **Section 6.0 Contextural Analysis** below. Here it is sufficient to note that this equipment can be traced to numerous sources, including Australia, New Zealand, Germany and the USA (the latter as a source of design rather than actual manufacture). One word of caution does need to be made regarding the Otago Pyrites Saving Company's convex table: this has often been referred to as a 'Cornish buddle' (eg Smith 1990; Sutherland 1973), but as described above it was actually manufactured in Germany.

The people involved with the mine complex are harder to associate with particular origins. As is common with most such sites, the records often provide the names of the shareholders, managers and engineers, but no information is provided about the 'sixteen men employed underground and eight men on the surface' (in the 1885-86 year) (AJHR 1886 C4: 22). For modern researchers it is often the lives of these workers that is of the greatest interest, as illustrated by the Caversham Project in Dunedin (www.caversham.otago.ac.nz). Some of the people that can be identified include the mine manager, Alfred Morrisby, the storekeeper/postmaster John McDougall, the proprietor of the Otago Pyrite Saving Company George Watson and the successive managers of the company's works J.B. Neal and W. Dickenson. Watson was a Scotsman who lived in Dunedin and was also involved with scheelite mining nearby at Glenorchy (Bradshaw 1997: 15), and a detailed account in the *Otago Witness* (27 August 1886: 12) described how Dickenson had been trained as an ore dresser at Mount Bischoff in Tasmania. A number of influential mining experts are also known to have visited the site, including Professor J.G. Black of the Otago School of Mines (a Scottish immigrant) and the American expert on stamp milling T.A. Rickard. Rickard's report on the Invincible (Rickard 1898: 191) forms part of his classic text on stamper batteries '*The Stamp Milling of Gold Ores*' that had an international audience. The available evidence therefore indicates a strong cosmopolitan presence at the Invincible Mine complex.

New Zealand has a history of planned and unplanned, successful and failed settlements, and each of these has a role in the history of the development of today's society. McGill (1980) listed 227 'ghost towns' in his work *Ghost Towns of New Zealand*, and while this is by no

means a complete survey, it does give a good idea of how many settlements have failed for one reason or another. Gold mining settlements were particularly prone to abandonment as most only existed to serve a single economic activity. Recent work in Australia by Geraldine Mate (Mate 2010) has focused on social meaning and constructs in the archaeological landscape of an abandoned mining settlement, and sites such as the Invincible (Rees Gorge) settlement that were briefly settled and then abandoned (meaning that the archaeological record is not complicated by subsequent activity) have potential for similar future research. Sutherland (1973) did some work on the Rees Gorge settlement and estimated that some 20 to 30 huts existed there, and there is much scope for further archaeological research.

The Invincible complex also has significance to modern populations. The reserve and track easement were created in 1978, and so there is now a 36 year history of free public access to the sites, and they are regularly visited by local and overseas visitors. During the 2014 site visit (on a non-holiday weekday) a van of four Chinese tourists and a single New Zealand visitor were all encountered at the buddle. Despite the apparent remote nature of the site, it is only a little more than an hours drive from Queenstown, and about 20 minutes drive from Glenorchy. The success of Peter Jackson's Lord of the Rings and Hobbit films has brought many visitors to the area either specifically seeking film locations or more generally enjoying the mountain scenery, and the Invincible track provides a relatively easy route up the mountainside to some spectacular viewpoints. Smith (1990: 234) noted the same values ('walking, exploring and appreciation of cultural heritage') in the Otago Goldfield Park draft management strategy (minus the Peter Jackson observations), and since she was writing the Queenstown-Glenorchy road has been sealed, making visits to this area much easier than previously.

There is an ongoing interest in local gold mining history, both amongst the general public, and amongst local businesses that see the promotional attractions of such interest: for example Arrowtown promotes itself as a gold rush village (www.arrowtown.com), and the Goldfields Jet runs on the kawarau River (www.goldfieldsjet.co.nz). The Central otago goldrushes of 1861 (Gabriels Gully) and 1862 (Dunstan) were the most influential events in the settlement of the area, and the network of modern roads and settlement largely evolved as a result of mining activity. The creation of the Otago Goldfields Park in the 1970s recognised the importance of a number of widely scattered goldfields historic sites, and incorporated them into a multi-site network of reserve areas linked by their themes and management/interpretation material (Mason 1981). The Park concept still exists, now under the Department of Conservation's management. The Invincible Mine complex is part of the Park, and was included for its evidence of mining techniques. At one time four-wheel-drive tours ran trips up to the Invincible battery site, but these were stopped because of the damage to the track (Smith 1990: 234). It is highly unlikely that such vehicle tours will ever be restarted, which has the advantage of making the track a more pleasant walking experience, and improves the experience of exploration for the visitor who does make it to the battery site.

6.0 Contextual Analysis

The Invincible Mine and Battery and the Otago Pyrites Saving Company's works were both elements of the late nineteenth century international hard rock gold mining industry that had its ultimate technological roots in the ancient world, but its immediate progenitor in the aftermath of the Californian gold rush of 1848-1850, when miners began to seek reef gold rather than just the easily-worked placer deposits. The series of Pacific Rim goldrushes (California 1849; Victoria 1851; Otago 1861) followed by the discovery of the South African Witwatersrand field (1885) saw not only the spread of mining activity around the world, but also the concomitant development and spread of mining technology (Morrell 1968; Petchey 2013). Traditional centres of mining technology in Germany and Cornwall were joined by other areas of innovation including California (the stamp mill), Glasgow (the cyanide process) and South Africa (very heavy stamp weights and large mills) (Del Mar 1912; Morrell 1968; Salmon 1963). Mining equipment and technological expertise travelled around the world either physically (as machinery exports) or as information (carried by individuals, mining journals, text books and the establishment of Schools of Mines). New Zealand benefitted from these developments, and the New Zealand mining industry was an active participant in the international mining industry (Petchey 2013: 318).

The first hard rock mine in Otago was the Shetland Reef at Waipori, where a 4 stamp battery was in operation by January 1863 (OPC V&P Session XVII 1863: 16). Subsequently many other hard rock mines were set up in the province (and in the other goldfields throughout the country), which used equipment sourced from Australia, America, Britain and New Zealand (Petchey 2013). The 1870s to 1900s were the period with the largest number of operating stamp mills in New Zealand (Petchey 2013: 154-155). The application of improving technology (such as the cyanide process) was necessary to keep the industry viable, and many mining companies failed despite possesing rich ore bodies because of the high loss of gold in their tailings. The Invincible Mine fits in to this general narrative of the development of hard rock gold mining in New Zealand very well, as it was discovered in the late 1870s, developed in the 1880s, initially used conventional crushing and gold recovery processes, and then had improved technology applied to address the loss of gold in the tailings. Finally, in common with all other mines, the gold ran out and the mine was abandoned. The involvement of a second company to reprocess the tailings was unusual but not unknown; the Ohinemuri River Syndicate dredged the Ohinemuri River from 1897 until 1903 to process tailings from stamper batteries upstream at Waihi (Ritchie 1990: 265a).

The Invincible Mine complex can be considered within several different contexts, including the international origins of the mining/processing technology and equipment (including both the origins of the designs and the actual place of manufacture), and the place of the mine within the history and archaeology of the New Zealand mining industry. The technology at the complex can be split into a number of discrete functional units: the mine; the water wheel; the stamp mill; the Berdans; the convex table (buddle). These units are used as the basis of the discussion below.

The mining technology is difficult to assess from an archaeological perspective as all of the underground workings have collapsed (even the Machine Level stands for only a few feet). Annual Mines Department reports (in the *Appendices to the Journals of the House of Representatives)* confirm that normal mining practices were used, whereby horizontal drives were put in, and the ore was then stoped out. The quartz was reported as being very loose in nature, and the ground required a great deal of timbering (AJHR 1886 C4: 22), which means that the workings would have quickly collapsed once the mine was abandoned. The size of the mullock heaps indicates that the underground workings were reasonably extensive, and the placing of these heaps indicates that there were at least five main drives. Photographic evidence (see Figure 7) and the presence of tramway formations confirm that typical

nineteenth century narrow gauge mine tramways were employed underground and on the surface to the battery and tipheads. No vertical shafts or winding gear were employed, as the mountainous nature of the county meant that all mining and ore handling could be carried out using gravity (ie, drives and overhead stopes, and a downhill run to the battery). The Invincible Mine can therefore be compared to other alpine mining operations where the main workings were above the processing plant and no winding gear or shafts were employed, such as the Macetown mines (including the Homeward Bound, Premier/Maryborough and Sunrise mines) (Petchey 2002).

The water wheel was a good example of a wooden overshot wheel of the period. Photographic evidence indicates that many wooden wheels were in use in New Zealand mines (and other industries), some of them very large. A good example was the 50 feet diameter Wealth of Nations wheel near Reefton (Smith 2001: 87; Thornton 1982: 63). However, wooden wheels decay, and it is only the large part-iron water wheels that have survived in reasonable condition, due to the robust nature of their cast- and sheet-iron rims. The best Otago examples are the Young Australian and Serpentine wheels (Figure 45) (Petchey 1996; Thornton 1982: 63). Despite is poor condition, it is possible to make a number of observations about the design of the Invincible water wheel. It was a very conventional simple wheel in many respects, with timber used for most of its construction. The buckets were formed by simple flat timber boards, at a time when curved iron buckets (which gave better water flow in and out) were commonplace. However, the wheel did utilise ring-gear drive, where the drive was taken by a spur gear running against a large iron ring gear mounted on the side of the wheel. This allowed wheels so fitted to be more lightly built than those that took the drive out through the wheel shaft. This design feature was the most common 'advanced' feature recorded in surviving water wheel in Otago (Petchey 1996: 65). Overall the Invincible water wheel was a typical wheel of the period, built of local materials, and serviceable and adequate but not particularly advanced. Given the availability of ample water at sufficient elevation to drive an overshot wheel nearby in Invincible Creek, there was probably no need to invest a great deal of money in an advanced wheel when a simpler one was sufficient and cheap to run.

Figure 45
The Serpentine water wheel and battery (site H42/2). This wheel has been restored by the Department of Conservation.

The stamp mill was a conventional ten-stamp machine, probably built by Thompson & Co. of Castlemaine in Australia (*Otago Witness* 17 May 1884: 12; 14 June 1884: 9). The stamps and mortar boxes were removed after the battery closed, so it is not possible to assess their design, but the camshaft is of conventional design appropriate for the reported stamp weight (8 cwt) and date of manufacture, and the cams are mounted in the most common drop order found in New Zealand mills (Petchey 2013: 225). The timber trestle frame is also typical for mid-weight mills of the period (Petchey 2014: 5). The best surviving example of this general frame form is probably the Canton Battery (site H44/831) at Waipori in Otago (Figure 46). The mill therefore appears to be a conventional machine of the period, typical of many that were built in Australia and New Zealand.

Figure 46
The Canton Battery at Waipori (site H44/831).
An example of a trestle-framed stamp mill.

The row of seven Berdans is more unusual. The Berdan grinding pan was developed in the USA by Hiram Berdan in the 1850s, and was widely adopted in New Zealand for the further grinding and amalgamation of tailings and concentrates (Berdan 1853; Petchey 2013: 130). Although H.A. Gordon (1906: 415) was dismissive of the design, the Berdans at the Invincible Battery do appear to have been very effective as they substantially reduced the gold loss through the tailings. They were manufactured by Kincaid McQueen & Co. of Dunedin, and are conventional in design other than their use of bottom-drive (top-drive is more common amongst surviving examples). The set of seven Invincible Berdans are the largest set to survive in New Zealand, the closest comparable group being the six Berdans at the Luck at Last Reduction Works (site T12/601) near Whangamata (Figure 47). However, these Berdans are no longer mounted, and have been removed from their site and then returned, so lack the intactness of the Invincible examples. The Taitapu Battery (site M25/86) in NW Nelson has four Berdans, still in association with the 20 stamp mill (although all of the timber framing is gone) (Petchey 2013: 458-462).

Figure 47
The row of six Berdans at the Luck at Last Reduction Works (site T12/601).

Buddles relied on the high specific gravity of gold and concentrates containing gold to separate these from the barren tailings. Round buddles were circular tables that sloped either in or out, and the finely crushed pulp was fed in at the high point and washed down with a flow of water. The heaviest material would settle out first, and the lightest material would be carried away and discarded. Buddles were used in a number of New Zealand mills, such as the Woodstock at Karangahake (*Auckland Star*, 20 April 1895: 5) and McGill's Battery at Macraes (*Otago Witness,* 23 September 1903: 23). The Otago Pyrites Saving Company's circular convex table is the only known surviving example in New Zealand, and it is not known whether any of the other buddles were similar in design. Davey (1996) has reported that the Museum of Victoria has German models of buddles, and thought that these may have been how the design was introduced to Australia. Certainly it is known that the Invincible buddle was of German manufacture, was probably influenced by the Mount Bischoff tin mining operation in Australia, and the concentrates were shipped to the Sandhurst Pyrites Works in Victoria for smelting (*Otago Witness* 2 January 1886: 14; 27 August 1886: 12). The common misconception that it is a 'Cornish buddle' has already been discussed above.

The Invincible Mine complex is therefore a very good representative example of a nineteenth century hard rock gold mining operation, and in particular of the alpine mines found in the Queenstown Lakes area. This context within the wider Otago goldfields has also been mentioned above in **Section 5.0 Cultural Connections**, in relation to the site's inclusion in the Otago Goldfields Park. The mining and processing technology at the Invincible Mine complex is in many ways typical of contemporary mines in New Zealand, Australia and America, with the water wheel, stamp mill and Berdans all being good representative examples, albeit quite decayed in the case of the wheel and mill. However, the set of seven Berdans is the largest surviving set in New Zealand, and represents how existing technology was adopted at a scale to suit the problem: where normally one or two Berdans would be used to treat concentrates, at the Invincible the loss of gold was so great a large number of Berdans was installed to be able to considerably increase the quantity of tailings that could be processed. The other method employed to recover the lost gold from the Invincible Mine, the Otago Pyrites Saving Company's buddle on the valley floor, is the only known example in

New Zealand, and is unusual in that it represents the direct importation of German equipment to New Zealand. Most goldfields machinery was sourced from Britain, Australia, the USA or locally manufactured, despite the fact that Germany was a long-established centre of mining technology. This underlines the international nature of the late nineteenth century mining industry, where although the main linkages were with the Empire and English speaking world, other associations with centres of mining expertise were also maintained.

7.0 Assessment of Significance

Most historic places in New Zealand are assessed using a recognised heritage values system. DOC uses the significance assessment criteria contained within the Historic Places Act 1993 (recently replaced by the Heritage New Zealand Pouhere Taonga Act 2014). Heritage New Zealand (previously the New Zealand Historic Places Trust) is the national authority in the assessment of the significance of historic places. The current Heritage New Zealand assessment criteria are used in its List (previously the NZHPT Register) proposal guidelines (www.heritage.org.nz/the-list/-/media/8c1c89c0ef5d48a19821975d1eef68de.ashx). These criteria are:

Historical, cultural, aesthetic, archaeological, architectural, scientific, social, spiritual, technological and traditional significance or value.

Section 66 (3) of the Heritage New Zealand Pouhere Taonga Act 2014 further describes these criteria for heritage sites to be included in the New Zealand Heritage List. For the purposes of this report these criteria have been amalgamated under three headings: Historical (historical, social); Physical (archaeological, architectural, scientific, technological); and Cultural (aesthetic, spiritual, traditional).

The Invincible Battery and Otago Pyrites Saving Company's buddle have long been recognised as significant sites, most notably by their inclusion in the Otago Goldfields Heritage Park and by their NZHPT registrations (now Heritage New Zealand 'listings'). Both the Department of Lands & Survey and the New Zealand Historic Places Trust therefore carried out significance assessments, and values raised in these assessments are included in the discussions below.

7.1 Historic Significance

Gold mining was one of New Zealand's most important industries in the late nineteenth century, and for much of the decade until 1871 gold exports constituted more than half of New Zealand's export value (Salmon 1963: 209). The infrastructure and settlement pattern of the main gold mining districts (Otago, West Coast, Thames/Coromandel) were established during and in the aftermath of the various gold rushes. Towns such as Lawrence, Alexandra, Clyde and Arrowtown were all established during this period, and survived because they became service centres for local farming and other activities that replaced the mining industry. Other settlements, such as Bendigo, Logantown, Macetown, Bullendale and Rees Gorge existed to serve only mining (in some cases just a single mine), and disappeared once mining ceased. The gold discoveries created an economic boom that made Dunedin the commercial centre of New Zealand for many years. Gold mining is therefore a central aspect of Otago's historical development.

The Invincible Mine complex is associated with the peak years of hard rock goldmining in Otago and New Zealand in the 1880s and 1890s, when the mining industry was a major employer and exporter, and production was being maintained by international technological advances and capital investment (Petchey 2013: 59). The Invincible Mine was an example of a smaller operation that was locally financed, and which focussed on relatively shallow and easily accesible gold deposits. This contrasts with some of the large and deep mines that were developed with overseas (particularly British) capital, such as around Karangahake (near

Waihi) and Reefton. The importance of improved technology was proven at the Invincible when the Otago Pyrites Saving Company installed their works to re-process the tailings that still contained much gold due to the pyritic nature of the ore. The works was novel and advanced enough to be the subject of an extremely detailed account published in the *Otago Witness* (27 August 1886: 12). The Invincible Company responded to this success by installing the less novel, but in practice just as effective, set of Berdans that still exists.

The Invincible Mine complex is therefore a good representative example of a moderate size late nineteenth century hard rock gold mine which was in many ways conventional, but which also displays interesting technological responses to the problem of refractory ore. It therefore fulfils a number of the Section 66 (3) criteria, including (a) the extent to which the place reflects important or representative aspects of New Zealand History, and (g) the technical accomplishment, value, or design of the place.

The Invincible complex is therefore locally and regionally significant as a representative example of an historical hard rock mine, and nationally significant as an example of the use of international technology in an attempt to address problems with refractory ore.

7.2 Physical Significance

The physical significance of the Invincible Mine complex rests in its overall intact nature, and the presence within this complete system of the set of seven linked Berdans, and the buddle/concentrator. In 1990 Smith (p 233) stated:

> 'What is important about the Invincible Mine and Concentrator is that the whole system, including the source of ore, the energy source, various methods of processing and the associated infrastructure of dwellings and roads, is intact, and the extant remains are in a relatively compact area.'

This statement still holds true. The complete system, although ruinous, is present and (archaeologically) intact and unmodified, within an unmodified landscape setting. The visible evidence of the mining and processing system can be appreciated by the casual visitor or studied by the researcher, and the overall site also contains a great deal of sub-surface archaeological evidence that has potential for future investigation.

The site meets a number of the Section 66 (3) criteria particularly (c) the potential of the place to provide knowledge of New Zealand History, (g) the technical accomplishment of the place and (k) the extent to which the place forms part of a wider historical and cultural area.

The archaeological potential of the complex is very high. The settlement has the potential to provide information about the lives of workers and their families in a remote and mountainous setting, while the battery and concentrator works have the potential to provide information about the technology employed. The concentrator works site on the valley floor would be particularly informative, as no similar site has ever been investigated in New Zealand.

The set of seven Berdans is not technologically unique, as Berdans were widely used in New Zealand and many survive, but it is the largest set in the country, and they are intact, in situ and in good condition with their drive train in place. The original timber was replaced in 2001, and so the framework is now a replica but this does not detract from their significance. The rotating convex table/concentrator/buddle is unique in the New Zealand goldfields, as no other examples are known. It is also in situ, and both surface (visible) and sub-surface archaeological evidence of the Otago Pyrites Saving Company's works survives, but has yet

to be investigated or even recorded in any detail. The table is not only a unique item, it is also a rare example of equipment that was imported from Germany, which was an important centre of mining tecchnology but not well represented in the Anglo-world orientated New Zealand goldfields.

The Invincible Mine is an element of the Otago and wider New Zealand goldfields, and its inclusion in the Otago Goldfields Park in 1978 not only recognised its individual significance, but also importantly recognised that the concept of the historical goldfields could be applied to discrete sites over a very wide area. This acknowledgement is important as it recognises that an historical or cultural area does not necessarily have to be contiguous.

The Invincible Mine complex is therefore regionally significant as a good representative example of a moderate sized alpine gold mining system, and nationally significant when the unique buddle/concentrator is taken into account within this intact system. All aspects of this system would repay further archaeological investigation. It must be emphasised that the physical significance of the buddle is high because it is in context with the rest of the overall site, and the entire Otago Pyrites Saving Company works site is part of this significant site, not just the buddle itself.

7.3 Cultural Significance

The cultural significance of the Invincible Mine complex is also high, although less than its historical and physical significance. The cosmopolitan nature of both the technology and the people involved with goldfields enterprises such as this were an important element in the development of modern New Zealand society. The goldfields were a mixing pot of people and ideas, and the infrastructure and settlement pattern of the modern landscape was largely formed during the gold mining period. The Invincible Mine complex is part of this wider historical/archaeological/social landscape. The archaeological potential of the settlement site in particular also has the potential to provide information about the lives of the people who lived in this remote place in the 1880s.

In the modern world the Invincible Mine represents both the opportunity to explore aspects of this history (for both the serious researcher and the casually interested visitor), and the opportunity to walk in an alpine environment with spectacular views. As a Reserve with free and unfettered public access it is part of a tradition of access to the back country that New Zealanders have always enjoyed, and is an important aspect of New Zealand culture.

The Invincible Mine complex is therefore locally and regionally moderately significant as both an example of the cosmopolitan goldfields population/technology, and as a modern visitor destination that shares both cultural heritage and scenic alpine values.

8.0 Comparative Analysis

The Invincible Mine complex is part of the New Zealand goldfields archaeological landscape, which stretches from Fiordland north to Great Barrier Island, and can be compared to a number of other hard rock gold mine sites around the country. The most directly comparable sites are the other Central Otago/Lakes District alpine sites, such as Bullendale and Macetown, although both of these are actually clusters of mines rather than a single unit. Other goldfields have simlar mountainous settings, and the Britannia (site L29/15) and Croesus (site L29/2) mines on the West Coast, and Kirikiri (site T12/1410) and Bendigo (site T13/90) in the North Island, are comparable, as they were moderately sized mines with 5 or 10 stamp mills. One of the features of many of these mountainous sites is that the reef

systems were accessible by driving and stoping, and shafts and winding gear were not required as all of the rock (mullock and ore) could be handled using gravity. The Invincible mine is a good example of a gravity fed system as the mullock heaps of the upper workings are visible from the battery site on the mountainside above, while the buddle/concentrator is on the valley floor far below. The Homeward Bound Mine (site F41/477) at Macetown gives a similar experience, as the battery is intact (with a Berdan and parts of a Wilfley table), and the pylons for a gravity aerial cableway still march up the mountainside to the mine workings above. One feature of the Otago sites is that they are often in open tussock country, and are relatively easy to see. Central Otago also has the best preservation of timber battery structures in the country due to its arid climate. Most West Coast, Nelson and Thames/Coromandel sites are in forest, and inspection is difficult, and in these damper conditions timber elements tend to decay more quickly. In addition, the North Island sites have a relatively poor survival rate of machinery when compared to the South Island, probably largely due to their ease of access and proximity to population centres and scrap dealers (Petchey 2013).

In terms of the technology used at the Invincible Mine complex, the discussions above have identified the set of seven Berdans and the rotating convex table/buddle/concentrator as the most significant elements in the system. Berdans are relatively common in New Zealand mining sites, but usually exist as single or double examples. There are no comparable sets of seven units, but one set of six Berdans (Luck at Last, site T12/601) and one set of four Berdans (Taitapu, site M25/86) are recorded (Table 3). The Invincible Berdans are also in relatively good condition, are still mounted (albeit now in a replica frame) with their drive gearing intact, and are unusual (but not unique) examples that were driven from below (top drive is most common).

Table 3
Surviving multiple Berdan installations in New Zealand

Site Name	NZAA No.	No. of Berdans	Drive
Albion	Q27/112	2	Top
Alpha	B46/42	2	Top
Battery Ck (Kirikiri)	T12/1410	2	Top
Croesus	L29/2	2	Bottom
Golden Lead	L31/29	2 (1 taken to museum)	Top
Golden Site	B46/88	2	Top
Govt. Coromandel	T10/1115	3	Top
Invincible	**E40/58**	**7**	**Bottom**
Johnston's United	M25/73	2	Top
Kirwan's Reward	L30/62	2	Top
Luck at Last	T12/601	6	Top
Taitapu	M25/86	4	Top
Welcome jack	T11/693	2	Top
Wellington	O28/47	2	Top

The Otago Pyrites Saving Company's rotating convex table is unique in New Zealand, as no other examples are known to survive. Historical sources record other buddles as having been used in New Zealand (*Auckland Star*, 20 April 1895: 5; *Otago Witness,* 23 September 1903: 23), but there is no evidence as to how these compare with the Invincible example. In addition to the rarity of the item, it is also an unusual example of German machinery in the goldfields. The New Zealand mining industry was receptive to international developments in technology, but most imported designs and equipment originated in the Anglo world of Britain, Australia and the USA (Petchey 2013: 311-312). While Germany was a long-established centre of mining expertise, its direct influence in New Zealand was relatively limited.

The rest of the Invincible Battery equipment is conventional. The stamp mill is a mid-weight ten stamp unit fitted to give the most commonly recorded drop order in New Zealand sites. The timber trestle frame is of a general type that is known to have been used for a long period, and is now in extremely poor condition. The water wheel was also a conventional design, and the upper half of the wheel has now completely collapsed. No original all-timber water wheels now survive in the goldfields (the small wheel at the Canton Mine (site H44/831) at Waipori was the last to succumb), but several good examples of iron-rimmed water wheels do exist including the Young Australian (site F42/28) and Serpentine (site H42/2) wheels.

The Invincible Mine complex is therefore overall a very good representative example of a moderate sized alpine hard rock mine of the late nineteenth century, typical of many that were locally funded and which focused on relatively shallow gold deposits. What makes the Invincible stand out from other similar mines are the seven Berdans and the Otago Pyrites Saving Company's processing site, which contains the best example of a circular buddle in New Zealand. The Invincible Mine complex therefore represents a complete system, with some elements that are highly represenative of similar sites, and other elements that are unique. The significance of the place is as a complete system where all elements are in context. Overall it is locally and regionally very significant, and the Otago Pyrites Saving Company's site is unique and nationally significant.

However, as stated above, a full detailed archaeological survey of the overall site has yet to be undertaken, and this is likely to identify further features and add to the archaeological significance of the site.

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10.0 1995 Photos

Photographs of the Invincible Battery and Otago Pyrites Company Buddle taken in 1995 by P. Petchey.

The overall battery site.

The water wheel, with one spoke still pointing to the sky.

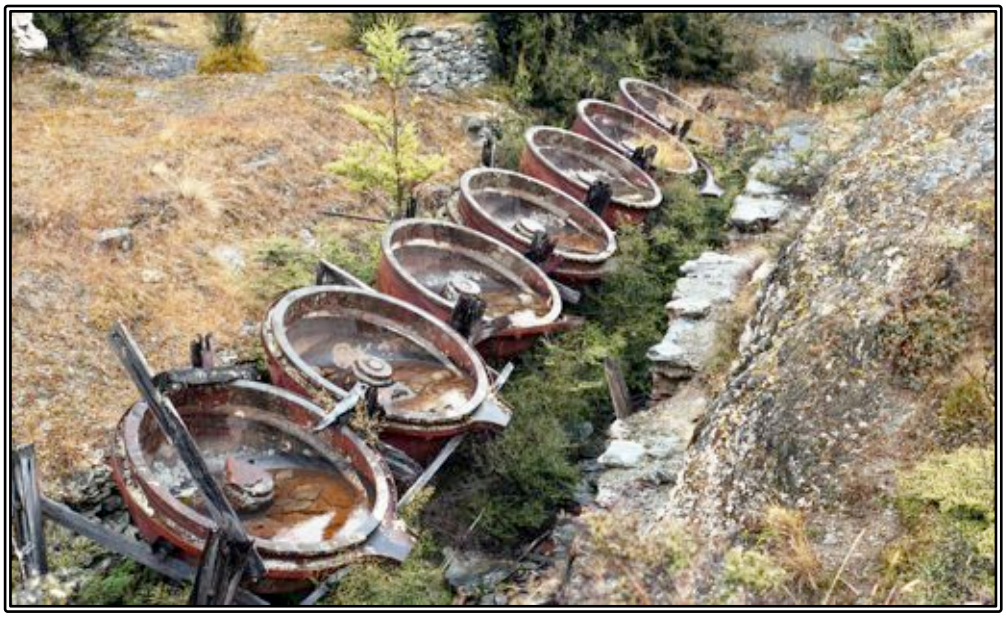
The water wheel hub.

The water wheel hub, and a view down into the wheel pit where much of the lower wheel structure was intact.

The water wheel (left) and collapsed stamp mill (right).

The collapsed stamp mill.

The collapsed stamp mill, showing one set of five cams.



The row of seven Berdans.

A detail of the Berdans.

A detail of the drive mechanism of the Berdans.

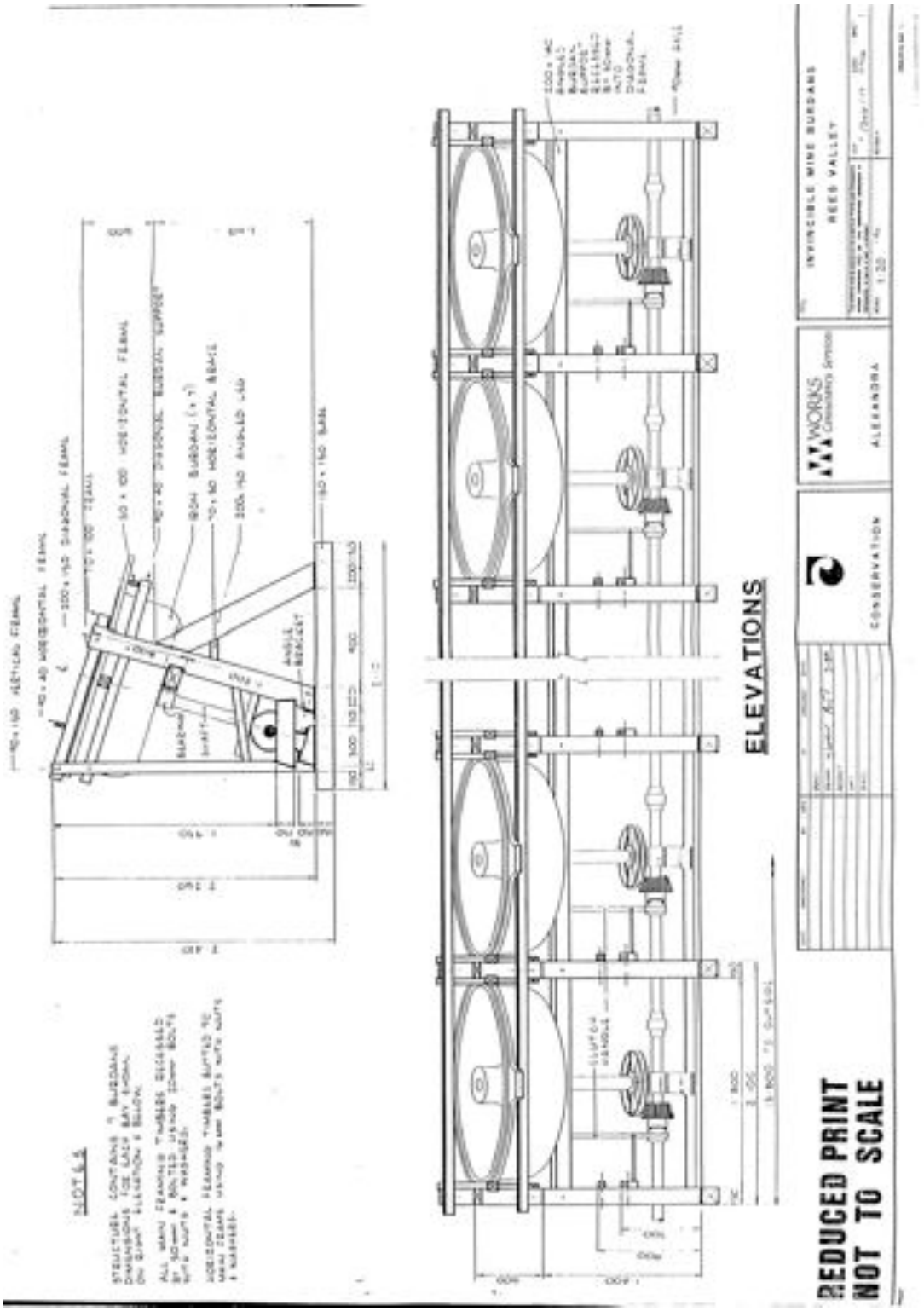
The Otago Pyrites Saving Company's circular convex table.

The central pylon on the buddle.

A detail of the peripheral drains of the buddle.

11.0 Other Data

Drawing of Berdans. Works Consultancy Services, 1989.



Otago Witness article, August 27th 1886

HEAD OF LAKE WAKATIPU.

OTAGO PYRITES SAVING CO'S WORKS.

A NEW DEPARTURE IN MINING IN NEW ZEALAND.

(By Our Special Reporter.)

Attempts to treat pyrites, which abound in all the reefs in this district, for the gold they contain have upon several occasions been made here in the past, but owing to various causes they have all proved futile, only in one instance proceeding beyond the talking-about-it stage, and even in this case it did not get beyond its embryonic troubles. As a consequence, a very great waste of gold has been allowed to go on until the Otago Pyrites Saving Co. has furnished a means by which the amount of the waste may be estimated, and a manner in which such a waste may be prevented in the future. It may here be explained to the uninitiated that pyrites is a name given to different combinations of minerals, which combinations are distinguished by the principal metal entering into their composition, such as iron pyrites, or copper pyrites. It is, however, with those kinds which occur in all quartz reefs, and which are the chief cause of the loss of gold, that the present company concerns itself. Near the surface the pyrites are found decomposed and in varying degrees of decay, but as excavations recede from the surface to greater depths, the pyrites increase in quantity and hardness, making the saving of gold a more and more difficult matter; so that, it may be safely accepted, that the loss of gold increases as the mines reach greater depths. This fact, which is generally accepted by all experts, and supported by experience, shows the importance of such works as form the subject of the present article. As the loss of gold from crushing mills has been touched upon, it may be mentioned that it is variously estimated by scientific men, who have made searching experiments, to range from 30 to 70 per cent. of the gold the ore originally contained. The loss of gold, as a matter of course, must vary according to the richness of the stone crushed, and the amount and nature of the chemical impurities it contains.

Sufficient having been said about the loss of gold and its causes, a description of the, to colonial miners, novel and unique machinery erected in Rees' Valley, near the head of Lake Wakatipu, in order to arrest the loss, may now follow. At the outset it must be explained that the machinery of the "Otago Pyrites Saving Company treats tailings only by washing, that is to say, it only separates the pyrites from the sand, which is accomplished by different modes of washing the tailings. No further crushing or grinding the tailings is attempted, nor are they subjected to any chemical process whatever. It is important to bear this in mind, as it will facilitate the comprehension of the following description:—When all the sand has been separated from the pyrites, all water is drained off from the mineral, which, when dry, is bagged in jute bags made for the purpose, double, so as to prevent the loss of the fine particles of mineral. The pyrites are then sent to the Sandhurst Pyrites Works, Victoria, where they are treated for the gold they contain. One consignment which has been sent to Germany has yielded 5oz of gold per ton of pyrites, but as the cost of transport came very high the company prefer to send their pyrites to Victoria, where the gold is extracted. At the time of my visit two and a half tons of pyrites, saved during the short time that the machinery had been working since the breaking up of the frost, were ready bagged for export, and waiting to be sent away.

The works are situated about 12 miles from Glenorchy, at the head of Lake Wakatipu, in the romantic gorge of the Rees River, at a sufficient elevation above high flood mark, and upon a terrace which is surrounded by some very extensive patches of stately birch trees. A flume 2200ft long, in the construction of which 11,000ft of sawn timber, 9in x 1½in, has been used, conducts the tailings from the Invincible battery to the Pyrites works, which are worked by water power applied to a Little Giant turbine wheel. The water right is a never-failing one, and comprises five Government heads, which is amply sufficient for all purposes *i.e.*, for motive power, and for washing purposes. As the tailings are subjected to a series of processes in regular order, it will be as well to follow them as they succeed one another. There is a difficulty that must be met at the outset, and that is that the machinery being of German invention and make, all its parts have most outlandish names which must be translated to make them intelligible to the general reader, for such terms as "Linkenbach" and "Läuterhausen" would perhaps convey no very clear conception of what they really mean, therefore they will be translated, and their meaning rendered in English as correctly as that is possible.

To begin, then. The tailings after they have been brought down from the mine are stored in a watertight dam, so that none are allowed to run to waste during occasional stoppages of the pyrites works. From the dam the tailings are conducted to the "classifiers," which are double V shaped boxes twice as long as they are wide, and of which there are two. The tailings are paid into the "classifiers" by flumes at the top, and on sinking they are met by a pressure stream of clear water discharged from a pipe at the bottom set at right angles with the tailings flume. In this manner the pyrites and the heavier particles of the sand are "classified" from the lighter material, which is carried off by the bubbling action of the water at the top of the classifier by overflow and thence conducted into two pyramidal boxes, of which more anon. The coarser pyrites, with the coarser and heavier particles of sand, are led from the bottoms of the classifiers by pipes into jigger No. 1, which is also a V box, the length of which is equal to twice its width, with a partition lengthwise reaching halfway down the box, so that a connection is kept open between the two

compartments. In one of these a sieve is fixed, having 196 holes to the square inch, and further bedded with coarse copper and scheelite ore; in the other compartment a wooden plunger works vertically by eccentric action, with a stroke of one-sixteenth of an inch, and about one inch below the surface of the water in the box. There are two such boxes connected endwise so that the stuff runs from one into the other. In this manner the coarse pyrites is settled in the bottom of each box, from whence it is drawn off, dried, and bagged, ready for exportation, while the overflow from the second jigger box is allowed to escape as refuse. When it is stated that the quantity of water must be regulated in these appliances, *i.e.*, the classifiers and the jigger, to the coarseness or fineness, and the richness or poorness of the tailings treated, it will be seen that the utmost care and attention is required in the adjustment of the exact quantity turned on.

We now follow the overflow tailings from the classifiers into the small pyramidal boxes, of which there are also two, measuring 5ft square on the top and 5ft deep, resembling inverted pyramids. In these pyramidal boxes the tailings are treated in the same manner as they were in the "classifiers" and the overflow runs into a large pyramidal settling box, to which we have to return further on. The finer pyrites, which are precipitated into these small pyramidal boxes, are run into jigger II, which is also double and works exactly in the same manner as No. I, the overflow from the second box being also refuse, and the pure pyrites are drawn off from the bottom as "medium coarse." These pyrites being finer, even greater care is required in their manipulation than was the case with that treated in jigger No. 1; a finer stroke being given to the plungers, viz., 1-20th of an inch, and finer sieves being used, having 256 holes to the inch, and which are bedded with finer bedding chiefly of scheelite ore. The plungers work with the speed of 280 strokes per minute.

We now return to the large pyramidal box, which measures 10ft square at the top and is 10ft deep, into which as has been shown the overflow of the small pyramidal boxes is poured. In the large pyramidal box the contents are simply allowed to settle, the overflow being discharged as refuse into the Rees river, while the settled slime—sand and pyrites—is conducted by a pipe from the bottom (apex), and by the aid of its own pressure, to a table, which is the gem of the works.

This table, which is 26ft in diameter, is built of concrete, but faced with the finest cement, made as smooth as marble. The centre of the table is raised, and there is a gentle and regular slope from the centre to the edge. The tailings, of which nothing now is left but the finest slime sand and very fine pyrites, which had been allowed to settle in the large pyramidal box, of course, also inverted—*i.e.*, with its widest parts uppermost and its point downwards,—are discharged by pressure into the revolving distributing gutter where the slime-sand is met by a stream of clear water in such a manner as to overflow the distributing gutter, fixed at the highest point of the table, evenly distributing a constant and regular stream of slime-sand and pyrites all over the sloping table at its highest part, spreading out wider and to thinner layers as the slime-sand nears the edge of the table. In its gradual descent from the centre to the edge of the table, the slime-sand is acted upon by three sets of clear water-jets (Läuterbrausen), discharged with a pressure of 100ft. These three sets of jets are fixed to three revolving arms, each of which commands a quarter of the table, and as at every revolution of the jets, which occupies about two minutes, the table is completely cleaned, it will be seen that a certain and definite work is performed by each of the three sets of jets within a certain time, and also within a well-defined section of the table. This must be borne in mind, as it will make clear how the pure pyrites are intercepted, and how the refuse slime is got rid of by a gutter revolving under the lip of the table, or its "drip nose."

The first set of jets separates the ore from the slime sand, washing the latter down the table a part of the way, leaving the pure ore behind.

The second set of jets is a water brush, being a perforated pipe about 2ft long, which may be adjusted to the sweep of the table it commands, and the pressure with which the water is discharged may and must be regulated according to the quality and quantity of slime-sand treated. This brush washes down the ore a further distance, and cleans out from it any sand that may have been left behind.

The third set of jets consists of two strong ball jets, which sweep all remaining sand off the table, leaving nothing but pure ore behind, which is acted upon by five strong ball jets, attached to a fourth revolving arm, washing off all ore, and finishing the work for that revolution of the jets.

To the four arms which carry round the jets over the table is fixed an iron gutter, revolving round the table under its "drip nose," to catch the sand and ore separated as it is washed off the table. This revolving iron gutter is divided into four compartments, and revolves above four stationary concrete gutters, running the full extent round the table, which may be numbered, counting from the inside, Nos. 1, 2, 3, 4. Each of the four compartments in the iron revolving gutter passes the ore or the sand, as either is received from the table, to one of the four stationary gutters by pipes, in the following order:—The first compartment in the iron gutter receives the first flush of slime-sand from the table, which is emptied into the inner stationary concrete gutter No. 1 and discharged by it as refuse into the Rees river; the second compartment of the iron gutter empties into the

next, or No. 2 stationary gutter, which conducts its charge to a central buddle; the third compartment of the revolving gutter catches the lighter particles of ore as they come from the table, and conducts them to "launders" or settling boxes by stationary gutter No. 3; the fourth and last compartment of the revolving gutter receives the remaining ore pure, which is discharged into stationary gutter No. 4, and from this conducted into settling boxes.

From the above description it will be seen that the machine is a complete and beautiful automaton, which to manage, however, requires great care and attention, and no small amount of experience. Mr W. Dickenson, who is in charge of the works, although still a young man, has had considerable experience as a professional ore dresser, at Mount Bischoff, Tasmania, acquired under the efficient tuition of Mr Kayser, the well-known manager of the Mount Bischoff Mining Company. Your special is indebted to Mr Dickenson for the patient and painstaking explanations of the somewhat complex machinery from which the above description has been compiled, and although the writer flatters himself to have produced a fairly intelligible account of the machines he feels called upon to point out that if there should be any mistakes or obscurities, they are to be attributed to his obtuseness and must not be laid to Mr Dickenson's charge.

But the stuff traced from the stationary gutters (2 and 3 of the table) to the central buddle and the "launders" must now be finally disposed of. The central buddle is a simple circular pit, into the centre of which the slime-sand is allowed to fall from a height of a few feet. The heavier particles of the slime-sand settle near the centre, while the lighter portions are washed to the periphery of the buddle, and carried off through an escape gate. The central portion of the sediment is then taken out, and passed again over the table; but the first process of manipulating the tailings is so carefully watched and attended to that treating the stuff retained in the buddle a second time would, under ordinary circumstances, not pay. However, as the machine can easily overtake all the tailings paid down by the Invincible Company, Mr Dickenson prefers to make sure of his work, and so the stuff from the buddle is treated a second time.

The "launders" are boxes provided with ripples, in which the ore is allowed to settle; but as they serve for catching the lighter particles of the ore, a certain amount of the heavier particles of sand also find a lodgment amongst them. To separate this sand from the ore a very simple yet interesting process is had recourse to. The stuff from the "launders" is taken up and placed into what is called a "tossing tub." The tub is of wood, about 3ft deep, wide mouthed at the top but tapering towards the bottom. In this tub the stuff, mixed with water, is agitated in a peculiar manner and tossed about with a square mouthed shovel until the whole contents are thoroughly mixed. An iron bar, with one end fixed in the ground outside the tub, is jerked up against the rim of the tub, causing a vibration of its contents, leading to the settling of the lighter portions. When the contents have had time to settle, the water is drawn off and the sediment taken off in layers until the clean pyrites are reached in the bottom of the tub.

The process of obtaining the pyrites from the tailings has now been described simultaneously with the appliances used in the process, and little more remains to be added. It will be seen that the whole process is an automatic one, requiring, however, great attention in the regulation of the water used, as all the boxes described discharge both at the bottom and the top at the same time, in either case the greatest nicety being absolutely necessary. That this part is properly attended to is proved by the almost complete absence of ore in the central buddle, a proof quite sufficient that there is no loss which could be prevented.

The machinery and appliances were erected by Mr J. B. Neal, who, having since taken the management of the scheelite mine has been succeeded by Mr Dickenson as the manager. Everything works with the greatest satisfaction, and considering that the plans were all marked in German, Mr Neal had greatly to depend upon his ingenuity, and under the circumstances has proved himself an efficient and clever machinist. The greater part of the machinery was procured in Germany; some of the timber used for the pyramidal boxes came from Tasmania and some from Victoria. It is not only the novelty of the machinery, but the perfect ease and regularity with which it works that strikes the visitor.

The whole machinery is enclosed in a substantially built house, measuring 45ft by 90ft, with a principle roof, well calculated to withstand any weight of snow. The building, flumes, boxes, &c., must have consumed considerably over 100,000 feet of timber, part of which was sawn upon the ground.

It would swell an already too lengthy article to undesirable proportions by going into detail on the wide application such machinery as that of the Otago Pyrites Saving Company might find in reefing. Suffice it, therefore, to say that the whole plant has cost about £3000 inclusive of cartage and erection. The works are carried on during two shifts of eight hours each, with two men to each shift, so that the working expenses are not heavy, and the wear and tear is almost nil, nor is any great amount of water required for washing purposes, a pipe 1½in in diameter under a pressure of 100ft supplying all that is required for the table. The machinery is capable of treating 90 tons of tailings per week with ease, and as 1½ per cent. of ore to the ton will leave a surplus over and above working expenses, it will be seen that it answers admirably the purpose it is designed for and should be introduced upon all goldfields.