



BUILDING A BETTER WORLD

REPORT

Priority Rivers – Flow Assessment, Sea Level Rise and Storm Surge

Prepared for Northland Regional Council

MARCH 2010

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1 Flow Assessment

1.1 Objective

Data from selected flow stations adjacent to the priority catchments were used to estimate flood peaks for the required design floods. Regional flood frequency methods were also used to determine design flood peaks.

1.2 Review and Assessment of Available Flow Data.

Flow data was provided by NRC and NIWA. Table 1 lists the data received. Figure 1 shows the locations of the flow stations.

Table 1: Priority 1 Catchment Flow Gauges

Site no.	*	River Name	Site Name	Easting	Northin g	Catchmen t Area km ²	Recordin g	Record Begins	Record Ends	Years Record
3707	4	Waiaruhe	Puketona	2598104	6654930	175	NRC	1-Feb-84	10-May-00	16
3710	4	Whangai	Wiroa R	2588686	6658302	2	NIWA	5-Oct-79	15-Aug-84	5
3722	4	Waitangi	Wakelins	2606139	6657724	302	NIWA	22-Feb-79		31
3806	6	Kawakawa	SHBr	2607202	6646627	315	NIWA	14-Dec-61	5-Apr-68	6
3819	6	Waiharakeke	Willowbank	2603396	6644629	229	NRC	2-Feb-67		43
3829	6	Tirohanga	D/S County	2610300	6646600	56	NRC	21-Mar-89	23-Dec-96	8
4901	17	Ngunguru	Dugmores Rock	2637800	6616400	13	NRC	22-Aug-69		40
5527	1	Waiarohia	Lovers Lane	2629802	6607579	19	NRC	17-Oct-79		30
5528	1	Raumanga	Bernard St	2629502	6606673	16	NRC	30-Oct-79		30
5901	2	Ruakaka	Flyger Rd	2637403	6591542	45	NRC	19-Mar-84		26
5538	5	Hatea	Whareora Rd	2631062	6610105	39	NRC	30-Jun-86	24-Mar-95	9
5539	1	Hatea	Town Basin **	2630700	6607600		NRC	7-Jan-86	10-May-94	8
47595	21	Punakitere	Taheke	2570700	6637300	284	NRC	16-Dec-94		15
47804	7	Waipapa	Forest Ranger	2573046	6658281	122	NIWA	17-Sep-75		34
48711	11	Rotokakahi	Kohe Rd	2539500	6654200	137	NRC	25-Jun-97	31 Jan-04	7

*NRC Priority Rivers Catchment Number

** Water level only

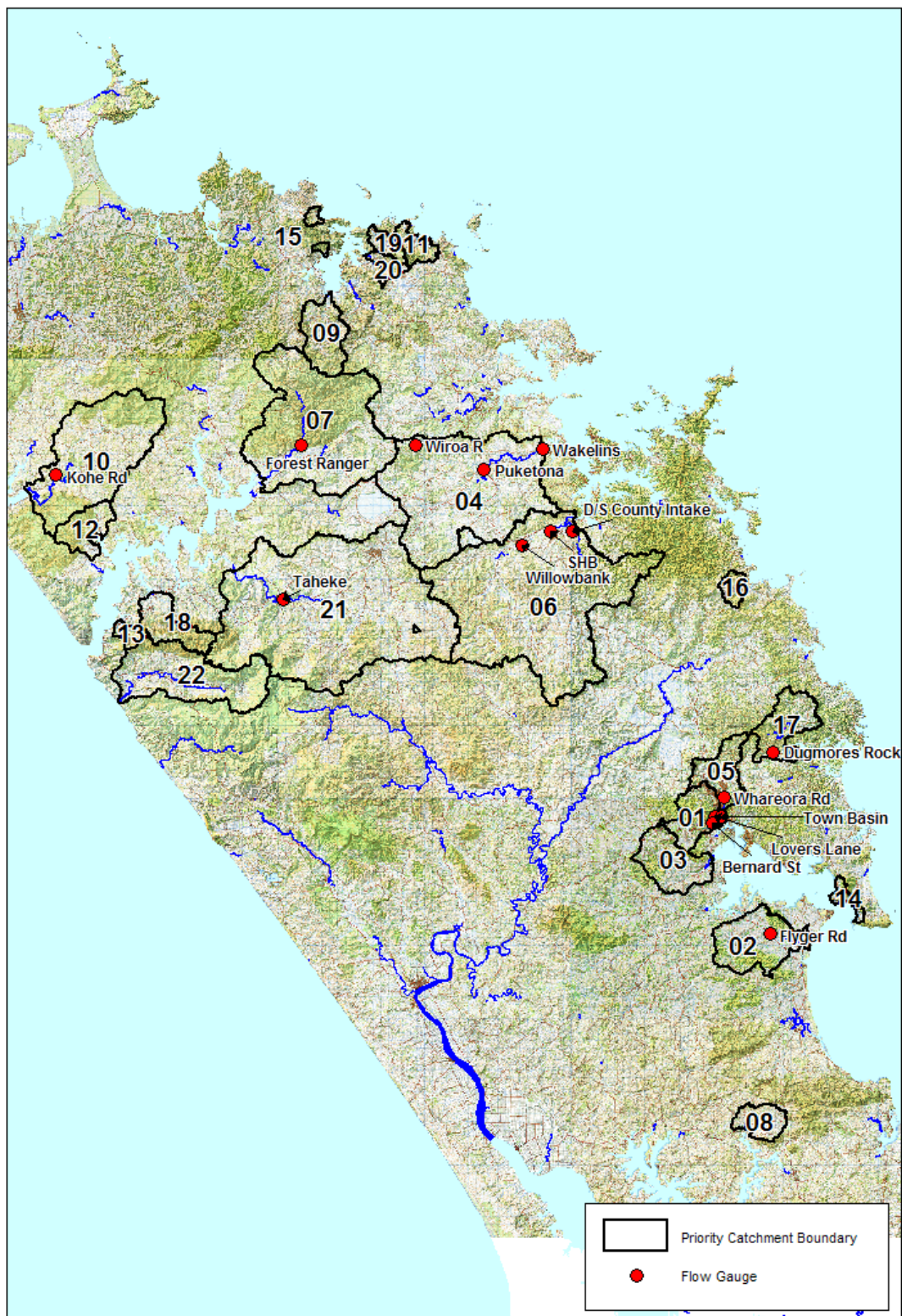


Figure 1: Flow Gauge Locations

1.3 At Site Flood Frequency

At site flood frequency analysis was carried out on data from flow gauges within the study catchments. The Extreme Value Type 1 (EV1) distribution was fitted to the annual maximum series for all but three sites. The EV1 (Gumbel) distribution is generally recommended as the most appropriate for New Zealand rivers (McKerchar and Pearson, 1989). However, the Generalised Extreme Value distribution was found to provide a better fit for the Waiarohia at Lovers Lane and Raumanga at Bernard Street records. The Pearson Type III distribution was found to provide a reasonable fit for the Waitangi at Wakelins record. Plots of the annual series and the fitted distribution for each site are shown in Appendix 1. Results of the frequency analysis are listed in **Table 2**.

NIWA investigated the return periods of floods in March 2007 and 1981 for Kerikeri. Results are reported in *Review of Flood Peak Estimates in the Kerikeri Area* (NIWA Client Report, 2009). The assessment included frequency analysis of the Waitangi at Wakelins record. A Gumbel frequency curve was fitted to biennial maxima. The resulting estimate for the 100 year ARI flood for Wakelins was 740 m³/s, compared to 780 m³/s estimated in this study and listed in Table 2.

1.4 Regional Flood Frequency

Regional flood frequency methodology described in "Flood Frequency in New Zealand" (McKerchar and Pearson, 1989) was used to estimate flood peaks in the study catchments. The results of the method are included in Table 2. There are significant differences between the at-site and regional flood estimates. Also the Regional Method produces some odd results even between sites in the same catchment. For example the estimate for Waitangi at Wakelins is less than Waiarohia at Puketona even though it is downstream. These results are not reflected in the at site frequency analysis.

Table 2: At Site & Regional Flood Frequency Analysis Results

Site no.	*	River Name	Site Name	Catchment Area km ²	Years Data	l/s/km ² At Site	100 Year ARI Flow (m ³ /s)	
							At-Site (Gumbel)	Regional Method
3707	4	Waiarohia	Puketona	175	16	1.9	331	405
3710	4	Whangai	Wiroa R	2	5	23.0	46	25
3722	4	Waitangi	Wakelins	302	31	2.2	780	260
3806	6	Kawakawa	SHB	315	6	0.6	179	259
3819	6	Waiharakeke	Willowbank	229	43	0.9	212	296
3829	6	Tirohanga	D/S County	56	8	2.2	124	65
4901	1	Ngunguru	Dugmores Rock	13	40	11.6	151	121
5527	1	Waiarohia	Lovers Lane	19	30	5.1	119	126
5528	1	Raumanga	Bernard St	16	30	4.5	79	113
5538	5	Hatea	Whareora Rd	39	9	4.7	183	229
5901	2	Ruakaka	Flyger Rd	45	26	3.1	141	272
4780	7	Wainana	Forest Ranger	122	34	6.1	741	602
4759	2	Punakitere	Taheke	284	15	-	Water overflows banks and high flows	
4871	1	Rotokakahi	Kohe Rd	137	7	-	No Med to high ratings for this site	

*Priority Rivers Catchment Number

Given this apparent anomaly and that an additional 20 years flood data has been recorded since the last update of the regional estimate regression equations it is recommended that at site estimates be used for all sites.

2 Sea Level Rise

Based on the IPCC Fourth Assessment Report presented in Coastal Hazards and Climate Change: Guidance Manual (2008), sea-level rise estimates for 2090 should use a base value sea-level rise of 0.5m relative to the 1980–1999 average. Where impacts are likely to have high consequence or where additional future adaptation options are limited, all assessments should (at the very least) consider the consequences of a mean sea-level rise of at least 0.8m relative to the 1980–1999 average.

For this project the 0.5m sea level rise scenario was adopted for the 2090 scenario for all catchments. A 0.8m sea level increase was also simulated for one catchment to test the impact of a high climate change prediction.

3 Storm Surge

Storm surge is defined as a temporary rise of mean sea level along a coast lasting for a few hours or days due to the effects of low atmospheric pressure and sea level gradients set-up by strong winds. There is relatively little known in New Zealand about the recurrence intervals of storm surges, waves or Tsunami because of the lack of good quality sea level data of any length, (Bell et al, 2000)¹.

To allow for storm surge as a boundary condition in the hydraulic flood models for the priority catchments a frequency analysis of Marsden Point sea level data for the period 1989 to 2009 was carried out. The record does not include Cylone Bola which occurred in March 1988. The results of the analysis are shown in Figure 2 below.

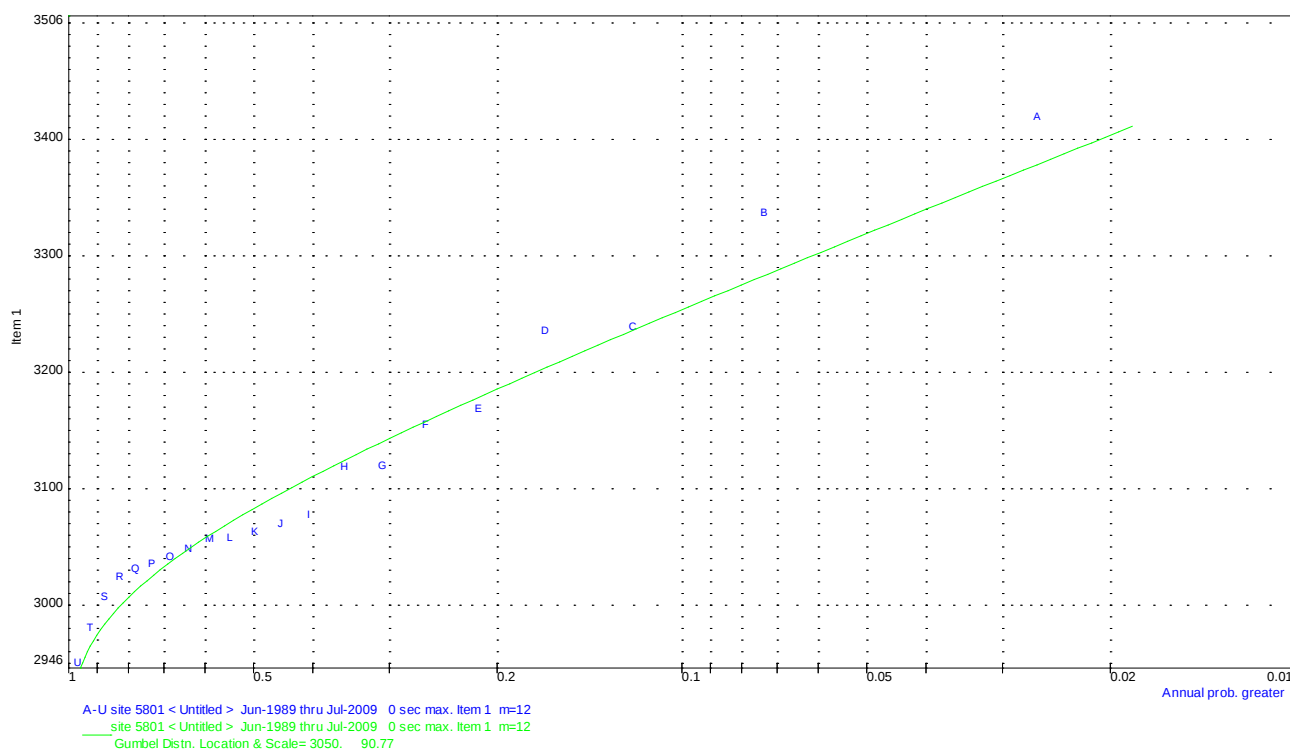


Figure 2: Marsden Point Sea Level Frequency Analysis

Peak annual flows and sea levels were compared for the Ruakaka at Flyers Road, Waiarohia at Lovers Lane and Ruamanga at Bernard Street records. Of the three flow records Bernard Street provided the best match with three annual flow events occurring near the time of peak annual sea level over a 21 year period. In crude terms, the annual peak flood coincided with peak sea level 14% of the time over the period of coincident record.

¹ "Sea-level change and storm surges in the context of climate change"; Bell, R G; Goring, D G; de Lange, W P. IPENZ Transactions, 2000, Vol. 27, No.1.

In taking into account the impact of storm surge it is recommended that the combined probability of flood peak and storm surge should not exceed 200 yr ARI. As the ARI of the design event is 100 years, storm surge should therefore have an ARI of 2 years. ($0.01 \times 0.5 = 0.005$ AEP)

From the frequency analysis plotted in Figure 2 above, the 2 year ARI sea level at Marsden Point is 3073mm which is 363mm higher than the Mean High Water Spring level (MHWS) and 1502mm higher than Mean Sea Level (MSL).

These levels are in terms of Marsden Point Chart Datum. Levels used in The Priority Rivers Project are in terms of LINZ datum – One Tree Point 1964. The difference between the two is 1.677m. That is $OTP = \text{Chart Datum} - 1.677\text{m}$ (Coastal Inundation Hazard Assessment for Selected Far North Settlements Bruce Howse, NRC, 2005).

The analysis was then used to prepare a time series of sea level and storm surge for input to the hydraulic models. The 2 year ARI storm surge event of 1396 mm OTP datum was extracted from the Marsden Point record as shown in Figure 3. An allowance for the estimated impact of climate change on sea level was made by adding 500 mm (base case scenario) to the 2 year ARI surge level. In the absence of any published data on the impact of climate change on the magnitude of storm surge the existing 2 year ARI storm surge level was left unchanged for the 2090 scenario.

Refer to Table 3 for a summary of the levels used.

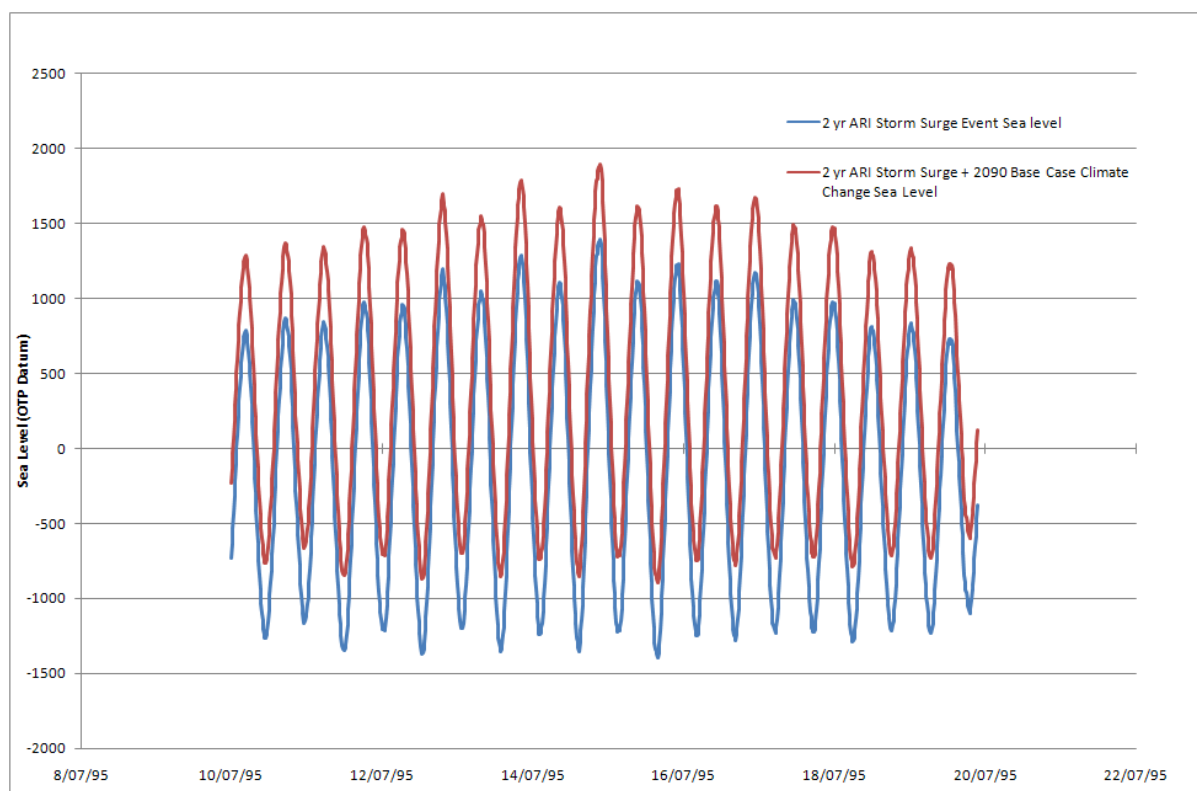


Figure 3: Marsden Point 2 Year ARI storm Surge Event + Allowance for Sea Level Rise

3.1 Variation in Sea Level around the Northland Coast

To take into account differences in sea level at locations away from Marsden Point, tide records for Opuia at Veronica Point, Kaipara Harbour at Pouto Point and NIWA's Anawhata tide gauge were assessed.

Figure 4 shows the locations of tide gauges in the region.

The Anawhata gauge is not surveyed to a national or regional datum and so could not be used directly. It does, however, provide a representative record of tide variation on the open coast and so was compared with Pouto Point which is just inside the Kaipara Harbour entrance. A comparison of the two records for the highest recorded tide at Pouto Point is shown in Figure 5. 2086mm was subtracted from the Anawhata data to better match the Pouto Point record which is based on OTP datum. It was concluded from the comparison that the Pouto Point record was reasonably representative of sea level on the west coast and in any case is the only useable data available.



Figure 4: Tide Gauge Recorder Locations

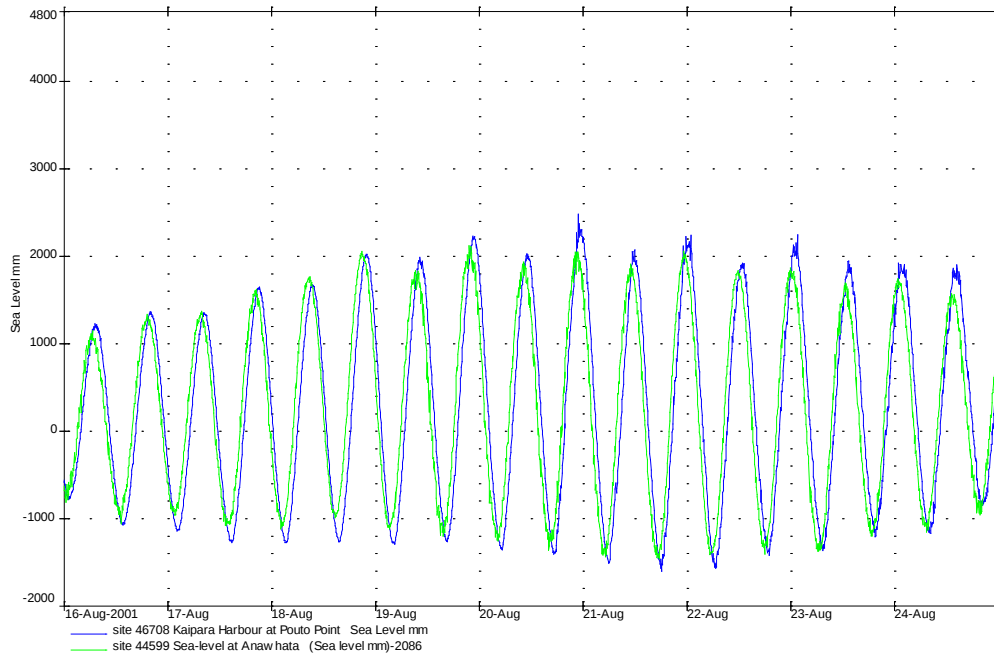


Figure 5: Comparison of Pouto Pt and Anawhata Sea Level.

The Opuia at Veronica Channel gauge records sea level data to chart datum. To convert this to OTP datum a constant of -1.56 was applied. (Dale Hansen personal comment)

As for Marsden Point, frequency analyses were carried out on the tide record for Opuia and Pouto Point and the 2 year ARI high tide extracted. Results from this analysis are shown in Figure 6 and Figure 7.

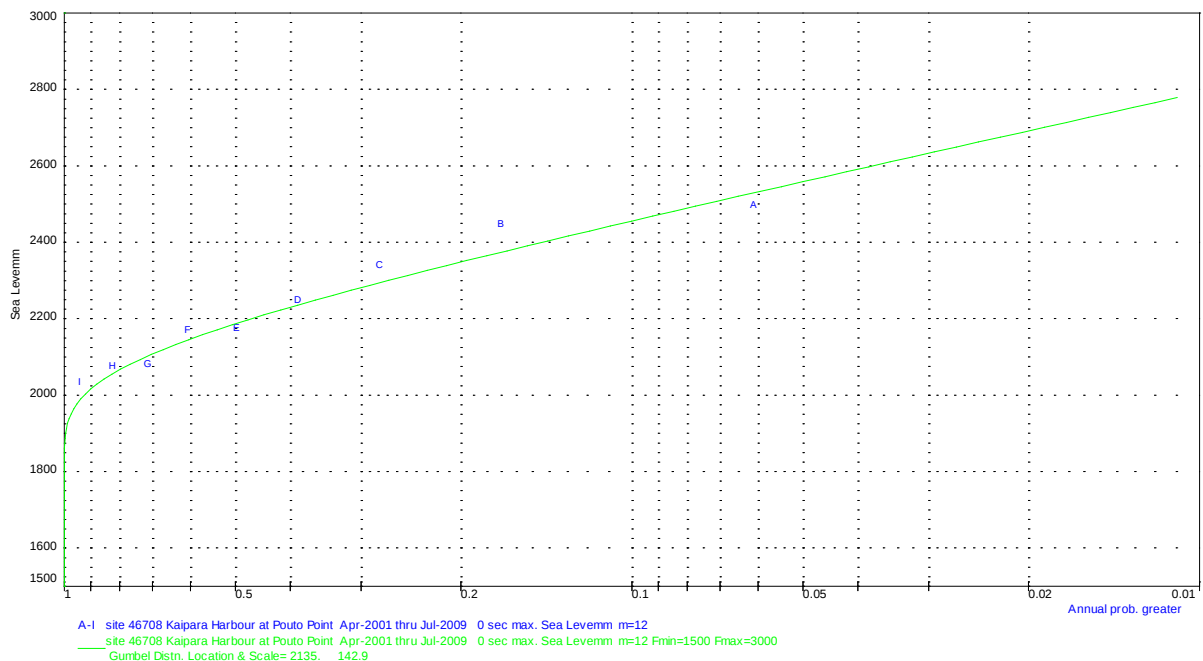


Figure 6: Kaipara Harbour at Pouto Point Sea Level Frequency Analysis

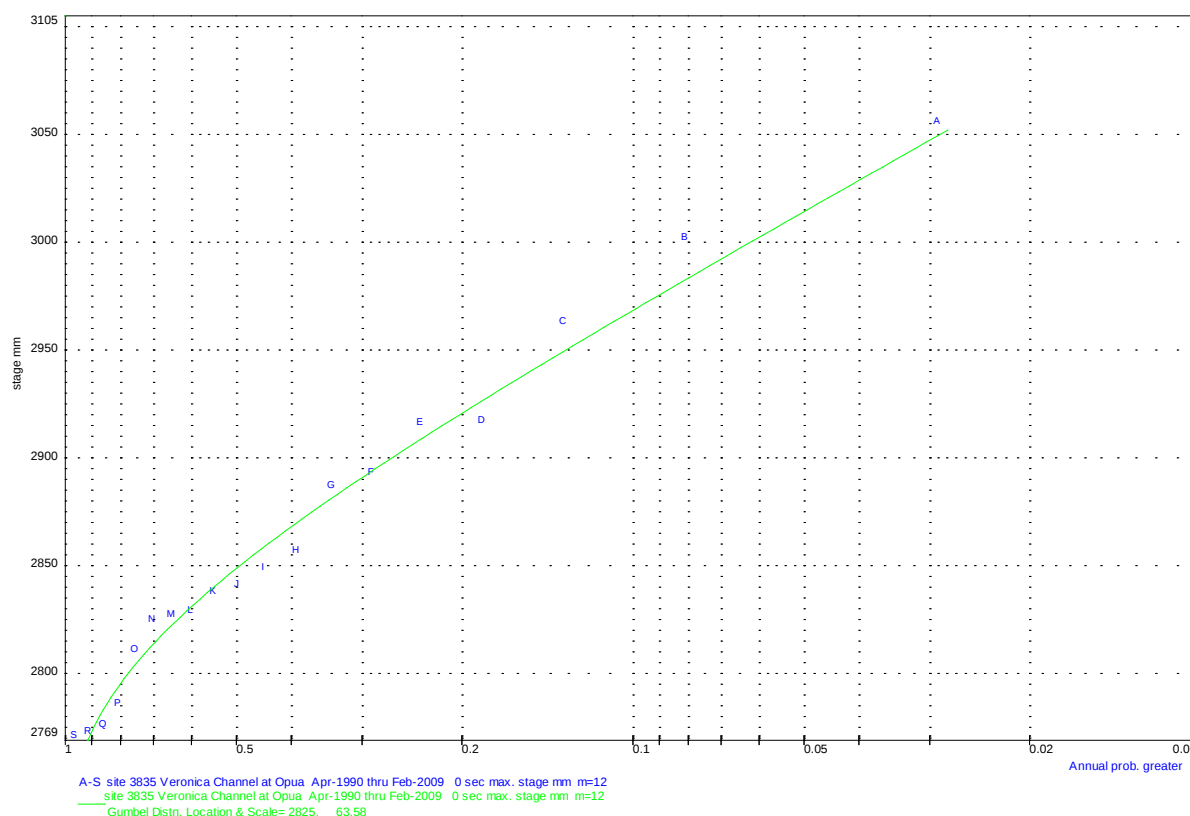


Figure 7: Opuia at Veronica Channel Sea Level Frequency Analysis

From the frequency analysis plotted in Figure 6 above, the 2 year ARI storm surge sea level at Pouto Point is 2161mm OTP Datum.

The 2 year ARI storm surge sea level at Veronica Channel is 2855mm Chart datum (from Figure 7). This equates to 1295 OTP datum.

The 2 year ARI storm surge events were extracted from the Pouto Point and Opuia tide records and an allowance for the estimated impact of climate change on sea level added. This was the 500 mm (base case scenario).

Figure 8 and Figure 9 show the 2 year ARI recorded time series and allowance for estimated sea level rise as result of climate change.

Table 3: Chart and OTP Datum 2 year ARI Tide Levels

	2 year ARI Tide Level (mm)		
	Marsden Point	Veronica Channel	Pouto Point
Chart Datum	3073	2855	-
Adjustment Constant	-1677	-1560	-
OTP Datum	1396	1295	2161

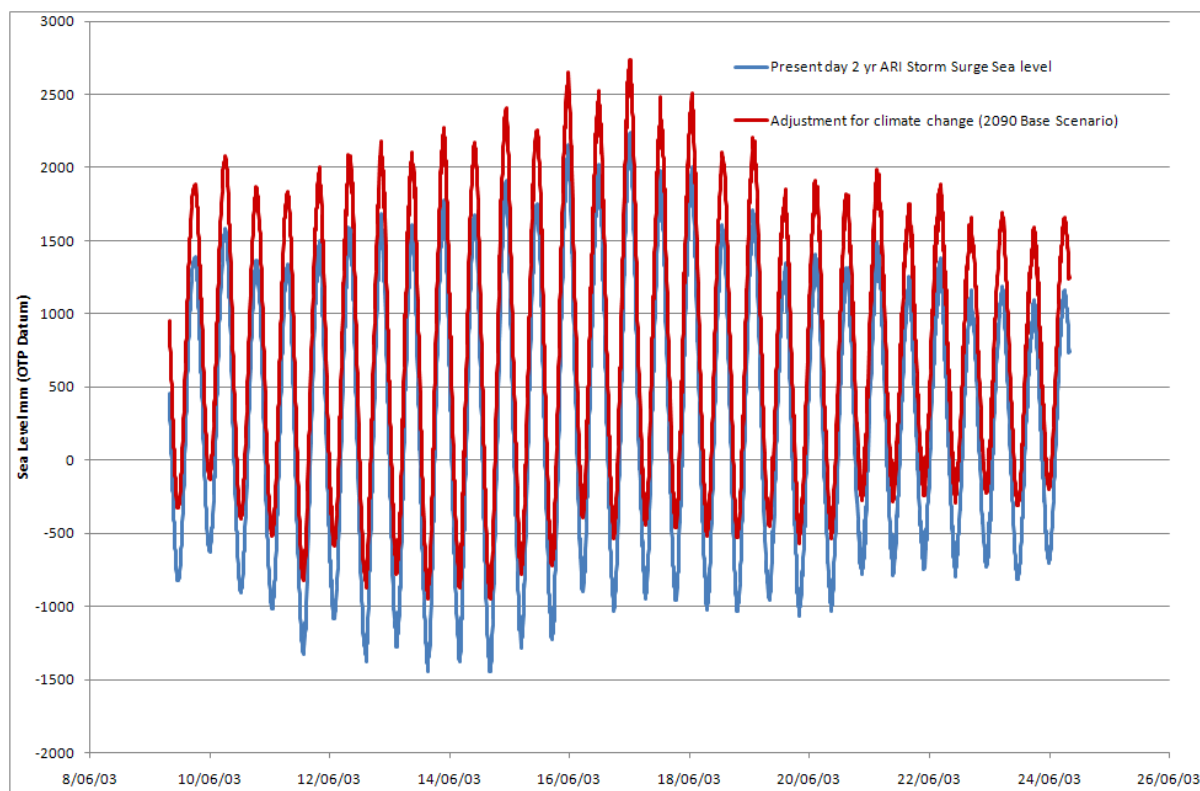


Figure 8: Kaipara Harbour at Pouto Point 2 Year ARI storm Surge Event + Allowance for Sea Level Rise

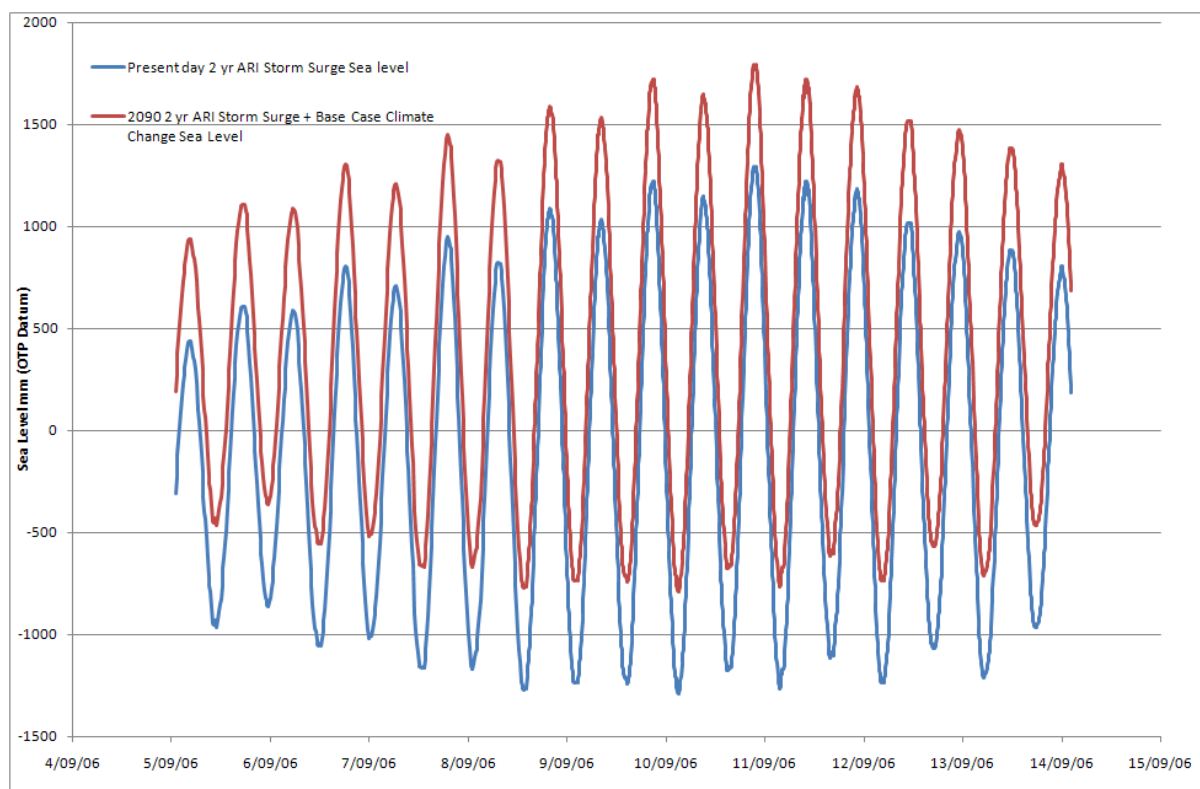


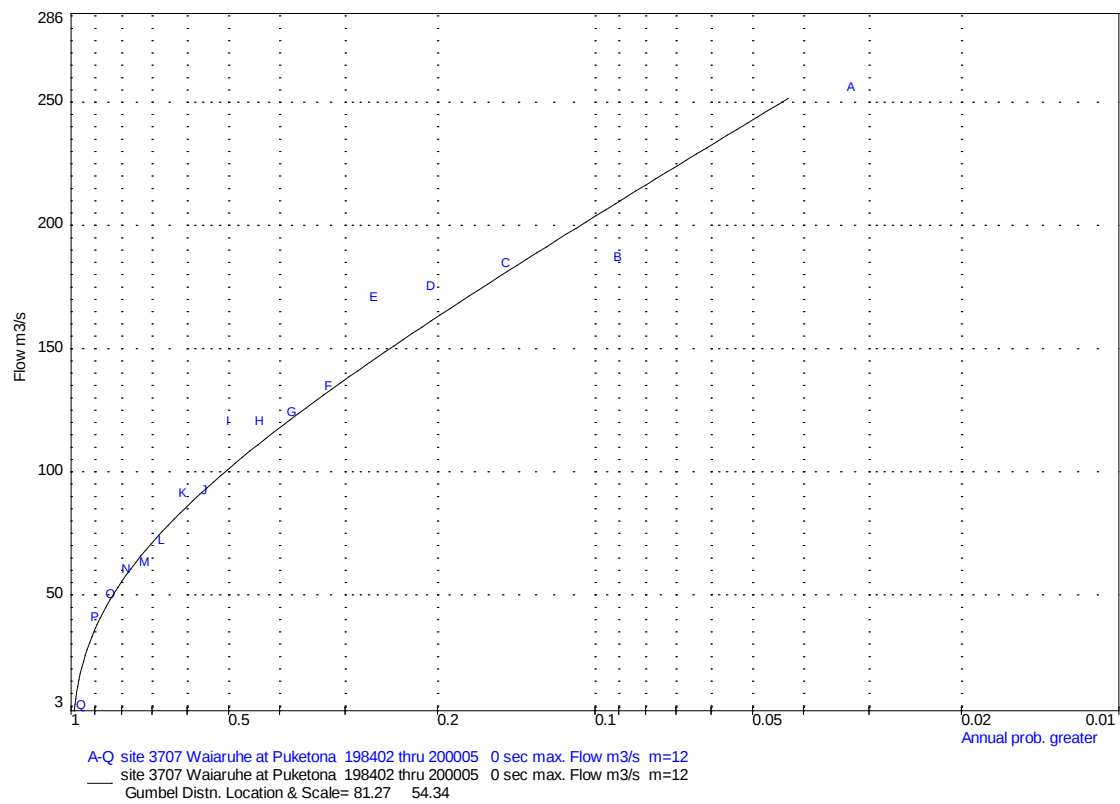
Figure 9: Opuia at Veronica Channel 2 Year ARI storm Surge Event + Allowance for Sea Level Rise

4 Uncertainty

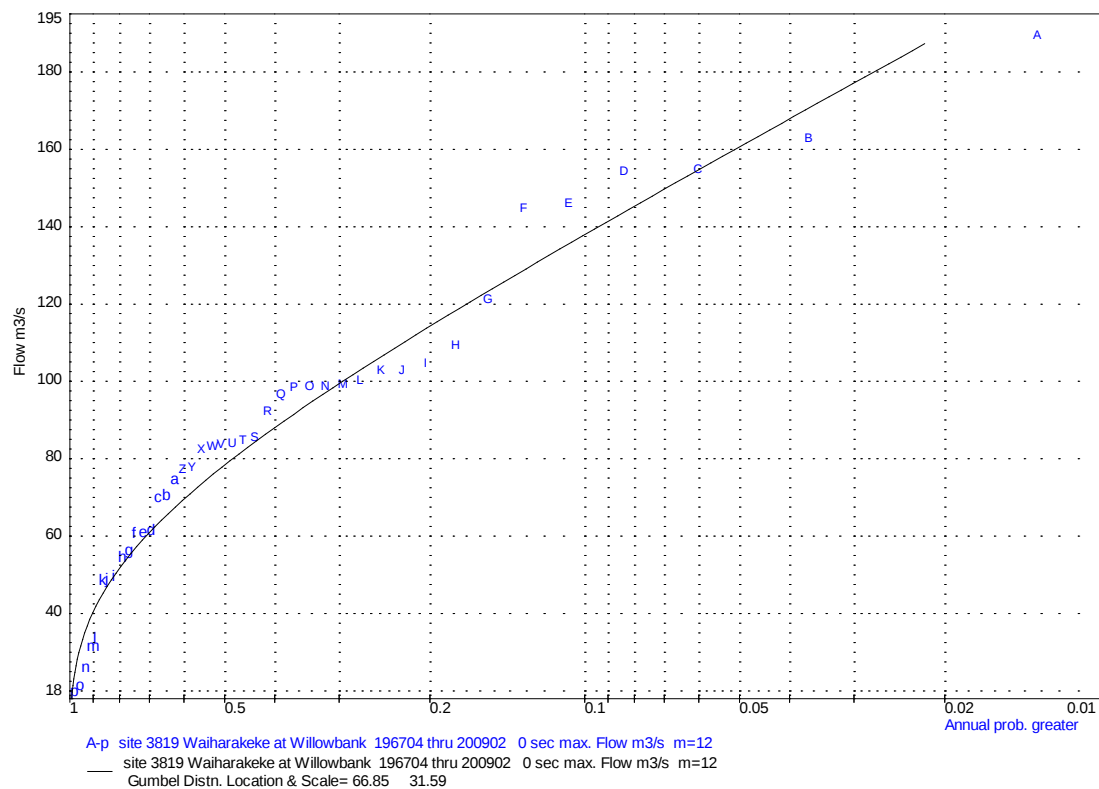
There is significant uncertainty associated with the results of the frequency analyses used in this assessment. This is primarily due to the relatively limited lengths of record available and lack of data to confirm the form of the frequency distribution used to extrapolate values. An appropriate allowance for uncertainty should therefore be made when using results reported in this document.

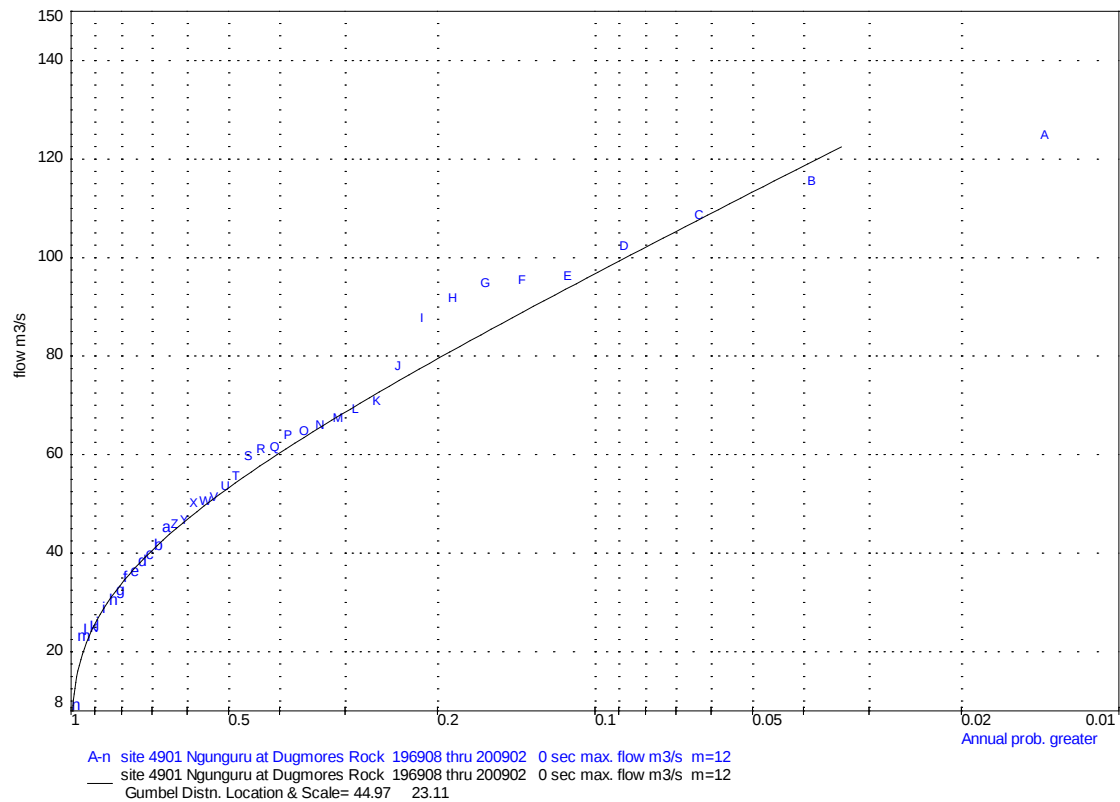
Appendix A Frequency Analysis Graphs

Site 3707 Waiaruhe at Puketona

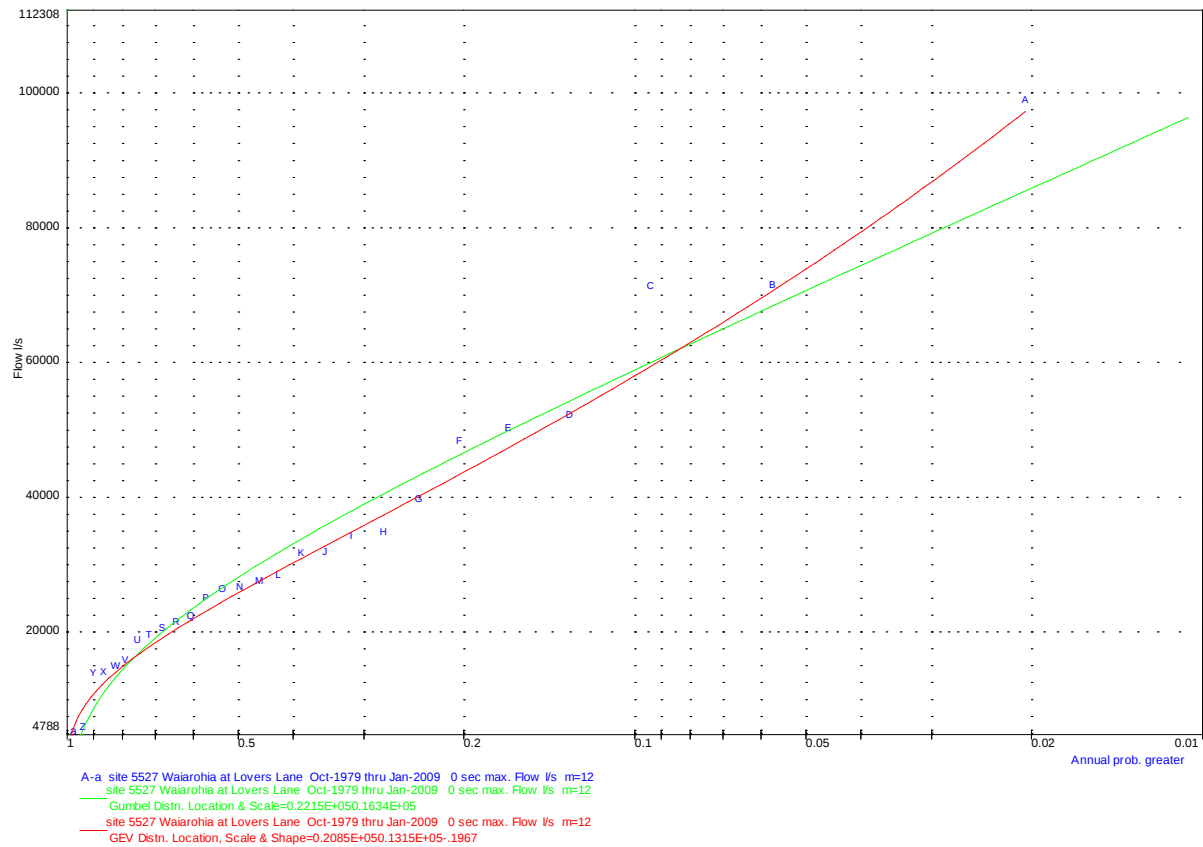


Site 3819 Waiharakeke at Willowbank

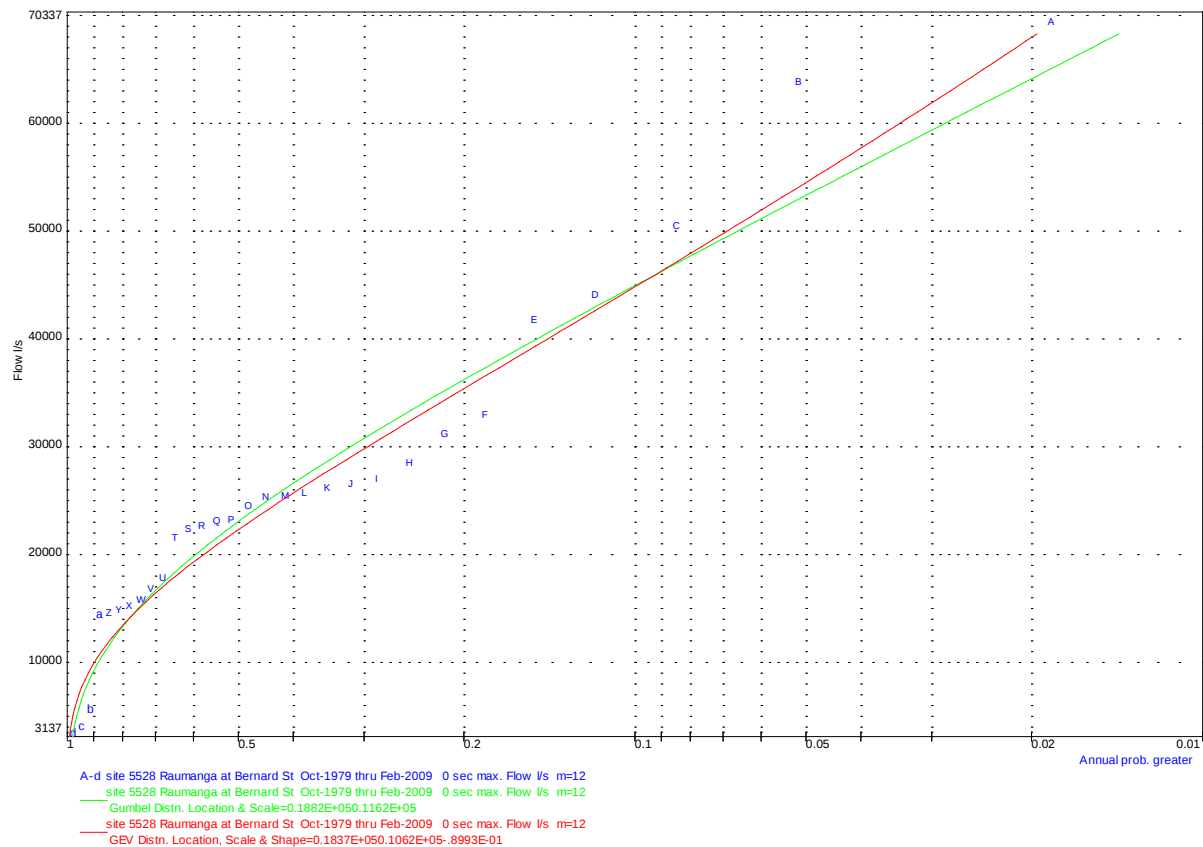


Site 4901 Ngunguru at Dugmores Rock


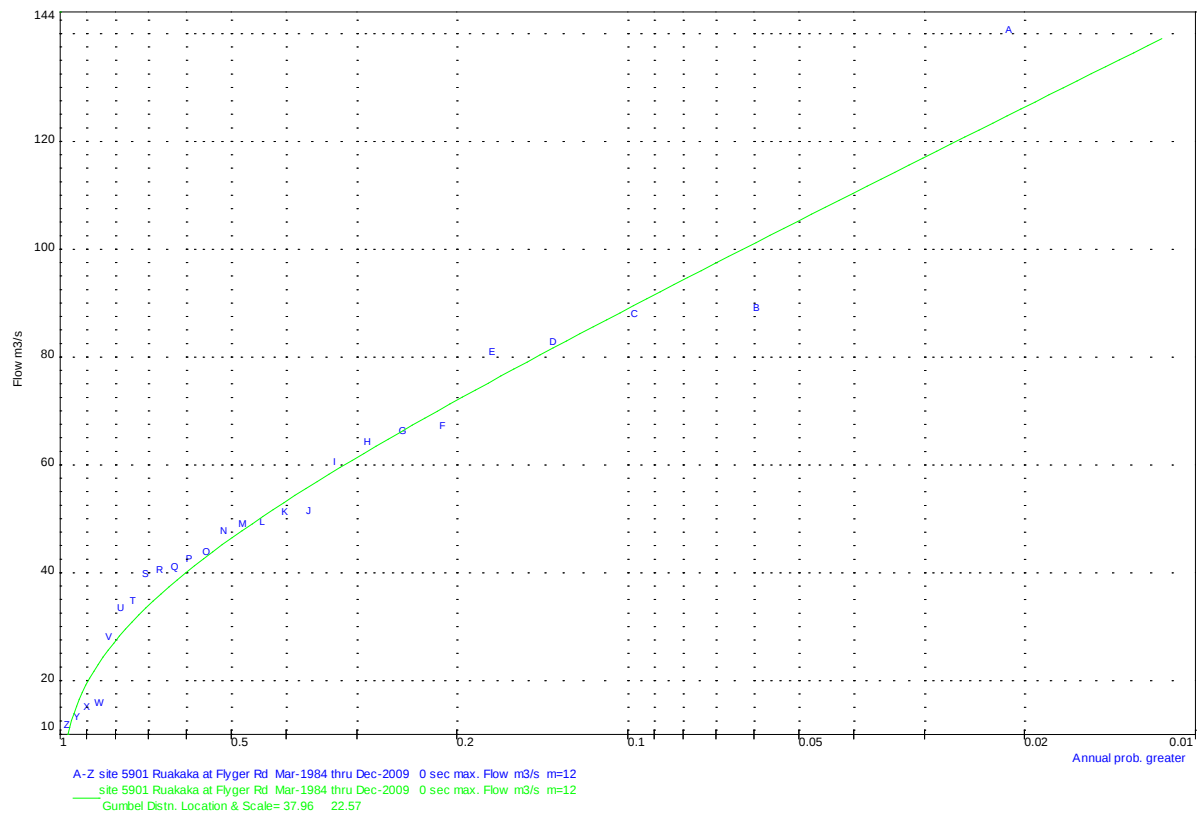
Site 5527 Waiarohia at Lovers Lane



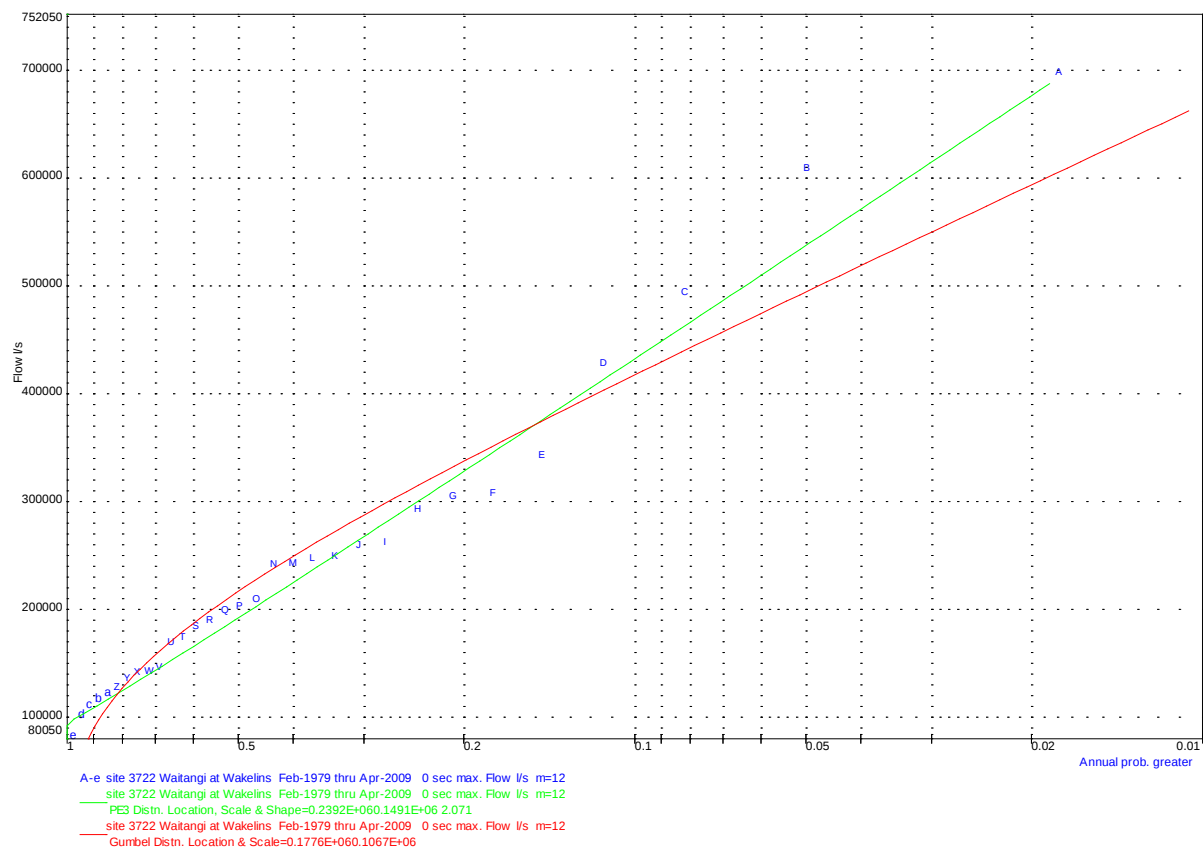
Site 5528 Raumanga at Bernard St



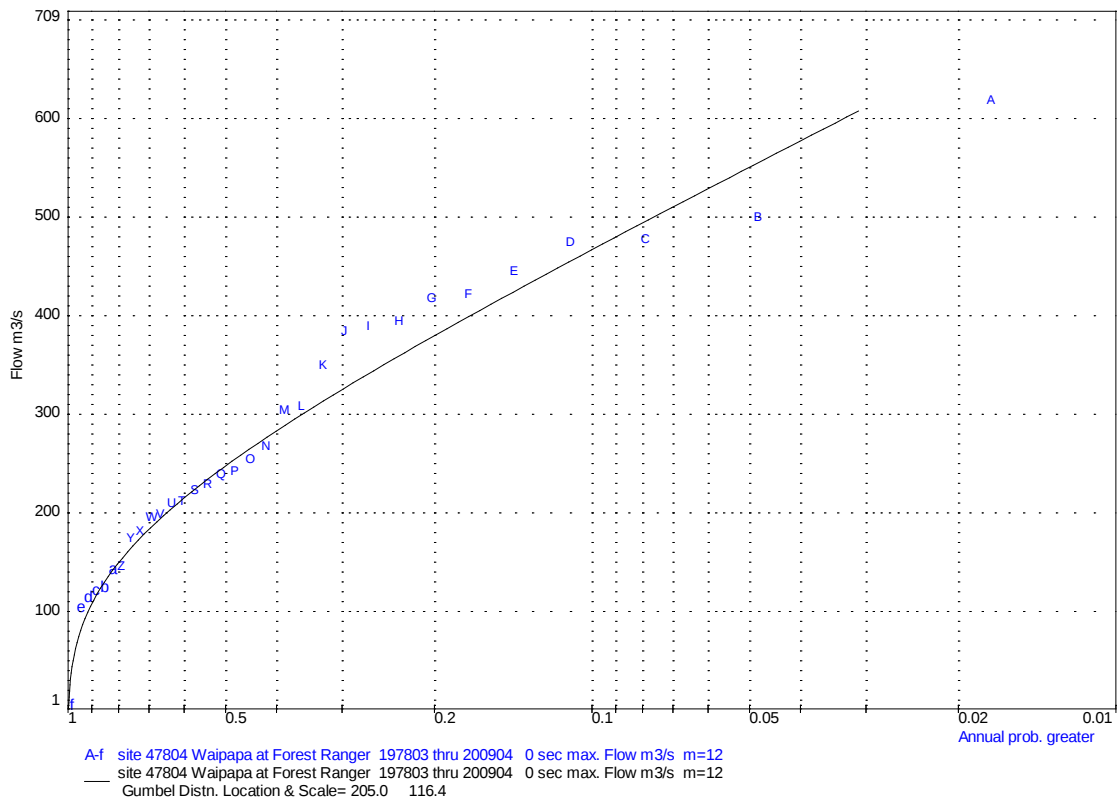
Site 5901 Ruakaka at Flyger Rd



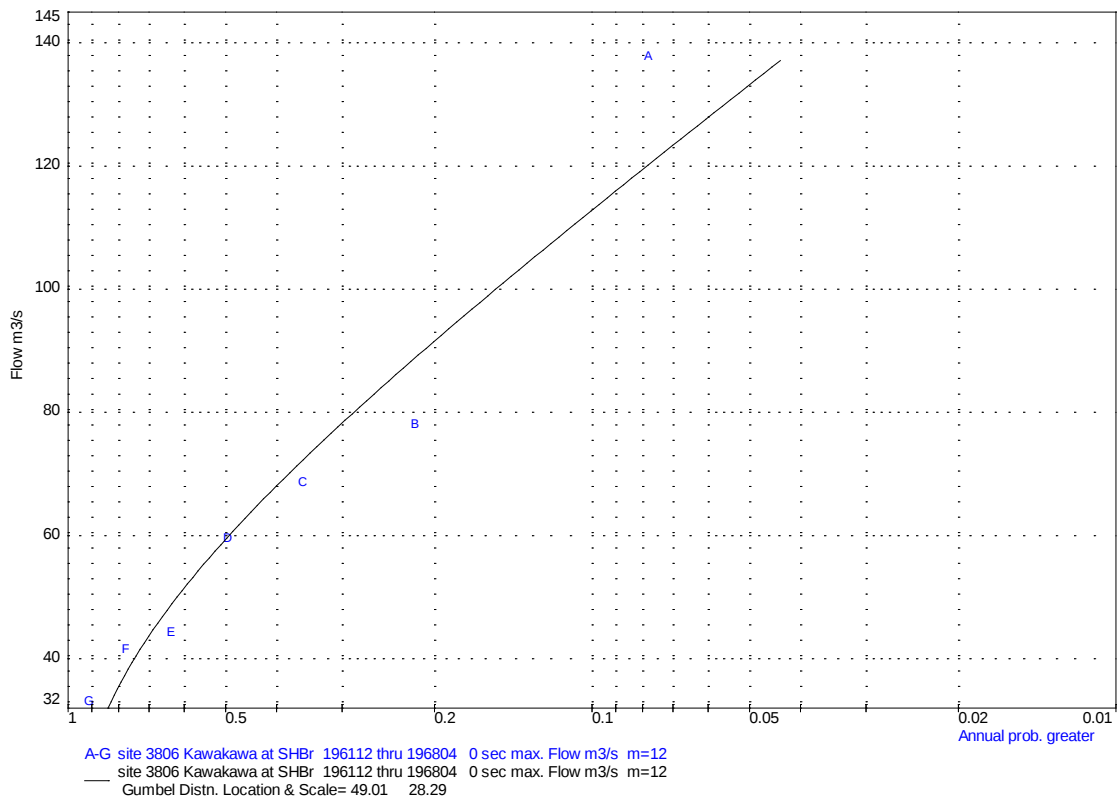
Site 3722 Waitangi at Wakelins

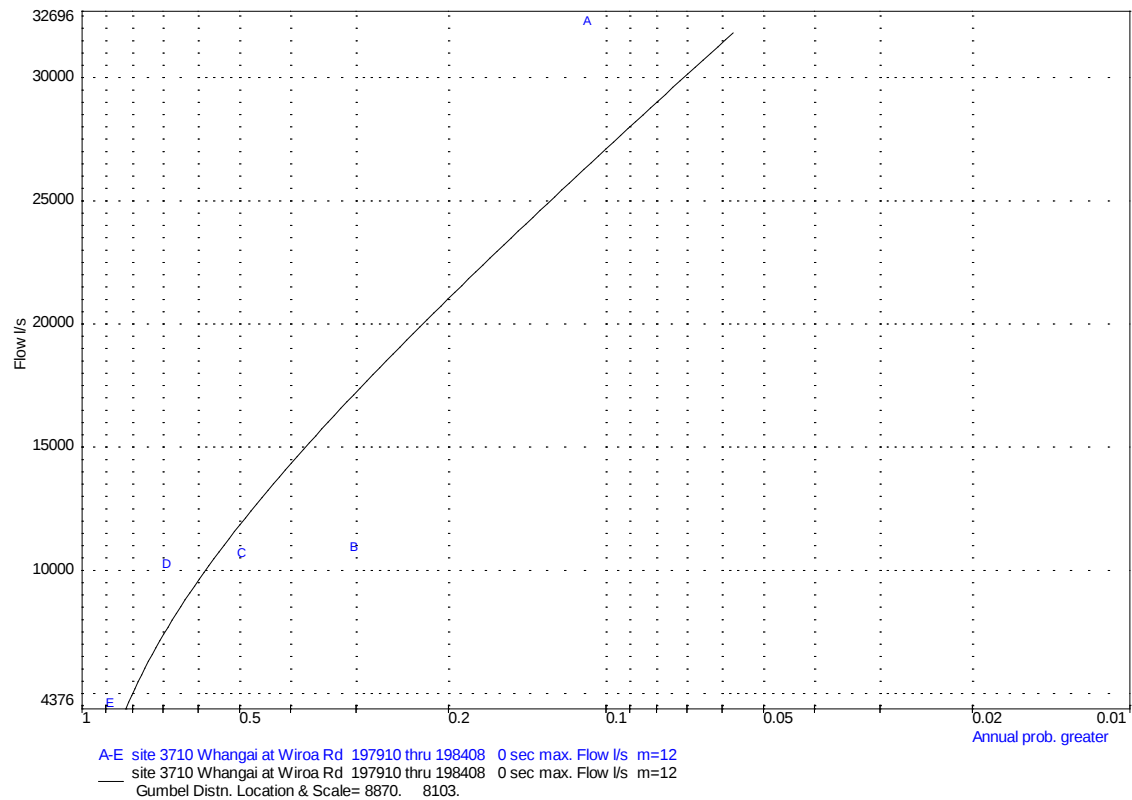
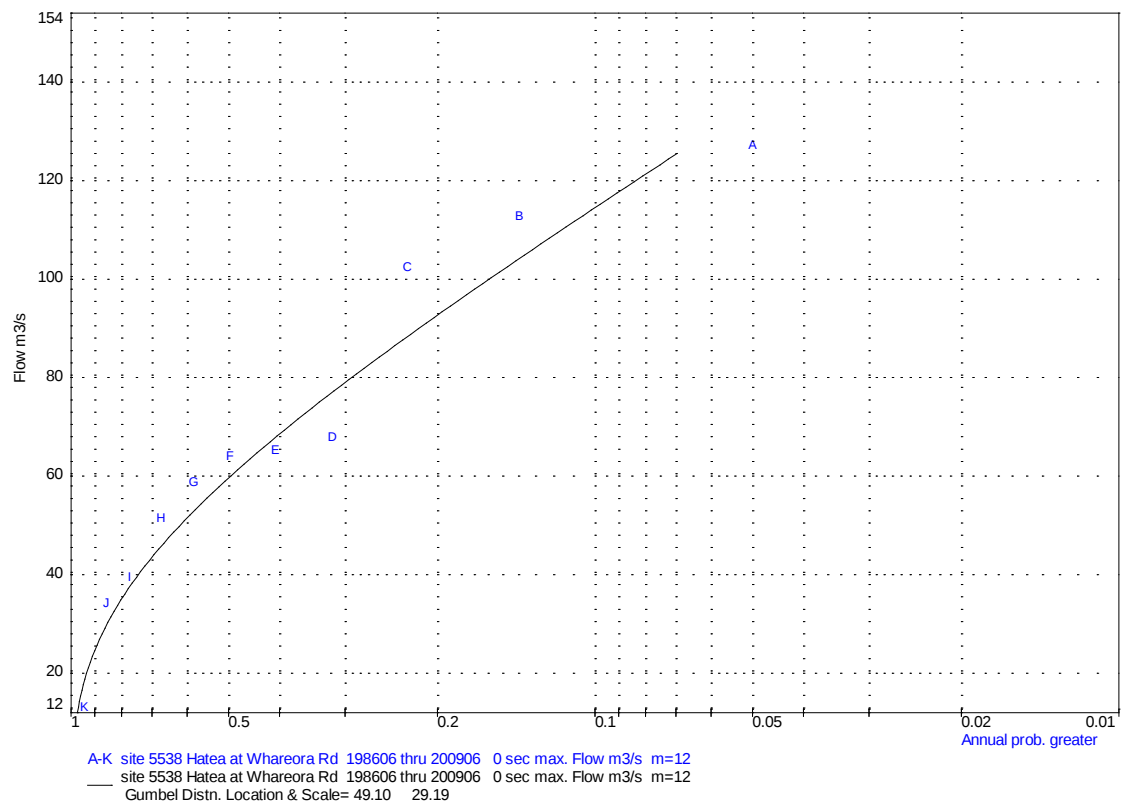


Site 47804 Waipapa Forest Ranger

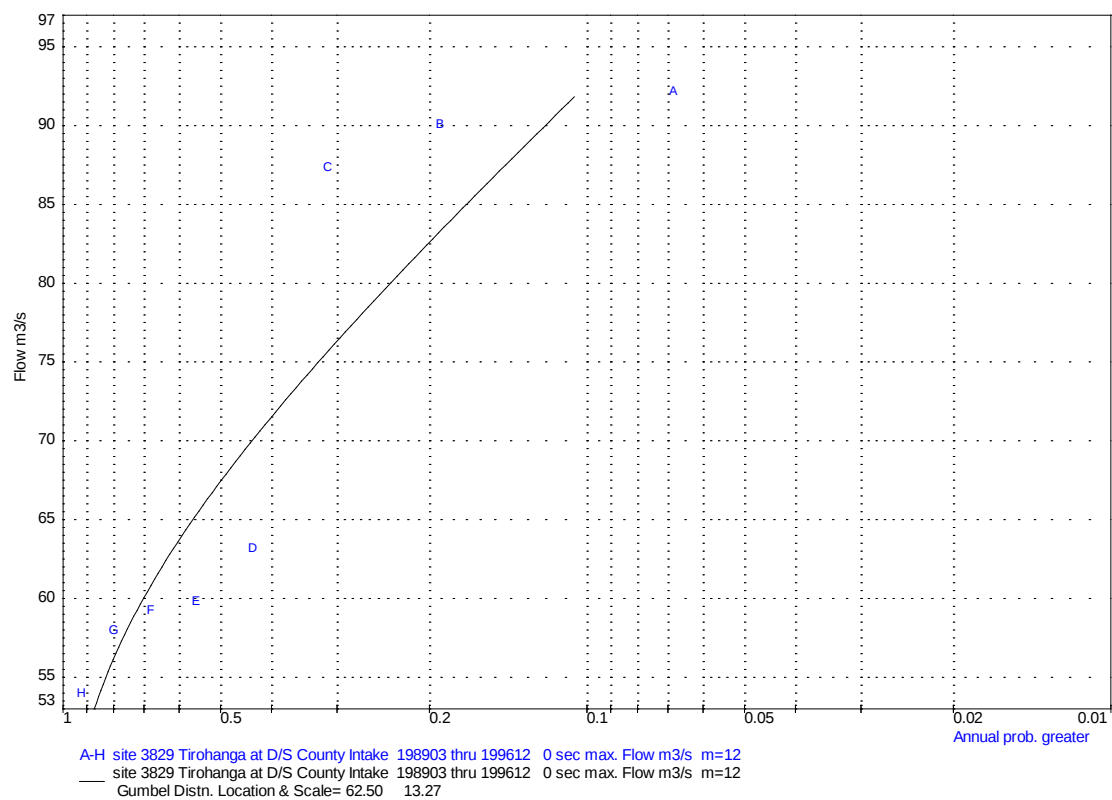


Site 3806 Kawakawa at SHBr

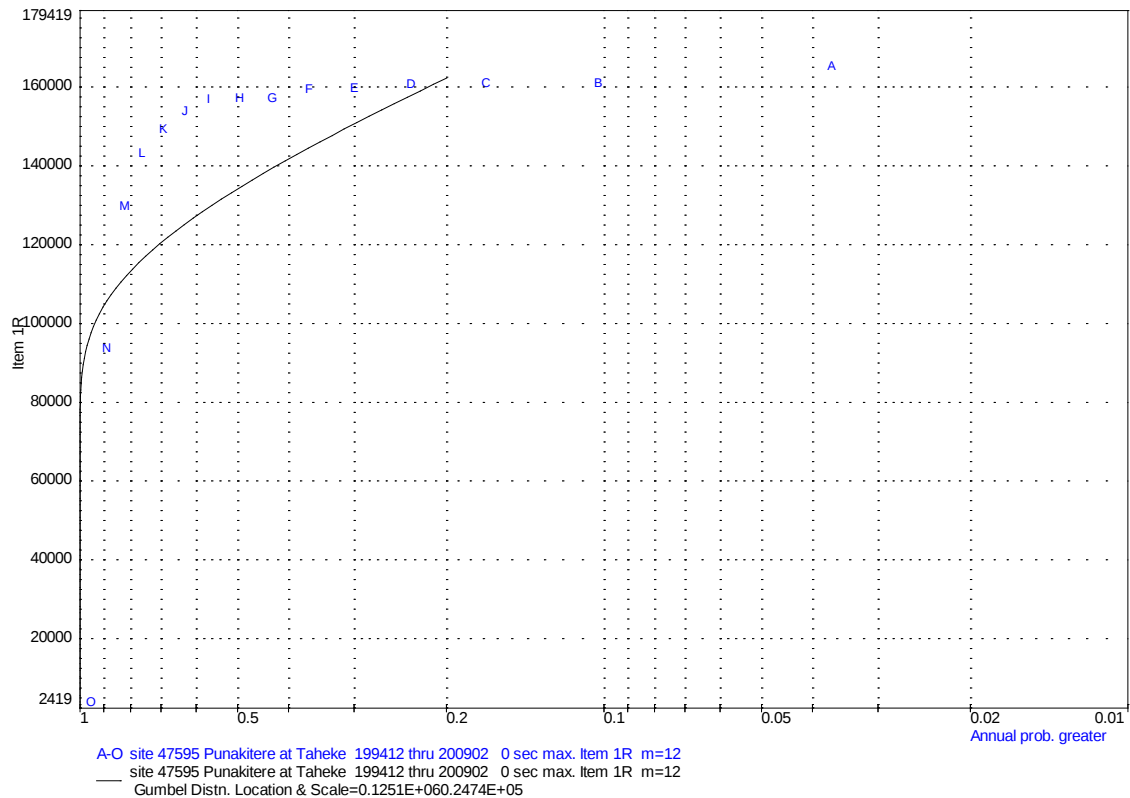


Site 3710 Whangai at Wiroa Rd – note the flow units are l/s

Site 5538 Hatea at Whareora Rd


Site 3829 Tirohanga at D/S County Intake



Site 47595 Punakitare at Taheke – not used



Site 48711 Rotokakahi at Kohe Rd – not used
