

# **Ngaruroro River Flow Naturalisation**

Prepared for Hawkes Bay Regional Council

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# HAWKES BAY REGIONAL COUNCIL

## Ngaruroro River Flow Naturalisation

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# 1 Introduction

This study is part of the Hawkes Bay Regional Council's (HBRC) commitment to the management of the region's water resources.

MWH has been commissioned to carry out a desktop hydrological investigation to develop a naturalised river flow dataset for the Ngaruroro River at Fernhill. Analysis of recorded flow data, metered abstraction data and resource consent records have been used in the naturalisation process.

MWH (2008) have previously derived a naturalised flow dataset covering the period 1997 to 2008. This was an update and extension of an earlier Opus (1997) study that derived a naturalised flow dataset covering 1969 to 1996.

This study uses the information gathered by MWH (2008) about actual volumes and rates of surface water abstraction from the Ngaruroro River to update the 1969 to 1996 naturalised flow dataset. The outcome is a naturalised flow dataset for the Ngaruroro River at Fernhill covering the entire period from 1969 to 2008 using the latest knowledge on abstraction rates within the catchment.

These days many catchments are 'managed'. The river flows we see are not natural but are influenced by pressures such as abstraction (e.g. irrigation, water supply), diversion, dams and urbanisation. To gain an appreciation of the true nature of a river's resource it is necessary to determine what the river flow would have been like with no abstractions or discharges of water, i.e. naturalised flow.

Essentially flow naturalisation involves taking the measured river flow and adding back in all the upstream abstractions. The naturalisation of a river flow is critically dependent on the availability of good quality data for both the river flow and all abstractions.

Naturalised flow records are vital in assessing the nature of the surface water resource and to what extent water may be allocated for use from it.

HBRC defines a surface water abstraction as any take within 400 metres of a surface water body. An abstraction may be taken from a borehole but if it is within 400 metres of surface water it is classed as a surface water take.

Groundwater losses and gains from the Ngaruroro River system are not included in this analysis. There can be significant losses to groundwater recharge, principally below SH50 at Maraekakaho and at Roy's Hill (HBRC 1997). Groundwater gains also occur in the lower reaches above and below Fernhill.

The groundwater losses and gains are considered part of the natural system here and not included in the flow naturalisation process. Although it is noted that factors such as abstraction from the groundwater aquifer could potentially cause higher recharge losses from the river.

## 1.1 Background

Naturalised flow records for six Hawkes Bay rivers were derived in *Flow Naturalisation for Six Hawkes Bay Rivers* (Opus 1997). The available data at the time was used to estimate the amount of actual water abstracted from rivers allowing naturalised flow records to be created for the period 1969 to 1996. The Ngaruroro River at Fernhill was one of the sites for which naturalised flow data were derived.

Since the 1997 work there has been a significant increase in the amount of water allocated for abstraction from these catchments and Hawkes Bay surface water resources in general. Knowledge and data on how much water is actually used has improved over time and MWH (2008) used the latest information to extend the Ngaruroro River at Fernhill naturalised flow record to 2008.

## 1.2 Objectives

The objective of this study is to provide HBRC with a naturalised daily flow dataset for the Ngaruroro River at Fernhill.

Reference should be made to the MWH (2008) report *Flow Naturalisation for Six Hawkes Bay Catchments: Tutaekuri, Ngaruroro, Waipawa, Tukipo, Tukituki and Maraetotara* for detailed presentation of the methodologies followed and analyses performed to derive the naturalised data. This study uses the same methodologies and the derived water abstraction characteristics as presented in the 2008 study.

## 2 Data

Data and information used in this study have been collected from a number of sources:

- Hydrological data from the HBRC Environmental Monitoring Database
- Hydrological data from NIWA
- Resource consent information from the HBRC consents database
- Previous hydrological, water resource and water management reports (see Bibliography for details)
- Local knowledge from HBRC staff

### 2.1 Hydrological Data

The flow data used in this study are detailed in Table 2-1. In addition to recorded data collected by HBRC and NIWA, the naturalised flow datasets created in 1997 (Opus 1997) and 2008 (MWH 2008) were used.

Flow gauging data, particularly concurrent flow gauging information, were also supplied by HBRC for many sites within the Ngaruroro catchment. The large database of flow gaugings at Fernhill are used extensively in the derivation of synthetic flow record at this site (Section 5.1).

**Table 2-1: River Monitoring Sites**

Site No.	River	Site Name	Period	Easting	Northing	Recording Authority
23104	Ngaruroro	Kuripapango	1963-2008	2796945	6197400	NIWA
23103	Ngaruroro	Whana Whana	1963-2008	2801900	6177700	HBRC
23102	Ngaruroro	Fernhill (Actual) <sup>1</sup>	1952-2008	2833000	6172900	HBRC
23102	Ngaruroro	Fernhill (Naturalised)	1969-2008	2833000	6172900	HBRC
23150	Ngaruroro	Chesterhope Bridge	1976-2008	2842492	6171513	NIWA

<sup>1</sup> Ngaruroro at Fernhill actual flow data only available 1952 to 1974. Only water level and flow gaugings recorded for remainder of record

## 2.2 Consent Data

Details of all resource consents for surface water abstraction from the Ngaruroro River catchment have been supplied by the HBRC consents department. The data were supplied in spreadsheet format detailing the abstraction, location, allocation amount, landuse type (e.g. cropping, vineyard, water supply etc), commencement and expiry date.

Additional information was obtained from reports by HBRC (1997) and Opus (1997).

MWH (2008) presents details of the surface water abstraction consents in the Ngaruroro River catchment.

## 2.3 Meter Data

A database of metered abstraction data is maintained by HBRC. Abstraction data relevant to the Ngaruroro catchment (Table 2-2) has been adopted from MWH (2008) to derive total catchment abstraction amounts.

The period of records are generally quite short and the data quality can be poor in some instances, but it does provide a relative picture of the actual abstractive use of the water resource in comparison to the amount allocated by resource consent.

**Table 2-2: Ngaruroro Catchment Metered Surface Water Abstraction Data**

Catchment	Meter Data Sites		Suitable Meter Data by Landuse				
	Total Sites	No. of Sites Suitable for Analysis	Pastoral Farming	Cropping	Orchard	Vineyard	Other
Ngaruroro	92	44	14	9	3	18	0

### 3 Methodology

Deriving a naturalised flow record consists of three basic steps:

- Convert actual recorded river (or derived synthetic) flow data to average daily flow
- Use recorded abstraction data and consent records to estimate actual abstraction rates
- Add the estimated abstraction rates to the daily flow record to derive a naturalised flow dataset

Table 3-1 breaks these basic steps down into a more detailed methodology followed in this investigation to derive naturalised flow records for the Ngaruroro River at Fernhill.

**Table 3-1: Flow Naturalisation Methodology**

<b>1 River Flow</b>
1.1 Derive <b>Average Daily Flow</b> (unnatural – i.e. modified by abstraction) for the Fernhill monitoring site: <ul style="list-style-type: none"> <li>• Actual recorded flow at Fernhill is not suitable</li> <li>• Need to create flow record using data from other sites on Ngaruroro River</li> </ul>
<b>2 Consented Allocation</b>
2.1 Collate all consented abstractions in Ngaruroro catchment from consent records/database: <ul style="list-style-type: none"> <li>• Divide into annual irrigation seasons (e.g. 2002/03)</li> <li>• Calculate total weekly consented <b>Allocation Volume</b> per irrigation season</li> </ul> 2.2 The <b>Allocation Volume</b> for each irrigation season is divided into landuse type (i.e. Pastoral Farming, Cropping, Orchard, Vineyard, Other)
2.3 Convert weekly <b>Allocation Volume</b> (per landuse) into average daily volume. Then convert to an average daily rate in litres per second. = <b>Average Daily Allocation Rate</b> for each landuse category.
<b>3 Metered Abstraction Data</b>
3.1 Collate <b>Metered Abstraction Data</b> in Ngaruroro catchment (surface water takes)
3.2 Use the <b>Metered Abstraction Data</b> and <b>Allocation Volume</b> to calculate the <b>Percentage Actual Water Use</b> for each metered abstraction per month of irrigation season (i.e. November to April)
3.3 Aggregate Step 3.2 by landuse type (from consent records) to derive a <b>Percentage Actual Water Use</b> for each landuse type
<b>4 Estimated Actual Water Use</b>
4.1 The <b>Percentage Actual Water Use</b> is applied to <b>Average Daily Allocation Rate</b> = <b>Estimated Actual Daily Average Abstraction</b> rate from the river (litres per second)
4.2 Use irrigation ban records to determine when abstractions were banned or reduced
4.3 Revise <b>Estimated Actual Daily Average Abstraction</b> dataset if necessary in after Step 4.2
<b>5 Naturalised Flow Data</b>
5.1 Add the <b>Estimated Actual Daily Average Abstraction</b> to the <b>Average Daily Flow</b> = <b>Naturalised Flow Dataset</b>



## 4 Deriving Ngaruroro Abstraction Dataset

To derive a naturalised flow dataset for the Ngaruroro River at Fernhill monitoring site the methodology detailed in Section 3 was followed. The actual recorded flow data from the Fernhill recorder is unsuitable for analysis so a synthetic flow record was derived using data from other monitoring sites on the river.

This investigation is able to apply actual estimates of the percentage of water used during the irrigation season according to landuse and the month rather than a constant 40% as applied by Opus (1997).

### 4.1 Recorded Flow Data

Water level and flow recording began at the Ngaruroro at Fernhill site in 1952. Difficulties in accurately rating the site after 1974 mean that only water level data is currently recorded. Flow gauging data are available from frequent gaugings at the site (especially during low flow periods).

A natural flow record for the Ngaruroro at Fernhill was previously created covering the 1969 to 1996 period (Opus 1997) and 1997 to 2008 (MWH 2008).

The main recording sites on the Ngaruroro River and its catchment are detailed in Table 4-1. Other recorders exist within the catchment but are not relevant to this study.

The Kuripapango and Whana Whana recording sites are situated in the upper reaches of the Ngaruroro River. These two sites have been relatively unaffected by abstractions with only the first consented abstraction above Whana Whana commencing in 2008.

The Ngaruroro at Chesterhope Bridge site is situated downstream of the Fernhill site and is operated by NIWA. Flow data are available since 1976 and is of good quality. The Chesterhope data is the preferred nearby site used to estimate flow at the Fernhill site (Section 5.1).

An extensive database of flow gaugings throughout the Ngaruroro catchment exists.

Flow records for two of the major abstractions from the Ngaruroro River are available. Data recorded at the Glazebrooks and Artificial Recharge water races are of reasonable quality and are sufficient to allow confidence in the estimation of the abstractions over time. However, recorded data only begins on the Glazebrooks take in 2000 and the Artificial Recharge in 1998. Prior to this the knowledge of the operation of the takes, and therefore the amount of abstraction, is poor.

**Table 4-1: Ngaruroro Catchment River Data**

Site No.	River	Site Name	Easting	Northing	Area (km <sup>2</sup> )	Period	Rec Authority
23104	Ngaruroro	Kuripapango	2796945	6197400	370	1963-2008	NIWA
23103	Ngaruroro	Whana Whana	2801900	6177700	1093	1960-2008	HBRC
23110	Ngaruroro	Ohiti	2827100	6170100	1750	1971-2008	HBRC
23102	Ngaruroro	Fernhill Fernhill (Naturalised)	2833000	6172900	1930	1952-2008 1969-1996	HBRC
23150	Ngaruroro	Chesterhope Bridge	2842492	6171513	1994	1976-2008	NIWA
1023186	The Race	Glazebrooks Recorder	2824200	6166700	-	2000-2008	HBRC
1123152	Recharge Race	Control Structure	2829400	6170700	-	1998-2008	HBRC

## 4.2 Consented Abstractions

MWH (2008) analysed records of surface water abstraction consents.

Figure 4-1 shows the changes in the number of consents and allocation volume over time. There is a noticeable increase in the allocation volume from 2000/01 and particularly after 2005/06.

The size of the takes range from the smallest at 130 m<sup>3</sup>/week up to 484,000 m<sup>3</sup>/week. The two largest abstractions WP000361T (Glazebrooks) and WP971303T (HBRC Artificial Recharge) have allocations of 484,000 m<sup>3</sup>/week and 362,880 m<sup>3</sup>/week respectively. These two abstractions account of for 73% of allocated abstraction in 1996/97 and 40% in 2007/08.

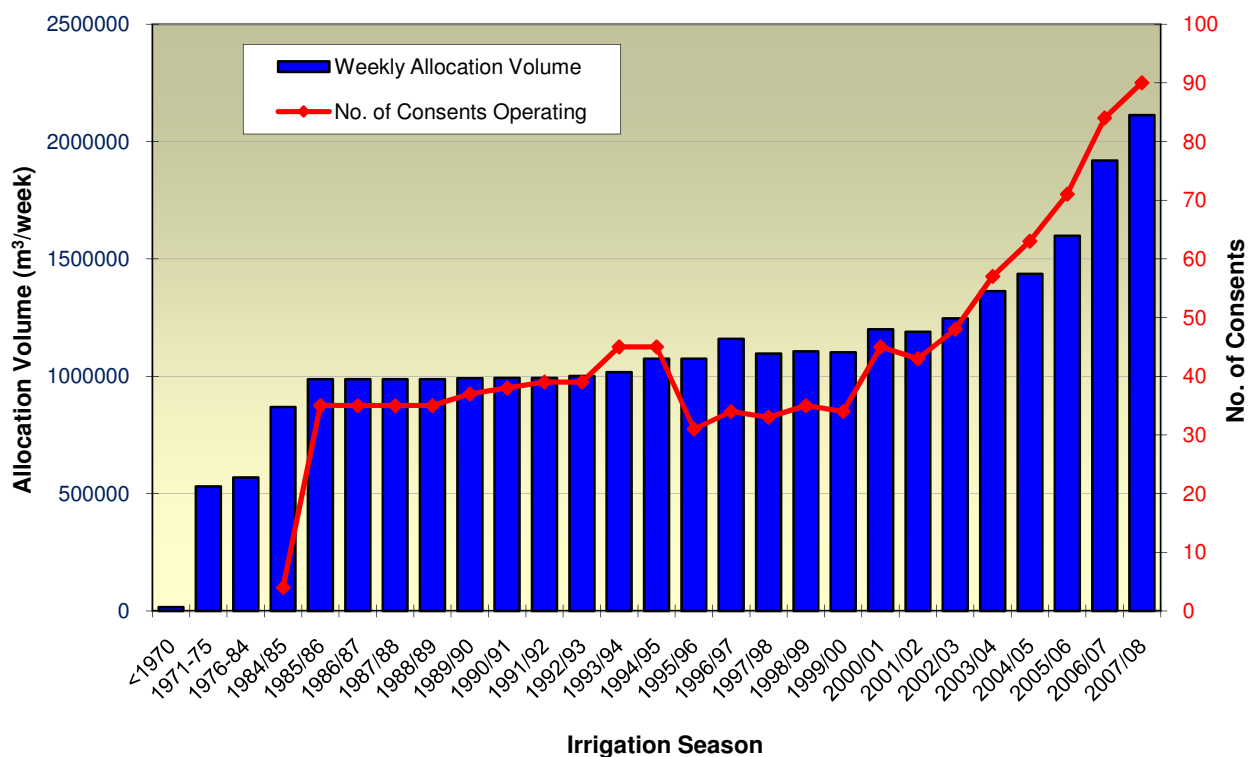


Figure 4-1: Ngaruroro Catchment - Trend in Consented Surface Water Abstractions

## 4.3 Metered Actual Water Use

MWH (2008) analysed 44 metered surface water abstractions in the Ngaruroro catchment. In addition, there is recorded water level and flow for the intakes to the large Glazebrooks and Artificial Recharge abstractions.

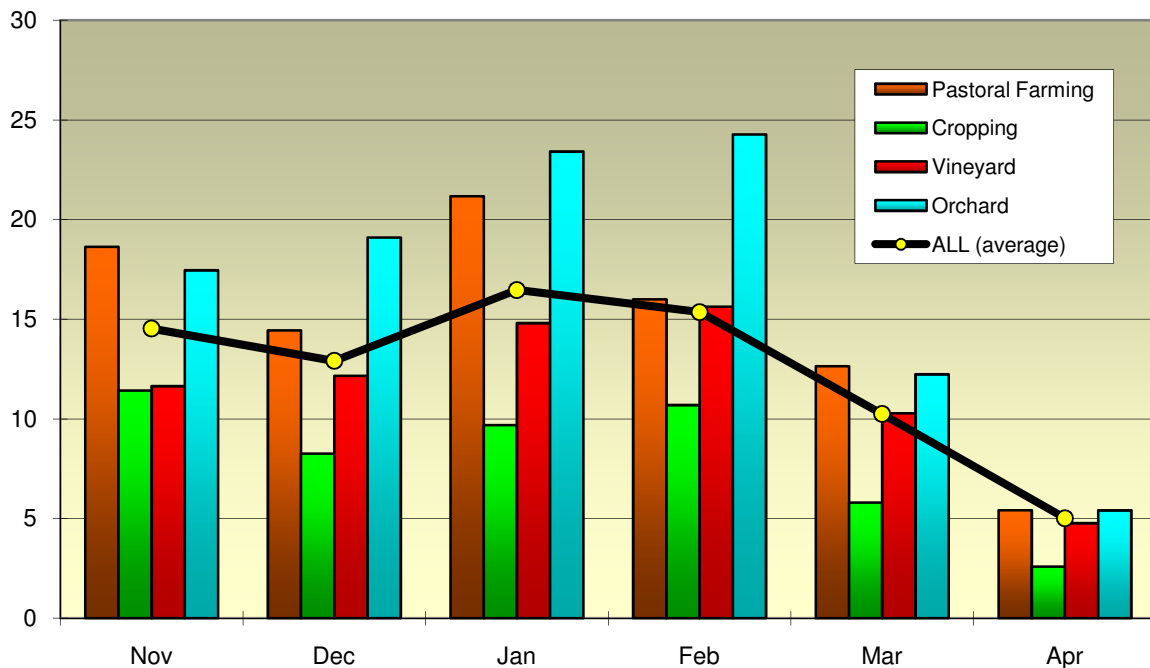
The collection of metered abstraction data has been carried out in the Ngaruroro catchment for a number of years. Many of the meter data sites in the Ngaruroro catchment begin in the 1999/2000 season. This length of data provides a good picture of water use over a variety of climatic conditions. Other Hawkes Bay catchments typically only have data from the 2007/08 season.

The large Glazebrooks and Artificial Recharge abstractions have recorded data available from 2000 and 1998 respectively.

### 4.3.1 Actual Use by Landuse Type

Figure 4-2 shows the variation of the percentage actual surface water use in the Ngaruroro catchment for the four landuse types of pastoral farming, cropping, vineyard and orchard (MWH 2008). Orchard and pastoral farming use the highest proportions of allocated water with January and February having the greatest abstraction.

Overall the percentage of actual water use in the Ngaruroro catchment was found to be relatively low (MWH 2008). The average percentage of water use only just gets above 15% in January. This contrasts to the value of 40% assigned to actual water use in the Ngaruroro catchment by the 1997 flow naturalisation work (Opus, 1997). Water abstraction data presented in the HBRC (2004) *State of Our Environment Report 1998-2003* estimated average actual water use at 10% in the Ngaruroro catchment.



**Figure 4-2: Ngaruroro Catchment Metered Data - Percentage Actual Water Use by Landuse Type**

### 4.3.2 Estimated Total Actual Daily Abstraction

The metered abstraction data is used to estimate the total water use/abstraction from all active consents in the Ngaruroro catchment by irrigation season. This is then applied to the recorded river flow data to produce a naturalised flow record.

The average percentage of actual water use for each metered abstraction per month (November to April) is calculated and collated by landuse type as presented in Table 4-2.

**Table 4-2: Average Monthly Percentage of Actual Water Use by Landuse Type**

Month	Pastoral Farming	Cropping	Orchard	Vineyard	Catchment Average
November	19	9	17	12	14
December	14	7	19	12	13
January	21	7	23	15	17
February	16	8	24	16	16
March	13	3	12	10	10
April	5	2	5	5	4

All the surface water abstraction consents for the Ngaruroro catchment have been grouped on an irrigation season basis from 1969/97 to 2007/08. For each irrigation season the total allocated volume (m<sup>3</sup>/week) is derived for five landuse categories:

- Pastoral farming
- Cropping
- Orchard
- Vineyard
- Other

Consented abstractions below the Ngaruroro at Fernhill flow recorder site are not included. Only those above the recorder are used so that the derived abstraction rates can be added to the recorded flow data to produce a naturalised flow record at the recorder site.

The total allocation volumes are divided further into total daily allocated volumes (m<sup>3</sup>/day) per landuse, and then into an average daily abstraction rate in litres per second (L/s). Table 4-3 details the total seasonal allocation for each landuse expressed as a daily abstraction rate.

The 'Cropping' and 'Other' categories are dominated by the Glazebrooks (800 L/s) and Artificial Recharge (600 L/s) allocations respectively.

**Table 4-3: Ngaruroro Catchment Average Daily Allocated Abstraction Rate (L/s)**

<b>Irrigation Season</b>	<b>Pastoral Farming</b>	<b>Cropping</b>	<b>Orchard</b>	<b>Vineyard</b>	<b>Other</b>
<1970*	0	11	16	0	0
1971/74*	0	12	16	0	0
1974/75*	0	812	16	0	0
1976/85*	0	814	18	4	0
1985/86/87/88/89	43	908	40	39	602
1989/90	49	907	40	39	602
1990/91/92/93	49	912	40	39	602
1993/94	52	915	40	47	602
1994/95	52	917	40	72	602
1995/96	30	1024	56	67	600
1996/97	89	1046	115	67	600
1997/98	146	928	2	136	600
1998/99	146	928	2	151	600
1999/00	170	926	11	114	600
2000/01	207	944	15	219	600
2001/02	194	928	15	228	600
2002/03	289	927	15	230	600
2003/04	339	927	15	371	600
2004/05	339	1023	39	371	600
2005/06	339	1025	39	638	600
2006/07	778	1046	39	709	600
2007/08	1080	1063	39	709	601

\* - Quality of records does not allow accurate breakdown of the total monthly water use by landuse type for these years. The figure displayed are assumed based on subsequent years

### 4.3.3 Consented Abstraction Data (excluding Artificial Recharge and Glazebrooks)

The percentages of actual water use (Table 4-2) for each landuse and month were applied to the average daily allocation (Table 4-3) which was adjusted to exclude the Artificial Recharge and Glazebrooks abstractions. These two have their own actual recorded abstraction data and therefore do not need to be included in this analysis to derive **estimated actual daily average abstraction** rate of water from the remaining consented abstractions.

Table 4-4 details the estimated actual average daily abstraction (L/s) for each month of each irrigation season.

**Table 4-4: Ngaruroro River (above Fernhill) Estimated Actual Average Daily Abstraction (L/s), Excluding the Artificial Recharge and Glazebrooks Abstractions**

<b>Irrigation Season(s)</b>	<b>November</b>	<b>December</b>	<b>January</b>	<b>February</b>	<b>March</b>	<b>April</b>
<1970	3	3	3	3	2	1
1970-76	3	3	3	4	2	1
1976-85	4	4	5	5	3	1
1985-93	30	26	32	32	18	8
1993/94	33	29	36	36	21	9
1994/95	38	34	42	42	24	11
1995/96	44	39	46	49	25	12
1996/97	64	56	69	69	40	18
1997/98	63	56	72	67	40	18
1998/99	65	59	76	71	42	18
1999/00	64	56	73	67	41	18
2000/01	91	83	107	101	59	26
2001/02	89	82	106	99	58	26
2002/03	107	96	126	115	71	31
2003/04	141	130	170	158	94	41
2004/05	153	139	181	169	100	44
2005/06	199	190	243	234	133	59
2006/07	295	269	354	323	198	87
2007/08	353	314	419	373	236	103

Irrigation ban records supplied by HBRC define a number of irrigation bans for Ngaruroro River water users linked to various minimum flow levels as measured at Fernhill and Whana Whana.

A dataset of average daily abstraction is compiled from 1969-2008 with adjustments made for these irrigation bans. For example, when the 5000 L/s minimum flow ban is implemented, all consented users linked to this level are defined as having zero abstraction until the ban is lifted. Likewise for the 2800 L/s and 2400 L/s minimum flow levels at Fernhill and the minimum flow levels at Whana Whana.

Records of irrigation bans were only available from 1994/95. Prior to this water abstractions were still linked to a minimum flow at Fernhill (2800 L/s), and this has been factored into the analysis with abstractions ceasing/easing when the river flow is below this.

The resulting average daily abstraction dataset is used to naturalise the Ngaruroro River flow (Section 5.1).

#### 4.3.4 Artificial Recharge Abstraction Data

Recorded abstraction data for the Artificial Recharge operation is available from 27 May 1998. To provide a complete dataset for naturalising the Ngaruroro River flow for the 1 July 1969 to 30 June 2008 period the Artificial Recharge data needs to be extended back to its commencement in 1988.

Opus (1997) put forward a method to derive the Artificial Recharge abstraction based on poor quality recording of whether the operation was “on” or “off” and then assumed that a constant abstraction of 750 L/s (1995 onwards) occurred whenever the system was “on”. Opus concludes this method provides a lack of quality information.

The Artificial Recharge became operational in 1988 and ran at approximately 1500 L/s under normal conditions. The original scheme took water directly from the Ngaruroro River and was subject to frequent disruption when river flow would become too turbid due to a fresh or high flow in the river. From 1995 the Artificial Recharge intake was changed and the maximum abstraction became 750 L/s.

A dataset of Artificial Recharge abstraction is constructed from:

- (i) 1998 to 2008 - Actual recorded data
- (ii) 1995 to 1998 - Assuming a constant maximum take of 750 L/s
- (iii) 1988 to 1994 - Assuming a constant maximum take of 1500 L/s

Steps (ii) and (iii) assume the abstraction stops when flow in the Ngaruroro River gets above 20,000 L/s to mimic the take ceasing when the river water becomes turbid.

The resulting complete average daily abstraction dataset is combined with the other abstraction datasets to naturalise the Ngaruroro River flow (Section 5.1).

#### 4.3.5 Glazebrooks Abstraction Data

Recorded abstraction data for the Glazebrooks abstraction operation is available from 9 October 2000. To provide a complete dataset for naturalising the Ngaruroro River flow for the 1 July 1996 to 30 June 2008 period the data needs to be extended back to when the abstraction commenced in 1974.

MWH (2008) and Opus (1997) presented a method to derive a Glazebrooks abstraction record from 1974 to 2000.

The maximum abstraction amount is taken as 850 L/s (design flow of the intake structure). This is assumed as the rate of take. The take could be run at half that rate but it has not been possible to discern from the records when the abstraction was at full rate or half rate (HBRC 1997). The ‘worst case’ was therefore assumed.

The abstraction does not operate all of the time and the recorded abstraction data between 2000 and 2008 a previous assumption (Opus 1997) to temporally distribute the abstraction over each month. The pattern used is detailed in Table 4-5. For example, the average number of weeks that abstraction occurs in January is three, and the weeks that this is applied to are the last three weeks of each January, i.e. weeks two to four.

**Table 4-5: Glazebrooks Abstraction – Average Weeks per Month of Abstraction**

	<b>Oct</b>	<b>Nov</b>	<b>Dec</b>	<b>Jan</b>	<b>Feb</b>	<b>Mar</b>	<b>Apr</b>	<b>May</b>
Average No. of Weeks	2	3	3	3	3	2	2	1
Abstraction Period (Week No.)	2, 4	1,3,4	1,3,4	2-4	1-3	2, 4	2, 4	1

The Glazebrooks abstraction dataset is extended back to 1 July 1974 using this method and the resulting average daily abstraction dataset is combined with the other abstraction datasets to naturalise the Ngaruroro River flow (Section 5.1).

#### 4.3.6 Total Consented Abstraction Dataset

Three abstraction datasets are derived that define all the consented abstractions for the Ngaruroro River above Fernhill:

- Consented Abstractions (Section 4.3.3)
- Artificial Recharge Abstraction (Section 4.3.4)
- Glazebrooks Abstraction (Section 4.3.5)

The three datasets are combined into one total abstraction dataset.



## 5 Ngaruroro Naturalised River Flow

Section 3 details the methodology used to produce abstraction data from the Ngaruroro River above Fernhill. The abstraction dataset (Section 4.3.6) must be added to the Ngaruroro at Fernhill flow record to produce a naturalised flow record for the site.

As detailed in Section 4.1, the actual flow data for the Ngaruroro River at Fernhill is of poor quality and is only available between 1952 and 1974. A 'synthetic' flow record is developed based on nearby flow recorders.

### 5.1 Synthetic Ngaruroro at Fernhill Flow Record

The Ngaruroro at Fernhill recorder site has collected data extending back to 1952. There are difficulties in accurately rating the site after 1974, therefore only water level data is currently recorded.

Opus (1997) created a naturalised Ngaruroro at Fernhill flow record from 1969 to 1996. MWH (2008) created a synthetic record of flow data (un-natural) at Fernhill based on the downstream Chesterhope flow recorder. The quality of data available made this method preferable to the number of different methods used by Opus in 1997 to derive a synthetic flow record at Fernhill.

The Ngaruroro at Chesterhope flow recorder began in 1977 and therefore other methods must be used prior to this to extend the synthetic Fernhill record back to 1969. This study creates a synthetic Fernhill flow record between 1969 and 2008 based on three methods:

- 1977 to 2008 – based on correlation with Chesterhope
- 1975 to 1976 – based on correlation with Whana Whana
- 1969 to 1974 – based on actual recorded flow at Fernhill

Data on which to extend the record back prior to 1969 is of poor quality and has not been used.

#### 5.1.1 Based on Chesterhope

A synthetic daily Ngaruroro at Fernhill data series is created covering 18/01/1997 to 30/06/2008.

The Ngaruroro at Chesterhope flow recorder (Table 4-1) is sited 11 km downstream of the Ngaruroro at Fernhill site draining an area of 1994 km<sup>2</sup>, compared to 1930 km<sup>2</sup> for Fernhill. The Chesterhope site has been operating between 1977 and 2008 and its flow record is of good quality.

A total of 107 concurrent flow gaugings exist between the two sites (as at 2008). This makes a very useful dataset upon which to derive a correlation so that Chesterhope flow can be converted to Fernhill flow.

The flow gaugings for both sites can be considered 'modified' or 'un-natural' (i.e. affected by abstractions). Over the period of record of the concurrent gaugings only four consented abstractions operated between the two sites. If all four had been operating to their maximum allocation at once then a total of 16 L/s would have been abstracted. This value is well within the accepted margin of error for flow measurement ( $\pm 8\%$ ) so is ignored and no adjustments are required to the Chesterhope flow.

MWH (2008) details the correlation and analysis of the two sites and presents the regression equations to convert Chesterhope flow to Fernhill flow.

Seventeen short duration gaps exist in the Chesterhope data between 1977 and 1996. These have been filled by creating a correlation relationship between Whana Whana and Chesterhope, and applying the relationship to the Whana Whana flow record for the duration of the missing record.

The Ngaruroro at Chesterhope daily average flow record (including filled gaps) from 1977 to 2008 is applied to the regression equations to develop a synthetic Ngaruroro at Fernhill daily average flow series.

### **5.1.2 Based on Whana Whana**

Recorded flow data is available for the Ngaruroro River at Whana Whana from 1960. Data quality is poor for data prior to 1978 due to coarse processing the chart record and rating curves that appear to be not totally representative of flow gaugings at the site (Opus 1997).

Daily synthetic Fernhill flow record is created by a non-linear (rating) relationship as developed by Opus (1997).

### **5.1.3 Actual Fernhill Data**

Rated flow data is available at the Fernhill site between 1953 and 1974. The site is very unstable and rating changes are frequent. Ratings were discontinued after 1974 due to this.

The early record also suffers from apparently coarse digitising of the recorded Foxboro charts (Opus 1997).

After checking the recorded water level and comparing the rating curves to gauged flow, the period of flow data between 1969 and 1974 was used to complete the Fernhill flow record dataset between 1969 and 2008.

Whana Whana data converted through the non-linear rating (as in Section 5.1.2) could have been used to extend the record back to 1969, but it was considered that with both the Whana Whana and Fernhill sites suffering equally from poor ratings and data over this period that using the actual recorded 'at-site' Fernhill data would be preferable.

### **5.1.4 Adjusting Synthetic Record to Gaugings**

The derived synthetic Fernhill flow record between 1969 and 2008 is compared to the flow gaugings that have been carried out at the Fernhill site. The gaugings are considered more accurate than the synthetic flow so they are used to correct the synthetic data.

There is a reasonably large dataset of flow gaugings at Fernhill and many of the low flow periods are represented.

There is greater certainty about the synthetic dataset after it has been corrected to the flow gaugings, particularly in the low to median flow range.

Appendix A contains hydrograph plots of the synthetic Fernhill flow record for the 1969 to 2008 period. The Fernhill flow gaugings are plotted and show that the derived flow record represents the actual gauged data.

## **5.2 Fernhill Naturalised Data**

Four datasets were created from which the naturalised flow for the Ngaruroro River can be derived:

- Daily average flow – Ngaruroro at Fernhill (Section 5.1)
- Daily average consented abstraction – excluding Artificial Recharge and Glazebrooks (Section 4.3.3)
- Daily average Artificial Recharge abstraction (Section 4.3.4)
- Daily average Glazebrooks abstraction (Section 4.3.5)

A spreadsheet was used to add all the abstraction data onto the derived Ngaruroro at Fernhill flow and the resulting dataset represents the naturalised daily average Ngaruroro at Fernhill flow record.

Table 5-1 details flow statistics for the naturalised flow and the actual recorded flow data for the Ngaruroro River at Fernhill between 1969 and 2008. The tabled statistics are for daily flow, except where denoted as 7-day averages.

**Table 5-1: Flow Statistics (L/s) for Naturalised and Actual Ngaruroro at Fernhill (1969-2008)**

	Mean	Median	Min	Min 7-day	MALF	MALF 7-day	Q <sub>95</sub> , 7-day	Q <sub>95</sub>	Q <sub>90</sub>	Q <sub>80</sub>	Max
Naturalised	40114	23651	308	456	4134	5240	5519	5063	6916	9461	1641953
Synthetic Actual	39581	23342	264	456	3517	4396	4519	4181	5815	8339	1641953
<b>1997-2008</b>											
MWH (2010)	37758	21515	1776	2019	3681	4190	4330	4213	5813	8187	1093795
MWH (2008)	37621	21530	1619	2135	3394	3880	4186	3948	5298	7793	1093795
<b>1969-1996</b>											
MWH (2010)	41179	24488	308	456	4365	5832	6277	5840	7626	10240	1641953
Opus (1997)	43725	24992	246	405	3658	4786	5278	4843	6560	9331	3778900

The table also shows statistics from the Fernhill naturalised flow data derived in this investigation compared to those previously derived by Opus (1997) and MWH (2008).

The difference between the MWH (2010) and MWH (2008) data is from a more accurate method used to match the derived synthetic flow data to actual flow gaugings at Fernhill. The data derived here supersedes the 2008 naturalised dataset.

The comparison of the 1969 to 1996 period between the naturalised flow derived in this investigation and that of Opus (1997) shows some differences in the flow statistics. The differences are caused by the different methods of deriving synthetic Fernhill flow data and the improved method of estimating abstraction amounts in 2010.

The MWH (2010) data is preferred as the 1977 to 1996 period is based on correlation with the nearby Chesterhope site. The 1969 to 1976 period for both datasets is considerably less accurate and should be used with caution. The Opus (1997) data is based on correlation with Whana Whana while the MWH (2010) data uses actual recorded Fernhill flow data between 1969 and 1974 and a correlation with Whana Whana in 1975 and 1976. The MWH derived synthetic data is corrected and ramped to match actual flow gaugings completed at Fernhill.

## 6 Summary

This investigation has derived a naturalised river flow record for the Ngaruroro River at Fernhill for the period 1969 to 2008.

The rate and volume of surface water abstraction from the river have been calculated from metered abstraction data and flow measurement records of the two largest abstractions – the Artificial Recharge and Glazebrooks.

A synthetic 'actual' flow record for the Ngaruroro River at Fernhill has been derived by correlation with other flow recorder sites on the river.

The derived abstraction amounts have been added to the synthetic river flow record to create a naturalised flow dataset.

The dataset covers the period 1969 to 2008 and supersedes previous naturalised flow datasets created for the Ngaruroro River by Opus (1997) and MWH (2008).

The naturalised flow dataset is considered of good quality between 1977 and 2008. From 1969 to 1976 the derived synthetic flow was based on the nearby Whana Whana sites and actual flow recorded at Fernhill. This data is of poor quality with a number of ratings not adequately supporting the gauged data. The 1969 to 1976 period of naturalised flow data is to be used with a degree of caution.

## 7 Recommendations

The naturalised flow record for the Ngaruroro River at Fernhill developed here should be added to the HBRC hydrological database and used instead of the previous naturalised datasets for the river.

The early flow records of the Ngaruroro at Whana Whana and Ngaruroro at Fernhill sites should be revisited at some stage with a view to improving the ratings at both sites. More accuracy and confidence in the ratings would allow the naturalised flow dataset to be extended further back into time.

Metering of water abstractions has been invaluable in this study and will be of great benefit in further defining the state of region's water resource. As such, HBRC should continue to encourage the collection of water abstraction data as well as also encouraging the meter readers to consistently take readings (e.g. regular weekly intervals).

## 8 References

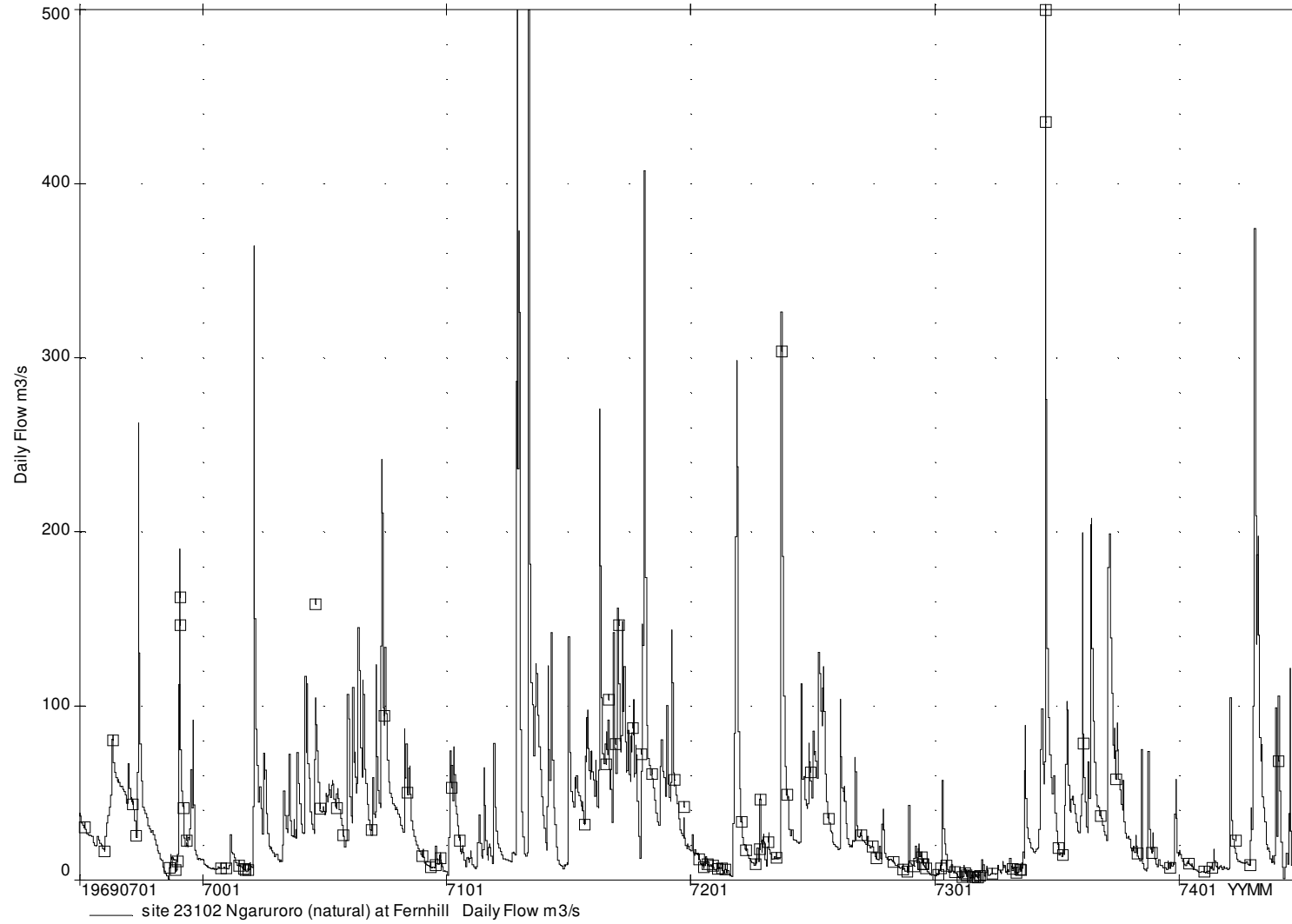
HBRC, 1997: *Sustainable low flow project Ngaruroro River*. Environmental Management Group Technical Report EMT 97/3. Hawke's Bay Regional Council. 109 p

MWH, 2008. *Flow Naturalisation for Six Hawkes Bay Catchments: Tutaekuri, Ngaruroro, Waipawa, Tukipo, Tukituki and Maraetotara*. Report Prepared for Hawkes Bay Regional Council

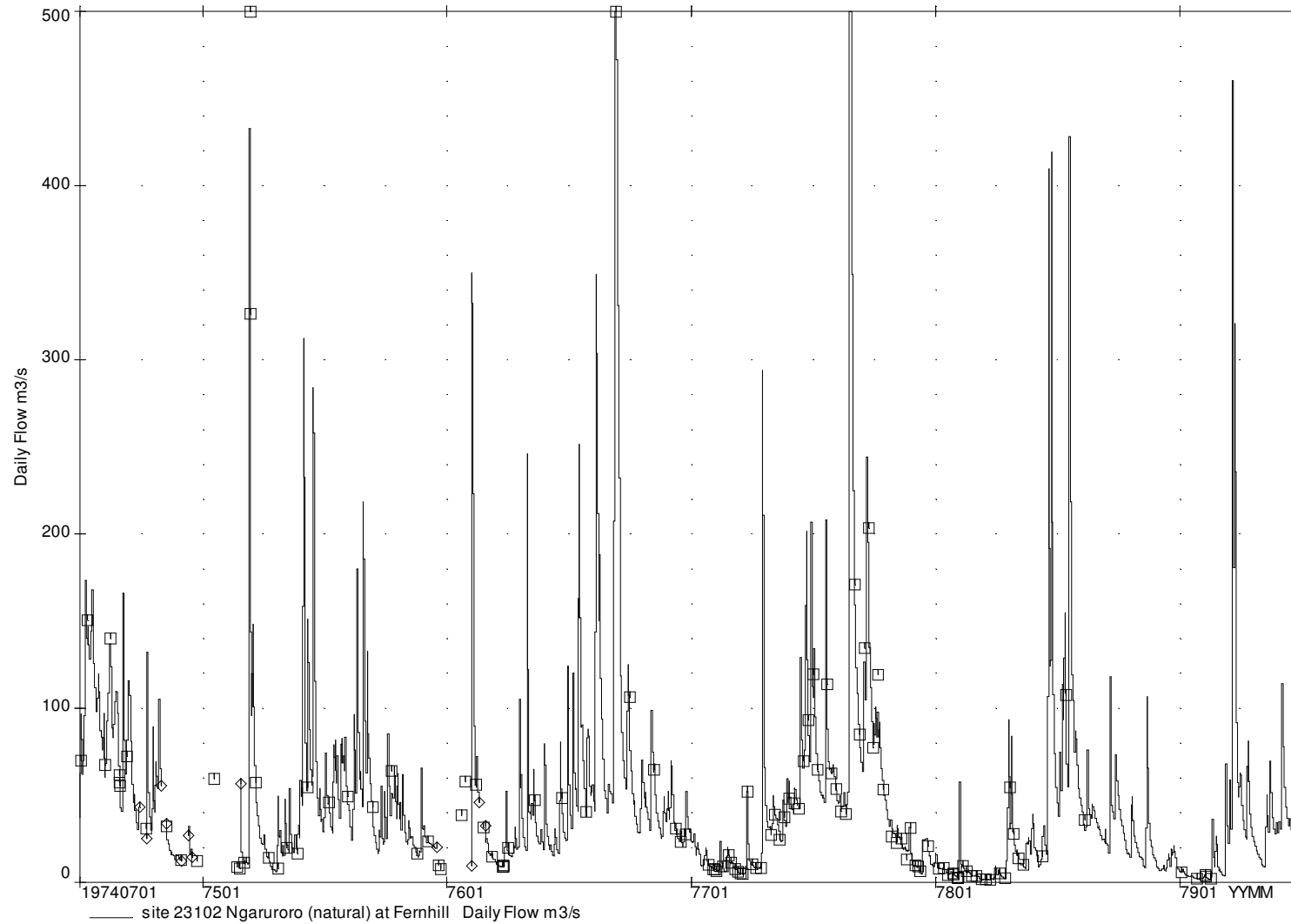
Opus, 1997. *Flow Naturalisation for Six Hawkes Bay Rivers*. Report Prepared for Hawkes Bay Regional Council

## **Appendix A: Naturalised Ngaruroro at Fernhill Flow Data – compared to actual Flow Gaugings at site**

Plotted 15-MAR-2010 16:44

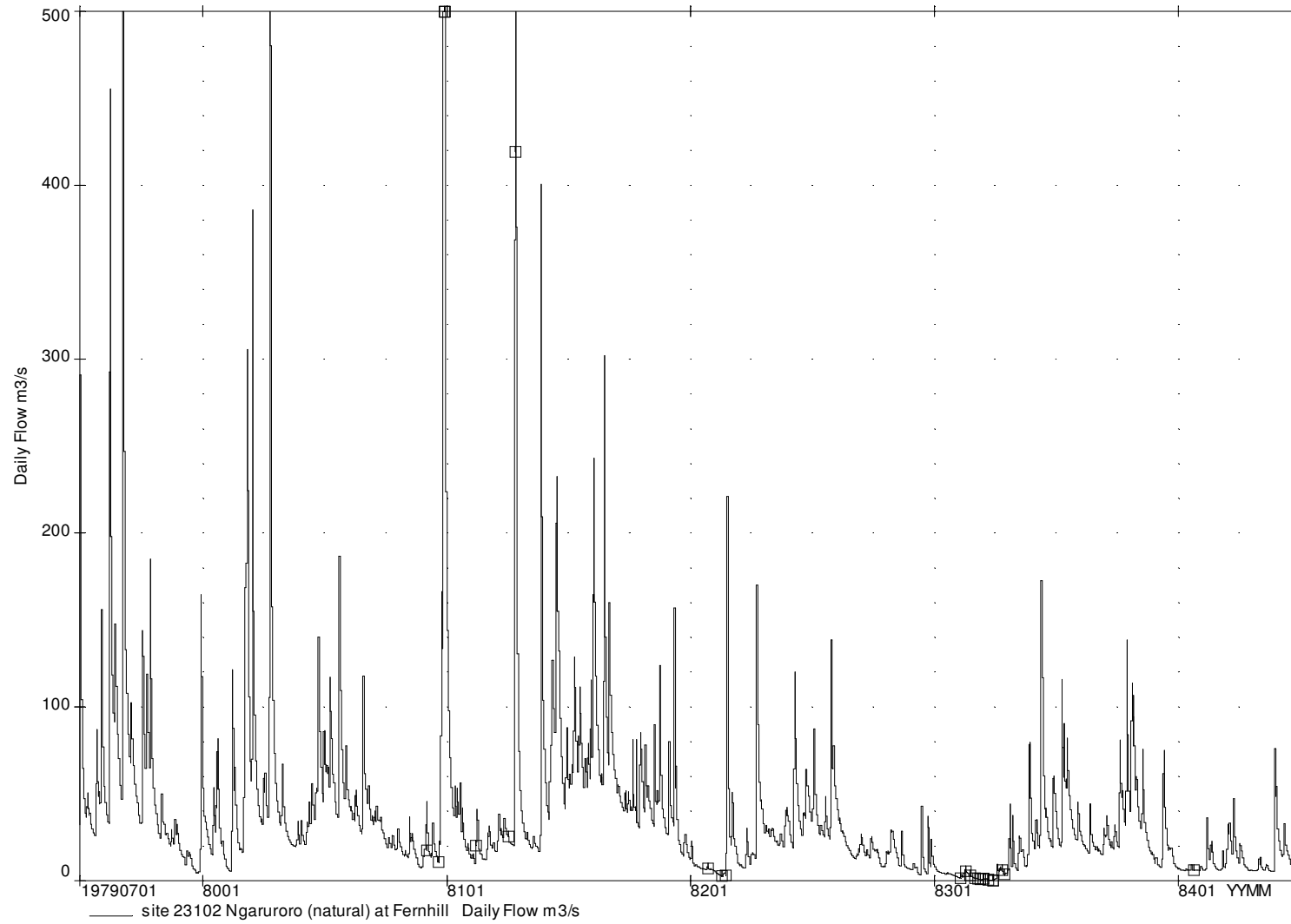


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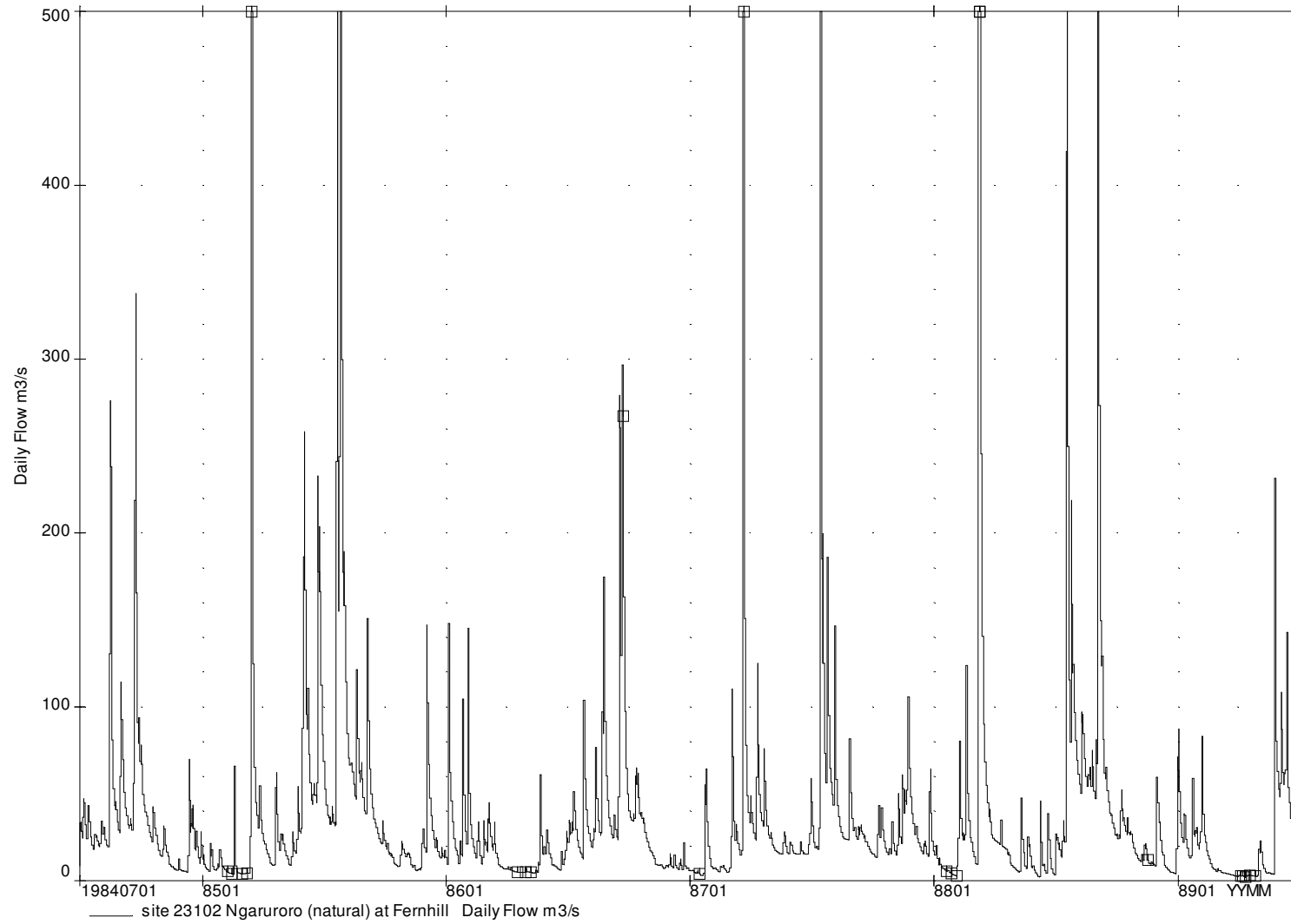




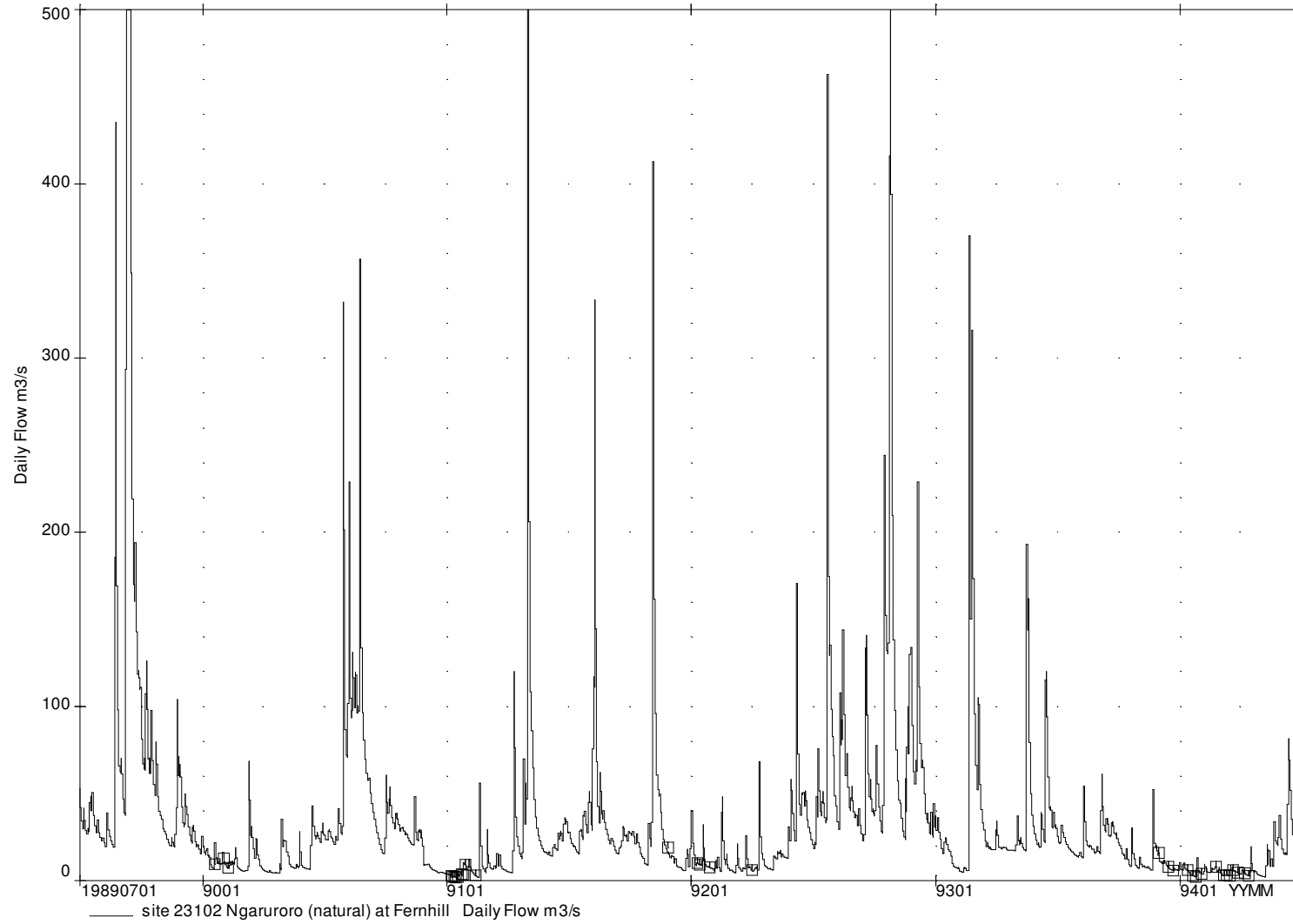
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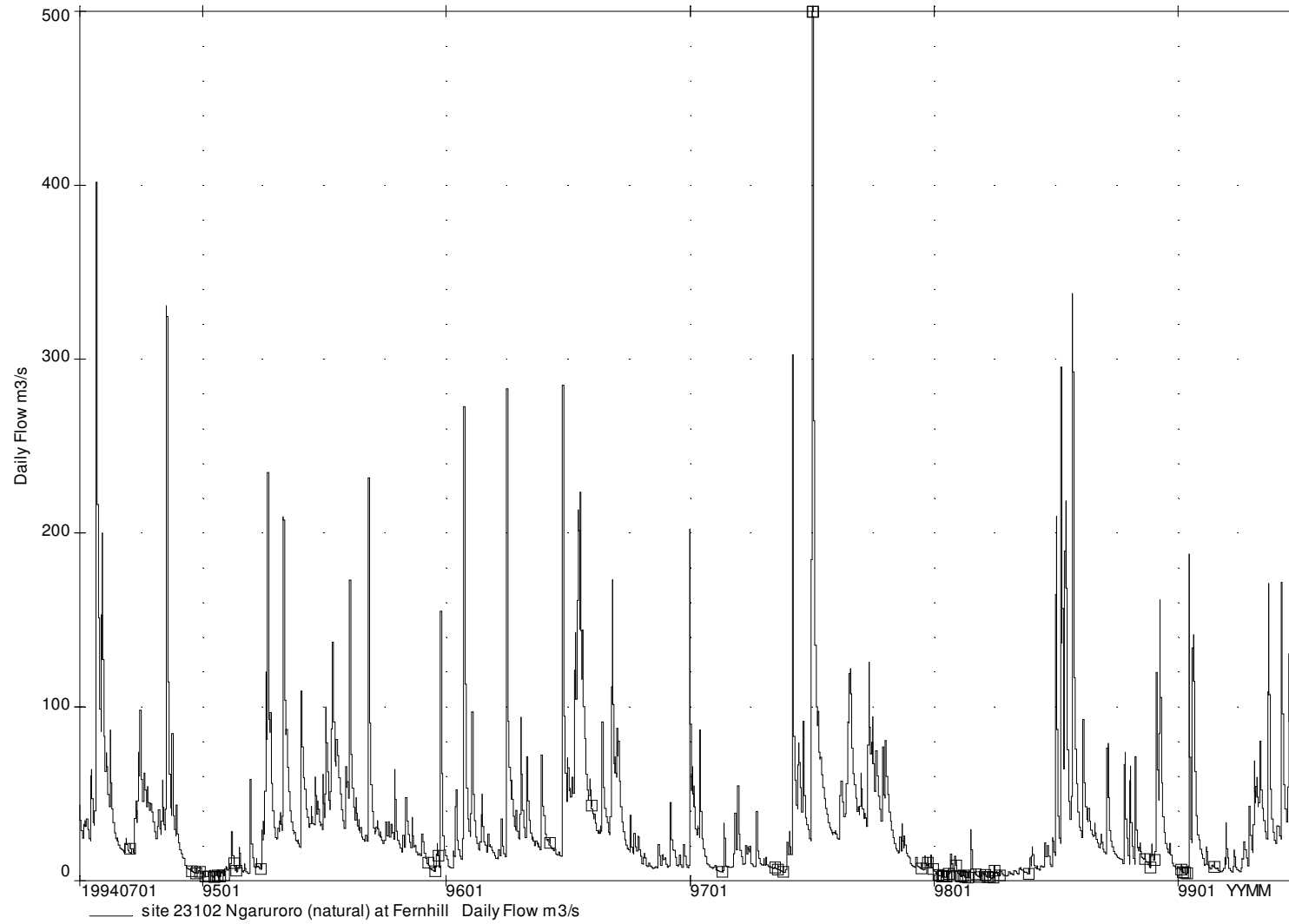
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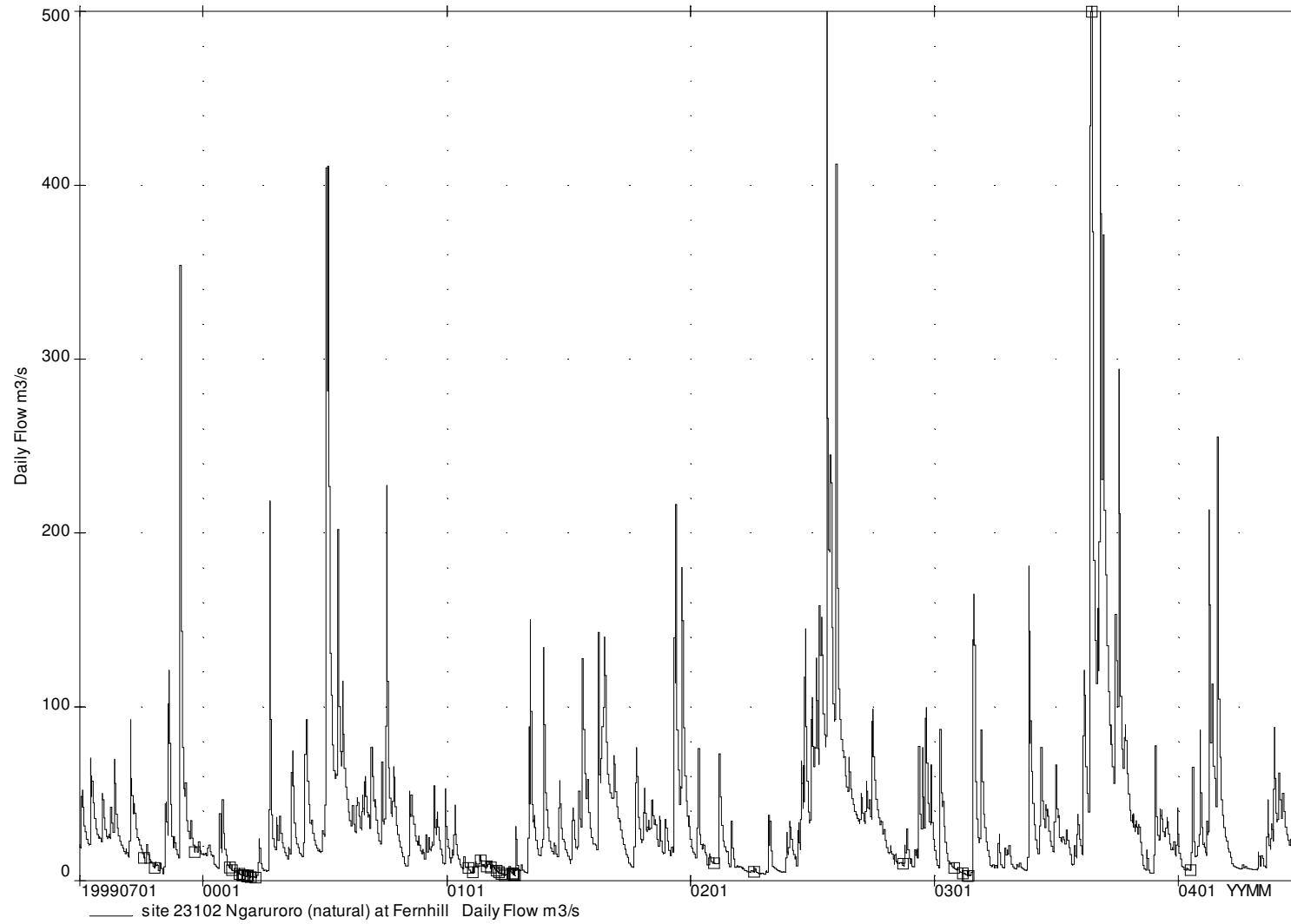
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Plotted 15-MAR-2010 16:46



Plotted 15-MAR-2010 16:47



Plotted 15-MAR-2010 16:47

