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Early Water Races in Central Otago

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SUMMARY: *Gold mining was the driver for the first water races constructed in Central Otago from the 1860s. As the easy gold was won and the races abandoned by the miners they were used for domestic and stock water and then irrigation of pasture and horticulture. Many of the races are long, on steep hillsides, and construction was undertaken with limited resources. These races continue to be used although a number have been upgraded to allow vehicle and machinery access. The paper presents two case studies: the 108 km Mt Ida Water Race constructed from 1873 to supply water to the Naseby gold mining area that still supplies water to Naseby township and farmers in the area; and the Teviot irrigation and hydro-electric power system near Roxburgh that was developed into the combined system after a goldmining venture failed in 1922. Both networks and water rights became owned by the Government. The Public Works Department carried out modifications and extensions for distributing water to both systems in the 1920s. The Mt Ida Water Race starts at 850m altitude and collects water from numerous small mountain catchments along the Hawkdun and Ida Ranges. The Teviot system relies on the Teviot River and a 13m high 46Mm^3 storage dam at Lake Onslow at 680m altitude and utilises some 370m of fall. The systems are now owned and operated by companies. The paper also introduces the principal irrigation dams in Central Otago in summary form. It concludes that the water supply systems originally built with their focus solely on gold mining have been successfully transformed into multipurpose water supply systems for irrigation, domestic, stockwater and hydropower.*

1. GENERAL

Gold mining was the driver for the first water races constructed in Central Otago from the 1860s. As the easy gold was won and the races abandoned by the miners they were used for domestic and stock water and then irrigation of pasture and horticulture. Many of the races are long, on steep hillsides, and construction was undertaken with limited resources. Two case studies are presented, the Mt Ida Race and the Teviot system. In addition older community irrigation dams in Central Otago are introduced.

2. MT IDA WATER RACE

2.1 Mining and construction

Alluvial gold mining began in Naseby in 1863 (Hamel), using water from the Hogburn and a number of other races from the East Eweburn and the Kyeburn. The disposal of tailings was difficult, because of the lack of flushing water and the relatively flat grade from the mining area out to the Maniototo plain. It was considered that two to three times as much water as was available in 1871 would be required and that the Manuherikia would provide the most reliable supply, although expensive. Figure 1 shows the nature of the catchment area. Estimated cost was $20,000 for the construction of this water race. The primary purpose was to flush accumulated and future tailings down the new sludge channel.

The race was designed and supervised by Mr DL Simpson, the Otago Provincial Engineer. He also designed the 16km long sludge channel down the Hogburn.

The Mt Ida Race works were authorised by Governor's Proclamation on 17 October 1873, and the route of the race and the streams reserved for its supply are identical with present day usage. The race was opened on 26 July 1877.

Figure 1. *Water supply catchment*

The Mt Ida Race sidles the Hawkdun Range from the tributaries of the Manuherikia River for 108km to

Naseby (see map in Appendix A). The start is at about 850 m above sea level and delivers water at 634m at Naseby. There is a drop of about 50m over 1.5km through use of a gully at Kirkwoods Creek. Water is diverted and taken from most streams the race crosses.

The original race dimensions were 1.2m bottom width, 2.1 m top width and 0.9m deep on a grade of 1 in 754.

By 1881 there was a permanent waterman with hack for inspection work and a draught horse and dray for cartage, plus five men stationed along the race, each looking after about 22 km. Extra hands were employed after slips and after the winter closure of two to three months.

Storage for the system is limited and consists of the West Eweburn reservoir (2.4 million m^3) which is 87 km from the start of the Mt Ida Race, and one smaller reservoir (Paisley's (Hore's) Dam) at the termination of the race in Home Gully near Naseby. Over the period 1898/99 to 1901/02 this 21m high earth dam was built immediately above the race in the West Eweburn (see Figure 2) to provide supplementary supplies to the Naseby area particularly in late summer.

Figure 2. *West Eweburn Dam construction 1898?*

Water for mining was supplied under agreement with the Mines Department at \$0.20 per 1000m^3 (1 Ml) and the income from the sales was intended to provide a profit over the operation and maintenance costs. The race initially supplied about 135 miners but by 1900 there were 65 miners using the water and by 1918 about 25-30 miners.

A plot of available water by section derived from Mines Department 1922 data is still considered to give a reasonable assessment of the potential supply from the 3 sections (described below) in a "normal" year. See Figure 3.

2.2 Irrigation Development

By 1920 the value of mining had fallen off, both the Blackstone Hill race and the upper part of the Mt Ida race having been abandoned, the latter since a storm in 1918 washed out many of the stream crossings. At this stage the Mines Department made the suggestion that the scheme be taken over for irrigation and/or power by the Public Works Department, but made the condition

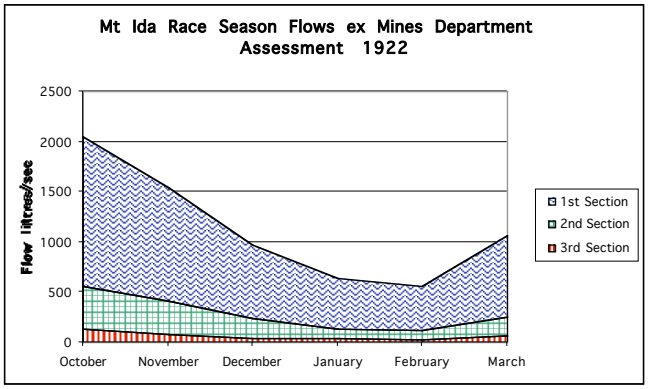

Figure 3. *Seasonal flows by race section*

that mining water should still be supplied. At this stage the mining system was running at an annual loss approaching \$1,400.

There is very little stream flow in these areas and some farms were without adequate water for stock.

Initial reports on the taking over of the scheme were not very favourable due mainly to the taking of water from the Manuherikia watershed, where it was required for other irrigation schemes. A proposal for using the Eweburn reservoir for hydro-power was mentioned but not carried further. However, following a certain amount of pressure from the farmers of the area, and a decision to provide a storage dam in the Manuherikia River, recommendations were made in early 1922 that the scheme be taken over for irrigation. At a meeting in January 1922, it was made clear to the farmers that only partial irrigation and stockwater would be available.

An estimated cost of reconstruction of the system, and new construction, was provided in mid-1924 with a figure of \$40,000 to be covered by a charge of \$1.85 per hectare over 4,000 hectares. A further delay was caused by difficulties with the miner's agreements, requiring additional clauses giving PWD the right to cut off mining supplies between 1 January and the end of March, and removing the requirement that miners maintain the system. The existing scheme and 2 officers of the Mines Department were transferred at the beginning of September 1924.

Owing to the widespread demand for water for irrigation and stock, and the relatively small supply of water available in summer, there was a choice between full irrigation for a few, and some water for the whole area. The latter course was decided upon and the Hawkdun is considered only a partial irrigation scheme and it was put to the farmers and accepted on that basis.

Before money was provided for construction it was necessary for farmers to sign a petition with the area

they proposed to irrigate, the final list of June 1925 giving 3,954 hectares with 65 signatures. The signing of agreements followed this, 68 with an area of 3,102 ha being signed by the end of January 1926. This was not the final figure but provided the 50% required by the Act, there being 126 irrigators within a total scheme area commanded of 30,920 ha.

The area was proclaimed an Irrigation District by an Order in Council of 8 April 1926, the full re-estimate at this stage giving cost as $118,000 (including $38,000 towards the cost of Falls Dam on the Manuherikia River), and the area charge of $2.60/ha allowed for agreements being automatically approved. Construction work was started almost immediately but not completed until mid-1929, and then at a cost of over $120,000. Supplies were commenced in 1929/30 season.

It was realised from the beginning that water supplies to the two areas would not be plentiful and experience has shown worse conditions than anticipated. At the original meeting of Hawkdun settlers on 5 December 1924, Mr Lindup of the PWD gave figures of 0.35 l/s/ha as average supply but falling to 0.21 l/s/ha in January and February. Agreements were to allow for the 0.35 l/s/ha (457mm per season) over an area of 4,047 ha. A slightly higher figure was allowed for supply to the Idaburn area.

The Mt Ida race was enlarged, as part of the reconstruction work, to carry 1.41 m^3/s as far as the Idaburn and 0.71 m^3/s from there to Naseby. A mean flow of 1.19 m^3/s was allowed for a minimum, with Eweburn dam being drawn down, of 0.85m^3/s.

Through the 1930's the main complaints about lack of water came from the miners. Despite the maintaining of supply at the $0.20 per 1000$m^3$, a considerably lesser return from the gold won led to the cancelling of the miners' agreements in 1938.

Figure 4. *Ten Chain Creek Bywash and control on Mt Ida Race in top section*

2.3 Description of Sections

First Section Mt Ida Race

The first or top section of the race runs 49 km from the head of the Manuherikia Valley to a gauging weir on the Manuherikia-Idaburn divide, and is solely a supply race picking up water from the streams it crosses. The top intake is at 850m above sea level. The race sidles high on the western slopes of the Hawkdun Range crossing into easier country of the Idaburn catchment below Johnstones Creek. Streams crossed by the race and able to provide water are:

- Johnstons or Head Creek or Top Johnstons Creek
- Manuka Creek
- Big German Creek
- Boundary or Kirkwoods Creek
- Big Bremners Creek
- Shepherds Hut Creek
- Healeys Creek
- Hut Creek
- Pierces Gorge Creek
- Johnstones Creek

In addition small quantities are picked up from Little German, Little Bremners, Trinity and Gate Creeks but as these effectively dry up when water is most needed late in the season they are not considered separately.

A number of these creeks traverse steep alluvial fans before reaching the Upper Manuherikia River. Under normal to low flow conditions many of these streams across the fans naturally dry up through infiltration in the gravel bed. The siting of the Mt Ida Race to be able to pick up creeks at a point where they have flow would no doubt have been a consideration of those involved with the original race construction.

By its nature this section of the race is very subject to washout, particularly at stream crossings, and maintenance and repair may be difficult and costly. Maintenance work is required in the streambeds from time to time, primarily after freshes or floods.

Mt Ida Race Second Section (49 to 76.6 km)

This section runs from the above section to a weir at the catchment boundary between the Idaburn (Clutha) and the Wetherburn (Taieri). Various streams are crossed by the race and picked up, including:

- Hills Creek (see Figure 5)
- Wades Creek
- North Idaburn
- Idaburn

Irrigation and stockwater is distributed to farms in the Idaburn valley through a mix of natural watercourses and distributary races.

Figure 5. *Hills Creek intake*

Mt Ida Race Third Section (76.6 to 108 km)
This section runs from the Taieri catchment boundary through to Home Gully, and follows the base of the southern slopes of the Mt Ida Range.

Figure 6. *Mt Ida Water Race west of Gorge Creek*

The race passes through the Naseby forestry (see Figure 8) and old mining areas to finish at an altitude of about 634m. Major streams crossed are:

- Wetherburn (main race does not pick up water as deeply incised channel) – see Figure 7
- West Eweburn (below main water storage reservoir)
- Butchers Gully (unreliable)
- East Eweburn (unreliable)

Figure 7. *Wetherburn syphon sluice valve in operation*

Figure 8. *Mt Ida Race adjacent to Naseby reservoir*

2.4 Current operation

In the 1980s the race was made more accessible by vehicle and hydraulic excavator over most of its length by widening the downhill berm.

The Mt Ida Water Race is today owned and operated by the Hawkdun Idaburn Irrigation Company Limited that is owned by the farmer shareholders with 3530 hectares under agreement for irrigation supplies. The race supplies domestic water for Naseby, back up supply for the township of Ranfurly, water supply for the curling and ice skating rinks, firefighting supplies for the forestry area and stockwater to the 30,000 ha commanded.

3. TEVIOT IRRIGATION AND HYDROPOWER DEVELOPMENT

3.1 Mining and Construction

Water race construction in the Teviot area was initiated by miners in the 1860s after gold was discovered in the Teviot River in 1862. Water was used for sluicing and hydraulic elevating. Mining water rights out of the Teviot River were held by the Roxburgh Amalgamated Mining & Sluicing Co. In 1888 Vincent Pyke gained a dam licence that he sold to the Company. Mr C C Rawlins (general manager of the Island Block Mining Co) designed a 5.5m high stone course dam, including the base set 0.9 to 1.2m into solid rock) in the same year at Dismal Swamp, now called Lake Onslow (see Figure 9). Lake Onslow is named after a governor of New Zealand, William Hellier, fourth Earl of Onslow, 1889-92. A further 1.52m was added to the dam in 1894 by Mr H M Davey, consulting engineer, of Dunedin (see Figure 10).

Lake Onslow is about 30km from the confluence of the Teviot River with the Clutha River and 600m higher in elevation. About 220m fall is available over the last 3.6km. Mean annual flow of the Teviot River is 2.3 m^3/s. See map in Appendix B.

In 1897 T Perham A.M.I.C.E. was employed by the Mines Department to report on various water

conservation schemes on goldfields. He prepared a plan for a further raising of the dam by 3m but considered that this would only benefit existing holders of water rights and he could not recommend government involvement as he was charged with finding water for new ventures. This addition was not carried out. See Figure 10.

Figure 9. *Lake Onslow Rock Dam after 1894*

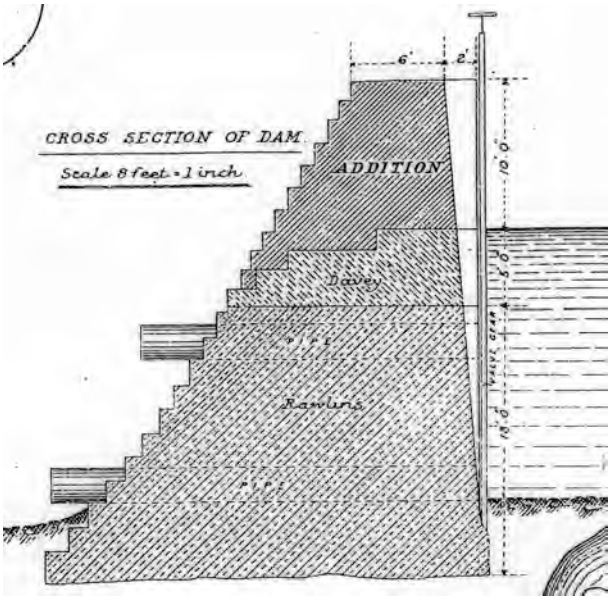

Figure 10. *Cross section of Lake Onslow Dam with T Perham possible addition shown*

The last large undertaking in gold mining was the Teviot-Molyneux Gold Mining Co.Ltd whose managing director was John R Ewing (Figure 11). Ewings race construction involved a tunnel, 2 km of 900 mm iron pipes taking water from the Teviot River gorge and 8 syphons. The race was over 200m above the Clutha River level and thus provided good pressure for sluicing and hydraulic elevating for gold mining (see Figure 14). The race capacity in 1971 was 500 l/s and total length of 6.9 km. Figures 12 and 13 show examples of the race features.

Pipes were manufactured locally. See Figure 15.

Figure 11. *John Ewing (front) on site*

Figure 12.. *Ewings Race at 2550m (1971)*

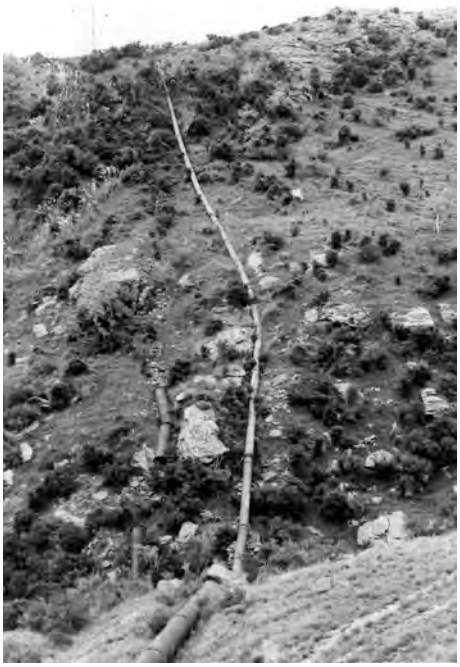

Figure 13. *Ewings Race Syphon No.3 (1971) 590mm diameter steel, 314m long*

Figure 14. *Sluicing and elevating at Roxburgh East using water from Ewings Race*

Figure 15. *Steel pipe at Roxburgh Foundry*

3.2 Irrigation and Hydropower Developments

In January 1920 three local landowners were discussing the current dry spell and a suggestion was made that they could divert the Teviot River through a tunnel and irrigate Roxburgh East. Mr R George was one of these three men and as Chairman offered the Ladysmith Gold Dredging Co water rights and plant as suitable to supply Roxburgh with electric power as that company was nearing liquidation. Thus was spawned the idea of a combined irrigation and power system. Two days after the initial discussion a public meeting was held with 70 attendees. A Mr CJ Drewett from AD Riley & Co. happened to be in the area and had been able to prepare a preliminary design and costings and estimates of revenue that day. A committee was formed to lodge tenders for the Ladysmith claim and plant. The committee adopted the name of the Teviot District Electric Lighting, Power and Irrigation Board and jointly guaranteed the sum of $6,000 to progress the matter. Within a few days they had tendered for and purchased the plant and water rights of the Ladysmith Co. for $3,020.

In 1920 the Roxburgh Amalgamated Company had folded disposing of its plant and water rights for $2,500 to the newly formed Teviot Electric Power Board (TEPB) that had been constituted as an electric power board district on 16 July 1920.

As at February 1921 there were three holders of water rights from the Teviot River:

Roxburgh Amalgamated Co (TEPB)	780 l/s
Ladysmith Company (TEPB)	850 l/s
Teviot-Molyneux Co.	1,175 l/s
Total	2,805 l/s

One of the first actions of the Board was to appoint an engineer, Mr A P Aldridge, who at the time was an engineer at the Dunedin City Council Waipori Falls Power Station.

The Board's early estimates of revenue were based on three 60W lights and one hot point per dwelling at $8 per annum or six 60W lights and one hot point for $12 per annum.

John Ewing died in 1922 and his company went into liquidation, the water rights being taken over with many of its assets by the Mines Department as mortgagee.

The Resident Engineer for the Public Works Department (PWD) at Alexandra, J R Marks, suggested taking 2.1 m^3/s from the Teviot R to irrigate 5,340 hectares on both sides of the Clutha R with two power drops to produce 950 kW. In 1922 Government approved the TEPB selling water for irrigation at $4 per hectare. A revised irrigation proposal to utilise existing races and water from the tailwater of the proposed power development was put to a meeting of settlers, TEPB and PWD in November 1922 and owners of land agreed to sign up 1,092 ha for irrigation water at this price.

Mr Aldridge had prepared the original scheme for the TEPB and was also involved with formulating the new proposals including irrigation. The level of the power station was set to allow for gravity supply of irrigation water to the north side of the Teviot River. See Figure 16 showing the relative levels of the races and powerhouse in diagrammatic form. Delay in commencement of supply was involved as reordering of turbines and generators and cancelling of existing orders was required. The first power pole was erected on 12 February 1923.

In January 1923 construction was approved at an estimated cost of $43,082. Proposals were altered in July 1923 when second hand pipes could not be obtained. An agreement as to site work responsibilities and cost sharing between the PWD and TEPB resulted in the TEPB surrendering all mining privileges and rights to sell irrigation water in return for the Crown maintaining all works apart from the powerhouse and electrical fittings, lines and poles.

The Teviot Irrigation District was gazetted on 5 July 1923 authorising the Minister of Public Works to construct and maintain water supply works in the District. A legal agreement between His Majesty the

King and the TEPB is dated 27 September 1924. A minimum of 708 l/s was to be supplied to the powerhouse. The first irrigation water officially supplied under the scheme was on 1 September 1924.

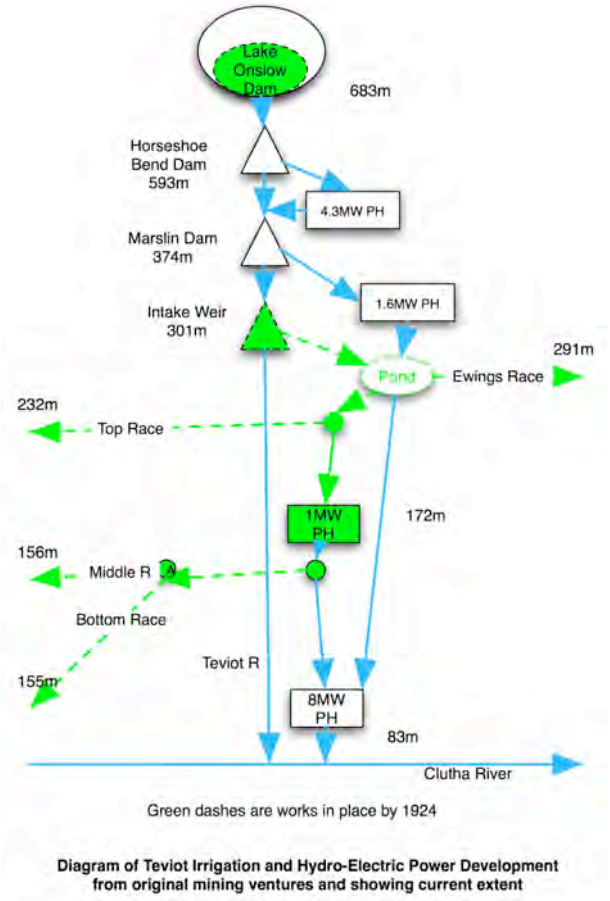

Figure 16. *Diagram of Teviot system*

The first power was officially turned on at a ceremony on 27 March 1924. Generation and distribution was at 3,300V. By November 1924 there were 321 consumers connected. Figure 17 shows the original powerhouse in operation.

An extension towards Millers Flat was mooted in 1927 and construction finished in 1929 serving an additional 490 ha under agreement.

In 1930 proposals to increase power were suggested. Also 1.77 km of 900mm pipe was to be replaced and the option of a 1.55 km tunnel to provide relief work and thus be subsidised by the Unemployment Board was taken with a concrete lined tunnel 1.45m x 1.12m finished size was in service by October 1935. Design capacity 2,830 l/s with mean velocity 2.35 m/s.

After a dry season in 1932/33 the TEPB suggested raising the dam by 900mm to increase storage by 3.45 Mm^3. This was accomplished in 1933 at the estimated cost of $600 using angle iron frames bolted to the top of the existing dam with 75mm hardwood sheathing.

Following another dry spell in 1937 an additional 225mm raising was carried out in May 1938 at an estimated cost of $100 for 0.94 Mm^3 of storage capacity.

Figure 17. *Original Teviot (George) power station*

In an April 1968 flood 28m of the timber and steel superstructure and 15m of masonry capping 0.6m deep was carried away, effectively reducing storage capacity by 60%. See Figure 18. Options to further increase storage based on the existing dam structure were ruled out with dam stability issues and the dam was reinstated to its level prior to the flood using a concrete cap. See Figure 19.

Figure 18. *Lake Onslow Dam 1968 flood damage and showing masonry construction*

Figure 19. *Lake Onslow Dam 1971*

The masonry quarried on site had a density of 2.515 t/m^3. Representative rock size used was 1.2 x 0.6 x 0.45m.

3.3 Recent changes

The Otago Central Electric Power Board (including the Teviot EPB generation and network) sought new development to build a new dam at Lake Onslow 14.6m high to store 46 Mm^3, and additional generation stations. This would require a new agreement as to cost sharing and responsibilities. The power generation system is now operated by Pioneer Generation Limited and the irrigation by the Teviot Irrigation Company Limited.

The new Lake Onslow Dam was completed in 1982 and the original dam is now submerged.

The high head available through the irrigation and power pipelines have been useful for gravity frost fighting of orchards at Roxburgh East. Capacity is however limited as the frost demand is by all orchards at once whilst irrigation supplies can be rostered over 2 to 3 weeks.

4. IRRIGATION DAMS

Apart from the two dams described under the Mt Ida and Teviot systems above there were no major dams for mining purposes and miners relied on picking up stream runoff and conveying the water many kilometres to their claims.

A number of good storage sites exist in Central Otago with narrow schist gorges and relatively wide flat basins above. Some of these sites are in relatively low rainfall zones with annual rainfall variability of ±30% about the mean. Storage at some sites is thus based on the ability to store water over years rather than just winter-spring runoff for the next summer-autumn. In order to improve reliability of supply old mining races have been used to add catchment area in some cases.

From 1914 to 1937 the Public Works Department constructed a number of purpose built irrigation dams. These are predominantly thin curved concrete arch dams with overflow spillways. Appendix C table summarises these irrigation dams and also includes the earlier two mining related dams and the Loganburn Dam completed in 1984.

Figure 20 shows Falls dam under construction (rockfill with concrete membrane) and Figures 21 and 22 show Conroys Dam as an example of the thin curved concrete arch dams.

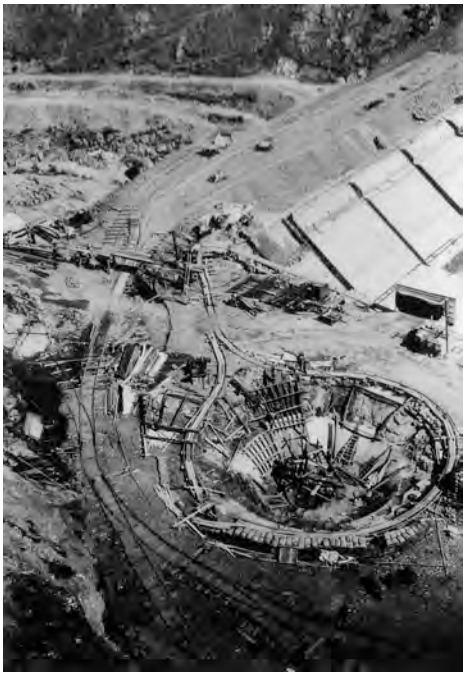

Figure 20. *Falls Dam under construction 1934 showing morning glory spillway in foreground*

These dams could provide sufficient material for papers on their own so this is only an introduction for engineering heritage record purposes.

Figure 21. *Conroys Dam 2006*

Figure 22. *Conroys Dam from right bank*

5. CONCLUSIONS

The early construction of water races for the purposes of gold mining were undertaken at a great pace and are remarkable for the engineering at the time. The Public Works Department was able to coordinate the development of community irrigation and assist hydro power development through acquisition of the mining water rights and assets as mining became less profitable in the 1920s. The ongoing use of the water distribution systems, originally built with their focus solely on gold mining, have been successfully transformed into multipurpose water supply systems for irrigation, domestic use, stockwater and hydropower.

6. ACKNOWLEDGMENTS

Assistance from the Naseby Museum and Teviot Museum is acknowledged for access to photographs. Access to information from Last Chance Irrigation Co Ltd, Hawkdun Idaburn Irrigation Co Ltd, Pioneer Generation Ltd and the Ministry of Agriculture and Forestry has been appreciated.

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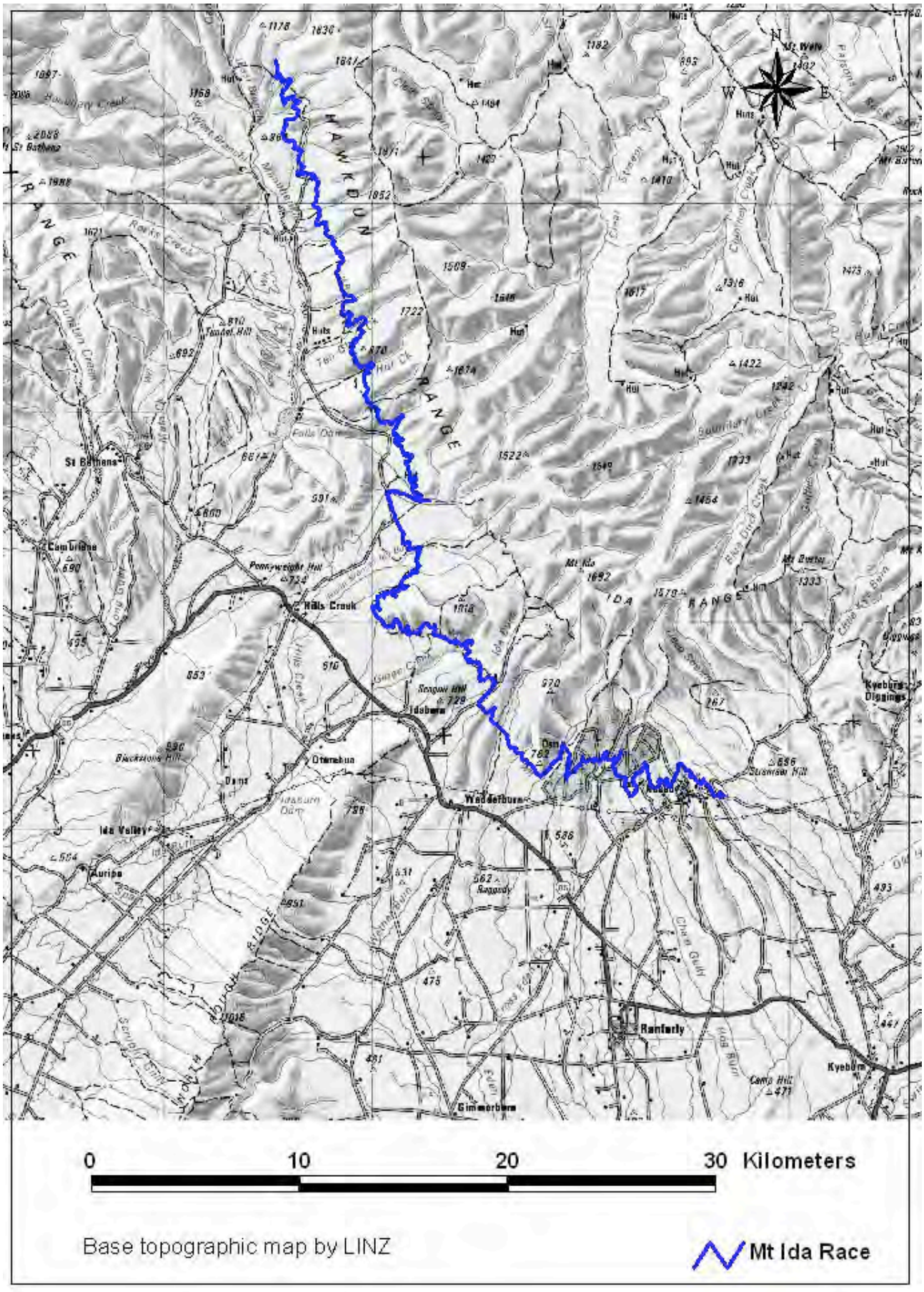
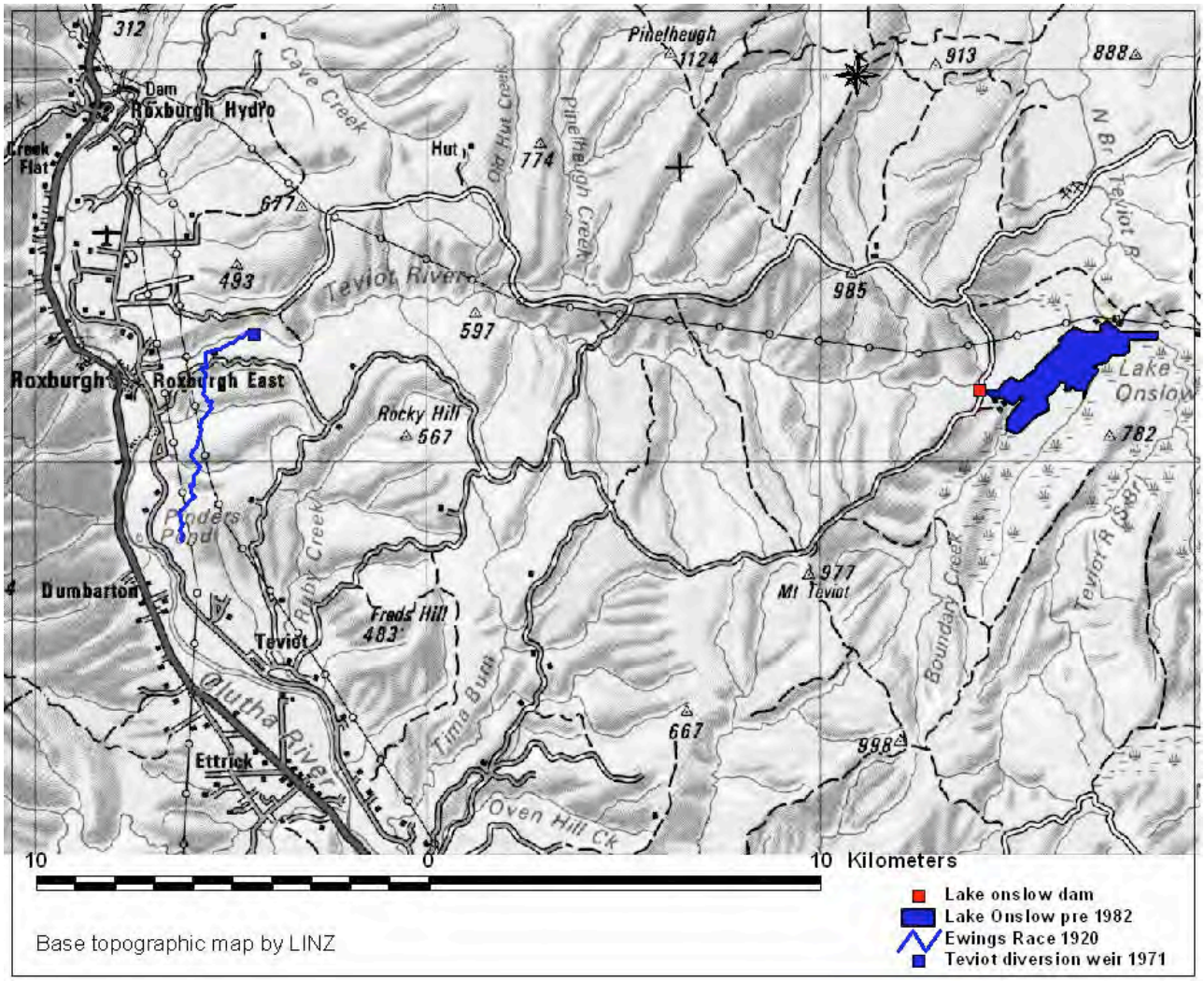
8. APPENDICES

Appendix A – Location map Mt Ida Water Race
Appendix B – Location map Teviot Lake Onslow and Ewings Race
Appendix C – Table 1 – Central Otago Irrigation Dams

Appendix A – Location map for Mt Ida Water Race



Appendix B – Location map for Teviot Irrigation and Power



Appendix C – Table of Central Otago Irrigation Dams

Dam	Date Completed	Brief description	Basic dimensions		Reservoir Volume (10^6 m^3)	Catchment Area (km^2)
			Height (m)	Length (m)		
Lake Onslow	1888 1894 1934 1938 1968 1982	Stone course gravity dam Increased height Steel frame hardwood sheath addition Additional height Flood damage reinstatement concrete cap + timber/steel frame Concrete arch downstream of original now drowned	5.5 7.0 7.9 8.13 8.13 12.8	 50 -	 10.16 10.16 46.5	175
Eweburn	1902	Earth embankment with clay u/s & rockfill d/s layers	21.3	189	1.65	14
Upper Manorburn	1914	Concrete arch with mass concrete right abutment	27	123.6	50.9	90
Poolburn	1931	Concrete arch with mass concrete right abutment	32.8	163	28	53
Idaburn	1931	Concrete arch	10.7	33.8	0.21	136
Butchers	1934	Concrete arch	25.4	68.6	2.47	34.5
Lower Manorburn Dam	1934	Concrete arch with mass concrete gravity abutments	15.9	115.2	0.23	398
Falls	1935	Rockfill embankment with concrete upstream membrane	33.5	155	10.3	365
Conroys	1935	Concrete arch	24.4	61	0.93	24.6
Fraser	1937	Concrete arch with mass concrete gravity right abutment	32	137	4.85	119
Loganburn	1984 2006	Rockfill embankment with concrete upstream membrane Concrete block spillway 0.4m raising	17	100	85 90	94
Note that 1 Mm^3 = 1 x 10^6 m^3 = 1000 megalitres = 1000 Ml						