Mangatarere Stream Hydrology

Greater Wellington Regional Council

Mangatarere Stream Hydrology

Greater Wellington Regional Council

Prepared by
Sheryl Paine
Water Resources Scientist

Reviewed by
Jack McConchie
Technical Principal - Hydrology

Opus International Consultants Ltd
Wellington Environmental Office
L10, Majestic Centre, 100 Willis St
PO Box 12 003, Thorndon, Wellington 6144
New Zealand

Telephone: +64 4 471 7000
Facsimile: +64 4 499 3699

Date: June 2014
Reference: 3-53166.00
Status: Final

Contents

1 Flow Data Overview

The Mangatarere Stream drains the eastern slopes of the Tararua Range, downstream to its confluence with the Waiohine River, and is located in the Wairarapa. There are three flow monitoring sites within the catchment: Mangatarere at Gorge (1999-2013); Mangatarere at Belvedere Bridge (2004-2014); and Mangatarere at SH2 Bridge (2009-2014) (Figure 1.1). The longest flow record is from the Gorge which has a catchment area of 33.2km² and drains largely steep forest-covered hill country (Table 1.1).

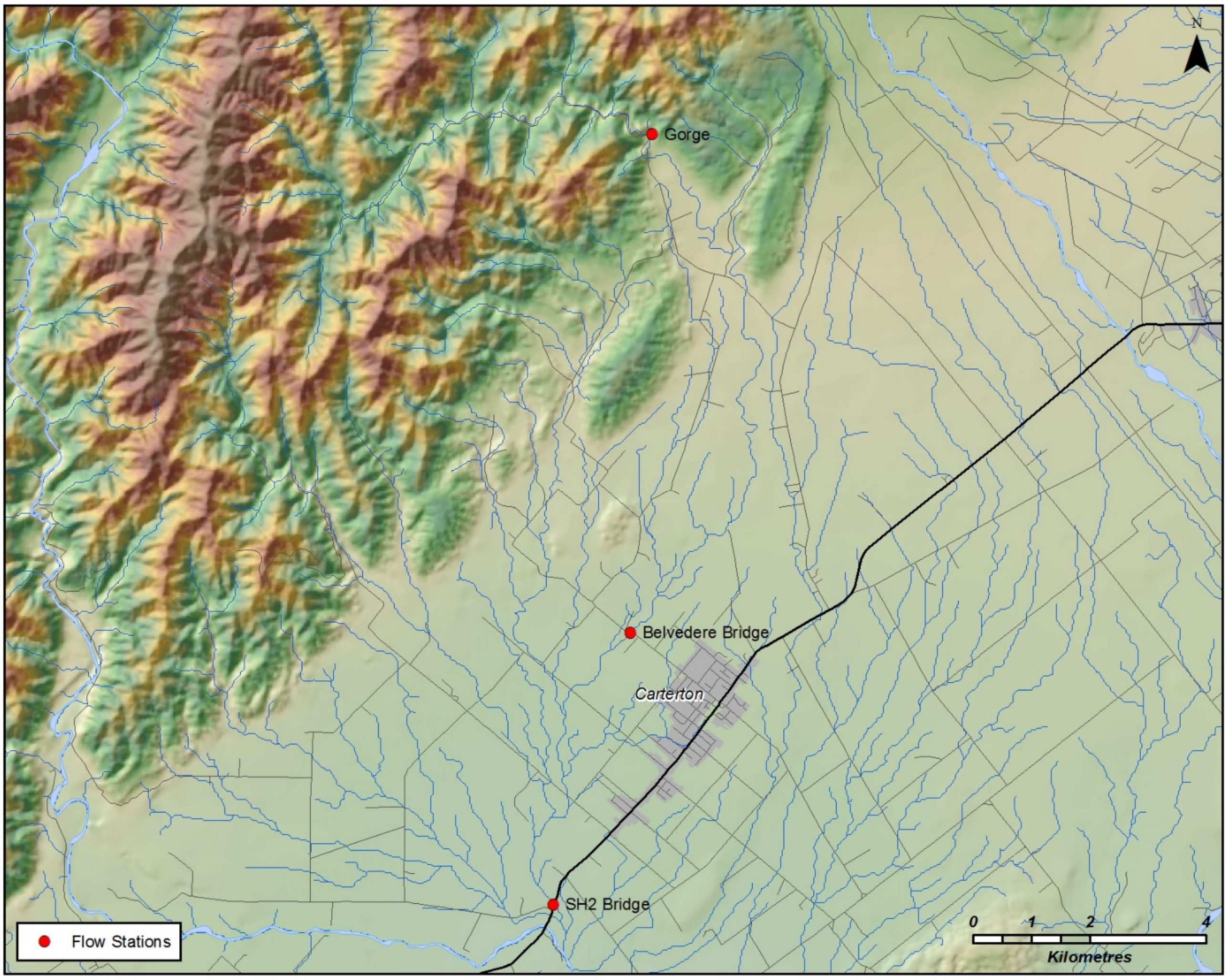

Figure 1.1 Location of the three gauging stations on the Mangatarere Stream.

Table 1.1 Characteristics of the Mangatarere Stream flow monitoring sites.

Name	Catchment	Area (km²)	Elevation (m)	Start Date	Record Length
Mangatarere at Gorge	Waiohine	33.2	~176	9-Feb-1999	~15 years
Mangatarere at Belvedere Bridge	Waiohine	55.9	~80	27-Jan-2004	~10 years
Mangatarere at SH2 Bridge	Waiohine	118.6	~57	1-Sep-2009	~5 years

Flows have been recorded in the Mangatarere Stream since 1999, providing approximately 15 years of data (Figure 1.2). The resulting flood maxima series, however, only exists for the Gorge site; the maxima series for the other two sites are significantly shorter than 15 years. These are all reasonably short records when estimating the frequency and magnitude of more extreme events. Consequently, there will be uncertainty with regard to design flood estimates with low annual exceedence probabilities (i.e. AEPs). The three flow records (Figure 1.2, Figure 1.3 and Figure 1.4) are summarised in Table 1.2.

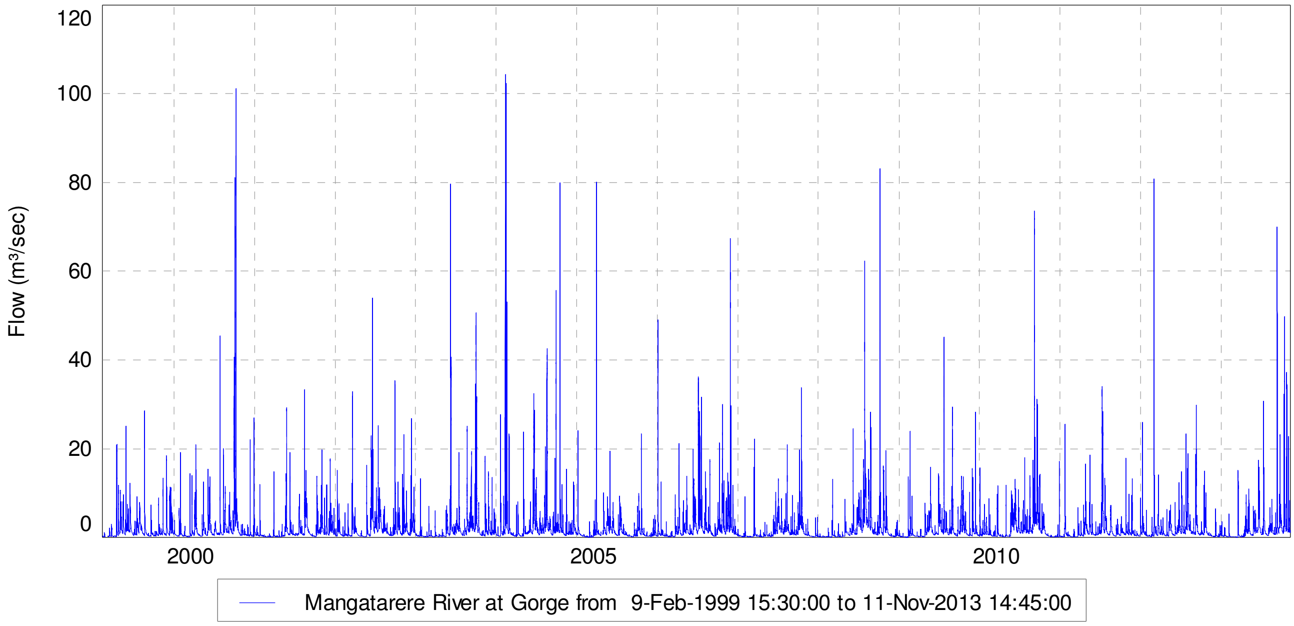

Figure 1.2 Flow record from the Mangatarere Stream at Gorge.

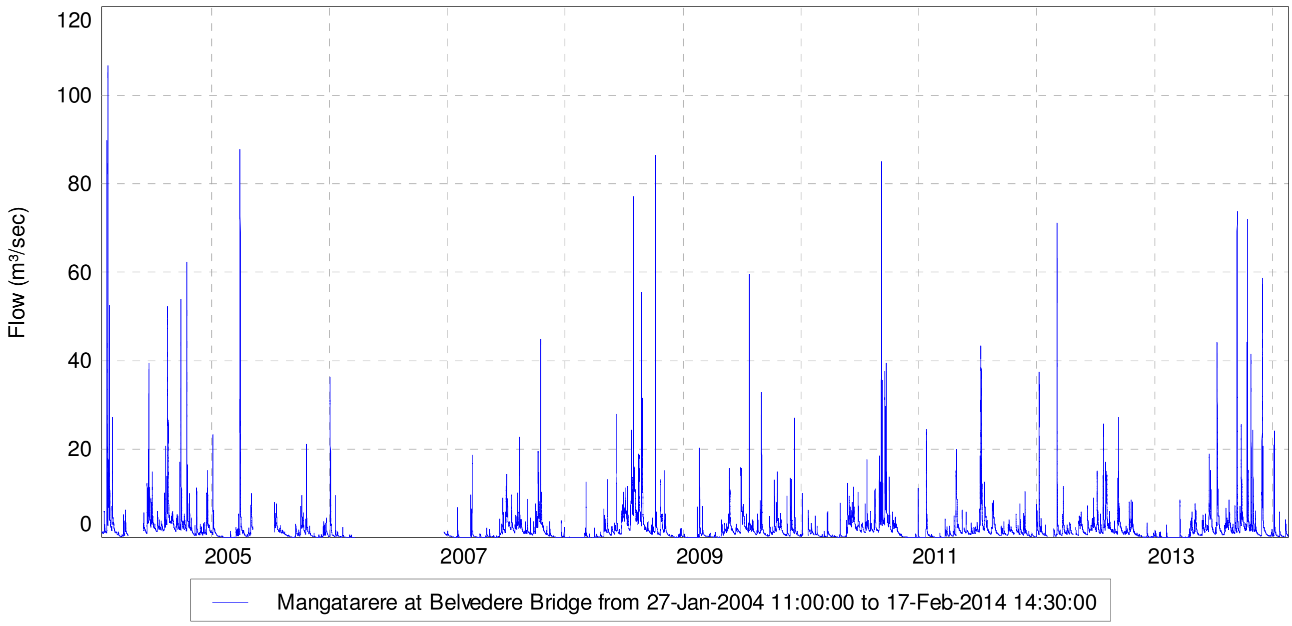

Figure 1.3 Flow record from the Mangatarere Stream at Belvedere Bridge.

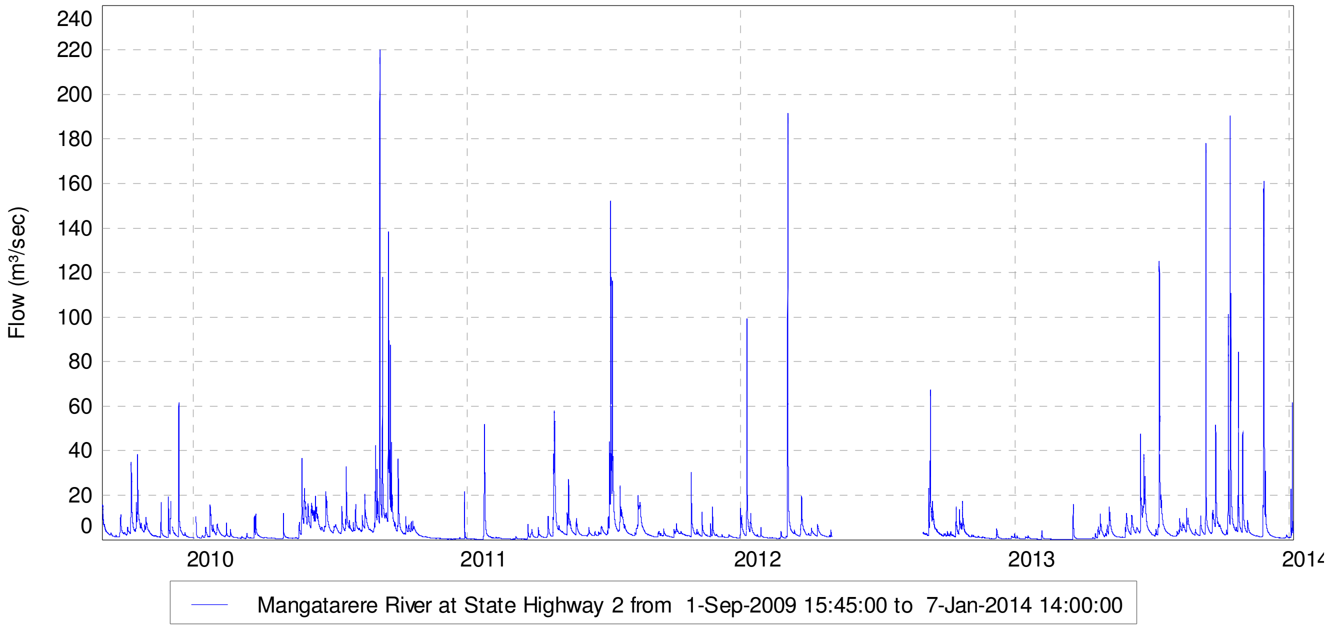

Figure 1.4 **Flow record from the Mangatarere Stream at SH2 Bridge.**

Table 1.2 **Summary statistics for the various flow records on Mangatarere Stream (m^3/s).**

Name	Min	Max	Mean	Std Dev	L.Q.	Median	U.Q.
Mangatarere at Gorge	0.04	104.3	1.8	3.3	0.42	0.87	1.9
Mangatarere at Belvedere Bridge	0.0	106.7	1.9	3.6	0.29	0.99	2.2
Mangatarere at SH2 Bridge	0.16	220.0	4.3	9.4	0.97	2.1	4.4

All three flow records contain a number of gaps; or periods of missing data. For example, the Gorge record is 99.6% complete; while the Belvedere Bridge and SH2 flow records are only 88.2% and 92.8% complete respectively. The more complete record from the Gorge is despite the fact that this flow record is significantly longer than those from the other two sites. There are five gaps in the Gorge dataset; 11 in the Belvedere Bridge dataset, and three in the SH2 Bridge dataset. Belvedere Bridge has the greatest total duration of missing record; approximately 433 days or 12% (Table 1.3). Consequently the flow series from the Gorge, as well as being the longest, is also of the highest quality with respect to continuity. The flow record from Belvedere Bridge is probably the poorest quality.

Table 1.3 **Distribution of the duration of gaps in the three Mangatarere Stream flow records.**

	>1 week	<1 week	<1 day
Mangatarere at Gorge	20%	60%	20%
Mangatarere at Belvedere Bridge	45%	27%	18%
Mangatarere at SH2 Bridge	33%	67%	0%

The Mangatarere Stream at Gorge has been gauged 177 times since the record started and the rating has been changed 46 times (Figure 1.5). The rating curves show some channel instability as a result of the dynamics of the gravel bed in response to flood events. The rating curve appears reasonable stable at flows above about 55m³/s.

The largest flow on record at this site is 104.3m³/s (2004) which is almost 50% higher than the largest gauged flow of 71.09m³/s (2008). Therefore, the reliability of the rating may be slightly less certain at higher flows. Consequently, there may be some uncertainty with respect to the reliability of estimates of the magnitudes of large flood events.

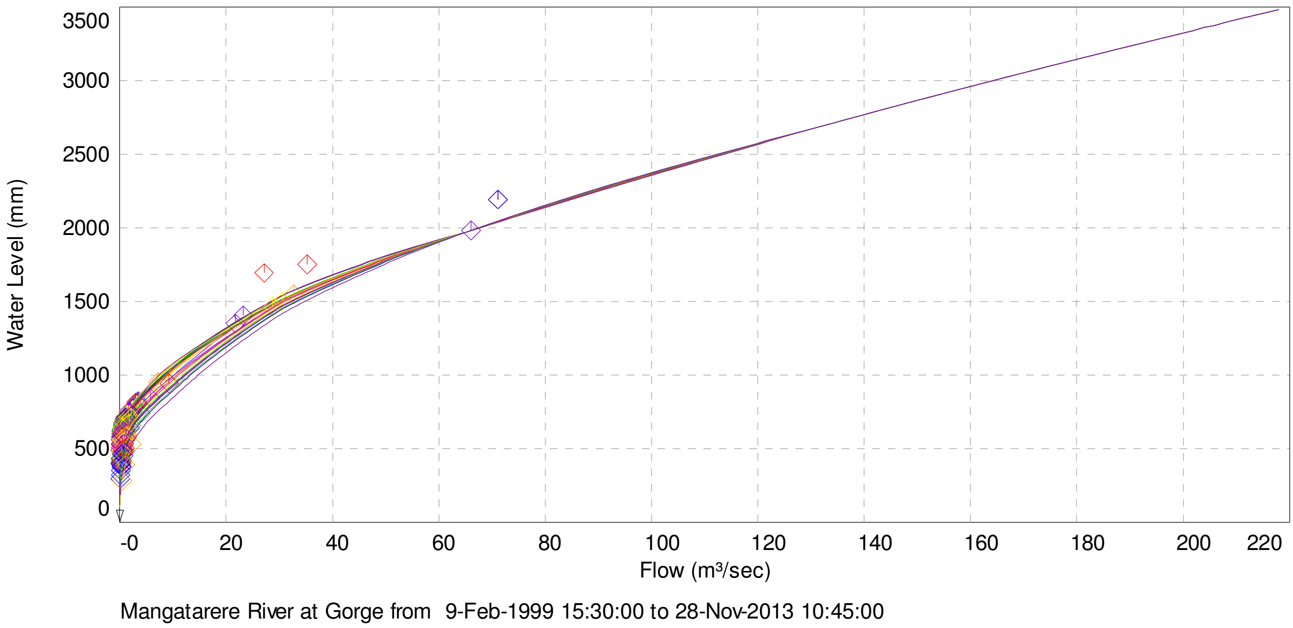

Figure 1.5 Mangatarere Stream at Gorge rating curves with the gaugings overplotted.

The Mangatarere Stream at Belvedere Bridge has been gauged 60 times since the record started, and there have been 12 rating changes (Figure 1.6). There appears to be considerable instability in the rating curve, and at least one shift in the datum.

The largest flow on record at this site is 106.7m³/s (2004) which is over three times higher than the largest gauged flow of 30.7m³/s (2008). Therefore, the reliability of the rating is unknown at higher flows. This results in considerable uncertainty with respect to the reliability of estimates of the magnitudes of larger flood events.

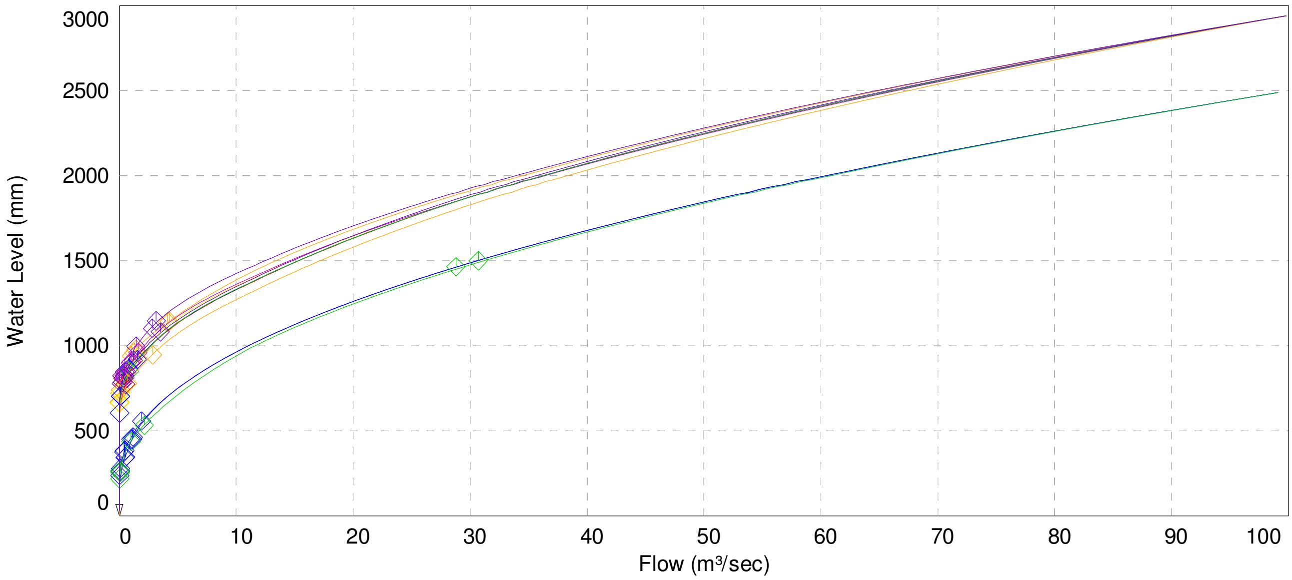

Figure 1.6 Mangatarere Stream at Belvedere Bridge rating curves with the gaugings overplotted.

The Mangatarere Stream at SH2 Bridge has been gauged 39 times since the record started and there have been nine rating changes (Figure 1.7). There appears to be considerable instability in the rating curve, although only relatively low flows have been gauged. There has been at least one datum shift.

The largest recorded flow at this site is 220.0m³/s (2010) which is dramatically higher (i.e. orders of magnitude) than the largest gauged flow of 8.4m³/s (2012). The reliability of the rating curve is therefore unknown at higher flows. This results in major uncertainty with respect to the estimates of the magnitudes of larger flood events at this site.

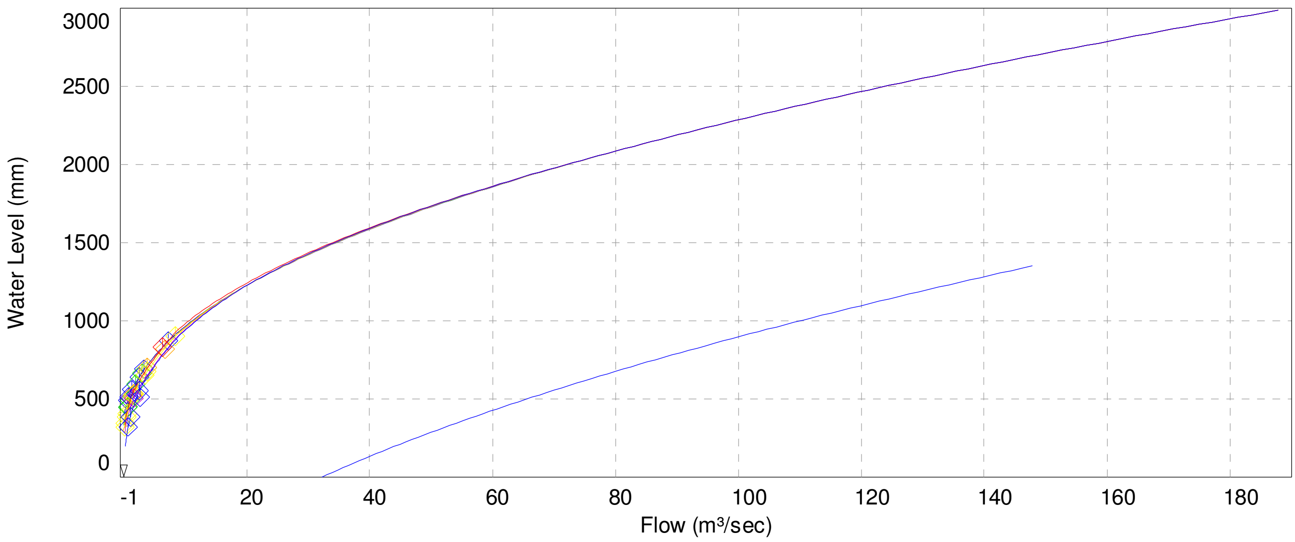

Figure 1.7 Mangatarere Stream at Belvedere Bridge rating curves with the gaugings overplotted.

Overall, the Mangatarere Stream at Gorge gauging site has a flow record of moderate length, with no major gaps, and has been regularly gauged. It is likely that this flow series contains a record of all the major flood events which have affected the catchment over the past 15 years. The biggest constraint relating to this flow series is the relative magnitude of the largest gauged flow compared to the largest recorded flow. The flow series from the Gorge is therefore likely to provide relatively robust estimates of the magnitude and frequency of various design events which affect the Mangatarere catchment.

The use of a flood hydrograph derived from the Gorge site is likely to under-estimate the volume of any flood event in the lower catchment. The change in flood magnitude, and attenuation of the flood wave as it moves through the catchment, are discussed later. However, design flood estimates derived from the Gorge annual maxima series can be scaled to account for the larger catchment area and flood attenuation downstream. The design flood hydrographs should be relatively robust, although confidence will decrease for the more extreme events.

2 Frequency Analyses

Design flow tables are developed by undertaking frequency analyses of the annual flood maxima series. Three types of statistical distributions were assessed (Gumbel, Pearson 3 (PE3) and GEV) for how well they modelled the actual flood maxima. The most appropriate distribution was then used to estimate flows for storm events of specific annual exceedence probabilities.

As is standard practice, the frequency analyses were performed on a 12-month partition. That is, only the largest value of each year was plotted, and the most appropriate statistical distribution fitted to those values. In a few cases it is difficult to find a single statistical distribution that provides the best model of the data. In these situations some subjectivity is required in selecting an appropriate model. The criteria adopted in this study were:

- The distribution that provided the best-fit through all the data points;
- The distribution with the most realistic shape;
- The distribution that provides the closest approximation to the extreme values; and
- The average of the distributions.

While this process may appear subjective, in most cases the choice of a specific statistical distribution results in relatively minor differences in the estimated flow magnitude-frequency table.

Using this approach, design flow tables were developed from the annual flood maxima series for the Mangatarere Stream at Gorge; Mangatarere at Belvedere Bridge and Mangatarere at SH2 Bridge (Table 2.1). This shows that the 1%AEP (i.e. the 100-year ARI flood) flood event has estimated peak discharges of 121.9m^3/s, 123.2m^3/s, and 261.0m^3/s respectively at the three sites. The corresponding frequency distributions for the Mangatarere Stream are shown in Figure 2.1, Figure 2.2 and Figure 2.3. It is apparent that the annual flood maxima series are modelled well by the PE3 statistical distribution at both the Gorge and Belvedere Bridge. The various design flood estimates are consequently likely to be reasonably robust.

Less confidence can be placed in the design flood estimates at the SH2 Bridge. This is largely a result of the relatively short flood maxima series available from this site.

Table 2.1 Mangatarere Stream design flow table (flows in m³/s).

		Gorge	Belvedere Bridge	SH2 Bridge
Distribution		**PE3**	**PE3**	**PE3**
AEP (%)	***ARI (yr)***			
39.3	*2.33*	70	71	172
18.1	*5*	87	89	210
9.5	*10*	97	99	229
4.9	*20*	106	108	243
2	*50*	116	117	255
1	*100*	122	123	261

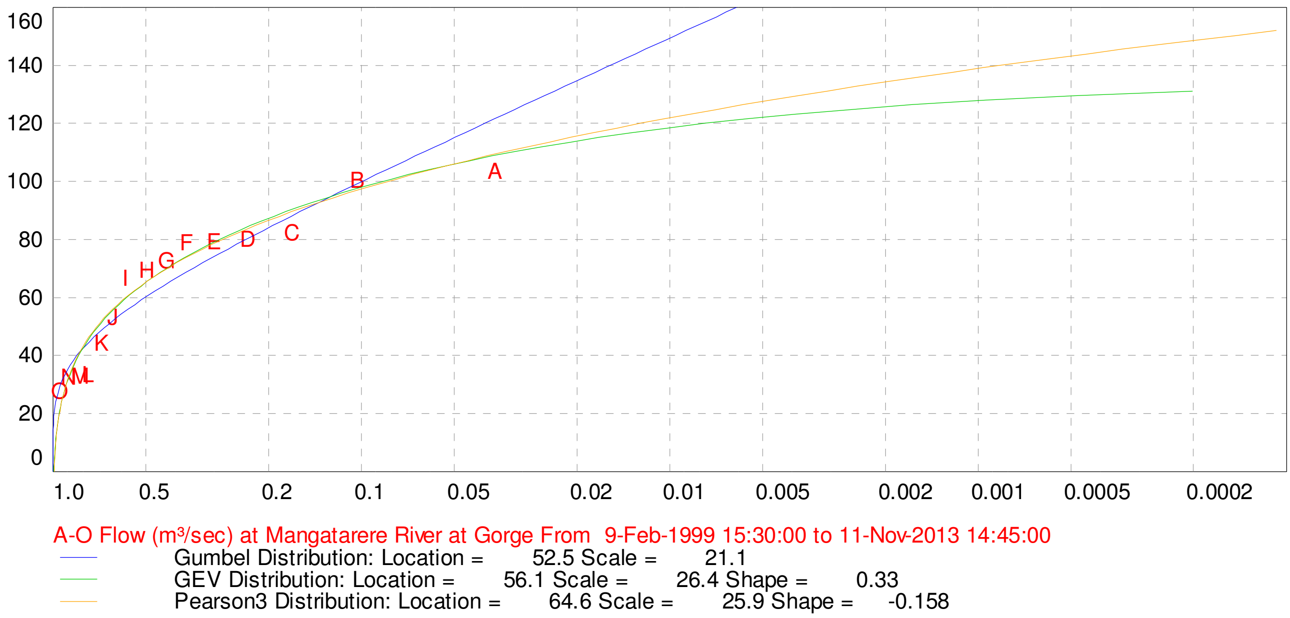

Figure 2.1 Mangatarere Stream at Gorge flow frequency analysis, 1999-2013.

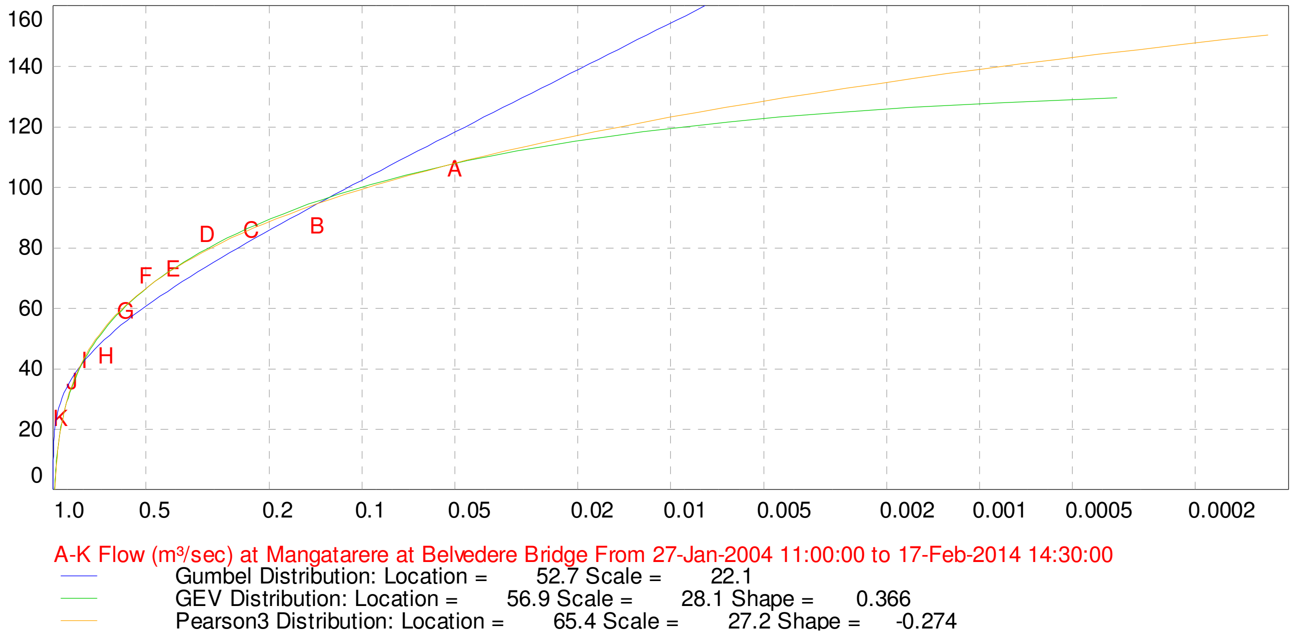

Figure 2.2 Mangatarere Stream at Belvedere Bridge flow frequency analysis, 2004-2014.

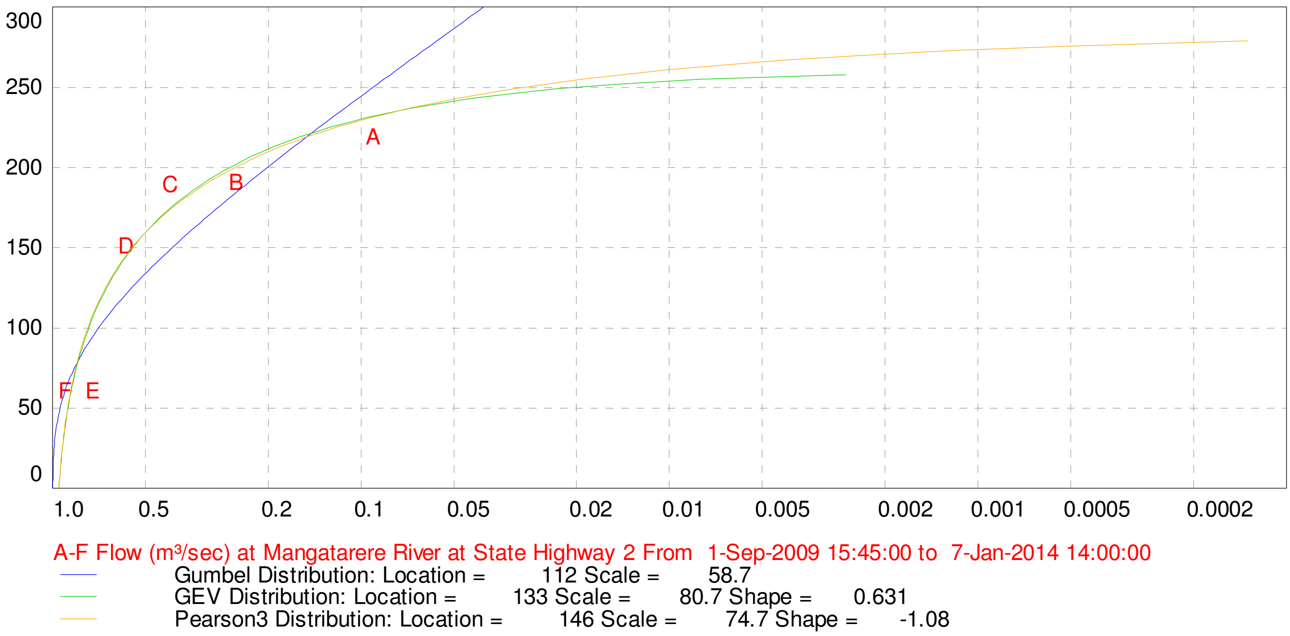

Figure 2.3 Mangatarere Stream at SH2 Bridge flow frequency analysis, 2009-2014.

3 Design Flood Hydrographs

There is a high degree of similarity in response in the Mangatarere Stream at Gorge during large flood events (Figure 3.1). The four largest flood hydrographs on record i.e. twice in 2004, 2000, and 2008, all have very similar shapes and characteristics.

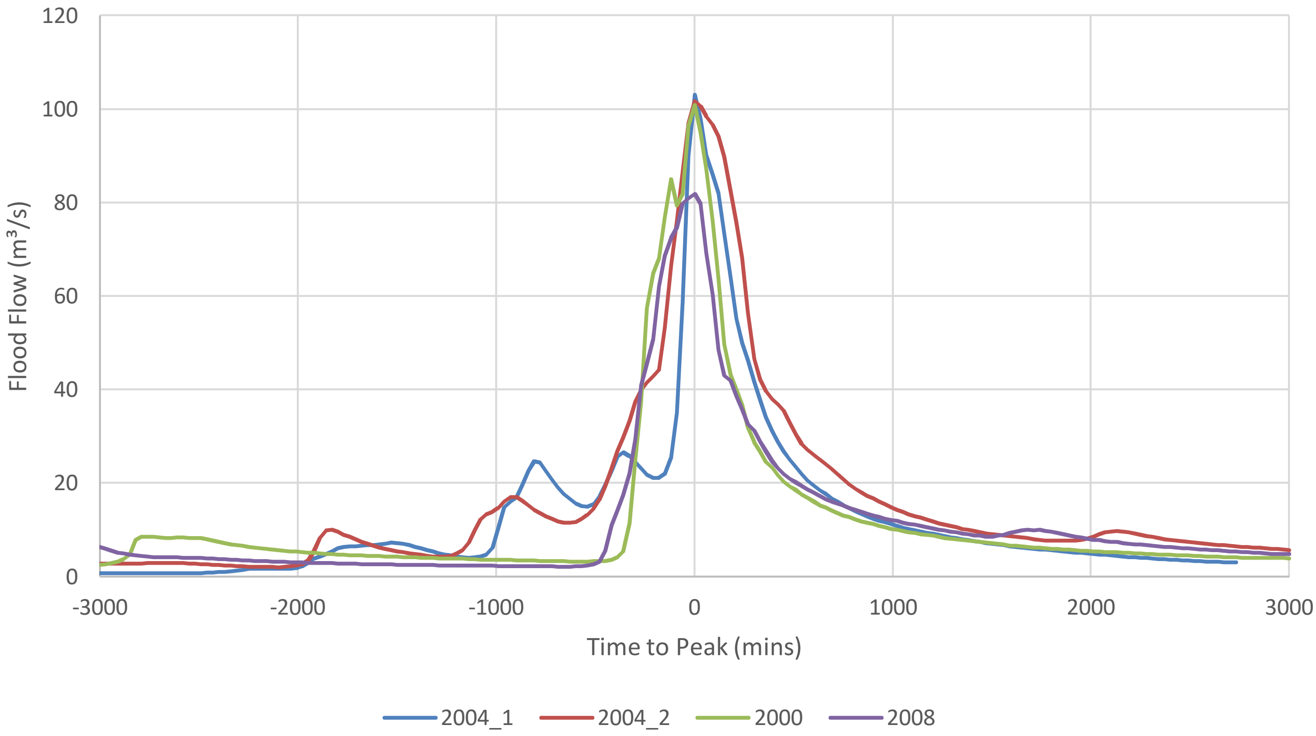

Figure 3.1 Comparison of the four largest floods on record in the Mangatarere Stream at Gorge (1999-2013).

Analysis of this series of flood hydrographs indicates a consistent pattern of runoff response to large rainstorm events within the Mangatarere catchment. The resulting floods typically have one major peak, often with a secondary peak just before the main peak. Water levels rise and fall rapidly with the main body of the flood lasting less than 24 hours.

Given the similarity of flood response over a range of events, it is likely that any future large flood will have very similar characteristics to those recorded in the past. The consistent nature of the flood response indicates that the use of a single type-hydrograph in any hydraulic model is appropriate.

4 Changes in Flood Magnitude

There is a high degree of similarity in response in the Mangatarere Stream at Gorge during large flood events. Flood events from the two shorter records were therefore correlated with events from the longer record at Gorge to determine whether consistent relationships exist between the flood magnitudes at the three sites. Figure 4.1 shows a moderate correlation between the flood magnitudes at Belvedere Bridge and at the Gorge. Approximately 58% of the variation in flood magnitudes at Belvedere Bridge can be explained by variation in the magnitudes of the same events at the Gorge. A weaker relationship exists between the flood magnitudes at the Gorge and SH2 Bridge (Figure 4.2).

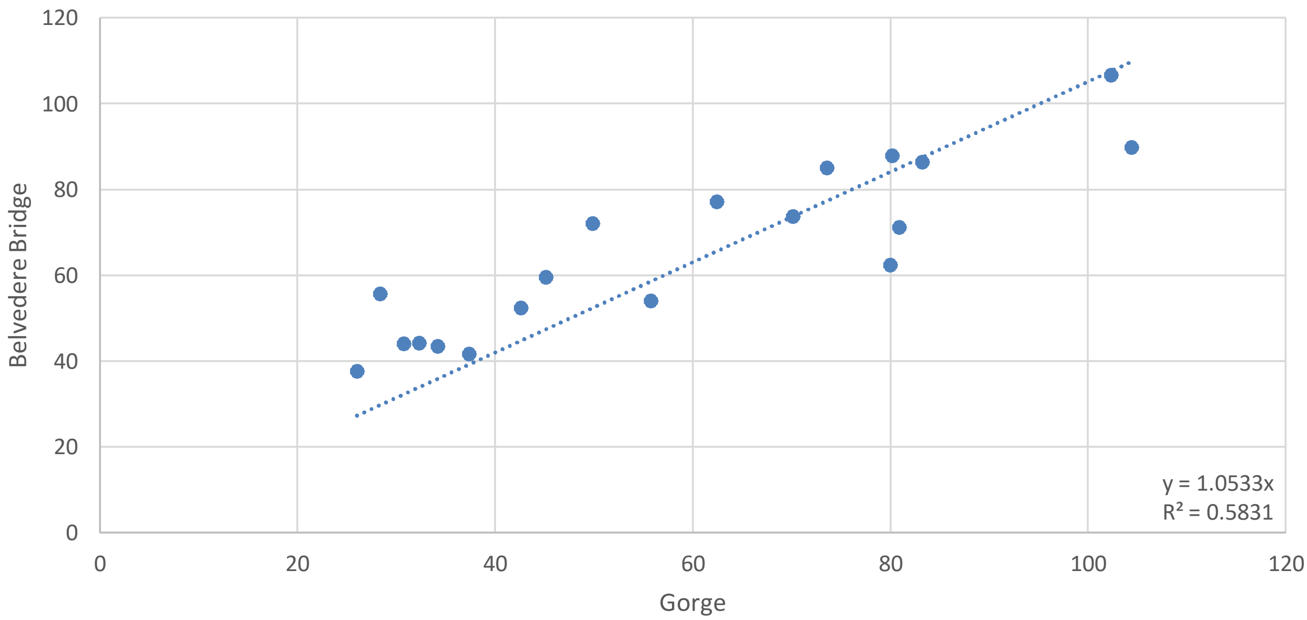

Figure 4.1 **The 20 largest floods on record at Belvedere Bridge correlated with the corresponding floods at the Gorge site (2004-2013).**

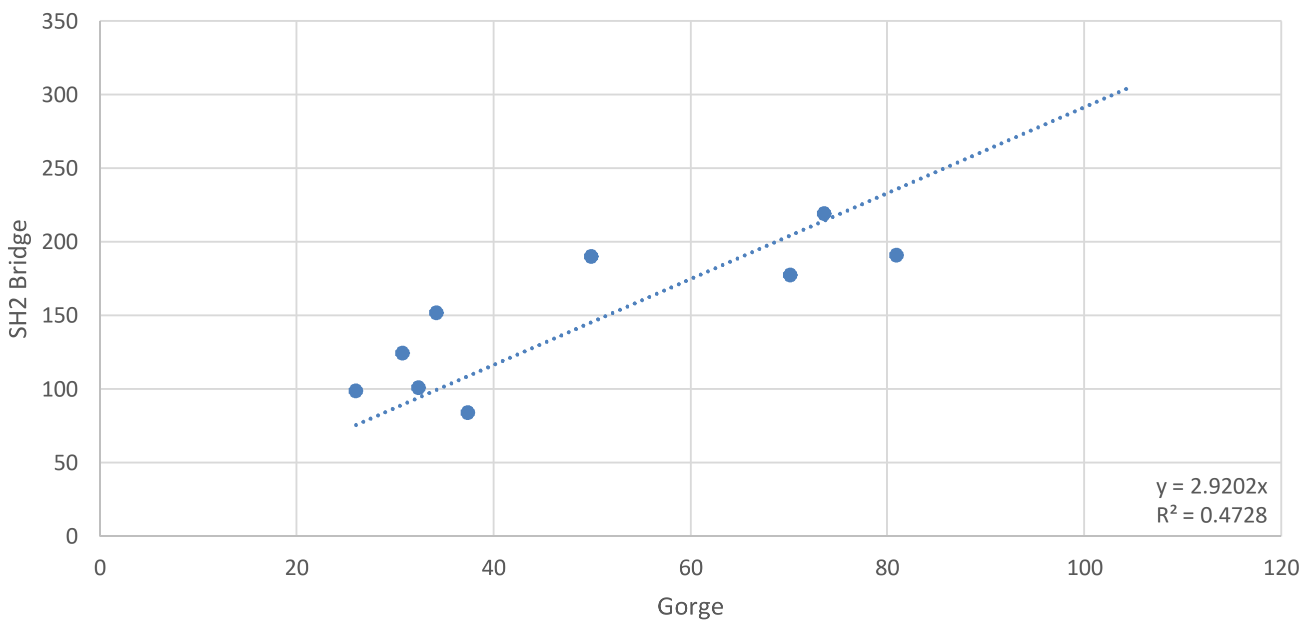

Figure 4.2 **The 10 largest floods on record at SH2 Bridge correlated with the corresponding floods at the Gorge site (2009-2013).**

It is interesting that the increase in flood magnitude downstream in the Mangatarere catchment does not appear to be a consistent simple function of catchment area. While it is generally accepted in New Zealand that flood magnitude varies as a function of the ratio of catchment area to the power of 0.8 (i.e. $A^{0.8}$), or simply the ratio of catchment area for low flows, this does not appear to be the case between the Gorge and Belvedere Bridge. It is likely that this is the result of the relatively steep rainfall gradient within the catchment, with significantly higher rainfalls and specific runoff upstream of the Gorge compared to the tributaries which enter downstream. In addition, the various tributary inputs to the main stem of the Mangatarere Stream are not regular and do not all drain similar terrain, with similar rainfall and rainfall-runoff relationships.

Although the magnitudes of only 10 flood events are correlated at the SH2 Bridge (Figure 4.2) the relationship actually does approximate flood magnitude varying as a function of the ratio of catchment $area^{0.8}$. For example, the ratio of catchment areas at these two sites, raised to the power of 0.8 is 2.77 compared to a slope of 2.92 shown on the graph.

The lack of high flow gaugings at Belvedere Bridge and the SH2 Bridge, and the relatively short flow records at these sites, means that the relationships regarding the change in flood magnitude downstream discussed above may not be robust.

It is suggested therefore, that the design flood events derived for the Gorge be used as the upstream boundary conditions to any hydraulic model. Additional flow should be input at the various tributaries as a function of the increase in catchment $area^{0.8}$. This is likely to result in slightly conservative design flows.

4.1 Flood attenuation

A particular flood can be 'traced' downstream past the three recorders on the Mangatarere Stream (Figure 4.3). This shows the time taken for the flood peak to move past the recorders, and also the attenuation of the peak as the flood wave moves downstream. For this flood, the lag time between the Gorge and Belvedere Bridge was 2.5 hours, and the lag time between Belvedere Bridge and SH2 Bridge was 1.0 hour.

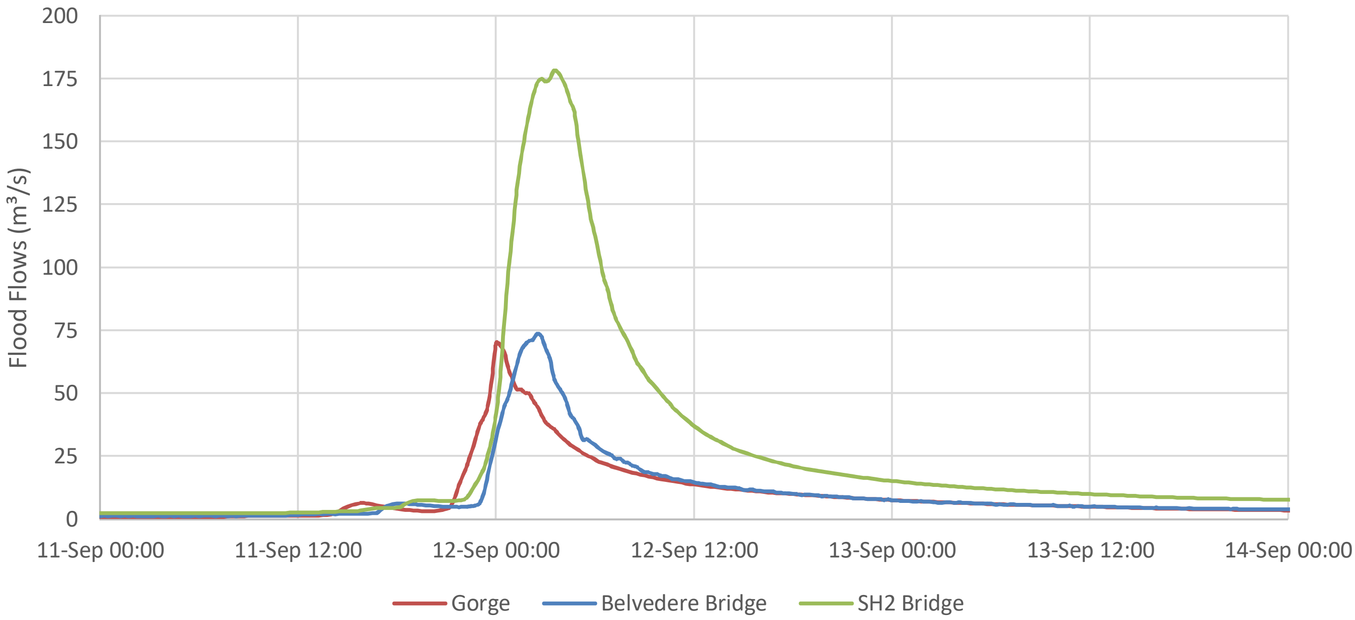

Figure 4.3 September 2013 flood showing the lag time and attenuation of the flood peak.

5 Climate Change

Incorporating the potential effects of predicted climate change into flood frequency analyses is problematic for a number of reasons. These include uncertainty over:

- The magnitude of predictions of increases in temperature. This uncertainty increases with the length of the period under consideration;
- The magnitude and significance of climate variability inherent in the annual flood maxima series;
- The relationship between increases in average temperature and increases in specific storm rainfall;
- The relationship between storm rainfall and event runoff and flood magnitude;
- The stability of the rainfall-runoff relationship with increasing flood magnitude and reducing flood frequency; and
- The stability of any existing rainfall-runoff relationship in response to climate change.

Consequently there is no single definitive way to include the potential effects of climate change into any flood frequency analysis. Any methodology adopted must involve a significant level of professional judgement and there will always be considerable residual uncertainty. This uncertainty must be accommodated through the use of conservative, but still realistic and reasonable, design flood estimates.

Many of these issues relate to 'theoretical' relationships which link changes in temperature to predicted changes in rainfall and consequential changes in runoff. There is currently no evidence of these relationships or their effect on the magnitude of floods within Mangatarere Stream.

5.1 Flooding in the Mangatarere

The longest available flow series is from the Mangatarere Stream at Gorge. This flow series shows no trends in flood activity besides the expected annual pattern (Figure 1.2). Both the magnitude and frequency of flood activity appear to be random, and the annual floods form a single series which approximates a PE3 statistical distribution. These characteristics of the flood activity are critical for robust frequency analysis.

These conclusions regarding flood activity in the Mangatarere Stream over the past 15-years are supported by a plot of the annual flood maxima series (Figure 5.1). The annual flood maxima series shows no significant trend over the past 15-years, although it could be argued that the largest flood each year has increased very slightly over time. The annual flood maxima series therefore shows no evidence of an increase in the magnitude of larger flood events in response to any temperature rise over this same period.

These conclusions are supported by McKerchar (2009) which concluded for adjacent catchments that "*No trend or cycles are apparent in the data. Also, no significant shifts corresponding to IPO phases are evident. It is concluded from this inspection that the data are free of trend, shifts, persistence and periodicity and that the standard extreme value analysis methods are applicable.*"

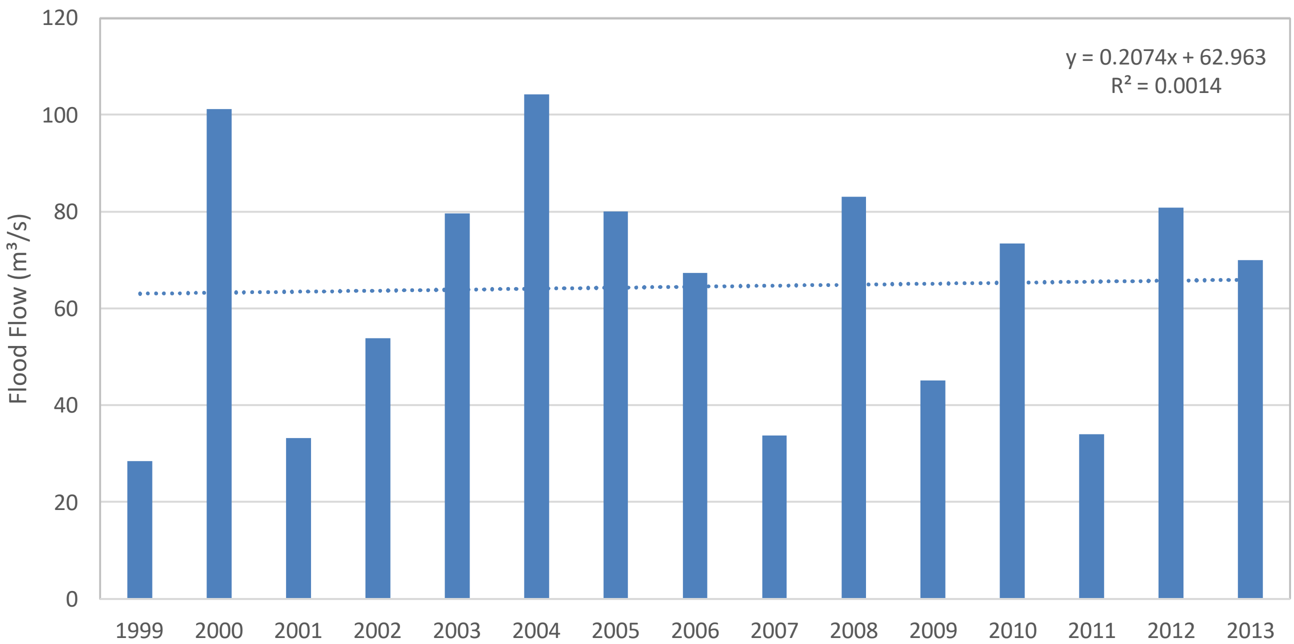

Figure 5.1 Annual flood maxima series for the Mangatarere at Gorge (1999-2013).

Since predicted increases in global temperatures are suggested to vary with season, any seasonality of flood activity is of importance. A review of the 10 largest floods over the past 15-years shows that 70% of the largest floods occurred in 'winter' or 'spring'; 40% in 'winter' and 30% in 'spring' (Figure 5.2).

It would appear therefore that flood activity in the Mangatarere Stream, is not related strongly to temperature. The passage of weather systems and antecedent conditions are more critical to flood activity than air temperature. Both the effects of past weather systems and antecedent conditions are inherent in the 15-year flow record of the Mangatarere Stream; as is any effect of temperature over the same period.

A review of the available data relating to flood activity in the Mangatarere Stream therefore shows:

- The apparent 'randomness' of both flood magnitudes and frequency over the past 15-years;
- No trend of increasing flood magnitude over time;
- The strong seasonality of the major floods within the catchment. The largest floods generally occur during 'winter' and to a lesser extent during 'spring'; and
- The lack of apparent 'control' of temperature on flood magnitude.

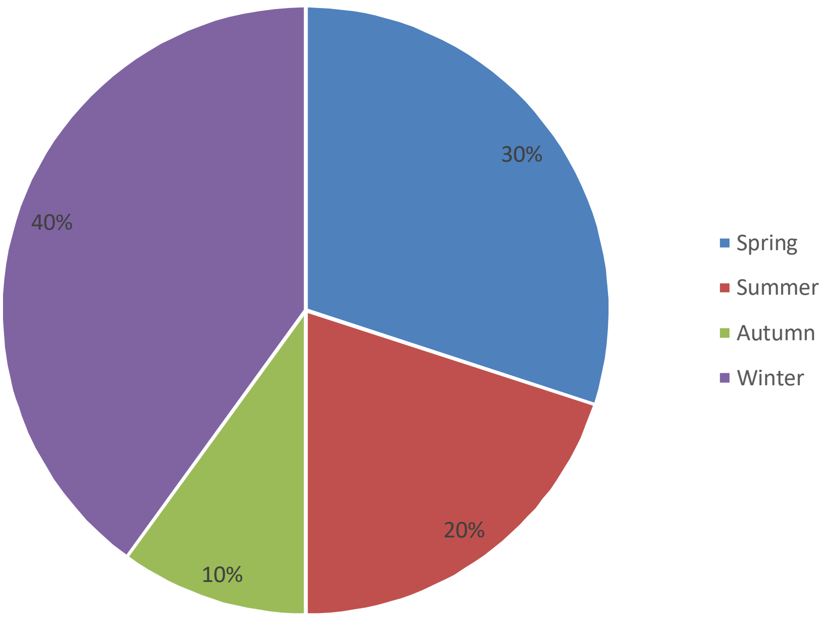

Figure 5.2 Seasonality of the 10 largest floods recorded in the Mangatarere Stream (1999-2013).

5.2 Incorporation of climate change

Notwithstanding the fact that no temperature-related trends are apparent in the annual flood maxima series for the Mangatarere Stream, the predicted effects of a rise in global temperatures on rainfall and runoff need to be considered.

Predicted temperature increase

Table 5.1 and Table 5.2 show the predicted changes in seasonal and annual mean temperatures for the Wellington Region. The increase in mean annual temperature based on the A1B scenario (Table 5.2) is the same as the average over all six illustrative scenarios (Table 5.1). Some consistency can therefore be assumed.

Table 5.1 Projected changes in seasonal and annual mean temperature (in °C) from 1990 to 2040 and 2090 for the Wellington Region. The average change, and the lower and upper limits (in brackets), over the six illustrative scenarios are given.

	Summer Dec-Jan-Feb	Autumn Mar-Apr-May	Winter Jun-Jul-Aug	Spring Sep-Oct-Nov	Annual
Wellington 2040	1.0 [0.2, 2.2]	1.0 [0.3, 2.5]	0.9 [0.2, 2.1]	0.8 [0.1, 1.9]	0.9 [0.3, 2.2]
Wellington 2090	2.2 [0.9, 5.7]	2.1 [0.6, 5.1]	2.1 [0.6, 5.0]	1.8 [0.3, 4.8]	2.1 [0.6, 5.2]

Table 5.2 Projected changes in annual mean temperature (in °C) from 1990 to 2040 and 2090 for the Wellington Region based on the A1B scenario.

	Annual
Wellington A1B 2040	0.9 [0.4, 1.5]
Wellington A1B 2090	2.1 [0.9, 3.6]

Even within just the A1B scenario, however, the predicted average change in temperature has a wide range of uncertainty. For example, by 2040 the uncertainty of the temperature increase is 1.1°C (0.4-1.5°C) compared to a predicted average increase of 0.9°C. By 2090 the uncertainty of the temperature increase is 2.5°C (0.9-3.6°C) compared to a predicted average increase of 2.1°C. The uncertainty of any predicted temperature rise out to 2115 would be even greater than that indicated in these examples.

It is significant that the predicted rise in 'winter and spring' temperatures, the seasons which experience more frequent floods in the Mangatarere catchment, is less than that assumed over the entire year. It is likely therefore that within the Mangatarere catchment, even if flood activity was related to temperature, any effects of a rise in temperature would be less than that assumed from mean annual temperature changes.

Despite the fact that any link between temperature and flood activity, both magnitude and frequency, within the Mangatarere catchment is at best weak, the magnitude of design flood events were increased in proportion to predicted rises in temperature and argued consequential increases in rainfall and runoff i.e. 8% per degree of warming. That is, the current design flood peaks can be increased by 7.2% to account for changes out to the 2040s, and 16.8% to account for possible changes out to the 2090s. If a 100-year future design event is required then increasing the magnitude of the design flood event by 20% would be appropriate. This is also consistent with the current GWRC policy.

Table 5.3 Mangatarere Stream design flow table for the Gorge, with adjustments for climate change (flows in m³/s).

		Current	2040s	2090s	2115
Distribution		PE3			
ARI (y)	*AEP (%)*				
2.33	*39.3*	70	75	82	84
5	*18.1*	87	93	101	104
10	*9.5*	97	104	114	117
20	*4.9*	106	114	124	127
50	*2*	116	124	135	139
100	*1*	122	131	142	146

Conclusion

Incorporating the potential effects of climate change into flood frequency analyses is problematic for a number of reasons. An analysis of the 15-year flow record from the Mangatarere Stream indicates that any link between temperature and flood activity, both magnitude and frequency, is weak. Despite this, it is proposed to increase the magnitude of design floods in proportion to predicted rises in temperature and rainfall i.e. by 8% per predicted degree of warming.

There is no evidence from the annual flood maxima series of an increase in either flood magnitude or frequency over the past 15-years. Flood magnitude is affected by the particular characteristics of the weather system delivering the rainfall, its path relative to the catchment, and antecedent conditions. The interaction of all these variables are difficult, if not impossible, to model. However, the catchment response to the interaction of these variables over the past 15 years is inherent in the flood maxima series. This flood maxima series therefore provides a robust basis for the analysis of the likely frequency and magnitude of future flood events.

The adoption of a level of detail and sophistication greater than what has been proposed would imply a level of understanding, and stronger causal links between various factors affecting the rainfall-runoff process, than is reasonable or realistic.

The proposed increase in the various design flood magnitudes by the percentage increase in predicted rainfall to account for the effects of climate change is likely to be conservative (i.e. producing higher than actual flood magnitudes).

6 Inflow Hydrographs

Design flood hydrographs for both the main stem of the Mangatarere Stream and its major tributaries are needed as inputs for any hydraulic model. Therefore, the largest flood on record (i.e. the flood of 12-Feb-2004) at the Gorge was scaled to the estimated magnitude of the 1% design event (i.e. 100 year ARI) design peak, and also to the climate-adjusted 1% AEP design flood peak estimated by 2115 (Figure 6.1).

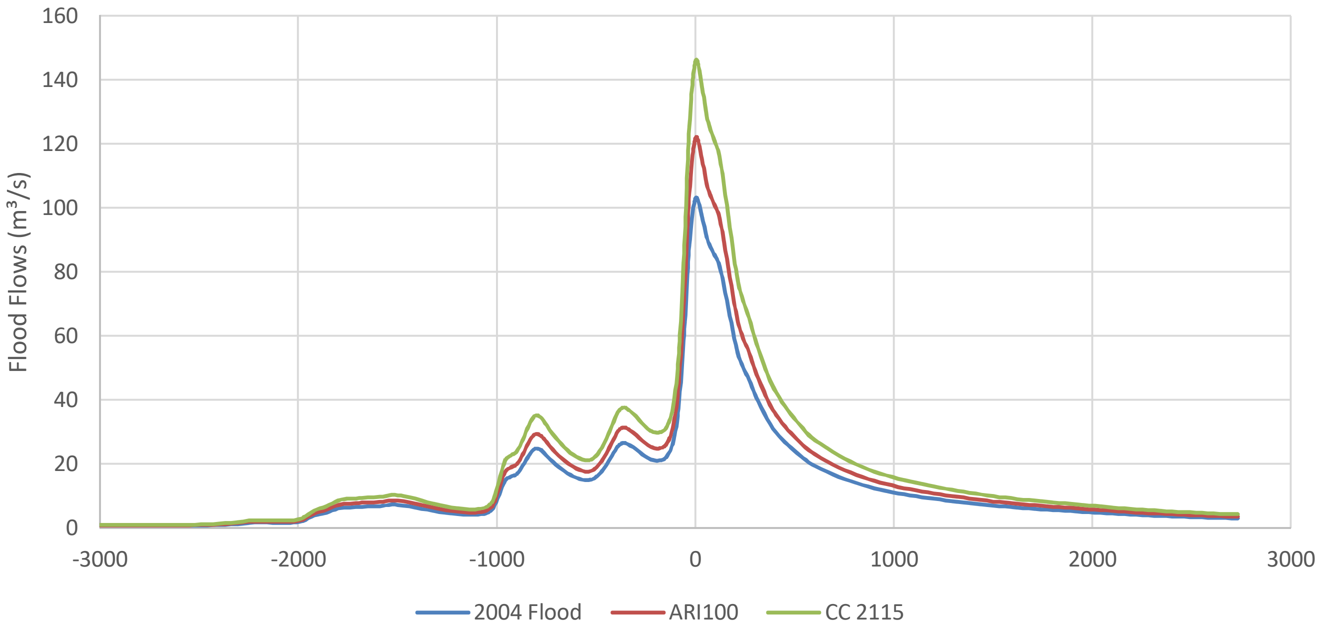

Figure 6.1 Flood hydrographs for the Mangatarere Stream at Gorge.

Design inflow hydrographs are also required for the major tributaries which enter Mangatarere Stream downstream of the Gorge monitoring site. No flow information is available specific to these tributaries. These tributaries enter at locations A through D on Figure 6.2.

The catchment areas upstream of each confluence were determined (Table 6.1). The ratio of the change in catchment area to the power of 0.8 (i.e. $A^{0.8}$) was used to scale the design flood hydrographs estimated for the Gorge (Figure 6.1) to those expected at the other downstream locations (Figure 6.3 and Figure 6.4). Previous work has shown that flood magnitudes in New Zealand vary as a function of catchment area to the power of 0.8 (i.e., $A^{0.8}$), rather than simply by catchment area (McKerchar and Pearson, 1989). While the exact reasons for this have not be discussed, it is likely to relate to the average rainfall depth and storm intensity which both decrease with increasing catchment size.

The local design inflow hydrograph was then obtained by subtracting the upstream hydrograph from the downstream hydrograph. For example, the local inflow hydrograph for the tributary entering at Point B was obtained by subtracting the design hydrograph at Point A from that at Point B (Figure 6.5 and Figure 6.6).

Table 6.1 Catchment areas of the gauging stations and inflow hydrograph points.

Catchment	Area (km²)
Mangatarere at Gorge	33.2
Point A	41.0
Mangatarere at Belvedere Bridge	55.9
Point B	85.0
Point C	117.3
Mangatarere at SH2 Bridge	118.6
Point D	150.9

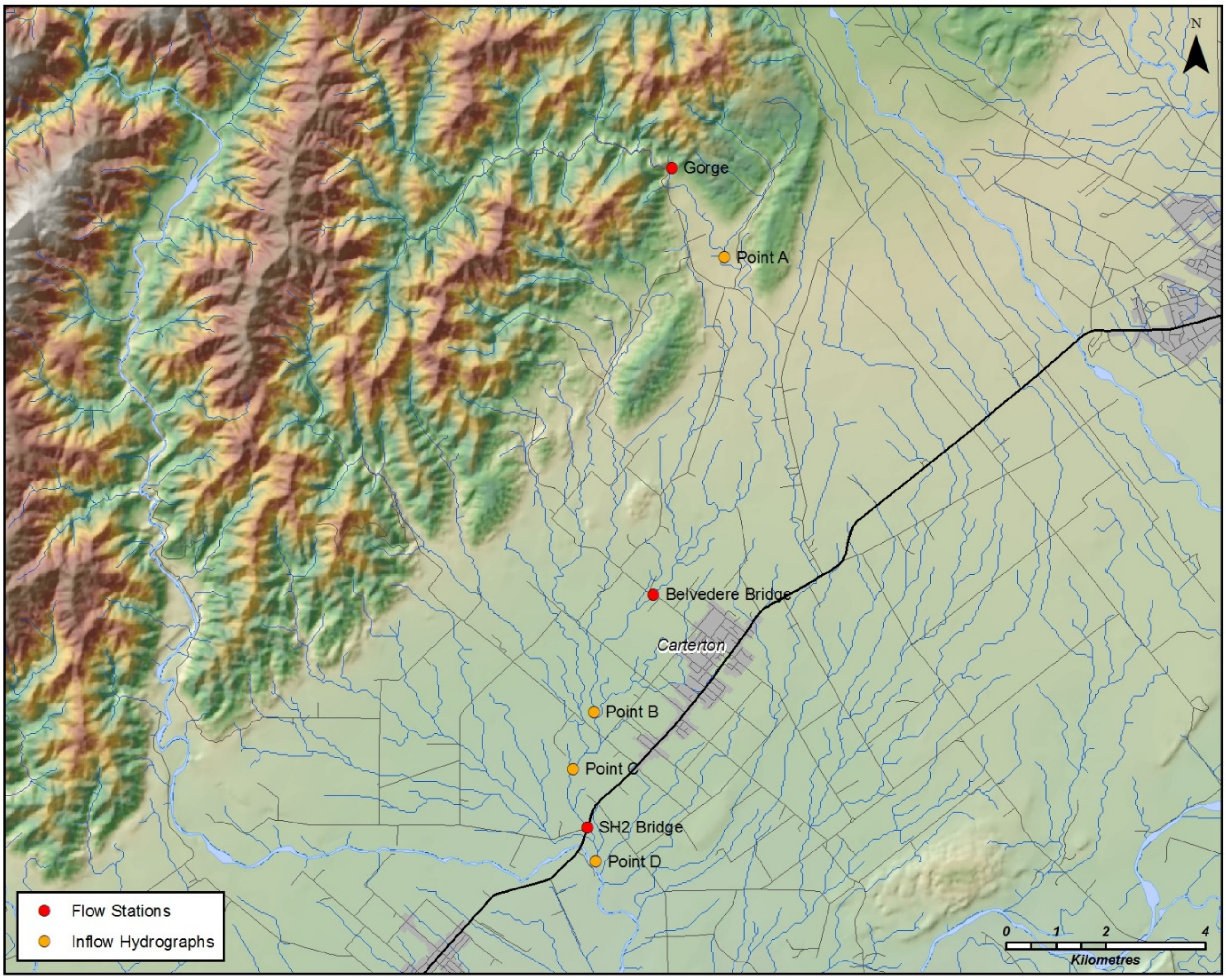

Figure 6.2 Location of the flow stations and also the location of each of the inflow hydrographs.

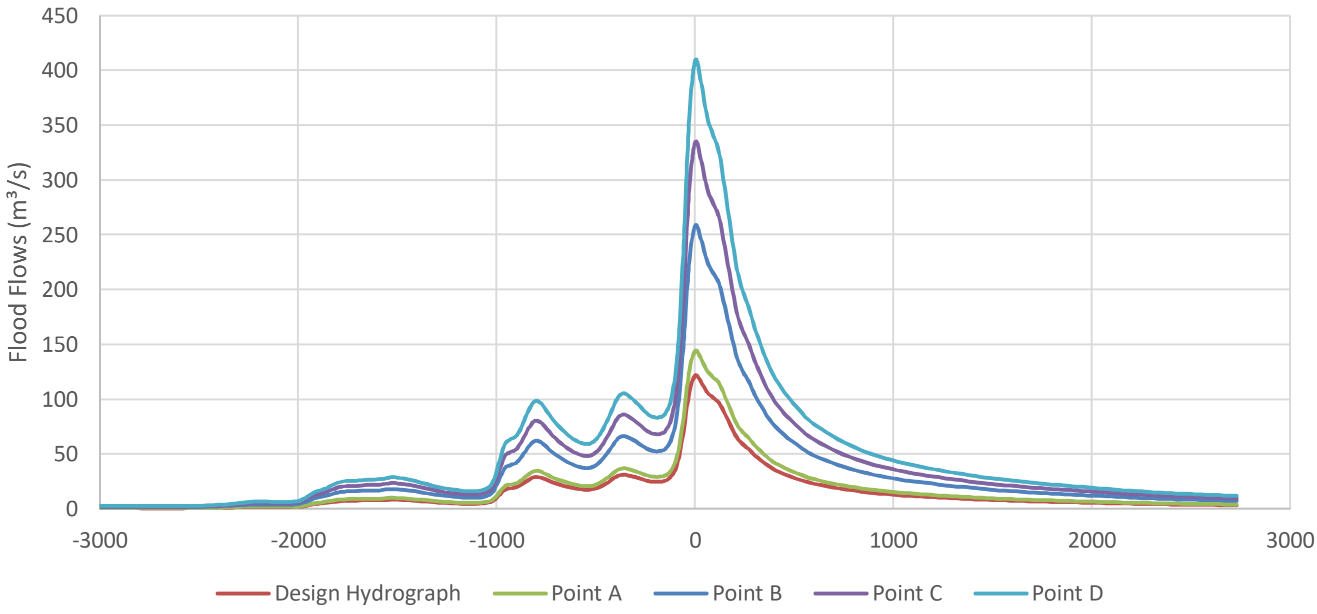

Figure 6.3 Flood hydrographs for the 1% AEP design event at each location.

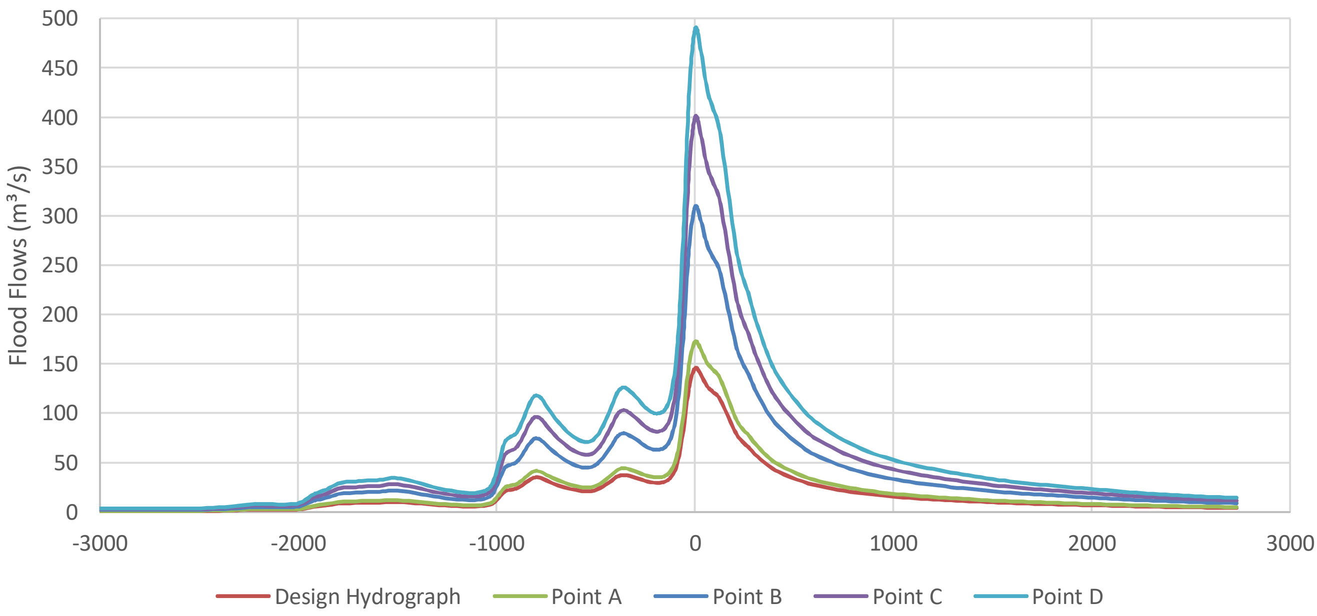

Figure 6.4 Flood hydrographs for the 1% AEP design event + climate change effect to 2115 at each location.

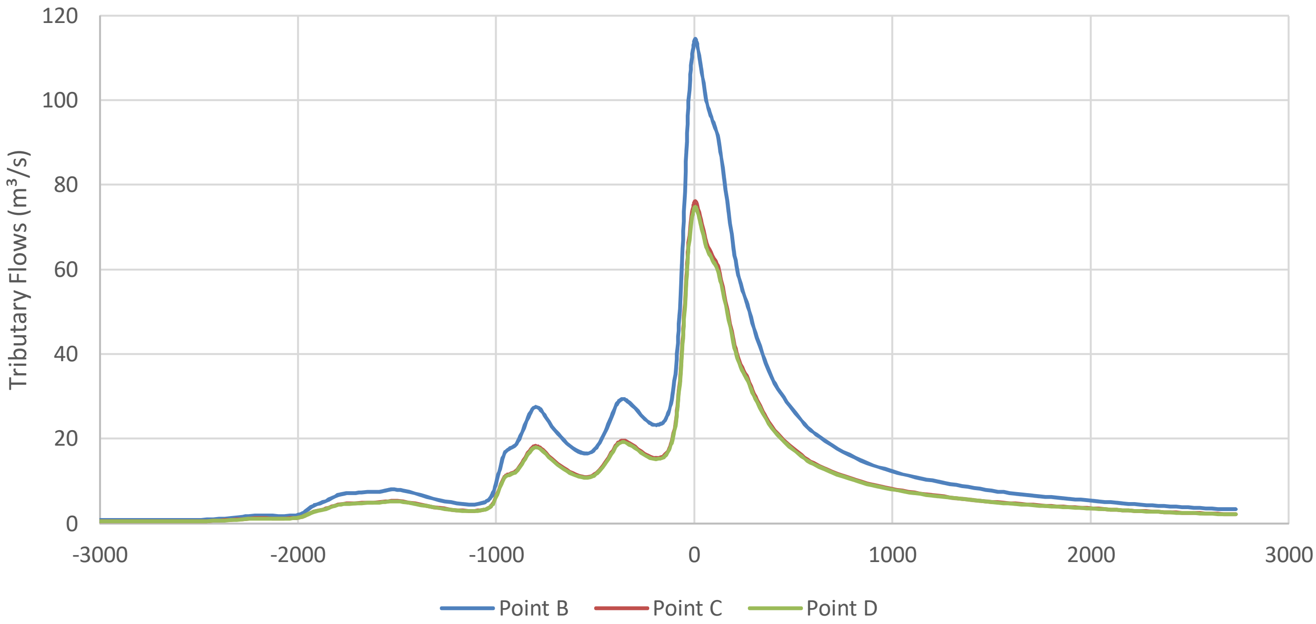

Figure 6.5 **Local inflow hydrographs for the three major tributaries during the 1% AEP design event.**

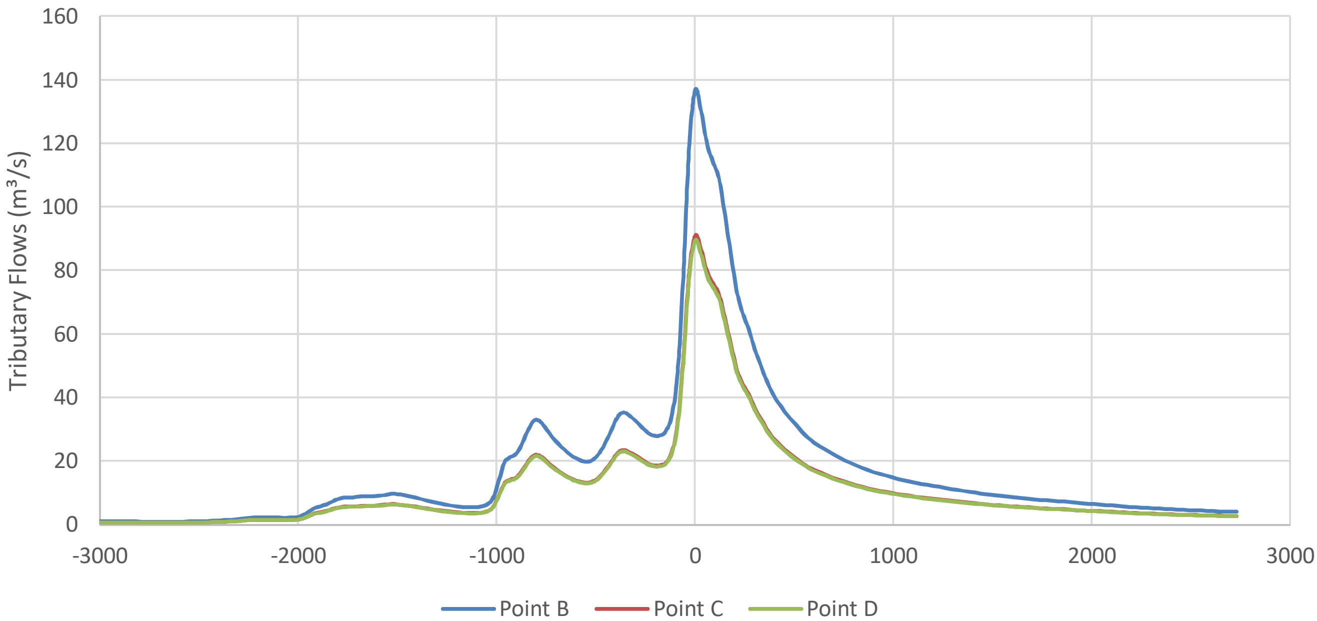

Figure 6.6 **Local inflow hydrographs for the three major tributaries during the 1% AEP + climate change effect to 2115 design event.**

The travel time to each local inflow hydrograph can be determined using the average lag times for a flood wave to pass downstream past the three gauging sites. For the design flood, the lag time between the Gorge and Belvedere Bridge was 2.5 hours, and the lag time between Belvedere Bridge and SH2 Bridge was 1.0 hour. Using the distance between each point the flood travel times from Location A to Locations B-D were determined (Table 6.2).

Table 6.2 Lag times between the major tributaries.

Location	Lag time (hrs)
Gorge to Belvedere Bridge	2.5
Belvedere Bridge to SH2 Bridge	1.0
Location A to Location B	2.5
Location A to Location C	2.7
Location A to Location D	3.1

7 References

McKerchar, A.I.; Pearson, C.P. 1989: Flood frequency in New Zealand. Publication No. 20 of the Hydrology Centre, Christchurch, Division of Water Sciences, Department of Scientific and Industrial Research.

McKerchar, A. 2009: Review of flood hydrology for the Waikanae and Otaki Rivers. Report prepared for Greater Wellington Regional Council. NIWA client report: CHC200-158, January 2009, NIWA Project: WRC09503

Opus International Consultants Ltd
L10, Majestic Centre, 100 Willis St
PO Box 12 003, Thorndon, Wellington 6144
New Zealand

t: +64 4 471 7000
f: +64 4 499 3699
w: www.opus.co.nz