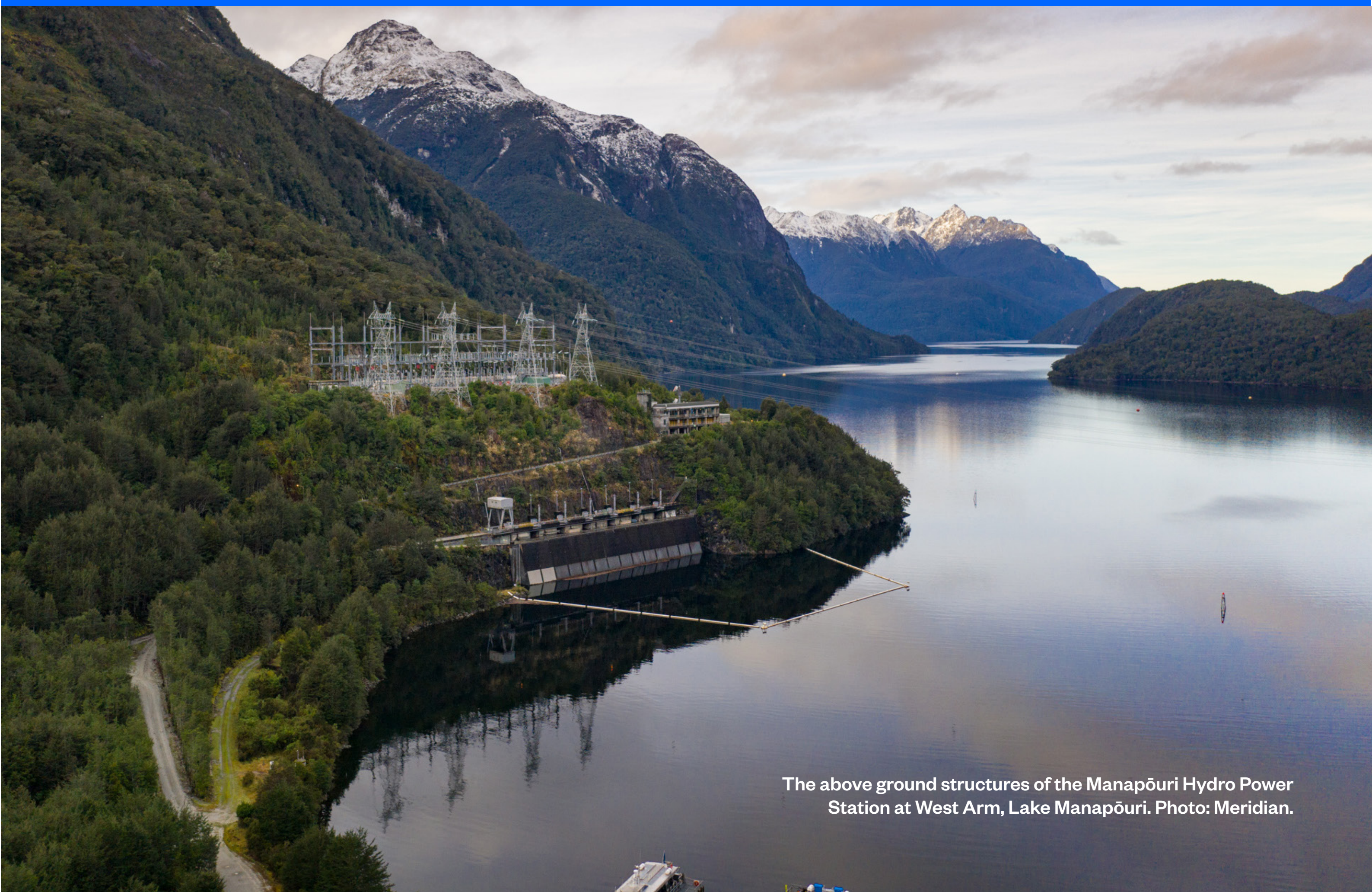
Manapōuri Hydro Power Station, Fiordland National Park

Engineering Heritage Register report

Written by Cindy Jemmett and Lily Pare Hallbutcher

Last amended 28 February 2024



The above ground structures of the Manapōuri Hydro Power Station at West Arm, Lake Manapōuri. Photo: Meridian.

CONTENTS

GENERAL INFORMATION

Name: Manapōuri hydro power station

Alternative names: Manapōuri Hydro-electrical Power Station, Manapōuri Hydro-electric Power Station, Manapōuri Hydro Station, Manapōuri Power Scheme

Location:
West Arm of Lake Manapōuri
Fiordland National Park
Southland

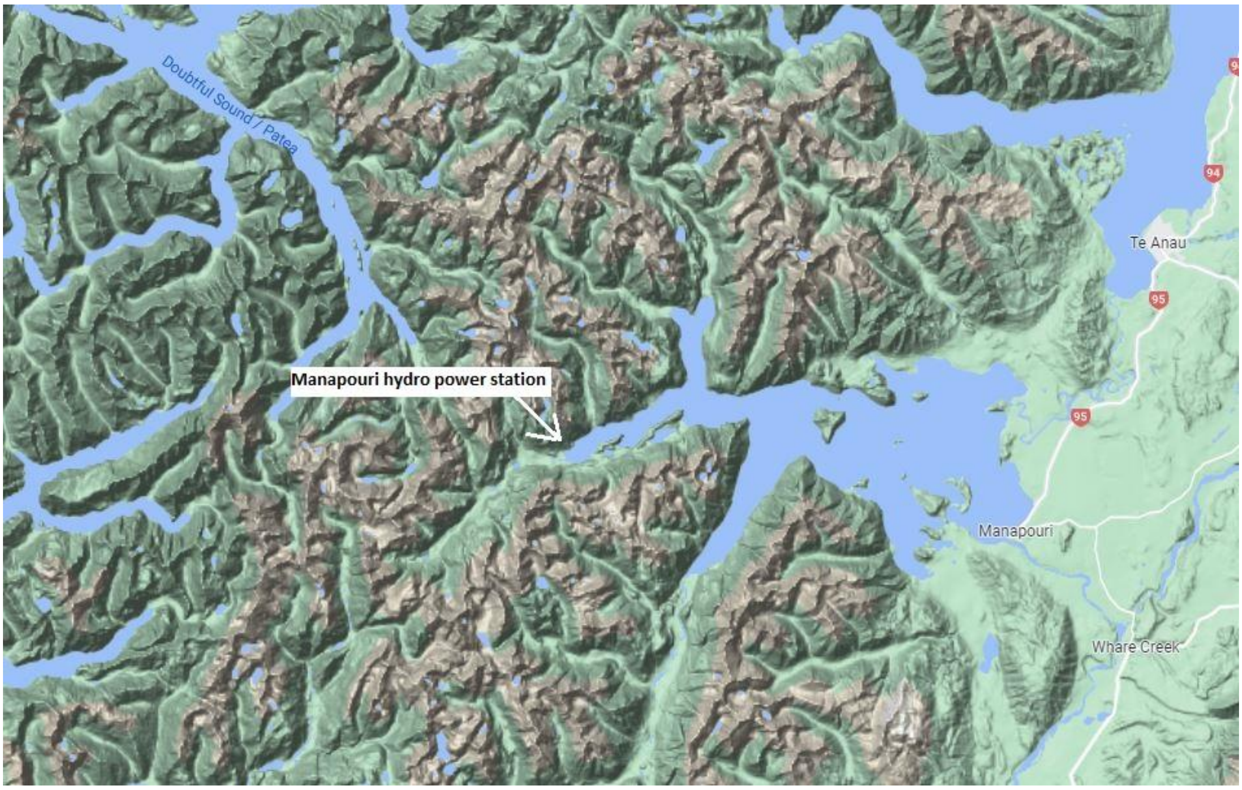
Geo-reference: Latitude -45.521; Longitude 167.278

Legal description: Sec 1-2 SO 12304, Sec 1 SO 12302, Sec 1 SO 12360, Sec 1-2 SO 12306 (Southland Land District), New Zealand Gazette 2007, p.1264

Access information: Manapōuri hydro power station is managed by Meridian. The station is currently closed to visitors.

City/District Council: Southland District Council

Location maps



Date registered: 6 March 2024

Other Engineering New Zealand recognition: None

Other heritage recognition:

- Heritage New Zealand, New Zealand Heritage List/Rārangi Kōrero: No
- Local Authority District Plan: No, the Manapōuri hydro power station is not included in the Southland District Plan Heritage Schedule.

DESCRIPTION

Summary

Manapōuri hydro power station is located in Fiordland National Park. The station was commissioned in 1971 and is New Zealand's largest hydro power scheme. The station is an outstanding technical engineering achievement and a vital part of New Zealand's electricity infrastructure. The Manapōuri hydro power station is also of outstanding heritage significance for its social impact. The environmental campaign that it sparked led to lasting change in public and political attitudes regarding large scale engineering works in the environment.

Interest in a hydro scheme utilising the waters of Lake Manapōuri dates from the early twentieth century. A number of proposals were put forward but did not gain sufficient backing until the 1950s. The project was initiated in order to provide cheap electricity to the, then yet to be built, aluminium smelter at Tīwai Point, 150 kilometres southeast of Manapōuri, at the bottom of the South Island. The New Zealand Government entered into an agreement with aluminium company, Comalco, in 1960 but due to Comalco's lack of capital funds, decided to develop the scheme itself. Construction of the station began in 1963.

The Ministry of Works managed the project and let contracts for the design, supervision and construction. North American company, Bechtel Pacific Corporation, undertook the design and supervision. The major construction contractor for the project was Utah-Williamson-Burnett – a joint venture of Utah Construction and Mining Company of the United States and two local firms, W. Williamson Construction Company Ltd., and Burnett's Motors Ltd., of New Zealand.

Constructing the station was a significant engineering undertaking, made even more challenging by the remote location, high rainfall and hard rock. The project took 1,800 workers eight years to complete and claimed the lives of 18. The station utilises the 178-metre drop between Lake Manapōuri and Doubtful Sound. Water travels through the penstocks to the power house 200 metres below Lake Manapōuri, before discharging through two 10-kilometre tailrace tunnels to Deep Cove in Doubtful Sound. When commissioned in 1971, the station's output was 700 megawatts (MW). This was less than the original designed capacity. The second tailrace tunnel was constructed in 2002 and brought the station's maximum operating output to 800 MW.

The construction of the second tailrace tunnel was overseen by Electricorp (ECNZ) and from 1999 by the newly created Meridian Energy. Engineering and design services for the project were undertaken by US-based engineering firm, Woodward-Clyde and ECNZ's engineering design arm, DesignPower. The contractor for the construction was a joint venture of New Zealand company, Fletcher Construction and international companies Dillingham Construction and Ilbau.

The original plan for the station would have seen the level of Lake Manapōuri raised by up to 30 metres, flooding the lake's islands and leaving the beech forest around the shoreline to rot in the water. As soon as plans were made public many groups expressed their concern and opposition to raising the lake level. The Save Manapōuri campaign, which opposed raising the level of the lake, was launched in 1969 and grew in momentum over the following years. The campaign drew people from across the political spectrum and opened a wider debate about how the nation should use its natural resources. A petition against raising the lake level was presented to parliament in 1970, and in 1972 the incoming Labour Government passed legislation protecting the natural level of the lake. The environmental campaign was nationally significant and has had lasting social and political impact.

HISTORICAL NARRATIVE

Manapōuri hydro power station sits on the shore of West Arm, Lake Manapōuri. The tailrace tunnels run from West Arm through to Deep Cove in Doubtful Sound. It is New Zealand's largest hydro power scheme.[1]

The number of original names bestowed by Māori for places and natural landscape features in Fiordland, Doubtful Sound and Lake Manapōuri show that Māori knew the area well and that these places hold layers of history and significance. Moturau is the name for Lake Manapōuri as a whole and Manapōuri the name of one of the bays. It was possibly due to a surveyor's error that the name Manapōuri was applied to the entire lake.[2] Doubtful Sound is named Pātea, and Deep Cove within the Sound is named Taipariiki, for a minor atua who assisted in shaping Fiordland for human habitation.[3]

Later, the area attracted the attention of Pākehā explorers and travellers. Fiordland, with its sounds, mountains and lakes was prized for its scenic beauty and tourism potential.[4] Fiordland was made a scenic reserve in 1904, and a national park in 1952.[5] In 1986, the area was listed by UNESCO as a World Heritage Site. In 1990 UNESCO expanded the listing to include Westland Tai Poutini, Aoraki/Mount Cook and Mount Aspiring National Parks. The listing designation is now Te Wāhipounamu – South West New Zealand. UNESCO recognises the area for its natural phenomena and beauty, ecology and biodiversity, and as habitat for an extensive range of endemic fauna and flora.[6]

Early interest in the hydroelectric potential of Lake Manapōuri

A hydro power station using water from Lake Manapōuri was first proposed in 1904. High rainfall and the storage capacity of Lakes Te Anau and Manapōuri made the area a promising one for hydro development. In 1903 government engineer Peter Seton Hay (1852-1907) and overseas consultant, L.M Hancock, an electrical engineer and General Superintendent of the Transmission Department of the California Gas and Electric Company in the United States, made a survey of the country's hydroelectric resource.[7] In his 1904 report, Hay discussed possible schemes for the development of Lake Manapōuri. These included utilising the difference in elevation between Lakes Manapōuri and Te Anau, and between Lake Manapōuri and sea level. Hay also discussed the possibility of a dam to raise the lake level but commented that any dam would not likely be high as "the present beauty of the lake is worth preserving to the fullest extent."[8]

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[1] "Manapōuri hydro station," Meridian Energy, accessed December 15, 2022, www.meridianenergy.co.nz/who-we-are/our-power-stations/hydro/manapouri

[2] David Grant, "Southland places - Fiordland's lakes," Te Ara - the Encyclopedia of New Zealand, accessed 15 November 2022, www.teara.govt.nz/en/southland-places/page-11

[3] Kā Huru Manu, Ngāi Tahu Atlas of place names and histories, www.kahurumanu.co.nz/atlas

[4] Benoni White, "Lake Manawapouri, New Zealand," 1902, postcard, Alexander Turnbull Library, Ref: Eph-A-POSTCARDS-1902-01-3, natlib.govt.nz/records/22661736

[5] David Grant, "Southland places - Fiordland's coast," Te Ara - the Encyclopedia of New Zealand, accessed 15 November 2022, www.teara.govt.nz/en/southland-places/page-10

[6] UNESCO, "Te Wahipounamu – South West New Zealand," accessed 15 November 2022, whc.unesco.org/en/list/551/

[7] "New Zealand water-powers, etc. (Reports on), founded on an examination made during October, November, and December, 1903, By L.M. Hancock, M.A.I.E.E, Electrical Engineer and General Superintendent of the Transmission Department of the California Gas and Electric Corporation." Appendix to the Journals of the House of Representatives, 1904 Session I, D-07, atojs.natlib.govt.nz/cgi-bin/atojs?a=d&d=AJHR1904-I.2.2.2.8&l=mi&e=-------10--1------0--

[8] "New Zealand water-powers, etc. report on) By Mr. P. S. Hay, M.A., M. Inst. C.E., Superintending Engineer of the Public Works Department." Appendix to the Journals of the House of Representatives, 1904 Session I, D-01a, p31, atojs.natlib.govt.nz/cgi-bin/atojs?a=d&d=AJHR1904-I.2.2.2.2&e=-------10--1------0--

Hay estimated that a hydro scheme utilising Lake Manapōuri could produce 420,000 b.h.p (brake horse-power) continuous working and suggested that the power could be used in electro-chemical and electro-metallurgical work.[9]

Further proposals to utilise the waters of Manapōuri for metallurgical industry arose in the 1920s and 1930s. Engineers from the Public Works Department and from private companies made surveys of the area and produced reports.[10] There were, however, a number of obstacles to the development of a power station during this era. These included a lack of interest from international partners, difficult financial situations during the Great Depression and objections from conservationists to constructing a power station in the middle of a scenic reserve.[11]

Development in the second half of the 20th century

Following the Second World War, interest in the hydroelectric potential of Lake Manapōuri was revived.[12] The government was anxious to diversify the New Zealand economy and actively looking for new industry opportunities.[13] Greater demand globally for aluminium made this industry a viable option. Aluminium smelting requires a huge amount of electricity, which a hydro scheme at Lake Manapōuri would provide at low cost. Aluminium resists corrosion, readily conducts electricity and is prized for its lightness and strength. It is used in the electricity and electronics industries, as well as for vehicles and aircraft.[14]

In 1952 the Ministry of Works (MOW) began preliminary investigations, including a proposal to raise the level of the lake.[15] In 1955 significant deposits of Bauxite – the main ingredient for manufacturing aluminium – were discovered in Queensland and the Government's plans for an aluminium smelter powered by a hydro power station utilising Lake Manapōuri began to solidify.[16]

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[9] Ibid.

[10] Aaron Patrick Fox, "The Power Game: The development of the Manapouri-Tiwai Point electro-industrial complex 1904-1969" (PhD diss., University of Otago, 2001), 67-95.

[11] Ibid.

[12] John E. Martin, ed., *People, Politics, Power stations: Electric power generation in New Zealand 1880-1990* (Wellington: Bridget Williams Books and Electricity Corporation of New Zealand, 1991), 206.

[13] Fox, "The Power Game," 142.

[14] Megan Cook, "Pulp and paper, aluminium and steel industries - Aluminium," Te Ara - the Encyclopedia of New Zealand, accessed 17 August 2023, http://www.teara.govt.nz/en/pulp-and-paper-aluminium-and-steel-industries/page-3

[15] Ibid.

[16] Fox, "The Power Game," 12.

The plan for the station which would eventually be the basis of the modern station got government approval in 1958. In 1960, the New Zealand government made a deal with American-Australian aluminium company Commonwealth Aluminium Corporation Limited (known as Comalco) to construct a power station at Lake Manapōuri which would provide cheap electricity to a proposed smelter to be owned by Comalco at Tīwai Point if Comalco agreed to offset the costs of construction. The agreement also allowed Comalco to raise the level of Lakes Manapōuri and Te Anau. This was validated in the Manapouri-Te Anau Development Act, passed in October 1960. The following year it became clear Comalco could not raise the capital to build both the hydro power station and the smelter, and the Government decided to develop the hydro scheme itself.[17] The 1963 Manapouri-Te Anau Development Act returned water rights to the crown but still allowed for lake levels to be raised.[18]

Environmental concern

As plans for a hydro power scheme utilising Lake Manapōuri began to consolidate, so too did public opposition. Protest against the raising of lake levels gained momentum through the 1960s, and the Save Manapōuri campaign was formally launched in 1969. Scientific reports detailing the impact raised water levels would have on the ecology of the lake galvanised support for the Save Manapōuri campaign from a wide cross section of society. The campaign exerted a large amount of public pressure on the government and became an election issue. Labour pledged not to raise lake levels if voted in, a promise that was honoured following the party's win at the 1972 election. The Save Manapōuri campaign has had a significant and lasting impact on the approach taken to engineering and the environment and to public consultation. This is covered in more detail in the social narrative section.

Construction

With Comalco's withdrawal due to lack of finance, the government took on responsibility for the construction of the hydro scheme. The Ministry of Works managed the project and let contracts for different aspects of the work to a number of contractors. Bechtel Pacific Corporation secured the design and supervision contract in February 1963.[19] Bechtel is a North American company, originally founded by Warren A. Bechtel (1872 – 1933) in 1898. From 1919 the company diversified from railways to work on pipeline and dam projects – most notably the Hoover Dam as part of a consortium. By the 1940s the company was taking on international projects.[20] The engineering design work for the Manapōuri hydro power station was completed by the company's engineers. Bechtel Pacific's project manager for Manapōuri was Neville S. Long (1923-2008).[21] Long was born in New Zealand and educated at the California Institute of Technology where he completed a Master of Science degree in civil engineering. He spent 25 years working for Bechtel International. After his time at Manapōuri, Long oversaw projects in Europe, Africa and Saudi Arabia.[22]

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[17] Megan Cook, "Pulp and paper, aluminium and steel industries – Aluminium," Te Ara - the Encyclopedia of New Zealand, accessed February 26, 2021, http://www.teara.govt.nz/en/pulp-and-paper-aluminium-and-steel-industries/page-3

[18] Martin, *People, Politics, Power stations*, 206-208.

[19] Martin, *People, Politics, Power stations*, 208; Fox, "The Power Game," 226.

[20] "History," Bechtel, accessed 30 August 2023, http://www.bechtel.com/about/history/

[21] Fox, "The Power Game," 205.

[22] "Neville S. Long," *East Bay Times*, accessed 30 August 2023, http://www.legacy.com/us/obituaries/eastbaytimes/name/neville-long-obituary?id=23879121

The major construction contractor for the project was Utah-Williamson-Burnett – a joint venture of Utah Construction and Mining Company of the United States and two local firms, W. Williamson Construction Company Ltd., and Burnett's Motors Ltd., of New Zealand.

Other New Zealand contractors and suppliers provided support on discrete tasks.[23]

Construction began in 1963 and was completed eight years later in 1971.[24] Construction on the Tīwai Point aluminium smelter began in 1969 and the first aluminium was produced in April 1971. From October 1971 Manapōuri hydro power station provided full power to the smelter.[25]

A second tailrace tunnel was completed in 2002, bringing the station up to, and above, its original designed capacity of 700 MW. The project was overseen by Electricorp (ECNZ) and from 1999 by the newly created Meridian Energy. Engineering and design services for the project were undertaken by Woodward-Clyde and DesignPower, with preliminary designs workshopped with ECNZ personnel, Woodward-Clyde staff and selected consultants.[26] Woodward-Clyde was a US-based engineering firm. It was acquired by URS Corporation in 1997, and in turn bought by AECOM in 2014.[27] DesignPower was ECNZ's engineering design arm. It was bought in 1999 by US multinational Parsons Brinckerhoff to become PB Power.[28]

The contractor for the construction was a joint venture of Fletcher Dillingham Ilbau. Key personnel included Tom Martin – Project Director; Marc Papke - Project Manager; Brian Heer – Assistant Project Manager; and Ken Smales – Generation Director.[29]

Between 1998 – 2001 the power station's transformers were refurbished and upgraded. In 2014 all seven original transformers were replaced.

The construction of the power station, tailrace, access roads and transmission lines was a major engineering achievement. The isolated location, rugged terrain and extreme weather in Fiordland presented transportation difficulties, construction challenges and extreme working conditions.

As well as being New Zealand's largest hydro power station, Manapōuri is unique in New Zealand in utilising the drop in elevation between a lake and the ocean. Other schemes are sited on lakes and rivers and often also include canals and dams. Manapōuri is unusual, but not unique, in that the scheme does not include a dam and that the power house is underground, with only the control building visible above ground. The Lake Coleridge scheme, completed in 1914, also does not use a dam but instead makes use of the difference in elevation between Lake Coleridge and the Rakaia River.

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[23] John Higham, email to author, 2 February 2024.

[24] Martin, *People, Politics, Power stations*, 205, 214.

[25] Martin, *People, Politics, Power stations*, 213-4.

[26] Brian Heer, Randall Essex, and David Young, "Second Manapouri tailrace tunnel design and construction considerations," in RETC Proceedings 1997, 4; Christine Negus, "Textbook Tunnel: The second Manapouri tailrace tunnel delivers," *e.nz*, November/December 2002, 9.

[27] "URS Corporation," Wikipedia, accessed 30 August 2023, **en.wikipedia.org/wiki/URS_Corporation**

[28] "Merger boosts international exposure," *Windpower monthly*, 1 December 1998, accessed 30 August 2023, **www.windpowermonthly.com/article/956778/merger-boosts-international-exposure**; Karyn Scherer, "Summit spawns local spin-off," *NZHerald*, 30 June 2000, accessed 30 August 2023, **www.nzherald.co.nz/business/summit-spawns-local-spin-off/6SYDQHK6NZVDKMXOJR244IW7NM/**

[29] *Manapouri: The Toughest Tunnel*, Baddock.

Details of the original and later construction of the Manapōuri hydro power station are covered in the physical narrative section.

SOCIAL NARRATIVE

Economic versus environmental impact

Long before construction began on the Manapōuri hydro power station, the idea of the scheme proved contentious and became the focus of competing visions for the future of Southland and the nation. Debate centred on the station's potential economic role and environmental impact.

Lake Manapōuri's isolated location in what would become the Fiordland National Park featured prominently in arguments for and against the development of a power station in the area. Geographically mountainous and prone to extremely heavy rainfall, the Southland terrain was viewed by government officials and others as hostile to most types of industry. Those in favour of the development of a power station and aluminium smelter powered by the waters of Lake Manapōuri were often motivated by a desire to increase industry in Southland. At the same time, Fiordland was recognised as a site of natural beauty. Concern about the possible environmental impact from any industrial development was present from the earliest public debates about the scheme.

Besides the government, which took up positions in favour of or against the scheme in the course of more than sixty years, other important players in the history of the Manapōuri hydro power station include corporations and local organisations. Government support for the scheme was considered an important factor for enticing corporate backing for the development. The government hoped that by providing cut-price electricity to an aluminium corporation, Manapōuri could become the basis of a local aluminium smelting industry. Organisations which supported this endeavour included the Southland Progress League, established 1919, and local businesses in the township of Manapōuri, Te Anau and Invercargill. Organisations challenging the development of the scheme were also active from the early twentieth century.

Campaigns to conserve Fiordland's unique environment began in the 1920s. A proposal to utilise the hydroelectric potential of Bowen Falls to power a nitrate fertiliser factory in Milford Sound met with sustained public criticism.[30] Opponents argued that industrial development would destroy the scenic value of the area and adversely affect tourism. In 1922, nearby Lake Monowai was raised 2.4 metres to create more head for a hydroelectric power station.[31] The raised water level caused widespread damage to local vegetation and a gigantic eyesore of dead rotting trees which lasted for many years.[32] Despite this, the Lake Monowai scheme attracted little criticism, and many newspaper reports instead suggested that the development would increase visitor numbers to the area.[33] The devastation around Lake Monowai would however resound through the coming decades as a visceral reminder of the consequences of industrial development without consideration for the environment.[34]

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[30] Fox, "The Power Game," 35; "Bowen Falls," *Evening Post*, 27 April 1925, p9, paperspast.natlib.govt.nz/newspapers/EP19250427.2.102.1

[31] Fox, "The Power Game," 36-37.

[32] Ibid.

[33] "Lake Monowai," *Southland Times*, 19 June 1922, 5, paperspast.natlib.govt.nz/newspapers/ST19220619.2.57; "Southland's largest public enterprise. Hydro-electric works at Lake Monowai," *Southland Times*, 20 February 1924, 7, paperspast.natlib.govt.nz/newspapers/ST19240220.2.71

[34] Fox, "The Power Game," 36-37.

Plans for utilising Lake Manapōuri for hydroelectric development foundered in the interwar period but were picked up by the government with renewed interest in the 1950s. The Ministry of Works began preliminary investigations in 1952 and in July 1955 Arthur Davenport (1901 – 1973), General Manager of the Hydroelectric Department, outlined a proposal for the scheme at a meeting of the Southland Progress League in Invercargill.[35] These plans included raising the level of Lake Manapōuri by 100 feet (30 metres), and Lake Te Anau by five feet (1.5 metres). The proposal was discussed in the press and attracted opposition and concern from a number of groups including residents of Manapōuri and Te Anau, the Forest and Bird Society and the Manapouri Progress Society.[36]

In January 1960 the New Zealand government signed an agreement with aluminium company, Comalco, guaranteeing the company cheap power for an aluminium smelter at Tīwai Point if Comlco agreed to pay part of the cost of building the Manapōuri hydro power station. The agreement also allowed Comalco to raise the level of Lakes Manapōuri and Te Anau. In response, the Royal Forest and Bird Society presented a 25,000-signature petition to parliament arguing that the agreement contravened the National Parks Act 1952 and that lake levels should not be raised. The petition was unsuccessful, and the Manapouri-Te Anau Development Act, validating the agreement, was passed in October 1960.[37]

When Comalco was unable to raise the capital funds required to construct the power station, the government opted to build and operate the hydroelectric scheme itself. The 1963 Manapouri-Te Anau Development Act returned water rights to the crown but still allowed lake levels to be raised. Construction began in 1963 and by 1969 the first of the turbines were in operation.[38]

Save Manapōuri campaign

Opposition by multiple groups continued throughout the 1960s but it was in 1969 that the question of lake levels came to greater national prominence. Against the advice of its own watch-dog nature-conservancy – the Nature Conservation Council, established 1962 – the government intended to raise Lake Manapōuri by up to eleven metres to generate an extra two hundred megawatts of energy.[39] This change in lake level was provided for under the empowering legislation and to do otherwise would require a renegotiation of the contract with Comalco.[40]

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[35] Martin, *People, Politics, Power stations*, 206; Fox, "The Power Game," 145.

[36] "Strait power cable," *Press*, 31 December 1956, p6, **paperspast.natlib.govt.nz/newspapers/CHP19561231.2.57**; Martin, *People, Politics, Power stations*, 206.

[37] Fox, "The Power Game," 172-3, 179; Martin, *People, Politics, Power stations*, 207.

[38] Martin, *People, Politics, Power stations*, 208.

[39] Jenny Carlyon and Diana Morrow, *Changing Times: New Zealand Since 1945* (Auckland: Auckland University Press, 2014), 167-168.

[40] Martin, *People, Politics, Power stations*, 216.

Environmental impact reports revealed the devastating result raised water levels would have on the ecology of the lake:

> [S]ome 160 miles of shoreline would be inundated and 800 hectares of shoreline forest drowned, along with all of Manapouri's beaches and 26 of its 35 islands; landslides might occur on steep slopes surrounding the lake; tree trunks and branches could become hazards for people seeking recreation; and silting would destroy the lake's ecology.[41]

These reports lent weight and credibility to those opposed to a change in lake levels and described for the first time how wide ranging and long term the impacts would really be.

In October 1969, farmer Ron McLean (1914 – 1980) and local MP Norman Jones (1923 – 1987) co-founded the Save Manapōuri campaign.[42] Over January-February 1970, McLean went on a speaking tour around the country and helped to establish regional committees. The Save Manapōuri Campaign organised various protest actions including meetings, conferences, marches, and letter writing. The campaign gained support from a wide cross-section of society and from people all over the country. Articles appeared in major newspapers running stories and editorials in favour of the campaign.[43] In December 1970, the Royal Forest and Bird Protection Society presented a petition to parliament against the raising of Lake Manapōuri. The petition, with 264,907 signatures, representing almost 9.5% of New Zealand's total population, was, at that time, the largest ever submitted in New Zealand.[44] Manapōuri became an election issue. Reading the depth of public feeling, Labour leader Norman Kirk (1923 – 1974) pledged not to raise the lake if Labour was voted in. Following the party's win in the 1972 election, Labour upheld its promise and appointed leading conservationists from among the campaigners as Guardians of the Lake.[45]

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[41] Carlyon and Morrow, *Changing times*, 168.

[42] Carlyon and Morrow, *Changing times*, 168; *A question of power – The Manapouri debate*, directed by Greg Stitt (New Zealand National Film Unit, 1980), NZ On Screen, **www.nzonscreen.com/title/a-question-of-power-the-manapouri-debate-1980**

[43] Neville Peat, *Manapouri saved!: New Zealand's first great conservation success story* (Dunedin: Longacre Press, 1994), 44.

[44] Carlyon and Morrow, *Changing times*, 168; **www3.stats.govt.nz/New_Zealand_Official_Yearbooks/1970/NZOYB_1970.html**

[45] *A question of power*, directed by Stitt; Peat, *Manapouri Saved!*, 66-69; Martin, *People, politics and power stations*, 216-217.

Left: Mrs Lawson and Miss Bellett with boxes full of the Save Manapouri petition. Dominion Post (Newspaper): Photographic negatives and prints of the Evening Post and Dominion newspapers. Ref: EP/1970/2201/12A-F. Alexander Turnbull Library, Wellington, New Zealand. /records/22305206

The Guardians of the Lake

The Guardians were tasked with developing guidelines on the lake's natural levels, within which the power station could safely operate without damaging the local environment.[46] The Guardians monitored lake levels for several years to develop these guidelines, ensuring the safety of the lake and the power station.[47] After negotiation with officials representing the power station, these guidelines were agreed to, and the Guardians were given statutory recognition.[48] The Guardians of the Lake continue to monitor lake levels and the organisation remains responsible for safeguarding the lake environment.[49] The appointment by the government of the Guardians of the Lake from among leading activists was "probably unprecedented

[46] *A question of power*, directed by Stitt.

[47] Ibid.

[48] *Manapōuri Power Station – celebrating 50 years*. Meridian Energy. Stellar Studios Video Production, 2021; *A question of power*, directed by Stitt; Stuart Chapin, Alan F. Mark, Robin A. Mitchell and Katherine J. M. Dickinson, "Design principles for social-ecological transformation toward sustainability: lessons from New Zealand sense of place," *Ecosphere* vol. 3 no.5 (May 2012): 6. **dx.doi.org/10.1890/ES12-00009.1**

[49] *Manapōuri Power Station – celebrating 50 years*. Meridian Energy. Stellar Studios Video Production, 2021.

anywhere in the world."[50] The formation of the Guardians of the Lake set a precedent for genuine consultation and community involvement in environmental matters. Other community conservation groups are also active in the Waiau Valley area, demonstrating the continued public interest and involvement of local people in conservation issues stemming from the hydro power station and the diversion of water that would have flowed down the Waiau River.[51]

Legacy and significance of the environmental campaign

The protest movement which formed to protect Lake Manapōuri is generally credited as the origin of the modern environmental movement in New Zealand.[52] It "became a benchmark against which public involvement in environmental issues in New Zealand would be measured."[53] The protests challenged the long-standing belief among Pākehā New Zealanders that environmental destruction was the inevitable consequence of industrial development.[54] A broad range of people from diverse backgrounds were successfully united around the cause of saving the lake, resulting in a solution which protected the lake but also allowed the power station to operate.[55]

The success of the Save Manapōuri campaign marked a shift in thinking around the role and responsibility of the engineer and reinforced the need for public consultation. Previously, environmental considerations had often been seen as secondary to functionality and cost.[56] Manapōuri proved that rather than being a 'nice to have,' environmental concerns could make or break an engineering project, but that through consultation, solutions could be found.

Public awareness of environmental issues had been building throughout the 1960s as New Zealand's growing population put pressure on existing infrastructure and pushed issues of wastewater treatment and land use into the public eye. Large scale public works including the Aratiatia and Tongariro hydro schemes had also drawn public concern and criticism. Engineers too, were discussing these issues and looking for solutions. A series of engineering conferences from the mid-1960s to the early 1970s focused on environmental issues. The Physical Environment Conference (1970), run in conjunction with the New Zealand Institution of Engineers recommended policy and practice changes, which resulted in the establishment of the Environmental Council in 1970 and the Commission for the Environment in 1972.[57]

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[50] Neville Peat, quoted in Guy Williams, "Powerful exploits of engineering," *Otago Daily Times*, 28 September 2019, **www.odt.co.nz/regions/southland/powerful-exploits-engineering**

[51] "Waiau Trust, about us," accessed 17 November 2022, **waiautrust.org.nz/general/about-us**; Debbie Ellis and Anna Palliser, "Damming the dam sixty years on: continued conflict over the Manapouri hydro-electric power scheme, New Zealand," *Southern Institute of Technology Journal of Applied Research* – Special edition: environmental publications (2019): 19-35; Roger Sutton, "Magic at Manapouri," *Otago daily times*, 5 Jan 2000, 17.

[52] Carlyon and Morrow, *Changing times*, 169; Michael King, *The Penguin History of New Zealand* (Auckland: Penguin Group, 2003), 443-448.

[53] John E. Martin, "Hydroelectricity - Hydro and the environment," *Te Ara - the Encyclopedia of New Zealand*, accessed 3 December 2021, **www.teara.govt.nz/en/hydroelectricity/page-4**

[54] Carlyon and Morrow, *Changing times*, 169.

[55] Carlyon and Morrow, *Changing times*, 167; Michael King, *The Penguin history of New Zealand* (Auckland: Penguin Books, 2003), 440.

[56] Rosslyn J. Noonan, *By design: a brief history of the Public Works Department, Ministry of Works, 1870 – 1970* (Wellington: Govt. Printer, 1975), 246.

[57] David Thom, "New Zealand where are you?," *New Zealand Engineering*, February 1982, 9-10; David Thom, "The engineer's response to the environmental challenge," *New Zealand Engineering*, May 1985, 15.

The debate that Manapōuri aroused brought environmental issues, already gently simmering, to the fore at a national level and placed the MOW and engineers under greater public scrutiny. The MOW had formed a Public Relations Committee in 1965 with the aim of publicising the department and its work. By 1970 it was clear that simply informing the public was no longer enough; involving them in decision-making from the beginning of a project was essential as was the need to nurture and hone engineers' design skills so that "the works they offer are environmentally sound right from the start." [58]

The Save Manapōuri campaign influenced later environmental campaigns and was pivotal in solidifying and translating environmental concern into policy and legislation, most notably the Resource Management Act 1991.[59] The Save Manapōuri campaign and the appointment of the Guardians of the Lake were milestones in the history of New Zealand environmentalism, centred around the Manapōuri hydro power station.

The Manapōuri story has continued to resonate and has been the subject of a number of books, documentaries and articles. Anniversaries of the formation of the Guardians of the Lake and of the commissioning of the hydro power station have continued to be marked and to receive news coverage. Commemorative news articles emphasise the lasting significance of the environmental campaign, retell the history of the struggle and celebrate those involved.

In October 1994, about 100 people gathered at Lake Manapōuri to mark 21 years since the appointment of the Guardians of the Lake in 1973.[60] In 1998, the Guardians' quarter century was marked with a memorial plaque commemorating the Save Manapōuri campaign, unveiled by founding campaigners, Roger Sutton (1921 – 2006) and Professor Alan Mark (1932 -).[61] The plaque overlooks Lake Manapōuri and is mounted on a rock marking the approximate water level of the lake had it been raised as originally proposed.

Between 2019 – 2021 the hydro power station's 50th anniversary was marked by news coverage and events. Articles discussed the station as one of New Zealand's greatest engineering achievements, and the environmental campaign as the beginning of New Zealand's conservation movement.[62] Station operator, Meridian, marked the occasion with a celebratory weekend for former workers and their families.[63] Meridian also produced a video about the history of the development of the station including interviews with those involved in the original construction.[64]

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[58] Noonan, *By design*, 256-257; Bob Norman, *You can't win 'em all: confessions of a public works engineer* (Porirua: Slide Rule Press, 1997), 128.

[59] King, *Penguin History of New Zealand*, 442-448; Chapin, Mark, Mitchell and Dickinson, "Design principles for social-ecological transformation toward sustainability," 5.

[60] Pete Barnao, "Lake Guardians Mark 21 Years," *Otago Daily Times*, 12 October 1994, 25.

[61] "Manapouri Saved Monument," Wikimedia Commons, accessed 17 November 2022, **commons.wikimedia.org/wiki/File:Manapouri_Saved_Monument_0.jpg**

[62] Guy Williams, "Powerful exploits of engineering," *Otago Daily Times*, 28 September 2019, **www.odt.co.nz/regions/southland/powerful-exploits-engineering**

[63] "Manapōuri Power Station celebrates 50 years," Meridian, accessed 17 November 2022, **www.meridianenergy.co.nz/who-we-are/our-power-stations/hydro/manapouri/manapouri-power-station-celebrates-50-years**; Laura Smith, "Former workers return to mark Manapouri milestone," *Otago Daily Times*, 17 May 2021, **www.odt.co.nz/regions/southland/former-workers-return-mark-manapouri-milestone**

[64] *Manapōuri Power Station – celebrating 50 years*. Meridian Energy. Stellar Studios Video Production, 2021.

Social and economic contribution to Southland

Besides its importance as the centre of a protest movement, the Manapōuri hydro power station has been an important source of employment and a stimulus for development in Fiordland.[65] The influx of people and the development of infrastructure during the construction period has also had a lasting social impact.

It took 1,800 people from twenty-seven different countries over a decade to build the Manapōuri hydro power station.[66] Some of these workers were accommodated on a converted passenger ship, the *Wanganella,* anchored in Deep Cove, while others, usually those with families, lived in a nearby village built by the Electricity Department.[67] Some of these families later relocated to Te Anau.[68] The introduction of a large culturally diverse workforce into Southland had an impact on the local community, as local children had the opportunity to go to school with children from other cultures and new cuisines were introduced to the Southland palate.[69]

The work on the Manapōuri hydro power station was extremely dangerous.[70] Hazardous terrain and long hours led to many accidents, some of which were fatal.[71] Misfired explosives and rock falls were among the key hazards on the project.[72] In 1967 alone, when 1,000 men were working on the project, there were "84 serious accidents at Deep Cove, 123 at West Arm and sixteen on the transmission lines."[73] Those who were seriously injured had to be evacuated by air to Invercargill.[74] Eighteen men were killed while working on the Manapōuri hydro power station.[75] Today there is a memorial plaque in their honour inside the first tailrace tunnel.[76] Even for those who escaped death or serious injury while working on the project, the same high average rainfall which made Fiordland ideal for a hydro power station made working there extremely difficult.[77] Water gushed out of cracks in the rock face as workers tunnelled, ensuring even those working deep inside the mountain were soaked through to the skin every single day.[78] On the *Wanganella,* the all-male-social group coped with the deaths and difficult conditions by drinking heavily.[79] Other responses to

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65 Williams, "Powerful exploits of engineering."

66 Williams, "Powerful exploits of engineering."

67 Gerard Fitzgerald, *Resource Community Formation and Change: A Case Study of Manapouri*, Working Paper 21, Taylor Baines & Associates, September 2000, 14.

68 Fitzgerald, *Resource Community Formation and Change*, 14.

69 *Manapōuri Power Station – celebrating 50 years*. Meridian Energy. Stellar Studios Video Production, 2021.

70 Ibid.

71 Ibid.

72 Ibid.

73 Martin, *People, Politics, Power stations*, 214.

74 Fitzgerald, *Resource Community Formation and Change,* 11.

75 Martin, *People, Politics, Power stations*, 214; "Manapōuri hydro station," Meridian Energy, accessed December 15, 2020, **www.meridianenergy.co.nz/who-we-are/our-power-stations/hydro/manapouri**; John E. Martin, "Hydroelectricity - Hydro and the environment," Te Ara - the Encyclopedia of New Zealand, accessed December 15, 2020, **teara.govt.nz/en/hydroelectricity/page-4**

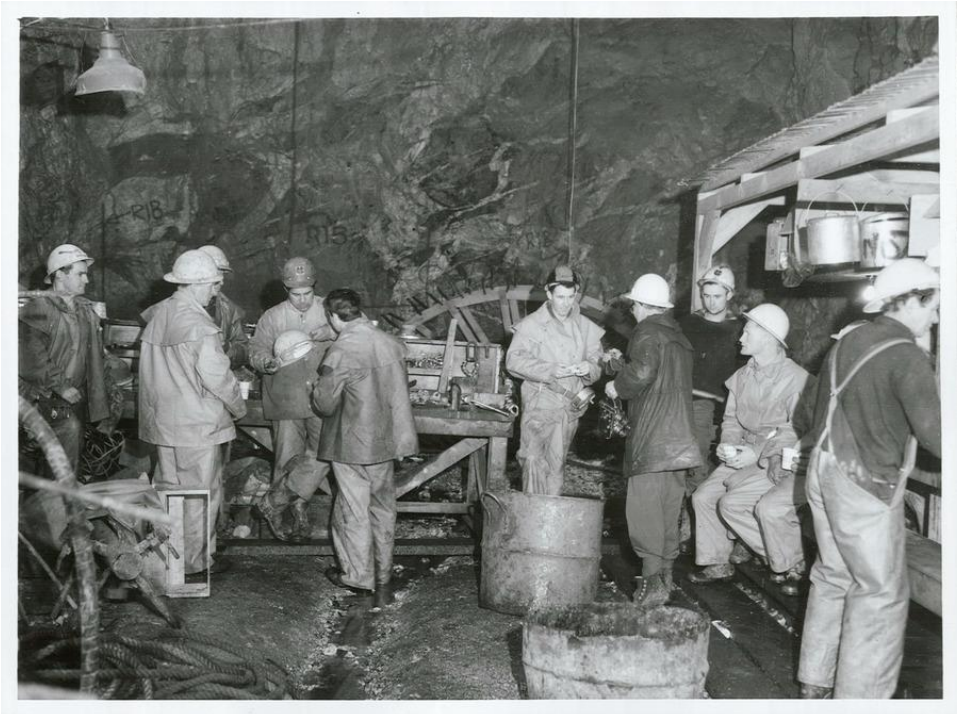
76 *Manapōuri Power Station – celebrating 50 years*. Meridian Energy. Stellar Studios Video Production, 2021.

77 *Manapōuri Power Station – celebrating 50 years*. Meridian Energy. Stellar Studios Video Production, 2021; Fitzgerald, *Resource Community Formation and Change,* 11; Martin, *People, Politics, Power stations*, 210.

78 *Manapōuri Power Station – celebrating 50 years*. Meridian Energy. Stellar Studios Video Production, 2021; Martin, *People, Politics, Power stations*, 210.

79 Fitzgerald, *Resource Community Formation and Change,* 11.

these conditions included the establishment of sports teams and social clubs for workers to keep up morale.[80] They developed a kind of subculture based around their work.[81] While only a small number of the workers settled in Southland permanently after construction was completed, they had an impact which locals recalled decades later.[82]



Above: Workers take a break for hot soup in the access tunnel at West Arm, Lake Manapouri, 1967. Archives New Zealand, R24730670, photographer: Mr Neill.

The economic impacts have also been lasting. The construction of a wharf at the West Arm of Lake Manapōuri and the Wilmot Pass Road reduced the isolation of the lake, enabling the expansion of the local tourism industry, which had previously struggled.[83] From late 1966, bus tours began to take visitors over the newly built Wilmot Pass Road to Doubtful Sound. More than 4,000 people made the trip in the first year. [84] The environmental campaign and the preservation of the lake at its natural level has been critical for tourism to the region. Tour operator, RealNZ (formerly Real Journeys), was founded in 1954 by Les (1924 – 2003) and Olive Hutchins; both were active in the Save Manapōuri campaign and Les was a founding member of the Guardians of the Lake.[85] The company runs a popular tour package taking visitors across Lake Manapōuri, and over the Wilmot Pass for a cruise on Doubtful Sound. Until 2015, the tour also included a visit to the hydro power station and underground machine hall. This was a popular part of the tour and demonstrated a continued public interest in the station. Reviewers on TripAdvisor described the

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[80] Williams, "Powerful exploits of engineering."

[81] Ibid.

[82] *Manapōuri Power Station – celebrating 50 years*. Meridian Energy. Stellar Studios Video Production, 2021.

[83] Ibid.

[84] Peat, *Manapouri Saved!*, 7.

[85] "Our Story," Realnz, accessed 17 November 2022, **www.realnz.com/en/about-us/our-story**

station as an “incredible engineering feat.” [86] Tours were discontinued “after WorkSafe raised concerns about safety measures in the event of a bus fire in the tunnel road to the power house.”[87]

Above: Turnbull's Coaches tourist bus at Deep Cove, Doubtful Sound, 1967. The Wanganella can be seen in the background. Auckland Libraries Heritage Collections 895-A81586, **kura.aucklandlibraries.govt.nz/digital/collection/photos/id/60575**

The hydro power station also allowed the Tīwai aluminium smelter to operate. The smelter “employs 800 people, produces about 10 percent of Southland's GDP and exports about $1billion worth of aluminium every year” as of 2019.[88] A further 2,000 people are indirectly employed because of the operation of the smelter.[89]

In this way, the Manapōuri hydro power station has made a significant contribution to social change and economic development in Southland. While the Manapōuri hydro power station’s history dramatically illustrates a conflict between the motives of environmental conservation and industrial development, its present state as the country’s largest producer of renewable energy in a National Park is an example of the compromise possible after public protest.

[86] “Manapouri hydro electric power station,” Trip Advisor review by BeverleyB779, Landsborough, Australia, January 2013, accessed 17 November 2022, **www.tripadvisor.com/ShowUserReviews-g676238-d2633671-r150634491-RealNZ-Bluff_Southland_Region_South_Island.html**

[87] Williams, “Powerful exploits of engineering.”

[88] Williams, “Powerful exploits of engineering.”

[89] Ibid.

PHYSICAL NARRATIVE

The Manapōuri hydro power station is located on the shore of Lake Manapōuri's West Arm. Water is drawn from Lake Manapōuri and Lake Te Anau and fed into seven vertical penstocks that lead to the power house two hundred metres below ground.[90]

The heritage assessment includes the underground power house including the machine hall and equipment within; the tailrace tunnels; access road; and above ground control building. Not included in the heritage assessment is the Mararoa weir and control gate structure; electricity transmission system including power lines and pylons; and the Wilmot Pass Road.

The power house consists of the machine hall, and below this the stator floor, turbine floor and penstock gallery; the transformer vaults sit to the side of the machine hall. The machine hall measures 111 metres long, 18 metres wide and 39 metres high.[91] A lift and a spiral road tunnel provide access to the power house. The road tunnel is two km long, 18 m wide and has a gradient of one in ten.[92]

Seven turbines drive seven, 100 MW generators.[93] The first four generators were installed in 1969, and the other three installed between 1970-1971.[94] Between 2014-2017 the old transformers were replaced with SF gas-filled transformers.[95]

After being drawn through the penstocks to the turbines, water flows through two ten-kilometre-long tailrace tunnels, which discharge into Deep Cove, Doubtful Sound.[96] The second of these tunnels was built to increase the power station's power generation capacity and was constructed between 1997-2002.[97]

Visible above ground is the control building and 220kV switchyard. The control building sits on the hillside 45 metres above Lake Manapōuri at West Arm. It was completed in 1975 and measures 165 metres long and 23.8 metres high.[98] Electrical cables run from the underground power house to the switchyard, connecting the power station to the national grid. Two parallel transmission lines run from the West Arm switchyard to Invercargill and on to the aluminium smelter at Tīwai Point.

The Mararoa weir and control gate structure was built in 1976 to control the level of Lake Manapōuri. It measures 770 metres long and 13.4 metres high and sits at the confluence of the Mararoa and Waiau Rivers.[99]

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[90] Martin, *People, Politics, Power stations*, 205.

[91] Williams, "Powerful exploits of engineering"; "Discover Manapouri Hydro Power Station," Meridian, **natlib.govt.nz/records/40324084**

[92] Martin, *People, Politics, Power stations,* 205.

[93] Ibid.

[94] Ibid.

[95] *Manapōuri Power Station – celebrating 50 years*. Meridian Energy. Stellar Studios Video Production, 2021.

[96] Williams, "Powerful exploits of engineering."

[97] *Manapouri: The Toughest Tunnel*, Baddock.

[98] Martin, *People, Politics, Power stations,* 205.

[99] Ibid.

As of 2021, forest regrowth as a result of revegetation efforts have largely concealed visible signs of the construction work undertaken on the site between 1963-2002.[100] Power lines and pylons are the more visible signs of the power station above ground.[101]

The total capacity of the station is around 800 MW.[102]

Construction of Wilmot Pass Road

The Wilmot Pass Road was constructed to transport the power station plant to site. The road runs from Deep Cove in Doubtful Sound, through rugged mountainous terrain, to the site of the power station on the West Arm of Lake Manapōuri. Bringing the plant for the power station overland from Doubtful Sound was considered a cheaper option than upgrading the Bluff to Manapōuri Road and taking the equipment across the lake to West Arm.[103] The road is just over 20 km long and at its highest point crosses the Wilmot Pass, 670 m above sea level. For a 2.4 km section near the pass the road has a gradient of 16 percent.[104] On the flat ground, workers struggled with swampy conditions, and through the pass encountered shear rock faces.[105] The contract for the construction of the road was awarded in July 1963 to Utah-Williamson-Burnett.[106] Construction began in October 1963 and progressed from both ends. The road was completed in two years.[107]

Construction of the tail race tunnel

Unlike other hydroelectric power schemes where a dam provides the necessary head for water to drive the turbines, the Manapōuri scheme utilises the difference in height between Lake Manapōuri and the ocean. Water from the lake travels through vertical penstocks to the turbines in the underground power house at West Arm. It is then directed through two tailrace tunnels out to Deep Cove in Doubtful Sound. The first tailrace tunnel is 10 km long and 9 m in diameter. At its lowest point it reaches a depth of 41 metres below sea level before rising to discharge into Doubtful Sound nine metres below sea level.[108] Construction of the tailrace tunnel was a huge undertaking and was described in a 1970 *New Zealand Engineering* article as "one of the world's notable underground engineering achievements."[109]

The contract for the construction of the tailrace tunnel was awarded to Utah-Williamson-Burnett in July 1963.[110] Construction began on 4 February 1964 and took four and a half years to complete. During this time the contract was extended twice, in recognition of the challenging conditions encountered. The

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[100] *Manapōuri Power Station – celebrating 50 years*. Meridian Energy. Stellar Studios Video Production, 2021.

[101] Ibid.

[102] Williams, "Powerful exploits of engineering."

[103] Martin, *People, Politics, Power stations*, 208.

[104] J. A. Langbein, "The Manapouri power project, New Zealand," *The Institution of Civil Engineers Proceedings*, Vol 50 (November 1971): 335.

[105] Langbein, "Manapouri Power Project," 340.

[106] S. E. Brooks, "Manapouri Power Project: Tailrace Tunnel Construction," *New Zealand Engineering* vol 25, no. 5 (May 1970): 124.

[107] Langbein, "Manapouri Power Project," 340.

[108] Martin, *People, Politics, Power stations*, 209; G. L. Thomson, "Construction methods employed in Manapouri tailrace tunnel," *Student Engineer* 1966, 112; "Discover Manapouri Hydro Power Station," Meridian, **natlib.govt.nz/records/40324084**

[109] Brooks, "Manapouri Power Project," 124.

[110] Ibid.

original contract stipulated the tunnel be holed through by September 1966. Hole through was achieved on 22 October 1968 and the tunnel finally completed by the end of August 1969.[111]

The tunnel was excavated using a 45-ton three-tiered drilling platform, known as a jumbo. After a test bore was taken to probe the rock ahead, the jumbo's 16 high-speed drills would bore about 140 holes into the face.[112] These were then filled with blast shot. About 450 kg of gelignite was used for each round of blasting. Each round advanced the tunnel between 1.8 and 3.6 metres. The spoil was then removed by rail-mounted mucking machines with conveyors to load the rock into wagons. Each cycle took about five hours. Tunnellers worked in eight-hour shifts, 24 hours a day, six days a week.[113]

The major challenges that delayed the tunnelling were the variability of the rock and, as the tunnel reached its lowest point, the increasing inflows of water. Steel arch supports were used where the rock was soft and crumbling or where multiple fissures let water into the tunnel. Where possible, fissures were sealed with grout. Pumping was also used to keep water levels manageable.[114] After boring was completed the tunnel was lined with concrete.[115]

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[111] Martin, *People, Politics, Power stations*, 209.

[112] "Manapouri tests man's ability," *New Zealand Engineering* vol 23, no. 1 (January 1968): 30-31.

[113] Ibid.

[114] Thomson, "Construction methods," 123-124.

[115] "Thomson, "Construction methods," 123-128.

Above: Workers use a "jumbo" to inspect the lining of the tailrace tunnel, August 1967. Archives New Zealand, R24730671, photographer: Mr Neill.

Excavation of machine hall and road access tunnel

The machine hall, just over 200 metres below ground, holds the power station's seven generators. The hall is accessed by a lift and a spiralling, two-kilometre road tunnel with a gradient of 10 percent.[116] The contract for the road tunnel was awarded in December 1963 to the joint venture of Morrison-Downer-Flectcher.[117] Work began in March 1964 and was completed in November 1965, a year behind schedule. As with the tailrace tunnel, the presence of water proved challenging and slowed progress. In the final stages, an industrial dispute caused disruption and further delay.[118] The road tunnel is unlined, and the roof reinforced with three-metre rock bolts.[119]

In June 1965, Utah-Williamson-Burnett won the contract for the underground power house and its associated surge chamber, penstocks, cable and lift shafts and for the installation of the first four generators, together with the work on the surface at West Arm on the intakes, switchyard and control

[116] "Manapouri tests man's ability," 29.

[117] Martin, *People, Politics, Power stations*, 210.

[118] Martin, *People, Politics, Power stations*, 210-211.

[119] "Manapouri tests man's ability," 29.

building.[120] The delayed completion of the road tunnel postponed work on the machine hall by a year. Excavation began in 1966 and was nearly finished by the end of the following year.[121] The main cavern of the machine halls is 110 metres long, 18 metres wide and 39 metres high and required the excavation of some 1.6 million cubic yards of granite. During construction, the space which was to become the power house was so large that clouds formed inside the cavernous space from moisture and humidity.[122] The hardness of the rock and the presence of fault lines made the machine hall a challenging excavation.

The machine hall houses seven 100 MW generators, installed in two stages. Two generators commissioned in September and two in October 1969, made up stage one.[123] A further three generators, installed in 1970 and commissioned in mid-1971 made up stage two.[124]

Above: Removing rubble from the machine hall, August 1967. Archives New Zealand, R24730709, photographer: Mr Neill.

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[120] Martin, *People, Politics, Power stations*, 211.

[121] Ibid.

[122] *Manapōuri Power Station – celebrating 50 years*. Meridian Energy. Stellar Studios Video Production, 2021. **www.meridianenergy.co.nz/power-stations/hydro/manapouri**

[123] Martin, *People, Politics, Power stations*, 211.

[124] Martin, *People, Politics, Power stations*, 213.

Above: West Arm Powerhouse. Generator No.5 – positioning rotor in stator. October 1970. Photo reference HA2394. Meridian.

Above: The machine hall, 1971. Archives New Zealand, R24802967, photographer: J. Waddington.

Construction of the above ground control building at West Arm

Work on the control building above ground began in 1968.[125] The building sits on the hillside 45 metres above lake level. A highspeed lift links this building with the power house below.[126]

Erection of the transmission lines

Design and erection of the transmission lines was another challenging aspect of the project requiring detailed engineering.[127] The transmission lines run for 170 km from the power house at West Arm to the National Grid substation at Invercargill and then on to Bluff. The lines cross the Turret Range and Percy and Grebe Valleys – mountainous, bush-clad country prone to extreme weather. In order to put the lines through such rugged country, sections of access road needed to be built, totalling some 58 km.[128] This was surveyed and constructed by New Zealand contractors under the supervision of the Bechtel Pacific Corporation.[129]

The New Zealand Electricity Department began to erect the first of the two double-circuit 220 kV transmission lines in June 1966.[130] At its peak, 230 people were engaged on the job.[131] Thomas Dickens, chief transmission line engineer for the New Zealand Electricity Department described some of the challenges, including extreme weather conditions, spans of over a kilometre, differences in elevation between adjacent towers of up to 300 metres, and a design ice loading of up to two inches radial thickness of ice on the conductors.[132]

Operation and performance

The original designed peak capacity for the Manapōuri hydro power scheme was 700 MW, but after commissioning, it was found that hydraulic losses in the tailrace system, predominantly in the tunnel limited peak power to approximately 600 MW.[133] The decision not to raise the level of the lake was also a factor in limiting the station's capacity.[134]

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[125] Martin, *People, Politics, Power stations*, 211.

[126] "Manapouri tests man's ability," 29; Martin, *People, Politics, Power stations*, 205.

[127] T. A. J. Dickens, "The design and construction of the first 220 kV Line from Manapouri," *New Zealand Engineering* vol 25, no. 1, (January 1970): 13-20.

[128] New Zealand Electricity Department, *Manapouri Power Station* (Wellington: New Zealand Electricity, 1972).

[129] "Manapouri tests man's ability," 32.

[130] Helen Reilly, *Connecting the Country: New Zealand's national grid 1886-2007* (Wellington: Steele Roberts, 2008), 147; Martin, *People, Politics, Power stations*, 211.

[131] Dickens, "Design and Construction," 15.

[132] Dickens, "Design and Construction," 13.

[133] Negus, "Textbook Tunnel," 6-7; Martin, *People, Politics, Power stations*, 213.

[134] Martin, *People, Politics, Power stations*, 213.

Later engineering work

The second tailrace tunnel

The problem of the station's capacity was eventually solved by the addition of a second tailrace tunnel, completed in 2002.[135] Using the same amount of water, the second tunnel brought the station's capacity from 600 MW to 715 MW and was described as "New Zealand's most ambitious civil engineering project for 40 years."[136]

Prompted by a severe winter and power blackouts in 1992, government-owned electricity supplier, Electricorp, began to reconsider its options for upgrading Manapōuri.[137] Engineering design work for the second tunnel began in 1994 and construction got underway in February 1997.[138] The contractor for the construction was a joint venture of Fletcher Dillingham Ilbau. Electricity sector reforms in 1999 spilt Electricorp into four energy suppliers and the newly formed Meridian Energy took on responsibility for Manapōuri and the tailrace tunnel project.

The second tailrace tunnel runs parallel to the first and is 10 km long and 10 m in diameter. In contrast to the original tunnel, which was constructed using drill and blast techniques, the second tailrace tunnel was constructed using a Tunnel Boring Machine (TBM).[139] This machine was one of the largest and most powerful of its type to have been designed at that point.[140] Despite this, the hard rock of the Fiordland National Park proved a challenge for the TBM. Its sixty-eight cutter wheels had to be replaced every 1.8 metres; four thousand cutter heads were used in total.[141] The tunnel passes through six fault lines, and fractured and highly variable rock was another challenge.[142] Steel supports and concrete lining were installed in the ten percent of the tunnel where the rock was most fractured. Twenty percent of the tunnel is shotcrete lined and the remaining 70 percent is bare rock.[143] Working in a national park also required special consideration. Precautions and mitigation works made up 10 percent of the project budget and included treatment of wastewater and revegetation.[144]

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[135] *Manapōuri Power Station – celebrating 50 years*. Meridian Energy. Stellar Studios Video Production, 2021; *Manapouri: The Toughest Tunnel*, documentary film written by Allan Baddock (Natural History New Zealand Limited, 2002), **www.nzgeo.com/video/manapuri-the-toughest-tunnel**

[136] Negus, "Textbook Tunnel," 5, 9.

[137] Negus, "Textbook Tunnel," 7.

[138] Negus, "Textbook Tunnel," 9.

[139] Brooks, "Manapouri Power Project," 121; *Manapōuri Power Station – celebrating 50 years*. Meridian Energy. Stellar Studios Video Production, 2021; *Manapouri: The Toughest Tunnel*, Baddock.

[140] *Manapouri: The Toughest Tunnel*, Baddock.

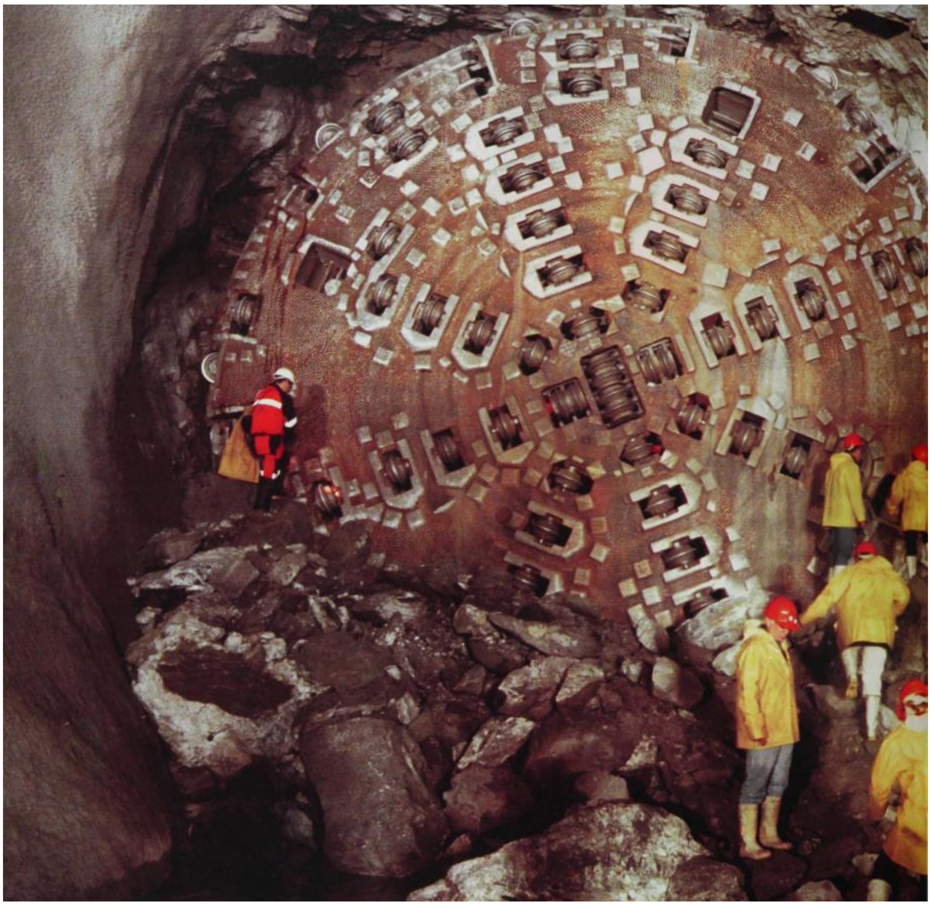
[141] Ibid.

[142] Chris Wilson, "Breaking through" *e.nz*, July/August 2001, 38; Negus, "Textbook Tunnel," 5.

[143] Negus, "Textbook Tunnel," 9; Wilson, "Breaking through," 38.

[144] Negus, "Textbook Tunnel," 14.

The project was completed in 5.3 years and was officially opened on 25 May 2002 by Prime Minister Helen Clark.[145] Contractor, Fletcher Dillingham Ilbau, won the Open Class in the Caltex Construction Awards 2002 for their work on the project and also received an ACENZ Gold Award of Excellence. The project's environmental consideration was recognised by a placing in the finals of the Financial Times Global Energy Awards 2001.[146]



Above: The Tunnel Boring Machine. Photo (cropped): Meridian.

Upgrade and replacement of the transformers

Between 1998 and 2001, the station's original transformers were refurbished and upgraded with new windings.[147]

In February 2014, Meridian Energy began a project to replace all seven of the original transformers after components in the transformers' oil coolers were found to be worn and damaged. The aluminium cooling fins surrounding the copper cooling tubes in the heat exchanger had dislodged, fractured and fretted resulting in aluminium particles being distributed throughout the transformer, presenting an operating risk.[148] The transformers were replaced with 135 megavolt amperes 220/13.8 kV power, SF6 gas insulated

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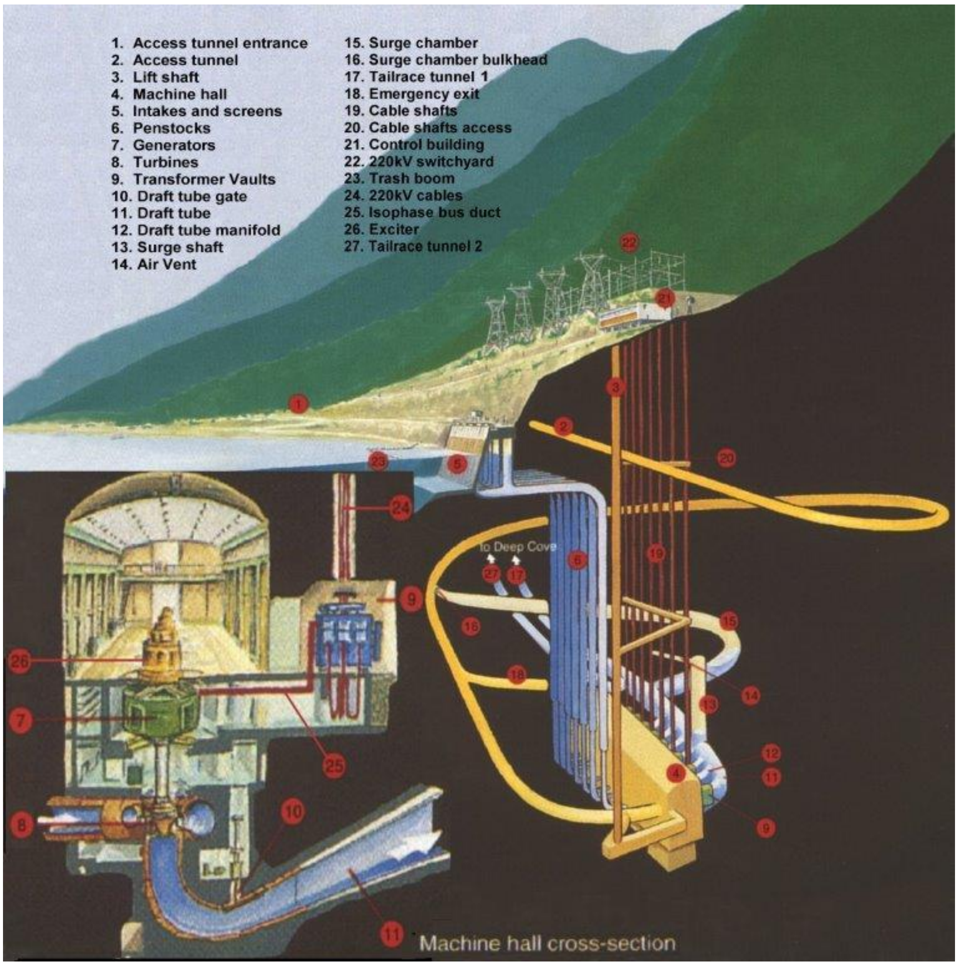
[145] Negus, "Textbook Tunnel," 5, 13-14.

[146] Negus, "Textbook Tunnel," 14.

[147] Grant Bradley, "Meridian to replace faulty Manapouri transformers," *NZ Herald*, 2 February 2015, **www.nzherald.co.nz/business/meridian-to-replace-faulty-manapouri-transformers/ALLOELAQN5RFHHB2FANMOPH3MM**

[148] Wilson Transformers, "Case study: Manapouri power station," **www.wtc.com.au/assets/Uploads/Meridian-Energy-Case-Study2.pdf**

transformers which are more environmentally friendly as they do not require oil and are a "first for New Zealand."[149] The transformers were manufactured, delivered and installed by Wilson Transformer Company.[150] The first three were replaced in 2014-2015 and the remaining four in 2017. The 150-tonne transformers were manufactured in Melbourne, shipped to Deep Cove, and then taken carefully, one at a time, on a multiwheel steerable trailer over the Wilmot Pass Road to the power station.[151] For each transformer, the turnaround time, from de-installation to commissioning, was six weeks.[152]



Above: Schematic drawing of the underground infrastructure. Image: Meridian.

Key physical dates

1963	Construction begins on power house.[153]
1963, Oct	Construction begins on Wilmot Pass Road.[154]

[149] Paul Applegarth, quoted in *Manapōuri Power Station – celebrating 50 years*. Meridian Energy. Stellar Studios Video Production, 2021.

[150] Wilson Transformers, "Case study: Manapouri power station," **www.wtc.com.au/assets/Uploads/Meridian-Energy-Case-Study2.pdf**

[151] Jennie Clarke, "What's up down south?" *EG*, issue 1 (2017): 24.

[152] Ibid.

[153] Ibid.

[154] Ibid.

1964, 4 Feb	Construction begins on first tailrace tunnel.[155]
1964, March	Construction begins on road tunnel
1965	Wilmot Pass Road completed.[156]
1966, June	Erection of transmission lines begins.[157]
1967	Power house construction completed.[158]
1968, 22 Oct	Hole-through of first tailrace tunnel.[159]
1969, Aug	First tailrace tunnel completed.
1969, 14 Sept	Water flows through the station for the first time.[160]
1969, Sept-Oct	Generators 1-4 commissioned.[161]
1971, Sep-Aug	Generators 5-7 commissioned.[162]
1971	Tīwai Point smelter produces first aluminium.[163]
1972	Power station fully commissioned.[164]
1997, Feb	Construction begins on second tailrace tunnel.[165]
2002, 25 May	Second tailrace tunnel officially opened.[166]
2014-2017	The seven transformers at the power station replaced with SF6 gas filled transformers.[167]

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155 Ibid.

156 Ibid.

157 Martin, *People, Politics, Power stations*, 211.

158 Williams, "Powerful exploits of engineering."

159 Ibid.

160 Ibid.

161 New Zealand Electricity Department, *Manapouri Power Station* (Wellington: New Zealand Electricity, 1972).

162 Ibid.

163 Williams, "Powerful exploits of engineering."

164 Ibid.

165 *Manapouri: The Toughest Tunnel*, Baddock.

166 Williams, "Powerful exploits of engineering."

167 Paul Applegarth, quoted in *Manapōuri Power Station – celebrating 50 years*. Meridian Energy. Stellar Studios Video Production, 2021.

ASSESSMENT OF SIGNIFICANCE

The Manapōuri hydro power station is of outstanding engineering heritage significance for its technical accomplishment and its social impact.

Building a hydro power station at Lake Manapōuri was a major engineering undertaking and has been described as “by far the most ambitious civil engineering project undertaken in New Zealand.”[168] The engineering is impressive for its scale, multiple design components and the challenges of construction in a remote location within a national park prone to extreme weather. The technical accomplishment of the second tailrace tunnel is also outstanding. It is an elegant solution to the challenge of increasing the station’s generating capacity while maintaining the lake at its natural level.

The social impact of the project has been significant and enduring. The public response was unprecedented, and the environmental campaign has been widely credited as the origin of the modern environmental movement in New Zealand. The campaign united people from across the political spectrum and marked a shift in attitude and approach to engineering works in the environment. The establishment of the Guardians of the Lake was a first for New Zealand and an important step towards later legislative change, most notably the Resource Management Act 1991.

Both the engineering and the social history story of the Manapōuri hydro power station has continued to resonate through the decades as a touch point within the country’s national narrative. As New Zealand’s largest hydro power scheme and a significant producer of renewable energy, it is a project that will remain significant for its engineering achievement, and social, legislative, and economic impact well into the future.

Therefore, Manapōuri hydro power station is of sufficient engineering heritage significance to merit inclusion in the Engineering New Zealand Engineering Heritage Register.

[168] *Manapouri: The Toughest Tunnel*, Baddock.

SUPPORTING INFORMATION

List of supporting information

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