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Sixth National Conference on
Engineering Heritage 1992
Hobart, 5 - 7 October 1992

Moorina Power Development

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SUMMARY. An integrated scheme to use available water resources for generating electricity to power mine machinery and supply sluicing requirements at mines is described. Particular attention is given to construction of the Frome dam showing how a close watch on costs was maintained.

1. INTRODUCTION

The Moorina Power Station is located in the North East of Tasmania four kilometres from Moorina which is on the Tasman highway. The mining activities to which it supplied water and electric power were at Pioneer and South Mt. Cameron on the Gladstone road.

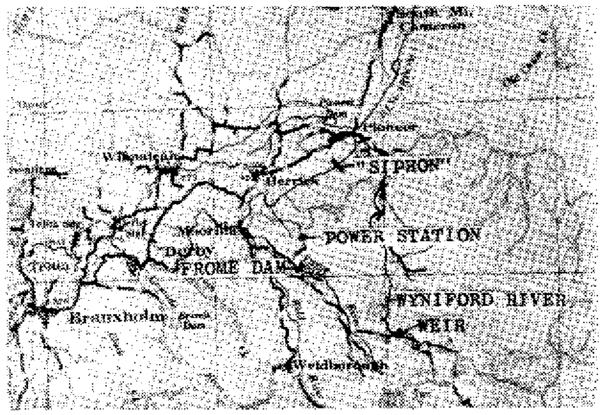

Figure 1. Location of Power Development and Mines

Prior to commissioning of the power station the Pioneer Tin Mining Company operated its workings using water collected from streams and conveyed by races and pipelines for jetting with hydraulic giants and for sluicing. Gravel pumps were mounted on barges and driven by steam power. Figure 2 shows the mine at Pioneer in 1918.

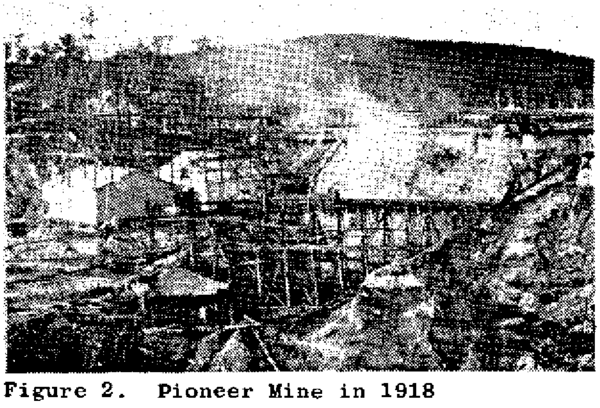

Figure 2. Pioneer Mine in 1918

Continuity of operation was dependent on rainfall, insufficient water being available in dry periods. To improve the water supply and to provide more economical power than steam, it was decided to build a power development using water from the Frome river, with the addition at a later stage of water from the upper reaches of the Wyniford river.

A diversion weir on the Wyniford river at an elevation of approximately 650 metres on the Western side of Blue Tier diverts water by a short race into Kent Creek whence it flows into Wickborg Creek which enters the Frome river at Emu Flat at an elevation of about 490 metres. The weir is constructed of logs faced with concrete and braced by concrete supports. Fig.3 shows details of the weir.

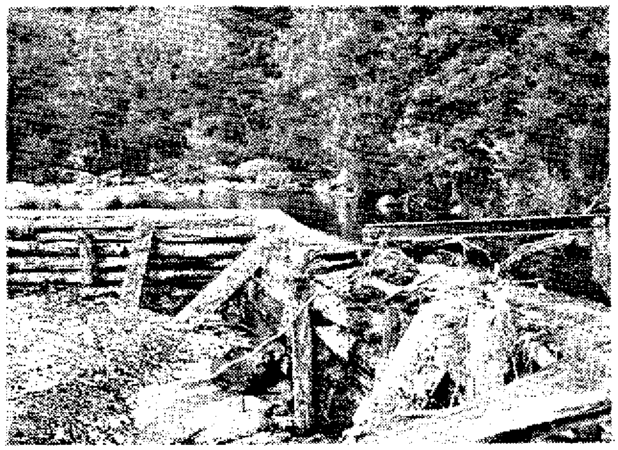

Figure 3. Diversion weir on Wyniford river

Frome lake at an elevation of approximately 330 metres feeds water to the power station at an elevation of 183 metres. Water from the dam is conveyed by a race 3 km in length to the power station penstock. Tail water from the station is taken 10 km by race and pipeline to Pioneer, the Ringarooma river being crossed by an "inverted siphon" shown in Fig.4.

Total catchment area is in the vicinity of 26 square km, average annual rainfall on the lower section being 1143mm and 1830mm on the upper portion.

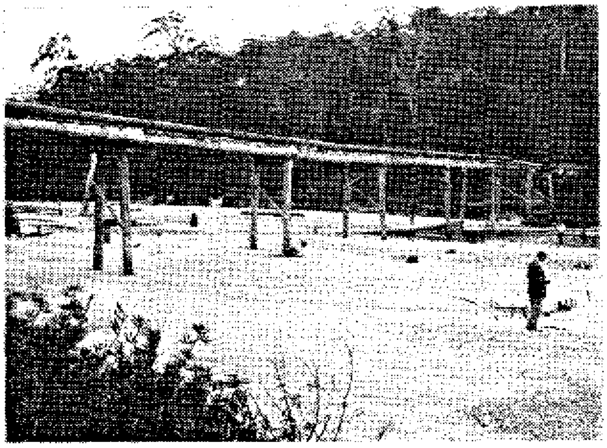

Figure 4. "Inverted siphon" crossing the Ringarooma river

2. CONSTRUCTION OF THE FROME DAM

The Engineer in charge of dam construction, Mr.A.J.Debenham read a paper to the Sydney University Engineering Society on the 10th of June 1910. This has provided a detailed insight into the methods of the time and shows that costs were closely watched.

2.1. Type of Dam

Three different methods of construction were considered, the first being an earth embankment with a clay puddle wall, the second a rock fill with an outside apron of clay. The final decision was in favour of rock fill with a concrete facing wall
The upstream face was dry walled behind the concrete and the downstream face was left rough. As built the length at the top was 192 metres and the capacity to the 15.5 metre level was 1900 Megalitres. Water leaves the dam through a culvert 762 mm (30") diameter 60 metres long.

Figure 5. Frome Dam under construction

2.2. Site Preparation

Where the embankment was to be built an area of 2 ha was cleared, surface material being stripped down to solid rock. Big trees were hand sawn, split and burnt. Sluicing of top soil commenced on the 1st. of December 1907, water being supplied by an old race of 5 sluice heads capacity 5 km long on the south side and a race of 3.5 S.H. capacity on the north side. (One Tasmanian sluice head equals 24 cubic feet per minute or 0.4 cusecs or 0.679 m^3 per minute). A 50.8mm (2") nozzle was fed by the southern race and a 38.1mm (1.5") nozzle by the northern race, working head varying from 12 to 18 metres. Soil removed by sluicing amounted to 5000m^3, sluicing costs ranging from 3.27 to 8.72 cents per cubic metre, with an overall average of 8.46 cents per cubic metre. A further 600 cubic metres of materials were removed by hand.

2.3. Cleaning River Bed

At the embankment site the river bed had previously been worked for tin to a maximum depth of three metres below the present bed level and had then been allowed to fill up with rock and sand. To clear this material, the river was dammed upstream and diverted by means of a fluming. An hydraulic lift with a 44.5mm (1.75") nozzle was used to clear water from the excavation allowing the drift and stones to be barrowed out. About 500 cubic metres of materials were removed in this way.

2.4. Culvert

A rubble concrete foundation 2 metres wide and 76 metres long was laid on a slope of 1 in 120, the thickness varying from 610mm (2 feet) to 2438mm (8 feet). Concrete for the foundation consisted of one part cement, two and a half parts of sand hand screened through 3.25mm mesh and five parts of rock hand broken to 50.8mm (2"). As the concrete was placed large rubble stones were added to constitute about 50% of the volume. A total of 190 cubic metres of foundation were laid before the culvert itself was commenced.

The culvert is of circular cross section 762mm (30") inside diameter with a length of 60 metres.Crown thickness is 304mm (12") and sidewall thickness is 381mm (15"). The centre portion is reinforced in the crown with 12.7mm diameter annular rods 1219mm (4 feet) long at a spacing of four per 3.6 metre (12 feet) length of culvert.Adjoining sections were joined with six 12.7mm rods 610mm (2 feet) long. On the inlet end an iron pipe 3.6 metres long with a wall thickness of 12.7mm was built in. It has a flanged end projecting just beyond the concrete for attachment of the control valve.

Concrete for the culvert was 1:2:4 of a "quaking" consistancy. Granite was hand broken to pass through a 32mm diameter screen and sand was screened through 6.35 mm mesh.

Table I shows the cost of concrete for both foundation and culvert including placing in position.

Cement was English Portland transported in barrels and cost $2-35 per barrel at site.

TABLE I

COST OF CONCRETE FOR CULVERT / M^3

	Foundation	Culvert
Forms................		$0.97
Sand.................	$0.36	0.27
Broken granite("metal")	1.46	1.15
Cement and M.P. stores	4.01	4.76
Mixing and placing....	1.31	0.82
General..............	1.06	0.82
Administration........	0.48	0.29
Totals...............	$8.68	$9.08

2.4. Quarries

The first quarry to be worked was No.3 at a height of 13 metres above datum. A two cylinder steam winch and shear legs were used for lifting rocks up to 3.5 tonnes weight on to end tipping 1066mm gauge trucks running on 20 kg/metre rails. Blasting powder in long holes was used for breaking down and gelignite for popping. This quarry was abandoned when rock quality deteriorated.

No.2 was the next to operate, the first level being 3.6 metres above datum and supplied material for covering the culvert. A second level at 6 metres above datum supplied rock for walling on the upstream face of the dam.

The final quarry, No.6, was located 240 metres south of the dam and 21 metres above the finished level of rock work. A self acting tramway was used to convey rock to the site, the maximum grade of the top half being 1 in 8.4 and of the lower half 1 in 4.15. The track was laid with three rails, a turnout being provided at the centre for trucks to pass. Two loading winches and six trucks of 2.14 cubic metres capacity were used. The haulage rope for the tramway was 16mm diameter made from galvanised wire. Two 1219mm (4 feet) dia. wheels were in the brake house, one with two grooves and one with three. A rim brake passed around the three grooved wheel and was actuated by a lever, screw and hand wheel.

In quarries other than Nos.2 and 3, blasting powder was not satisfactory and after trials it was found that "Rack a Rock" was most suitable in the deep holes being cheaper and breaking well to the bottom of the hole without shattering.

Costs associated with quarrying are set out in Table II.

2.5. Dry Walling

The front face of the embankment was dry walled with stones up to two tonnes in weight placed with the aid of Trewhella jacks and wedged with spalls to the proper angle of 1:1 given by guide lines. Behind the front stones the interstices were packed with small rocks for a distance back of 3 metres. The back of the embankment was left rough at a slope of 1 in 1.5.

2.6. Concrete Facing Wall

A foundation trench was cut for the whole length of the embankment varying from 3 to 1.2 metres deep. The concrete wall was 1066mm (42") thick at the bottom reducing to

TABLE II

COST OF QUARRYING

		QUARRIES				
		No.1	No.2	No.3	No.5	No.6
Total quantities dumped,Cubic metres		4,237	2,991	4,118	1,082	12,190
Drilling & charging holes,cents/m^3		18.9	15.15	3.43	9.53	11.1
Drill sharpening	ditto	3.44	1.79	1.66	2.93	3.72
Explosives	"	2.76	3.0	3.51	1.03	1.75
Trucking	"	13.8	19.55	14.45	8.9	11.1
Winch	"	3.8	3.31	3.18	2.76	4.08
Dumping	"	4.08	7.57	2.46	3.39	5.26
Administration	"	3.42	3.18	2.76	2.76	1.39
General charges	"	7.57	4.27	4.13	6.2	4.08
TOTAL,cents per cubic metre		57.77	57.82	35.58	37.50	42.48
mm drilled/m^3, broken		124-219	110-221	52-157	68-116	147-187
kg of explosives per cubic metre, broken.	Gelignite	.077-.052	.075-.051	.014	.019	.024
	Powder	---	.079	.192	---	---
	Cheddite	.016	---	---	.017	---
	Rack a Rock	.047	---	---	---	.064
Metres drilled per set per day		3 men 2.44-3.51	3 men 2.30-2.78	2 men 2.59-6.50	2&3 men 2.58-2.74	3 men 2.57-4.28
Cost of drilling,cents/metre.		98-68	96-86	62-25	77-72	93-56
No. of bits per metre drilled		14.6-26.5	---	---	9.48-12.5	8.53-16.6
Cost of sharpening, per bit.		1.34 cents to 2.96 cents				

(From an average compiled each fortnight)

457mm (18") at the 12 metre level and 152mm (6") at the top. A flying fox was used for placing concrete utilising steel bound wooden buckets supported from pivots just below the centre of gravity so that they would tip when a catch was released. The operation of running out 150 metres, emptying and returning the bucket took two minutes under fair conditions.

Moveable forms of 38mm timber, 3657mm(12 ft.) long and 610mm (2 ft.) wide were used.They were secured by 16mm bolts 305mm (12") long placed with nuts embedded in the concrete. The day after pouring the bolts were rotated to avoid bonding with the concrete. When the forms were to be lifted the bolts were unscrewed leaving the nuts in the concrete. As the forms were raised the lower holes were fitted with bolts that picked up the nuts left in the concrete.

2.7. Spillway

The spillway was 54.4 metres wide and 915mm (3 ft.) deep. It is interesting to note that in the big flood of 1929 the crest of the dam was topped to a depth of 305mm (3 feet).

2.8. Walkway and Outlet Valve

A walkway 25 metres long was built to a control platform supported by 228mm (9") mine column cast iron pipes braced with 63.5mm (2.5") angle section steel. A gate valve operated by a 63.5mm (2.5") dia. rod was fitted to the entrance of the outlet culvert.

2.9. Material Used

Materials used included 25,000 cubic metres of rock filling, 330 cubic metres of concrete for the foundations of the facing wall and 650 cubic metres of concrete for the wall.

2.10. Manpower

The average number of men for six months was one hundred, and sixty for the remainder of the project.

Fig.6 is a recent photograph of the dam taken when the water level was low.

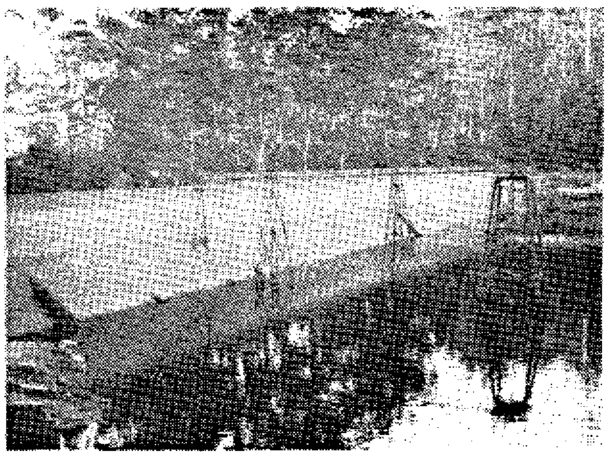

Figure 6. Frome Dam showing walkway.

2.11. General Comment

It is evident that the dam was well engineered and constructed and that close cost control was exercised. Eighty three years have passed since the scheme became operational and time has proven the quality of design and workmanship. The dam was raised by 1.83 metres (6 feet) in 1911

3. POWER STATION

The power station was commissioned in April 1909 and is believed to be the oldest hydro electric station still operating in Australia. It was predated by the Duck Reach power station in Launceston which commenced service in December 1895, and by the Mt. Bischoff power station at Waratah which was producing electricity before December 1907. Neither of these stations are now in service.

Ordering of machinery commenced in 1907, the major construction work taking place in 1908 with substantial completion by April 1909.

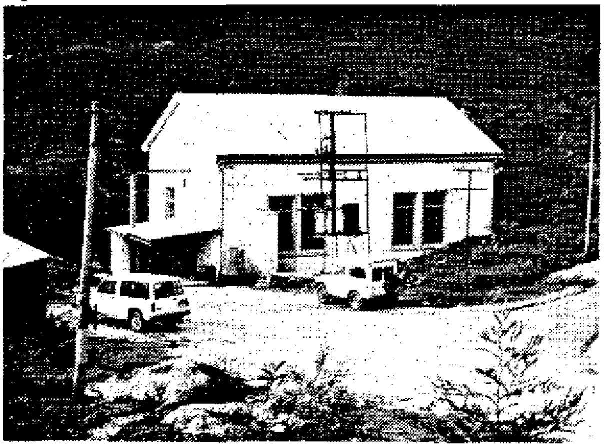

Figure 7. Moorina Power Station

3.1. Penstock

The penstock consists of 385 metres of 914mm (36") dia. steel pipe of rivetted construction. The static head is 132 metres.

3.2. Building

Machinery is housed in a galvanised steel building framed in large section timber.

3.3. Machinery

Three impulse turbines, serial numbers 3028, 3029 and 3030 made by J.M.Voith (Heidenheim) in 1908, rated at 480 HP (358KW) on a static head of 129 metres with a flow of 355 litres/second drive three A.G.E. three phase 6,500 volt 50 cycle 360 KVA alternator.. Excitation is provided by direct current units mounted on the end of each alternator shaft. For optimum efficiency, loading is 300 to 330 KW per machine and 900KW for the station.

Figures 8,9 and 10 illustrate the machines and the control panel, all of which are maintained in very good condition.

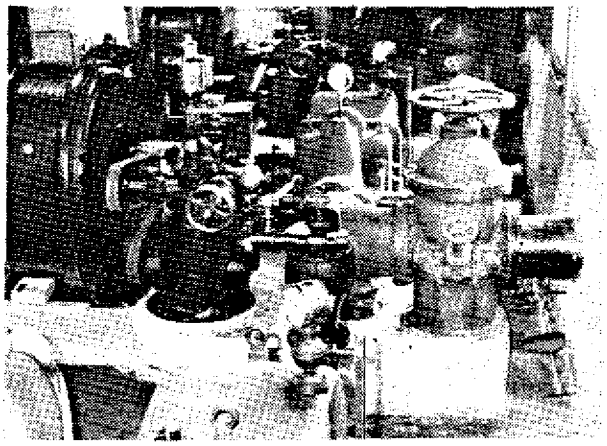

Figure 8. General view of Turbines and Alternators

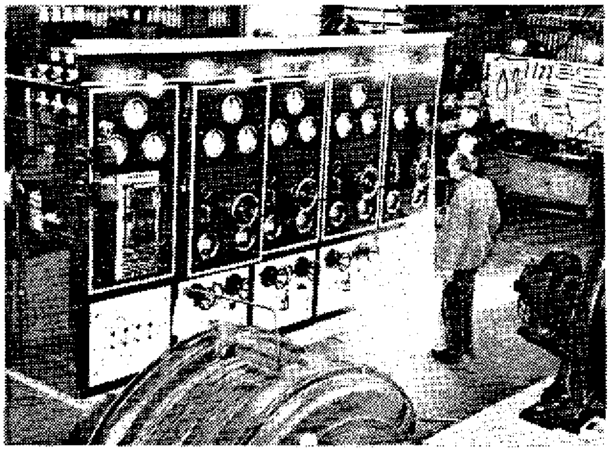

Figure 10. Control Panel, in almost original condition

On each turbine shaft is a flywheel and the outer component of a flexible coupling that uses a long leather belt woven through the outer unit and an inner unit mounted on the alternator shaft. The coupling also acts as a mechanical overload protection device. The governor and servo pump are belt driven from the alternator shaft.

The control panel with instruments and switchgear which is located in the power station building is in almost original condition. Twin carbon filament globes are used for phase synchronisation when connecting to the Tasmanian H.E.C. grid which takes the full output of the station at 22,000 volts.

Power was supplied to the mines through solid 9.2mm copper wires on wooden poles.

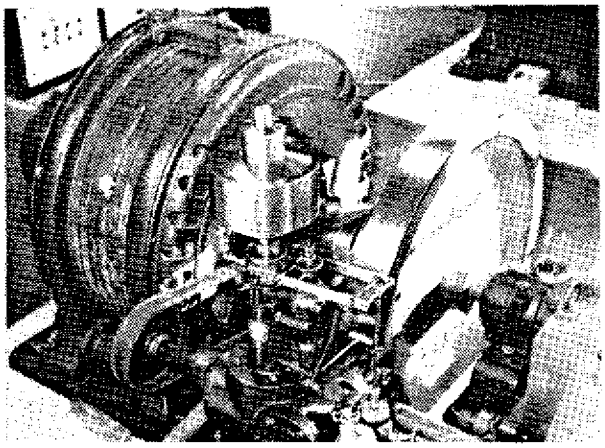

Figure 9. Alternator, flywheel and governor

4. CONCLUSION

Since tin mining ceased at Pioneer and South Mt. Cameron the power station has continued to operate supplying power to the H.E.C. grid. It is to be hoped that the H.E.C. will be in a position to continue the purchase of the station output as it would be unable to remain in service if this market ceased. Should operation be discontinued deterioration of the whole Power Development would be rapid.

The power scheme is being worked and maintained at the present time (1992) by Messrs Tas King, Mike Cook, and Peter Dixon who have invested their own resources to do so. It is of prime historical and heritage value not only due to its age, but also its good design and intact condition.

5. ACKNOWLEDGEMENTS

Paper read to the Sydney University Eng. Society by Mr. A.J.Debenham, 16 June 1910

Reports of the Secretary of Mines 1907, 1908 and 1909.

The Institution of Engineers Heritage Committee file CF6.

Mr. Henry MacFie who collected and researched most of the material on file CF6.

Messrs T.King, M.Cook and P.Dixon who provided information and access to the Power Development.

The Tin Mine Museum at Derby for permission to use photographs Fig. 2 and 5.