# ADDITIONAL SPECTRA SITES
***(5 Sites)***

# Additional Spectra Sites

## (5 Sites)


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# Contents

# 1 Introduction

Spectra records have been assembled at a number of sites throughout New Zealand for proposed hydro-electric investigations. Opus has regularly provided the Electricity Commission (and its predecessors) with Spectra updates. The aim of this report is to create an additional five sites as recommended in the 2007 Spectra report. Construction of the datasets is based on, firstly, existing datasets with significant record lengths not already included in the current spectra updates, and secondly, datasets that have significant GWH pa capability.

The five sites were correlated with existing long term records to produce data back to 1931.

The five sites constructed in this report are:

- Wheao/Flaxy (129 GWH)
- Patea (80 GWH)
- Highbank (75 GWH)
- Kaimai (174 GWH)
- Waipori (220 GWH)

# 2 Wheao/Flaxy (129 GWH) TrustPower

### Scheme Description

The Wheao and Flaxy Scheme had it's beginnings in 1974; the scheme was commissioned in 1980. The Wheao Hydro Electric Scheme, in the Kaingaroa Forest, is 82 km from Rotorua, 25 km from Murupara and 74 km from Taupo.

The 26MW scheme produces power using water from the Wheao and Rangitaiki Rivers as well as from Flaxy Creek. Water from the Rangitaiki River flows through a 4.7 km open canal into the Wheao penstock intake. When a lot of power is needed, the Flaxy Power Station supplements supply. A complex arrangement of canals, tunnels and pipelines feed the water from the upper Wheao River and Flaxy Creek to the Flaxy Power Station.

Here two Norwegian designed, water driven turbines and generators produce 12,000 kW each. The generators turn at 428 revolutions per minute and develop 16,000 hp at full power. Above the power station are the two massive penstocks through which the water plunges 126 m down a rock wall at up to 45 degrees to the generators inside the power station.

Figure 2.1 shows the Wheao/Flaxy Power Stations and the associated flow recorders on or in the vicinity of the Wheao/Flaxy Power Stations. Table 2.1 shows the site number, site name, and the length of record existing for the sites in the vicinity.

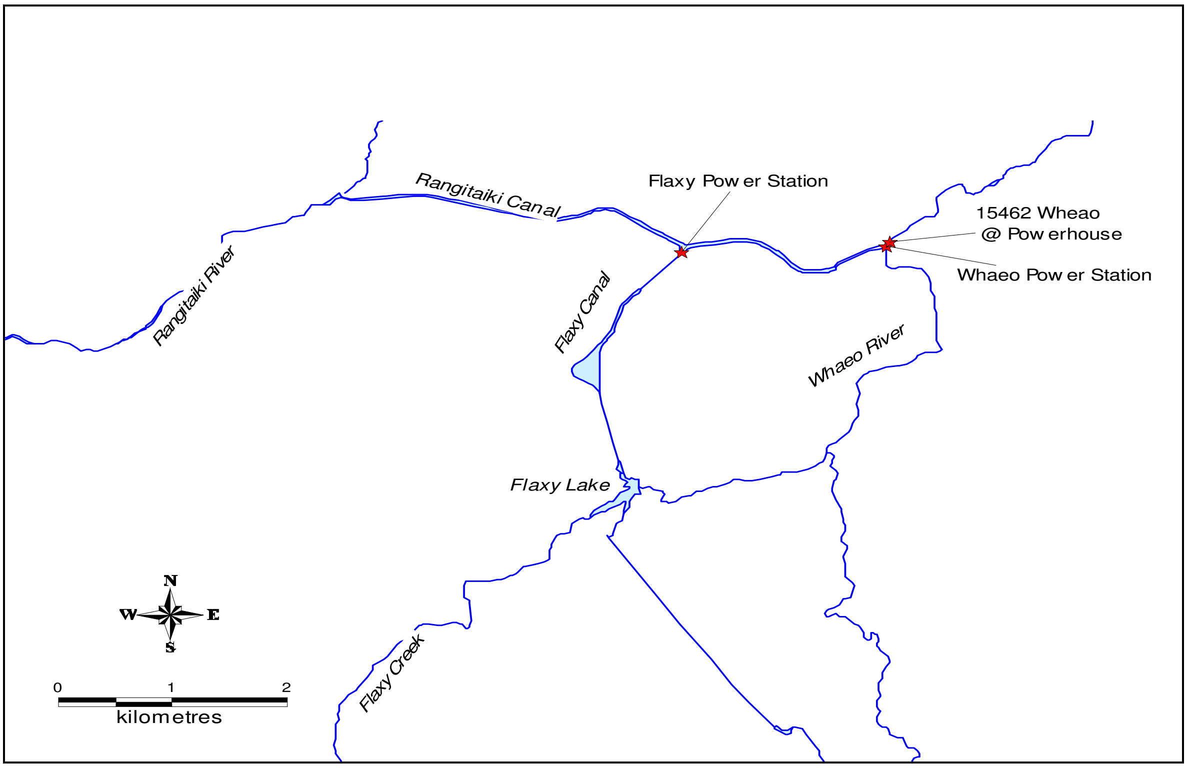



**Figure 2.1 Wheao/Flaxy Power Station location diagram**

**Table 2.1 Flow Recording Stations in the vicinity of the Wheao/Flaxy Power Stations**

| Site Number | Site Name | Record Length |
|---|---|---|
| 15462 | Wheao at Powerhouse | Nov 85 to Sep 98 |
| 15408 | Rangitaiki at Murapara | Jun 48 to present |

**Creation of synthetic data for Wheao Power Station**

Data for the Wheao Power Station was supplied by TrustPower from 1999 to 2007. It was therefore necessary to extend this record back from 1999 to 1931. Data was available from Rangitaiki at Murapara from 1948 to 2007.

To create a synthetic record for Rangitaiki at Murupara from 1948 back to 1931 a flow distribution rating (obtained via analysis of Taupo Natural Outflows and Rangitaiki at Murupara) was applied to Taupo Natural Outflow.

In order to reduce the Rangitaiki at Murupara flow range to resemble Wheao Power Station flows another flow distribution rating was derived using Rangitaiki at Murupara and Wheao Power Station. This flow distribution was then applied to actual and synthetic Rangitaiki at Murupara data to derive synthetic Wheao flow data.

Care was taken to maintain the water balance of the power station output. Table 2.2 details the mean flows for the synthetic and actual data. Mean monthly flow values and the distribution of the flow are displayed in Appendix A. A comparison plot showing actual Wheao Power Station flow and the synthetic record over the same time period is displayed in Figure 2.2. The combined flow record of the actual Wheao Power Station data and the synthetic Wheao record are displayed in Figure 2.3.

**Table 2.2 Mean flows for Actual and Synthetic Wheao Power Station Data**

| Record | Record Length | Mean Flow ($m^3/s$) |
|---|---|---|
| Actual Wheao Power Station (TrustPower) | 1999-2007 | 12.5 |
| Synthetic Wheao Power Station | 1999-2007 | 12.3 |
| | | |
| Actual and synthetic Wheao Power Station | 1931-2007 | 13.0 |
| Synthetic Wheao Power Station | 1931-2007 | 13.0 |

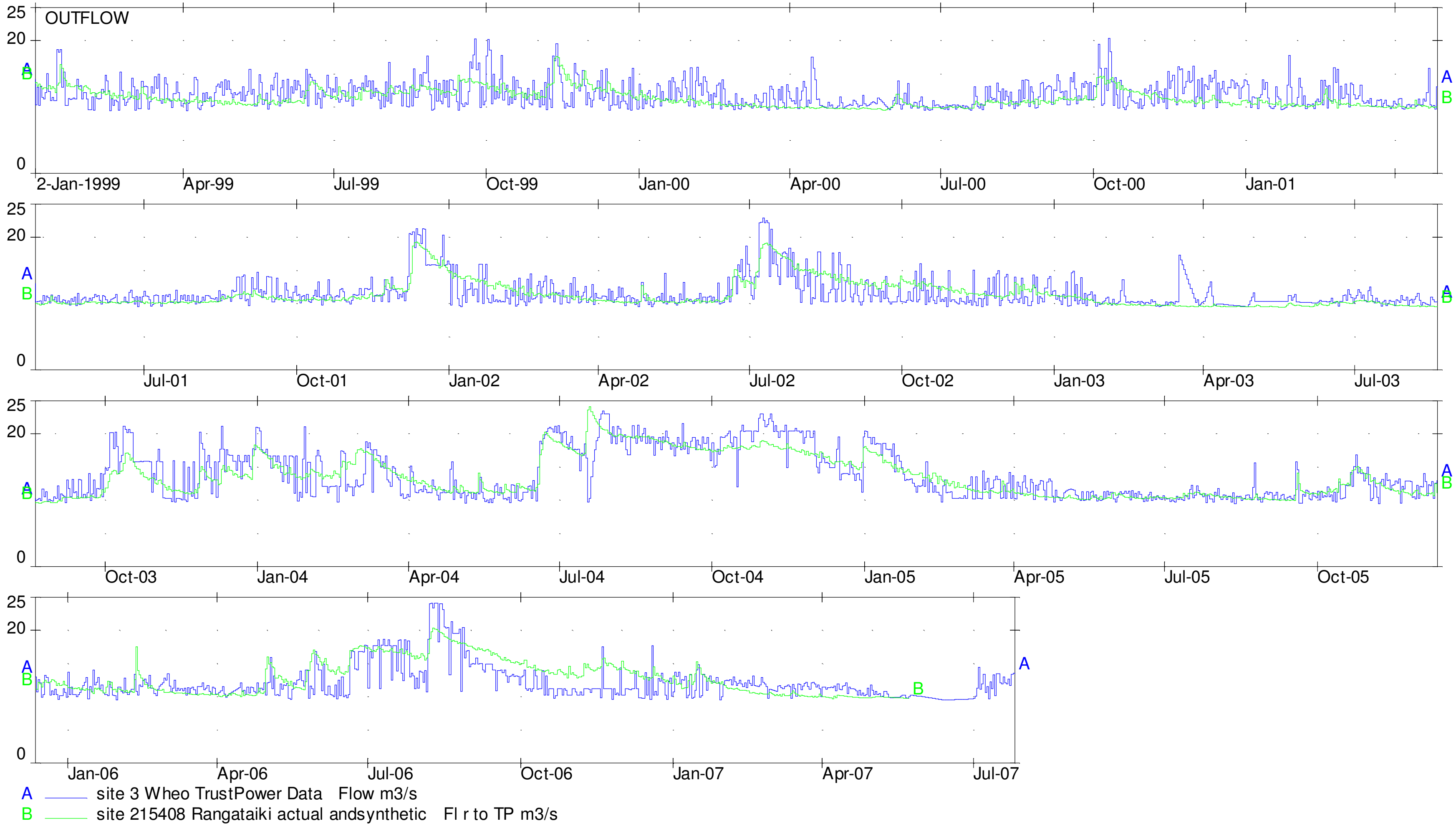



**Figure 2.2 Comparison between the actual Wheao Power Station record and synthetic Wheao record.**

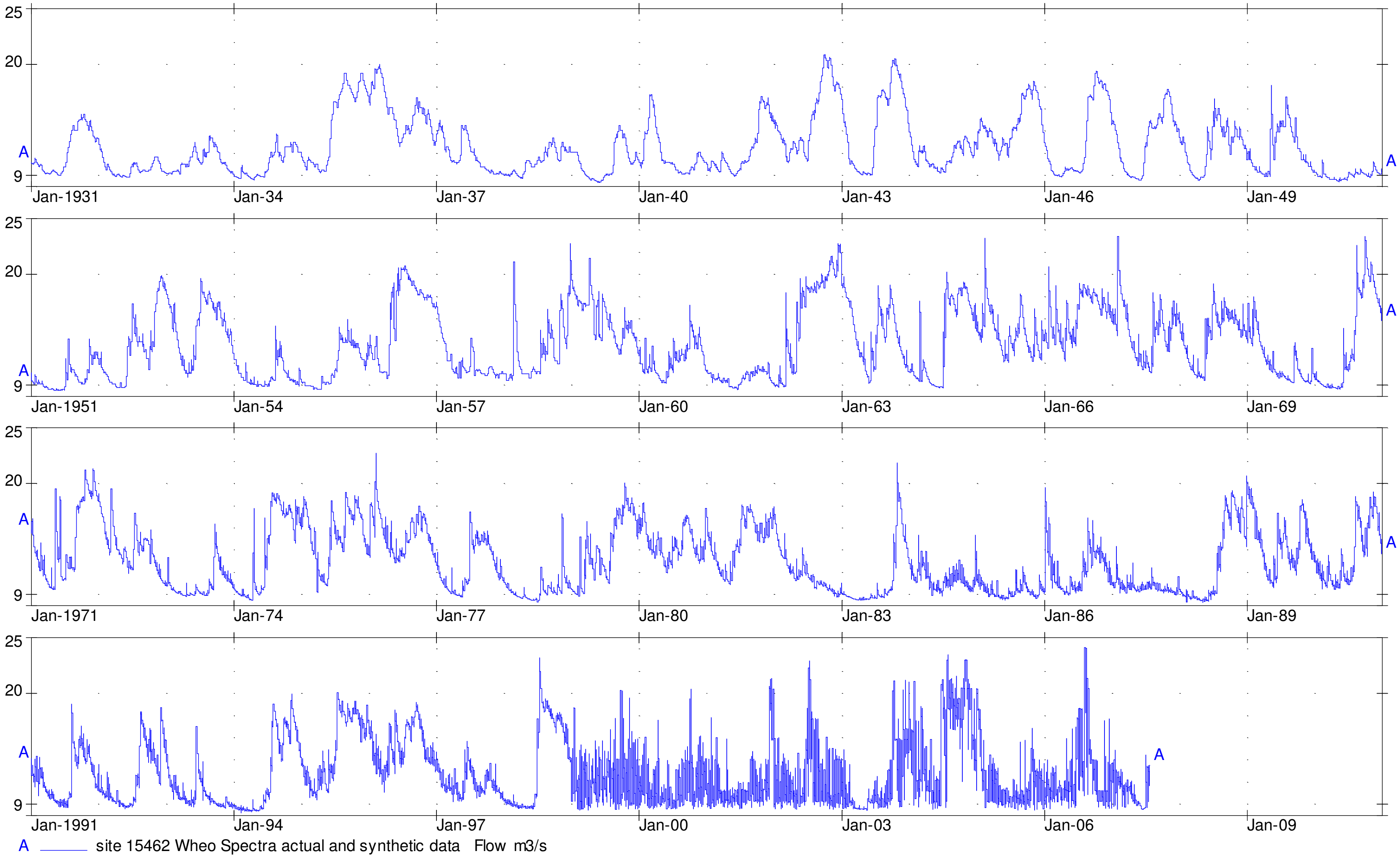



**Figure 2.3 Wheao Spectra dataset 1931 to 2007**

# 3 Patea (80 GWh) TrustPower

### Scheme description

This catchment has an existing hydro-electric power station (Patea) and controlled lake storage (Lake Rotorangi). Figure 3.1 shows the Patea River and the associated flow recorders on or in the vicinity of the Waiau River. Table 3.1 shows the site number, site name, and the length of record existing for these sites.

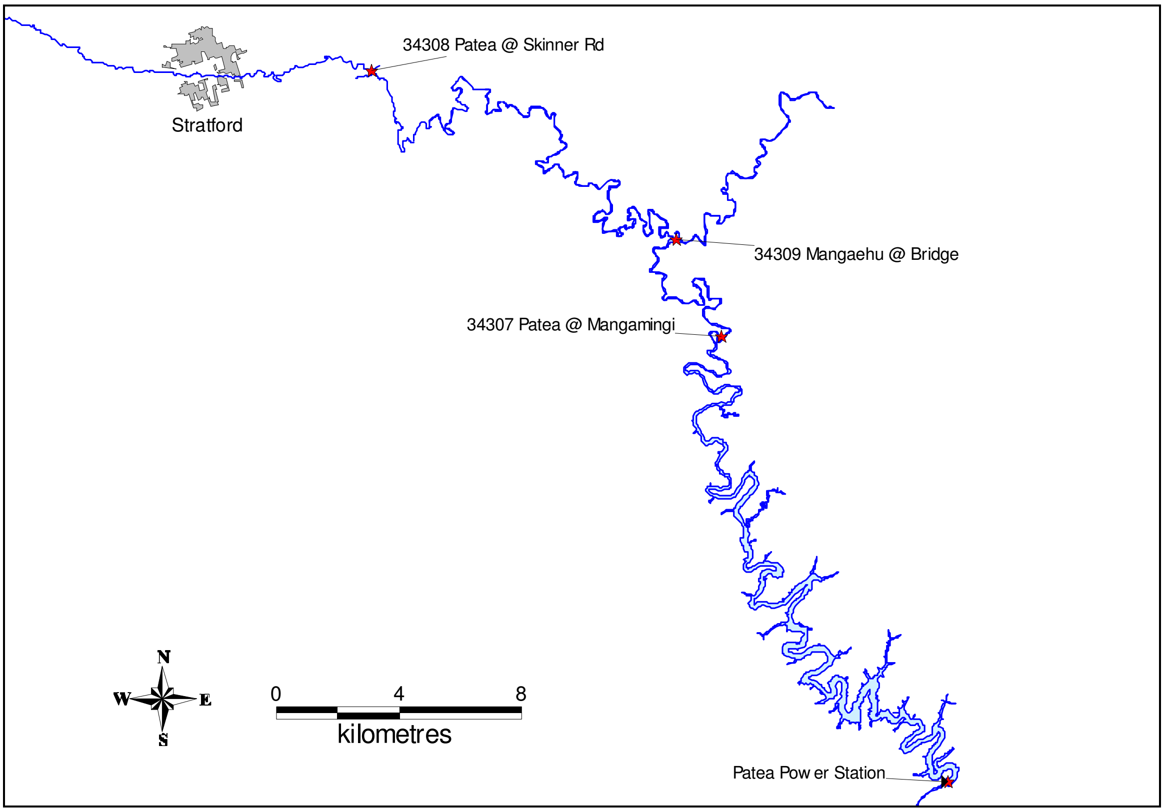



**Figure 3.1 Patea River Location diagram**

**Table 3.1 Flow Recording Stations in the vicinity of the Patea power station**

| Site Number | Site Name | Record Length |
|---|---|---|
| 34308 | Patea at Skinner Road | Feb-78 to present |
| 34307 | Patea at Mangamingi | Apr 75 to May 84 |
| 34309 | Mangaehu at Bridge | Jan 78 to present |
| 34305 | Patea at McColls | Nov 86 to Jul 95 |

### Patea – Diversion into Mangaehu

The Patea River originates on the eastern side of Mt Taranaki and flows down through Stratford and into the inland hill country where it is joined by a major tributary, the Mangehu Stream.

The upper reaches of the Patea River are not as deeply incised as the middle reaches, upstream of Lake Rotorangi behind Patea Dam. However, approximately 1.7 km upstream of the Mangamingi Bridge there is a site suitable for a storage dam with an overall height up to 64 m. The river channel itself is about 30 m deep.

A reservoir area of 3.9 $km^{2\ at}$ an impoundment height of 50 m with an installed capacity of 18 MW would generate approximately 79 GWh p.a. (50% plant factor).

**Creation of synthetic data for Patea River**

Data for the Patea Power Station was supplied by TrustPower from 1999 to 2007. It was therefore necessary to extend this record back from 1999 to 1931. To do this data from Patea River at Mangamingi and McColls were used.

The Patea at Mangamingi record begins in April 1975 and ends in April 1984. The Patea at McColls records is from November 1986 to July 1995. Data from these two sites were combined to give a non-continuous record from 1975 to 1995.

To create a synthetic record for Patea from 1975 back to 1931 a flow distribution rating (obtained via analysis of Taupo Natural inflow and combined Patea) was applied to Taupo Natural inflow.

In order to reduce the combined Patea flow range to resemble Patea Power Station flows another flow distribution rating was derived using combined Patea and Patea Power Station. This flow distribution was then applied to actual and synthetic Patea data to derive synthetic Patea flow data.

Care was taken to maintain the water balance in the Patea River. Table 3.2 details the mean flows during the record for the synthetic and actual data.

Mean monthly flow values and the distribution of the flow are displayed in Appendix A. A comparison plot showing the Patea Power Station flow and the Spectra synthetic record (prior to superimposing the actual record over the Spectra series) is displayed in Figure 3.2. The synthetic and actual Patea Power Station record is displayed in Figure 3.3.

**Table 3.2 Mean flows for Patea Power Station and Patea River**

| Record | Record Length | Mean Flow ($m^3/s$) |
|---|---|---|
| Patea at Mangamingi | 1975-1984 | 24.2 |
| Patea at McColls | 1986-1995 | 28.1 |
| | | |
| Patea Power Station (TrustPower) | 1999-2007 | 18.5 |
| Synthetic Patea Power Station Data | 1999-2007 | 16.9 |
| | | |
| Synthetic Patea Power Station Data | 1931-2007 | 18.2 |
| Patea Power Station (synthetic and actual data) | 1931-2007 | 18.4 |

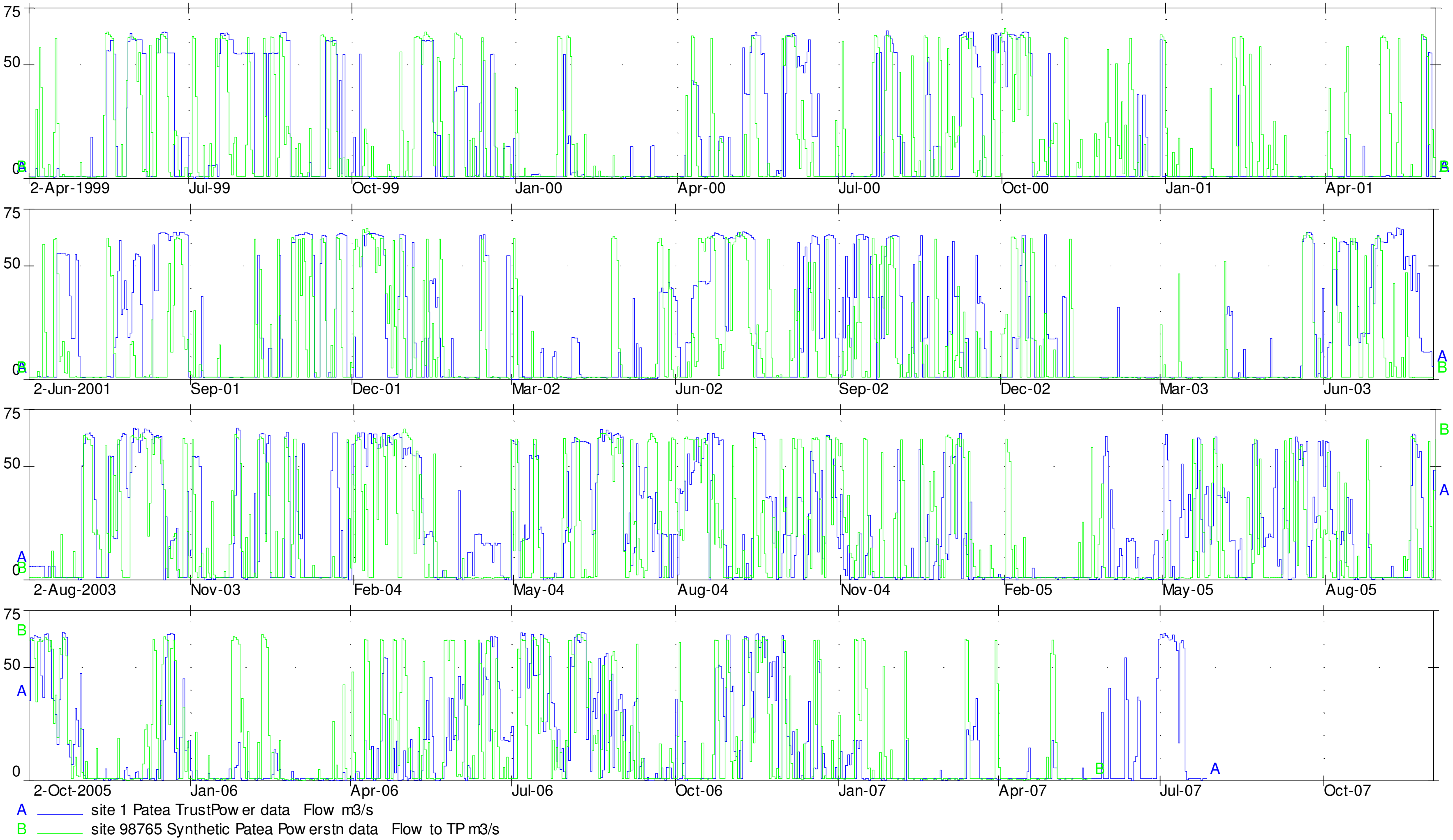



**Figure 3.2 Comparison between the actual Patea Power Station record and the rated record used to extend the Spectra series 1999 to 2007**

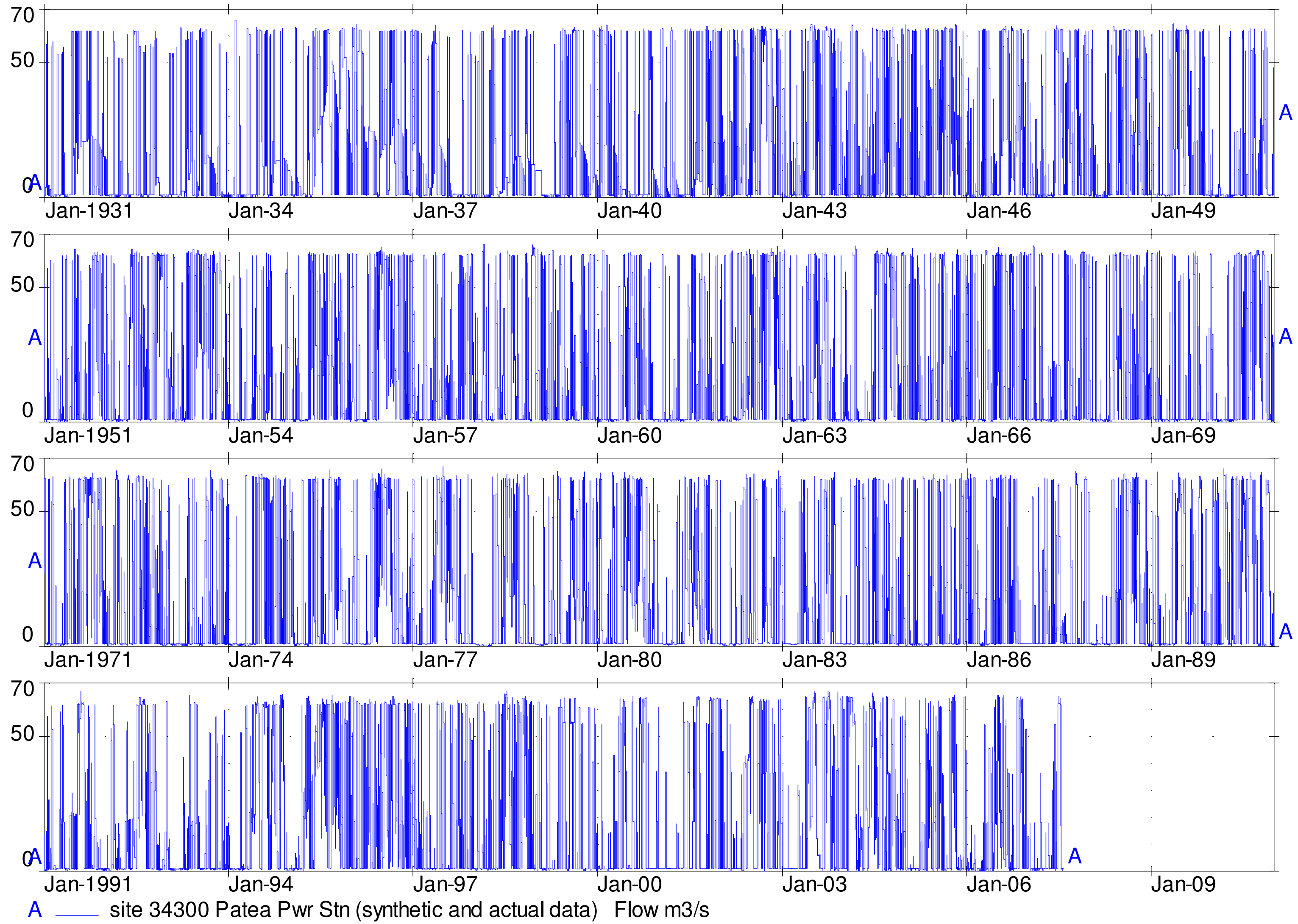



**Figure 3.3 Patea Spectra dataset 1931 to 2007**

# 4 Highbank (75 GWH) TrustPower

## Scheme Description

The Highbank Power Station was constructed between 1939 and 1945 as part of a combined project to irrigate dry farmland and generate electricity. Water for the station is collected from the Rangitata River by means of a 66 km long irrigation race, which provides water for use by farms in summer, when demand for electricity is lower. In winter when electricity demand increases, and demand for irrigation water reduces, the water is used for power generation purposes.

With an installed capacity of 25,200 kW, the Highbank scheme has an average annual output of 94 GWh.

Figure 4.1 shows the Highbank Power Station and the associated flow recorders on or in the vicinity of the Highbank Power Station. Table 4.1 shows the site number, site name, and the length of record existing for the sites.

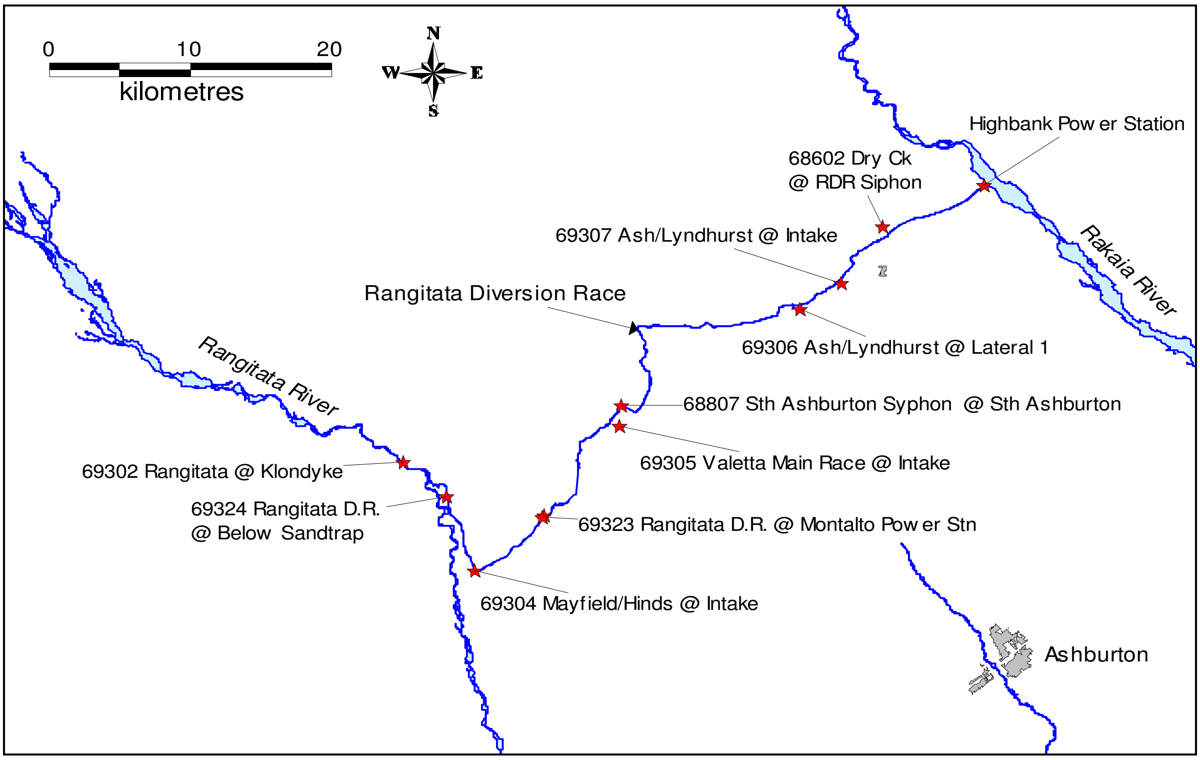



**Figure 4.1 Highbank Power Station Location diagram**

**Table 4.1 Flow Recording Stations in the vicinity of the Highbank power station**

| Site Number | Site Name | Record Length |
|---|---|---|
| 7968 | Highbank Power Station (Machine Output) | May 51 to Jul 98 |
| 77963 | Highbank Power Station (Ext Flow Record) | Jan 30 to May 98 |

**Creation of synthetic data for Highbank Power Station**

The ECNZ Highbank Power Station record begins in May 1951 and ends in May 1998. In June 2002 TrustPower began recording flow which extends to 2007.

In a 1990 Opus report "Extended Flow Study – Mohaka, Mangahao, Grey, Arnold and Highbank" a synthetic Highbank dataset was created from 1931 to 1951. Some gaps exist in the dataset so as part of this report a synthetic dataset was created to fill these gaps. The same PSIM that was used in the 1990 report was used in this study.

The PSIM uses variations in Lake Coleridge inflows to produce synthetic data. Actual Highbank data (ECNZ and TrustPower) and synthetic data were combined to provide a Spectra flow record for Highbank Power Station from 1931 to 2007.

Table 4.2 shows the mean flow for each record for the synthetic and actual data. Comparisons were made to ensure a similar water balance was maintained for the Highbank Power Station when creating synthetic data. The differences in mean flow may be partly caused by different companies running the power station in different ways.

**Table 4.2 Mean flow for Highbank Power Station**

| Record | Record Length | Mean Flow ($m^3/s$) |
|---|---|---|
| Highbank actual (ECNZ) | 1951-1988 | 13.7 |
| Highbank actual (TrustPower) | 2002-2007 | 12.2 |
| Synthetic Highbank | 1931-2007 | 14.2 |
| Actual and synthetic Highbank | 1931-2007 | 13.4 |

A comparison plot showing the actual Highbank Power Station record from 1951 to 1988 and the synthetic record for the same period (prior to superimposing the actual record over the synthetic series) is displayed in Figure 4.2. The combined flow record of the actual Highbank Power Station data and the synthetic Highbank record are displayed in Figure 4.3. The mean monthly values and distribution of the Spectra record are displayed in Appendix A.

Details of the 1990 report are included in Appendix B.

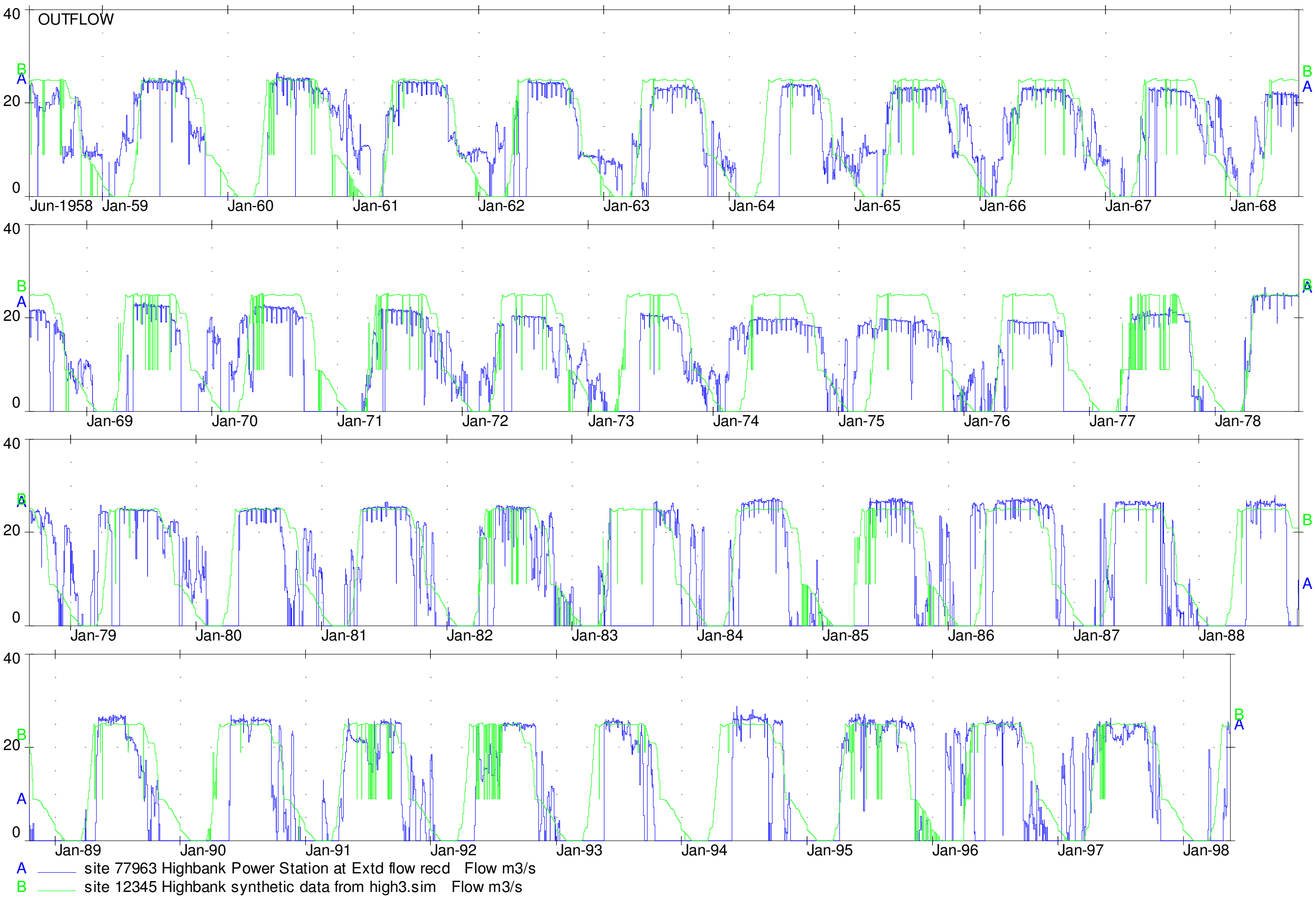



**Figure 4.2 Comparison between actual Highbank data and the rated record used to extend the Spectra series**

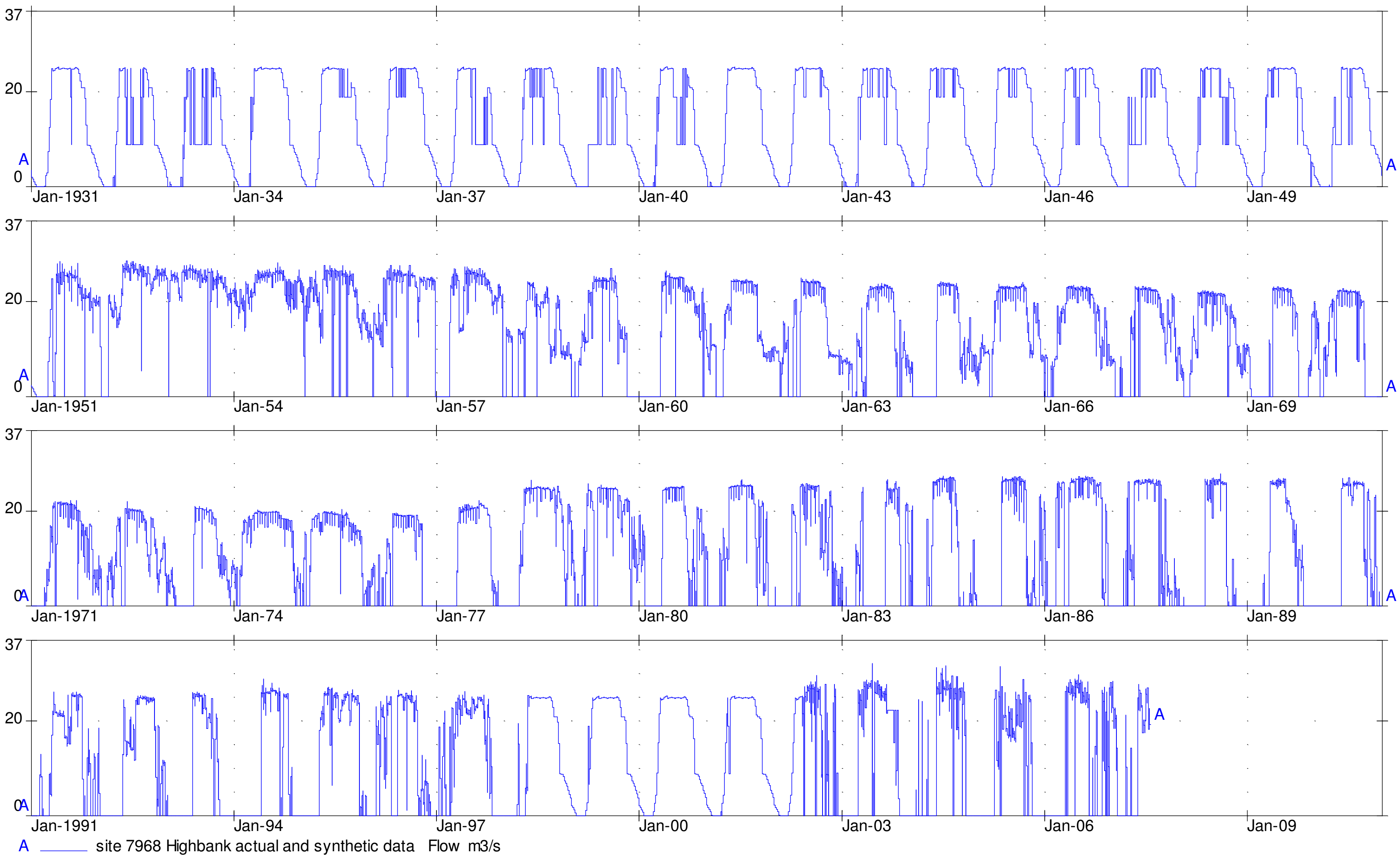



**Figure 4.3 Highbank Spectra dataset 1931 to 2007**

# 5 Kaimai Hydro Power Scheme (174 GWH) TrustPower

**Scheme Description**

Electricity generation in the Wairoa River Catchment had it's beginnings in 1915 with the construction of a 150kW plant at Omanawa Falls which was increased to 750kW in 1921. This was followed in 1925 by the commissioning of the 2700kW McLaren Falls Station.

Today the scheme consists of the 350kW Kaimai 5 Station on a diversion tunnel feeding Lake Mangaonui, the 15,600kW Lloyd Mandeno station, sited on the west bank of the Mangapapa River, the 6,000kW Lower Mangapapa Station, and 4km further downstream the 20, 000kW Ruahihi Station. The total annual output of the scheme is 165GWh. The McLaren Falls power station was decommissioned in 1989 and a bypass was subsequently installed to allow the continued release of recreational flows into the Wairoa River on set days each year for activities such as rafting and canoeing.

**Ruahihi Power Station**

The Ruahihi Power Station is situated on the Wairoa River adjacent to SH29. Ruahihi is the third and largest section of the overall scheme. Construction contracts were let in mid 1977, and the station was commissioned in 1981, but a failure in the feed canal later that year required major rebuilding. The station was recommissioned in 1983.

The reservoir for this station is Lake McLaren and the canal links the reservoir to the station. Lake McLaren was formed in 1925 by the construction of a 26m high concrete arch dam across the lower Mangapapa River to operate the now decommissioned McLarens Falls Power Station. Water from the lake passes through a gated inlet structure into a 2.5 kilometre-long canal. The construction of the canal involved moving 2, 400, 000 cubic metres of soil at depths up to 46 m below original ground level, making it one of the larger canals in New Zealand. The depth of the water in this canal is 6m and the width at normal operating level is 30m. Flow velocities are up to 0.9m per second depending on machine settings and water levels.

Transition from the canal to penstock is a fore bay which again has screens, a cleaner and control gates. Downstream of the fore bay is a 1.6km low pressure conduit leading to twin high pressure penstock pipes down the escarpment and under State Highway 29 into the power house. There are two generating sets in the station, each producing 10, 000kW at 86.4m head of water. Operating speed is 500 rpm and the average energy produced is 75.6GWh per annum.

Figure 5.1 shows Power Stations of the Kaimai Power Scheme and the associated flow recorders on, or in, the vicinity of the Kaimai Power Scheme. Table 5.1 shows the site number, site name, the length of record existing for each flow site.

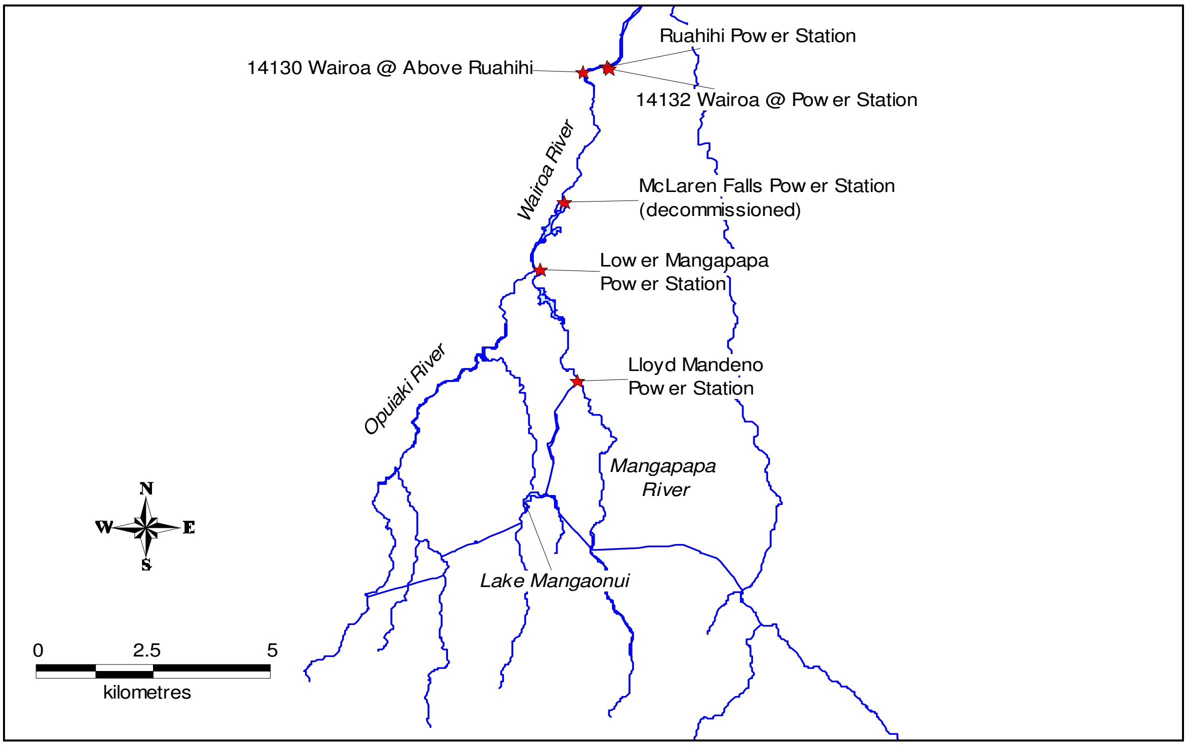



**Figure 5.1 Kaimai Hydro Power Scheme Location diagram.**

**Table 5.1 Flow Recording Stations in the vicinity of the power station, plus possible power station records.**

| Site Number | Site Name | Record Length |
|---|---|---|
| 14130 | Wairoa at Above Ruahihi | Sep 90 to present |
| 14132 | Wairoa at Power Station | Jul 93 to present |

### Creation of synthetic data for Ruahihi Power Station

To create a Spectra dataset for the Kaimai scheme, site 14132 Wairoa at Power Station was used. The site begins July 1993 and finishes in February 2007. The Wairoa at Power Station record was extended back from 1993 to 1931. Synthetic data was created by analysing simulated natural Taupo inflow and Wairoa at Power station and applying the distribution rating to the simulated natural inflow record at Lake Taupo.

Actual data and synthetic data were combined to provide a flow record for Wairoa at Power Station from 1931 to 2007.

Table 5.2 shows the mean flow for each record for synthetic and actual data. Comparisons were made to ensure a similar water balance was maintained for Wairoa at Power Station when creating synthetic data.

**Table 5.2 Mean flow for Wairoa at Power Station**

| Record | Record Length | Mean Flow ($m^3/s$) |
|---|---|---|
| Wairoa at Power Station (actual) | 1993-2007 | 12.0 |
| Synthetic Wairoa at Power Station | 1993-2007 | 12.1 |
| Extended synthetic Wairoa at Power Station | 1931-2007 | 11.8 |
| Actual and synthetic Wairoa at Power Station | 1931-2007 | 11.8 |

A comparison plot showing the actual Wairoa at Power Station record from 1993 to 2007 and the synthetic record for the same period is displayed in Figure 5.2. Both the combined flow record of the actual Wairoa at Power Station data and the rated record are displayed in Figure 5.3.

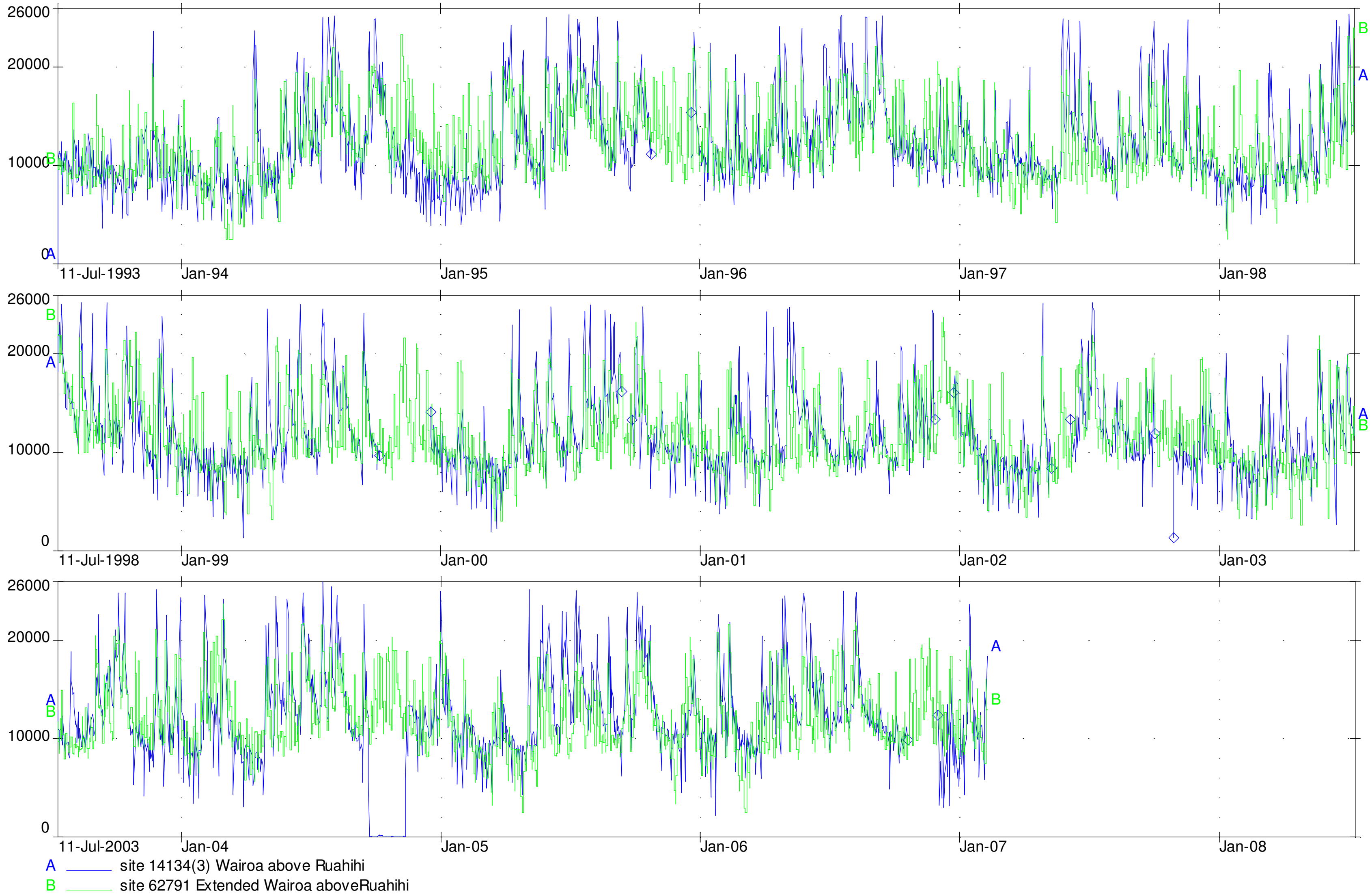



**Figure 5.2 Comparison plot between actual Wairoa at Power Station and synthetic record from 1993 - 2007**

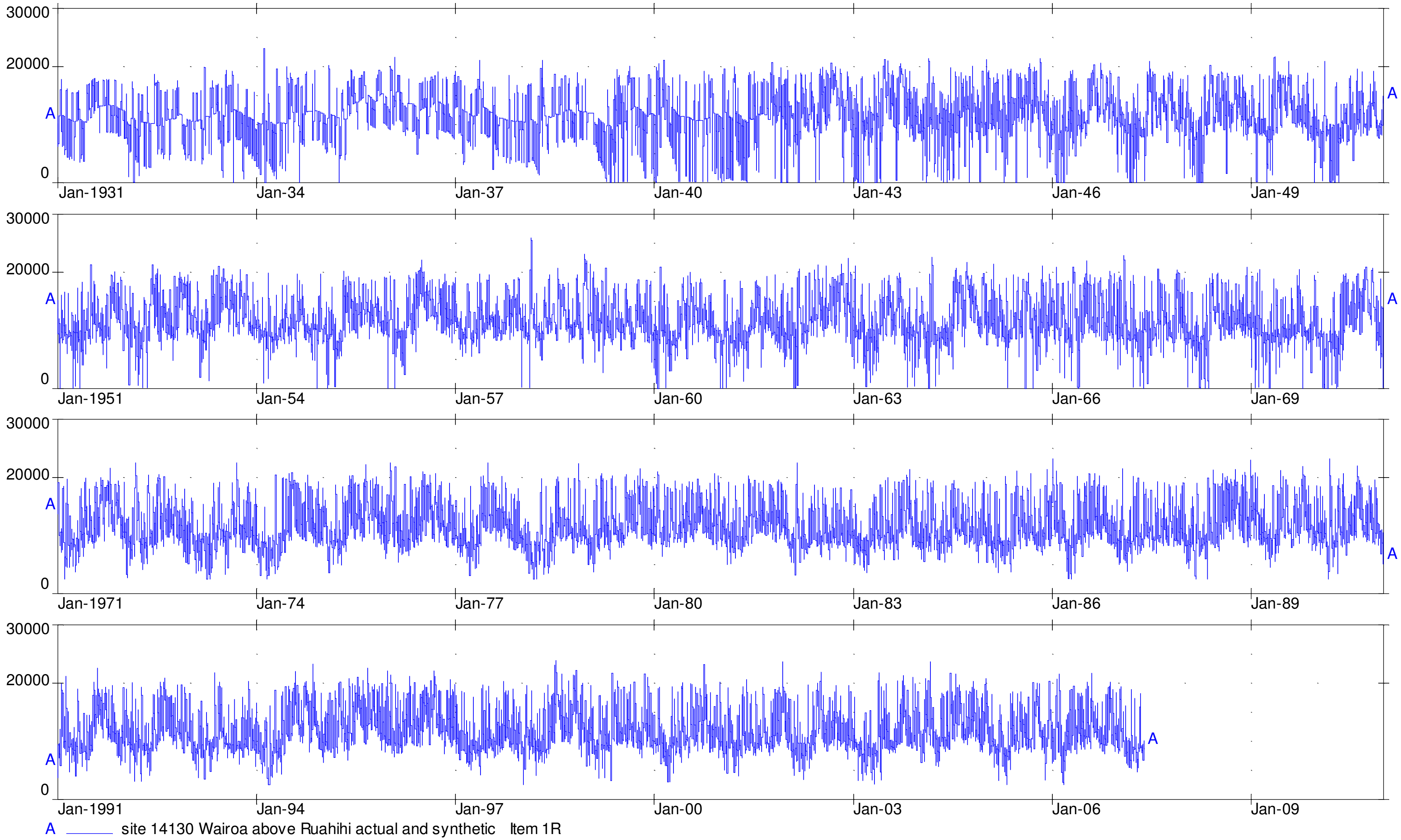



**Figure 5.3 Kaimai Spectra record 1931 - 2007**

# 6 Waipori (220 GWH) TrustPower

## Scheme Description

The scheme comprises a network of four dams and power stations on the Waipori River. It is a remarkable feat of engineering skill - an ingenious system of underground tunnels, surge chambers and a workable marriage of vintage machinery and the latest high tech generation equipment.

The result is a high quality efficient power supply. The topography of the upper Waipori River catchment provides the ideal setting for generating hydro electricity. After a winding course the river emerges into a valley of 27 km in length but with only a 30m fall, providing the ideal setting for Lake Mahinerangi. In contrast this valley becomes a narrow gorge with a sharp decent of 165m over 4 km, giving the fall necessary for water to drive the turbines.

The system beginning near the headwaters of the Waipori River, high in the Lammerlaw Range. A web of water races, open channels, diversion tunnels and pipelines feed the scheme beginning with the 2,000 hectare Lake Mahinerangi and Station 1 below the dam. Downstream the dark, peat-stained waters pause at a further 3 dams to repeat the effort.

Figure 6.1 shows the Waipori Power Station and the associated flow recorders on or in the vicinity of the Waipori Power Station.

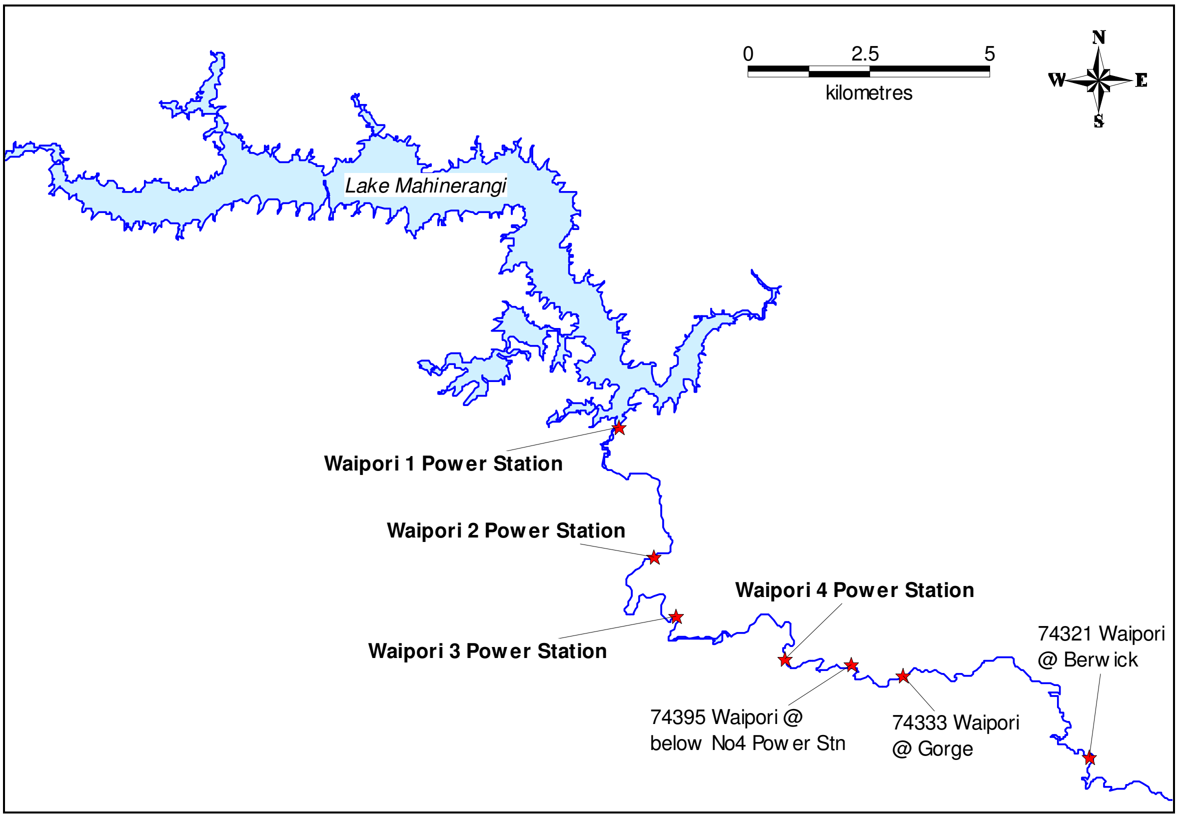



**Figure 6.1 Waipori Power Station and Gauging Station Location diagram.**

**Creation of synthetic data for Waipori 4**

Waipori at Berwick and Waipori at Below No 4 Power Station data were correlated and compared with long term flow stations in the vicinity of the Waipori catchment. The long term flow stations used in comparisons were Lake Wanaka, Lake Te Anau, Lake Manapouri, Lake Wakatipu, and Lake Roxburgh inflow, Clutha at Alexandra Bridge and Clutha at Balclutha.

None of the seven lakes/flow sites had a comparable flow relationship with Waipori at Below No 4 Power Station (74395) or Waipori at Berwick (74321). The Waipori catchment contains a large lake, Lake Mahinerangi and four power stations along the Waipori River. Lake Mahinerangi has storage and therefore can soak up any flood events, combined with any flow released from the lake having to go through four power stations means that the flows in this catchment are totally controlled and behave differently from the natural flow occurrences in adjoining catchments.

Figure 6.2 shows a flow hydrograph for Waipori at Below No 4 power station.

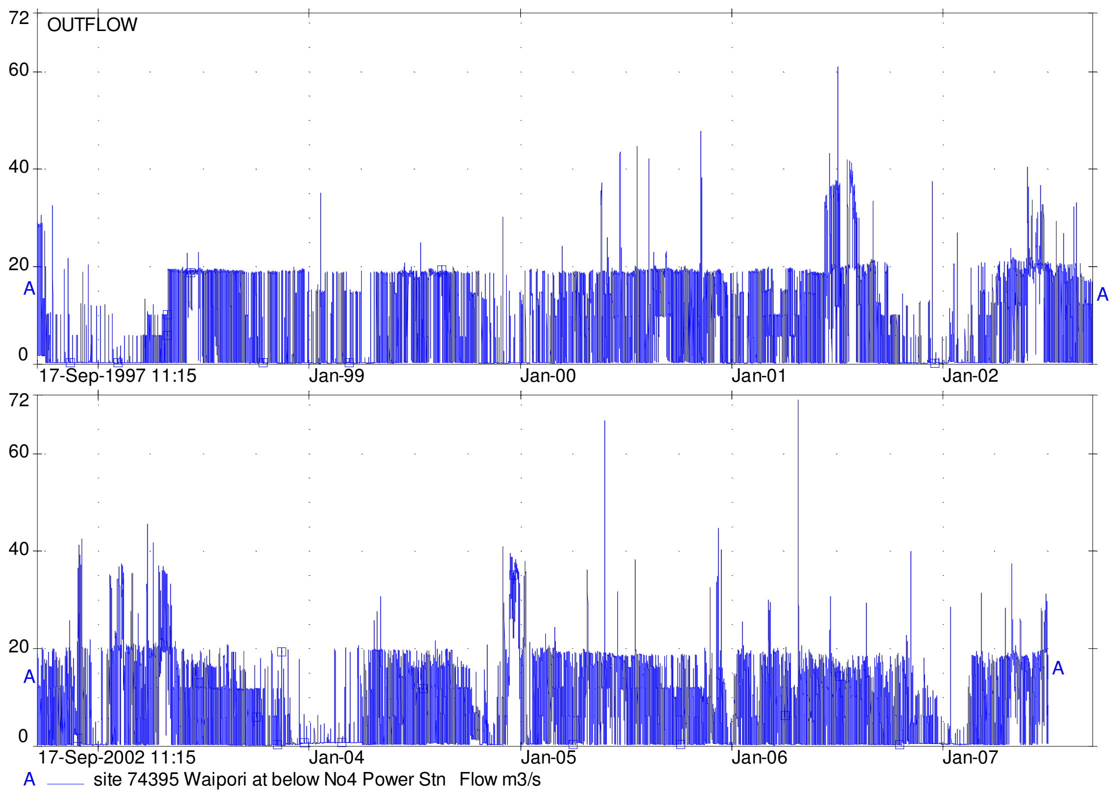



**Figure 6.2 Waipori at Below No 4 Power Station flow**

Figure 6.3 highlights how the Waipori catchment does not reflect the behaviour of the surrounding catchment. Figure 6.3 shows Waipori at Below No 4 power station versus Lake Wakatipu outflow. It can be seen that Waipori mainly has the profile associated with turbine discharge and occasional spill discharges. The spill discharges do not coincide with high flow events at Wakatipu. This comparison was found to occur for all flow sites compared with Waipori.

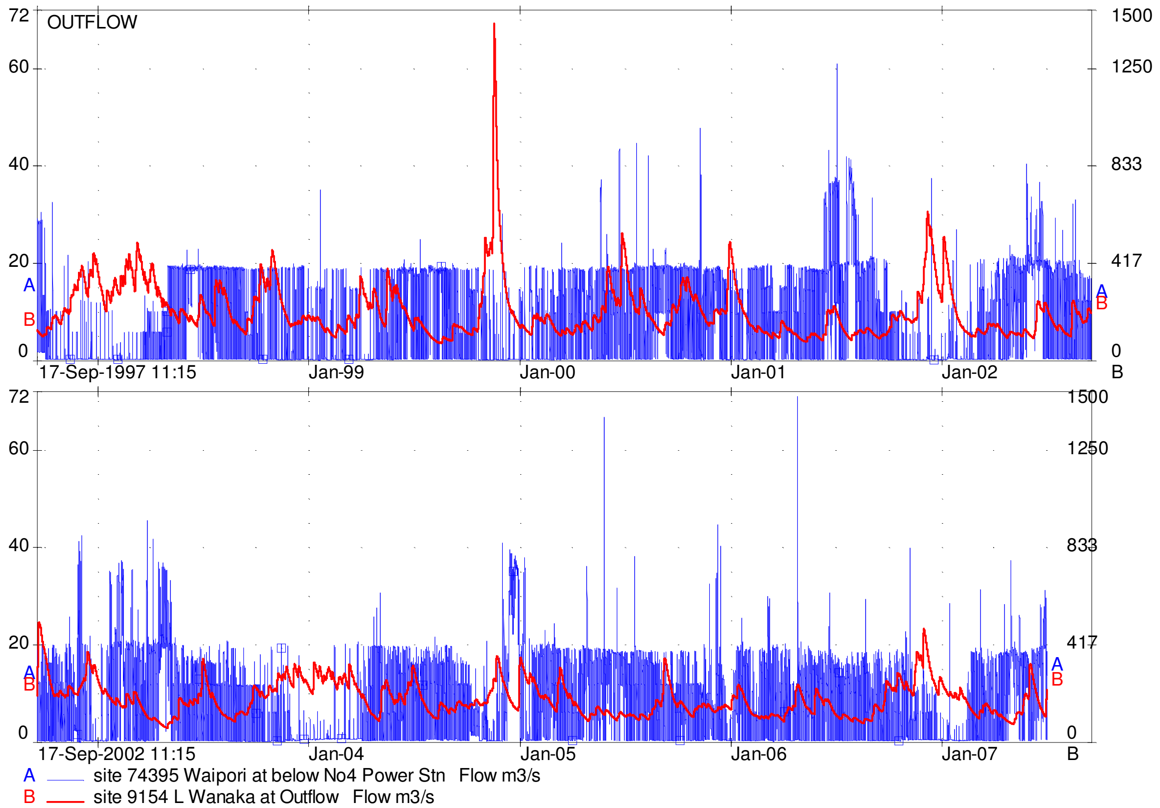



**Figure 6.3 Waipori at Below No 4 Power Station flow compared with Lake Wanaka Outflow**

To create a synthetic flow dataset for this catchment a flow analysis was conducted for Waipori at Berwick and Waipori at Below No 4. The resultant flow distribution rating was then applied to Waipori at Berwick to reduce flows to that of Waipori at Below No 4.

Synthetic Waipori at Below No 4 data was combined with actual Waipori at Below No 4 Power Station to give a record from 1988 to 2007. The ratios from the Trends in Flow Data report (1993) were sourced and annual data series that had means that reflected the historic means were used to infill the dataset from 1931 to 1988.

Actual data and synthetic data were combined to provide a flow record for Waipori at Below No 4 Power Station from 1931 to 2007.

Table 6.1 shows the mean flow for each record for synthetic and actual data. Comparisons were made to ensure a similar water balance was maintained for Waipori at Below No 4 Power Station when creating synthetic data.

**Table 6.1 Mean flow for Waipori at Below No4 Power Station**

| Record | Record Length | Mean Flow ($m^3/s$) |
|---|---|---|
| Waipori at Below No 4 Power Station (actual) | 1997-2007 | 7.6 |
| Waipori at Berwick (actual) | 1988-2007 | 10.9 |
| Synthetic Waipori at Below No 4 | 1998-2007 | 7.1 |
| Actual and synthetic Waipori at Below No 4 Power Station | 1931-2007 | 7.2 |

A comparison plot showing the actual Waipori at Below No 4 Power Station record from 1997 to 2007 and the synthetic record for the same period is displayed in Figure 6.4. Both the combined flow record of the actual Waipori at Below No 4 Power Station data and the rated record are displayed in Figure 6.5.

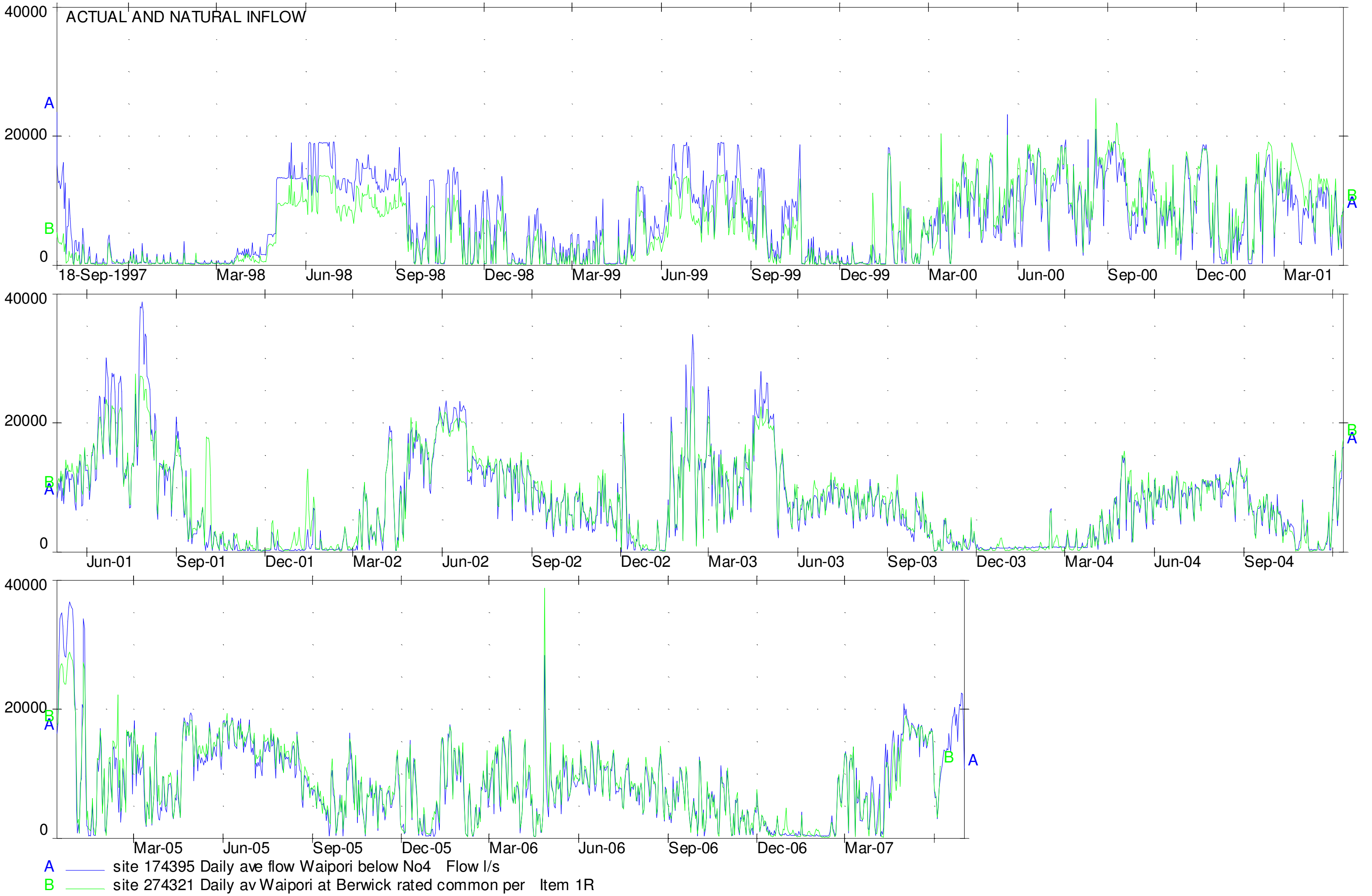



**Figure 6.4 Comparison plot between actual Waipori at Below No 4 Power Station and synthetic Waipori at Below No4 record from 1997 - 2007**


**Figure 6.5 Waipori Spectra record 1931 - 2007**

# 7 Summary

Four of the five sites created as part of this report correlated and compared very well with the long term flows stations used to extend their record back to 1931.

These sites were:

- Wheao/Flaxy
- Patea
- Highbank
- Kaimai

The Waipori at Berwick and Waipori at Below No 4 Power Station sites did not correlate or compare well with any of the long term flow stations located in the south of the South Island. The reason for this is Lake Mahinerangi can store many of the flood events that occur because of the operational practices that are part of TrustPower's hydro power operations (Lake Mahinerangi rarely spills).

To create part of the synthetic record for Waipori the two Waipori sites were analysed and Waipori at Berwick was used to extend the record for Waipori at Below No 4, giving 19 years of record from 1988 to 2007.

The Trends in Flow Data report was then used as a reference to obtain annual ratio's to the mean for the years 1931 to 1988. Annual data series from the extended Waipori record that had a mean close to the ratio obtained from the Trends in Flow Data report was then inserted for that year.

For example 1936 had a ratio of 1.04 compared to mean for the south of the South Island. For the Waipori extended record 1998 had a ratio of 1.04 to the Waipori mean, therefore the annual series for 1998 was inserted and became the annual Waipori data series for 1936.

# 8 Bibliography

J R Duffy, H J Freestone, D C Maslin, (1993)Trends in Flow Data – for Manapouri Local Inflows, Mangahao, Cobb, Coleridge Inflows and Waikato Tributary Flows, Works Consultancy Services Limited, Wellington.

# Appendix A

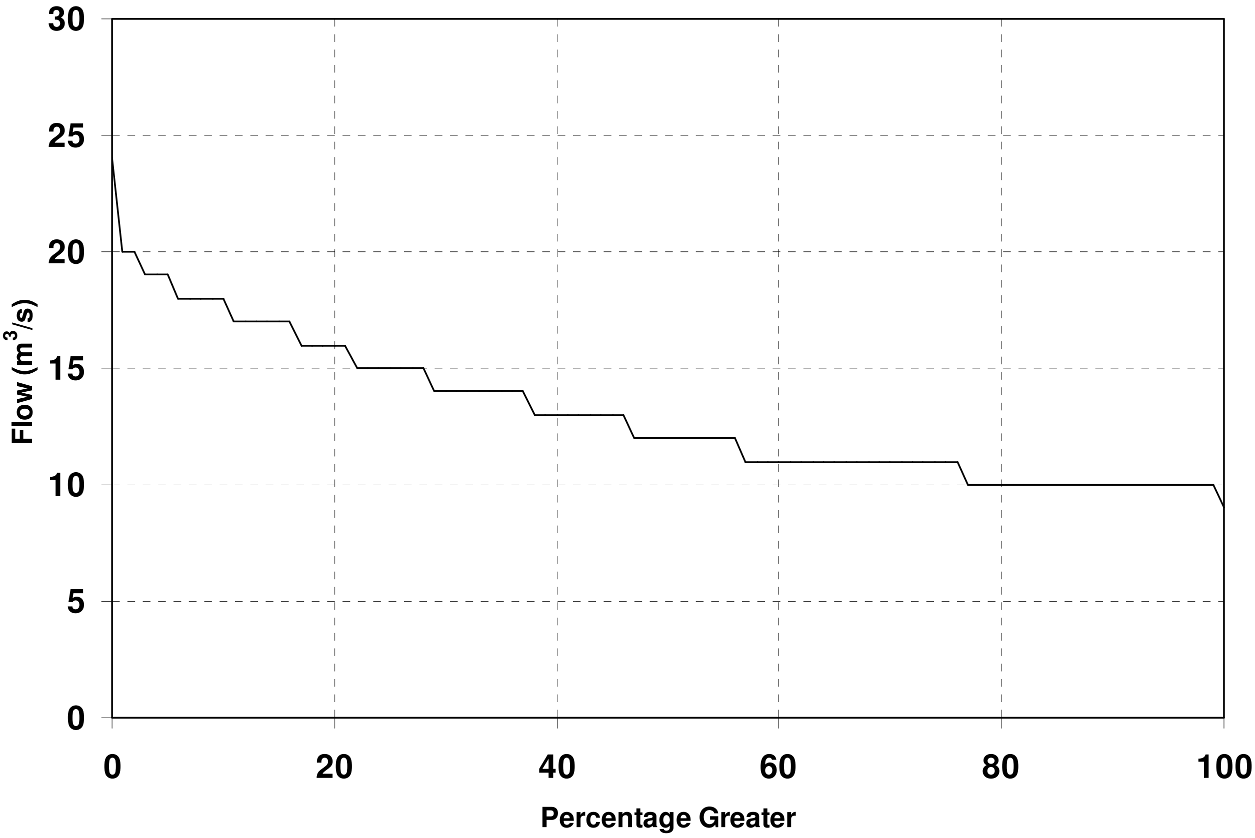
## Mean monthly flow values and the distribution of the flow

**Table A: Site 15462 Wheao Power Station – Monthly Means ($m^3/s$), 1931 – 2007**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1931** | 11 | 11 | 10 | 10 | 10 | 10 | 12 | 14 | 15 | 15 | 14 | 13 | 12 |
| **1932** | 12 | 11 | 10 | 10 | 10 | 10 | 11 | 10 | 10 | 11 | 11 | 10 | 11 |
| **1933** | 10 | 10 | 11 | 11 | 12 | 12 | 12 | 12 | 13 | 12 | 11 | 10 | 11 |
| **1934** | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 13 | 12 | 12 | 13 | 12 | 11 |
| **1935** | 11 | 11 | 11 | 10 | 11 | 15 | 17 | 18 | 18 | 17 | 19 | 18 | 15 |
| **1936** | 18 | 19 | 19 | 16 | 15 | 13 | 14 | 14 | 16 | 16 | 15 | 13 | 16 |
| **1937** | 14 | 13 | 12 | 11 | 13 | 14 | 12 | 11 | 11 | 10 | 10 | 10 | 12 |
| **1938** | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 12 | 13 | 12 | 13 | 12 | 11 |
| **1939** | 12 | 11 | 10 | 10 | 10 | 10 | 10 | 11 | 14 | 13 | 11 | 12 | 11 |
| **1940** | 11 | 14 | 17 | 13 | 11 | 11 | 11 | 10 | 10 | 11 | 12 | 11 | 12 |
| **1941** | 11 | 11 | 11 | 11 | 10 | 10 | 11 | 12 | 13 | 16 | 17 | 15 | 12 |
| **1942** | 14 | 13 | 12 | 13 | 13 | 12 | 14 | 16 | 19 | 20 | 19 | 18 | 15 |
| **1943** | 15 | 12 | 11 | 10 | 10 | 11 | 16 | 17 | 18 | 20 | 19 | 16 | 15 |
| **1944** | 13 | 11 | 12 | 11 | 11 | 10 | 11 | 12 | 13 | 13 | 13 | 12 | 12 |
| **1945** | 14 | 14 | 14 | 13 | 13 | 13 | 14 | 15 | 17 | 18 | 18 | 15 | 15 |
| **1946** | 12 | 10 | 10 | 10 | 11 | 10 | 10 | 14 | 17 | 19 | 18 | 17 | 13 |
| **1947** | 14 | 12 | 10 | 10 | 10 | 10 | 14 | 14 | 15 | 17 | 17 | 14 | 13 |
| **1948** | 13 | 11 | 10 | 10 | 11 | 13 | 16 | 15 | 14 | 13 | 14 | 13 | 13 |
| **1949** | 12 | 11 | 10 | 10 | 13 | 14 | 15 | 15 | 14 | 12 | 11 | 11 | 12 |
| **1950** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 10 | 10 |
| **1951** | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 11 | 10 | 12 | 13 | 11 |
| **1952** | 12 | 11 | 10 | 10 | 10 | 13 | 16 | 14 | 13 | 13 | 18 | 19 | 13 |
| **1943** | 18 | 16 | 13 | 11 | 12 | 15 | 18 | 18 | 17 | 17 | 15 | 14 | 15 |
| **1954** | 12 | 11 | 11 | 10 | 10 | 10 | 10 | 12 | 13 | 11 | 10 | 10 | 11 |
| **1955** | 10 | 10 | 10 | 10 | 10 | 11 | 12 | 14 | 14 | 14 | 13 | 12 | 12 |
| **1956** | 13 | 13 | 11 | 12 | 17 | 20 | 20 | 19 | 19 | 18 | 18 | 17 | 16 |
| **1957** | 16 | 14 | 12 | 11 | 11 | 11 | 13 | 11 | 11 | 11 | 11 | 11 | 12 |
| **1958** | 11 | 12 | 14 | 11 | 11 | 11 | 12 | 14 | 14 | 12 | 16 | 17 | 13 |
| **1959** | 19 | 17 | 17 | 18 | 16 | 16 | 16 | 15 | 13 | 15 | 15 | 14 | 16 |
| **1960** | 12 | 12 | 12 | 11 | 10 | 12 | 13 | 13 | 13 | 15 | 14 | 12 | 12 |
| **1961** | 11 | 11 | 11 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| **1962** | 10 | 10 | 13 | 12 | 16 | 18 | 19 | 19 | 19 | 20 | 21 | 22 | 17 |
| **1963** | 19 | 17 | 15 | 13 | 11 | 12 | 16 | 15 | 17 | 16 | 13 | 12 | 15 |
| **1964** | 11 | 11 | 11 | 11 | 10 | 10 | 16 | 18 | 18 | 19 | 18 | 16 | 14 |
| **1965** | 15 | 18 | 17 | 15 | 13 | 13 | 14 | 16 | 15 | 13 | 14 | 13 | 15 |
| **1966** | 15 | 15 | 16 | 13 | 15 | 15 | 18 | 19 | 18 | 18 | 17 | 17 | 16 |
| **1967** | 16 | 19 | 17 | 14 | 13 | 12 | 12 | 14 | 16 | 14 | 15 | 16 | 15 |
| **1968** | 14 | 13 | 11 | 11 | 12 | 15 | 17 | 16 | 17 | 16 | 15 | 15 | 14 |
| **1969** | 15 | 16 | 14 | 12 | 12 | 11 | 11 | 11 | 12 | 11 | 10 | 11 | 12 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1970** | 11 | 10 | 10 | 10 | 10 | 12 | 12 | 17 | 19 | 21 | 20 | 17 | 14 |
| **1971** | 15 | 13 | 12 | 11 | 14 | 14 | 12 | 13 | 18 | 19 | 19 | 20 | 15 |
| **1972** | 18 | 15 | 17 | 14 | 14 | 13 | 15 | 14 | 15 | 14 | 12 | 11 | 14 |
| **1973** | 11 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 12 | 13 | 12 | 11 | 11 |
| **1974** | 10 | 10 | 10 | 11 | 10 | 12 | 16 | 19 | 18 | 17 | 17 | 17 | 14 |
| **1975** | 18 | 16 | 13 | 12 | 11 | 16 | 15 | 15 | 18 | 18 | 17 | 15 | 15 |
| **1976** | 16 | 18 | 16 | 14 | 14 | 13 | 14 | 16 | 16 | 17 | 16 | 14 | 15 |
| **1977** | 12 | 11 | 10 | 10 | 10 | 12 | 15 | 15 | 15 | 14 | 13 | 12 | 12 |
| **1978** | 11 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 10 | 12 | 11 | 10 |
| **1979** | 10 | 11 | 13 | 13 | 13 | 13 | 12 | 15 | 17 | 18 | 18 | 17 | 14 |
| **1980** | 17 | 15 | 14 | 14 | 13 | 13 | 14 | 14 | 17 | 15 | 13 | 15 | 15 |
| **1981** | 15 | 13 | 12 | 11 | 12 | 14 | 17 | 17 | 17 | 15 | 16 | 17 | 15 |
| **1982** | 16 | 14 | 13 | 12 | 12 | 12 | 11 | 11 | 11 | 11 | 10 | 10 | 12 |
| **1983** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 14 | 18 | 15 | 11 |
| **1984** | 12 | 12 | 13 | 12 | 11 | 10 | 11 | 11 | 12 | 11 | 11 | 12 | 11 |
| **1985** | 11 | 11 | 10 | 10 | 10 | 10 | 10 | 11 | 11 | 10 | 10 | 11 | 10 |
| **1986** | 15 | 12 | 11 | 10 | 10 | 11 | 11 | 13 | 14 | 14 | 13 | 12 | 12 |
| **1987** | 12 | 11 | 11 | 11 | 10 | 11 | 11 | 11 | 11 | 10 | 10 | 10 | 11 |
| **1988** | 10 | 10 | 10 | 10 | 10 | 10 | 11 | 14 | 18 | 18 | 17 | 17 | 13 |
| **1989** | 19 | 17 | 15 | 12 | 12 | 14 | 15 | 13 | 13 | 16 | 16 | 14 | 15 |
| **1990** | 13 | 12 | 12 | 11 | 12 | 12 | 12 | 17 | 15 | 16 | 18 | 16 | 14 |
| **1991** | 13 | 13 | 12 | 11 | 10 | 10 | 10 | 15 | 15 | 15 | 14 | 12 | 12 |
| **1992** | 11 | 11 | 11 | 10 | 10 | 10 | 11 | 16 | 16 | 15 | 13 | 16 | 13 |
| **1993** | 13 | 12 | 11 | 11 | 10 | 13 | 12 | 11 | 10 | 10 | 10 | 10 | 11 |
| **1994** | 10 | 10 | 9 | 10 | 10 | 10 | 13 | 18 | 15 | 17 | 18 | 16 | 13 |
| **1995** | 13 | 12 | 11 | 13 | 12 | 13 | 18 | 18 | 18 | 19 | 18 | 17 | 15 |
| **1996** | 16 | 14 | 13 | 14 | 15 | 15 | 16 | 17 | 18 | 16 | 14 | 14 | 15 |
| **1997** | 13 | 12 | 12 | 12 | 11 | 14 | 13 | 11 | 11 | 13 | 12 | 11 | 12 |
| **1998** | 10 | 10 | 10 | 10 | 10 | 10 | 19 | 19 | 18 | 18 | 17 | 15 | 14 |
| **1999** | 13 | 11 | 12 | 12 | 12 | 13 | 12 | 13 | 13 | 13 | 13 | 12 | 12 |
| **2000** | 12 | 12 | 11 | 11 | 11 | 11 | 11 | 12 | 13 | 13 | 13 | 13 | 12 |
| **2001** | 12 | 12 | 11 | 11 | 11 | 11 | 11 | 11 | 12 | 11 | 12 | 17 | 12 |
| **2002** | 12 | 12 | 11 | 11 | 11 | 12 | 17 | 13 | 11 | 11 | 11 | 12 | 12 |
| **2003** | 11 | 10 | 10 | 10 | 10 | 10 | 11 | 10 | 12 | 17 | 13 | 16 | 12 |
| **2004** | 16 | 13 | 14 | 12 | 11 | 15 | 18 | 19 | 19 | 19 | 20 | 15 | 16 |
| **2005** | 17 | 12 | 12 | 12 | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 11 | 12 |
| **2006** | 11 | 12 | 11 | 11 | 12 | 13 | 16 | 19 | 14 | 11 | 11 | 11 | 13 |
| **2007** | 12 | 12 | 11 | 11 | 10 | 10 | | | | | | | 11 |
| **Min.** | 10 | 10 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| **Mean** | 13 | 12 | 12 | 11 | 11 | 12 | 13 | 14 | 14 | 15 | 14 | 14 | 13 |
| **Max.** | 19 | 19 | 19 | 18 | 17 | 20 | 20 | 19 | 19 | 21 | 21 | 22 | 17 |

**Figure A: Site 15462 Wheao Power Station – Distribution of flows ($m^3/s$), 1931 – 2007**




| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 24 | 20 | 20 | 19 | 19 | 19 | 18 | 18 | 18 | 18 |
| **10** | 18 | 17 | 17 | 17 | 17 | 17 | 17 | 16 | 16 | 16 |
| **20** | 16 | 16 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 14 |
| **30** | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 13 | 13 |
| **40** | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 12 | 12 | 12 |
| **50** | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 11 | 11 | 11 |
| **60** | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| **70** | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 10 | 10 | 10 |
| **80** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| **90** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| **100** | 9 | | | | | | | | | |

**Note: Figure and table depicting percentage of time flow exceeded, 0% is the maximum outflow and 100% is the minimum outflow.**

**Summary Table: Flow ($m^3/s$)**

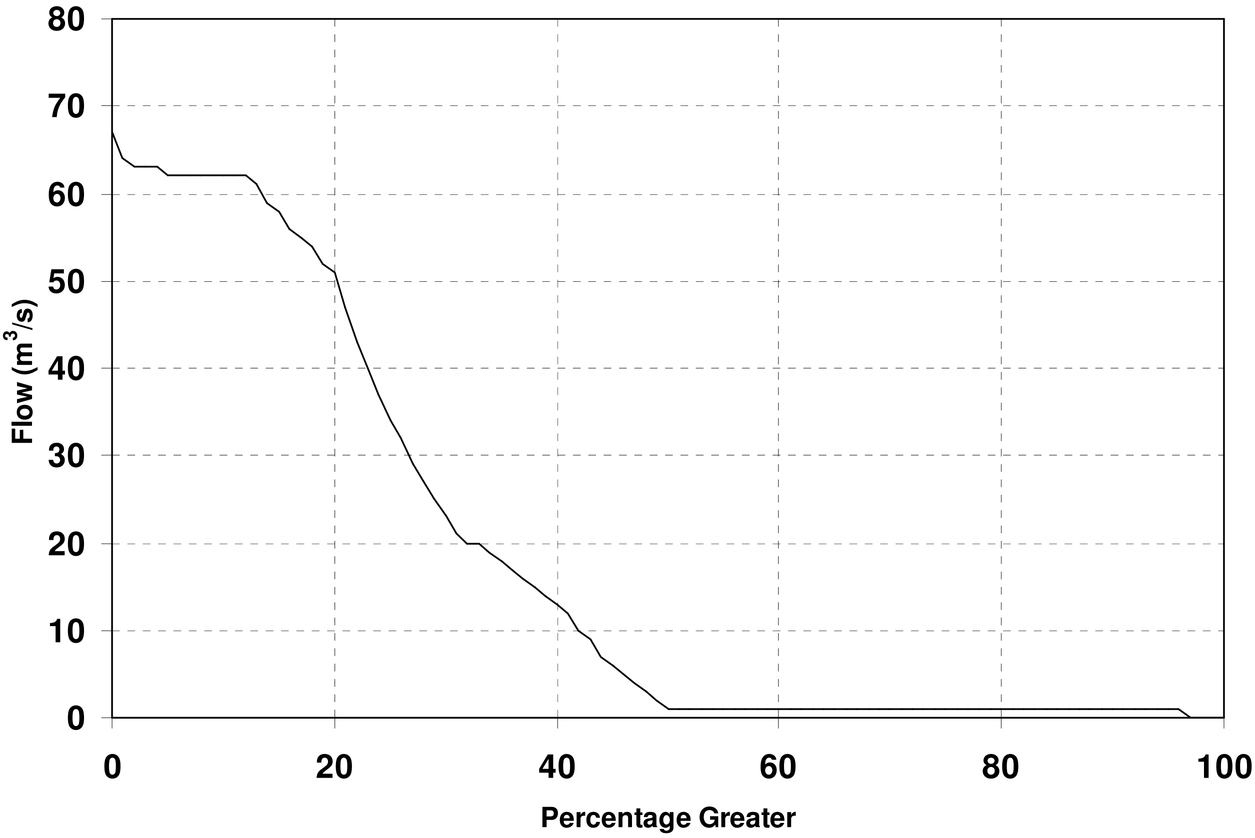
| Record Length | Minimum | Mean | Median | Maximum |
|---|---|---|---|---|
| Jan 1931 to Jul 2007 | 9 | 13 | 12 | 24 |

**Table B: Site 34300 Patea Power Station – Monthly Means ($m^3/s$), 1931 – 2007**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1931** | 14 | 7 | 5 | 12 | 3 | 23 | 35 | 33 | 34 | 19 | 21 | 15 | 19 |
| **1932** | 7 | 10 | 5 | 9 | 8 | 30 | 14 | 10 | 6 | 24 | 5 | 1 | 11 |
| **1933** | 5 | 11 | 20 | 7 | 33 | 12 | 19 | 28 | 13 | 5 | 11 | 5 | 14 |
| **1934** | 1 | 13 | 4 | 10 | 9 | 17 | 29 | 27 | 13 | 21 | 20 | 9 | 14 |
| **1935** | 2 | 15 | 7 | 10 | 26 | 49 | 38 | 53 | 25 | 31 | 54 | 18 | 27 |
| **1936** | 34 | 52 | 17 | 20 | 15 | 12 | 35 | 31 | 33 | 23 | 22 | 14 | 26 |
| **1937** | 32 | 10 | 10 | 8 | 31 | 14 | 11 | 7 | 1 | 7 | 4 | 9 | 12 |
| **1938** | 8 | 28 | 1 | 26 | 10 | 11 | 16 | 28 | 21 | 8 | 26 | 14 | 16 |
| **1939** | 10 | 2 | 1 | 7 | 4 | 23 | 15 | 42 | 27 | 12 | 6 | 20 | 14 |
| **1940** | 27 | 36 | 16 | 7 | 10 | 7 | 2 | 6 | 7 | 19 | 27 | 4 | 14 |
| **1941** | 19 | 6 | 23 | 4 | 1 | 20 | 23 | 23 | 17 | 44 | 28 | 23 | 19 |
| **1942** | 16 | 14 | 18 | 18 | 23 | 7 | 48 | 32 | 61 | 41 | 20 | 27 | 27 |
| **1943** | 9 | 10 | 3 | 12 | 8 | 37 | 38 | 31 | 45 | 38 | 20 | 11 | 22 |
| **1944** | 4 | 18 | 15 | 9 | 12 | 13 | 23 | 27 | 22 | 24 | 9 | 19 | 16 |
| **1945** | 29 | 14 | 21 | 12 | 23 | 27 | 28 | 39 | 32 | 27 | 19 | 11 | 24 |
| **1946** | 7 | 3 | 8 | 21 | 15 | 5 | 19 | 53 | 37 | 34 | 29 | 11 | 20 |
| **1947** | 13 | 4 | 4 | 7 | 2 | 42 | 35 | 22 | 27 | 49 | 9 | 17 | 19 |
| **1948** | 16 | 2 | 1 | 16 | 38 | 26 | 41 | 26 | 13 | 43 | 28 | 7 | 21 |
| **1949** | 9 | 8 | 6 | 14 | 24 | 48 | 43 | 28 | 12 | 15 | 15 | 7 | 19 |
| **1950** | 1 | 12 | 1 | 8 | 5 | 12 | 12 | 18 | 15 | 12 | 28 | 7 | 11 |
| **1951** | 10 | 6 | 5 | 7 | 9 | 8 | 37 | 11 | 5 | 29 | 43 | 32 | 17 |
| **1952** | 12 | 15 | 2 | 9 | 13 | 52 | 31 | 22 | 11 | 25 | 59 | 44 | 25 |
| **1943** | 15 | 11 | 4 | 7 | 29 | 41 | 51 | 36 | 28 | 36 | 27 | 10 | 25 |
| **1954** | 5 | 5 | 12 | 7 | 7 | 13 | 14 | 26 | 20 | 2 | 4 | 14 | 11 |
| **1955** | 3 | 10 | 1 | 13 | 37 | 31 | 25 | 35 | 27 | 26 | 15 | 18 | 20 |
| **1956** | 19 | 10 | 1 | 32 | 25 | 55 | 49 | 45 | 23 | 40 | 33 | 30 | 30 |
| **1957** | 11 | 3 | 15 | 2 | 28 | 13 | 14 | 9 | 5 | 28 | 30 | 28 | 16 |
| **1958** | 5 | 28 | 14 | 1 | 16 | 19 | 26 | 41 | 9 | 12 | 17 | 48 | 20 |
| **1959** | 20 | 14 | 18 | 21 | 19 | 17 | 12 | 13 | 10 | 28 | 13 | 6 | 16 |
| **1960** | 4 | 23 | 6 | 1 | 8 | 29 | 30 | 25 | 30 | 14 | 8 | 1 | 15 |
| **1961** | 14 | 4 | 4 | 11 | 1 | 9 | 34 | 13 | 24 | 11 | 3 | 9 | 11 |
| **1962** | 15 | 6 | 26 | 17 | 26 | 39 | 30 | 37 | 39 | 51 | 40 | 36 | 30 |
| **1963** | 12 | 12 | 3 | 6 | 10 | 27 | 36 | 15 | 45 | 7 | 8 | 6 | 16 |
| **1964** | 12 | 8 | 21 | 1 | 2 | 6 | 43 | 42 | 43 | 49 | 20 | 33 | 23 |
| **1965** | 18 | 24 | 20 | 9 | 6 | 26 | 18 | 40 | 12 | 9 | 34 | 20 | 20 |
| **1966** | 18 | 23 | 15 | 14 | 21 | 24 | 39 | 24 | 27 | 12 | 18 | 24 | 22 |
| **1967** | 16 | 17 | 13 | 2 | 10 | 5 | 8 | 39 | 16 | 5 | 31 | 27 | 16 |
| **1968** | 5 | 4 | 1 | 5 | 18 | 36 | 21 | 21 | 11 | 26 | 12 | 16 | 15 |
| **1969** | 16 | 21 | 4 | 5 | 14 | 7 | 4 | 13 | 31 | 8 | 3 | 14 | 12 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1970** | 3 | 1 | 5 | 9 | 14 | 33 | 24 | 37 | 53 | 36 | 29 | 13 | 21 |
| **1971** | 18 | 19 | 2 | 1 | 16 | 26 | 14 | 30 | 48 | 53 | 35 | 24 | 24 |
| **1972** | 11 | 3 | 37 | 4 | 17 | 8 | 36 | 21 | 25 | 18 | 11 | 6 | 17 |
| **1973** | 9 | 1 | 3 | 2 | 10 | 17 | 2 | 22 | 31 | 6 | 19 | 12 | 11 |
| **1974** | 1 | 3 | 1 | 10 | 14 | 18 | 46 | 30 | 22 | 30 | 12 | 23 | 18 |
| **1975** | 17 | 1 | 7 | 9 | 31 | 19 | 17 | 24 | 25 | 40 | 9 | 2 | 17 |
| **1976** | 16 | 13 | 3 | 4 | 38 | 46 | 48 | 48 | 19 | 17 | 3 | 11 | 22 |
| **1977** | 7 | 9 | 5 | 4 | 35 | 51 | 38 | 38 | 27 | 13 | 11 | 7 | 21 |
| **1978** | 1 | 0 | 0 | 8 | 17 | 17 | 49 | 34 | 24 | 12 | 13 | 4 | 15 |
| **1979** | 1 | 7 | 8 | 14 | 36 | 4 | 14 | 29 | 23 | 32 | 14 | 16 | 17 |
| **1980** | 25 | 1 | 11 | 27 | 13 | 32 | 43 | 33 | 50 | 13 | 9 | 12 | 22 |
| **1981** | 1 | 2 | 2 | 7 | 5 | 38 | 35 | 35 | 19 | 26 | 5 | 11 | 16 |
| **1982** | 3 | 3 | 2 | 4 | 21 | 25 | 13 | 8 | 33 | 12 | 7 | 26 | 13 |
| **1983** | 6 | 1 | 1 | 15 | 25 | 7 | 13 | 14 | 35 | 28 | 21 | 5 | 14 |
| **1984** | 2 | 5 | 18 | 13 | 11 | 8 | 28 | 17 | 13 | 6 | 9 | 23 | 13 |
| **1985** | 10 | 4 | 8 | 8 | 4 | 27 | 15 | 13 | 17 | 9 | 9 | 24 | 12 |
| **1986** | 39 | 17 | 4 | 5 | 19 | 14 | 25 | 26 | 21 | 24 | 3 | 1 | 17 |
| **1987** | 12 | 2 | 6 | 24 | 14 | 13 | 14 | 4 | 12 | 23 | 6 | 29 | 14 |
| **1988** | 1 | 1 | 2 | 2 | 20 | 21 | 36 | 48 | 42 | 44 | 9 | 12 | 20 |
| **1989** | 8 | 16 | 2 | 2 | 17 | 50 | 30 | 11 | 20 | 40 | 11 | 9 | 18 |
| **1990** | 32 | 10 | 35 | 14 | 24 | 37 | 45 | 51 | 23 | 20 | 38 | 7 | 28 |
| **1991** | 6 | 14 | 1 | 18 | 5 | 12 | 25 | 57 | 20 | 16 | 4 | 1 | 15 |
| **1992** | 2 | 21 | 4 | 1 | 18 | 10 | 43 | 49 | 37 | 29 | 5 | 7 | 19 |
| **1993** | 9 | 1 | 1 | 9 | 20 | 31 | 6 | 3 | 16 | 10 | 9 | 7 | 10 |
| **1994** | 2 | 1 | 6 | 15 | 24 | 50 | 40 | 52 | 32 | 31 | 49 | 3 | 26 |
| **1995** | 1 | 3 | 15 | 43 | 21 | 51 | 54 | 30 | 41 | 41 | 29 | 25 | 30 |
| **1996** | 15 | 17 | 15 | 33 | 22 | 19 | 42 | 39 | 50 | 25 | 23 | 30 | 27 |
| **1997** | 13 | 12 | 4 | 6 | 10 | 14 | 10 | 14 | 20 | 19 | 14 | 13 | 12 |
| **1998** | 11 | 13 | 5 | 6 | 17 | 24 | 57 | 29 | 23 | 47 | 27 | 16 | 23 |
| **1999** | 15 | 2 | 11 | 1 | 20 | 34 | 28 | 37 | 18 | 3 | 21 | 16 | 17 |
| **2000** | 4 | 1 | 2 | 11 | 26 | 31 | 15 | 12 | 37 | 36 | 1 | 7 | 15 |
| **2001** | 1 | 2 | 1 | 2 | 11 | 20 | 14 | 46 | 2 | 15 | 40 | 37 | 16 |
| **2002** | 12 | 15 | 5 | 4 | 14 | 38 | 32 | 33 | 40 | 20 | 17 | 18 | 21 |
| **2003** | 4 | 2 | 1 | 5 | 18 | 38 | 48 | 3 | 41 | 38 | 17 | 22 | 20 |
| **2004** | 18 | 61 | 23 | 12 | 23 | 55 | 26 | 42 | 25 | 30 | 6 | 13 | 28 |
| **2005** | 14 | 1 | 7 | 8 | 31 | 23 | 33 | 16 | 14 | 44 | 2 | 17 | 18 |
| **2006** | 2 | 2 | 1 | 9 | 13 | 29 | 36 | 38 | 8 | 15 | 41 | 13 | 17 |
| **2007** | 5 | 2 | 6 | 2 | 3 | 12 | | | | | | | 5 |
| **Min.** | 1 | 0 | 0 | 1 | 1 | 4 | 2 | 3 | 1 | 2 | 1 | 1 | 10 |
| **Mean** | 11 | 11 | 8 | 10 | 17 | 25 | 28 | 28 | 25 | 24 | 19 | 16 | 19 |
| **Max.** | 39 | 61 | 37 | 43 | 38 | 55 | 57 | 57 | 61 | 53 | 59 | 48 | 30 |

**Figure B: Site 34300 Patea Power Station – Distribution of flows ($m^3/s$), 1931 – 2007**




| | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 67 | 64 | 63 | 63 | 63 | 62 | 62 | 62 | 62 | 62 |
| **10** | 62 | 62 | 62 | 61 | 59 | 58 | 56 | 55 | 54 | 52 |
| **20** | 51 | 47 | 43 | 40 | 37 | 34 | 32 | 29 | 27 | 25 |
| **30** | 23 | 21 | 20 | 20 | 19 | 18 | 17 | 16 | 15 | 14 |
| **40** | 13 | 12 | 10 | 9 | 7 | 6 | 5 | 4 | 3 | 2 |
| **50** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **60** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **70** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **80** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **90** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| **100** | 0 | | | | | | | | | |

**Note: Figure and table depicting percentage of time flow exceeded, 0% is the maximum outflow and 100% is the minimum outflow.**

**Summary Table: Flow ($m^3/s$)**

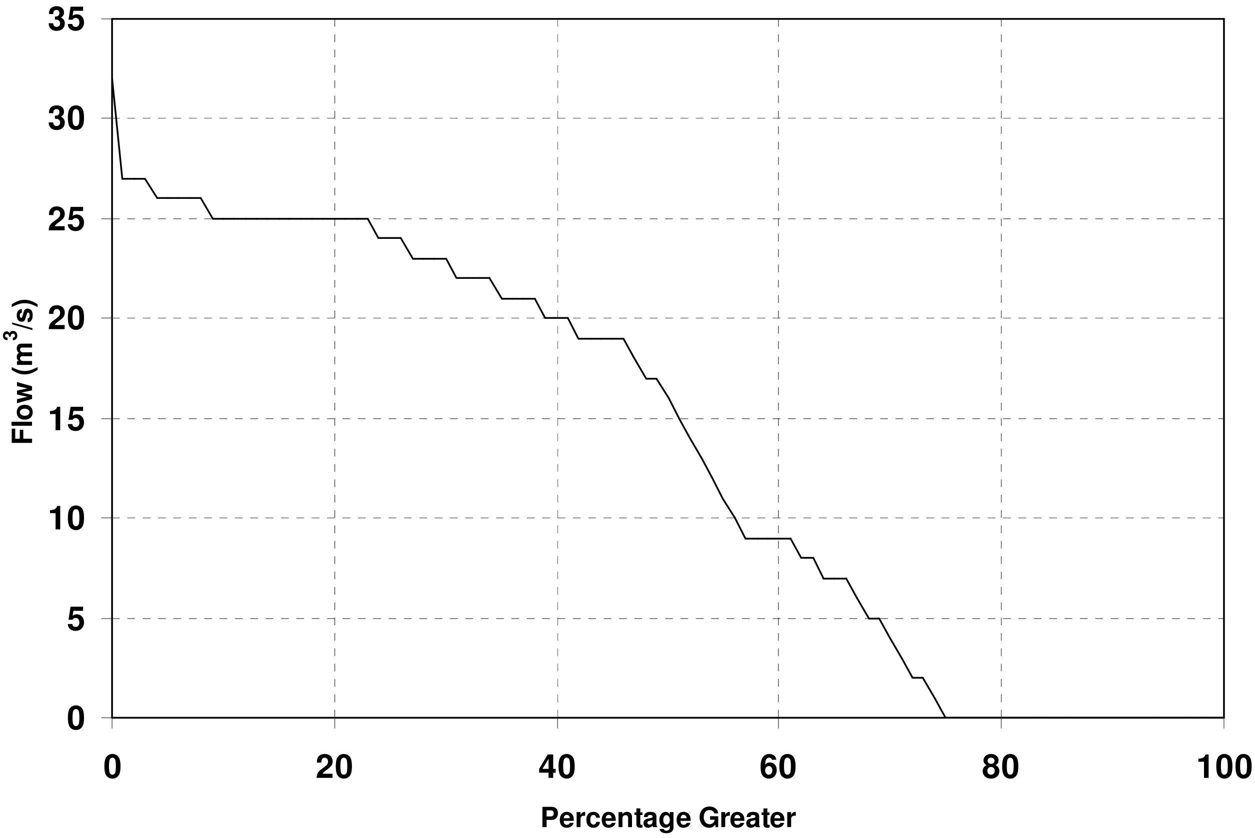
| **Record Length** | **Minimum** | **Mean** | **Median** | **Maximum** |
|---|---|---|---|---|
| Jan 1931 to Jul 2007 | 0 | 19 | 1.4 | 67 |

**Table C: Site 7968 Highbank Power Station – Monthly Means ($m^3/s$), 1931 – 2007**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1931** | 1 | 0 | 1 | 15 | 25 | 25 | 25 | 23 | 24 | 19 | 8 | 5 | 14 |
| **1932** | 1 | 0 | 0 | 16 | 23 | 11 | 9 | 12 | 23 | 19 | 8 | 5 | 11 |
| **1933** | 1 | 0 | 0 | 15 | 22 | 12 | 14 | 16 | 22 | 19 | 8 | 5 | 11 |
| **1934** | 1 | 0 | 0 | 19 | 25 | 25 | 25 | 25 | 24 | 19 | 8 | 5 | 15 |
| **1935** | 1 | 0 | 1 | 15 | 25 | 25 | 24 | 21 | 20 | 19 | 8 | 5 | 14 |
| **1936** | 1 | 0 | 1 | 15 | 25 | 22 | 23 | 25 | 24 | 19 | 8 | 5 | 14 |
| **1937** | 1 | 0 | 1 | 15 | 25 | 25 | 23 | 9 | 10 | 18 | 8 | 5 | 12 |
| **1938** | 1 | 0 | 1 | 15 | 23 | 22 | 22 | 21 | 24 | 19 | 8 | 5 | 14 |
| **1939** | 1 | 0 | 0 | 9 | 12 | 20 | 14 | 14 | 24 | 19 | 8 | 5 | 11 |
| **1940** | 1 | 0 | 0 | 16 | 25 | 25 | 17 | 11 | 19 | 19 | 8 | 5 | 12 |
| **1941** | 1 | 0 | 1 | 15 | 25 | 25 | 25 | 25 | 24 | 19 | 8 | 5 | 14 |
| **1942** | 1 | 0 | 1 | 15 | 25 | 23 | 25 | 25 | 23 | 19 | 8 | 5 | 14 |
| **1943** | 1 | 0 | 1 | 19 | 23 | 23 | 24 | 18 | 23 | 19 | 8 | 5 | 14 |
| **1944** | 1 | 0 | 1 | 15 | 24 | 22 | 25 | 25 | 23 | 19 | 8 | 5 | 14 |
| **1945** | 1 | 0 | 1 | 15 | 25 | 23 | 21 | 24 | 24 | 19 | 8 | 5 | 14 |
| **1946** | 1 | 0 | 1 | 15 | 25 | 18 | 19 | 25 | 24 | 19 | 8 | 5 | 14 |
| **1947** | 1 | 0 | 0 | 11 | 10 | 20 | 23 | 23 | 24 | 19 | 8 | 5 | 12 |
| **1948** | 1 | 0 | 0 | 14 | 23 | 24 | 25 | 19 | 14 | 19 | 8 | 5 | 13 |
| **1949** | 1 | 0 | 1 | 16 | 23 | 25 | 25 | 25 | 23 | 18 | 8 | 4 | 14 |
| **1950** | 1 | 0 | 0 | 12 | 12 | 24 | 20 | 25 | 24 | 19 | 8 | 5 | 13 |
| **1951** | 1 | 0 | 0 | 15 | 14 | 26 | 25 | 25 | 24 | 20 | 20 | 20 | 16 |
| **1952** | 8 | 5 | 19 | 17 | 25 | 27 | 27 | 26 | 26 | 24 | 26 | 26 | 21 |
| **1943** | 21 | 25 | 23 | 26 | 27 | 26 | 25 | 22 | 25 | 25 | 23 | 21 | 24 |
| **1954** | 20 | 20 | 20 | 22 | 25 | 26 | 26 | 26 | 26 | 22 | 21 | 23 | 23 |
| **1955** | 17 | 21 | 22 | 17 | 26 | 22 | 24 | 26 | 22 | 23 | 16 | 15 | 21 |
| **1956** | 10 | 15 | 16 | 24 | 21 | 26 | 23 | 26 | 22 | 24 | 24 | 20 | 21 |
| **1957** | 0 | 0 | 12 | 25 | 15 | 25 | 26 | 26 | 25 | 23 | 20 | 19 | 18 |
| **1958** | 8 | 8 | 6 | 11 | 22 | 21 | 19 | 21 | 10 | 17 | 10 | 9 | 14 |
| **1959** | 0 | 6 | 12 | 21 | 25 | 23 | 24 | 24 | 16 | 11 | 0 | 0 | 14 |
| **1960** | 0 | 0 | 0 | 2 | 23 | 25 | 23 | 25 | 23 | 22 | 17 | 17 | 15 |
| **1961** | 9 | 8 | 1 | 17 | 22 | 24 | 24 | 24 | 23 | 14 | 9 | 9 | 15 |
| **1962** | 9 | 8 | 7 | 9 | 7 | 24 | 24 | 24 | 23 | 14 | 9 | 8 | 14 |
| **1963** | 7 | 5 | 3 | 8 | 12 | 23 | 23 | 23 | 23 | 14 | 6 | 8 | 13 |
| **1964** | 4 | 0 | 0 | 0 | 3 | 23 | 24 | 24 | 20 | 8 | 10 | 7 | 10 |
| **1965** | 7 | 10 | 4 | 20 | 23 | 23 | 23 | 23 | 22 | 11 | 18 | 9 | 16 |
| **1966** | 4 | 4 | 13 | 18 | 23 | 23 | 23 | 23 | 21 | 16 | 12 | 9 | 16 |
| **1967** | 4 | 1 | 0 | 9 | 14 | 23 | 23 | 22 | 20 | 14 | 17 | 11 | 13 |
| **1968** | 4 | 0 | 11 | 18 | 21 | 22 | 21 | 21 | 12 | 17 | 8 | 8 | 14 |
| **1969** | 5 | 0 | 0 | 1 | 11 | 23 | 22 | 22 | 18 | 1 | 1 | 11 | 10 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1970** | 12 | 3 | 12 | 14 | 22 | 22 | 22 | 20 | 17 | 0 | 0 | 0 | 12 |
| **1971** | 0 | 0 | 2 | 11 | 17 | 22 | 21 | 21 | 17 | 15 | 12 | 5 | 12 |
| **1972** | 3 | 3 | 6 | 16 | 5 | 20 | 20 | 20 | 15 | 15 | 9 | 11 | 12 |
| **1973** | 4 | 3 | 0 | 0 | 0 | 20 | 20 | 20 | 19 | 10 | 8 | 6 | 9 |
| **1974** | 4 | 11 | 18 | 17 | 20 | 19 | 20 | 20 | 19 | 18 | 13 | 4 | 15 |
| **1975** | 4 | 6 | 18 | 18 | 20 | 19 | 19 | 17 | 18 | 16 | 14 | 2 | 14 |
| **1976** | 5 | 2 | 1 | 10 | 15 | 19 | 19 | 19 | 16 | 9 | 0 | 0 | 10 |
| **1977** | 0 | 0 | 0 | 3 | 20 | 21 | 21 | 21 | 21 | 15 | 2 | 0 | 10 |
| **1978** | 0 | 0 | 1 | 16 | 25 | 25 | 25 | 25 | 24 | 23 | 15 | 13 | 16 |
| **1979** | 7 | 0 | 11 | 23 | 7 | 25 | 24 | 24 | 22 | 21 | 13 | 10 | 16 |
| **1980** | 13 | 0 | 0 | 0 | 21 | 25 | 25 | 25 | 14 | 5 | 14 | 11 | 13 |
| **1981** | 2 | 0 | 5 | 9 | 25 | 25 | 26 | 25 | 19 | 15 | 9 | 0 | 13 |
| **1982** | 0 | 0 | 0 | 15 | 9 | 24 | 25 | 25 | 15 | 17 | 9 | 4 | 12 |
| **1983** | 1 | 0 | 4 | 9 | 0 | 0 | 0 | 4 | 24 | 24 | 10 | 12 | 7 |
| **1984** | 5 | 0 | 0 | 6 | 23 | 26 | 27 | 26 | 17 | 0 | 1 | 4 | 11 |
| **1985** | 0 | 0 | 0 | 0 | 15 | 26 | 26 | 26 | 22 | 1 | 3 | 13 | 11 |
| **1986** | 4 | 0 | 20 | 16 | 17 | 26 | 26 | 27 | 26 | 25 | 12 | 4 | 17 |
| **1987** | 0 | 0 | 3 | 10 | 26 | 26 | 26 | 26 | 18 | 9 | 2 | 2 | 12 |
| **1988** | 0 | 0 | 0 | 0 | 12 | 25 | 26 | 26 | 11 | 1 | 0 | 0 | 8 |
| **1989** | 0 | 0 | 0 | 0 | 24 | 26 | 25 | 21 | 13 | 7 | 0 | 0 | 10 |
| **1990** | 0 | 0 | 0 | 0 | 6 | 26 | 25 | 26 | 22 | 13 | 8 | 1 | 11 |
| **1991** | 0 | 3 | 1 | 7 | 22 | 21 | 18 | 24 | 24 | 8 | 7 | 5 | 12 |
| **1992** | 4 | 0 | 0 | 0 | 12 | 16 | 19 | 25 | 25 | 25 | 9 | 7 | 12 |
| **1993** | 1 | 0 | 0 | 0 | 9 | 25 | 24 | 21 | 13 | 6 | 0 | 0 | 8 |
| **1994** | 0 | 0 | 0 | 0 | 2 | 26 | 26 | 26 | 15 | 21 | 2 | 0 | 10 |
| **1995** | 0 | 0 | 0 | 16 | 25 | 24 | 24 | 24 | 24 | 25 | 11 | 1 | 15 |
| **1996** | 0 | 13 | 18 | 21 | 2 | 24 | 23 | 25 | 17 | 5 | 4 | 0 | 13 |
| **1997** | 6 | 9 | 8 | 19 | 23 | 23 | 23 | 24 | 21 | 12 | 0 | 0 | 14 |
| **1998** | 0 | 0 | 4 | 0 | 20 | 25 | 25 | 25 | 24 | 19 | 8 | 5 | 13 |
| **1999** | 1 | 0 | 1 | 16 | 25 | 25 | 25 | 25 | 24 | 19 | 8 | 5 | 15 |
| **2000** | 1 | 0 | 1 | 15 | 25 | 25 | 25 | 25 | 24 | 19 | 8 | 5 | 15 |
| **2001** | 1 | 0 | 1 | 14 | 23 | 25 | 25 | 25 | 24 | 19 | 8 | 5 | 14 |
| **2002** | 1 | 0 | 1 | 15 | 25 | 23 | 25 | 23 | 12 | 10 | 9 | 1 | 12 |
| **2003** | 0 | 0 | 1 | 23 | 27 | 20 | 27 | 26 | 22 | 19 | 3 | 0 | 14 |
| **2004** | 0 | 2 | 1 | 2 | 5 | 26 | 27 | 22 | 24 | 23 | 1 | 0 | 11 |
| **2005** | 0 | 0 | 0 | 15 | 21 | 20 | 19 | 21 | 15 | 11 | 0 | 0 | 10 |
| **2006** | 0 | 0 | 0 | 5 | 26 | 26 | 27 | 25 | 0 | 6 | 14 | 19 | 12 |
| **2007** | 20 | 0 | 3 | 1 | 11 | 21 | | | | | | | 10 |
| **Min.** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 7 |
| **Mean** | 3 | 2 | 4 | 12 | 19 | 23 | 23 | 23 | 20 | 16 | 9 | 7 | 13 |
| **Max.** | 21 | 25 | 23 | 26 | 27 | 27 | 27 | 27 | 26 | 25 | 26 | 26 | 24 |

**Figure C: Site 7968 Highbank Power Station – Distribution of flows ($m^3$/s), 1931 – 2007**




| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 32 | 27 | 27 | 27 | 26 | 26 | 26 | 26 | 26 | 25 |
| **10** | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| **20** | 25 | 25 | 25 | 25 | 24 | 24 | 24 | 23 | 23 | 23 |
| **30** | 23 | 22 | 22 | 22 | 22 | 21 | 21 | 21 | 21 | 20 |
| **40** | 20 | 20 | 19 | 19 | 19 | 19 | 19 | 18 | 17 | 17 |
| **50** | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 9 | 9 |
| **60** | 9 | 9 | 8 | 8 | 7 | 7 | 7 | 6 | 5 | 5 |
| **70** | 4 | 3 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| **80** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **90** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **100** | 0 | | | | | | | | | |

**Note: Figure and table depicting percentage of time flow exceeded, 0% is the maximum outflow and 100% is the minimum outflow.**

**Summary Table: Flow ($m^3$/s)**

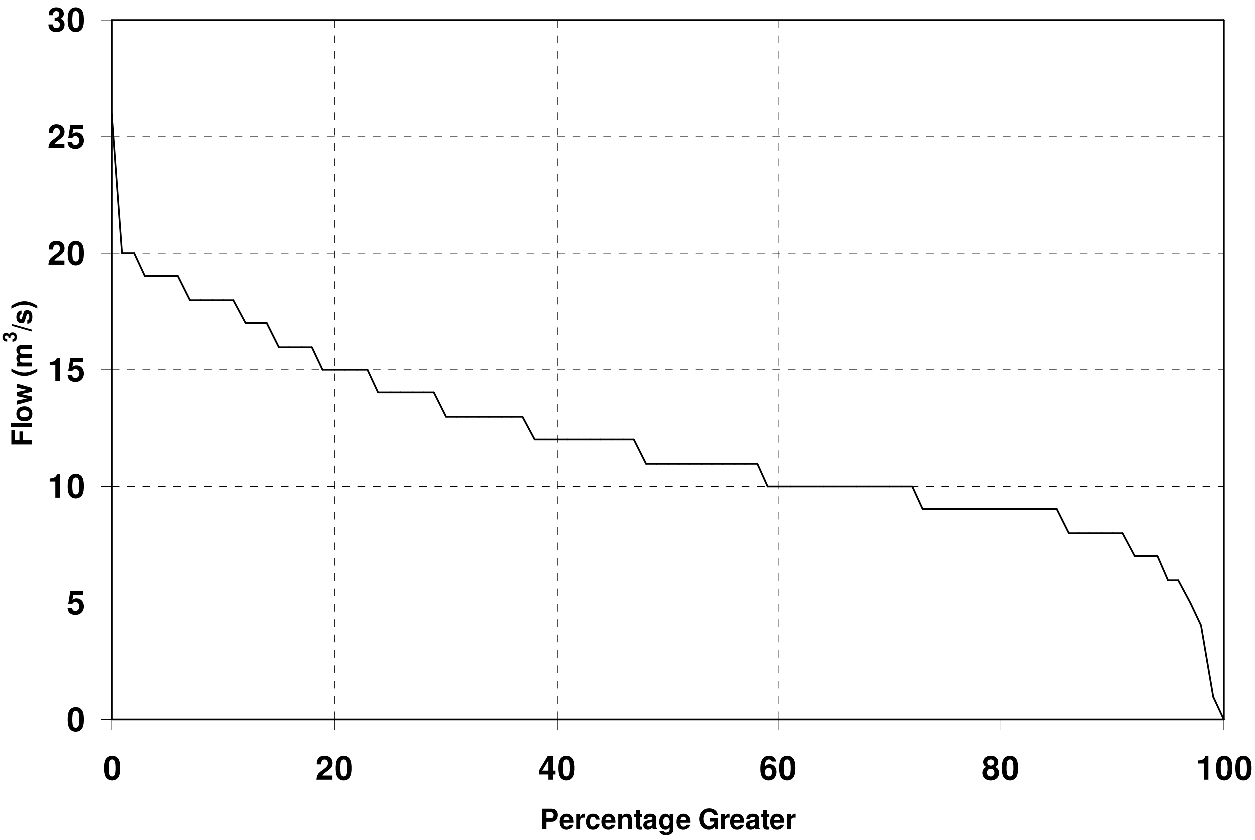
| Record Length | Minimum | Mean | Median | Maximum |
|---|---|---|---|---|
| Jan 1931 to Jul 2007 | 0 | 13 | 16 | 32 |

**Table D: Site 14130 Kaimai Power Station – Monthly Means ($m^3/s$), 1931 – 2007**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1931** | | | | | | | 15 | 14 | 15 | 13 | 13 | 12 | 13 |
| **1932** | 10 | 9 | 8 | 10 | 9 | 14 | 11 | 10 | 11 | 13 | 10 | 9 | 10 |
| **1933** | 10 | 12 | 11 | 11 | 14 | 10 | 12 | 13 | 12 | 10 | 10 | 9 | 11 |
| **1934** | 8 | 9 | 8 | 9 | 10 | 12 | 14 | 12 | 11 | 13 | 13 | 11 | 11 |
| **1935** | 9 | 12 | 11 | 10 | 13 | 16 | 15 | 16 | 13 | 14 | 16 | 12 | 13 |
| **1936** | 15 | 16 | 12 | 12 | 12 | 11 | 14 | 14 | 14 | 13 | 13 | 11 | 13 |
| **1937** | 14 | 10 | 11 | 11 | 14 | 12 | 11 | 10 | 11 | 10 | 10 | 10 | 11 |
| **1938** | 9 | 12 | 7 | 13 | 11 | 12 | 12 | 13 | 13 | 10 | 13 | 12 | 11 |
| **1939** | 12 | 9 | 8 | 8 | 7 | 12 | 11 | 15 | 13 | 10 | 10 | 12 | 11 |
| **1940** | 12 | 15 | 12 | 9 | 10 | 11 | 10 | 10 | 11 | 13 | 13 | 10 | 11 |
| **1941** | 10 | 9 | 12 | 9 | 7 | 12 | 12 | 13 | 13 | 15 | 14 | 11 | 12 |
| **1942** | 11 | 11 | 10 | 12 | 13 | 10 | 16 | 14 | 18 | 15 | 12 | 13 | 13 |
| **1943** | 9 | 7 | 9 | 11 | 9 | 15 | 15 | 14 | 16 | 15 | 12 | 11 | 12 |
| **1944** | 9 | 10 | 11 | 10 | 11 | 10 | 12 | 13 | 13 | 12 | 11 | 12 | 11 |
| **1945** | 14 | 11 | 12 | 10 | 13 | 12 | 14 | 15 | 14 | 14 | 13 | 10 | 13 |
| **1946** | 9 | 7 | 9 | 12 | 11 | 11 | 12 | 17 | 15 | 15 | 14 | 11 | 12 |
| **1947** | 12 | 9 | 7 | 9 | 9 | 15 | 14 | 13 | 14 | 16 | 11 | 12 | 12 |
| **1948** | 11 | 7 | 7 | 10 | 15 | 13 | 15 | 13 | 12 | 15 | 14 | 11 | 12 |
| **1949** | 11 | 10 | 9 | 10 | 13 | 16 | 16 | 14 | 12 | 12 | 12 | 10 | 12 |
| **1950** | 8 | 11 | 7 | 8 | 10 | 11 | 11 | 12 | 12 | 11 | 13 | 10 | 10 |
| **1951** | 10 | 10 | 9 | 10 | 9 | 10 | 15 | 11 | 10 | 13 | 16 | 14 | 11 |
| **1952** | 11 | 12 | 8 | 9 | 11 | 17 | 14 | 13 | 11 | 13 | 18 | 16 | 13 |
| **1943** | 12 | 11 | 9 | 10 | 14 | 15 | 17 | 15 | 13 | 15 | 14 | 12 | 13 |
| **1954** | 10 | 9 | 10 | 9 | 11 | 11 | 12 | 13 | 13 | 10 | 10 | 11 | 11 |
| **1955** | 9 | 10 | 8 | 10 | 15 | 14 | 13 | 15 | 13 | 14 | 12 | 12 | 12 |
| **1956** | 12 | 10 | 8 | 14 | 13 | 18 | 17 | 16 | 13 | 15 | 14 | 14 | 14 |
| **1957** | 12 | 9 | 12 | 9 | 13 | 12 | 13 | 11 | 11 | 13 | 14 | 14 | 12 |
| **1958** | 10 | 14 | 12 | 9 | 12 | 13 | 13 | 15 | 11 | 11 | 12 | 17 | 12 |
| **1959** | 13 | 11 | 12 | 13 | 12 | 12 | 11 | 12 | 10 | 14 | 12 | 10 | 12 |
| **1960** | 8 | 13 | 9 | 8 | 10 | 14 | 13 | 13 | 14 | 12 | 11 | 9 | 11 |
| **1961** | 9 | 9 | 8 | 10 | 8 | 11 | 14 | 11 | 13 | 11 | 9 | 10 | 10 |
| **1962** | 11 | 9 | 13 | 12 | 14 | 16 | 14 | 15 | 15 | 17 | 15 | 15 | 14 |
| **1963** | 11 | 11 | 8 | 9 | 10 | 14 | 15 | 12 | 16 | 10 | 10 | 9 | 11 |
| **1964** | 11 | 9 | 12 | 8 | 9 | 10 | 16 | 15 | 16 | 16 | 13 | 14 | 13 |
| **1965** | 12 | 13 | 12 | 11 | 10 | 13 | 12 | 14 | 11 | 10 | 14 | 13 | 12 |
| **1966** | 12 | 12 | 11 | 10 | 12 | 12 | 15 | 13 | 14 | 11 | 12 | 13 | 12 |
| **1967** | 11 | 12 | 11 | 9 | 9 | 10 | 11 | 15 | 12 | 10 | 14 | 13 | 11 |
| **1968** | 9 | 9 | 7 | 8 | 10 | 15 | 13 | 13 | 12 | 13 | 12 | 12 | 11 |
| **1969** | 11 | 12 | 8 | 8 | 11 | 10 | 10 | 11 | 14 | 10 | 10 | 12 | 11 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1970** | 9 | 5 | 9 | 8 | 11 | 15 | 13 | 15 | 17 | 15 | 14 | 10 | 12 |
| **1971** | 12 | 11 | 9 | 8 | 11 | 13 | 11 | 14 | 16 | 17 | 14 | 13 | 13 |
| **1972** | 10 | 9 | 15 | 9 | 12 | 10 | 15 | 13 | 13 | 12 | 11 | 10 | 12 |
| **1973** | 10 | 8 | 9 | 7 | 11 | 12 | 9 | 13 | 14 | 10 | 12 | 11 | 10 |
| **1974** | 8 | 9 | 7 | 9 | 11 | 12 | 16 | 14 | 13 | 14 | 11 | 13 | 11 |
| **1975** | 12 | 8 | 9 | 10 | 13 | 15 | 14 | 15 | 15 | 15 | 13 | 11 | 13 |
| **1976** | 14 | 12 | 11 | 10 | 12 | 13 | 15 | 15 | 14 | 13 | 11 | 12 | 13 |
| **1977** | 11 | 10 | 9 | 8 | 12 | 16 | 15 | 14 | 13 | 13 | 11 | 11 | 12 |
| **1978** | 9 | 8 | 6 | 10 | 8 | 9 | 14 | 12 | 12 | 11 | 12 | 11 | 10 |
| **1979** | 8 | 11 | 13 | 11 | 13 | 11 | 11 | 14 | 13 | 15 | 14 | 12 | 12 |
| **1980** | 14 | 10 | 12 | 13 | 11 | 12 | 13 | 13 | 15 | 12 | 13 | 14 | 13 |
| **1981** | 11 | 10 | 10 | 10 | 11 | 15 | 15 | 14 | 13 | 13 | 14 | 13 | 12 |
| **1982** | 10 | 11 | 10 | 9 | 12 | 12 | 10 | 11 | 12 | 11 | 10 | 12 | 11 |
| **1983** | 9 | 8 | 8 | 11 | 11 | 11 | 11 | 11 | 13 | 16 | 13 | 12 | 11 |
| **1984** | 10 | 11 | 13 | 9 | 10 | 10 | 14 | 13 | 12 | 11 | 11 | 13 | 11 |
| **1985** | 11 | 9 | 9 | 9 | 9 | 13 | 12 | 11 | 12 | 10 | 11 | 13 | 11 |
| **1986** | 16 | 12 | 9 | 8 | 12 | 11 | 13 | 14 | 13 | 13 | 11 | 10 | 12 |
| **1987** | 11 | 8 | 11 | 12 | 11 | 11 | 10 | 11 | 12 | 13 | 11 | 13 | 11 |
| **1988** | 9 | 9 | 10 | 9 | 11 | 13 | 13 | 16 | 15 | 16 | 14 | 13 | 12 |
| **1989** | 15 | 13 | 10 | 9 | 11 | 15 | 13 | 11 | 12 | 17 | 13 | 11 | 13 |
| **1990** | 11 | 10 | 12 | 11 | 13 | 11 | 13 | 17 | 12 | 13 | 13 | 10 | 12 |
| **1991** | 10 | 12 | 9 | 10 | 10 | 9 | 13 | 16 | 15 | 13 | 11 | 10 | 12 |
| **1992** | 12 | 10 | 10 | 9 | 9 | 11 | 15 | 16 | 14 | 13 | 12 | 14 | 12 |
| **1993** | 10 | 9 | 9 | 9 | 11 | 14 | 10 | 10 | 10 | 10 | 12 | 10 | 10 |
| **1994** | 10 | 9 | 6 | 9 | 11 | 13 | 15 | 16 | 14 | 15 | 16 | 11 | 12 |
| **1995** | 10 | 11 | 12 | 15 | 12 | 14 | 17 | 14 | 15 | 15 | 14 | 14 | 14 |
| **1996** | 12 | 12 | 12 | 15 | 13 | 12 | 16 | 15 | 17 | 14 | 13 | 14 | 14 |
| **1997** | 11 | 11 | 9 | 10 | 10 | 12 | 11 | 11 | 12 | 13 | 12 | 11 | 11 |
| **1998** | 10 | 11 | 10 | 10 | 11 | 13 | 18 | 14 | 13 | 17 | 13 | 12 | 13 |
| **1999** | 11 | 9 | 10 | 10 | 12 | 13 | 13 | 13 | 13 | 11 | 15 | 12 | 12 |
| **2000** | 11 | 9 | 8 | 11 | 11 | 13 | 12 | 12 | 13 | 15 | 11 | 12 | 12 |
| **2001** | 10 | 12 | 9 | 9 | 13 | 11 | 11 | 12 | 10 | 12 | 14 | 16 | 12 |
| **2002** | 12 | 9 | 9 | 9 | 10 | 14 | 14 | 12 | 13 | 12 | 11 | 13 | 12 |
| **2003** | 9 | 8 | 9 | 8 | 11 | 12 | 11 | 10 | 14 | 15 | 12 | 13 | 11 |
| **2004** | 10 | 16 | 12 | 10 | 12 | 15 | 14 | 15 | 13 | 15 | 13 | 13 | 13 |
| **2005** | 13 | 10 | 10 | 7 | 11 | 11 | 13 | 11 | 12 | 16 | 9 | 13 | 11 |
| **2006** | 11 | 11 | 9 | 13 | 13 | 13 | | | | | | | 11 |
| **Min.** | 8 | 5 | 6 | 7 | 7 | 9 | 9 | 10 | 10 | 10 | 9 | 9 | 10 |
| **Mean** | 11 | 10 | 10 | 10 | 11 | 13 | 13 | 13 | 13 | 13 | 12 | 12 | 12 |
| **Max.** | 16 | 16 | 15 | 15 | 15 | 18 | 18 | 17 | 18 | 17 | 18 | 17 | 14 |

**Figure D: Site 14130 Kaimai Power Station – Distribution of flows ($m^3/s$), 1931 – 2007**




| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 26 | 20 | 20 | 19 | 19 | 19 | 19 | 18 | 18 | 18 |
| **10** | 18 | 18 | 17 | 17 | 17 | 16 | 16 | 16 | 16 | 15 |
| **20** | 15 | 15 | 15 | 15 | 14 | 14 | 14 | 14 | 14 | 14 |
| **30** | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 12 | 12 |
| **40** | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 11 | 11 |
| **50** | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 10 |
| **60** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| **70** | 10 | 10 | 10 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| **80** | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 8 | 8 | 8 |
| **90** | 8 | 8 | 7 | 7 | 7 | 6 | 6 | 5 | 4 | 1 |
| **100** | 0 | | | | | | | | | |

**Note: Figure and table depicting percentage of time flow exceeded, 0% is the maximum outflow and 100% is the minimum outflow.**

**Summary Table: Flow ($m^3/s$)**

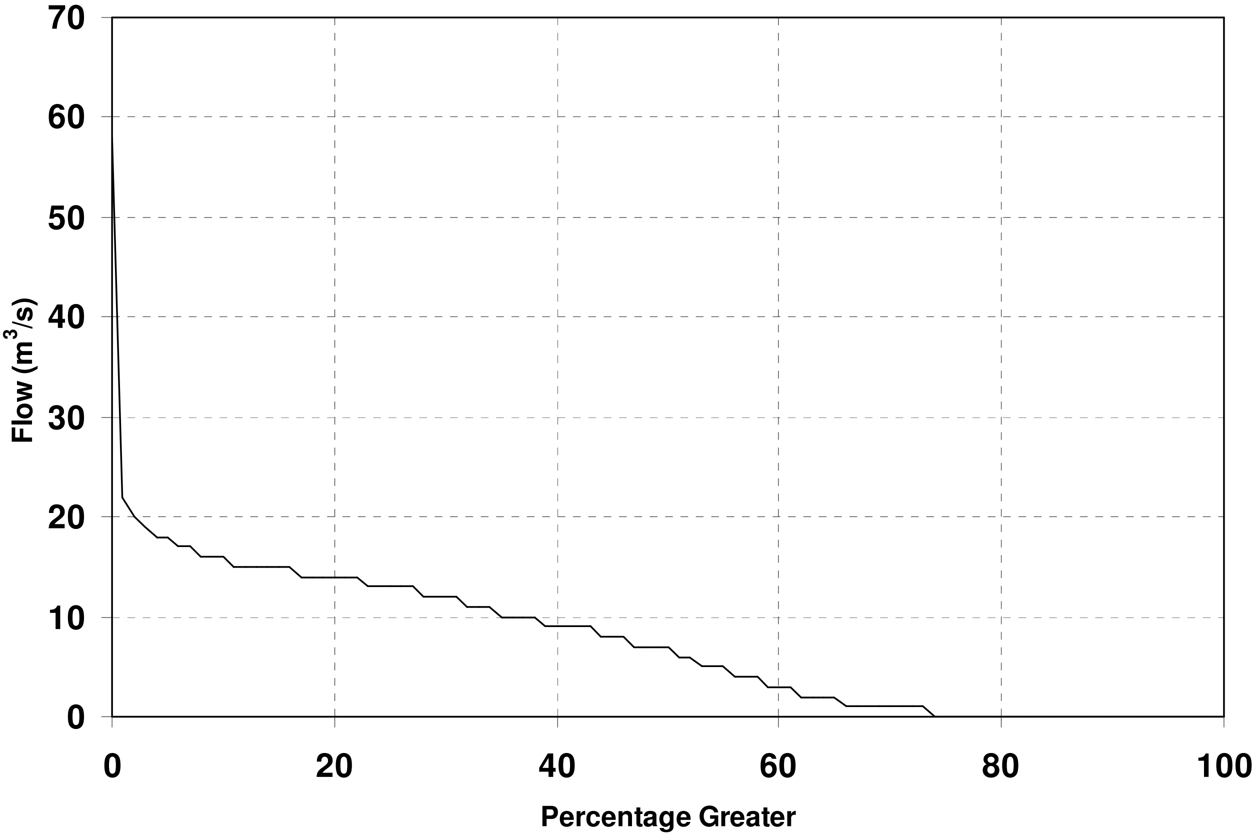
| Record Length | Minimum | Mean | Median | Maximum |
|---|---|---|---|---|
| Jul 1931 to Jun 2006 | 0 | 12 | 11 | 26 |

**Table E: Site 174395 Waipori Power Station – Monthly Means ($m^3/s$), 1931 – 2007**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1931** | | | | | | | 18 | 18 | 12 | 1 | 0 | 0 | 8 |
| **1932** | 0 | 0 | 4 | 0 | 4 | 11 | 12 | 10 | 8 | 1 | 7 | 8 | 5 |
| **1933** | 1 | 1 | 4 | 10 | 16 | 20 | 13 | 11 | 7 | 6 | 6 | 3 | 8 |
| **1934** | 1 | 0 | 1 | 3 | 14 | 17 | 13 | 13 | 8 | 7 | 5 | 5 | 7 |
| **1935** | 9 | 5 | 10 | 6 | 8 | 10 | 8 | 8 | 6 | 6 | 3 | 2 | 7 |
| **1936** | 1 | 0 | 1 | 3 | 14 | 17 | 13 | 13 | 8 | 7 | 5 | 5 | 7 |
| **1937** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1938** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1939** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1940** | 1 | 0 | 1 | 3 | 14 | 17 | 13 | 13 | 8 | 7 | 5 | 5 | 7 |
| **1941** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1942** | 1 | 2 | 10 | 4 | 12 | 18 | 18 | 17 | 17 | 1 | 0 | 0 | 8 |
| **1943** | 0 | 0 | 0 | 1 | 14 | 17 | 18 | 18 | 12 | 1 | 0 | 0 | 7 |
| **1944** | 1 | 0 | 1 | 3 | 14 | 17 | 13 | 13 | 8 | 7 | 5 | 5 | 7 |
| **1945** | 4 | 4 | 7 | 10 | 9 | 13 | 12 | 11 | 13 | 9 | 8 | 9 | 9 |
| **1946** | 1 | 1 | 4 | 10 | 16 | 20 | 13 | 11 | 7 | 6 | 6 | 3 | 8 |
| **1947** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1948** | 1 | 0 | 1 | 3 | 14 | 17 | 13 | 13 | 8 | 7 | 5 | 5 | 7 |
| **1949** | 1 | 1 | 4 | 10 | 16 | 20 | 13 | 11 | 7 | 6 | 6 | 3 | 8 |
| **1950** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1951** | 3 | 2 | 2 | 2 | 7 | 13 | 11 | 12 | 6 | 6 | 1 | 1 | 6 |
| **1952** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1943** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1954** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1955** | 9 | 5 | 10 | 6 | 8 | 10 | 8 | 8 | 6 | 6 | 3 | 2 | 7 |
| **1956** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1957** | 4 | 4 | 7 | 10 | 9 | 13 | 12 | 11 | 13 | 9 | 8 | 9 | 9 |
| **1958** | 8 | 10 | 8 | 11 | 13 | 16 | 13 | 11 | 5 | 7 | 6 | 5 | 9 |
| **1959** | 3 | 2 | 2 | 2 | 7 | 13 | 11 | 12 | 6 | 6 | 1 | 1 | 6 |
| **1960** | 3 | 2 | 2 | 2 | 7 | 13 | 11 | 12 | 6 | 6 | 1 | 1 | 6 |
| **1961** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1962** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1963** | 0 | 0 | 4 | 0 | 4 | 11 | 12 | 10 | 8 | 1 | 7 | 8 | 5 |
| **1964** | 0 | 0 | 0 | 1 | 14 | 17 | 18 | 18 | 12 | 1 | 0 | 0 | 7 |
| **1965** | 0 | 0 | 0 | 1 | 14 | 17 | 18 | 18 | 12 | 1 | 0 | 0 | 7 |
| **1966** | 3 | 2 | 2 | 2 | 7 | 13 | 11 | 12 | 6 | 6 | 1 | 1 | 6 |
| **1967** | 5 | 12 | 9 | 8 | 11 | 19 | 21 | 15 | 7 | 1 | 1 | 1 | 9 |
| **1968** | 1 | 1 | 4 | 10 | 16 | 20 | 13 | 11 | 7 | 6 | 6 | 3 | 8 |
| **1969** | 2 | 8 | 10 | 9 | 13 | 14 | 14 | 10 | 9 | 2 | 1 | 1 | 8 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1970** | 1 | 1 | 4 | 10 | 16 | 20 | 13 | 11 | 7 | 6 | 6 | 3 | 8 |
| **1971** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1972** | 2 | 8 | 10 | 9 | 13 | 14 | 14 | 10 | 9 | 2 | 1 | 1 | 8 |
| **1973** | 9 | 5 | 10 | 6 | 8 | 10 | 8 | 8 | 6 | 6 | 3 | 2 | 7 |
| **1974** | 0 | 0 | 4 | 0 | 4 | 11 | 12 | 10 | 8 | 1 | 7 | 8 | 5 |
| **1975** | 1 | 1 | 4 | 10 | 16 | 20 | 13 | 11 | 7 | 6 | 6 | 3 | 8 |
| **1976** | 0 | 0 | 4 | 0 | 4 | 11 | 12 | 10 | 8 | 1 | 7 | 8 | 5 |
| **1977** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1978** | 5 | 8 | 3 | 6 | 13 | 16 | 16 | 12 | 10 | 1 | 0 | 2 | 8 |
| **1979** | 1 | 2 | 10 | 4 | 12 | 18 | 18 | 17 | 17 | 1 | 0 | 0 | 8 |
| **1980** | 8 | 10 | 8 | 11 | 13 | 16 | 13 | 11 | 5 | 7 | 6 | 5 | 9 |
| **1981** | 1 | 0 | 1 | 3 | 14 | 17 | 13 | 13 | 8 | 7 | 5 | 5 | 7 |
| **1982** | 8 | 10 | 8 | 11 | 13 | 16 | 13 | 11 | 5 | 7 | 6 | 5 | 9 |
| **1983** | 8 | 10 | 8 | 11 | 13 | 16 | 13 | 11 | 5 | 7 | 6 | 5 | 9 |
| **1984** | 5 | 12 | 9 | 8 | 11 | 19 | 21 | 15 | 7 | 1 | 1 | 1 | 9 |
| **1985** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1986** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1987** | 5 | 8 | 3 | 6 | 13 | 16 | 16 | 12 | 10 | 1 | 0 | 2 | 8 |
| **1988** | 1 | 1 | 4 | 10 | 16 | 20 | 14 | 17 | 14 | 1 | 0 | 0 | 8 |
| **1989** | 0 | 1 | 1 | 0 | 12 | 14 | 13 | 8 | 9 | 1 | 0 | 0 | 5 |
| **1990** | 0 | 0 | 0 | 1 | 8 | 10 | 10 | 9 | 8 | 1 | 0 | 0 | 4 |
| **1991** | 0 | 2 | 0 | 1 | 14 | 15 | 15 | 13 | 14 | 1 | 0 | 0 | 6 |
| **1992** | 0 | 0 | 0 | 1 | 14 | 17 | 18 | 18 | 12 | 1 | 0 | 0 | 7 |
| **1993** | 5 | 8 | 3 | 6 | 13 | 16 | 16 | 12 | 10 | 1 | 0 | 2 | 8 |
| **1994** | 1 | 2 | 10 | 4 | 12 | 18 | 18 | 17 | 17 | 1 | 0 | 0 | 8 |
| **1995** | 0 | 0 | 4 | 0 | 4 | 11 | 12 | 10 | 8 | 1 | 7 | 8 | 5 |
| **1996** | 8 | 2 | 5 | 9 | 9 | 11 | 10 | 9 | 9 | 9 | 4 | 2 | 7 |
| **1997** | 2 | 8 | 10 | 9 | 13 | 14 | 14 | 10 | 9 | 2 | 1 | 1 | 8 |
| **1998** | 1 | 0 | 1 | 3 | 14 | 17 | 13 | 13 | 8 | 7 | 5 | 5 | 7 |
| **1999** | 3 | 2 | 2 | 2 | 7 | 13 | 11 | 12 | 6 | 6 | 1 | 1 | 6 |
| **2000** | 4 | 4 | 7 | 10 | 9 | 13 | 12 | 11 | 13 | 9 | 8 | 9 | 9 |
| **2001** | 5 | 12 | 9 | 8 | 11 | 19 | 21 | 15 | 7 | 1 | 1 | 1 | 9 |
| **2002** | 1 | 1 | 4 | 10 | 16 | 20 | 13 | 11 | 7 | 6 | 6 | 3 | 8 |
| **2003** | 5 | 16 | 11 | 17 | 12 | 7 | 8 | 7 | 5 | 3 | 1 | 1 | 8 |
| **2004** | 1 | 1 | 1 | 5 | 8 | 9 | 9 | 10 | 7 | 4 | 1 | 23 | 7 |
| **2005** | 8 | 10 | 8 | 11 | 13 | 16 | 13 | 11 | 5 | 7 | 6 | 5 | 9 |
| **2006** | 9 | 5 | 10 | 6 | 8 | 10 | 8 | 8 | 6 | 6 | 3 | 2 | 7 |
| **2007** | 1 | 3 | 7 | 10 | 16 | 14 | | | | | | | 9 |
| **Min.** | 0 | 0 | 0 | 0 | 4 | 7 | 8 | 7 | 5 | 1 | 0 | 0 | 4 |
| **Mean** | 2 | 3 | 4 | 5 | 12 | 15 | 14 | 12 | 10 | 4 | 3 | 3 | 7 |
| **Max.** | 9 | 16 | 11 | 17 | 16 | 20 | 21 | 18 | 17 | 9 | 8 | 23 | 9 |

**Figure E: Site 174395 Waipori Power Station – Distribution of flows ($m^3/s$), 1931 – 2007**




| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 58 | 22 | 20 | 19 | 18 | 18 | 17 | 17 | 16 | 16 |
| **10** | 16 | 15 | 15 | 15 | 15 | 15 | 15 | 14 | 14 | 14 |
| **20** | 14 | 14 | 14 | 13 | 13 | 13 | 13 | 13 | 12 | 12 |
| **30** | 12 | 12 | 11 | 11 | 11 | 10 | 10 | 10 | 10 | 9 |
| **40** | 9 | 9 | 9 | 9 | 8 | 8 | 8 | 7 | 7 | 7 |
| **50** | 7 | 6 | 6 | 5 | 5 | 5 | 4 | 4 | 4 | 3 |
| **60** | 3 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 |
| **70** | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **80** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **90** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **100** | 0 | | | | | | | | | |

**Note: Figure and table depicting percentage of time flow exceeded, 0% is the maximum outflow and 100% is the minimum outflow.**

**Summary Table: Flow ($m^3/s$)**

| Record Length | Minimum | Mean | Median | Maximum |
|---|---|---|---|---|
| Jul 1931 to Jun 2007 | 0 | 7 | 7 | 58 |

# Appendix B

**Highbank – extract from 1990 report.**

# 5. Highbank Power Station

## 5.1 General

The Highbank development is a combined hydro-electric/irrigation scheme. It involves diversion of water from the Rangitata River in Canterbury, with an intake at the foot of the Rangitata Gorge. An irrigation race of 66 km length carries the water north across mid Canterbury to the Rakaia River. Irrigation requirements are drawn from the race at control gates placed at convenient points along the race. The remaining flow is then passed through the Highbank Power Station (near Methven) for electrical generation and discharged to the Rakaia River. Figure 5.1 shows the general layout of the scheme.

The scheme has an installed capacity of 25 MW and was completed in 1945. The scheme was planned so that in summer, water could be taken for irrigation when demand for electricity was lower, and in the winter, used for electricity generation when electricity demands were high and irrigation requirements low.

The catchment area for the Rangitata River at the intake for the Highbank power scheme is 1460 $km^2$, draining the very steep and high bare slopes in a region of sparsely vegetated rugged topography at the western edge of the Canterbury Plains. The Rangitata has a mean flow of about 90 $m^3/s$ upstream of the intake at the Klondyke gauging station, however, the mean flow through the turbines at Highbank is 14 $m^3/s$, with maximum diverted flow being approximately 30 $m^3/s$.

## 5.2 Correlation

Highbank flow extension is the most difficult of those covered by this report because of the fact that Highbank power generation is to a large extent a residual of irrigation.

Although irrigation is largely weather dependent it is also effected by economics, farming practices and scheme maintenance.

Highbank generation 1952-57 is greater than in latter years and the irrigation scheme was obviously under utilised. Because of this the record extension is based on correlation with Highbank records from 1957 to 1989. The computer programme was only tested over the 1957-74 period because of the use of Lake Colleridge inflows which are subject to alteration in the mid 1970s.

Before starting with the record extension, a check was made with the 7 years of Rangitata flow records (1980-87). There appears to be little flow restriction caused by water shortages in the Rangitata which supplies the diversion race and the power station. However this was not studied in depth and nor were the water rights associated with the whole scheme which have recently been amended.

## Highbank Power Station

If development work was to be undertaken at Highbank power station then water rights and water availability would need to be studied further.

For the task in hand a special PSIM computer programme was developed.

This was built up from typical annual patterns of flow for Highbank for the period 1957-89. Flow is the total power station flow and the records were extended on this basis. The optimum generation would be continuous supply and with no irrigation off-take. Such an option is not realistic at present and so was discounted.

Also built into the model is a condition search path which produces departures form normal according to variations in the Lake Colleridge inflows. This aspect of the programme is somewhat arbitrary due to the whimsical nature of irrigation practice, but provision is made for climatic variations by incorporating the Lake Colleridge inflows.

### 5.3 Results

A statistical summary is rather difficult to compile for this programme. However, simulated flows were compared with actual flows for the 1957-89 period and results are as follows:

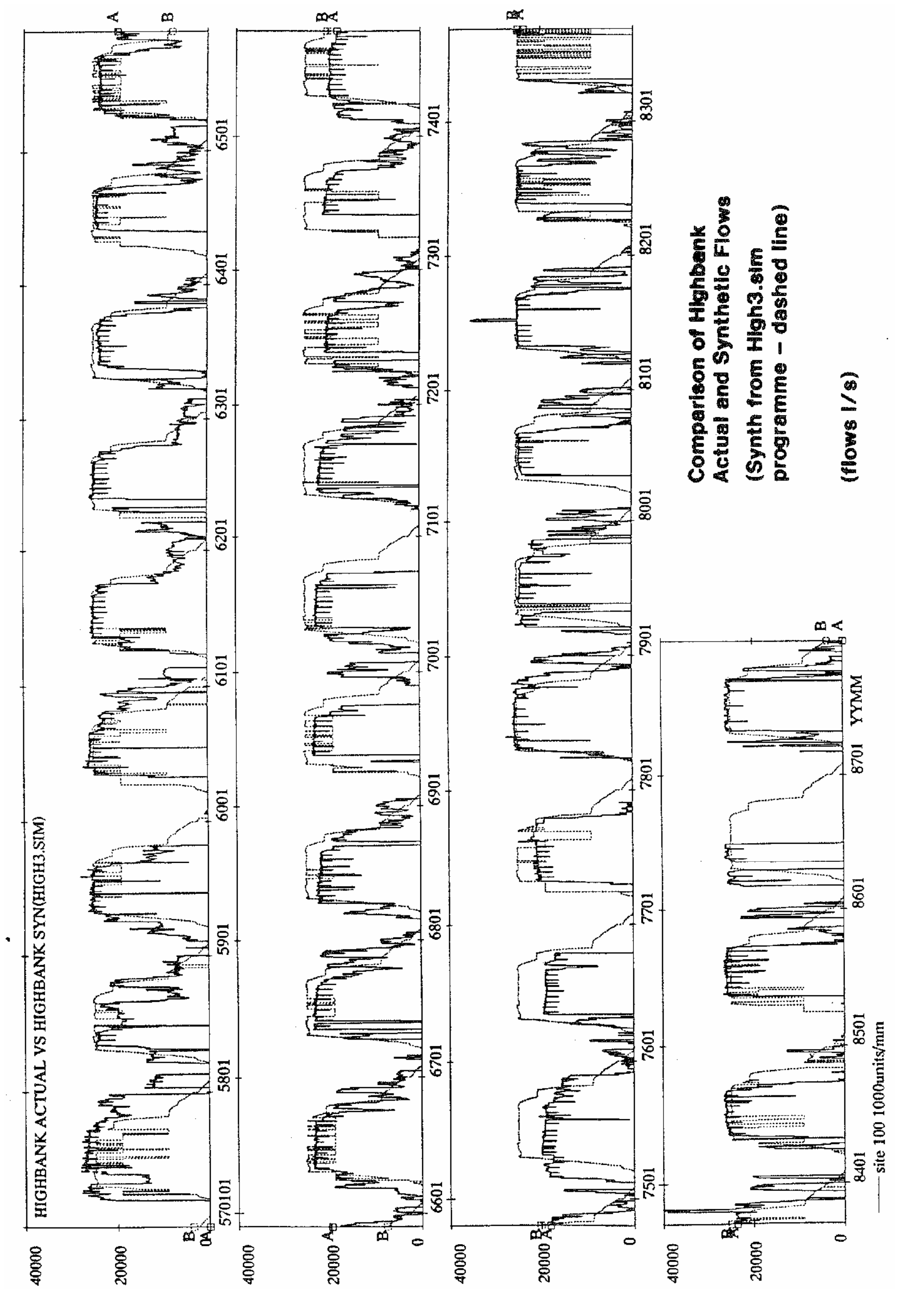
Highbank Power Station flow from the computer programme High3.Sim ["Equation 10"]
$r = 0.68$ $r^2 = 0.46$ std error = 6.9 $m^3/s$ (± 3.5 $m^3/s$)
Note "$r^2$" for 1978 and 1961 were 0.79 and 0.77 respectively (e = 4.9 and 4.3 $m^3/s$)

A comparative plot for the calibration period is included (Figure 5.2) as is a plot covering the full period of record 1930-1989 (Figure 5.3). The calibration period was essentially 1957-74 but the longer period 1957-87 has been checked as well. Figure 5.3 data only extends to 1987 although flows on the computer extend to 1989.

The 1930-89 record is constructed as follows:

(a) 1930 to April 1951 - using computer programme High3.Sim to produce synthetic record. ["Equation 10"]

(b) April 1951 to 1989 - actual Highbank Power Station record.


HIGHBANK ACTUAL VS HIGHBANK SYN(HIGH3.SIM)
Comparison of Highbank Actual and Synthetic Flows
(Synth from High3.sim programme – dashed line)
(flows l/s)
YYMM
site 100 1000units/mm

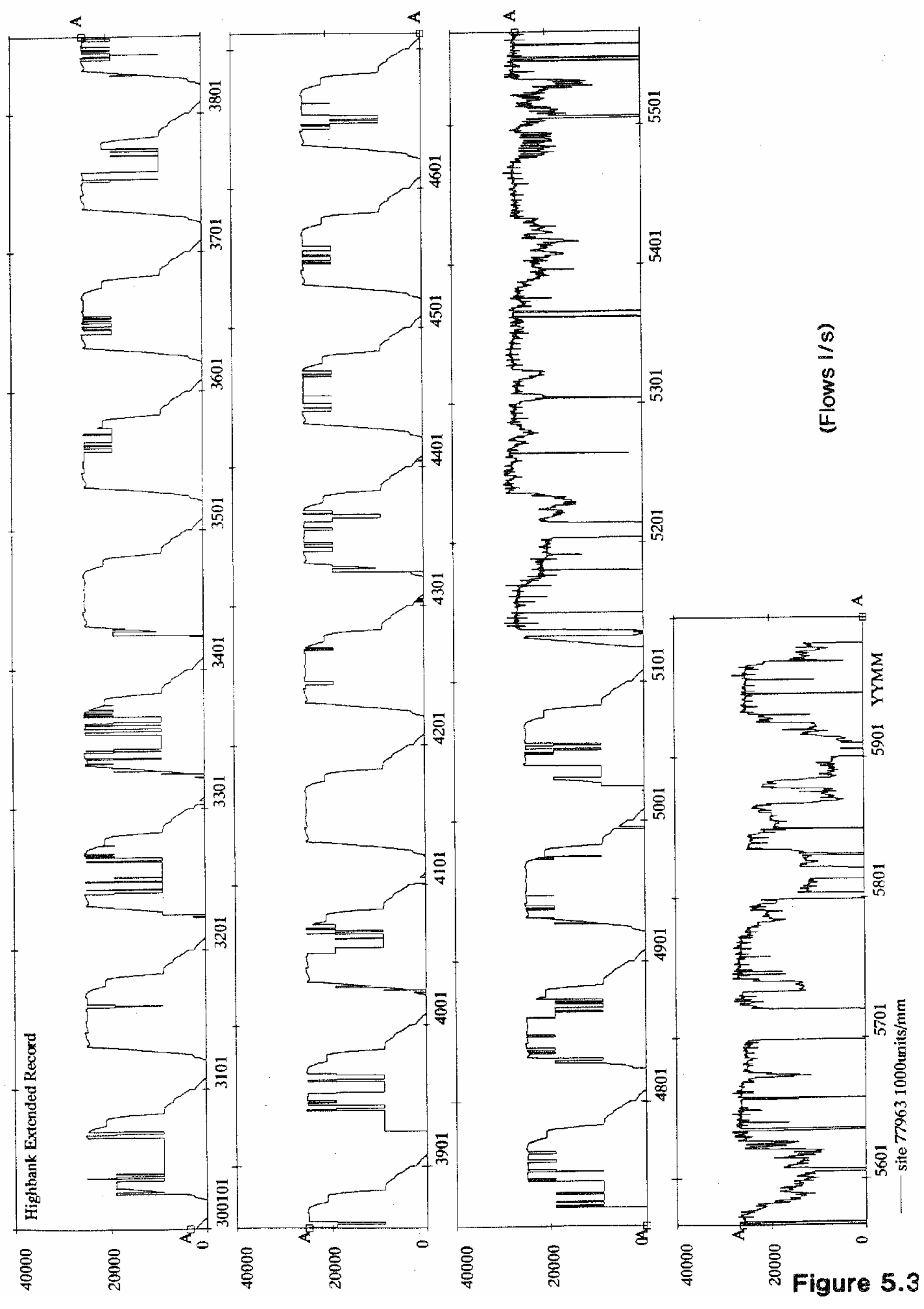

Highbank Extended Record
(Flows l/s)
site 77963 1000units/mm
YYMM

Figure 5.3