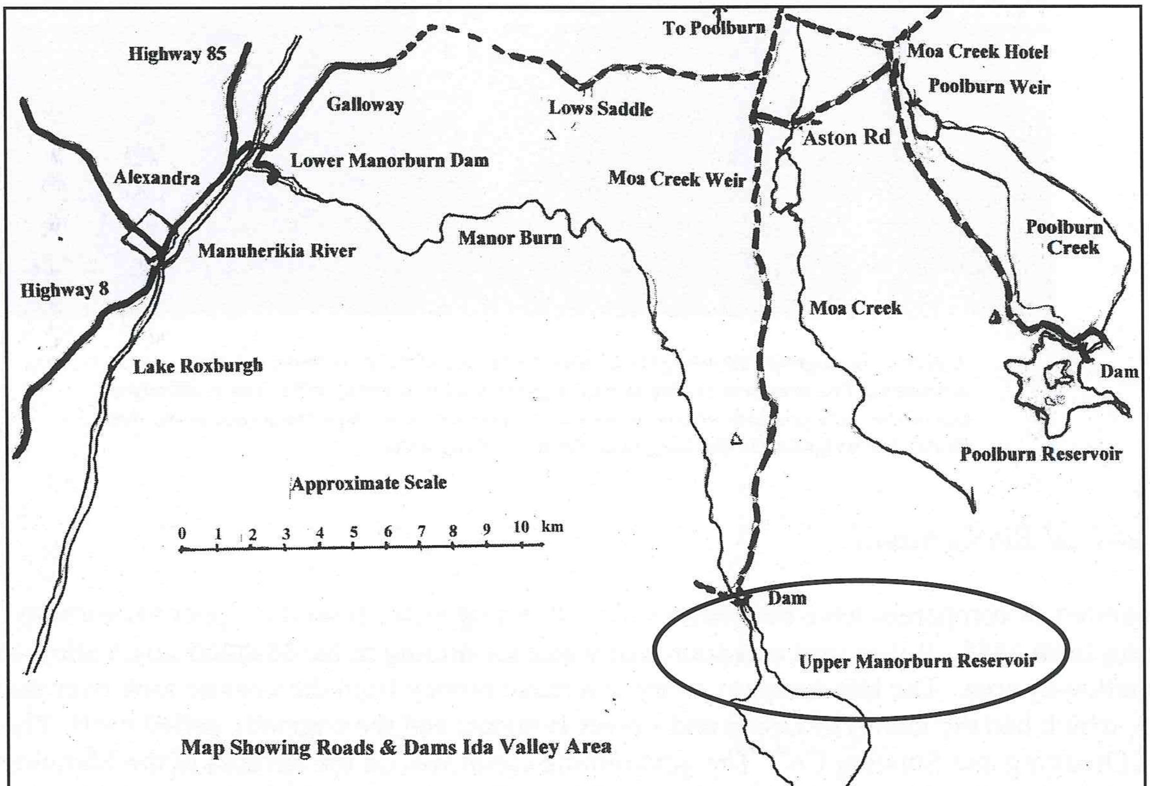
Upper Manorburn Dam

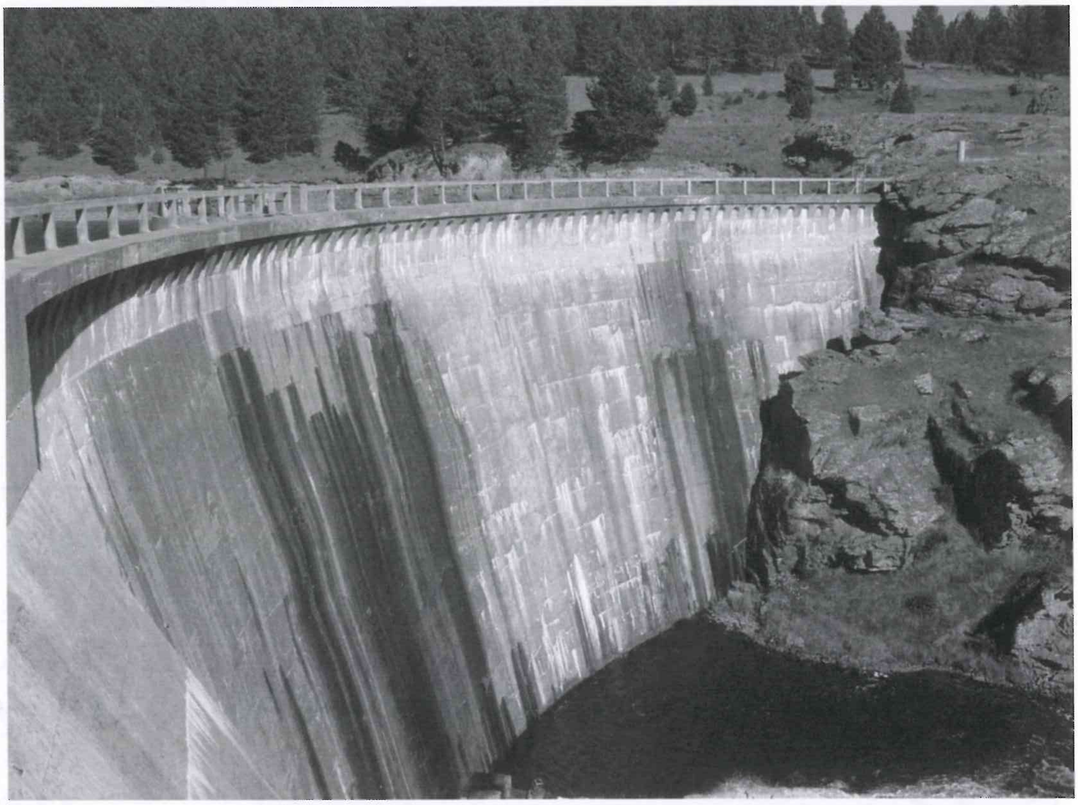
Concrete Arch Dam	7500 cu yd concrete
Completed	1916
Height Above Stream bed	88 ft
Radius of dam	195 ft
Length of Crest	387 ft



Map Showing Roads & Dams Ida Valley Area

Upper Manorburn Dam

This account is prepared from the Engineering presentation to the NZ Society of Civil Engineers in the Proceedings 1920-21, Volume 7, and research of the Public Works Department files held at NZ Archives in Dunedin.



A recent photograph showing the downstream face of the dam from the right abutment. The arch was replaced with a gravity section about 1955. The walkway on top of the dam provides access to the valve chamber on the upstream face of the dam. Water for irrigation is discharged at the base of the dam.

Historical Background

A number of companies have been involved in diverting water from the Upper Manorburn Creek, starting from 1865. It was seen as a source of water for mining in the Manuherikia Valley, mainly in the Galloway area. The last company to try and make money from the venture took over the races in 1889, which had the names of Upper and Lower Bonanza and the company called itself 'The Bonanza Gold Dredging and Sluicing Co'. The gold mining claim was on the terraces of the Manuherikia River near where Dip Creek meets the Manuherikia River. To secure a better water supply for sluicing, the company built a 22 ft high arch dam at the exit of the Greenland Swamp. This dam was later flooded by the water impounded in the Upper Manorburn Dam. By 1906 the gold recovery from the mining claim was no longer economic and the shareholders were anxious to sell the scheme. The Government purchased the company assets and undertook a review of irrigation schemes. Money had been set aside and public funds allocated to irrigate the Ida Valley in 1906.

J. H. Dobson an engineer with the Public Works Department conducted a survey with J. L. Bruce of the Department of Agriculture and found that 60 farmers in the Ida Valley were prepared to pay 10 shillings per head of water per week.

An amendment was made to the Public Works Act in 1910, requiring the Government to assure itself that any scheme implemented would be self supporting before proceeding with development. F. W. Furkert was the District Engineer in Dunedin for the Public Works Department from 1908 until 1912, and it was due to his interest in irrigation and foresight that the Ida Valley irrigation scheme was developed. Survey established that a storage reservoir in the Upper Manorburn, sufficiently large to store the whole annual run off of the catchment area, could be built. The proposal was to build a new dam, and enlarge the existing Upper Bonanza race to pass the increased flow. This race allowed water to be dropped down into Moa Creek, and by enlarging the Lower Bonanza race, it could provide water to the Galloway basin via Lows Saddle. The race system was designed to irrigate the lower slopes of both sides of the Ida Valley. Diversion weirs were envisioned for both the Moa and Poolburn Creeks.

Approval for the irrigation scheme

On 4 February 1912 an Order in Council was being prepared for the Ida Valley Irrigation Scheme and the Engineer in Chief of the Public Works advised the District Engineer to commence construction of the dam. The order was passed by the Government on 29 February and by 16 March, the Under-Secretary to the Minister advised the District Engineer that the Minister wanted construction work started before the winter with £500 approved for work.

Early work on the scheme

The District Engineer F. W. Furkert, advised the Under–Secretary that the following work could be commenced:

- Road improvements could be made to the dam site
- Barracks could be erected at the site for accommodation. (Tents were considered unsuitable due to the altitude)
- Sand pits and quarries could be opened at the site
- A phone line could be built to the dam

The Maniototo County Council Engineer was asked to provide a grader, and he said that six horses would be needed to pull the grader for a level road, but eight would be required to keep the grader fully employed. The extra two horses would cost 10 shillings a day.

An early road grader working in a street at Christchurch. This would have been similar to the road grader which was used on the road up to the Upper Manorburn Dam site. These graders were made by Caterpillar and required an operator at the rear who controlled the blade and a second person who handled the horses.

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In April F. W. Furkert was advised that he had been promoted to the position of Inspecting Engineer and he left the Dunedin District for Wellington. J. H. Dobson, who was the engineer at the Alexandra Residency of the Public Works Department, was left in charge, to carry out the survey of the irrigation scheme, and sign up the farmers to irrigation agreements. By 13 May the road had been graded sufficiently to allow timber to be carted to the dam site by a local runholder, Sinnamon, using his horses and wagon. The cost of cartage from Aston Rd to the dam provided by Sinnamon using six horses and wagon driver was 40 shillings per day, and for four horses 30 shillings per day.

On 24 May, Sinnamon advised that he wanted £2 per ton mile for cartage of cement from Aston Rd to the dam site. The Engineering Report indicates that the cost of the horse drawn transport was later let at a rate of 3 shillings and 9 pence per ton mile which is considerably less than Sinnamon's asking price! Lack of water and feed on the road to the dam was one of the troubles of letting the contracts, said F. W. Furkert.

By 17 May J. Turnbull had been appointed Project Overseer and was staying at the Moa Creek Hotel. A decision was made to build a house to accommodate Turnbull and his family because of a lack of suitable housing available. It was intended that the house could be used later by the raceman. A site was selected at the school reserve and £500 was approved for the house.

Plans for the barrack accommodation at the dam were completed and the building was to be lined with timber inside and outside with paper between to provide insulation against the winter conditions. The Under-Secretary approved the construction of the barracks, and two, two roomed cottages, at the site, with all buildings to be equipped with ranges. It was decided to mark the side of the road to the dam with 6ft poles, which indicates the amount of snow expected during the winter months.

On 8 June J. Turnbull advised the District Engineer that stores and cement sheds had been built at Aston Rd and at the dam site. He needed the location of the dam so that the foundations could be excavated. A plan was provided by the Engineer in Chief, and on the 28 August J. H. Dobson had sent the plan of the dam back to Wellington with the ground contours marked up.

By 12 August a phone line extension from Moa Creek to the dam site had been costed at £20 per mile using reinforced concrete posts, 66 yards apart, and on 11th September construction was well advanced. Details of the plant to be used on the dam were given to the District Engineer T. M. Ball by the Engineer in Chief, and these included a 30HP engine for the rock crusher, and a 15HP engine for the transporter that was to be located above the dam site. Steel wire rope had already been ordered for the transporter and a tender was let to John McGregor in Dunedin for the steelwork in September.

On 18 September the Engineer in Chief advised that he would visit the dam site and sent a plan of the proposed dam site with a request to have the foundations excavated. A sample of rock from the quarry adjacent to the dam site was taken to Dunedin to be crushed and tested in concrete blocks.

A telegram from Wellington to Dunedin on the 6 March 1913 advised that the site of the dam was being altered to avoid a fault line. The District Engineer advised Turnbull to open up the quarry and sand pit and press on with the Moa Creek and Poolburn weirs, while the dam site issue was being resolved.

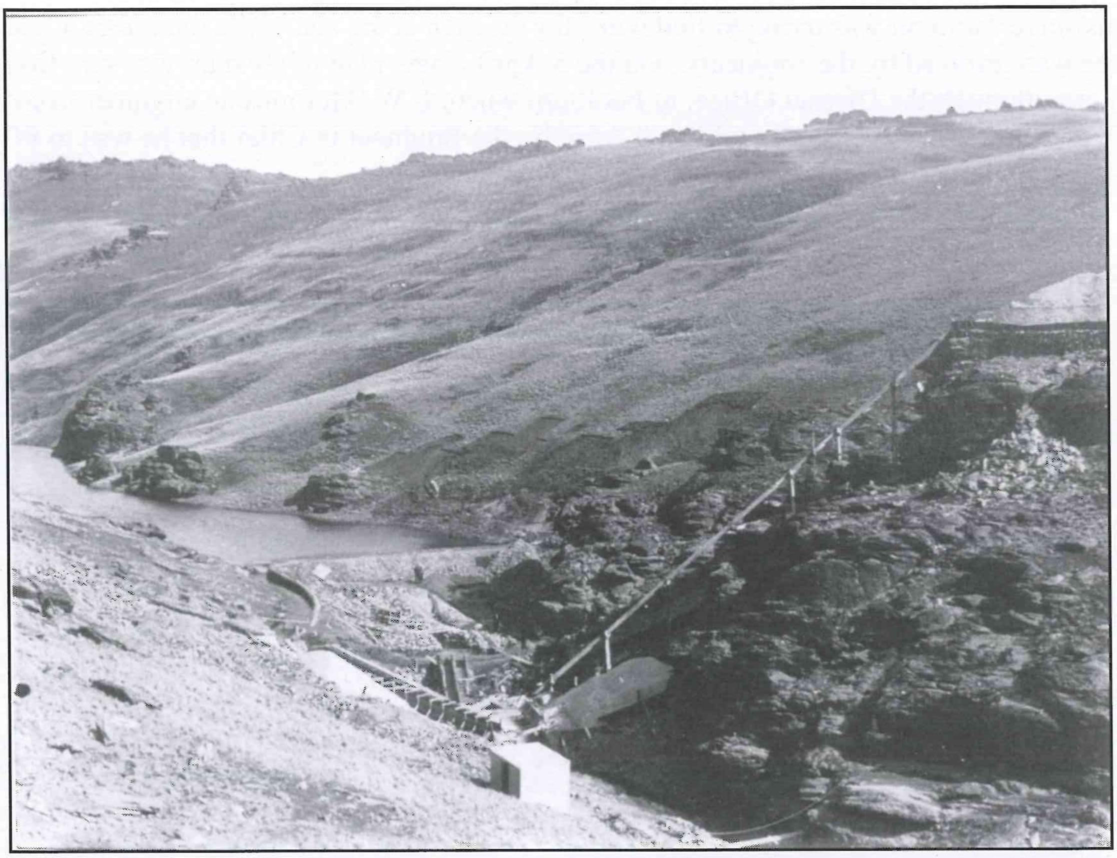
R. E. Holmes, the Engineer in Chief, told T. M. Bolt that the fault in the dam site should have been advised before the excavation was completed. To which Bolt replied that the fault was only discovered when loose debris was being removed from the foundations.

At this stage Turnbull was trying to find work for the men at the site while the effect of the fault on the dam site was resolved by the engineers. On the 5 April a new plan of the dam was sent from Wellington through the District Office, to Poolburn where E.W. McEnnis an engineer from Head Office, was now located. He was told on 9 April by the Engineer in Chief that he was to fill the crack in the foundation with concrete.

A close up of work on the fault in the base of the dam. The excavation is being done by hand tools and it would have been laborious work lifting the material out of the deep slot in the rock. On the right of the photograph is the sand cleaning operation with the shute and raw sand behind, and washed sand at the front.

E. W. McEnnis was summoned to Wellington by the Under-Secretary to meet the Minister of Works regarding other issues, but he had by then gone inland to Hawea Flat. While there he advised that a map of the fault was being sent down to Dunedin from Poolburn. By 16 April E.W. McEnnis was back in Dunedin and Tyndall, an Assistant Engineer at Moa Creek, informed him that the survey of the Moa Creek weir was nearly finished. What would he do next Tyndall asked? On 24 April Tyndall advised that he had pegged out the Manorburn dam site to the best of his ability, but there was a lack of information concerning the top section of the dam. E. W. McEnnis who had arrived back at the dam site, advised the District Engineer that the belting to drive the crusher had not yet arrived by 13 May. Heavy floods occurred in the Manorburn Stream on 3 June and the District Engineer wanted to know what J. Turnbull had the men doing.

On 5 June the District Engineer advised that nothing was to be done at Poolburn until the decision by the Minister regarding the whole irrigation scheme was known.



An early view of the dam construction. The upstream coffer dam is diverting the water around the right side of the valley in a race and flume. The long shute on the left bank is to allow the sand, which was being carted to the site, to be washed where there was access to water below the dam site. The dam site was still being investigated.

Start made on the dam foundations

On 4 August 1913, T. M. Bolt, the District Engineer, told J. Turnbull to start excavating the foundations as there was no use waiting for the stream to go down. He was to erect a fifteen inch diameter siphon across the excavation to pass the water. J. Turnbull advised on 14 August that the floods were continuing and the excavation was full of water. He was told to install more siphons!

In the meantime an issue arose with Trades Hall in Dunedin, who wrote to the Minister on the 2 September as follows; 'that improvements are required to accommodation for workers on irrigation schemes in Central Otago. Men are living in calico tents and the mens bedding is practically wet all winter due to frost and rain coming through the calico. The tents should have wooden floors and a real rain proof roof.'

J. Turnbull replied to the District Engineer that all the tents had flys on frames well pitched above. Only one man wanted a timber floor and he had been supplied with three boards.

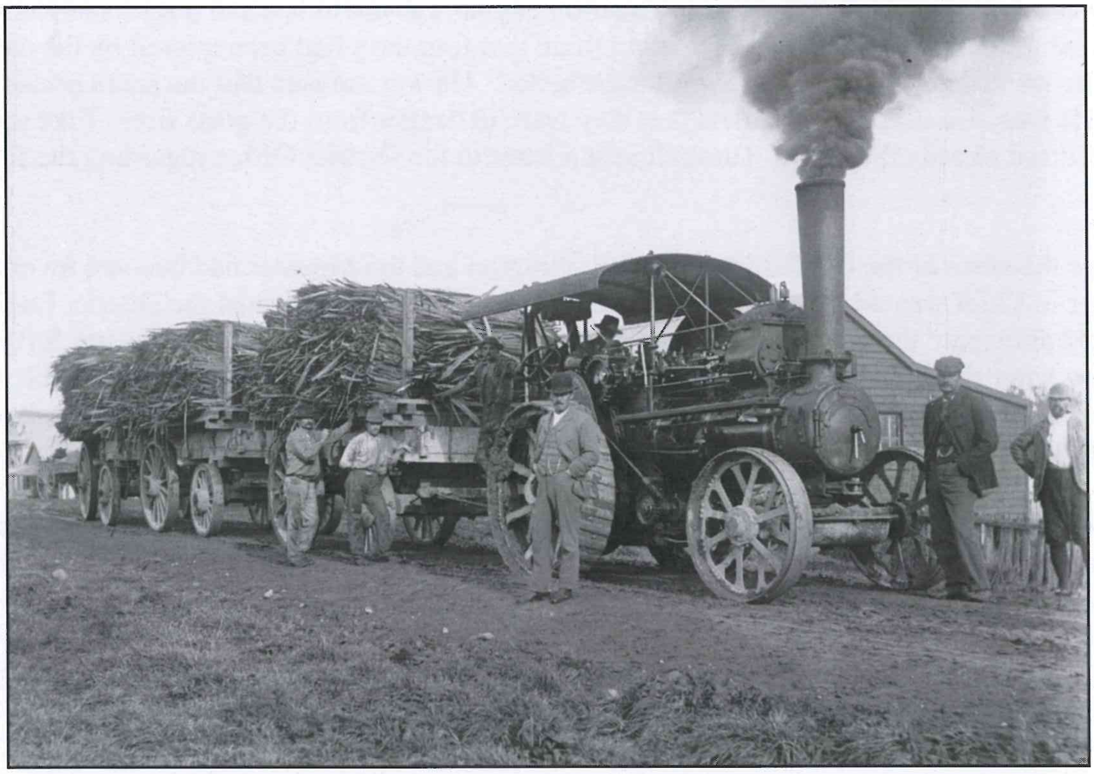
On 11 September J. Turnbull advised that he had started pumping again on the excavations but on the next day there was a bad leak in the upstream bag dam caused by heavy rain. Progress was then made and all the water pumped out and mud cleared from the fault by 19 September. E. W. McEnnis, who by this time had returned to Wellington, was told that the fault had been excavated to a depth of 10ft and was still 18 inches wide. There were twenty six men working on the excavation. McEnnis advised that they were to excavate the fault down to 14ft, and clean up the excavation.

Getting the plant ready for concreting

Meanwhile the winch for the transporter had been delivered to the site from Andersons in Christchurch, and the steelwork from J. McGregor in Dunedin. The District Engineer asked J.Turnbull if the transporter was ready to use, and if the rock bins had been completed at the concrete batching plant. On 3 October J. Turnbull advised T. Ball that the excavation of the fault would be completed in a week, the rock bins were nearly ready, and the crusher had been tried. The transporter bed was also completed. Water had been pumped to a reservoir cut into the hillside but it leaked badly. There was now storage for 80 tons of cement at the dam and 40 tons at Aston Rd. E. W. McEnnis advised the Engineer in Chief on 23 October that the fissure in the foundation had been cleaned and the rock was now closed. There was no need to shift the alignment of the dam.

The Engineer in Chief advised the District Engineer on 30 October 1913 that the dam was now ready for concreting. By 3 November cement was being carted to the dam site. The District Engineer reported to the Engineer in Chief that the plant was ready on site. Andersons were testing the transporter winch but the haulage was slow, and the cast iron items were breaking. These items were to be replaced by steel. In the meantime, an inclined tramway was being used to deliver concrete from the batching plant to the bottom of the gully in one and a half yard wagons.

On 21 November the District Engineer advised J.Turnbull that a traction engine, together with two twelve ton trucks, were being dispatched from Canterbury to take over haulage of the cement from the Ida Valley rail head to Aston Rd. The engine could travel 40 miles a day and a coal stage would be required to feed the steam engine.



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A traction engine of the period steam driven with a coal fired boiler. The engines were rated at six horsepower and could pull wagons along flat roads. This engine is pulling a load of flax but similar wagons would have been used for hauling the cement in the Ida Valley.

Advice was received by the District Engineer that the Engineer in Chief R. E. Holmes would be arriving on 3 December to inspect the works.

It appeared that the District Office had become aware of the cost of telegrams from Moa Creek and J.Turnbull was told by telegram that 'there are too many telegrams'.

After a lot of correspondence between Turnbull and District Office, where he pointed out that the horse and buggy was not suitable transport for him to the dam, as it was required to meet men arriving at the rail and for transport of goods, he was given a motorcycle. However by 5 January 1914 he was requesting a bolt for the bike and a repair kit. He also wanted spare nuts and bolts because the journey on the road to the dam was very rough. He was told by the Dunedin Office to check the nuts and bolts before setting out!

Men were arriving on the same day as advice was received from Dunedin that they had been hired. The horse and buggy was often in use elsewhere and the Labour Department needed to advise Turnbull before the men left Dunedin by train.

Saga of the Traction Engine

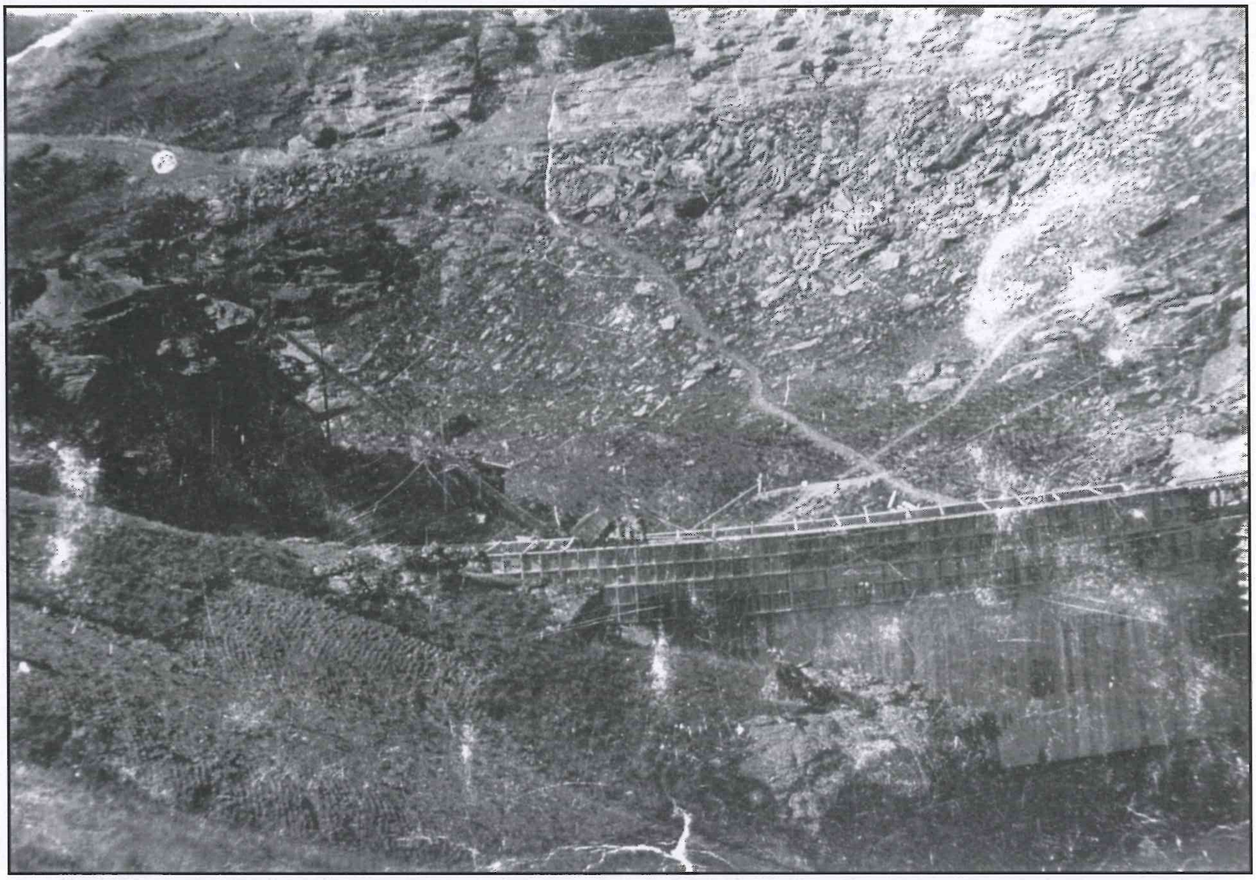
On 12 January1915 fires were being started along the roadside from the railway station to Aston Rd as the steam engine ferried the cement, but by 15 January the engine had stopped, due to a broken belt which had to be replaced.

Turnbull was advised on 15 January that the traction engine was not to be used until a spark arrestor had been fitted to the chimney. He told District Office that four days had been missed by the traction engine and he wanted cement supplies by rail to be halted. He was advised that the spark arrestor had been sent. He was also told by the settlers that they were in danger from the grass fires. Five small fires had occurred already they said. Turnbull sent a letter to the District Office regarding the fires and liability.

By this time the news of the fires had spread to Wellington and the Minister had become involved. The Engineer in Chief wanted to know if the spark arrestor worked and advised the District Engineer that he should anticipate these problems to avoid complaints to the Minister! Matters were further inflamed by a letter from the Engineer in Chief to the District Engineer on 27 January in which he said 'settlers are still complaining about fires, and the bituminous coal being used, which was nearly all slack, resulting in sparks still flying'.

The District Engineer advised Wellington on 5 February that the spark arrestor was now working. However on 2 March the Minister was upset because the settlers had written to say there were more sparks causing fires!

Finally on 6 March 1915 the traction engine broke down completely and a replacement was requested urgently.



The dam is over halfway in height as concrete is being lowered from the overhead cableway and poured into the prepared boxing. Behind the dam on the left hand side can be seen the shute for the sand with the unloading point above. There is an access track on the right below the cliffs to allow cement to be taken to the concrete plant. The overhead wire can be seen just above the track level.

Concrete is poured at the dam

Meanwhile back at the dam site on 29 January 1914, the cog wheels on the transporter were overheating and Turnbull wanted Andersons to replicate them. This was followed with advice on 3 February that the jig wheel brake on the transporter had to be replaced as it was faulty. He also said that lighting was being set up at the site so concreting could be carried out at night for continuous or eighteen hour pours. The transporter winch was to be used continuously to lift sand for the concrete batching plant and to take concrete out to the dam wall. On 12 February Turnbull proposed the use of rails instead of trestles on the dam to the District Engineer.

The Chief Engineer advised the District Engineer on the use of expansion joints on the dam and on 27 February Turnbull was told that the vertical and horizontal construction joints were to be faced with brown paper.

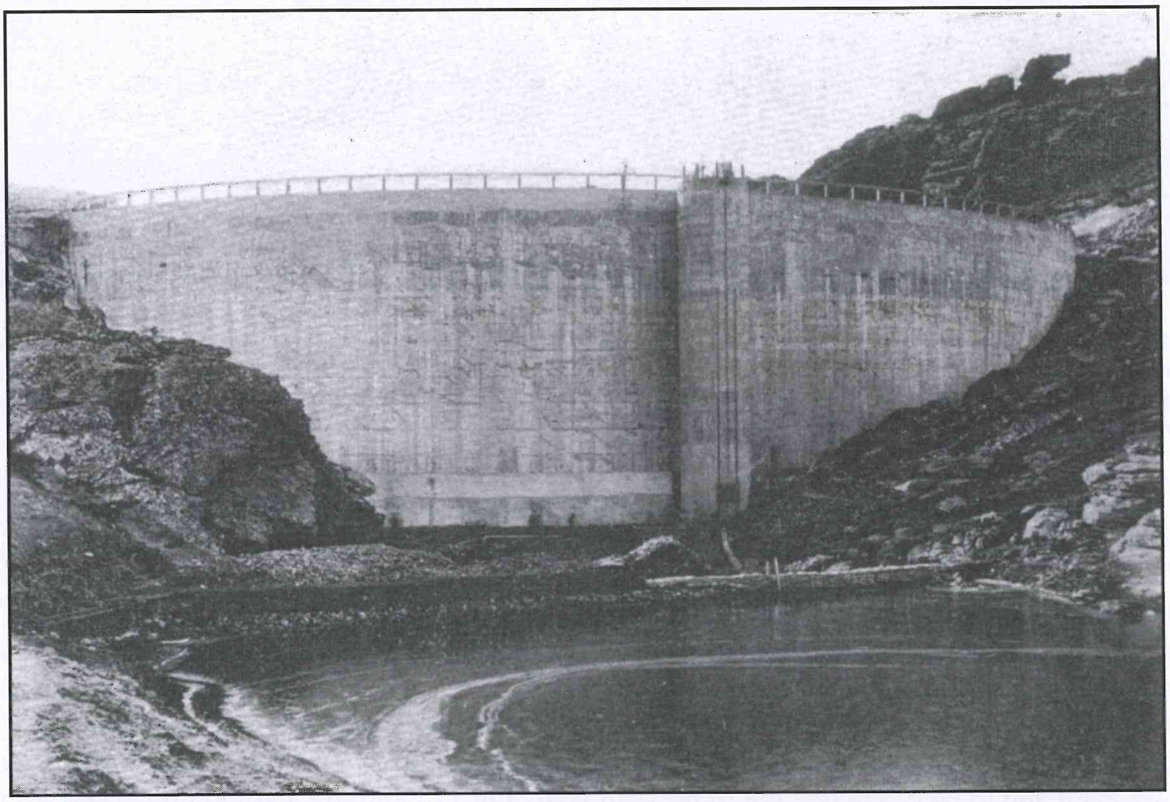
On 7 March there was a report that 3000 bags of cement had been carted into the dam site over the last twelve months and much of it was now too weak to be used in the dam. The proposed use was in strengthening the sides of the Upper Bonanza race.

There was a gap in the file and the next entry is on 9 November when there are 2000 bags of old cement that had been marked. The Assistant Engineer on site was Tyndall and he was told to change the mix for the concrete on the dam.

On 15 February 1915 a new Assistant Engineer G. W. King advised the District Engineer that they had resumed concrete pours using a chute. A new truck for the floor of the dam was urgently required. The incline from the batching plant had been discarded and they were now using a staging and a chute. By 23 February King advised that 41 trucks of cement were required to complete the dam but this did not include the Moa Creek Weir. There were daily telegrams to the District Engineer giving the amount of concrete poured in the dam and by 13 March the dam had reached the 2435ft level and men were leaving the site. A telegram followed from E. W. McEnnis to the Engineer in Chief saying 'heavy frosts have set in and in one case the concrete took 24 hours to set'.

The work was finished for the season with the dam at the 2439ft level.

On 20 October 1915 J. R. Marks appeared as the Engineer and advised that 50 tons of cement were required to complete the dam with the 1000 bags on hand that had been tested.



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A view of the upstream coffer dam and the face of the dam before the gate was shut and the area flooded. The circular valve tower shows clearly and at the bottom can be seen the shut off gate valve. At the stage the photograph was taken the water was being released through the valve chamber and into the pipes through the dam wall.

By 24 January 1916 the dam had been completed and J R Marks asked the District Engineer if he could start the excavation of the Poolburn weir. He was told to put the men on to the concreting of the Upper Bonanza race instead.

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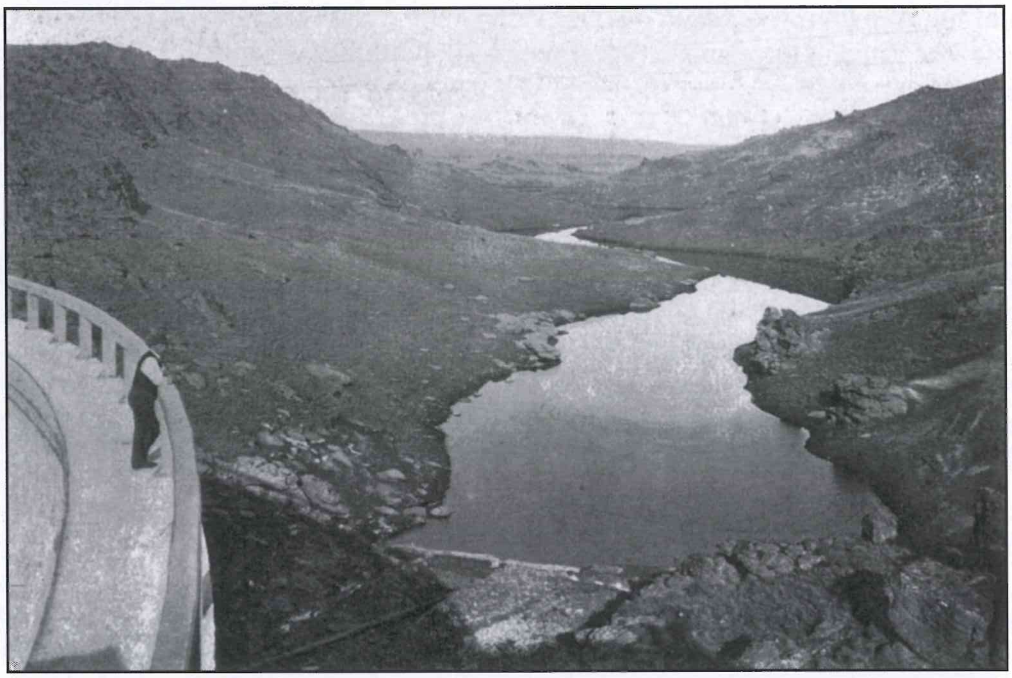
The Upper Bonanza race is being lined with concrete to reduce the leakage of water. The cement was judged to be too old to be used in the dam. Concrete is mixed in the race and the bags of aggregate along the race, will have been carried in by workmen. Looking on is J. R. Marks, on the left, the site Engineer, and alongside C. J. McKenzie the Engineer in Chief from Wellington.



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Looking back up the Manorburn Creek from the left of the dam before it is filled. The upstream coffer dam is still in operation. The quarry and concrete batching plant is on the right hand abutment and out of sight.

On 29 February the inside face of the dam was plastered to seal the leaks which had appeared on the downstream face of the dam when it was first filled.

An article appeared in the Otago Daily Times on 23 May 1916 at the completion of the Upper Manorburn Dam, and featured C. J. McKenzie the Engineer in Chief and J. R. Marks who was the Engineer in charge of the construction.

A report appeared later from J. R. Marks on 10 August 1916 from Poolburn, advising that the water level in the dam was now 25ft and the Greenland Dam was submerged.

Engineering Report

Storage of the reservoir

A complete contour survey of the storage basin was undertaken to ascertain the storage capacity of any dam height selected. Rainfall and water flow records for the Upper Taieri headwaters were used to predict the probable runoff from the catchment. It was decided to use a figure of 1.45 times the mean anticipated annual flow as being the storage required. The dam height of 88ft produced a lake seven miles long and a lake area of 1728 acres. It was not anticipated that the reservoir would be full very often, but in order to take no risks, the dam was designed for an overflow of 2ft 6 inches.

The dam site selected was in a schist gorge, with the left abutment being craggy and the right sloping gradually, with the rock covered by a few feet of soil.

Design of the dam

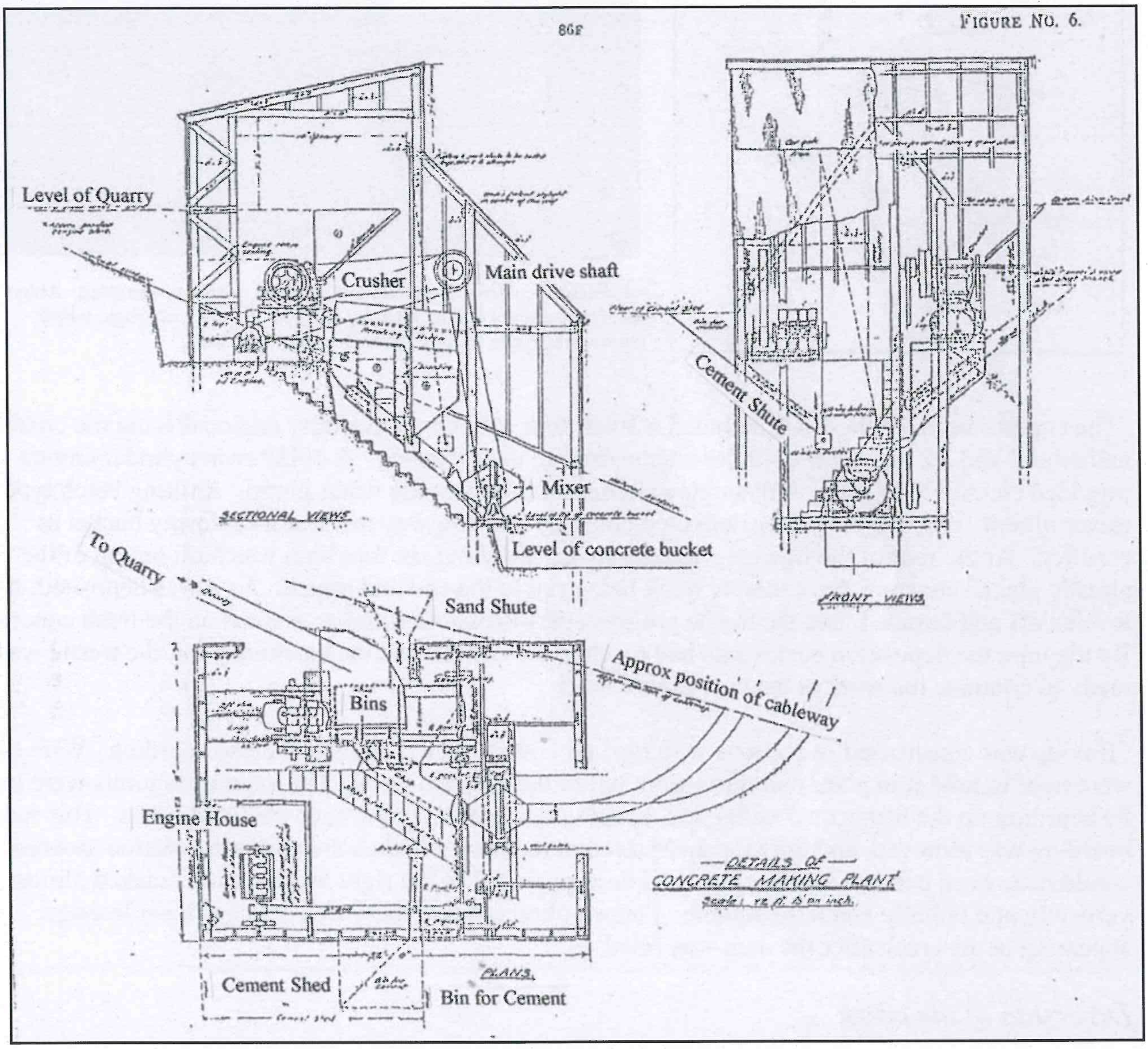
The design of the arch dam was based on a maximum stress in the concrete of 310 lbs per square inch. Concrete was rated to have an average strength of 2240 lbs per square inch which provided a safety factor of seven. The horizontal thickness was computed for a cylinder under external pressure. A minimum thickness of 3ft just below the crest was used, and the base thickness was 25ft with the dam section tapering evenly between top and bottom. The dam had a crest length of 387ft and contained 7,500cu yards of concrete.

An unusual feature of the dam was the use of a separate valve chamber 16ft in diameter, located on the upstream side of the dam. This contained two 24 inch diameter gate valves which are connected to 24 inch cast iron pipes carried through the wall of the dam. The purpose of the tower was to enable inspection of the valves. The valves are operated by hand wheels at the top of the tower. A sluice valve was located on the upstream face of the tower to shut off the water entry, and allow the tower to be drained for inspection of the gate valves.

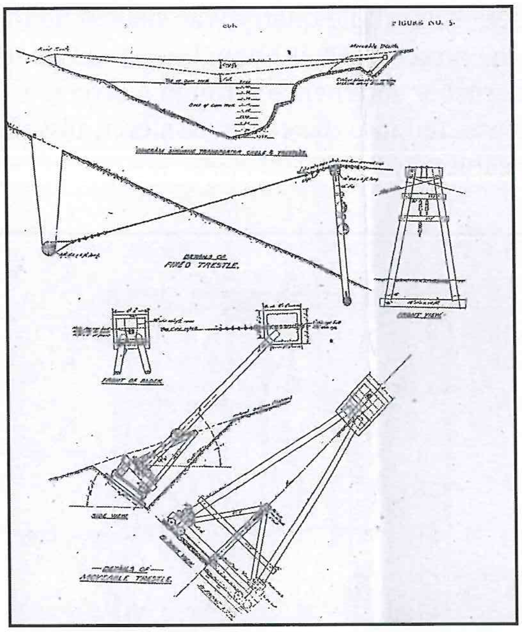
Aggregate, sand and batching plant

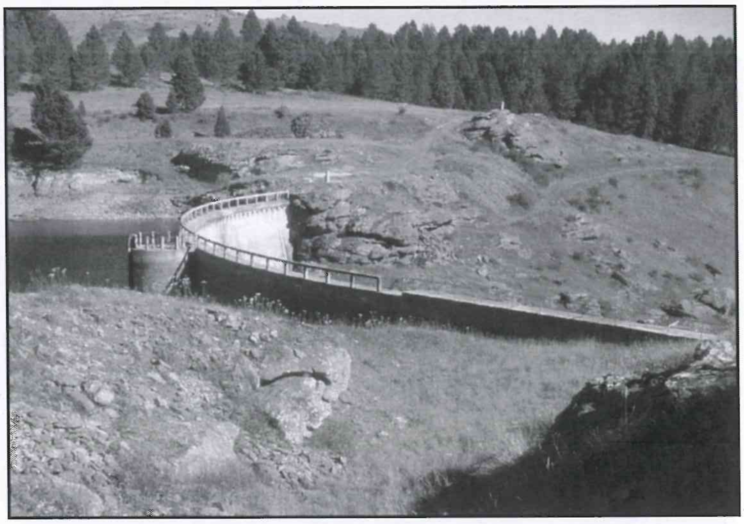
Rock at the site was found to be hard and the experimental concrete blocks proved satisfactory. Sand however proved a problem as there was no sand in the neighbourhood. The whole country for miles around was scoured, and nothing better could be found than the deposit from which the Greenland Dam had been built. The sand was lying on top of schist rock in a large basin and covered in soil. It was angular and all sizes and contained a good deal of earth. As there was no water where the sand was located, it had to be carted to the dam site and washed. The sand was carted in drays and wagons and tipped on the edge of the gorge into a shute down to river level. The sand came from the opposite side of the gorge from the quarried rock.

At a convenient height for gravity operation, a quarry was selected, tunnels driven and loaded with 1450lbs of gelignite, 25lbs of dynamite, and 130lbs of powder. The whole quarry was shaken up in one blast. A total of 8,075 cubic yards of rock was used on the project. After being broken down to convenient sizes by pop shots, the rock was conveyed to the crusher and thence through a screen to reject the dust, and then into measuring bins. The aggregate was fed into the concrete mixer, together with the sand, which had been lifted across the gorge by the cableway.



A cableway, which was also called the transporter, was designed to cover the greater part of the dam without any dismantling. The loading end was fixed above the batching plant while the other end was attached to a pier mounted on a truck. This pier was inclined backwards at about 45° and the upper end weighted with concrete. The truck moved on a railway track set at the radius of the cableway, and was hauled along with a winch, but due to the engine power being too small, the transporter was too slow to handle both the sand from the washer and the concrete delivery to the dam. A jig was installed to deliver the concrete and this proved satisfactory until the thickness of the dam became less than necessary to support the trestle for the truck. The rest of the dam was then filled from the cableway.





A recent view from the location where the cableway operated. Above the left abutment can be seen the platform for the rail track, which allowed the cable to span the main part of the dam.

The engines used for the work included a 30HP four cylinder heavy duty engine driving the crusher and mixer, and a 21HP three cylinder engine driving the cableway. A 10HP twin cylinder engine provided electric light and a 4HP single cylinder motor drove the water pump. A tilting batch type mixer of half cubic yard capacity delivered concrete into a jigway truck or a cableway bucket as required. At the foot of the jigway, a temporary trestle about six foot high was built on top of the already placed concrete, the concrete truck being run to the end and tipped. As it was deposited, it was leveled off and rammed, and the trestle progressively dismantled and re-erected on the fresh concrete. By the time the deposition backwards had reached the end nearest the batching plant the trestle was ready to continue the work at the next higher level.

Boxing was constructed in sections with top and bottom plates, studs and close boarding. Wire ties were used to hold it in place and these were left in the finished work. The expansion joints were made by boarding up the forms on a radial line, keeping one section in advance about 24 hours. This radial boarding was removed, and brown paper pasted in its place and then the adjoining section poured. It would have been better if another joint had been provided as the right hand section cracked almost vertically and radially about the middle. Furkert observed that there was no significant leakage appearing at the crack after the dam was filled.

Diversion of the creek

To allow the construction, an earthen dam was built a short distance above the permanent dam, to a height a little above the outlet valves, which are placed ten feet above the creek bed. From the by-wash of this dam, a wooden flume carried water over the new dam in the earlier stages of the work, and later, into the outlet pipes after these had been placed. The Greenland dam also acted as a regulator to prevent floods at the new dam. Irrigators had to be supplied from the Greenland dam during construction. Owing to the climate, it was impossible to carry on work during the winter, after which the water rose and swept over the unfinished work. However no damage was done.

In response to questions raised at the delivery of his paper F. W. Furkert made the following comments. He did not know what the dam cost to build as it was only one element in the total irrigation scheme. However the cost of the dam was about one third of the total cost. As to the value of the scheme he cited the case of one settler with 316 acres who, before irrigating his land, scratched out a living by working in mines, on dredges, and on roads, and ran about 70 sheep on his property. He saw this mans land about a fortnight ago and the farmer had just shorn 1500 sheep and was running 1700 sheep in total with only 250 acres being irrigated.

A view of the Ida Valley from the Upper Manorburn Road. Indicated in the photograph is the Moa Creek weir lined with willow and on the far right, out of sight, is the Poolburn Weir. The valley is intensively farmed as a result of the water available from the irrigation dams.

Subsequent events

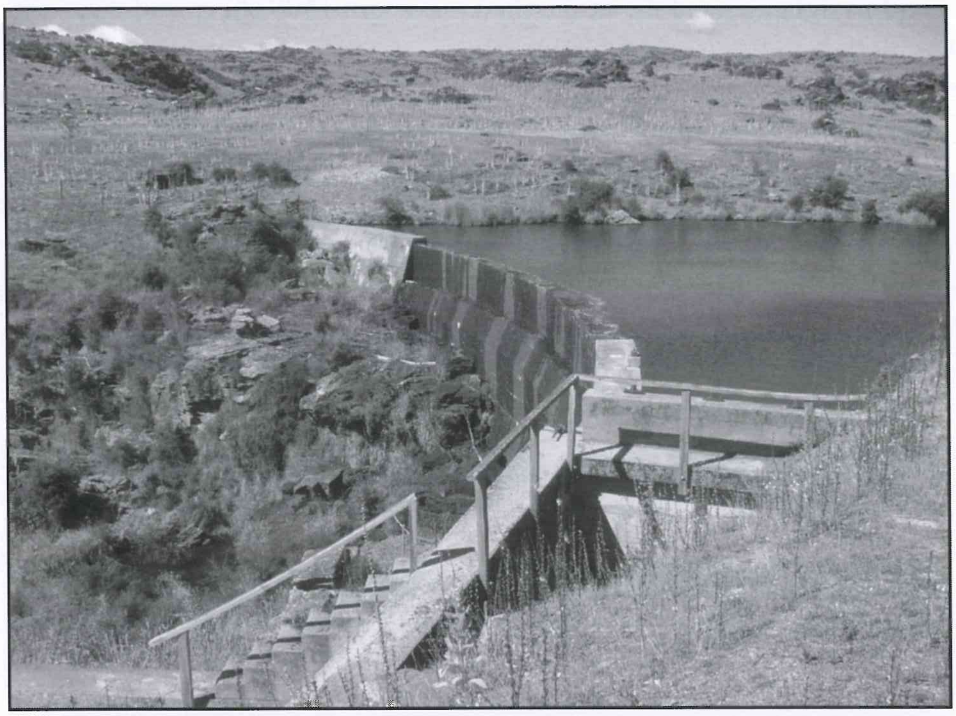
Leakage at the dam, which had increased considerably over the period from 1942 to 1948, was controlled by the guniting of the upstream face in 1948-9. Later cracking in the right abutment of the arch was considered sufficiently serious to warrant the removal of about 100ft of arch concrete which was replaced by a mass concrete abutment block in 1955.

Moa Creek and Poolburn dams

The files do not make it clear when these structures were built. Reference is made to the survey of each but not the pouring of the concrete. Also the size is not detailed. The Report on Irrigation in Central Otago by F. W. Lindup and J. D. Watt provides the following information.

Moa Creek weir

This is a concrete arch structure 41ft high and 200ft across the crest. It has a stilling basin to allow water to be diverted into a race. The dam has a storage of 31 acre ft and is used for day to day regulation of irrigation flows.

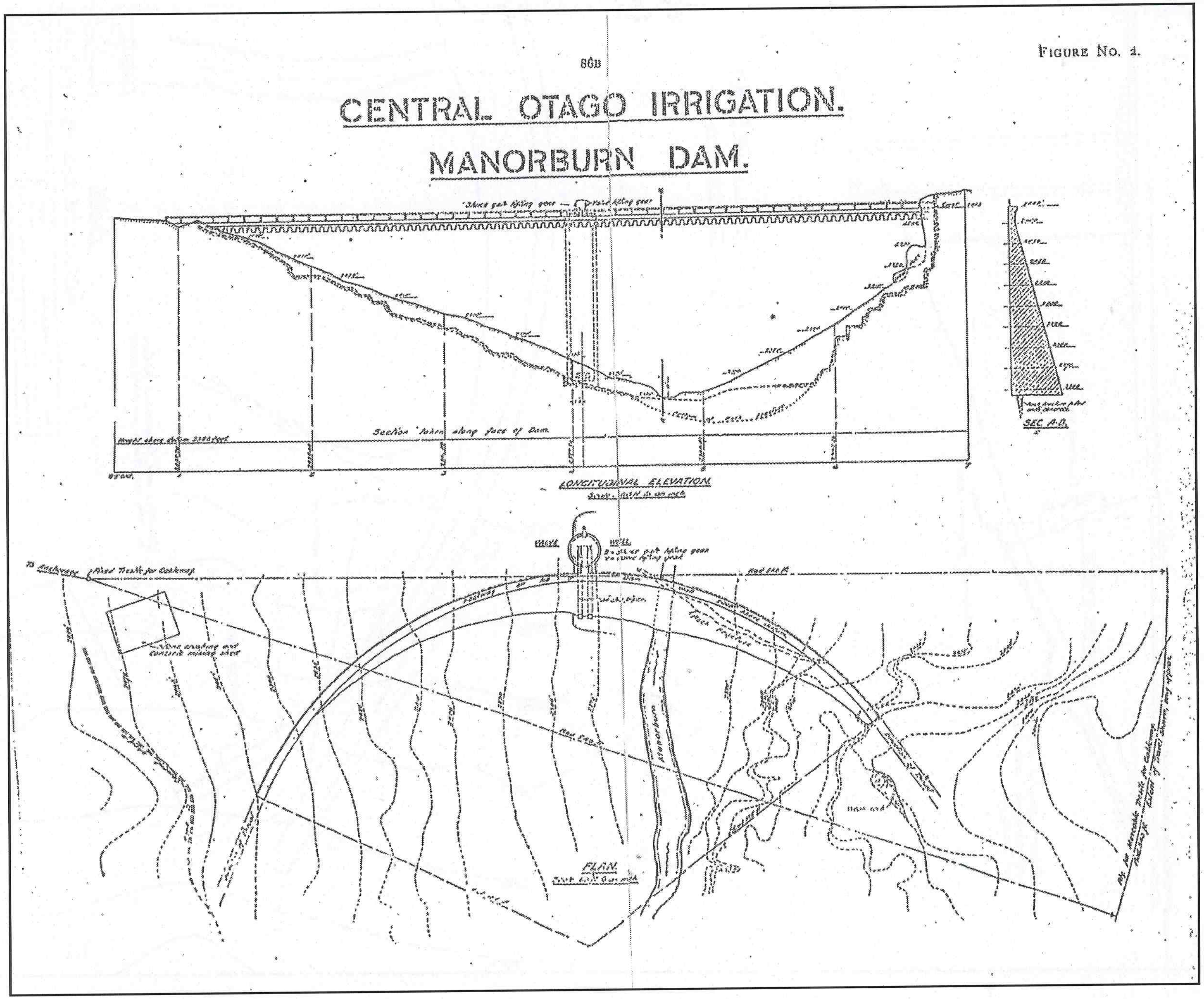


There is an unusual front face on this dam. The structure on the left abutment is a settling chamber and an outlet measuring weir to deliver water to the race system. A valve sets the water discharge from the dam.

Poolburn diverting weir

This dam was in service long before the main Poolburn dam was constructed. It is a concrete arch dam 37ft high and 248ft across the crest. A race interconnects the Moa Creek weir and the Poolburn weir providing water for irrigation of the east side of the Ida Valley. The Poolburn weir stores 48 acre ft of water, and is also used for daily regulation of irrigation flows.

There is a more conventional concrete arch structure at this dam. Water flows in from the Moa Creek weir at the left abutment and discharges to the race system on the east side of the valley at the right abutment.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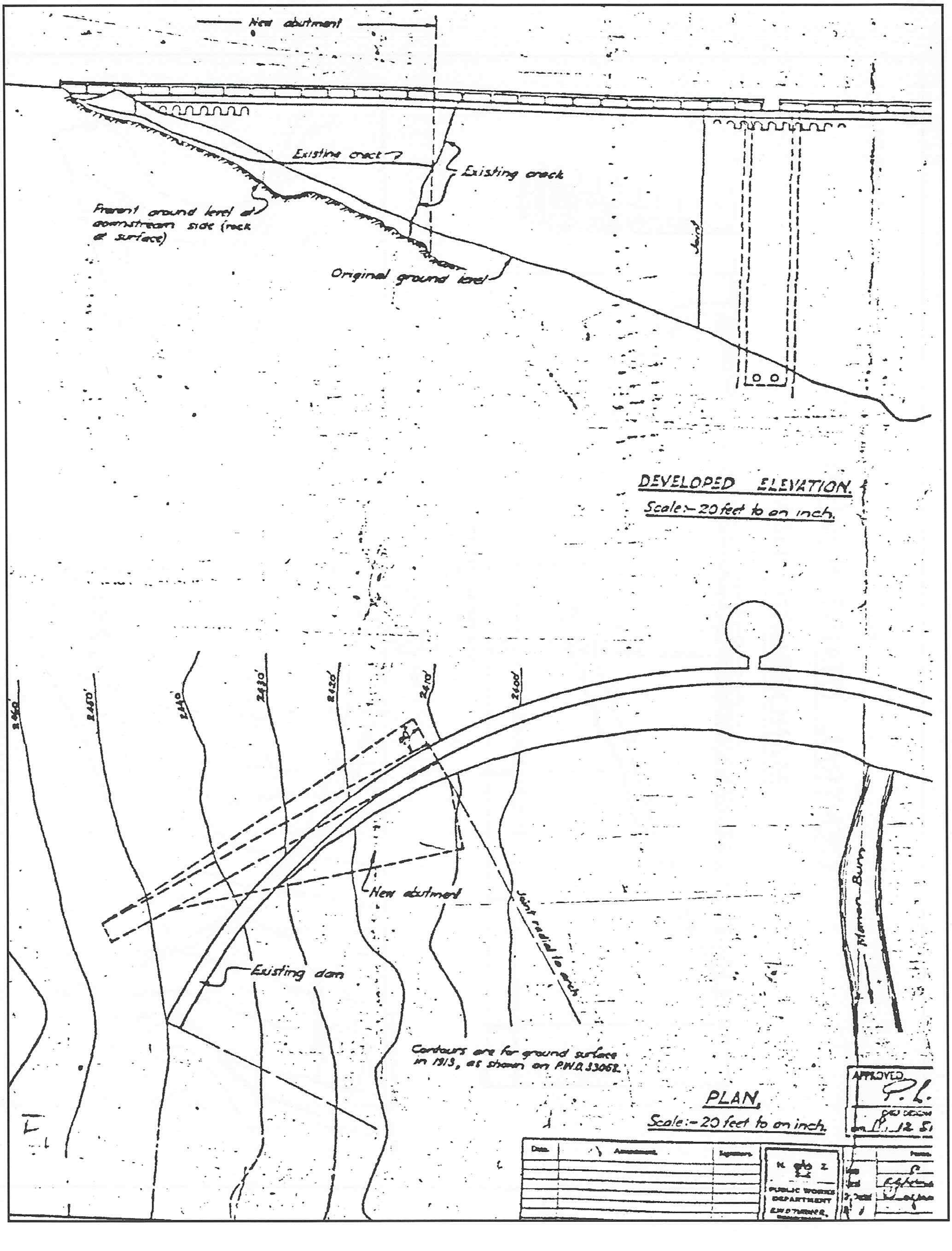
86b
CENTRAL OTAGO IRRIGATION.
MANORBURN DAM.
Section taken along face of Dam.
LONGITUDINAL ELEVATION
SEC. A.B.
WELL
To Anchorage
Fixed Track for Cableway
Manorburn
PLAN



New abutment
Existing crack
Existing crack
Present ground level at downstream side (rock at surface)
Original ground level
Joint
DEVELOPED ELEVATION.
Scale:- 20 feet to an inch.
2450'
2450'
2440
2430'
2420
2410'
2400
New abutment
Joint radial to arch
Existing dam
Moran Burn
Contours are for ground surface in 1913, as shown on P.W.D. 33062.
PLAN.
Scale:- 20 feet to an inch.
APPROVED
Date
Amendment
Signature
PUBLIC WORKS DEPARTMENT