

## **Appendix E**

# **Mangaone Stream at Ratanui Hydrological Gauging Station –Influence of IPO on Stream Flow**

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## Cyclic behaviour and trends

Climatic trends and oscillations have the potential to bias any rainfall or flow record. This is not a major issue with long-term records that include a number of oscillations e.g. positive and negative phases of the IPO, or El Niño and La Niña phases of the SOI. The effects of both phases of the oscillation will be inherent in the flow record, and their effects will therefore be included in the results of any hydrometric analysis. However, when a flow record coincides largely with one or other of these phases, the data may be biased. The resulting record may reflect either higher or lower flows depending on the exact period of the record.

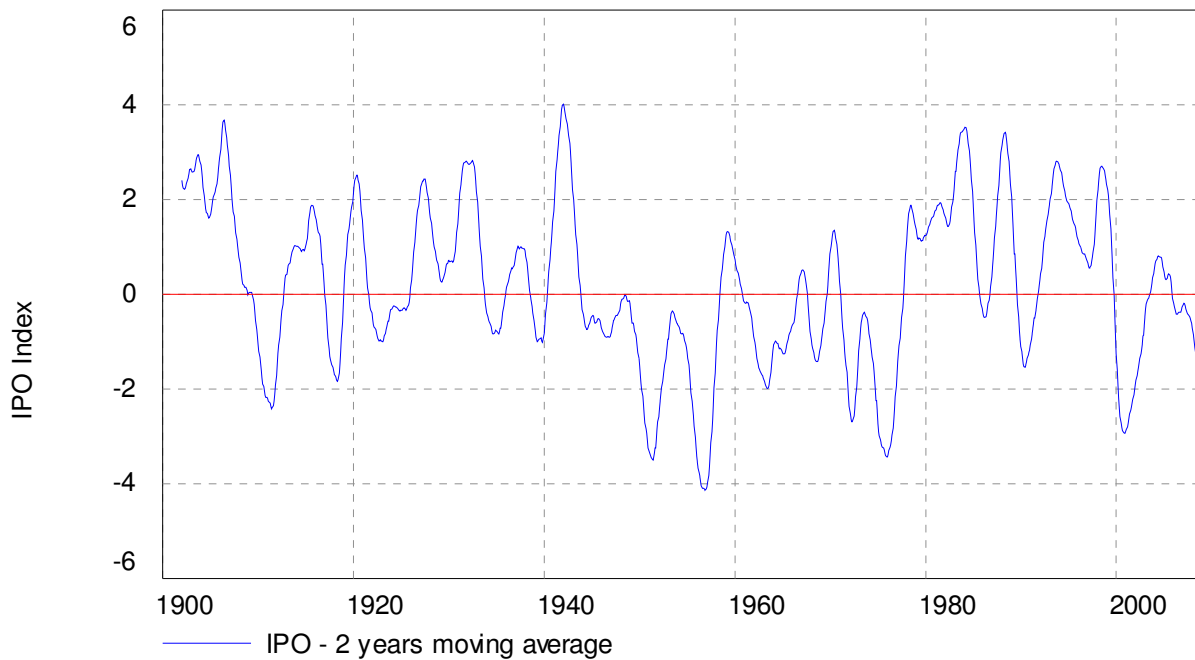
The flow record for Mangaone Stream is only 18 years long. This record is therefore too short to determine with any certainty whether various climatic oscillations (i.e. IPO or SOI) affect the flow regime.

### Interdecadal Pacific Oscillation

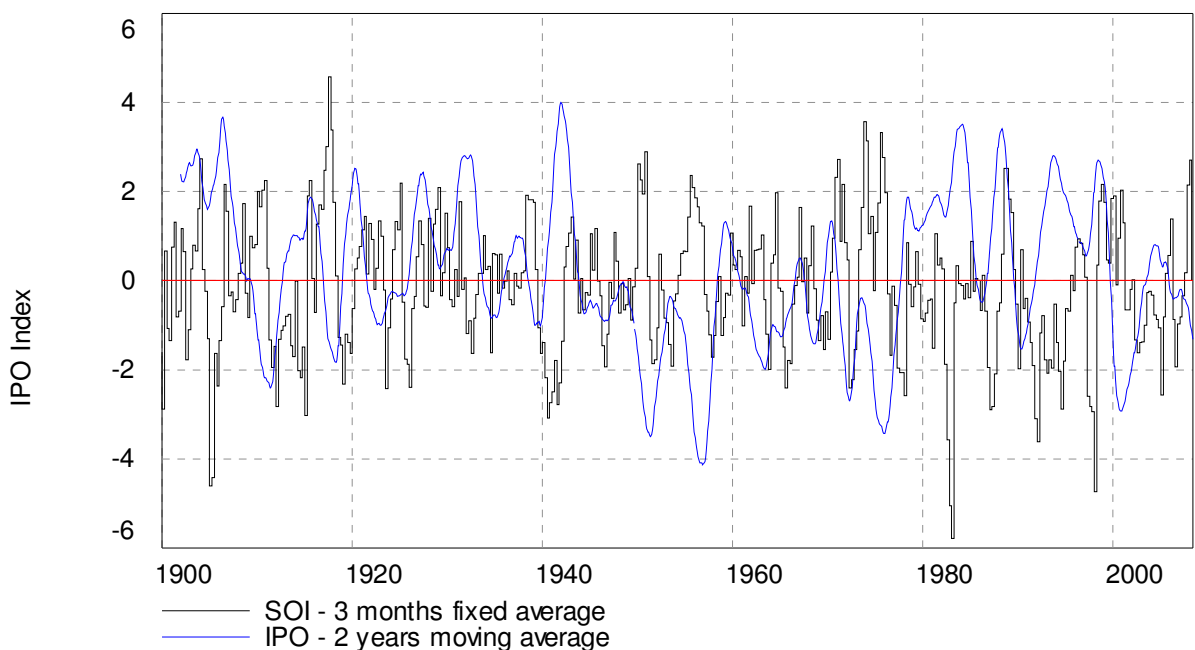
The Interdecadal Pacific Oscillation (IPO) is a climatic fluctuation in atmospheric and sea surface temperatures (i.e. SST) in the Pacific Basin that operates over a time scale of decades. Studies have shown that in some areas of New Zealand there is a strong correlation between heavy rainfall and flooding, and the IPO phases. This results in successive 'benign' and 'active' phases in flooding that occur in conjunction with negative and positive phases of the IPO respectively. A positive IPO phase persisted from 1922-1945, and again from 1977-1999; while from 1946-1976 the IPO was in a negative phase. The IPO is currently in a negative phase, and so the incidence of heavy rainfall is likely to be less than the long-term average (Figure 1). The flow record for the Mangaone Stream used in the analysis runs from 1993-2011 and therefore includes some of both the positive and negative phases of the IPO, although significantly more of the negative phase.

Shifts in the IPO modulate the frequency of occurrence and intensity of El Niño and La Niña phases of the ENSO (i.e. El Niño – Southern Oscillation). The positive phase is most commonly associated with higher frequency and intensity of El Niño-like conditions, while the negative phase is associated with a prevalence of La Niña patterns. For example, more El Niño episodes occurred from 1978 to 1999 than the previous three decades which saw more La Niña episodes (McKerchar & Henderson, 2003) (Figure 2). El Niño episodes tend to give more rain in the south and west of the country, and drier conditions in the northeast. La Niña episodes tend to give less rain in the south and east, and more rain in the north-east.





**Figure 1: Variation in the IPO phase which has been related to changes in the rainfall regime. (Source: [www.iges.org/c20c/IPO\\_v2.doc](http://www.iges.org/c20c/IPO_v2.doc))**



**Figure 2: Relationship of the SOI index with the IPO phase.**

Recent climatological studies have demonstrated that the assumption of stationarity (i.e., that all data are drawn from the same continuous population) may not be valid, at least for annual rainfall in New Zealand. Compared with the period 1947-1977, consistent rainfall decreases of up to 8% occurred for the period of 1978-1999 in the north and east of the North Island, and increases of up to 8% occurred in the west and south of the South Island. These changes are attributed to shifts in the phase of the IPO.



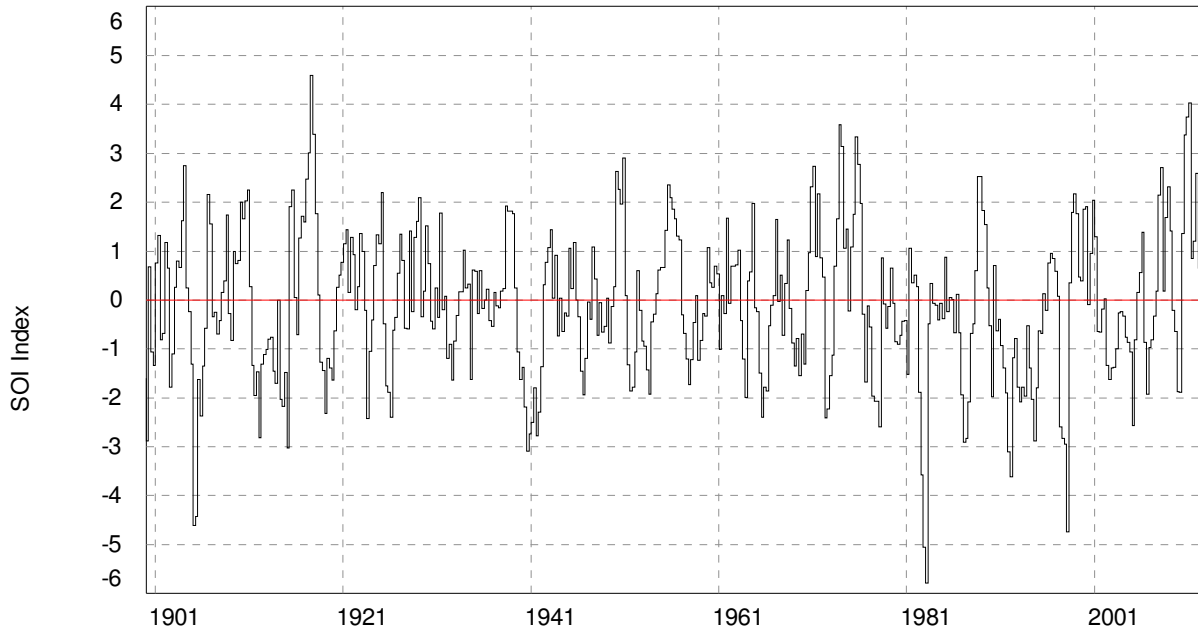
## El Niño – Southern Oscillation

The El Niño – Southern Oscillation (ENSO) is a global climate phenomenon that is triggered by changes in the ocean-atmosphere system in the tropical Pacific. These changes are measured by the pressure difference between Tahiti and Darwin known as the Southern Oscillation Index (SOI).

El Niño, the negative phase in the SOI, occurs when the westerly trade winds soften, and warmer sea surface temperatures (SSTs) occur off the coast of South America. Although New Zealand is not usually affected as strongly by El Niño conditions as parts of Australia, there is often still a significant influence. Typically, during El Niño conditions New Zealand experiences stronger and more frequent westerly winds in summer, and lower SSTs. During summer months this can lead to higher rainfall in south-western parts of the South Island, and drought conditions in the east. These conditions also bring more benign weather in the north and east of the North Island. During winter the wind becomes dominant from the south, leading to overall colder conditions. El Niño conditions generally bring colder temperatures. These are more noticeable in the North Island in all but the summer months (Kidson and Renwick, 2002). Although El Niño has an important influence on New Zealand's climate, it accounts for less than 25% of the year to year variance in seasonal rainfall and temperature at most New Zealand measurement sites. East coast droughts may be common during El Niños, but they can also happen in non El Niño years (for example, the severe 1988-89 drought). Also, serious east coast droughts do not occur in every El Niño, and the districts where droughts occur can vary from one El Niño to another. However, the probabilities of the climate variations discussed above happening in association with El Niño are sufficient to warrant their consideration. Where the effects of these climatic variations are considered significant, appropriate management actions and planning can be implemented.

Alternatively La Niña, the positive SOI phase, occurs when strengthened trade winds and colder SST in the eastern Pacific extend further west than usual. La Niña years tend to have a weaker effect on the climate of New Zealand; with more north-easterly winds which bring more moist, rainy conditions to the north-east parts of the North Island, and reduced rainfall to the south and south-west of the South Island. Warmer temperatures are typically experienced over the whole country. Higher rainfall is experienced in the north and eastern part of the North Island during summer.

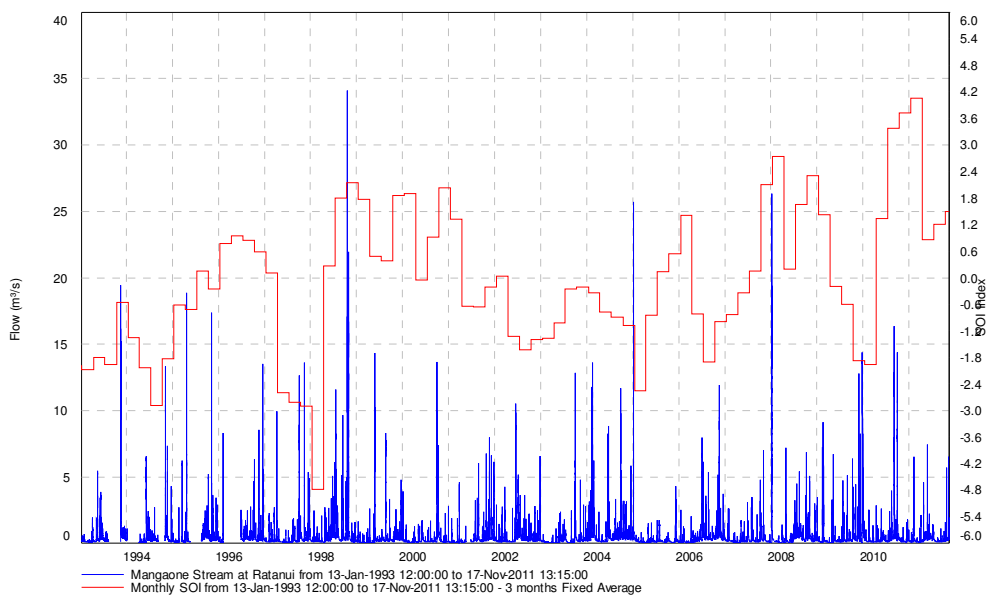
Consequently, the ENSO has the potential to affect the climate of the Mangaone catchment, and as a result the runoff regime and the frequency and magnitude of flood events. The inter-annual ENSO events vary in strength, can last from several months to several years, and tend to occur three to seven years apart. Figure 3 shows the occurrence of the ENSO events from 1900-2012. More recently, a La Niña event occurred during the summer of 2010 and 2011.



**Figure 3: Variation in the 3-month average SOI index. (Source: [www.cgd.ucar.edu/cas/catalog/climind/soi.html](http://www.cgd.ucar.edu/cas/catalog/climind/soi.html))**

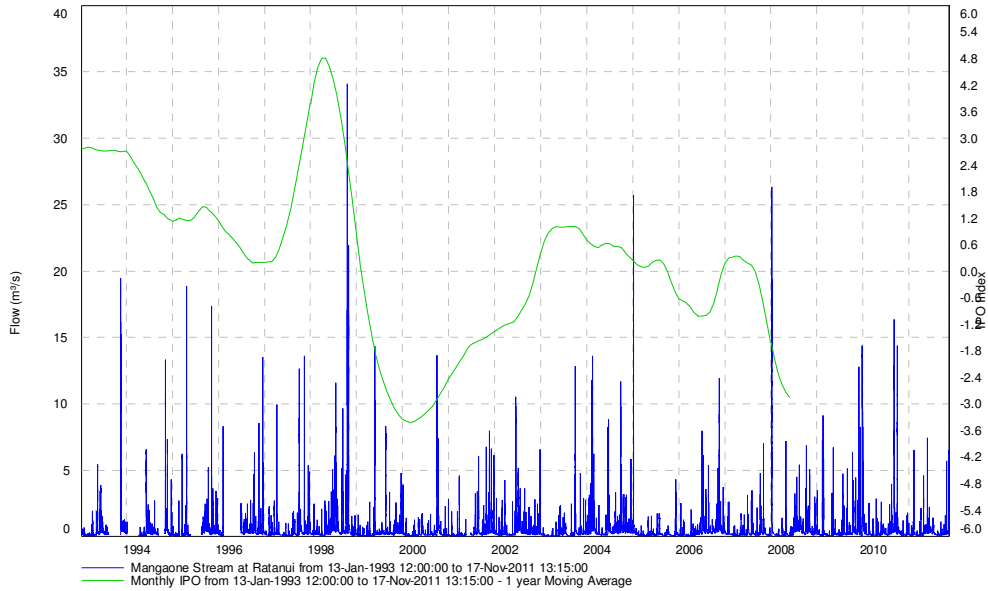
### Effect of climatic oscillations

Variations in the SOI and IPO were compared to both the flow regime (Figure 4 & Figure 5) and various flow statistics from Mangaone Stream. Over the 18 years for which data are available there is no strong evidence of either the SOI or IPO affecting the flow regime, or the magnitude and frequency of flood events in Mangaone Stream. Therefore, while various climatic indices may affect rainfall patterns in some areas of New Zealand, and in particular variability of rainfall, a strong signature is not apparent in the available flow record for Mangaone Stream. This may be because of the length of the flow record, the location of the catchment, or because runoff in a river is the net result of a wide range interacting factors.



**Figure 4: Comparison of the flow regime of Mangaone Stream with variation in the SOI (1993-2012).**





**Figure 5: Comparison of the flow regime of Mangaone Stream with variation in the IPO (1993-2012).**

To further assess any potential link between flow and climatic oscillations, the annual average SOI and IPO indices were compared to the annual median, minima; and maxima flows for Mangaone Stream (Figure 6 to Figure 11).

These graphs confirm that there is no direct relationship between variation in the SOI or IPO and changes in the annual median, maximum or minimum flows, at least over the duration of the available flow record for the Mangaone Stream.

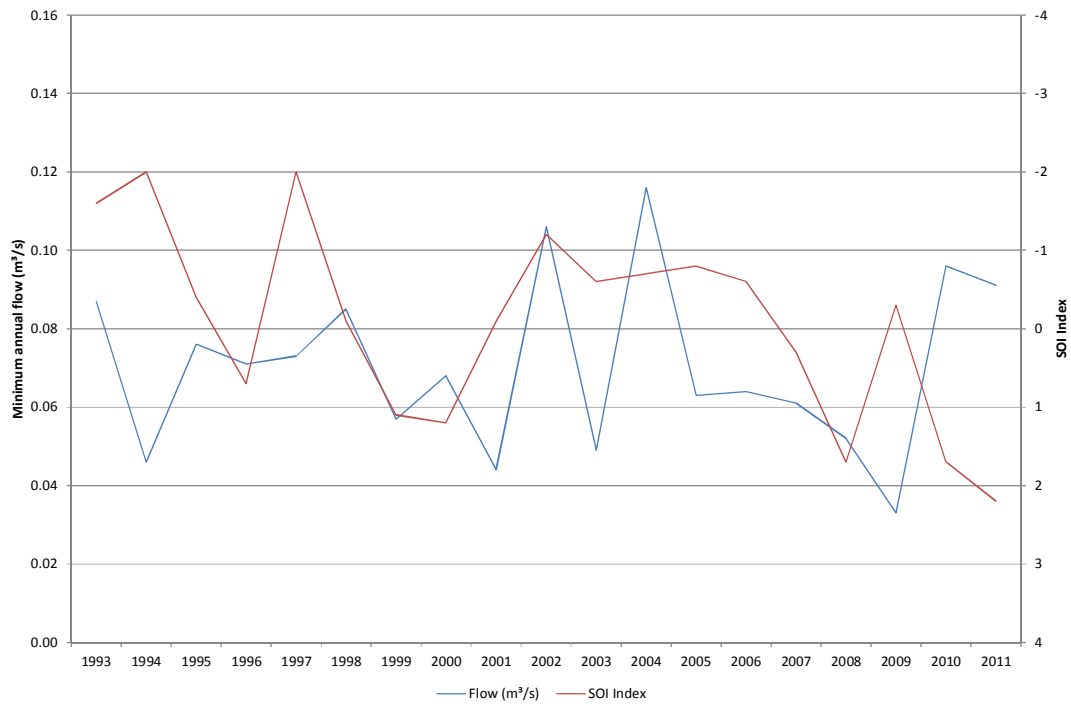


**Figure 6: Comparison of the median annual flows in Mangaone Stream with variation in the SOI (1993-2012).**



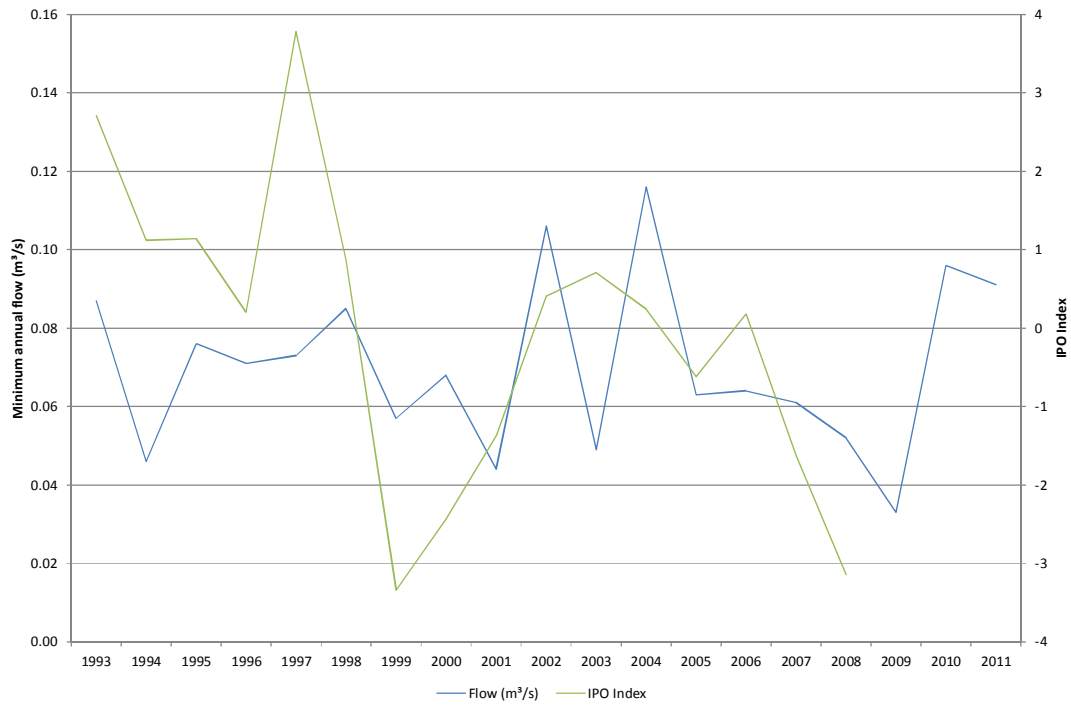


**Figure 7: Comparison of the median annual flows in Mangaone Stream with variation in the IPO (1993-2012).**

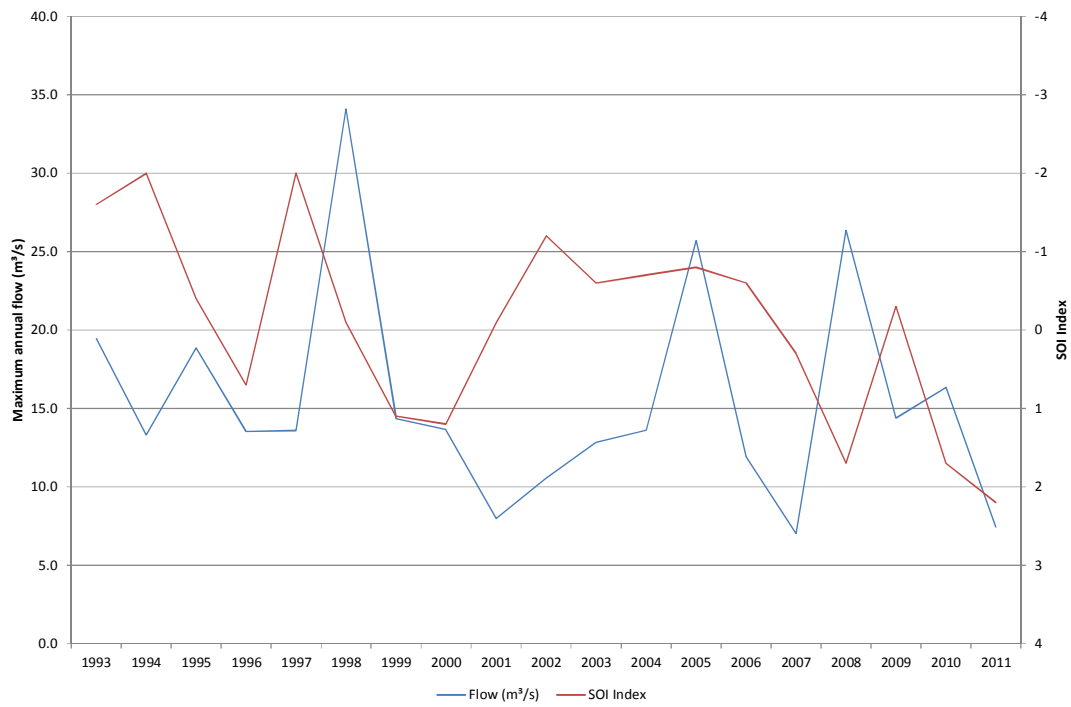


**Figure 8: Comparison of the minimum annual flows in Mangaone Stream with variation in the SOI (1993-2012).**





**Figure 9: Comparison of the minimum annual flows in Mangaone Stream with variation in the IPO (1993-2012).**



**Figure 10: Comparison of the maximum annual flows in Mangaone Stream with variation in the SOI (1993-2012).**







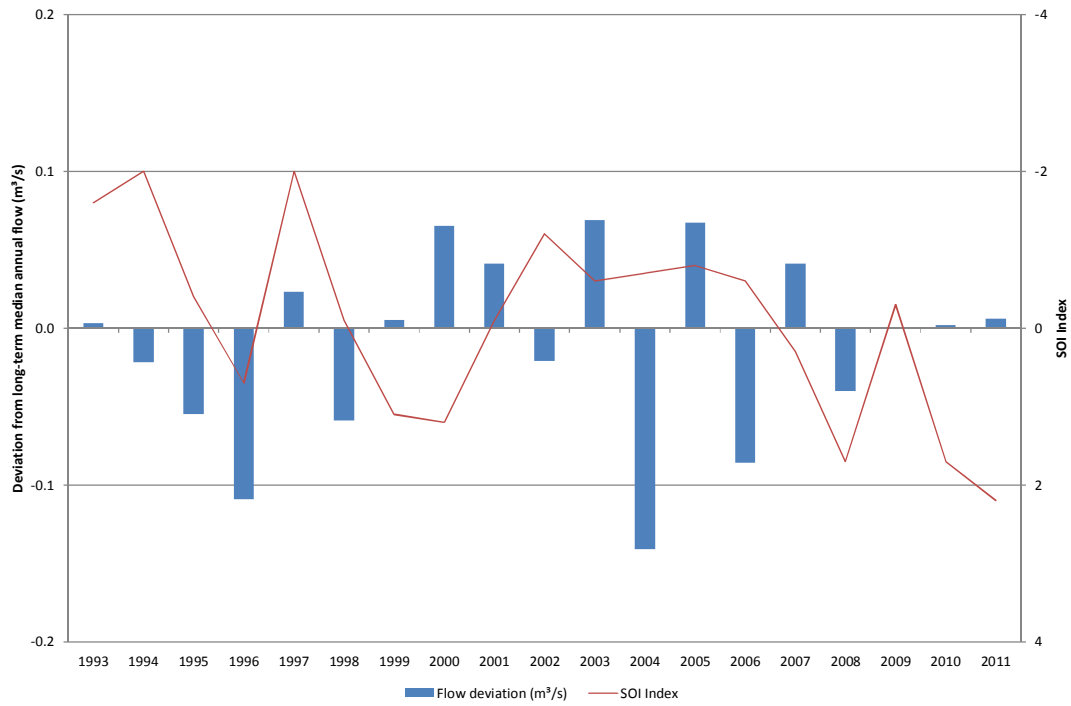
**Figure 11: Comparison of the maximum annual flows in Mangaone Stream with variation in the IPO (1993-2012).**

To further examine whether the SOI and IPO indices affect variation around average conditions, rather than the flow regime *per se*, both indices were compared to the deviation about the long-term median flow in Mangaone Stream (Figure 12 & Figure 13).

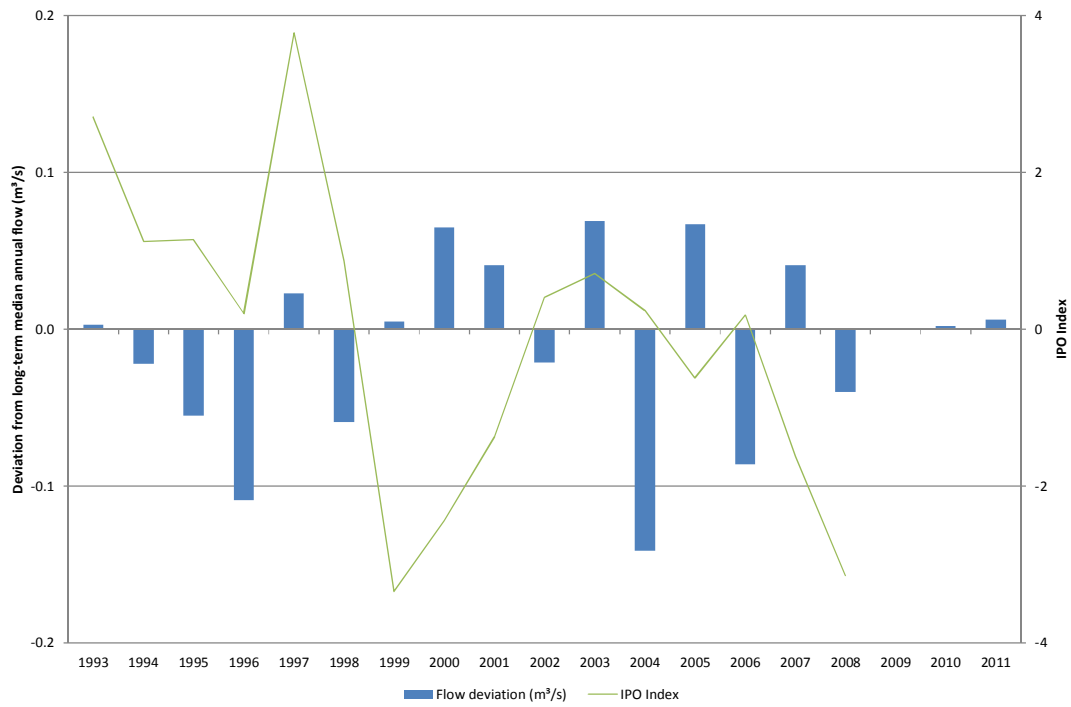
It would appear that both the SOI and IPO indices may potentially have a weak effect on the variation flow relative to median conditions. Periods when the SOI is strongly negative tend to be associated with higher than average flow conditions and *vice versa*. These periods of higher than average flows are also associated with periods when the IPO is strongly positive. Periods with negative IPO indices are associated with lower than average flow conditions.

However, despite this potentially weak relationship between the IPO and SOI and variation in flow conditions around ‘average’ conditions, no relationship exists with annual maximum flows as discussed previously. It is the annual maximum flows which affect the frequency/magnitude distribution of flood events, and consequently the magnitude of any design flood.





**Figure 12: Comparison of the deviation from long-term median flows in Mangaone Stream with the variation in the SOI (1993-2012).**



**Figure 13: Comparison of the deviation from long-term median flows in Mangaone Stream with the variation in the IPO (1993-2012).**



## Summary

The flow record for Mangaone Stream is only 18 years long. This is not long enough to determine with any certainty whether variation in the SOI or IPO affect the flow regime.

Variation in the SOI and IPO indices appear to have a weak effect on median flow conditions. Periods when the SOI is strongly negative tend to be associated with higher than average flow conditions and *vice versa*. These periods of higher than average flows are also associated with periods when the IPO is strongly positive. Periods with negative IPO indices are associated with lower than average flow conditions.

Despite a potentially weak relationship between the IPO and SOI and variation in flow conditions around 'average' conditions, no relationship exists with annual maximum flows. It is the annual maximum flows which affect the frequency/magnitude distribution of flood events, and consequently the magnitude of any design flood.

Therefore it is not necessary to consider the potential effect of either the IPO or SOI on the annual flood maxima series, or the magnitude of any design flood. The annual flood maxima series, and the magnitude of design flood estimates based on the available flow record from Mangaone Stream can therefore be considered realistic and robust; accepting the constraints inherent in all frequency analyses of relatively short duration hydrometric records.

## References

Kidson, J.W. and Renwick, J.A. 2002. Patterns of convection in the Tropical Pacific and their influence on New Zealand weather. *International journal of climatology* **22**: 151-174

McKerchar, A.I. and Henderson, R.D., 2003. Shifts in flood and low-flow regimes in New Zealand due to interdecadal climate variations. *Hydrological Sciences* **48(4)**: 637-654.