Review of flow records and estimates for the mean annual seven day low flow (MALF) for the Waipaoa and Te Arai Rivers

NIWA Client Report: CHC2010-014
April 2010

NIWA Project: ELF10202
Envirolink Grants 745-GSDC59
and 746-GSDC60

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Review of flow records and estimates for the mean annual seven day low flow (MALF) for the Waipaoa and Te Arai Rivers

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Prepared for

Gisborne District Council

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Reviewed by: *Approved for release by:*

Dr Helen Rouse Roddy Henderson

1. Introduction

This report provides outputs from a NIWA review of flow records for the Waipaoa and Te Arai Rivers, carried out under Envirolink Small Advice Grants for the Waipaoa River (745-GSDC59) and Te Arai River (746-GSDC60).

The aims of this work were to:

i) provide comment on the quality of the flow record for each site with regard to estimating low flows (i.e., the mean annual low flow - MALF);

ii) calculate MALF for each site; and

iii) recommend an estimate of MALF that GDC could use for the purpose of an interim minimum flow limit if and when the Proposed National Environmental Standard on Ecological Flows and Water Levels (MfE 2008) (the NES) comes into force.

The need for this work arose from recommendations in an earlier report prepared for GDC titled *Implications of the Proposed National Environmental Standard on Ecological Flows and Water Levels* (Norton 2009).

2. Waipaoa River

Two flow records were reviewed for the Waipaoa River, one from the NIWA recorder site at Kanakanaia Bridge and one from the GDC recorder site at Kanakanaia Bridge. Graphical presentations for the two Waipaoa records are provided in Appendix 1. Figures 1 and 2 show the flow record and rating curves (respectively) for the NIWA site. Figures 3 and 4 show the flow record and rating curves (respectively) for the GDC site. Figure 5 shows a comparison between the two stage records.

2.1. Comments on the records

Overall, the entire reach of river represented by the recorder sites at Kanakanaia Bridge appears to have a very mobile and a generally aggrading bed. This has caused stage bed rise over time (decades) and periodic problems with silting of instruments making this a difficult site to measure stage. Standard stilling wells cannot be used due to siltation, transducers can often be buried. For this reason NIWA have opted for a radar unit (in March 2000) and more recently a gas bubbler system to try and improve recording resolution.

There have been some periods of bed degradation, specifically the 1 – 2 years following Cyclone Bola effects in 1988.

The riverbed appears to be more mobile through the cableway section, and this partly influenced NIWA's decision to move the recorder to the upstream bridge location in 1994.

Since 1993 the NIWA Rotorua team has been responsible for the NIWA sites on the Waipaoa. Servicing the sites from Rotorua has involved gauging the river flow on a monthly basis and so low flows have only been gauged when they coincided with a routine site visit.

The NIWA record (1967 to present) has suffered at times from occasional instrument drift, faults and physical blockages. Periods of poor stage data or gaps have already been replaced by the NIWA (Rotorua) team with (NIWA) back-up data or data from the GDC recorder. For example GDC stage data were used for the period February 1998 – March 2000 (see Figure 6).

The GDC record has more high stage flood gaugings than have been achieved with the NIWA record. This was especially of significance during the Cyclone Bola event (1988). However for the current work it is the low flows that are of interest rather than flood flows.

For the early part of the flow record (1980 – 1981), the summer period low flow record compares poorly between the two recorders. From 1982 onward, the summer period low flow comparisons between the two records improve.

Generally, with summer flows less than $10m^3/s$ the NIWA data has the lower flow record, until the 2008/2009 summer period when the GDC flow record is generally the lower. The last GDC rating was applied in December 2007.

GDC flow data generally does not deviate by more than 10% – 20% from the NIWA record in the low flow range (less than $10m^3/s$). The GDC gauging visits have been more regularly targeted to low flows but the GDC gauging data generally conforms better to the NIWA flow record than the GDC rated data (Figures 7 to 9). The accuracy of GDC flow data at low flows appears to suffer from poorly applied rating curves (see Figures 7 to 9).

In summary, from 'eye-balling' these data records the NIWA flow record generally appears more reliable at low flows, due to the presence of both NIWA and GDC gauging data to confirm ratings at low flows. Note that this is not intended as a criticism of the GDC record. The GDC record is valuable for other parts of the flow

range than the very low end of the range. For this particular project there is a need to decide which record to choose to calculate low flows (i.e., MALF). However flood flow records are also very important for GDC at this site and the GDC record is undoubtedly useful for this purpose.

2.2. MALF calculation

We have calculated MALF using both the GDC and NIWA flow records for the period from 1982 onwards (i.e., the period of most reliable record and closest agreement between the two records as identified above) but excluding years with only partial data. See Appendix 3 for minimum seven day moving averages over the period of record.

Calculated MALF for the Waipaoa @ Kanakanaia (NIWA) is 2,008 L/s (2.008 m^3/s).

Calculated MALF for the Waipaoa @ Kanakanaia (GDC) is 4,226 L/s (4.226 m^3/s).

These figures compare to an estimated MALF of 2,600 L/s (2.6 m^3/s) provided by GDC for the earlier report (Norton 2009).

2.3. Recommended MALF for use as an interim minimum flow limit

Based on our review of the two datasets we recommend that the NIWA flow record is the more reliable for the purpose of estimating low flows and we therefore recommend that GDC consider using the estimate for Waipaoa MALF of (say rounded) 2,000 L/s (2.0 m^3/s) for application to the NES.

Therefore, under the terms of the proposed NES, the interim minimum flow for the Waipaoa River would be 1,600 L/s (1.6 m^3/s), this being 80% of MALF. This is slightly higher than the 1300 L/s (1.3 m^3/s) flow at which current abstraction consents may be subject to cease at the discretion of the District Conservator (see section 3.11 in Norton 2009 for explanation).

In addition we recommend that GDC continues to undertake targeted gauging at low flows so that rating curves (and particularly the lower end of the curves) can be updated in future. If the interim minimum flow comes under significant pressure in future (i.e., if there is regular risk of takes needing to cease) then there would be merit in periodically combining the NIWA and GDC gauging data to update rating curves. There would also be merit in closely examining the years in the record with only partial data (see Appendix 3) because some of these years may have sufficient data

over the summer low flow period to include in the MALF calculation. Doing all these things will provide the most reliable review of the MALF estimate in future.

Note that our recommendation to use the NIWA flow record here applies only to consideration of estimates for low flows - we make no recommendation in this report about the relative reliability of the two records for estimating high (flood) flows.

3. Te Arai River

There is a single flow record available from the GDC recorder site at Pykes Weir. Graphical presentations for this record are provided in Appendix 2.

3.1. Comments on the record

The original GDC flow record was based on a rating curve that was not particularly supported by gauging evidence and may have been based on a weir rating assumption for convenience reasons. For this project we are concerned with accurate estimates of very low flows and we therefore created a new rating curve based on the gauging data supplied by GDC. Figures 10 to 13 show a comparison between the old and new rating curves (Figure 10 shows the full range of flows while Figures 11, 12 and 13 zoom in to allow a more detailed view of the curve at low flows).

We applied the new rating curve to produce a more accurate flow record. The new rating curve gives better flow approximation up until the end of summer low flows in August 2008. There is a gap in the data record from August 2008 to December 2008. After this period the gaugings tend to plot lower than the flow record – which suggests the rating may have changed. We have not investigated what caused the gap period from August to December 2008 but it is possible a flood in that period affected the rating.

There is some variability in low flow gauging results that can be seen in Figure 13. We also observed this variability in bed plots for the Te Arai record (data not shown). This raises a question about the accuracy of gaugings and the rating at low flow. It is difficult to make further comment about the accuracy of this record due to the lack of gauging cards and data comments.

In summary, the flow record derived with the new rating curve is more reliable than the old record but there is still some question about accuracy at low flows.

3.2. MALF calculation

We have calculated MALF using the GDC flow record derived from the new rating curve for the period from 1982 onwards ignoring gaps (i.e., the period of most reliable available record). See Appendix 3 for minimum seven day moving averages over the period of record.

The calculated MALF for the Te Arai @ Pykes Weir (GDC) is 68 L/s (0.068 m^3/s).

3.3. Recommended MALF for use as an interim minimum flow limit

Under the terms of the proposed NES, the interim minimum flow for the Te Arai River would be 61 L/s (0.061 m^3/s), this being 90% of MALF (as the Te Arai has a mean flow of around 2m^3/s). This could be rounded to 60 L/s.

In addition, because there is still some question about accuracy of the Te Arai record at low flows, we recommend that GDC continues to undertake targeted gauging at low flows so that rating curves (and particularly the lower end of the curves) can be updated in future. If the interim minimum flow comes under significant pressure in future (i.e., if there is regular risk of takes needing to cease) then there would be merit in undertaking increased effort to update rating curves at low flows. This would provide the most reliable measure of low flows in the Te Arai.

4. References

MfE (2008). Proposed National Environmental Standard on Ecological Flows and Water Levels. Ministry for the Environment Publication Number ME868, Wellington. 61 p.

Norton, N. (2009). Implications of the Proposed National Environmental Standard on Ecological Flows and Water Levels for the Gisborne District. NIWA Client Report: CHC2009-120, prepared for Gisborne District Council, July 2009.

Appendix 1:

Graphical presentations of flow record from Waipaoa @ Kanakanaia Bridge (comparison of NIWA and GDC records)

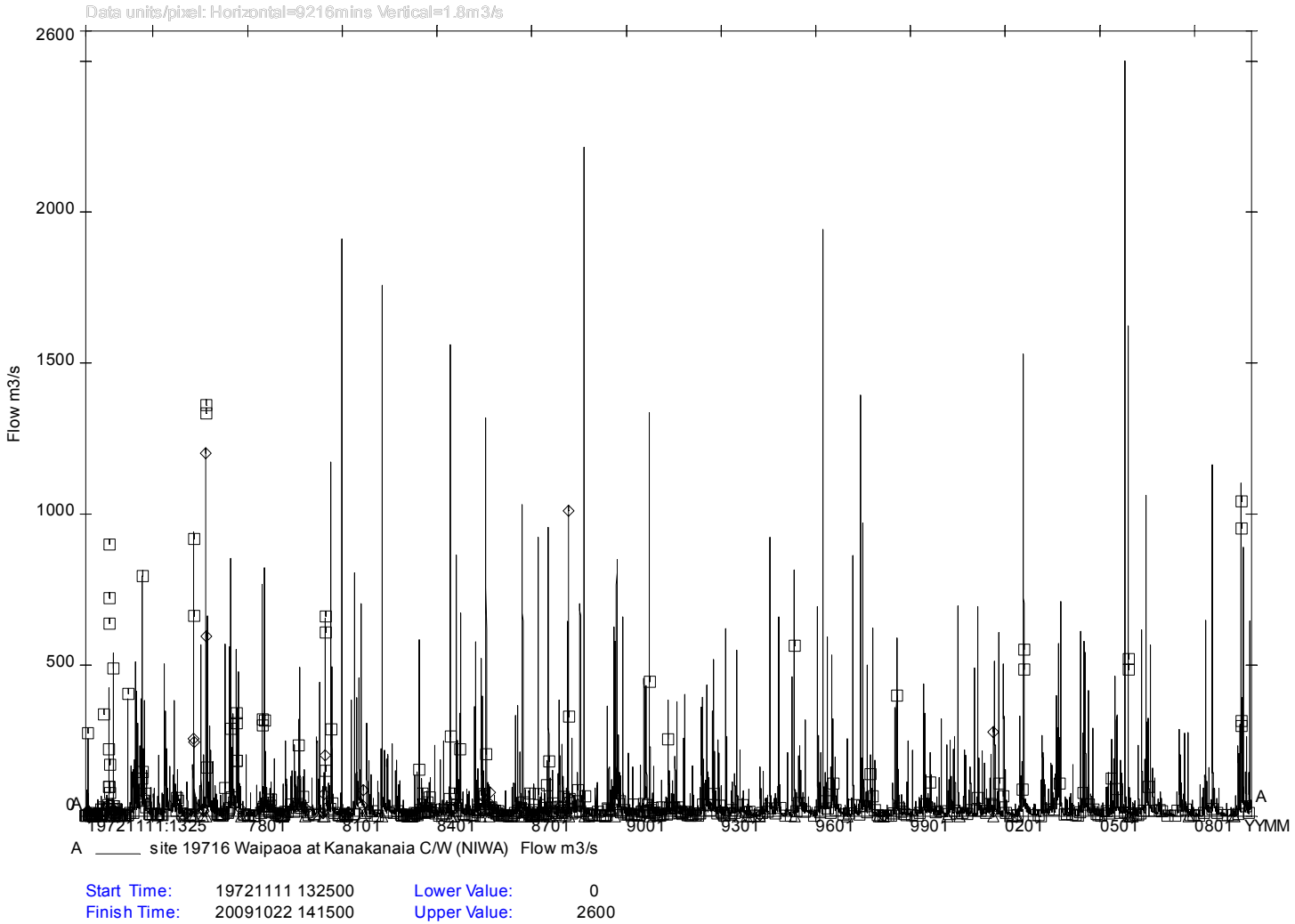

Figure 1. Flow record for the Waipaoa at Kanakanaia (NIWA record) – 1972 to 2009

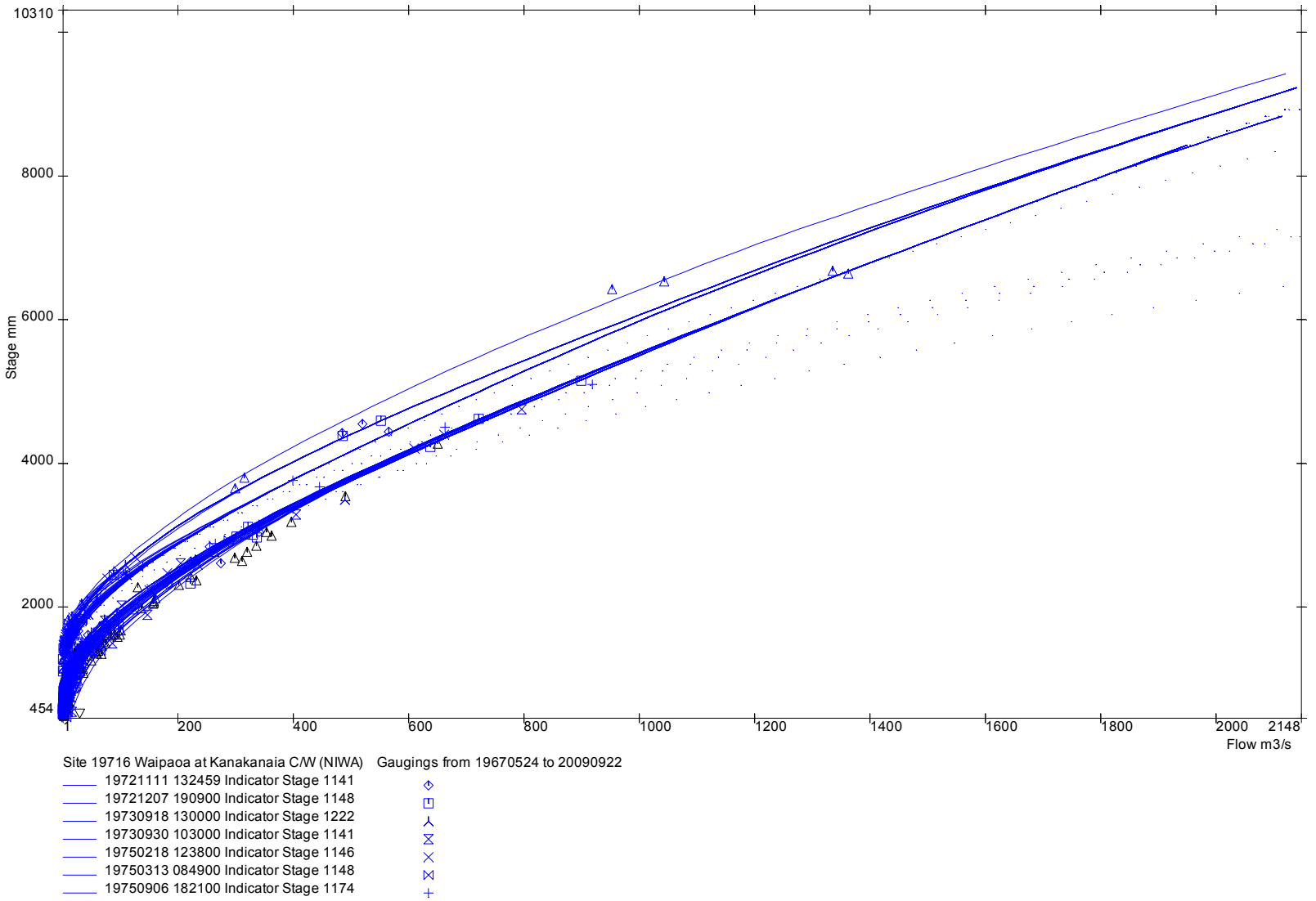

Figure 2: Rating curves and gaugings for the Waipaoa at Kanakanaia (NIWA record)

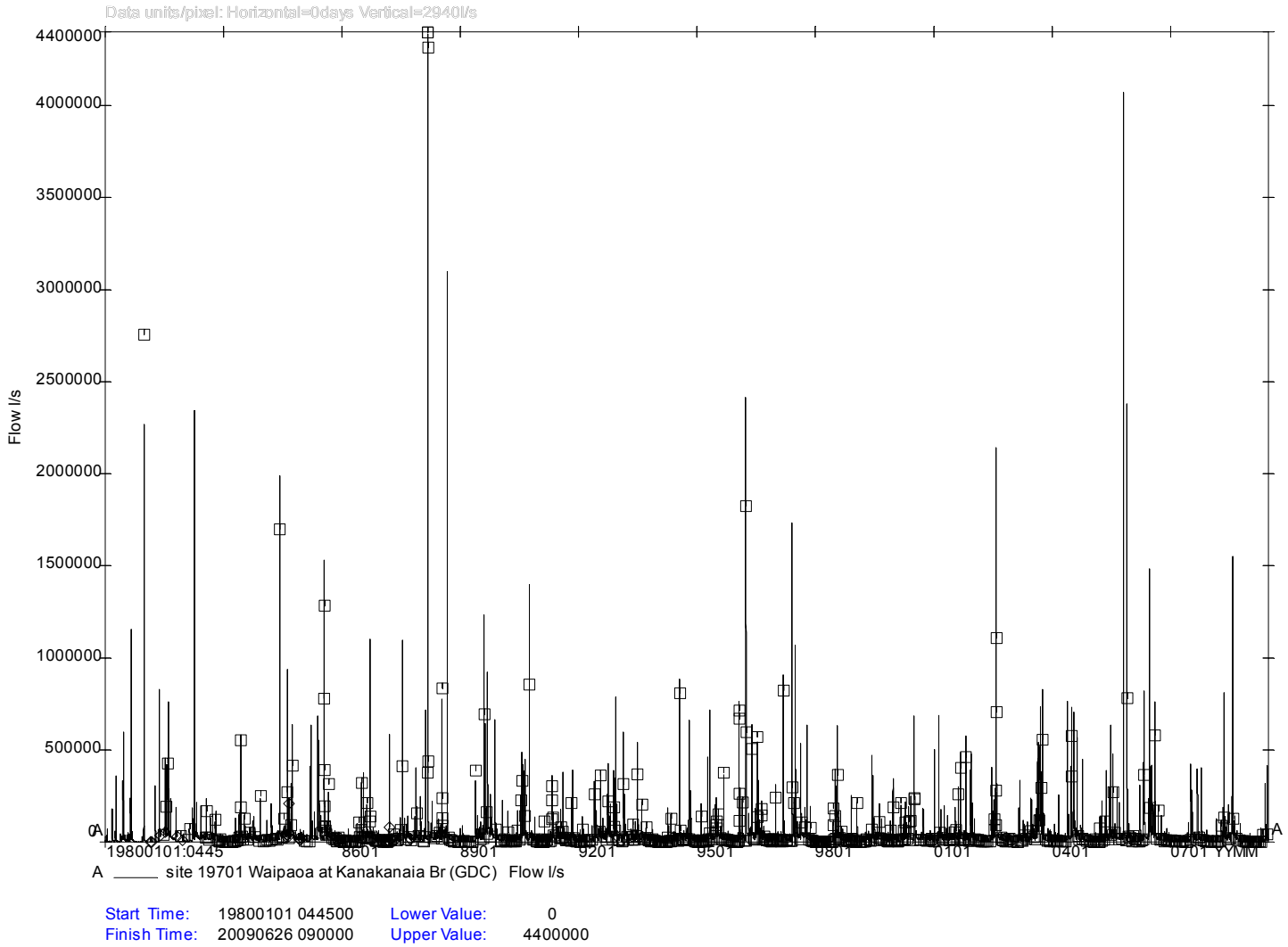

Figure 3: Flow record for the Waipaoa at Kanakanaia (GDC record) – 1980 to 2009.

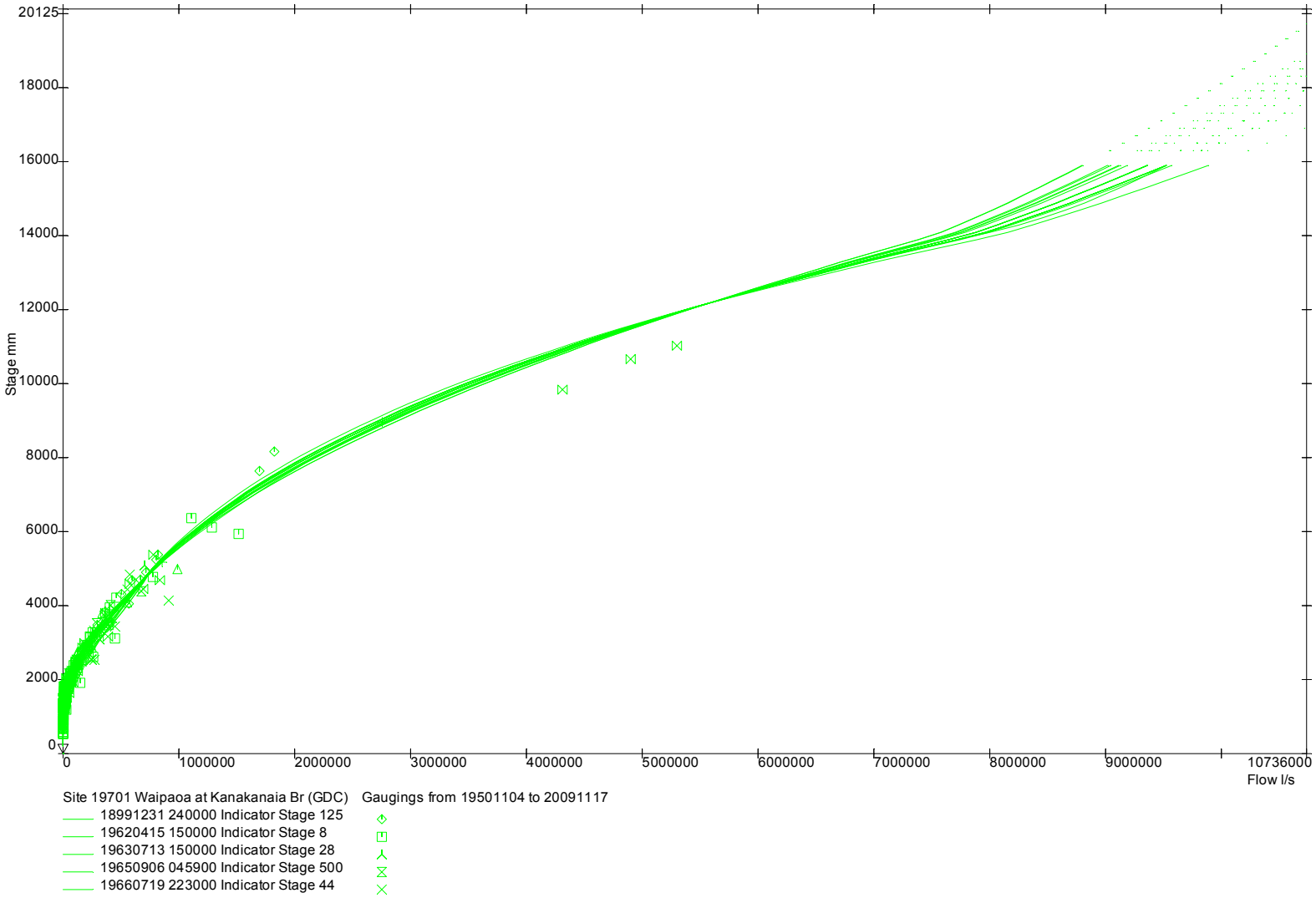

Figure 4: Rating curves and gaugings for the Waipaoa at Kanakanaia (GDC record)

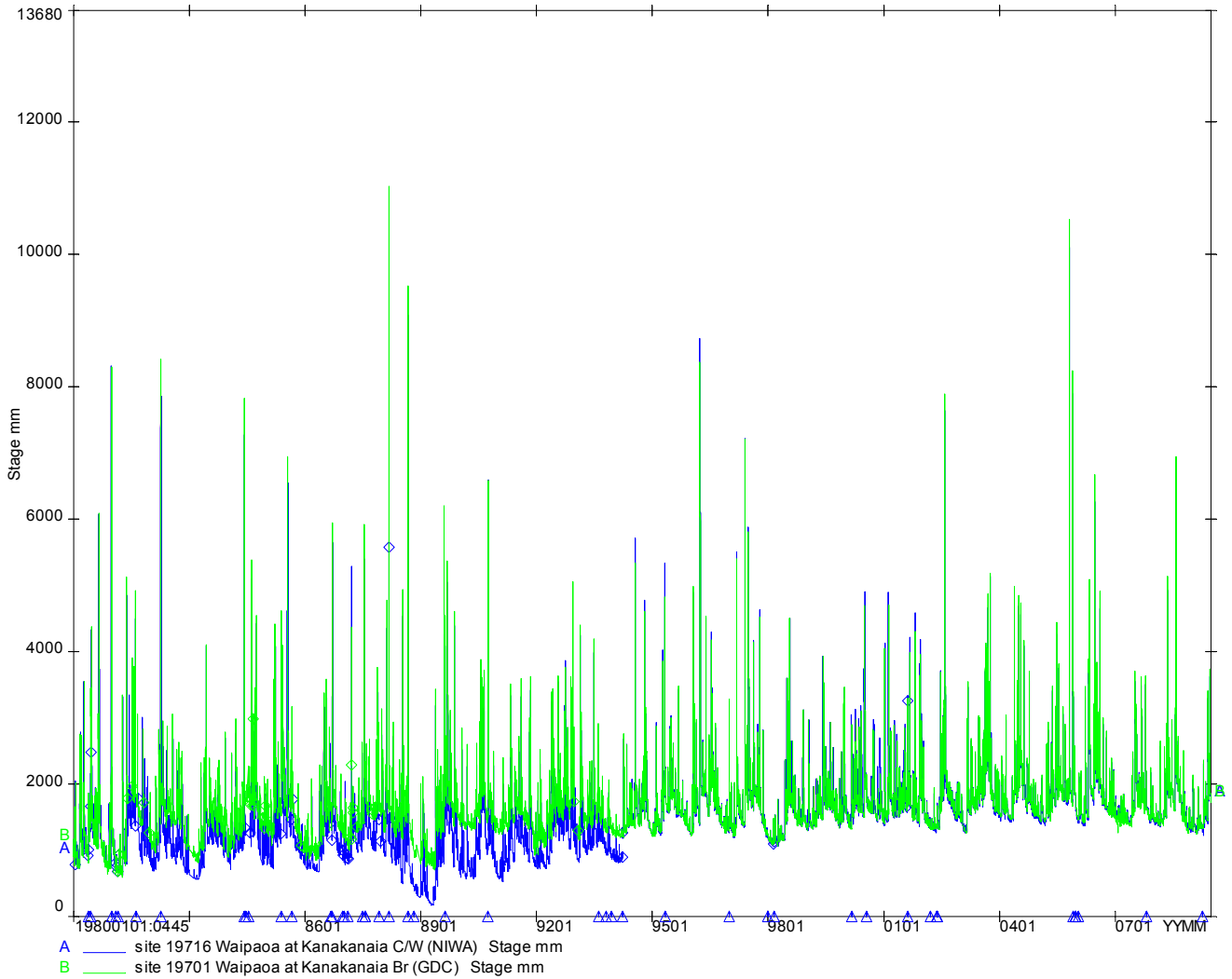

Figure 5: Comparison of NIWA stage record (blue) and GDC stage record (green) for the Waipaoa at Kanakanaia (1980 - 2009)

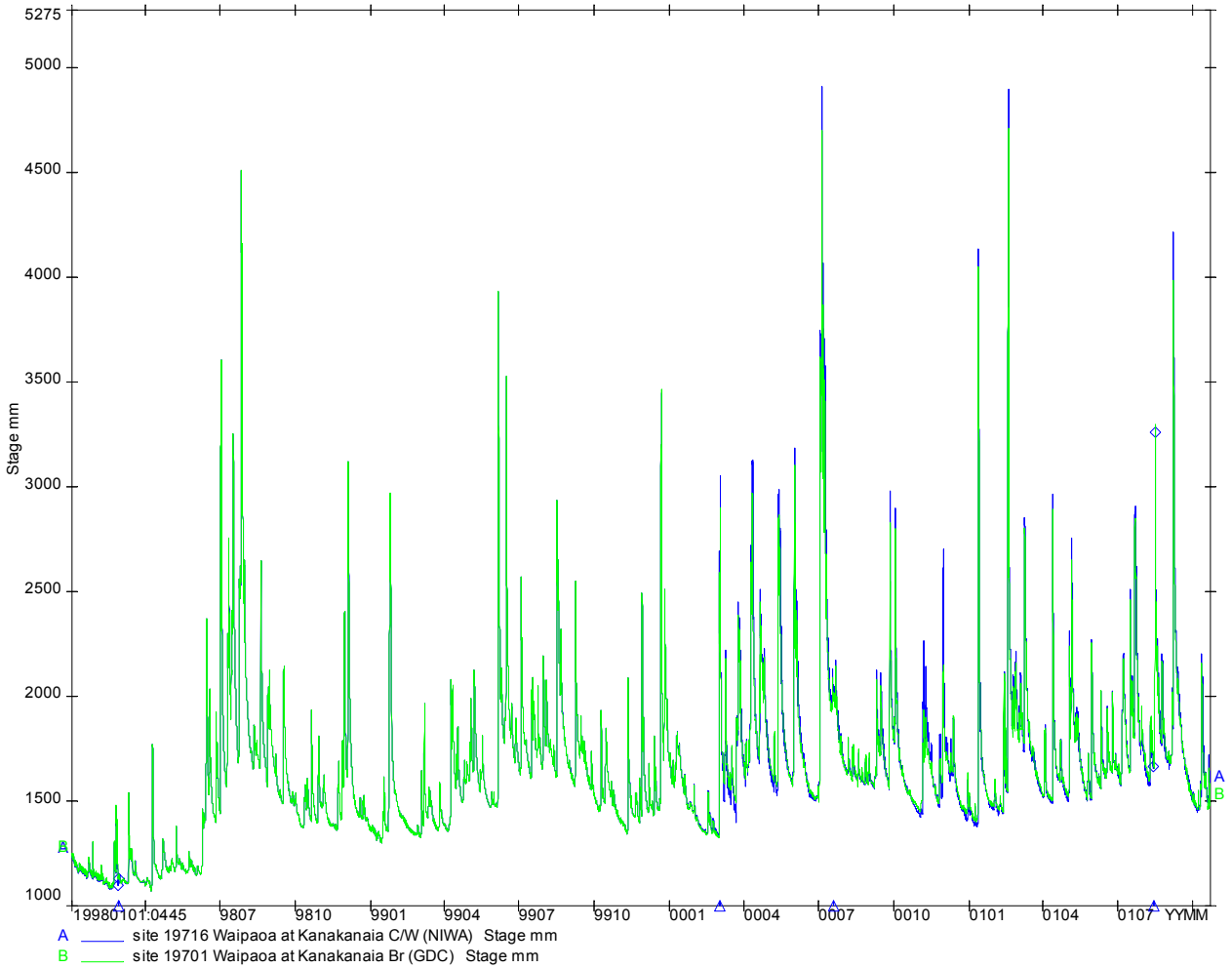

Figure 6: Comparison of NIWA stage record (blue) and GDC flow record (green) for the Waipaoa at Kanakanaia – showing missing NIWA data from February 1998 – March 2000

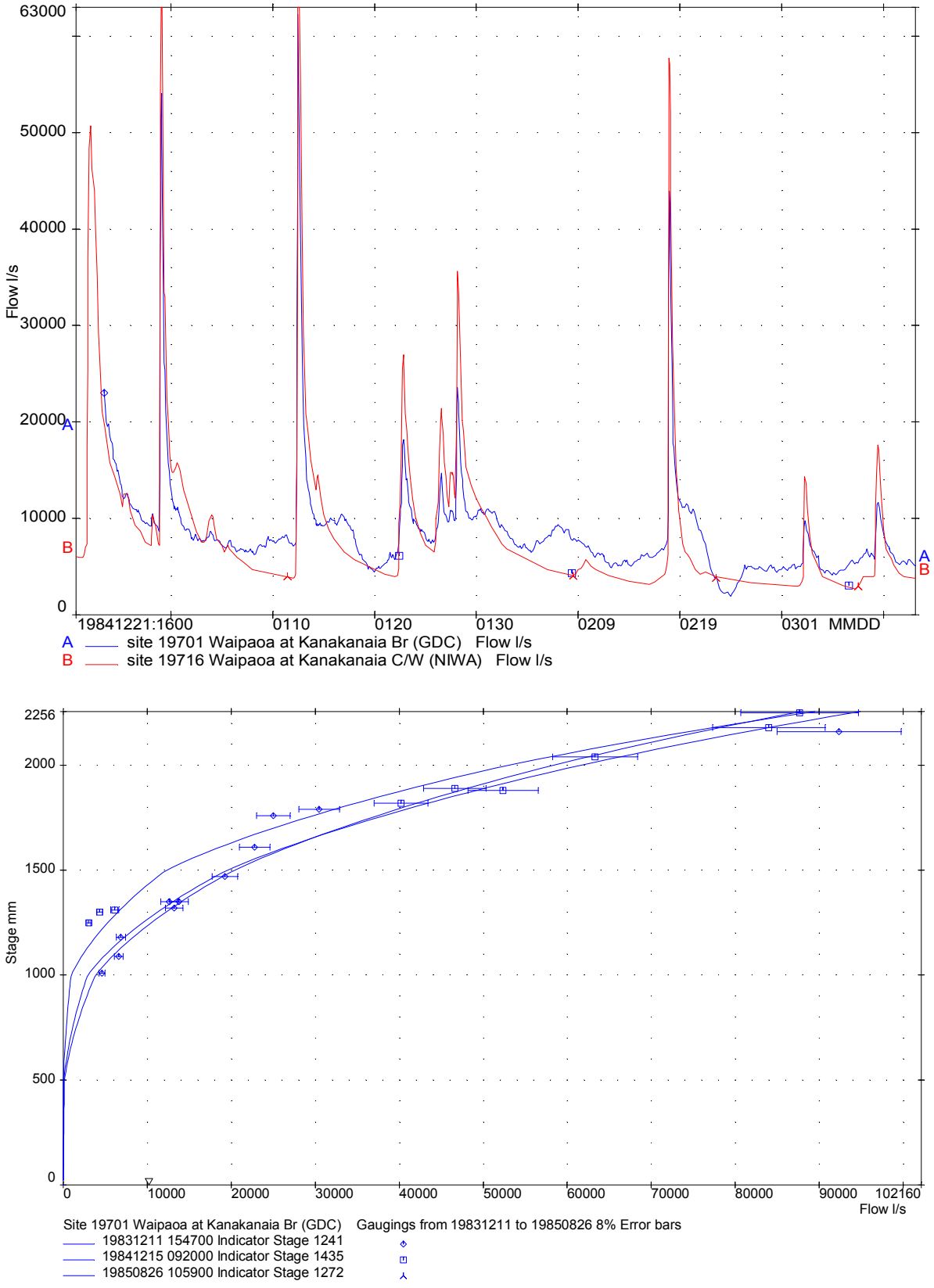

Figure 7: Comparison of NIWA flow record (red) and GDC flow record (blue) for the Waipaoa at Kanakanaia during summer 1984/85 (top plot). GDC rating curves are shown in the bottom plot and GDC gaugings are shown (small blue squares) in the top plot. Generally the GDC gaugings better fit the NIWA (red) record in the top plot.

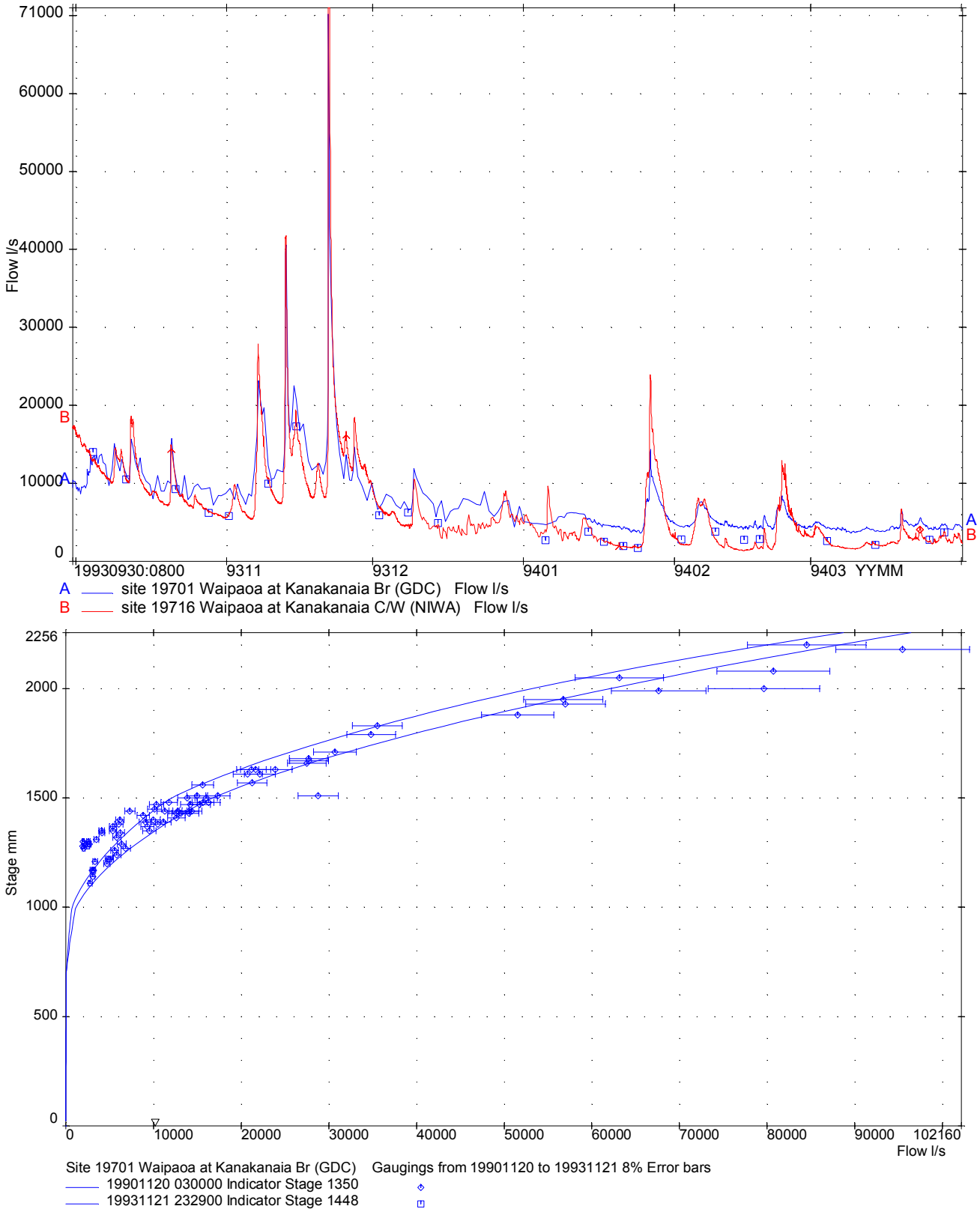

Figure 8: Comparison of NIWA flow record (red) and GDC flow record (blue) for the Waipaoa at Kanakanaia during 1993/94 (top plot). GDC rating curves are shown in the bottom plot and GDC gaugings are shown (small blue squares) in the top plot. Generally the GDC gaugings better fit the NIWA (red) record in the top plot.

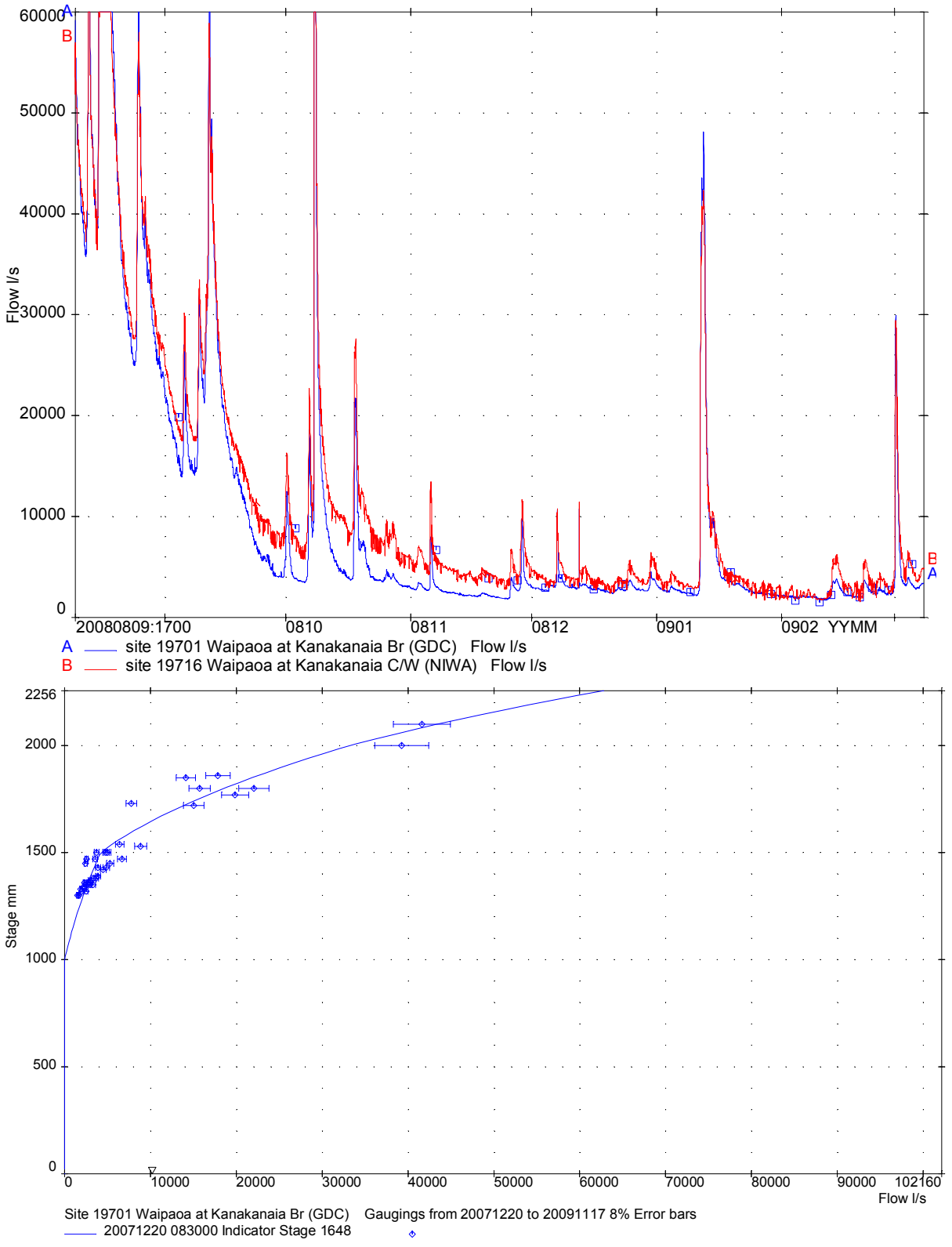

Figure 9: **Comparison of NIWA flow record (red) and GDC flow record (blue) for the Waipaoa at Kanakanaia during summer 2008/09 (top plot). GDC rating curves are shown in the bottom plot and GDC gaugings are shown (small blue squares) in the top plot. Generally the GDC gaugings better fit the NIWA (red) record in the top plot.**

Appendix 2:

Graphical presentations of flow record from Te Arai @ Pykes Weir (GDC)

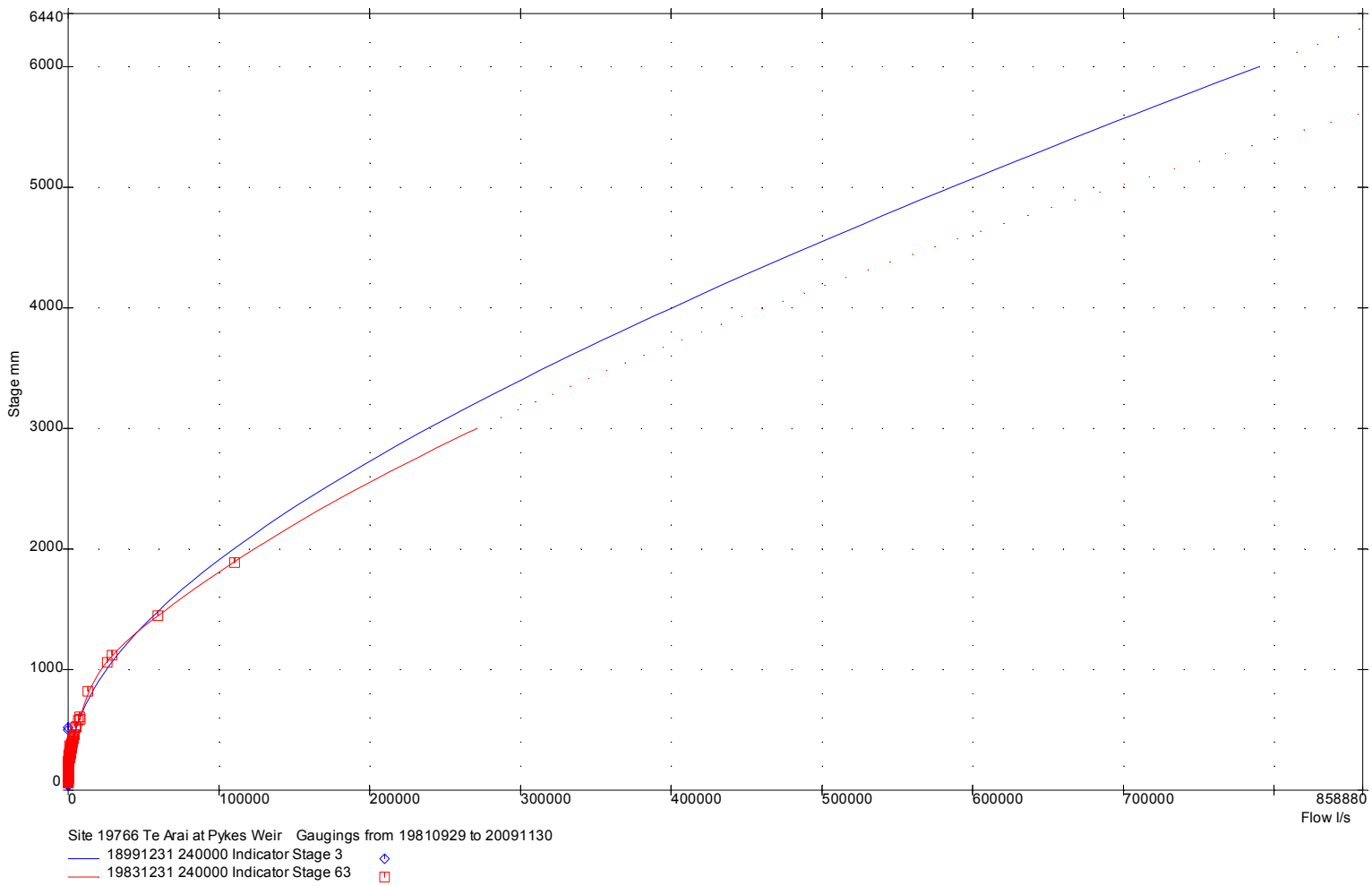

Figure 10: Comparison of old (blue) and new (red) rating curves for the Te Arai at Pykes Weir. Gaugings are shown as small squares. The old (blue) rating curve is presumed derived from a theoretical weir rating. The new curve was derived to fit the gauging data. See Figures 11 to 13 for 'zoomed in' plots showing curves at lower stage levels.

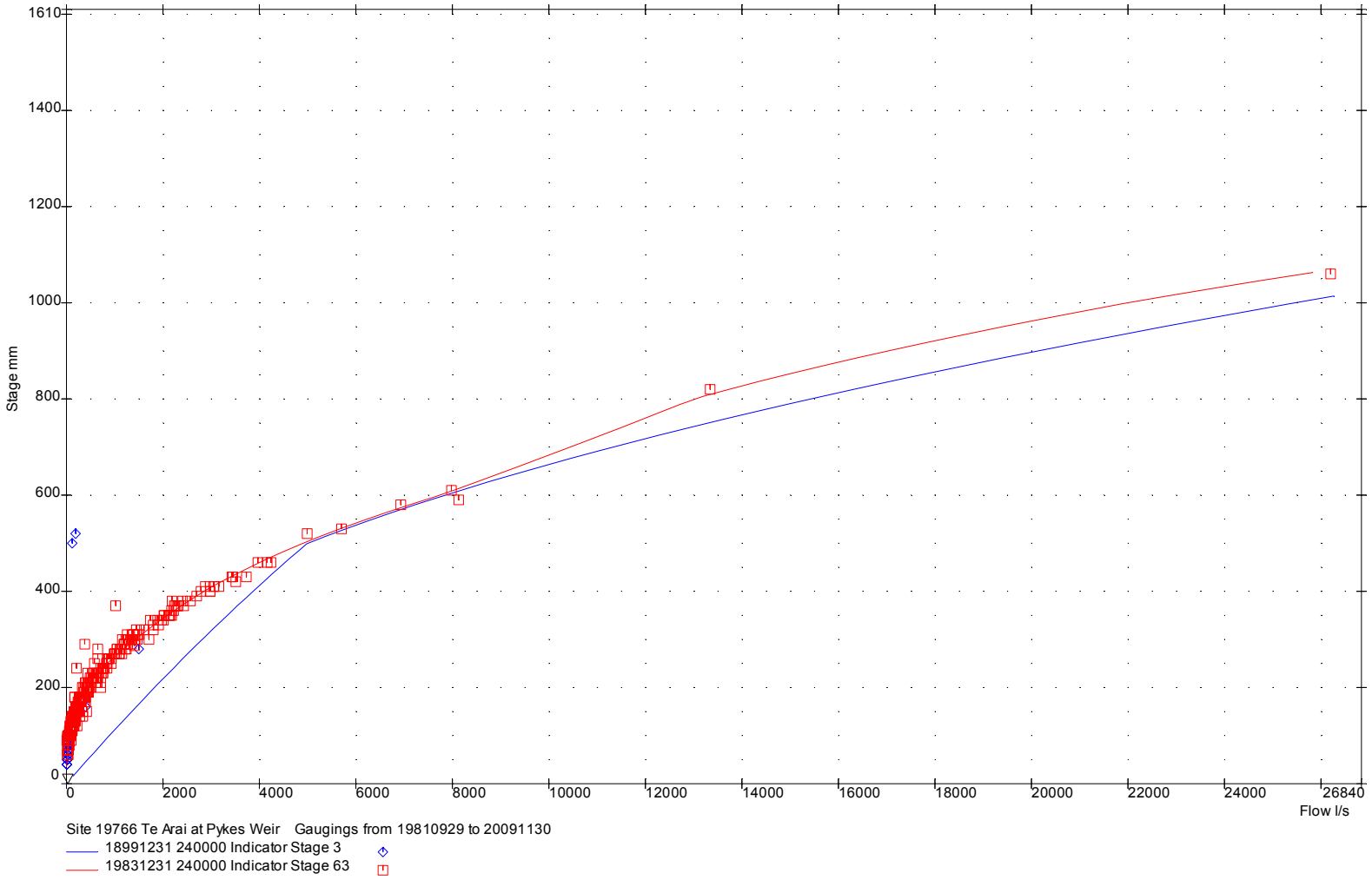

Figure 11: Comparison of old (blue) and new (red) rating curves for the Te Arai at Pykes Weir. Gaugings are shown as small squares. The old (blue) rating curve is presumed derived from a theoretical weir rating. The new curve was derived to fit the gauging data. See Figures 12 to 13 for 'zoomed in' plots showing curves at lower stage levels.

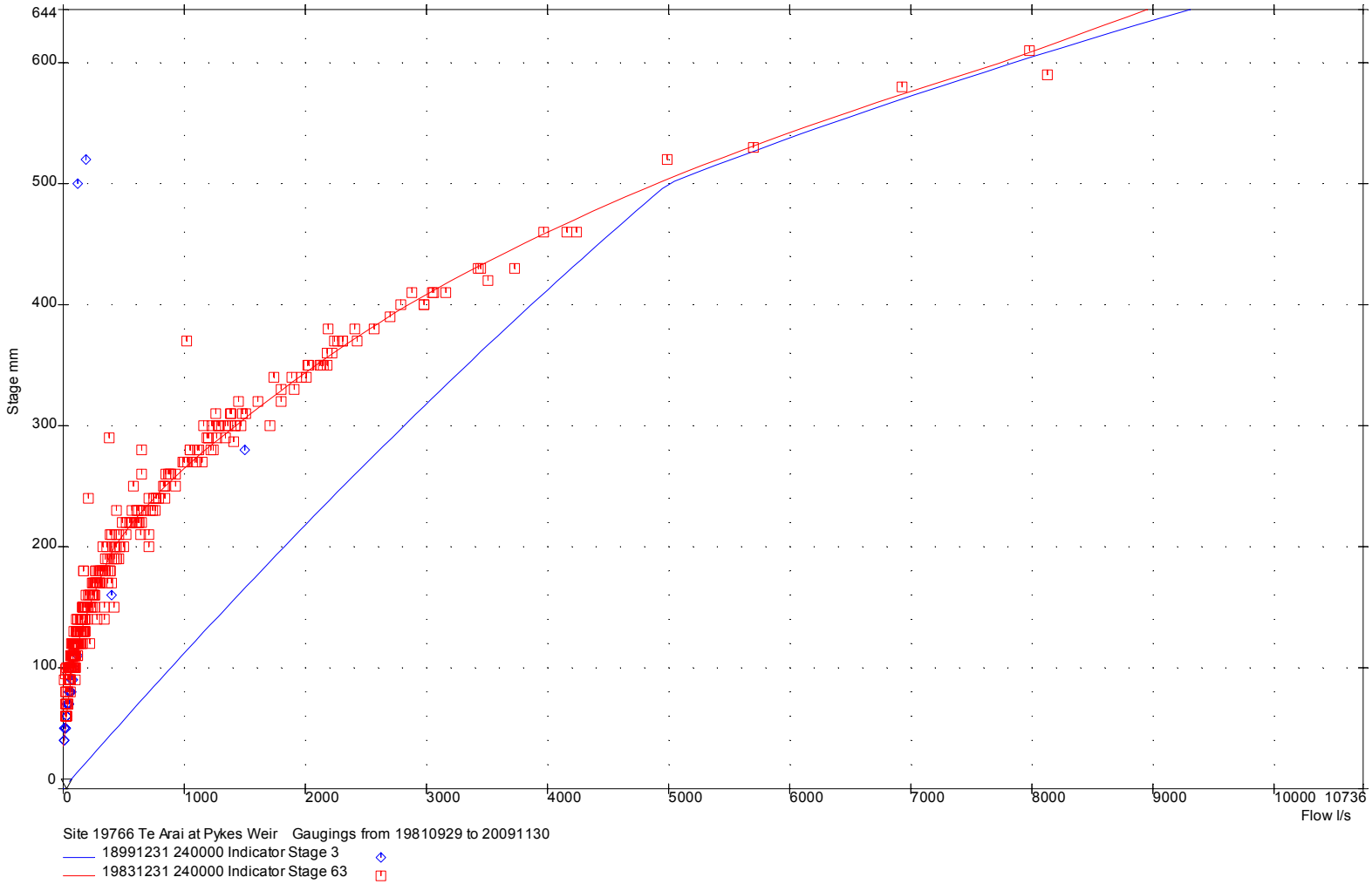

Figure 12: Comparison of old (blue) and new (red) rating curves for the Te Arai at Pykes Weir. Gaugings are shown as small squares. The old (blue) rating curve is presumed derived from a theoretical weir rating. The new curve was derived to fit the gauging data. See Figure 13 for 'zoomed in' plot showing curves at lower stage levels.

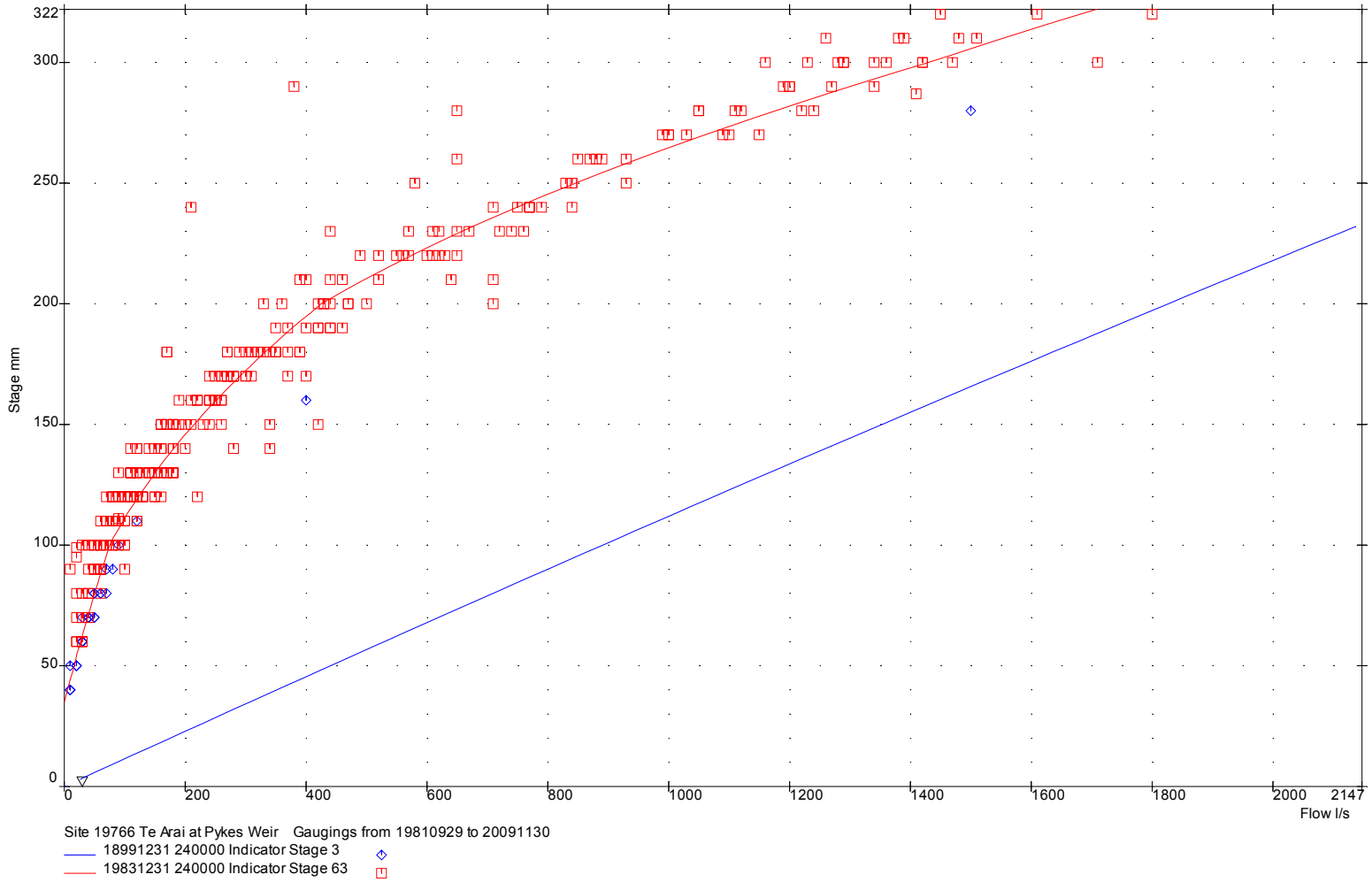

Figure 13: Comparison of old (blue) and new (red) rating curves for the Te Arai at Pykes Weir. Gaugings are shown as small squares. The old (blue) rating curve is presumed derived from a theoretical weir rating. The new curve was derived to fit the gauging data.

Appendix 3:

Calculations of the seven day mean annual low flow (MALF)

Site 19701 Waipaoa at Kanakanaia Br (GDC)
From 1-Jul-1982 00:00:00 to 26-Jun-2009 09:00:00

Minimum moving averages over 7.000days interval

Year Ending	Minimum Value (Flow l/s)
30-Jun-1983 24:00:00	1182 at interval beginning 28-Mar-1983 04:37:00
30-Jun-1984 24:00:00	4170 at interval beginning 31-Dec-1983 05:10:00
Gap from 6-Aug-1984 01:59:00 to 13-Aug-1984 21:14:00 of	7.80 Days
Gap from 27-Aug-1984 09:00:00 to 31-Aug-1984 15:20:00 of	4.26 Days
Gap from 26-Nov-1984 09:35:00 to 24-Dec-1984 10:51:00 of	28.05 Days
30-Jun-1985 24:00:00(PARTIAL)	4022 at interval beginning 21-Feb-1985 23:40:00
Gap from 2-Dec-1985 01:55:00 to 24-Dec-1985 00:13:00 of	21.93 Days
30-Jun-1986 24:00:00(PARTIAL)	2099 at interval beginning 6-May-1986 03:22:00
Gap from 9-Mar-1987 05:19:00 to 16-Mar-1987 13:40:00 of	7.35 Days
Gap from 24-Mar-1987 07:44:00 to 5-May-1987 15:15:00 of	42.31 Days
30-Jun-1987 24:00:00(PARTIAL)	2094 at interval beginning 22-Feb-1987 21:33:00
Gap from 21-Sep-1987 05:45:00 to 28-Sep-1987 11:11:00 of	7.23 Days
30-Jun-1988 24:00:00(PARTIAL)	5013 at interval beginning 20-Jan-1988 10:49:00
30-Jun-1989 24:00:00	4063 at interval beginning 25-Dec-1988 11:43:00
30-Jun-1990 24:00:00	7896 at interval beginning 3-Mar-1990 00:07:00
30-Jun-1991 24:00:00	7591 at interval beginning 7-Jan-1991 15:32:00
30-Jun-1992 24:00:00	1122 at interval beginning 18-Dec-1991 18:14:00
Gap from 22-Dec-1992 00:00:00 to 27-Jan-1993 22:42:00 of	36.95 Days
30-Jun-1993 24:00:00(PARTIAL)	5022 at interval beginning 3-Feb-1993 10:18:00
30-Jun-1994 24:00:00	3956 at interval beginning 8-Mar-1994 08:00:00
30-Jun-1995 24:00:00	4223 at interval beginning 3-Jan-1995 19:00:00
30-Jun-1996 24:00:00	4828 at interval beginning 5-Jan-1996 12:00:00
30-Jun-1997 24:00:00	4540 at interval beginning 11-Feb-1997 15:00:00
30-Jun-1998 24:00:00	1876 at interval beginning 14-Feb-1998 19:00:00
30-Jun-1999 24:00:00	5242 at interval beginning 8-Jan-1999 18:00:00
30-Jun-2000 24:00:00	5650 at interval beginning 24-Feb-2000 08:01:00
30-Jun-2001 24:00:00	7290 at interval beginning 4-Jan-2001 20:00:00
30-Jun-2002 24:00:00	5315 at interval beginning 20-Mar-2002 14:01:00
30-Jun-2003 24:00:00	2028 at interval beginning 17-Feb-2003 20:00:00
30-Jun-2004 24:00:00	3172 at interval beginning 21-Apr-2004 22:00:00
30-Jun-2005 24:00:00	2918 at interval beginning 5-Mar-2005 02:30:00
30-Jun-2006 24:00:00	5204 at interval beginning 15-Mar-2006 23:30:00
30-Jun-2007 24:00:00	3264 at interval beginning 27-May-2007 03:00:00
30-Jun-2008 24:00:00	3211 at interval beginning 21-Feb-2008 19:30:00
26-Jun-2009 09:00:00(PARTIAL)	1969 at interval beginning 6-Feb-2009 05:30:00

Mean annual Minimum = 4226
(For complete years only)

Site 19716 Waipaoa at Kanakanaia C/W (NIWA)

From 1-Jul-1982 00:00:00 to 22-Oct-2009 14:15:00

Minimum moving averages over 7.000days interval

Year Ending	Minimum Value (Flow l/s)
30-Jun-1983 24:00:00	941 at interval beginning 5-Mar-1983 24:00:00
Gap from 22-Jun-1984 09:52:00 to 30-Jul-1984 14:30:00 of	38.19 Days
30-Jun-1984 24:00:00(PARTIAL)	3793 at interval beginning 24-Jan-1984 03:56:54
Gap from 20-May-1985 12:30:00 to 28-May-1985 13:48:00 of	8.05 Days
30-Jun-1985 24:00:00(PARTIAL)	3260 at interval beginning 23-Feb-1985 24:00:00
Gap from 27-Aug-1985 16:02:00 to 6-Sep-1985 14:45:00 of	9.95 Days
30-Jun-1986 24:00:00(PARTIAL)	1599 at interval beginning 6-May-1986 24:00:00
Gap from 1-Sep-1986 07:57:00 to 15-Sep-1986 09:10:00 of	14.05 Days
Gap from 23-Dec-1986 07:15:00 to 29-Dec-1986 17:35:00 of	6.43 Days
Gap from 9-Feb-1987 10:22:00 to 16-Feb-1987 14:41:00 of	7.18 Days
30-Jun-1987 24:00:00(PARTIAL)	2606 at interval beginning 22-Feb-1987 06:00:00
Gap from 30-Nov-1987 13:40:00 to 15-Dec-1987 09:35:00 of	14.83 Days
Gap from 7-Mar-1988 17:00:00 to 16-Mar-1988 14:12:00 of	8.88 Days
30-Jun-1988 24:00:00(PARTIAL)	4256 at interval beginning 29-Jan-1988 12:00:00
30-Jun-1989 24:00:00	1620 at interval beginning 10-Apr-1989 24:00:00
30-Jun-1990 24:00:00	3234 at interval beginning 13-May-1990 18:00:00
30-Jun-1991 24:00:00	1496 at interval beginning 10-Feb-1991 23:00:00
30-Jun-1992 24:00:00	2793 at interval beginning 27-Mar-1992 16:45:00
30-Jun-1993 24:00:00	3732 at interval beginning 4-Feb-1993 12:00:00
30-Jun-1994 24:00:00	1655 at interval beginning 12-Feb-1994 07:45:00
30-Jun-1995 24:00:00	2005 at interval beginning 3-Jan-1995 17:00:00
30-Jun-1996 24:00:00	1670 at interval beginning 4-Jan-1996 14:30:00
30-Jun-1997 24:00:00	1712 at interval beginning 12-Feb-1997 01:45:00
30-Jun-1998 24:00:00	830 at interval beginning 14-Feb-1998 19:00:00
30-Jun-1999 24:00:00	2094 at interval beginning 8-Jan-1999 18:01:00
30-Jun-2000 24:00:00	2047 at interval beginning 24-Feb-2000 08:00:00
30-Jun-2001 24:00:00	1375 at interval beginning 4-Jan-2001 20:00:00
Gap from 14-Aug-2001 15:45:00 to 16-Aug-2001 14:30:00 of	1.95 Days
30-Jun-2002 24:00:00(PARTIAL)	2436 at interval beginning 8-May-2002 16:15:00
30-Jun-2003 24:00:00	1792 at interval beginning 18-Feb-2003 05:30:00
30-Jun-2004 24:00:00	2430 at interval beginning 16-Apr-2004 16:15:00
30-Jun-2005 24:00:00	1629 at interval beginning 5-Mar-2005 14:45:00
30-Jun-2006 24:00:00	3738 at interval beginning 12-Jan-2006 14:30:00
30-Jun-2007 24:00:00	2059 at interval beginning 27-May-2007 05:30:00
30-Jun-2008 24:00:00	1486 at interval beginning 24-Feb-2008 16:45:00
30-Jun-2009 24:00:00	1837 at interval beginning 13-Apr-2009 13:15:00
22-Oct-2009 14:15:00(PARTIAL)	13167 at interval beginning 17-Sep-2009 12:15:00

Mean annual Minimum = 2008
(For complete years only)

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Site 19766 Te Arai at Pykes Weir
From  1-Jul-1982 00:00:00 to  6-Nov-2009 09:00:00
Data starts at 31-Dec-1983 24:00:00

Minimum moving averages over      7.000days interval

    Year Ending           Minimum Value (Flow l/s)
30-Jun-1983 24:00:00          No valid values for this year
30-Jun-1984 24:00:00(PARTIAL)         99 at interval beginning 22-Jan-1984 07:30:00
30-Jun-1985 24:00:00                  37 at interval beginning  4-Feb-1985 15:12:00
30-Jun-1986 24:00:00                  29 at interval beginning 15-Jan-1986 16:25:00
 Gap from 22-Dec-1986 08:00:00 to 27-Jan-1987 09:02:00 of   36.04 Days
30-Jun-1987 24:00:00(PARTIAL)         47 at interval beginning 27-Jan-1987 09:02:00
 Gap from  4-Apr-1988 07:40:00 to 18-Apr-1988 14:33:00 of   14.29 Days
30-Jun-1988 24:00:00(PARTIAL)         49 at interval beginning 20-Jan-1988 10:10:00
 Gap from 26-Jun-1989 09:32:00 to 30-Jun-1989 11:35:00 of    4.09 Days
30-Jun-1989 24:00:00(PARTIAL)         35 at interval beginning 24-Dec-1988 08:37:00
 Gap from 31-Dec-1989 23:02:00 to  1-Jan-1990 03:58:00 of    4.93 Hours
30-Jun-1990 24:00:00(PARTIAL)         83 at interval beginning  1-Mar-1990 20:41:00
30-Jun-1991 24:00:00                  40 at interval beginning  6-Feb-1991 16:28:00
30-Jun-1992 24:00:00                  75 at interval beginning 21-Mar-1992 14:00:00
 Gap from 26-Oct-1992 22:01:00 to  2-Nov-1992 14:00:00 of    6.67 Days
 Gap from 21-Dec-1992 18:00:00 to  5-Jan-1993 08:10:00 of   14.59 Days
30-Jun-1993 24:00:00(PARTIAL)        141 at interval beginning  3-Feb-1993 21:10:00
30-Jun-1994 24:00:00                  87 at interval beginning  3-Mar-1994 07:17:00
30-Jun-1995 24:00:00                  65 at interval beginning 13-Jan-1995 11:01:00
30-Jun-1996 24:00:00                  40 at interval beginning 19-Jan-1996 01:13:00
30-Jun-1997 24:00:00                  88 at interval beginning 29-Nov-1996 16:00:00
30-Jun-1998 24:00:00                  32 at interval beginning 15-Feb-1998 18:00:00
30-Jun-1999 24:00:00                  78 at interval beginning  6-Jan-1999 10:00:00
30-Jun-2000 24:00:00                 118 at interval beginning  9-Feb-2000 07:15:00
 Gap from  5-Jun-2001 10:00:00 to 20-Jun-2001 14:30:00 of   15.19 Days
30-Jun-2001 24:00:00(PARTIAL)        100 at interval beginning  1-Jan-2001 18:00:00
30-Jun-2002 24:00:00                  82 at interval beginning 26-May-2002 05:00:00
30-Jun-2003 24:00:00                  81 at interval beginning  2-Jan-2003 07:45:00
 Gap from 15-Aug-2003 15:00:00 to 26-Aug-2003 17:30:00 of   11.10 Days
30-Jun-2004 24:00:00(PARTIAL)        135 at interval beginning 20-Apr-2004 11:45:00
30-Jun-2005 24:00:00                  51 at interval beginning 13-Jan-2005 14:45:00
30-Jun-2006 24:00:00                 104 at interval beginning 16-Mar-2006 02:00:00
30-Jun-2007 24:00:00                  46 at interval beginning 27-May-2007 20:00:00
30-Jun-2008 24:00:00                  98 at interval beginning 25-Feb-2008 16:00:00
 Gap from 29-Aug-2008 15:00:00 to 22-Dec-2008 13:45:00 of  114.95 Days
30-Jun-2009 24:00:00(PARTIAL)         45 at interval beginning 28-Jan-2009 23:45:00
 6-Nov-2009 09:00:00(PARTIAL)        374 at interval beginning 17-Sep-2009 11:30:00

Mean annual Minimum =          68
(For complete years only)
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