BEFORE THE HEARINGS' COMMITTEE

IN THE MATTER of hearings on submissions concerning the proposed One Plan notified by the Manawatu-Wanganui Regional Council

STATEMENT OF EVIDENCE OF

Dr JOHN (JACK) ALLEN McCONCHIE

ON BEHALF OF:

PALMERSTON NORTH CITY COUNCIL

1.0 INTRODUCTION

1.1 I am a Principal Water Resources Scientist working for Opus International Consultants Ltd.

1.2 Prior to the start of 2008, I was an Associate Professor with the School of Earth Sciences at Victoria University of Wellington. I hold a Bachelor of Science degree with First Class Honours, and a PhD. I am a member of the New Zealand Hydrological Society, the American Geophysical Union, the New Zealand Geographical Society, the Australia-New Zealand Geomorphology Group, and the Environment Institute of Australia and New Zealand. I taught undergraduate courses in geomorphology and hydrology, and a post-graduate course in hydrology and water resources. For more than 20 years my research focused on various aspects of hydrology and geomorphology, including: slope and surface water hydrology; hydrometric analysis; slope and fluvial coupling; hydraulic modelling; soil-water interactions; landscape evolution; slope stability and erosion; and natural hazards.

1.3 Within these fields I have edited one book. I have written, or co-authored, 10 book chapters and over 40 internationally-refereed scientific publications.

1.4 I was the New Zealand Geographical Society representative on the Joint New Zealand Earth Science Societies' Working Group on Geopreservation. This group produced the first geopreservation inventory; published in 1990 as the *New Zealand Landform Inventory.*

1.5 For three years I coordinated an investigation, and undertook a range of field studies, into the effect of hydro-electric operations on the fluvial and geomorphic processes of the Waikato River. This was part of the *Assessment of Environmental Effects* required for Mighty River Power Ltd's resource consent application to operate the Waikato hydro-electric system.

1.6 Specific to this evidence I have undertaken a field visit to the Turitea catchment and the various flow monitoring and control sites. I have compiled a comprehensive hydrometric archive of the available climatic and hydrologic data relating to the Turitea and surrounding catchments. I have analysed these data in detail, and therefore have an excellent understanding of the climate and hydrology of this area.

1.7 In my evidence I will address specifically:

- The flow regime of the Turitea Stream;
- The effects of the existing take for water supply purposes from the Turitea Stream;
- The present minimum and residual flows in the Turitea Stream;
- The development of a 'naturalised' flow regime for the Turitea Stream;
- The appropriateness of a minimum flow of 33l/s at Ngahere Park; and
- The appropriateness of a core allocation of 37,000m^3.

1.8 I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note (31 July 2006). I agree to comply with the Code of Conduct. Except where I state that I am relying upon the specified evidence of another person, my evidence in this statement is within my areas of expertise. I have not omitted to consider any material facts known to me that might alter, or detract from, the opinions that I express.

2.0 EXECUTIVE SUMMARY

2.1 The flow regime of Turitea Stream has been modified to supply water to Palmerston North for over 100 years.

2.2 The flow regime has only been monitored since August 2000 (at Ngahere Park). The catchment area above the monitoring site is approximately 32.13km^2. Of this total area the flow from 66% is affected by abstraction and the water supply dams. Flow from the remaining 34% of the catchment is essentially natural.

2.3 The effect of the two dams in the upper catchment on the flow regime downstream depends on the status of the dams prior to any inflow. When the dams are full their effect is minimal. Any inflow is passed over the spillway to the lower catchment. When the dams are not full a portion of the inflow is 'captured', reducing the potential flow downstream. In general, however, the dams fill very quickly and so their effect on flows can be relatively short-lived. Overall, the dams and abstraction of water tend to moderate and attenuate flood events, and reduce total flow downstream. The maintenance of a residual flow tends to stabilise low flow conditions downstream.

2.4 The moderation and attenuation of flows by the dams, and the extraction of water for supply purposes, therefore modify the flow regime in the lower valley. Despite this, Turitea Stream above Ngahere Park maintains the flow characteristics typical of a small hill country catchment, and supports a healthy aquatic environment.

2.5 Analysis of the flow record indicates a mean annual low flow (MALF) of 42l/s, which reduces to 33l/s when only complete years of record are included. Annual low flows range from about 10l/s to 85l/s. Because the flow record coincides with a period of higher than average rainfall and runoff, the present MALF is likely to be higher than the long term index.

2.6 Therefore, a long term MALF based on only the complete years of record, and considering rainfall variability, would be 30-35l/s.

2.7 Palmerston North City Council maintains a residual flow from the lower dam of 25l/s. This is equivalent, when scaled appropriately for contributing area, to a minimum flow of 38l/s in the Turitea Stream at Ngahere Park.

2.8 Raising the minimum flow threshold to 50l/s as proposed in the draft One Plan, which would require PNCC to increase the residual flow from the lower dam to 33l/s, cannot be justified using existing hydrological information from the catchment.

2.9 The amount and distribution of rainfall has a significant effect on the flow regime of the river as expected. A reduction in annual rainfall by 50% reduces median and lower flows by approximately 50%.

2.10 The period for which there are flow data from Ngahere Park has a mean annual rainfall of 1316mm. This period was significantly wetter than the long term average (i.e., 1270mm) despite having the driest year recorded (i.e., 2003 had only 786mm).

2.11 To set a higher minimum flow than recorded even during a period that was 'wetter than average' would require the maintenance of flows at levels higher than would occur naturally, and would restrict municipal water takes to extreme levels.

2.12 To assess whether a maximum daily allocation of 37,000m^3 can be sustained by flows from the Turitea catchment a synthetic naturalised flow record was created. This synthetic record is likely to over-estimate flows in the Turitea, because it is biased by the higher rainfalls in catchments to the south.

2.13 A maximum daily allocation of 37,000m^3 is equal to only 28% and 47% of the mean and median daily flows respectively. The stream can sustain this maximum level of take without adversely affecting the flow regime.

2.14 There are days when the maximum daily allocation of 37,000m^3 cannot be met by natural flow in the catchment. During 'wet' years (1980) with higher flows the maximum daily allocation can be satisfied every day. However, during a 'dry' year (2003) there were 153 days when this maximum daily allocation could not have been met by daily inflows. Even during this extremely dry year, however, the maximum daily allocation represented only 36% and 65% of the mean and median daily flows respectively. This is the reason for the existence of the dams; they buffer periods of higher and lower flow thereby allowing the average take to be met.

2.15 A maximum daily allocation of 37,000m^3 represents a relatively small proportion of flows within the catchment. It should also be noted that this maximum daily allocation would not be taken every day; therefore its overall effect on the flow regime is likely to be relatively minor.

3.0 TURITEA CATCHMENT

3.1 The Turitea catchment is situated in the Tararua Ranges on the south-eastern side of Palmerston North (Figure 1). The Turitea Stream is dammed for Palmerston North's water supply and drains into the Manawatu River. The catchment area above the Ngahere Park flow recorder is 32.13km^2 but it is split into two sectors by the Turitea Water Supply dams. The lower sub-catchment, from the dam to the Ngahere Park flow site, is 10.96km^2. Any flow sourced from this sub-catchment is unaffected by the dams and any abstraction. The larger, upper sub-catchment above the dam covers 21.17km^2. The highest peak (560m) is found in the upper catchment between the two southern tributaries.

3.2 Two other catchments referred to in this evidence are found to the south of the Turitea (Figure 1). The Kahuterawa catchment borders the Turitea, and has an area of 36.0km^2 (to the Johnston's Rata flow site). The Tokomaru River lies further to the south and is also dammed in its headwaters. This dam, however, truncates the upper catchment rather than modifying the downstream flow regime as is the case in the Turitea. The Tokomaru is the largest catchment of the three having an area of 57km^2 (from the dam to the S. H. Bridge flow site).

3.3 The natural flow regime of the Turitea catchment has been modified, with water being abstracted to meet Palmerston North's potable supply needs, for over 100 years. Since the granting of the last consent, Palmerston North City Council (PNCC) has maintained a residual flow of approximately 25l/s past the lower dam. The reservoirs behind the dams allow this residual flow to be maintained largely irrespective of the water balance and runoff processes in the upstream catchment; particularly during the summer low-flow period. This residual flow has the effect of stabilising hydraulic and environmental conditions in the lower catchment during periods of low flow.

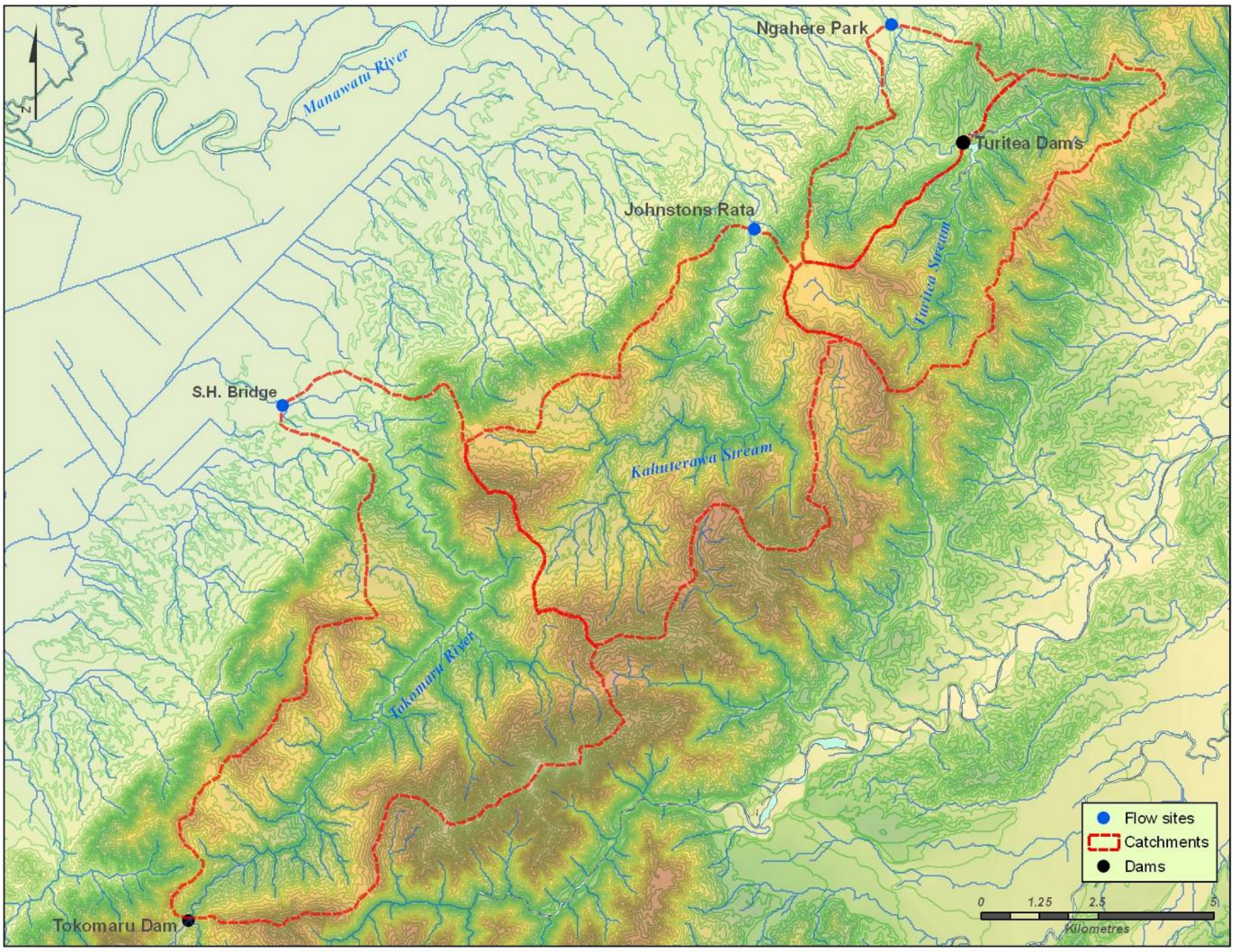

Figure 1 Location of the Turitea, Kahuterawa and Tokomaru catchments.

3.4 The control of flows within the Turitea catchment, and the abstraction of water to meet the needs of Palmerston North City, means that the flows recorded at Ngahere Park are not 'natural'. The nature of flow within the catchment, its modification, and manipulation make it impossible to derive a high resolution, accurate, naturalised flow regime for the Turitea Stream.

3.5 To overcome this problem a longer-term synthetic flow record has been created using the correlation between flows within the Tokomaru and the Kahuterawa catchments. This is discussed in detail later in this evidence.

4.0 NGAHERE PARK FLOW RECORD

4.1 The hydrometric site on the Turitea Stream at Ngahere Park (Figure 1) began recording stream flow data from 25 August 2000. The data record includes five gaps; all relatively short. Two of the gaps occurred during mid November 2004 (2.01 and 2.87 days), while the other 3 occurred in February, March and May of 2006 (2.88, 6.73, and 1.92 days respectively). The short duration of these gaps, and their dispersed nature in the data record, mean that they are unlikely to affect the results of any analyses based on the flow record.

4.2 Flow data for the Turitea Stream has a number of limitations. Flows have been recorded at Ngahere Park for only the past 9 years (Figure 2). It is possible that these data do not accurately reflect the longer-term flow variability of the catchment, especially since this period coincides with higher than average annual rainfall. Flows are augmented during periods of low flow by the residual flow past the lower dam of 25l/s. A proportion of each flood flow is also stored behind the dams; depending on their levels at the start of the flood, and the total flow involved. A relatively small proportion of the flow from the catchment is also diverted to meet the potable water needs of Palmerston North City. Finally, flow from 34% of the catchment is essentially natural and unaffected by any operations or controls related to the provision of potable water. These flows are not monitored. Despite the limitations discussed above, the flow record at Ngahere Park is of considerable value.

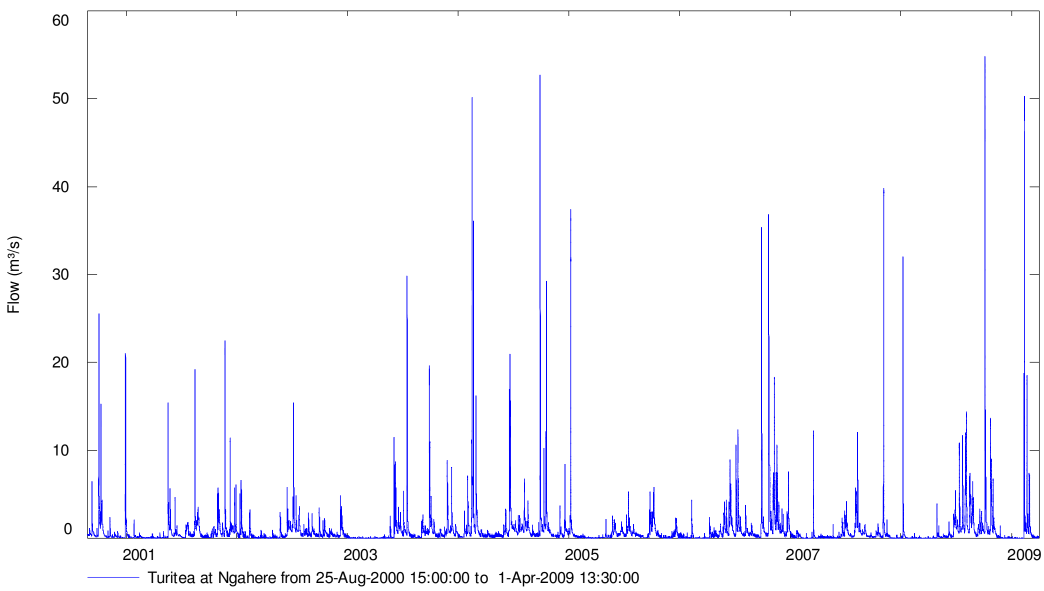

Figure 2 Flow record for Turitea Stream at Ngahere Park.

4.3 The flow record is characterised by a high degree of variability (Figure 2). This is typical of relatively small hill country catchments. The minimum recorded flow is approximately 7l/s, despite PNCC attempting to maintain a residual flow of 25l/s past the lower dam. The peak flow has been 55m^3/s or 55,000l/s (Table 1). While flows are generally higher and floods more frequent during winter, large flood events can occur at any time of the year. It should be noted that the flow recorded at this site includes all the effects of modifications in the upper catchment for water supply purposes.

Table 1 Summary of the flow regime for the Turitea Stream @ Ngahere Park (l/s).

Minimum	Mean	Maximum	Standard deviation	Lower quartile	Median	Upper quartile
7	774	54,783	1,795	90	312	802

4.4 The flow regime at Ngahere Park (Figure 2; Table 1) reflects a stream that retains the majority of its natural characteristics. The stream would appear to be 'healthy' and in equilibrium with current conditions (Figures 3 & 4). There is no documented evidence that I am aware of that the Turitea Stream has suffered significantly as a result of water abstraction from the upper catchment. Likewise, the basis for the proposed changes outlined in the draft One Plan is a '*policy call*' rather than any hydrological analysis or science. In fact, the dams provide some flood mitigation and have the potential to maintain higher than natural baseflow during periods of low flow, particularly towards the end of summer.

4.5 The only detailed study that I am aware of into the ecology of the Turitea has shown that while there are three notable effects of the dams and abstracting water from the stream *"the lower Turitea Stream generally continues to support a viable and healthy assemblage of macroinvertebrate communities that are present at comparable densities to reaches of the stream upstream of the water supply reservoirs."* (Coffey, B.T. September 2007)

4.6 As a condition of PNCC's consent to dam the stream and abstract water, a residual flow of approximately 25l/s must be passed through the dam. The flow record, however, shows that flows have gone below this level on occasion (Figure 2; Table 1). This is despite the fact that flow from approximately 11km^2 (34%) of the catchment is completely unaffected by the dam. All of these periods of low flow are during summer, and during periods of very little or no rainfall. Since flow past the dam is affected by the head (water level in the dam) it is likely that flow does drop below 25l/s on occasion during summer, when the water level in the dam is very low.

4.7 While an existing consent condition relates to maintaining a minimum flow of 25l/s at the lower dam, all monitoring is undertaken at Ngahere Park which is a considerable distance downstream. The monitoring site includes the effect of any inflows and losses from a catchment of 11km^2 over which PNCC and their consents have no effect. It would seem logical that the residual flows should be monitored directly at the dam. This would not only provide more accurate data to monitor consent compliance, but would allow the flows from both the modified and un-modified catchments to be quantified separately.

Figure 3 Turitea Stream, downstream of PNCC's water supply dams.

Figure 4 Turitea Stream, downstream of PNCC's water supply dams.

5.0 RAINFALL RECORD AT TURITEA

5.1 The rainfall record for the Turitea catchment dates from 1 December 1923, although much of these data are monthly totals. Daily rainfall totals were, however, recorded from 1 January 1967 to 29 February 1992, and then from 3 November 2003 to present. There is one 4.3-month long gap in the rainfall series; from 1 June 2003 to 9 October 2003. This gap in the record has been filled with the rainfall data from an adjacent site that has previously been shown to correlate strongly with rainfall at Turitea. For this evidence the entire record was analysed as monthly totals for consistency (Figure 5).

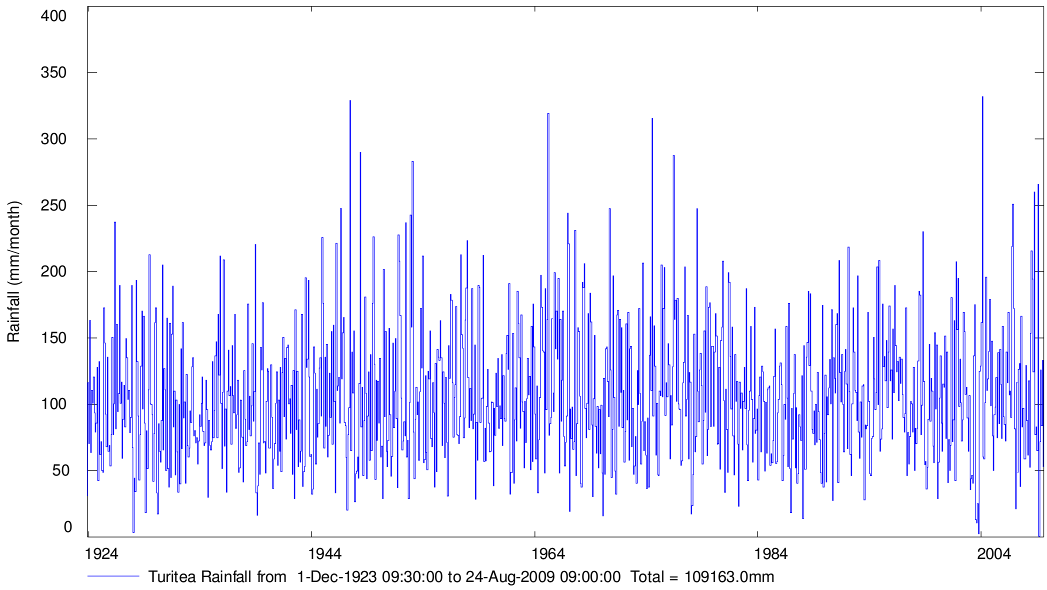

Figure 5 Monthly rainfalls for Turitea Stream at the water supply dams.

5.2 Rainfall varies from 0 to 365mm a month; with an average of about 110mm. There is a strong cyclic pattern to the rainfall distribution; with certain periods having consistently above average rainfall, and others having less than normal. This cyclic pattern of rainfall is reinforced when the annual totals are considered (Figure 6).

5.3 The monthly rainfall statistics since 1924 were compared to those for the period over which flows have been recorded at Ngahere Park (25-Aug-2000 to 1-Apr-2009). The rainfall statistics for the period of the flow record indicate a higher mean, median, and particularly upper quartile rainfall when compared to the longer-term values (Table 2). This is despite the fact that 2003 had the lowest rainfall on record (786mm); half the average.

Table 2 Summary statistics for the monthly Turitea rainfall data.

Summary statistics for monthly rainfall data (mm)							
	Min	**Max**	**Mean**	**Std Dev**	**L.Q.**	**Median**	**U.Q.**
1-Dec-1923 to 1 April 2009	0	365	105	45.9	73	99.5	130
1-Dec-1923 to 25-Aug-2000	6.7	327	108	45.4	77.1	102	134
25-Aug 2000 to 1 Apr-2009	0	303	115	56.6	76.5	104	147

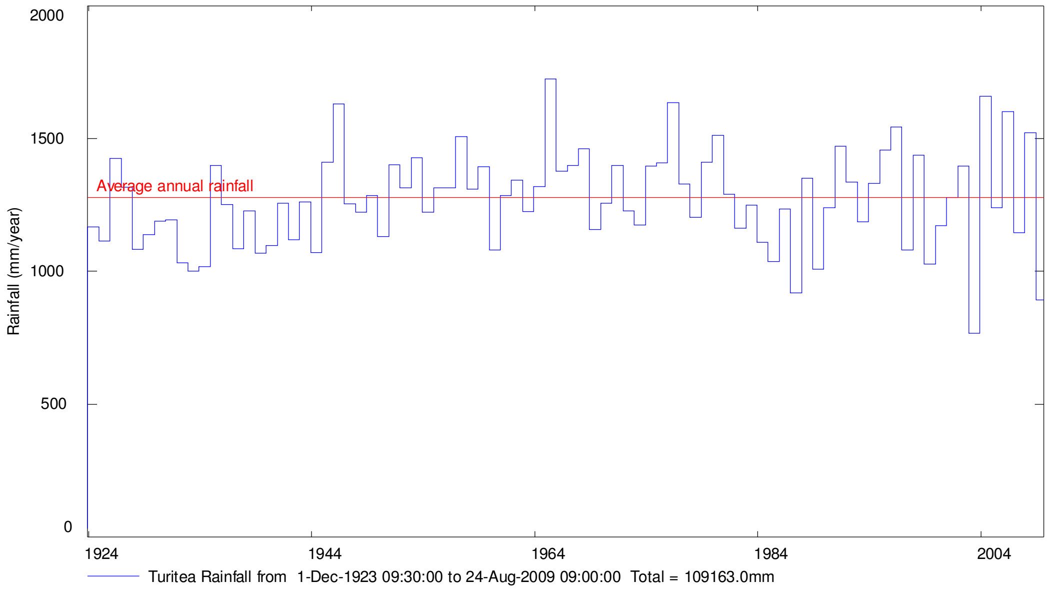

Figure 6 Annual rainfalls for Turitea Stream at the water supply dams.

5.4 Flow conditions within the Turitea, as with most streams, are strongly related to rainfall, even annual rainfall (Figure 7). The recent period of higher than average rainfall coincides with when flows have been recorded at Ngahere Park. This higher rainfall is reflected in higher than average flows in Turitea Stream. This means that flow indices derived from the flow record will over-estimate long term conditions i.e., the MALF determined from the flow record will over-estimate the long term MALF.

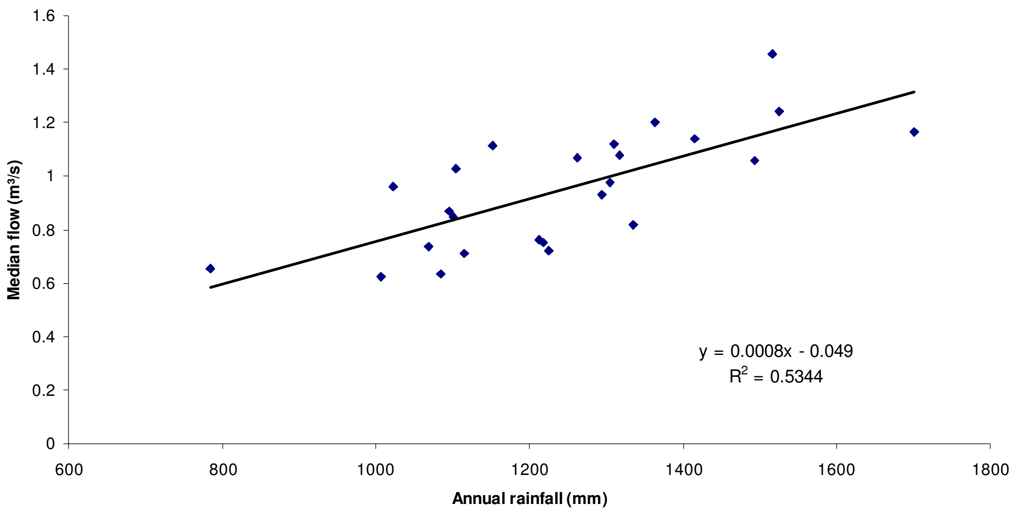

Figure 7 Relationship between annual rainfall and median flow in the Turitea Stream.

6.0 MEAN ANNUAL LOW FLOW (MALF)

6.1 The mean annual low flow (MALF) is often used as an indication of when environmental stress may be experienced within a river or stream. In the majority of situations the 7-day MALF is considered. This is the average of the lowest flows sustained over a period of 7-days over the length of record. In the draft One Plan a 1-day MALF has been used as this index.

6.2 When reviewing the MALF (either the 1-day or 7-day) it is important to consider the variability in the specific annual low flows (ALF), the length of record from which the MALF was calculated, and how representative this period is of the longer-term flow regime. These considerations complicate the derivation of an appropriate minimum flow for the Turitea.

6.3 The MALF for the Turitea catchment determined in this study includes all the various effects of PNCC's activities in the upper catchment on the flow regime. However, these effects have now been apparent for 100 years. Therefore, the flow regime as recorded is likely to reflect the actual conditions to which the stream environment and ecology have adjusted, even if these conditions are not entirely natural.

6.4 The mean annual low flow (MALF) was therefore calculated for the Turitea from the flow record from Ngahere Park. There is a slight difference in the MALF depending on whether specific days or 24-hour periods are used in the analysis. For example, the MALF is 42l/s using 24-hour periods but 46l/s when using discrete days. These results, however, include data for years which contain missing periods of record. This can bias the results depending on which data are missing. If only 'complete' years are included in the analysis the MALF values are 33l/s and 35l/s respectively. It must be remembered that this 'mean' is determined from eight years of data, containing only five complete years. The MALF is also derived during wetter than average conditions.

6.5 Within this period of flow record there is a high degree of variability in low flow conditions from year to year (Figure 8). ALFs range from as low as 10l/s to 108l/s. It should be noted therefore that the MALF can provide a poor indication of actual low flow conditions experienced within the Turitea catchment.

6.6 It is important to note that the 25l/s residual flow maintained by PNCC, when scaled for the effect of catchment area, is equal to the MALF recorded at Ngahere Park.

6.7 Based on the above analysis, there is no justification for the minimum flow at Ngahere Park to be 50l/s as proposed in the draft One Plan.

6.8 Maintaining a minimum flow of 35l/s at Ngahere Park would appear to be appropriate. This value recognises the bias caused by incomplete years, and the wetter than average period over which flows have been recorded. It also recognises the fact that the stream and stream ecosystem have adjusted to a MALF of about this magnitude over the past 100 years.

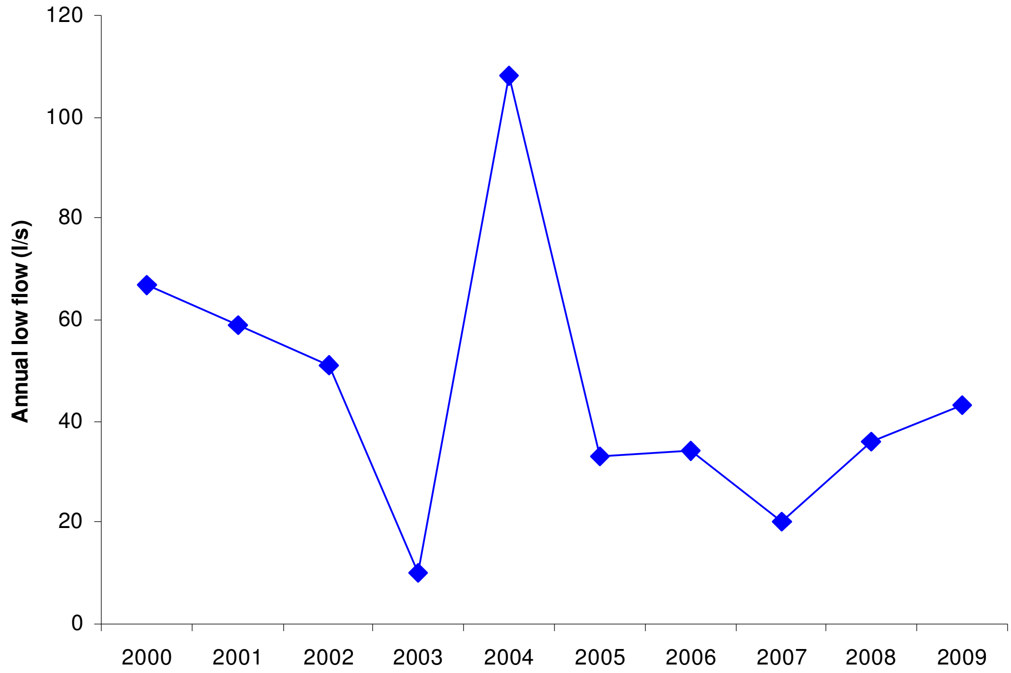

Figure 8 **1-day annual low flows for Turitea Stream, using actual days rather than 24-hour periods.**

7.0 SYNTHETIC FLOW RECORD FOR TURITEA STREAM

7.1 The flow record for the Turitea Stream at Ngahere Park therefore reflects a modified flow regime; including the maintenance of a residual flow of 25l/s, and water abstractions from the upper catchment. Synthesising a naturalised flow record for the Turitea Stream would require using reservoir levels, abstractions, residual flows, and estimated flows from the undammed portion of the catchment. Such a naturalised record would be subject to significant error, particularly since several of the necessary data sets either do not exist, or exist at different resolution, accuracy, and precision. Therefore, a naturalised record was synthesised using continuous flow records from adjacent, unmodified catchments.

7.2 Flow data from two neighbouring catchments were used to create a synthetic flow record for the Turitea Stream. Data from the Tokomaru River dates from 13 December 1979 to 11 January 2006, and has no gaps. The Kahuterawa Stream flow record is shorter, from 30 April 2005 to 11 January 2006. The flow data, specific yields, and 7-day moving mean for these two catchments during the overlapping period are all very similar; once the difference in catchment areas has been taken into account. While there are some differences in the various flood peaks, caused by the characteristics of specific storm events, the periods of low flow are remarkably consistent (Figures 9 & 10).

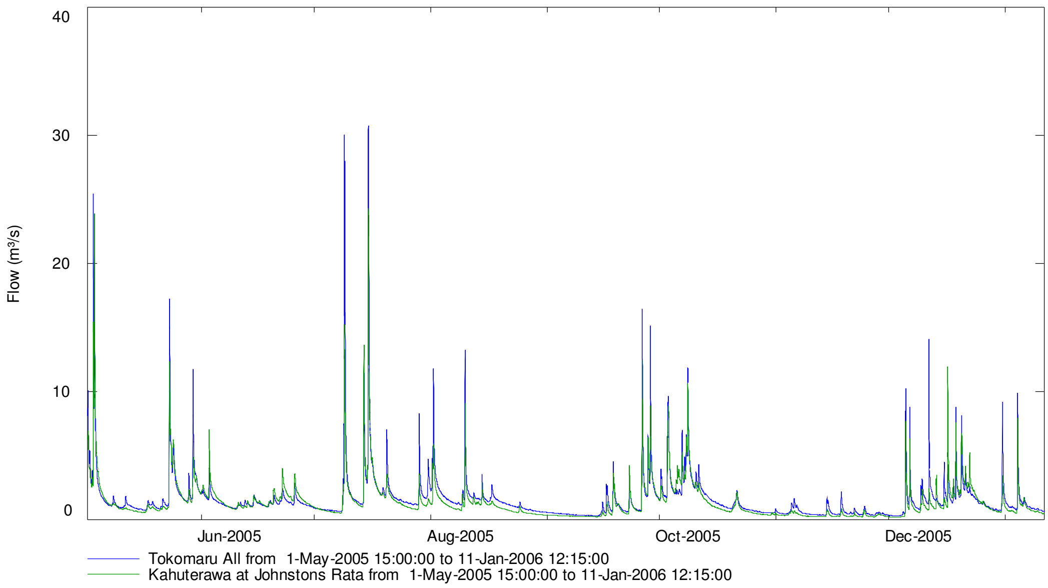

Figure 9 Flows in the Tokomaru River and Kahuterawa Stream over their common period.

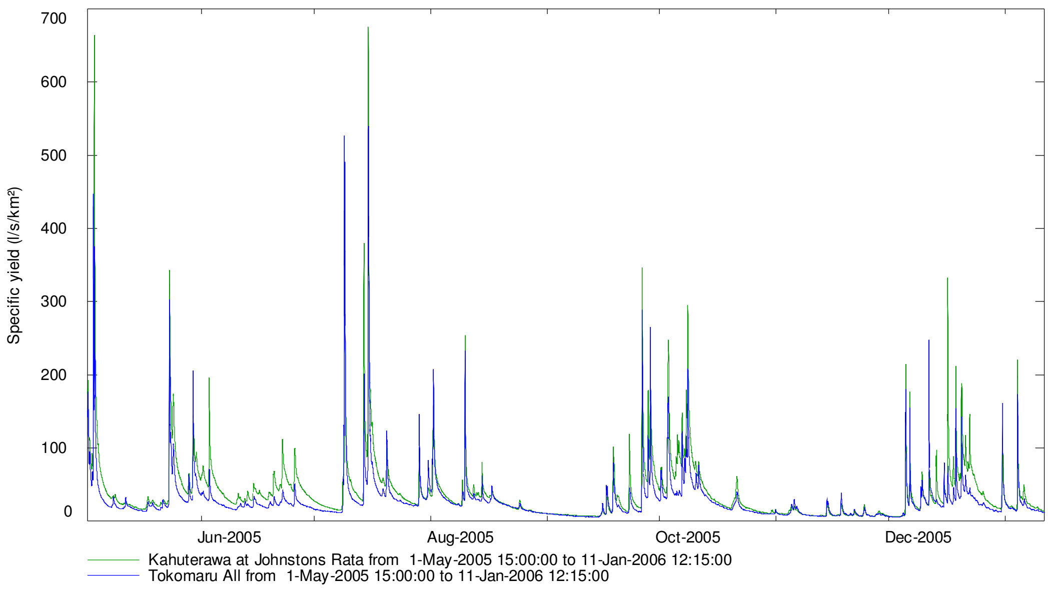

Figure 10 Specific yields from the Tokomaru River and Kahuterawa Stream over their common period.

7.3 The relationship between flow in the Tokomaru and Kahuterawa catchments was compared using the mean daily flows (Figure 11). Given the nature of the apparent relationship, and the physical processes involved, both linear and power models were used. The coefficients of determination of both models were high (i.e., r^2 = 0.90 and 0.92 respectively). This shows that there is a robust correlation between the flows in the two catchments. The correlation is particularly strong at low flows when the effect of specific storm characteristics, including rainfall distribution and passage, are removed. The coefficients of determination show that variation in flow in the Tokomaru River can be used to explain over 90% of the variation in flow in the Kahuterawa Stream.

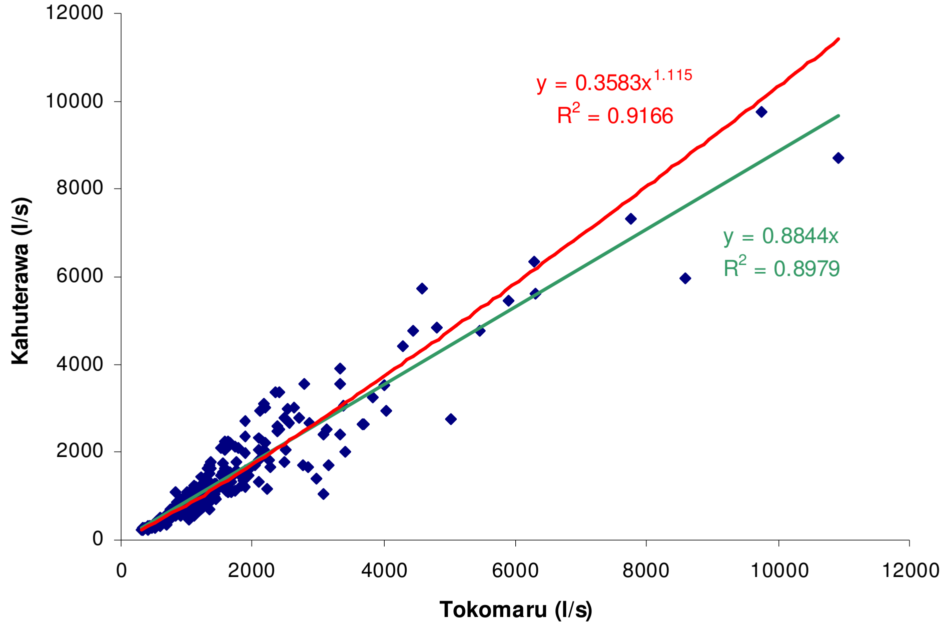

Figure 11 Relationship between mean daily flows in the Tokomaru River and Kahuterawa Stream.

7.4 Using the above regression models the daily flows in the Kahuterawa Stream were estimated using the longer flow record from the Tokomaru River. These modelled flows provide a good indication of the magnitude and variability of the actual flows recorded in the Kahuterawa Stream (Figure 12; Table 3). The model based on simple linear regression passing through the origin appears to provide the most accurate estimates of flow. This was therefore the model, and data, used in the subsequent analysis.

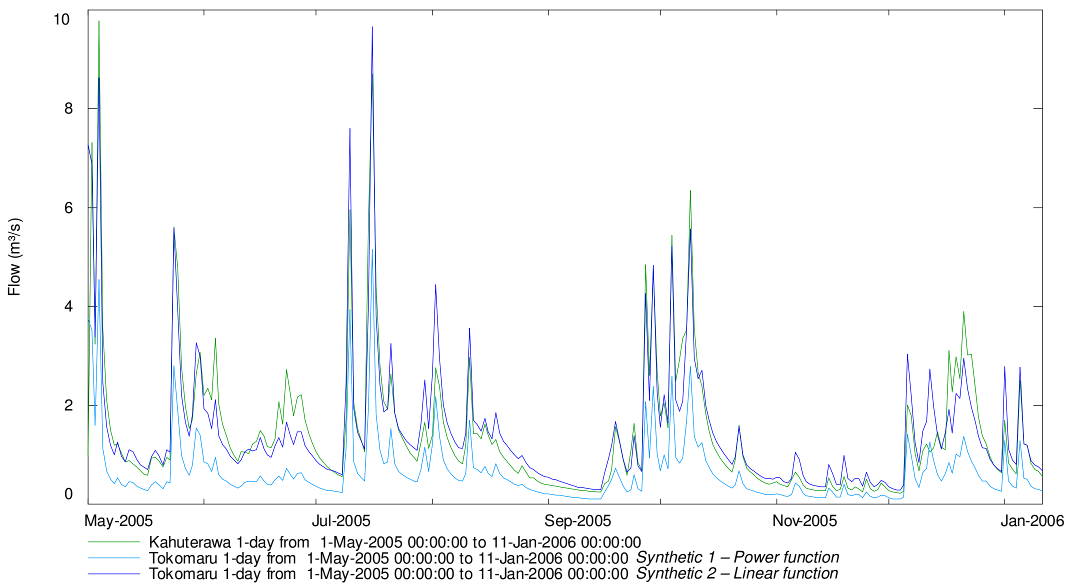

Figure 12 Comparison between the actual and synthetic flows for Kahuterawa Stream.

Table 3 **Summary statistics for the actual and synthetic Kahuterawa Stream flow records over the common period.** **Note: Synthetic 1 is a power function while Synthetic 2 is a linear function through the origin.**

Summary statistics for overlapping period							
	Min	**Max**	**Mean**	**Std Dev**	**L.Q.**	**Median**	**U.Q.**
Kahuterawa at Johnstons (l/s)	227	9773	1428	1273	598	1074	1819
Kahuterawa Synthetic 1 (l/s)	100	5154	646	622	280	469	760
Kahuterawa Synthetic 2 (l/s)	281	9663	1451	1209	709	1125	1731

7.5 Given that the stream gaugings upon which flow data are based are only reliable to ±8% under optimum conditions, the synthetic flow series can be regarded as a good analogue for the longer-term actual flows in the catchment (Figure 13).

7.6 This longer term synthetic flow series for the Kahuterawa Stream was then scaled, as a function of differences in catchment area, to provide a model of the naturalised flow in the Turitea Stream (Figure 14).

7.7 Although the Kahuterawa Stream is adjacent to the Turitea, and they share a common catchment divide, the synthetic flow series for the Turitea is biased by the higher rainfall to the south. This is a result of the higher elevations of the headwaters of the catchments to the south, and the orographic enhancement of rainfall i.e., these catchments get more rain and therefore experience higher flows.

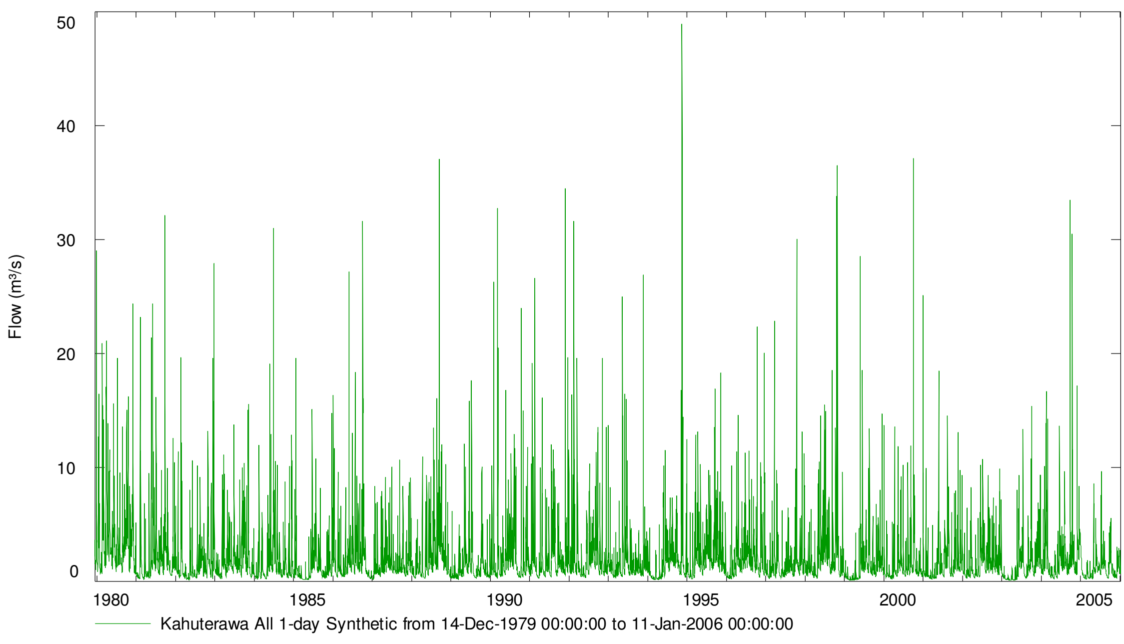

Figure 13 **Longer term synthetic flow record for Kahuterawa Stream.**

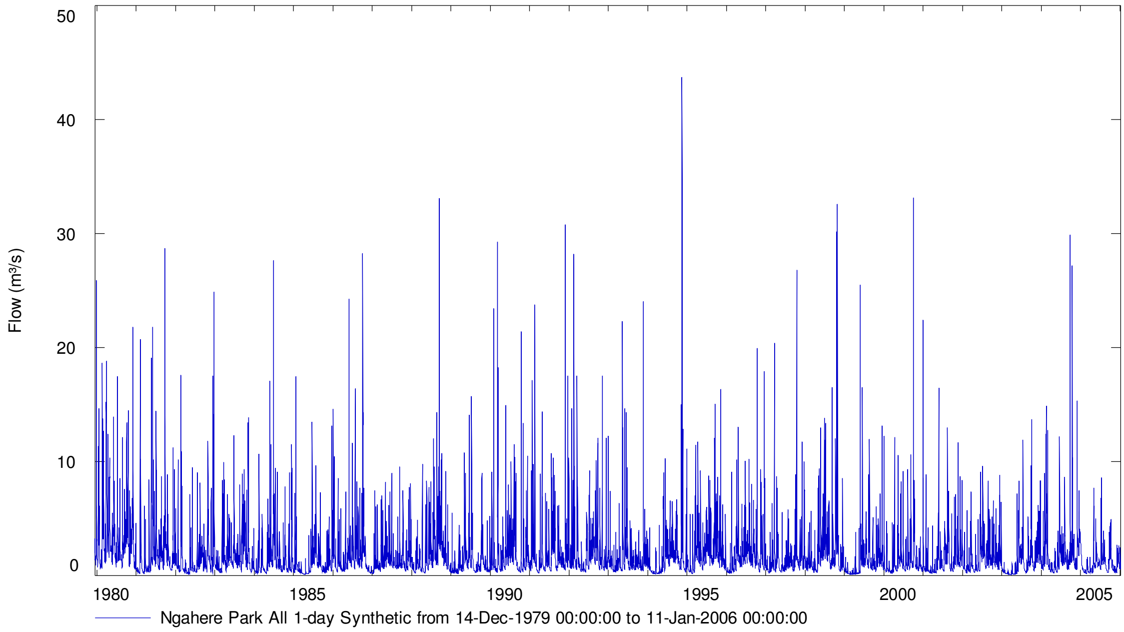

Figure 14 Synthetic flow record for the Turitea Stream at Ngahere Park.

7.8 Obviously, the flow regimes shown in Figures 13 & 14 are identical. The magnitude of the flows in Figure 14 is less because the Turitea catchment is smaller than the Kahuterawa.

7.9 In an attempt to adjust the flows for reduced rainfall within the Turitea catchment, the annual runoff from a number of catchments at increasing distance south of the Manawatu Gorge, and estimated in the national River Environment Classification, was reviewed (Figure 15). Based on this relationship the synthetic flows in the Turitea were scaled to account for lower rainfall.

7.10 A comparison of this synthetic record and that actually recorded at Ngahere Park shows good agreement in the general runoff pattern (Figure 16). This agreement is particularly strong during 'winter' when the dams are full and any inflow is essentially passed down stream i.e., the flow pattern is 'natural'. The synthetic flows are, however, generally too high. This is likely a reflection of the inability to remove entirely the effect of differences in rainfall. It may also reflect the flow moderation, flood attenuation, and water abstraction from the upper Turitea.

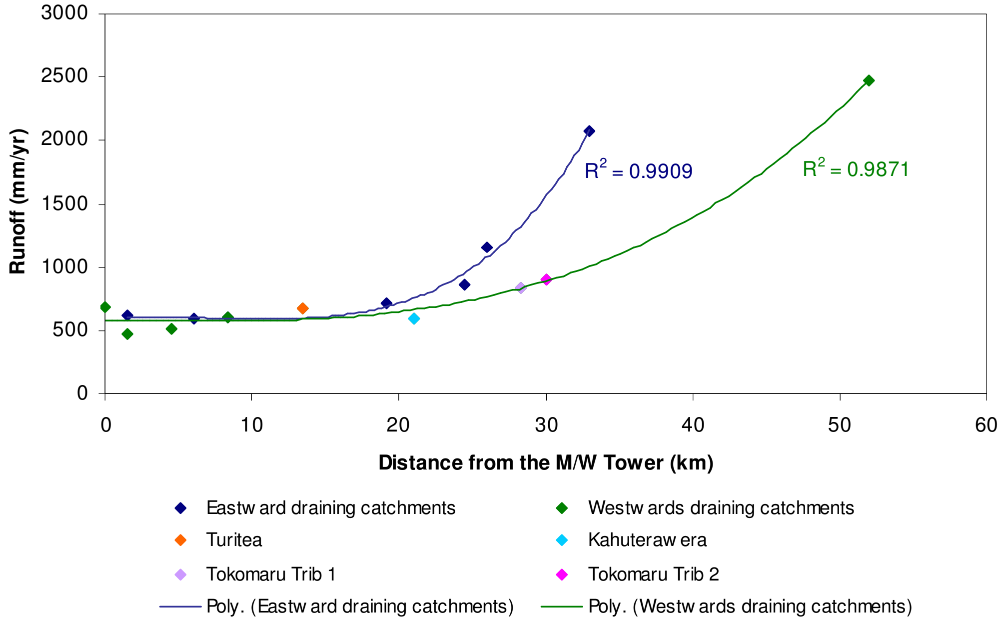

Figure 15 Increase in runoff with distance south of the Manawatu Gorge.

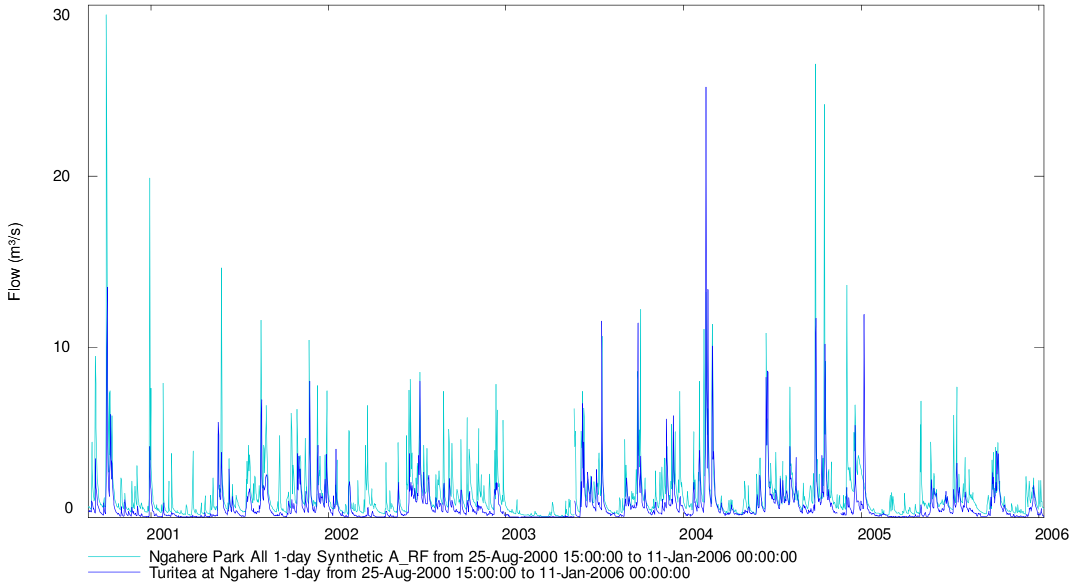

Figure 16 Comparison of synthetic and recorded flows for the Turitea Stream at Ngahere Park.

8.0 CORE ALLOCATION

8.1 Using the synthetic 'naturalised' flow record for the Turitea Stream at Ngahere Park it is possible to assess the relative magnitude of the existing consented maximum daily allocation of 37,000m^3 (Figure 17).

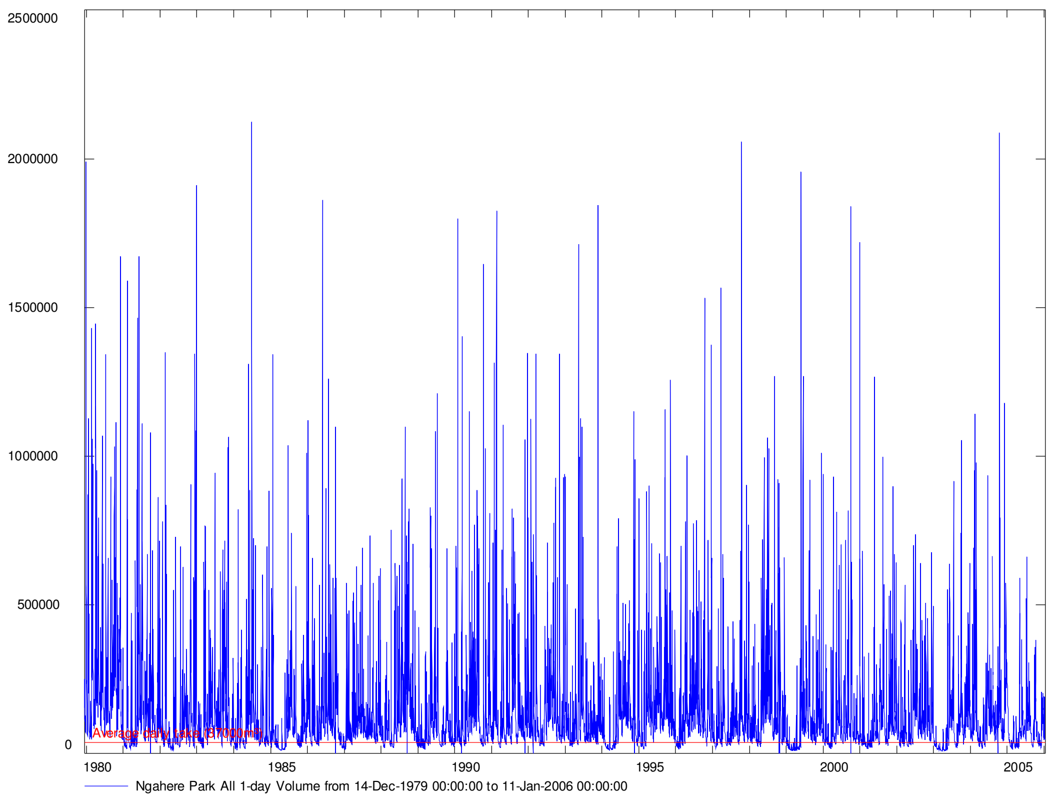

Figure 17 Daily flow volume compared to a maximum daily take of 37,000m^3.

8.2 The current maximum daily allocation represents a very small proportion of the total daily flow volume in the Turitea Stream. There is certainly no indication that this allocation should be reduced on the basis of the hydrology of the catchment.

8.3 In an attempt to simplify the pattern, and identify how the potential effect of this maximum daily allocation varies over time and with rainfall, the maximum allocation was plotted as a proportion of the annual mean and median flows (Figure 18).

8.4 While there is a high degree of variability, because of the annual variability in flow, the maximum daily allocation is usually about 30% and 50% of the mean and median daily flows respectively. During wet years (e.g., 2004) the maximum daily allocation is 28% and 47% of the mean and median daily flows respectively. During extremely dry years (e.g., 2003) these values increase to 36% and 65% respectively.

8.5 Obviously, a maximum daily allocation of 37,000m^3 is not available from inflow alone every day of every year. Whether the daily maximum allocation is available depends on the inflow which varies as a function of rainfall etc. The dams were actually built to smooth this miss-match between inflows and the demand for water. Using the synthetic flow record it is possible to analyse when, and how often, inflows are less than those required to meet the maximum daily allocation (Figure 19). It should be noted that this analysis simply looks at whether inflows exceed the maximum daily allocation. It does not consider the magnitude of any miss-match. For example, even if the daily inflow is only 1l/s less than the maximum allocation it will be deemed that there is insufficient inflow (i.e., it will plot at ‘1’). The analysis therefore presents the most extreme interpretation. The actual situation will be dramatically less severe when considering the actual volume of water involved.

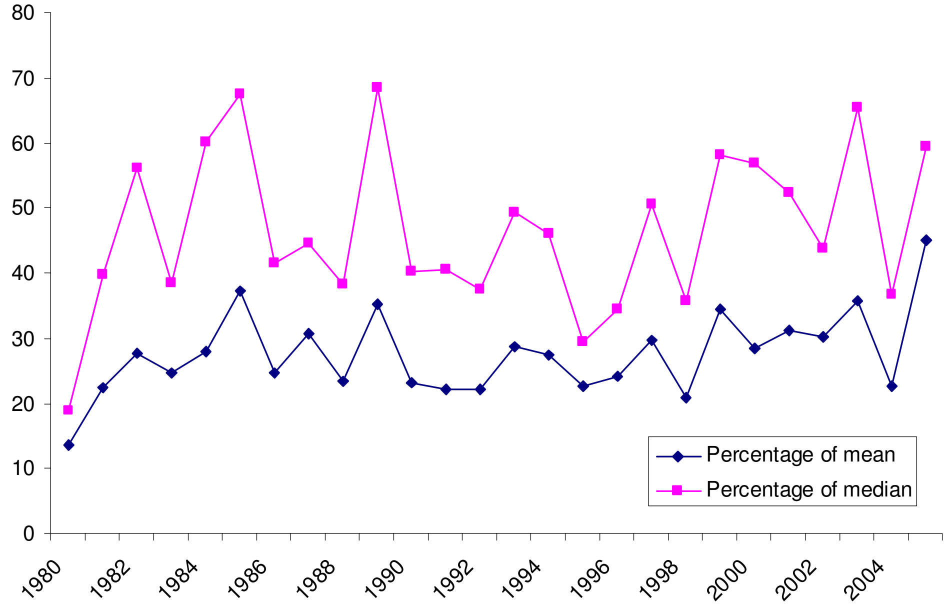

Figure 18 Maximum daily allocation of 37,000m^3 as a proportion of mean and median daily flows.

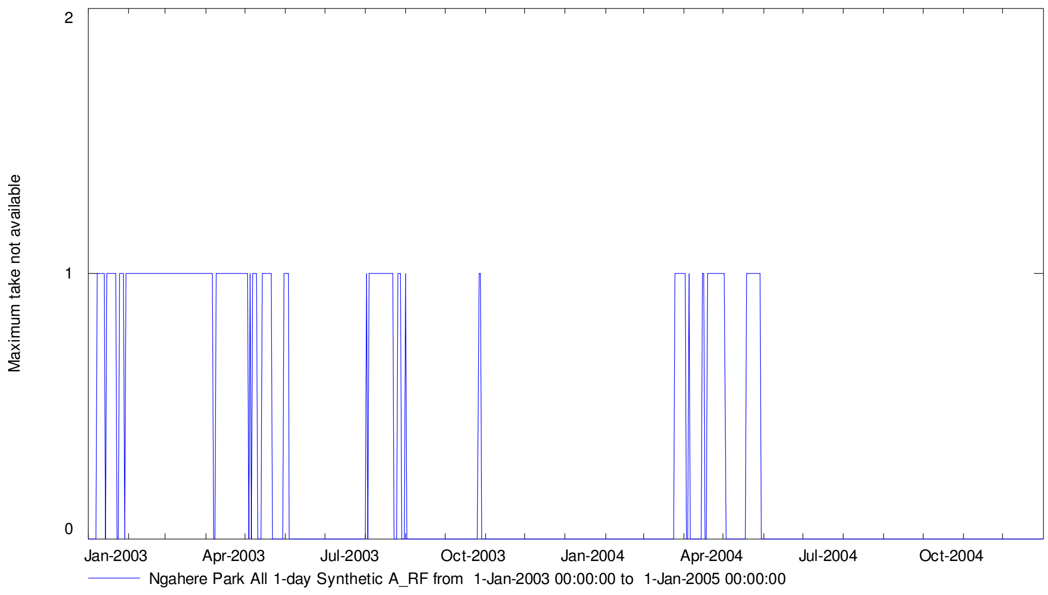

Figure 19 Days when a maximum daily allocation of 37,000m^3 is not all available from inflow. Note: 2003 was an extremely dry year while 2004 was a wet year. Points plotting at '0' indicate that inflows exceed the maximum daily allocation. Points plotting at '1' indicate that inflows are less than the allocation; they do not indicate how much less.

8.6 Inflows are most likely to fall below the maximum daily allocation at the end of summer, and following prolonged periods of no or low rainfall. When rainfall is high and evenly spread throughout the year it is possible that the maximum daily allocation can be met from inflows alone (e.g., 1980). However, this is not the norm and the dams are needed to buffer inflows to meet daily water demand; particularly towards the end of summer (2004 in Figure 19). During 2003, the driest year on record, inflows were less than the maximum daily allocation for 153 days. It should be noted that these days were, however, not all continuous (Figure 19) and that there were still inflows, just not the required volume.

8.7 The effect of annual rainfall on runoff, and therefore days when the maximum allocation is not available from inflows alone is highlighted in Figure 20. While the status of the dams has a limited capacity to buffer against short term variations in annual rainfall, they cannot mitigate against longer dry periods.

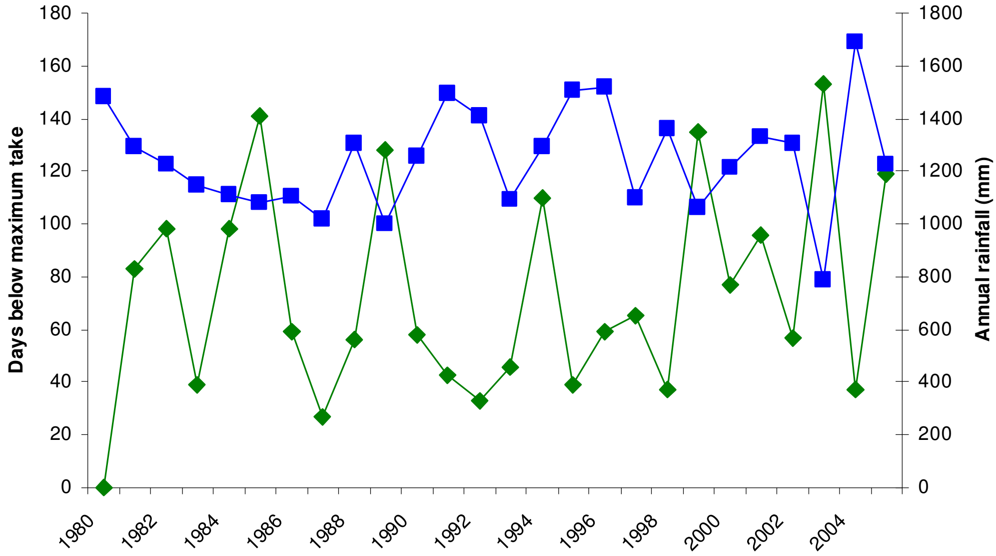

Figure 20 Annual rainfall (blue symbols) and the total number of days when a maximum daily take of 37,000m^3 is not available (green symbols).

8.8 It is apparent that the Turitea catchment can sustain a maximum average daily allocation of 37,000m^3. Furthermore, the maximum daily allocation would never be taken continuously, and it would only be taken at certain times of the year. Therefore, the effect of a maximum allocation of 37,000m^3 on the flow regime of the Turitea is significantly less even than that indicated above.

8.9 There is no justification for a reduced core allocation from the Turitea Stream. The existing allocation represents a relatively small proportion of the total flow in the stream. The dams provide an effective buffer against short term variability in inflows, and mitigate the miss-match between inflows and abstractions during periods of low flow.

9.0 CONCLUSIONS

9.1 The flow regime of the Turitea Stream has been modified to help meet PNCC's potable water needs for approximately 100 years.

9.2 There is no evidence that existing practices are having a significant adverse effect on either the flow regime or the environment of the Turitea Stream.

9.3 A minimum flow of 35l/s at Ngahere Park would appear to be realistic and consistent with the flow data available. There is no hydrological justification for the minimum flow to be set at 50l/s as proposed.

9.4 A naturalised flow record indicates that a core allocation of 37,000m^3 per day from the upper Turitea Stream represents a relatively small proportion of the total flow from the catchment.

9.5 Inflows do not meet the core allocation every day of every year. However, the dams provide an effective buffer to not only manage any miss-match, but to also mitigate any adverse effects downstream by providing water to maintain a residual flow.

9.6 There appears to be no hydrological justification that the core allocation should be reduced to 22,896m^3 per day as proposed in the draft One Plan.

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