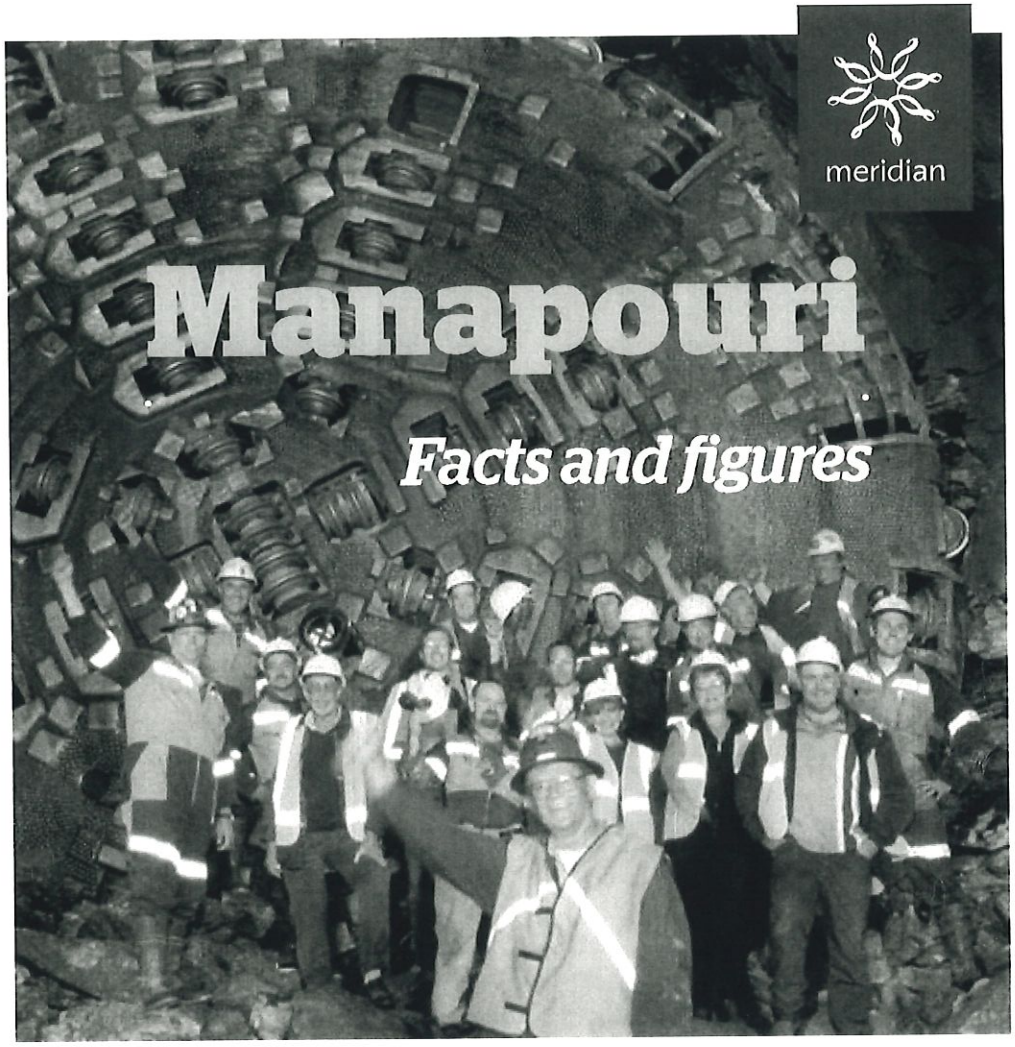
(Meridian Energy, 2008)

1904



3rd

Significant dates

Lake Manapouri discovered by Europeans	*1852*
Potential for a hydro scheme first recognised by Mr P.S Hay, of Public Works Department	*1904*
Public Works Department survey parties investigate the area	*1927*
Aluminium Co. of Canada examines water resources	*1947*
Ministry of Works reports on various possible schemes	*1954*
Building restrictions on Crown Land within 100 feet (30m) of average water level of Lake Manapouri	*1955*
NZ Government invites Consolidated Zinc to consider hydro-electric potential of Lakes Manapouri and Te Anau	*1959*
Consolidated Zinc Prop. Ltd. granted rights to develop power from Manapouri/ Te Anau lakes, Waiau and Mararoa rivers	*1960*
Petition of 25,000 signatures against raising of Lake Manapouri	*1960*
Manapouri Development Validity Act enacted	*1960*
Bechtel Corporation's investigations for Consolidated Zinc begin	*1961*
Power station site reached by vertical tunnel	*1961*
Work and investigation suspended	*Apr, 1962*
Government to build power station	*Jan, 1963*
Bechtel instructed by Ministry of Works to start construction	*Feb, 1963*
Manapouri – Te Anau Development Act enacted	*Aug, 1963*
The Wanganella arrives at Deep Cove	*29 Aug, 1963*
Wilmot Pass Road commenced	*Sept, 1963*
First shot fired on Tailrace Tunnel	*4 Feb, 1964*
Wilmot Pass Road completed	*1 Nov, 1965*

1963 Act amended to let Crown take more power from Manapouri for National Grid	*1966*
Transmission Line started	*June, 1966*
Manapouri controlled level 610ft (185.9m) ASL 27.5 ft (8.4m) above natural mean level	*July, 1966*
Pilot shoreline clearing carried out	*1967*

Justice Minister Ralph Hanan fires the last shot in the first tunnel, which was packed with too much dynamite.

Tailrace Tunnel hole through	*5.42am, 22 Oct, 1968*
Work on Tailrace Tunnel completed	*29 Aug, 1969*
Tunnel filled with water	*6 Sep, 1969*
First power transmission	*14 Sep, 1969*
Second machine commissioned	*29 Sep, 1969*
Third machine commissioned	*16 Oct, 1969*
Fourth machine commissioned	*30 Oct, 1969*
Wanganella leaves Deep Cove for Hong Kong	*17 Apr, 1970*
Second petition of 264,900 signatures presented	*Dec, 1970*
First aluminium smelted at Tiwai Point	*Apr, 1971*
Power Station complete	*Sept, 1971*

nificant dates *continued*

au Lake Control started	*Feb, 1972*
mission lines completed	*28 Apr, 1972*
Manapouri Lake control started	*July, 1972*
Guardians of the Lake established	*10 Feb, 1973*
Te Anau outlet into Waiau river diverted	*Apr, 1974*
Manapouri to be operated within natural levels	*Nov, 1975*
Guardians of the Lake Guidelines announced	*17 Sep, 1977*
Government endorses the Guardians' guidelines	*22 Dec, 1977*
Second Manapouri Tailrace Tunnel (2MTT) given go-ahead	*10 Dec, 1997*
2MTT: First blast of construction at West Arm	*9 Jun, 1997*
2MTT: First blast of construction at Deep Cove	*23 Sep, 1997*
Tunnel Boring Machine (TBM) arrives at Deep Cove	*10 Apr, 1998*
Work continued 24 hours a day, seven days a week	*12 Jun 1998 – 13 Mar, 2001*
TBM demobilisation completed	*12 May, 2001*
Second tailrace fully operational	*5 May, 2002*

e refurbishment *March, 2008*

Major quantities

(Approximations only)

Original project	
Total underground rock excavated from all areas	*1,391,490 m³ 1,820,000 yards³*
Total open cut excavation in all areas	*1,758,476 m³ 2,300,000 yards³*
Total concrete poured in all areas	*298,176 m³ 390,000 yards³*
Approximate tonnage hauled over Wilmot Pass	*86,000 tonnes*
Total quantity of explosives	*3,300 tonnes*
Total reinforced steel used in all areas	*3,333 tonnes*
Total power consumed in all areas	*2.4 GWh*

Largest load to be hauled over Wilmot Pass was 97 tonnes of transformers.

Transmission line

Length – Manapouri to Invercargill	*145 km/90 miles*
First span of transmission line from switchyard	*1.18 km/3,870 ft*
Weight of cable on first towers	*21 tonnes*
Conductor cables	*Twin pheasant 37/146 ACSR*
Distance between each phase	*9.14 m/30 ft*
Voltage	*220,000 volts*
Number of towers to Invercargill	*352*

Rainfall

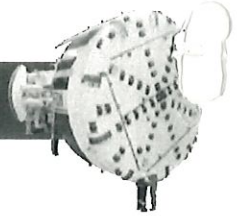
At 4am on 26 August 1980 the Mararoa flow reached 950 cumecs, taking out the centre support for the bridge at Red Cliffs. With Manapouri control gates fully open, an estimated 500 cumecs flowed into Lake Manapouri. The contaminated flood water reached half-way to Stoney Point.

Deep Cove	
802.6 mm (31.6 inches) of rain in three days	*22-25 April, 1967*
400 mm (15.75 inches) of rain in one day	*25 April, 1967*
West Arm	
276.4 mm (10.9 inches) on 27 January 1984	

1975 was the second wettest year on record in Te Anau, with a rainfall of 1303 mm (51.3 inches). West Arm recorded 4565 mm (179.7 inches), Milford 7792 mm (306.8 inches).

Generators

Made by Siemens Aktiengesellschaft, Germany	
Rated voltage	*13,800 volts*
Weight of rotating generator parts	*284 tonnes*
Diameter of stator bore	*5.6 m/18 ft 4.5 in*
Diameter of rotor	*5.55 m/18 ft 2.5 in*
Total thrust bearing load	*477 tonnes*
Original:	
Rated current	*4,390 amps*
Rated output	*1-4, 105 MVA* *5-7, 120 MVA*
Upgraded:	
Rated current	*5,648 amps*
Rated output	*1-7, 135 MVA*



Type was Atlas Copco Robbins built by Markhams, Sheffield, England.

Tunnel Boring Machine (TBM)

Weight	*1,500 tonnes*
Total length (including trailings)	*500 m/1640 ft*
Average advance rate achieved	*10m per day/32.81 ft*
Best advance rate achieved	*April 2000, 20m per day. 65.62 ft*
Total number of cutters on face of TBM	*68*
Total cutters replaced	*4084*

Original power station project

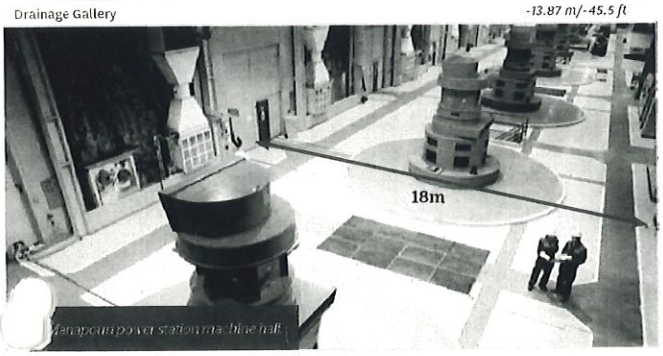
Total man hours on contract	*7,999,136*
Total reported accidents	*1,707*
Total fatal accidents on the job	*16*

Second tailrace tunnel

Total man hours on contract	*1,500,000*
Total fatal accidents on the job	*nil*

Machine hall

[illegible]th	111 m/364 ft
[illegible]th	18 m/59 ft
Height (total excavation)	39 m/127.5 ft
Average temperature (at floor level)	20°C/68°F
Number of units	7, 12.8 m/42 ft apart
Floor levels (el*):	
Machine floor	7.9 m/26 ft
Stator floor	3.66 m/12 ft
Turbine floor	0.3 m/-1 ft
Penstock Gallery	-6.7 m/-22 ft
Draft Tube Gallery	-8.33 m/-27.33 ft
Drainage Gallery	-13.87 m/-45.5 ft



Manapouri power station machine hall

Cranes

Made by Savigliano, Italy	
Main	150 tonnes capacity
Auxiliary	15 tonnes capacity
Span	17 m/55.5 ft

Costs *(Approximations only)*

1963 – 1971	*$ NZD*
Original Tailrace Tunnel	41,000,000
Powerhouse and access tunnel (including installation of four machines)	47,000,000
Equipment (purchase of four machines)	7,000,000
Transmission line (four circuits)	18,500,000
Machines 5, 6, and 7 (purchase and installation)	12,000,000
Minor items	2,000,000
Engineering	8,000,000
OVERALL COST OF ORIGINAL PROJECT	135,500,000
1997 – 2002	
Second Tailrace Tunnel	200,000,000
November 1999 – August 2001	
Upgrade of Transformers	10,265,000
1999 – 2007	
Refurbishment of Generators & Mechanical Equipment (Includes Exciters, Generators, Turbine & Wicket Gates)	90,000,000

220 KV cables

Length of cable (from generator to switchyard)	*263 m/862.9 ft*
Height of cable shaft (from stator floor to switchyard)	*233 m/765 ft*
Diameter of shaft	*1.85 m/6 ft*
Original Cable:	
Single core - oil filled - paper insulated	
Conductor cross section	*Copper 1.94 cm^2/0.3 in^2*
Sheath	*Lead Alloy*
Replacement Cable:	
XLPE (Cross link polyethylene) cable	
Conductor cross section	*Copper 6.26 cm^2/0.97 in^2*
Sheath	*Alloy 1/2 C*

Turbines

Original:	
Vertical Francis built by Harland Engineering Co. Ltd., Scotland	
Nominal output	*105 MW*
Operating speed	*250 rpm*
Diameter of runner (turbine)	*3.2 m/10.5 ft*
Centre line of turbine	*(el*) -3.1 m/-10 ft*
Weight of turbine	*18 tonnes*
Replacement:	
Vertical Francis built by General Electric Canada International Inc	
Nominal output	*121.5 MW*
Weight of turbine	*16 tonnes*

Intakes and penstocks

Diameter - Concrete section:	*3.65 m/12 ft*
Diameter - Steel section (el*) 33.5 m (110 ft) to bottom:	*3.35 to 2.9 m 11 to 9 ft 8¼"*
Volume of water at full load	*80 m^3/s, 104.6 yd^3/s*
Speed of water - Concrete section.	*6-7.6 m/s, 20-25 ft/sec*
Speed of water - Steel section:	*9-11.6 m/s, 30-38 ft/sec*
Thickness of steel at:	
(el*) 33.5 m (110 ft)	*19 mm/¾"*
bottom of vertical section	*41 mm/1⅝"*
dresser coupling	*57 mm/2¼"*
Intake area (per unit)	*914.4 m^2/1584 ft^2*
Clear space between bars	*11.4 cm/4½"*
Water velocity through intake	*1.25 m/s, 4.1 ft/sec*
Trashrack sill	*(el*) 169.5 m/556 ft*
Size of headgate opening	*5 m x 3.6 m, 16.5 ft x 12 ft*
Weight of headgate	*27 tonnes*
Size of stop log	*5.4 m x 5 m, 17.7 ft x 16.5 ft*
Weight of stop log	*12.5 tonnes*

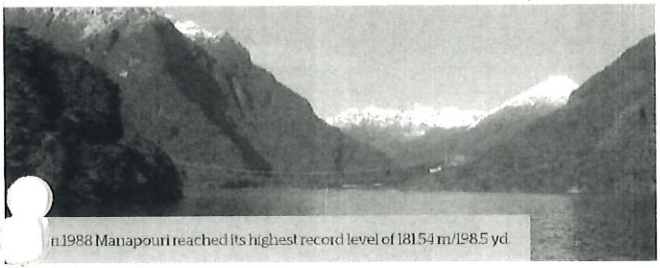
Weight of headgate - 27 tonnes

Wilmot Pass Road

Height of pass	*671 m/2,100 ft*
Length of road	*21.6 km/12.75 miles*
Material excavated	*865,889 m^3/1,132,540 yds^3*
Cost of building	*$2 per 25mm/$2 per inch*

ydrology

	6.4 to 6.8
l dissolved solids	*23 parts per million*
Very soft with 90% saturation of dissolved oxygen even at 443.5 m deep (1455 ft)	
Summer temperature, surface up to: Upper 50 ft Below 300 ft (yearly constant) Winter temperature, surface down to:	*22 C/71.6 F* *16°C/60.8°F* *8°C/46.4 F* *7°C/44.6°F*
Lake Te Anau area	*357 km²/138 miles²* *(35,612 hectares)* *(88,000 acres)*
Shoreline	*281 km/175 miles*
Normal operating levels	*201.5 m to 202.7 m* *220 yd to 221.7 yd*
Catchment area	*3,302 km²* *1,275 miles²*
Lake Manapouri area	*142 km²/55 miles²* *(14,164 hectares)* *(35,000 acres)*



n 1988 Manapouri reached its highest record level of 181.54 m/198.5 yd.

Shoreline	*161 km/100 miles*
Normal operating levels	*176.8 m to 178.6 m* *193 yd to 195 yd*
Catchment area	*1,320 km²/510 miles²*
Catchment for Mararoa River	*1,256 km²/485 miles²*
Total catchment for both lakes and Mararoa River	*5,879 km²* *2,270 miles²*
The maximum recorded levels of both lakes before control gates were installed were: (recorded in October 1928)	
Te Anau	*204.9 m/224 yd*
Manapouri	*181.2 m/198 yd*
During construction of the control structures in 1975 the lakes reached:	
Te Anau - 8 April	*204.78 m/223.9 yd*
Manapouri - 11 April	*180.84 m/197.8 yd*

With the control gate clear of the water, the outflow from Lake Te Anau reached 841 cumecs on 7 April. Inflow into Te Anau on 30 March was 3,848 cumecs, by 6 April this had dropped to 3,141 cumecs.

In 1988 the lakes reached the highest recorded levels:	
Te Anau	*205.11 m/224.3 yd*
Manapouri	*181.54 m/198.5 yd*

Lift shaft

Diameter of unlined rock	*4.5 m/14.66 ft*
Control room (Equivalent to a 70 storey building)	*(el*) 227 m/745 ft*
Machine floor	*(el*) 7.9 m/26 ft*
Speed of car	*6.4 kmh/4 mph*

*el - Elevation above sea level.

Transformers

Made by Savigliano, Italy	*13.8 kV to 220 kV*
Original:	
Weight of core winding	*78 tonnes*
Overall weight	*133 tonnes*
Weight of oil	*36 tonnes*
Continuous rating	*1-4, 105 MVA, 5-7, 120 MVA*
Upgraded:	
Weight of core winding	*83 tonnes*
Overall weight	*138 tonnes*
Weight of oil	*36 tonnes*
Continuous rating	*1-7, 135 MVA*

Tailrace tunnels

Amount of water to pump out if dewatering	*567,811,768 litres* *150,000,000 gallons*
Plus seepage of	*34,068 litres p/m, 9,000 gallons p/m*
Original: (by drill and blast method)	
Diameter (Horse shoe shaped)	*9.1 m/30 ft*
Length (fully lined)	*10 km/6.25 miles*
Outlet (to sea level)	*(el*) -9.14 m/-30 ft*
Deepest point (to sea level)	*(el*) -40.44 m/-132.69 ft*
Net head of water	*148 m/487 ft*
Rock removed during excavation	*782,904 m³/1,024,000 yds³*
Total concrete to line tunnel	*210,906 m³/275,855 yds³*
Total concrete for grouting	*9,948 m³/13,012 yds³*
Grouting pressure, up to	*2,200 psi*
Discharge velocity - 450 cumecs	*20.9 kmh/13 mph*
Maximum water inflow during excavation March 1968	*43,418 litres p/m, 11,470 gallons p*
Average labour force 1964 - 68	*531*
Average terminations 1964 - 68	*626*
Annual turnover percentage	*12[illegible]%*
Second: (9.6km by TBM, 0.2km by drill and blast)	
Diameter (circular)	*10.0 m/32.81 ft*
Length (70% unlined)	*9.8 km/6.09 miles*
Outlet (to sea level)	*(el*) -4.88 m/-16 ft*
Deepest point (to sea level)	*(el*) -43.35 m/-142 ft*
Net head of water	*160 m/524 ft*
Rock removed during excavation	*approx. 1,630,000 m³, 2,132,000 yd³*
Total stresscrete to line tunnel	*1094.4 m/3591 ft*
Total shotcrete (75mm to 150mm thick)	*2000 m/6562 ft*
Discharge velocity - 510 cumecs (using both tunnels)	*11 kmh/6.8 mph*
Maximum water inflow during excavation. October 1999	*61,020 litres p/m* *16,120 gallons p/m*
Approx labour force	*200*
Total man hours	*1,500,000*

No loss of life or serious permanent injuries (most serious recorded were broken bones or crushing).

Rock spoil has created a new "hill" to the left of the original outlet and channel. 1500m long, 250m wide and between 10 - 15 m high, covered by 250,000 native plants grown especially for this project.

Access tunnel

Diameter	*6.7 m/22 ft*
Length	*2,042 m/6,700*
Gradient	*1:10*

WE'RE HERE TO HELP

Please feel free to contact our Customer Service Team.

Phone 0800 496 496
Fax 0800 497 498

Monday to Friday, excluding public holidays, between 7.30am and 7.30pm

Email info@meridianenergy.co.nz
Website www.meridian.co.nz
Address Meridian Energy Ltd
322 Manchester Street
PO Box 2128
Christchurch

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