HYDROLOGICAL AND ENGINEERING ISSUES ASSOCIATED WITH DRAINING AND RESTORING LAKE PEDDER

Andrew Livingston[1]

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The available rainfall, streamflow and flooding data for the Gordon River and Huon River catchments was re-examined and used to evaluate the yield of the existing Lake Pedder, drainage scenarios, flooding in the Huon River and likely changes to the flow regime in the Huon and Gordon rivers.

A standard 30 year period was adopted to assess the fragmentary rainfall data and the rainfall distribution map for South West Tasmania was revised. From this rainfall map the annual catchment rainfalls of Lake Pedder and Lake Gordon were estimated to be 2200 and 1890 millimetres respectively. Hence 40% of the rainfall volume falling on the Pedder/Gordon system lands on the Lake Pedder catchment. Using streamflow data, the long term average inflow to Lake Pedder was estimated to be 42.75 cumecs, which is about 42.5% of the total inflow to the Pedder/Gordon system. This small increase in the streamflow-based estimate of Lake Pedder's contribution over the rainfall-based estimate is due to the higher runoff/rainfall ratio from the wetter Lake Pedder catchment.

Lake Pedder has three outlets, McPartlan Pass Canal, Edgar Dam riparian outlet and Serpentine Dam outlet. The usefulness of the first two outlets is limited and the major drainage outlet is through Serpentine Dam. This outlet cannot drain the Huon section of the storage below the level of the saddle connecting the Huon and Serpentine catchments. Scotts Peak dam must be breached to drain the Huon storage. Simulations of drainage options showed that Lake Pedder can be drained in about 12 months but it is not possible to keep the level behind Serpentine Dam below the level of the old Lake Pedder unless the dams are breached.

The frequency and size of pre- and post-dam floods in the Huon River were examined and it was found that there has been a reduction in flooding in the Huon River consistent with the reduction in catchment area above Scotts Peak Dam. Flow duration patterns in the Huon and Gordon Rivers were examined. The Huon would revert to the pre-dam conditions with the median flow increasing by 15% and low flows by about 8% over the current flows. The situation in the Gordon is more complex due to changes in the operation of Gordon Power Station; the low flows would be similar to the present situation, mid-range flows would be less common, while high flows and floods would increase.

Key Words: Australia, Tasmania, Lake Pedder, restoration, hydrology, engineering, draining

INTRODUCTION

This paper presents the available rainfall and streamflow data for the Pedder/Gordon area used to calculate catchment rainfalls and catchment runoffs. A range of lake inflows, storage volumes, outlet structure hydraulic capacities, and the bathometric shape of Lake Pedder are used to illustrate drawdown times and other engineering issues associated with draining Lake Pedder.

Also examined are the effects of upper Huon River flows on flooding in the lower reaches of the Huon River and changes in the flow regimes of the Huon and Gordon River that would follow any draining of Lake Pedder[2].

LAKE PEDDER CATCHMENT RAINFALL

Rainfall records for South West Tasmania

South West Tasmania lies in the path of the 'Roaring Forties'. The moisture laden clouds strike the mountains of South West Tasmania and the resulting orographic lifting produces the high

[1] Hydrologist, Hydro Tasmania, Hobart.

[2] *Editors note*: Throughout this paper, the term "Lake Pedder" refers to the Huon-Serpentine Impoundment, except where the original Lake Pedder is specifically referred to.

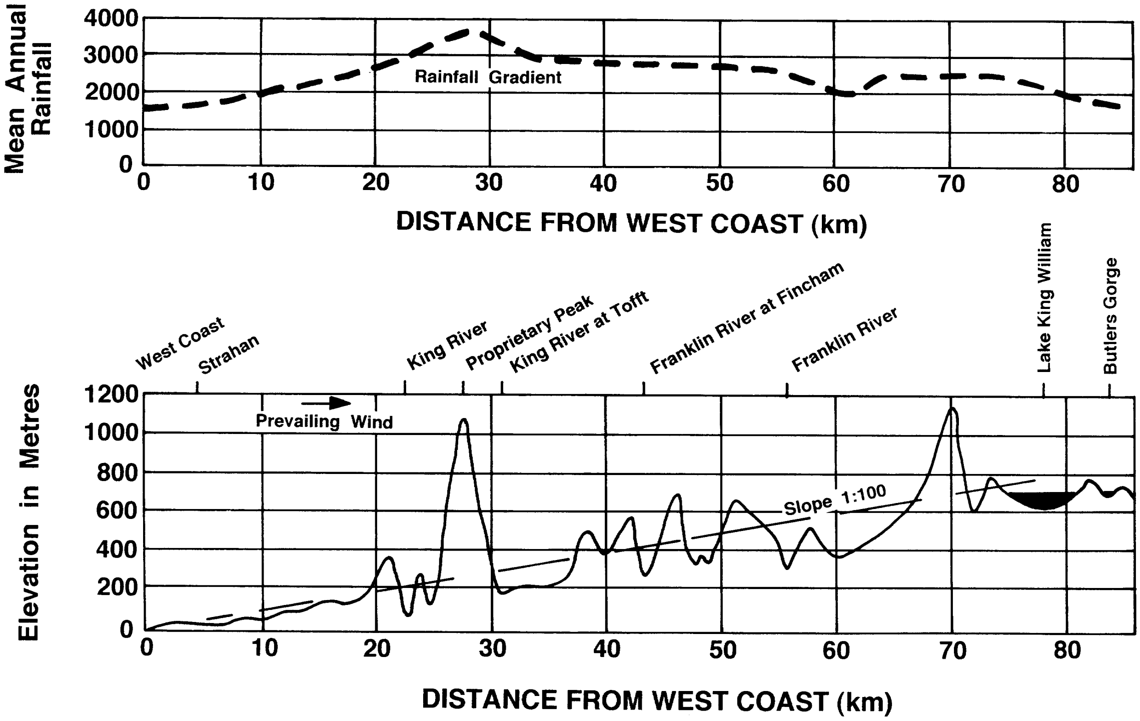

Figure 1: Relationship between rainfall (top) and terrain (bottom) from Strahan to Butlers Gorge.

rainfall typical of the area. Figure 1 shows a transect from the western coast across to the centre of Tasmania. Annual rainfall increases from 1600 millimetres along the western coastline to over 3200 millimetres at some points along the major mountain barrier then decreases to below 1400 millimetres in the Derwent Valley.

Rainfall records for Tasmania's South West were described by Searle (1976) as "scarce and fragmentary, with no reliable long term stations south of Queenstown or west of Sharps Siding". Rainfall data recorded since 1976 has been assembled and used to update the rainfall distribution maps. Appendix 1 shows the available rainfall gauges, their periods of record, observed average annual rainfall, estimated annual rainfall for the standard period and the type of rainfall recording method. A standard 30 year period, from 1964 to 1993, was chosen to allow direct comparison of rainfall data from sites with different periods of record. To improve the estimation of rainfall at un-gauged locations in Tasmania's South West the influence of several factors on rainfall in the area was examined by Searle (1976). These factors were:

- distance from the west coast;
- distance from the major mountain barrier;
- average height of the major mountain barrier;
- distance from major downwind mountain range;
- average height of major downwind mountain range;
- distance from minor upwind mountain range; and
- elevation.

A revised isohyetal (or rainfall distribution) map of South West Tasmania was estimated using the data in Appendix 1 and the work by Searle (1976). This map is shown as Figure 2.

Calculation of average rainfall

Average catchment rainfall is calculated by multiplying rainfall isopleths (lines of equal rainfall) from Figure 2, by their associated areas then dividing the sum of these products by the total area. Table 1 gives areas associated with each rainfall isopleth and the weighted average rainfalls for the catchments of Lake Gordon and Lake Pedder.

The area weighted average annual rainfall for the 736 km^2 Lake Pedder catchment is 2200 millimetres while the area weighted average annual rainfall for the 1281 km^2 Lake Gordon catchment is 1890 millimetres. This means that although the Lake Pedder catchment is only 34% of the total contributing catchment of the Gordon Power Station it contributes 40% of the rainfall volume.

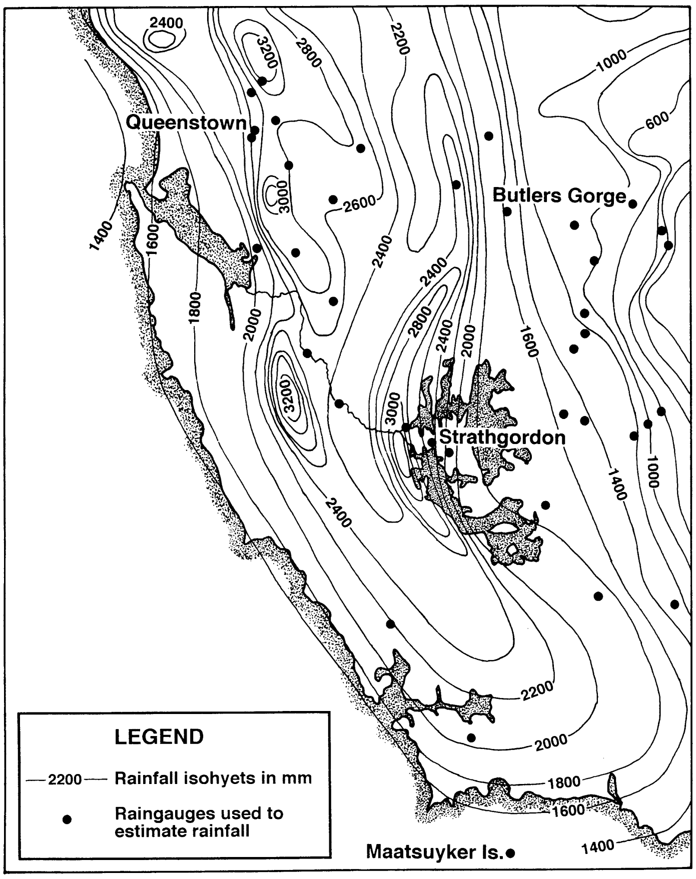

Figure 2: Isohyetal Map of South West Tasmania.

Lake Pedder		**Lake Gordon**	
Rainfall Isopleth (mm)	Contributing Area (km^2)	Rainfall Isopleth (mm)	Contributing Area (km^2)
1750	132	1500	89
1900	251	1700	660
2100	73	1900	198
2300	58	2100	111
2500	54	2300	84
2700	49	2500	89
2900	71	2700	35
3100	25	2900	5
3300	17	3100	10
3400	6		
TOTAL	**736**		**1281**
Weighted Average 2200 mm		**1890 mm**	

Table 1: Weighted average annual catchment rainfall.

LAKE PEDDER CATCHMENT YIELD

Before the dams were built the streamflow stations, *Gordon River below Knob, Huon River at Scotts Peak* and *Serpentine River above Gordon* provided a direct measure of the runoff from the catchments of the present Lakes Pedder and Gordon. These stations were installed in the early 1960's and lasted until dam construction began in the early 1970's. To estimate the long-term catchment yield it is necessary to correlate these relatively short records with long-term streamflow and rainfall stations.

Appendix 2 shows the available streamflow data for the Huon, Gordon and nearby catchments. The quality of the longest record, *Huon River at Judbury* is poor. The *King River at Crotty* has a long record of reasonable quality but it is now under Lake Burbury while *Gordon River below Huntley* was closed in 1979. The combined Gordon/Pedder catchment yield is estimated from changes in storage and power station water outflow. The streamflow station, *Gordon Power Station Tailrace,* provides a direct measure of power station water outflow. This direct measure is preferable to using energy generated, head and machine rating data because the operational characteristics of Gordon Power Station mean that this calculation is not always accurate.

Lake Pedder catchment yields for use in HEC system modelling are estimated using the following (Marshall 1994):

1924 to **1952** Regression with *King River at Crotty* & Tyenna rainfall

1953 to **1961** Regression with *King River at Crotty,* Tyenna rainfall and *Gordon River below Huntley.*

1961 to **1972** Measured flows in *Huon River at Scotts Peak* & *Serpentine River above Gordon.*

1972 to **1974** Change in storage of Lake Pedder.

1974 to **date** Scaled from combined Gordon/ Pedder catchment yield.

Lake Pedder catchment yield can also be estimated independently using streamflow data from *McPartlan Pass Canal at Control Gate* and changes in Lake Pedder storage. The results of these different estimation methods are given in Table 2 below.

Using streamflow and changes in storage Lake Pedder contributes 42.5% of the total inflow to Lake Gordon, some 2.5% higher than the rainfall based estimate. This higher figure is consistent with a higher Lake Pedder catchment rainfall producing a higher rainfall/ runoff ratio.

The upper Huon River catchment is approximately 34% of the current Lake Pedder catchment. The average flow recorded by the *Huon River at Scotts Peak* streamflow station for the period 1963 to 1972 was 13.7 cumecs. Some small additional pickup catchments and scaling for long term average means that the upper Huon River catchment contributes an average of just over 14 cumecs to the total Lake Pedder inflows.

To demonstrate the variability of streamflow in the area the monthly inflows to Lake Gordon are given in Figure 3.

The issue of how to allow for any changes to catchment yields caused by the creation of two very large lakes was considered in the original investigation report (HEC 1969). Because of a lack of data it was assumed that changes to rainfall/runoff ratios and evapo-transpiration rates would cancel out and that there would be no net change. Evaluation of pre- and post-dam catchment yield data supports this assumption.

STORAGE BASIN, OUTLET STRUCTURES AND DRAWDOWN SCENARIOS

Figure 4 gives the storage curves for the current Lake Pedder. Figure 5 gives the head vs. flow characteristics of the two outlets and McPartlan Pass Canal. McPartlan Pass Canal would be used to drain as much of Lake Pedder as possible into Lake Gordon to recover the energy value of the water. Above SL 303.3 metres both the Edgar Dam riparian outlet (maximum capacity 5.8 cumecs) and the Serpentine Dam outlet (maximum capacity 236 cumecs) can be used to drain Lake Pedder. These capacities assume that there is no blockage of the outlets caused by debris and dead trees becoming jammed in the valves. From SL 303.3 metres down to the SL 300.5 metres level of the Huon/Serpentine saddle only the Serpentine Dam outlet can be used to drain the lake basin.

Option	**Lake Pedder Catchment Yield** cumecs	**Lake Gordon Catchment Yield** cumecs	**Lake Pedder as percentage of total Gordon Power Scheme** percentage
Pre-dam streamflow data	43.73	59.17	42.5
System modelling data (1924-91)	42.75	57.84	42.5
Storage change and McPartlan Pass (1974-78)	40.75	56.31	42.0

Table 2: Estimates of Lake Pedder catchment yield.

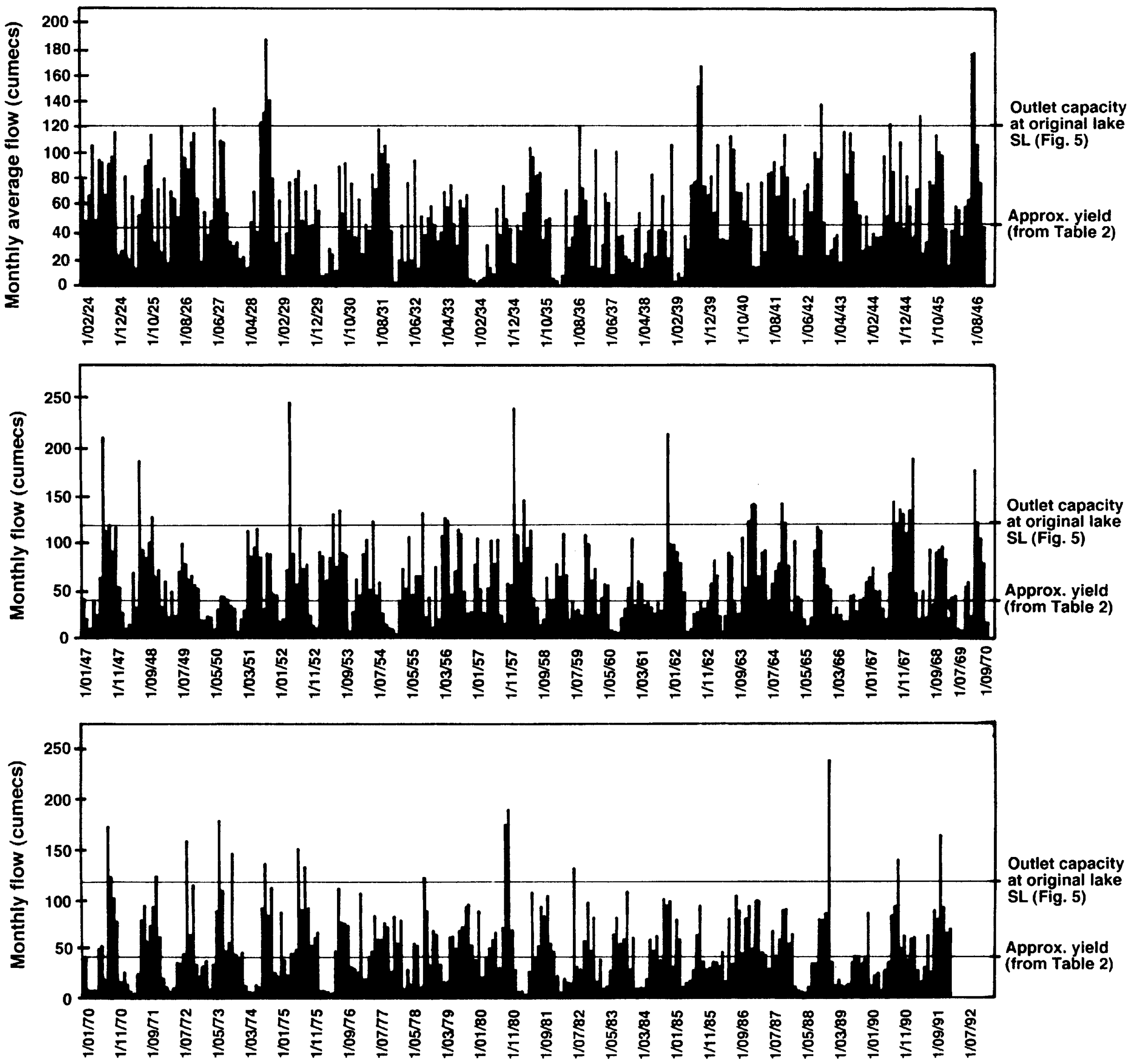

Figure 3: Estimated annual inflows to Lake Gordon from Pedder catchment.

Below SL 300.5 metres the Huon part of the impoundment cannot be drained unless Scotts Peak Dam is breached. The invert of the Serpentine Dam outlet is SL 282.4 metres, some ten metres lower than the level of the old lake Pedder.

Estimated Lake Pedder inflows, storage curves and the hydraulic characteristics of the outlet structures were used to simulate a range of Lake Pedder draining scenarios. Figures 6 and 7 summarise the results of these simulations. Two different draining start times, July and January, were examined. In both cases the Huon Impoundment hovered about the level of the connecting saddle. With a July start time the Serpentine Impoundment level has a 50% chance of reaching the SL 282.4 metres invert level of the Serpentine Dam outlet by March of the following year. On average, the storage level will then begin to rise because the inflows will generally exceed the capacity of the outlet. With a January start time Serpentine water levels have a 50% chance of reaching the same SL 282.4 meters invert level by the following January. The water level would remain close to this invert level until inflows began to exceed the outlet capacity in April when the level would begin to rise again.

Depending on the pattern of future catchment inflows, the water level behind Serpentine Dam would vary from the SL 282.4 meter invert level of the Serpentine Darn outlet up to over SL 292 metres. In wet years the level would rise above the SL 292.5 metres level of the old Lake Pedder. Figure 8 gives the simulated water levels behind Serpentine Dam for the period 1924 to 1991 assuming:

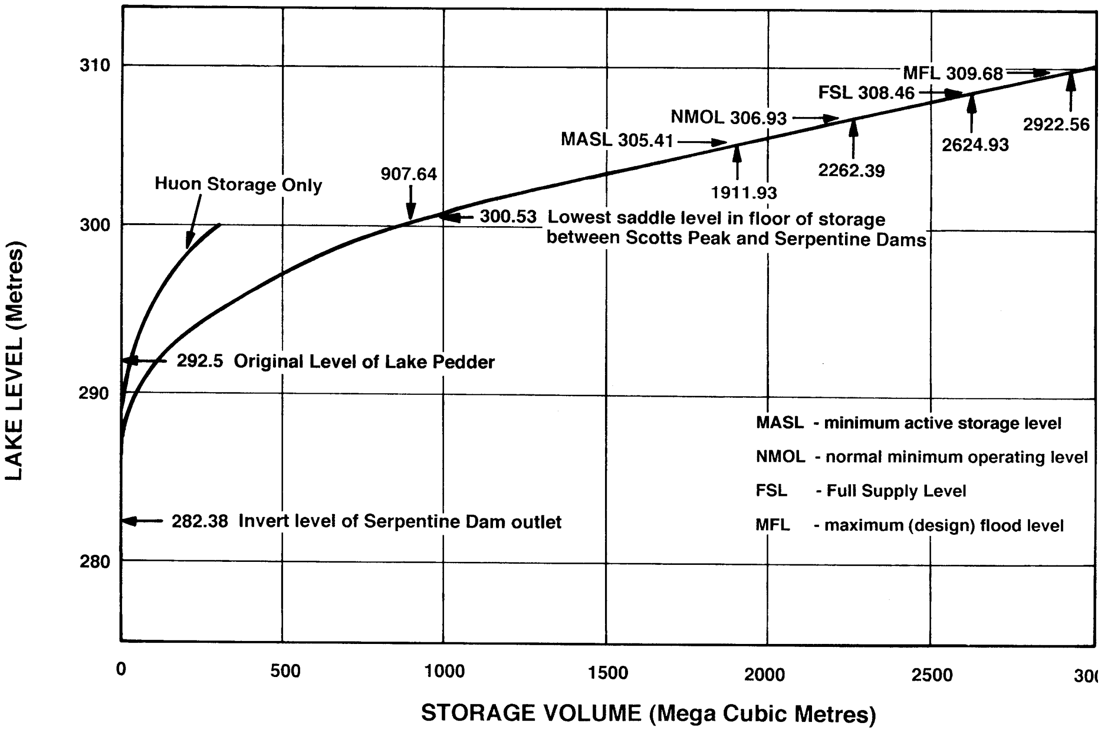

Figure 4: Lake Pedder storage curve.

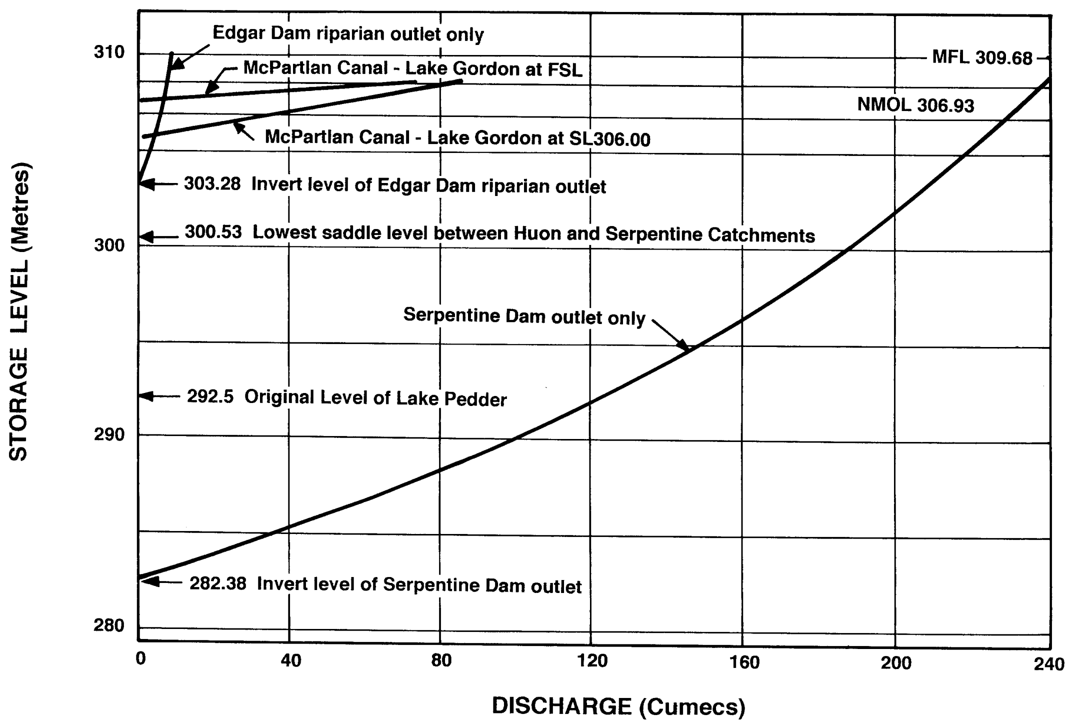

Figure 5: Lake Pedder outlet ratings.

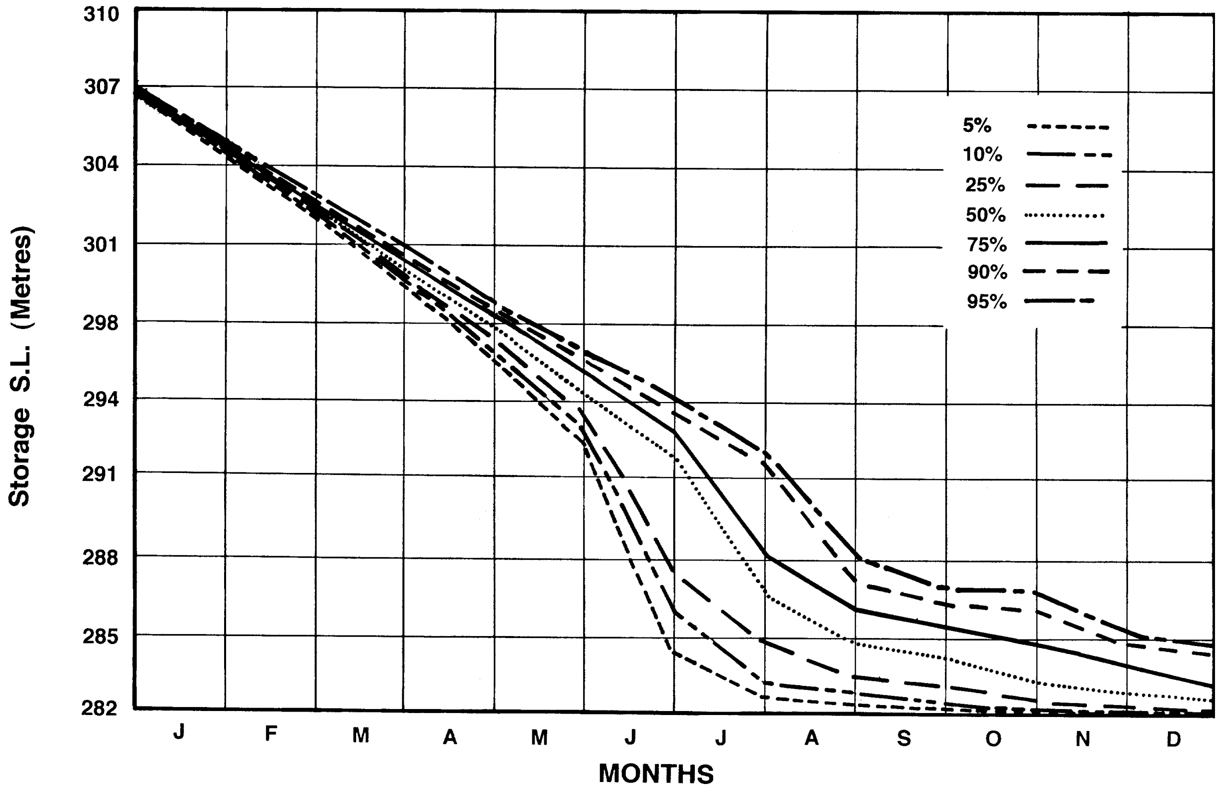

Figure 6: Lake Pedder January dewatering curves.

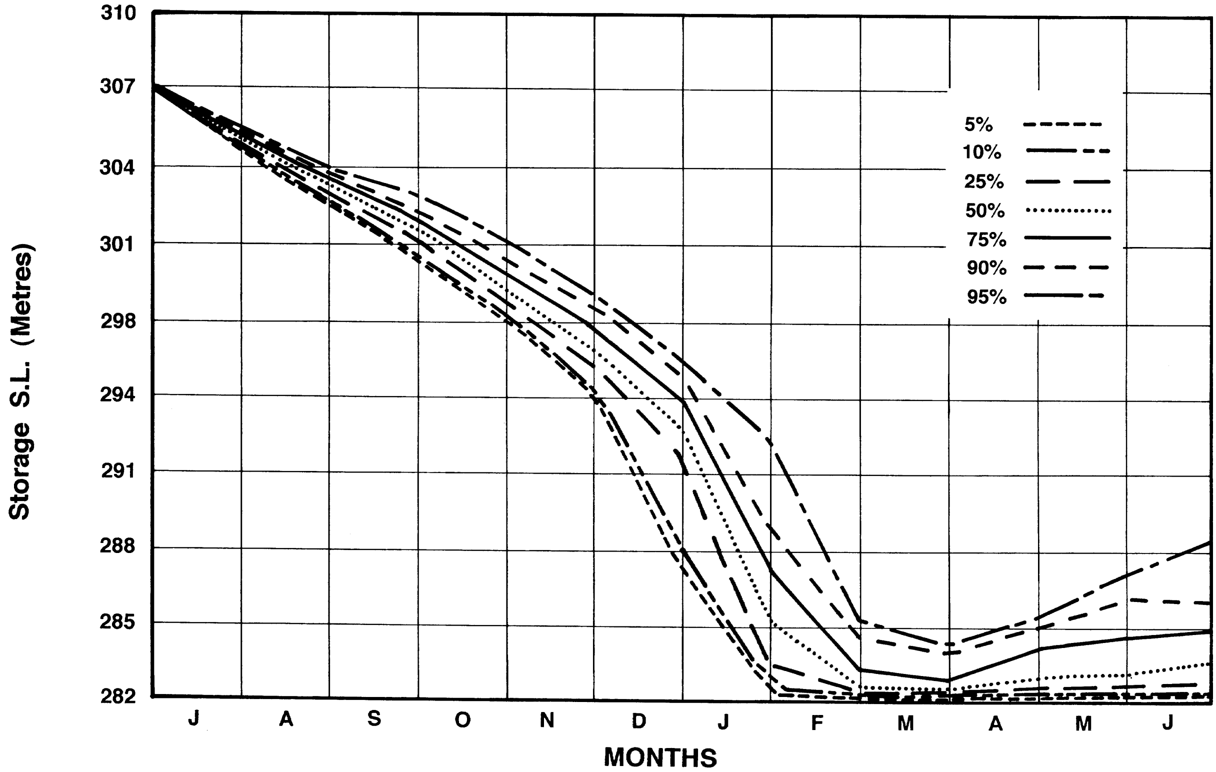

Figure 7: Lake Pedder July dewatering curves.

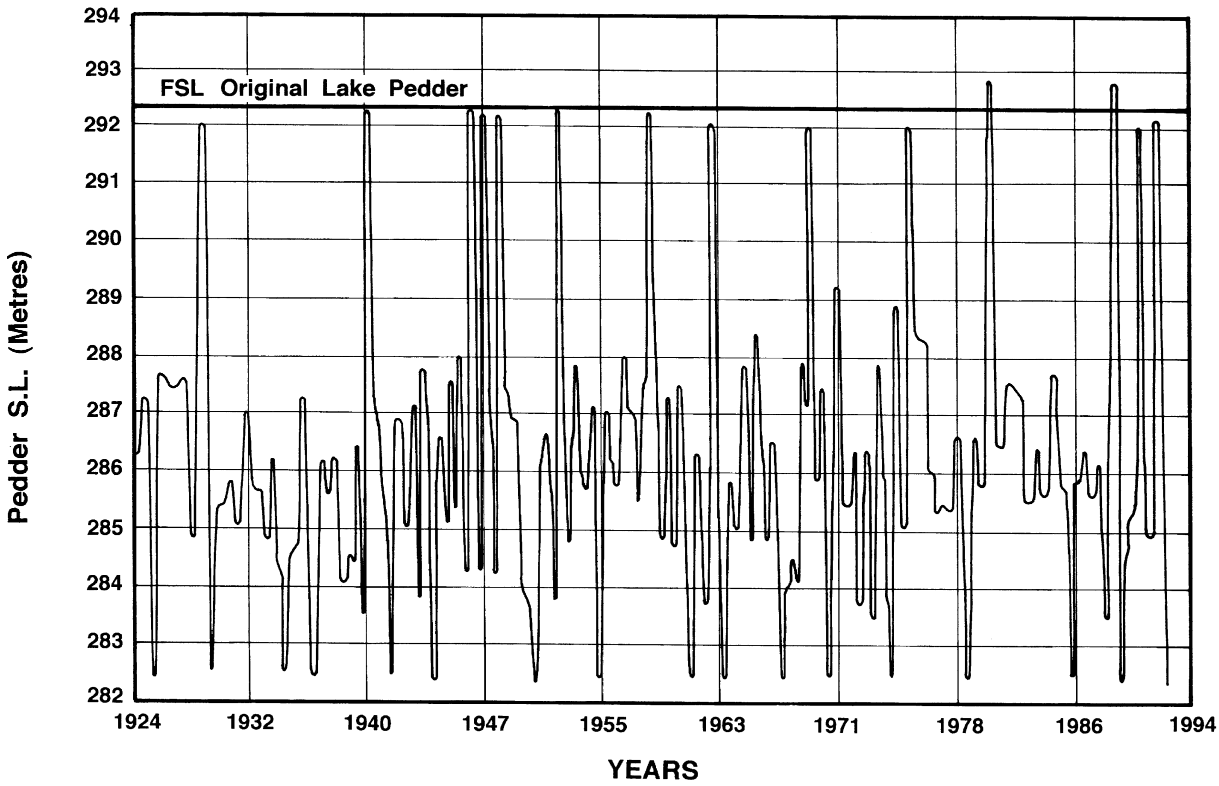

Figure 8: Simulated lake level behind Serpentine Dam with outlet open and 1924 to 1991 rainfall.

- Scotts Peak Dam is not breached and Upper Huon water is diverted into the Serpentine River;
- there is no spill from Lake Gordon through McPartlan Pass canal;
- runoff per unit area from the drained area is similar to historic values; and
- there are no debris/blockage problems.

A second simulation showed that if Scotts Peak Dam is breached and the Upper Huon does not contribute to Serpentine River flows then the maximum water level reached would be about SL 288 behind Serpentine Dam. Any additional water from Lake Gordon, increased runoff or blockage of the Serpentine Dam outlet would rapidly cause the water level to rise well above this level. Even without these problems this no upper Huon diversion option would still routinely flood 10 km back up the Serpentine Valley exposing large areas of mud flats.

HUON RIVER FLOODING

Available streamflow records

The earliest recorded floods in the Huon River were the 1901 and 1914 flood levels. These were noted by the Wallis family on their farm, Hermitage, upstream of the Russell River junction. Flow peaks can be estimated by comparison with the 1948 flood level noted at the same site. The 1901 flood was probably the biggest since the 1850's.

In 1915 the PWD installed a gauge board at Judbury. This PWD gauge was not rated and systematic flow records only began in 1921 when the Hydro-Electric Department opened Site No. 14, *Huon River at Judbury*. This site operated continuously until 1949, then intermittently up to the present day. There are doubts about the accuracy of the high flow rating at this site because of the lack of high flow gaugings and problems with the gaugings that are available. At present *Huon at Judbury* is only used as a flood warning station and data from this station should be used with caution.

In 1948 the HEC installed a streamflow station on the *Huon River above Frying Pan Creek.* This station is still in operation. Figure 9 shows the rating curves and high gaugings for this site. The flow data for this station is considered to be good, it has been gauged many times and the highest gauging is almost 90% of the largest flood peak.

The streamflow station on the *Huon River at Scotts Peak* operated from early 1963 until work on Scotts Peak Dam caused it to be closed in June 1971. The annual flood series for the streamflow stations *Huon at Judbury* and *Huon River above Frying Pan Creek* and other historic flood data are given in Appendix 3.

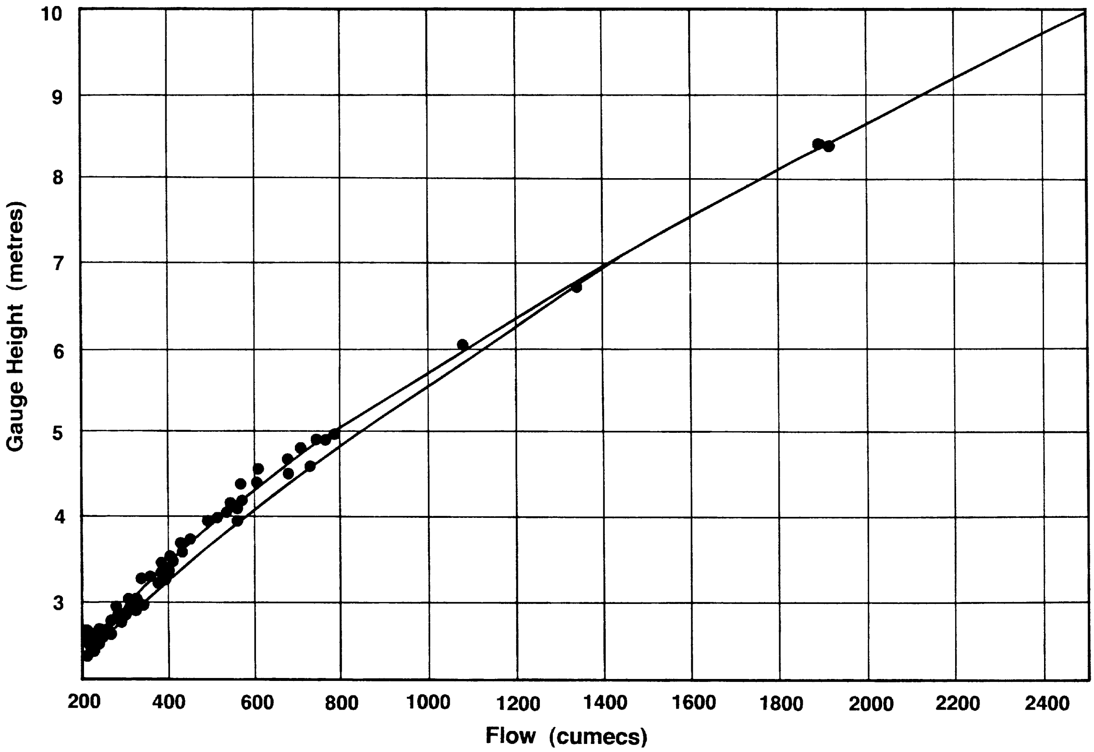

Figure 9: Huon above Frying Pan Creek, rating curve and gaugings.

Effect of area reduction on flood peaks

A general 'rule of thumb' often applied to estimating the effect of catchment area on flood peaks in Tasmanian rivers is that flood peaks are proportional to the ratio of catchment areas raised to the power 0.8. If the flood in River A ($\mathbf{Q}_{\text{river A}}$) is known then the flood in River B ($\mathbf{Q}_{\text{river B}}$) is given by:

$$\mathbf{Q}_{\text{river B}} = (\mathbf{A}_{\text{river A}} / \mathbf{A}_{\text{river B}})^{0.8} * \mathbf{Q}_{\text{river A}}$$

where **A** = catchment area

Using this "rule of thumb" we would expect Scotts Peak Dam to reduce flood peaks in the *Huon above Frying Pan Creek* by 10%, by 9% at Judbury and some 8% at Huonville.

The effect of Scotts Peak Dam on floods in the lower Huon River has been examined a number of times. The annual flood series for the *Huon above Frying Pan Ck.* was generally used because it is the most accurate record and no 'a priori' assumptions needed to be made about the effects of catchment area changes on floods.

Site	**km^2**	**Area below Scotts Peak**
Huon at Scotts Peak	258	-
Huon above Frying Pan Creek	2098	1840 km^2
Huon at Hermitage	2218	1960 km^2
Huon at Judbury	2368	2110 km^2
Huon at Huonville	2737	2469 km^2

Table 3: Catchment areas of Huon River flood recording sites.

Early estimates of post-dam flood size and frequency were influenced strongly by the large floods in 1981 and 1975. These two post-dam floods were the second and third largest floods measured in the *Huon above Frying Pan Ck.* We now have 23 years of post-dam record (1972 to 1994) for the *Huon above Frying Pan Ck.* compared to 24 years of pre-dam record (1948 to 1971) and the effects of the two large floods immediately after dam closure on post-dam flood frequency analysis is now less significant.

Estimates of flood size and frequency

To determine the size and frequency of pre- and post-dam floods a Log Pearson Type 3 distribution (LPIII) was fitted to the pre- and post-dam annual flood series for the *Huon above Frying Pan Ck.* The results are summarised in Tables 4 and 5.

The LPIII distribution fitted to the pre-dam *Huon above Frying Pan Ck.* annual flood series has a skew of -0.21 while the skew for the post-dam series is +0.86. This difference in skew values means estimates of the frequency and size of pre- and post-dam floods are not directly comparable unless the differing skew values are allowed for. Because of the problems with estimating the skew of short annual flood series Australian Rainfall & Runoff (IEA 1987) recommends that a regional value of skew be applied. Examination of the annual flood series for the other Tasmanian rivers including *King at Crotty* (1924-90), *Franklin at Mt. Fincham* (1953-94) and *Huon at Scotts Peak* (1963-71) all showed small positive skews.

The combined record of the *Huon River at Judbury*, the *Huon River above Frying Pan Creek* and the historic levels at Hermitage Farm can be combined in one Huon River flood record by adjusting for catchment area changes. This combined, area adjusted, Lower Huon River record (1853-1994) had a small positive skew of 0.4. To allow direct comparison of pre- and post-dam flooding the small positive 0.4 skew of the combined, area adjusted, Lower Huon River record (1853-1994) or a skew of zero should be used.

Comparison of pre- and post-dam Huon River flooding

Flood frequency analysis is a probabilistic process and any comparison of the size and frequency of pre- and post-dam floods must allow for the uncertainty inherent in flood frequency analysis techniques. Table 4 gives the best or "most likely" estimate of the flood sizes for a range of average recurrence intervals (ARI's) and skew values. The 24 years of pre-dam data and the 23 years of post-dam data provide reasonable estimates of the 2, 5, 10 and 20 year ARI floods; the 50 and 100 year ARI flood estimates are less certain.

Measures of this uncertainty are the 5% and 95% confidence bands shown in Table 5. In this table the most likely value is the 50% estimate but there

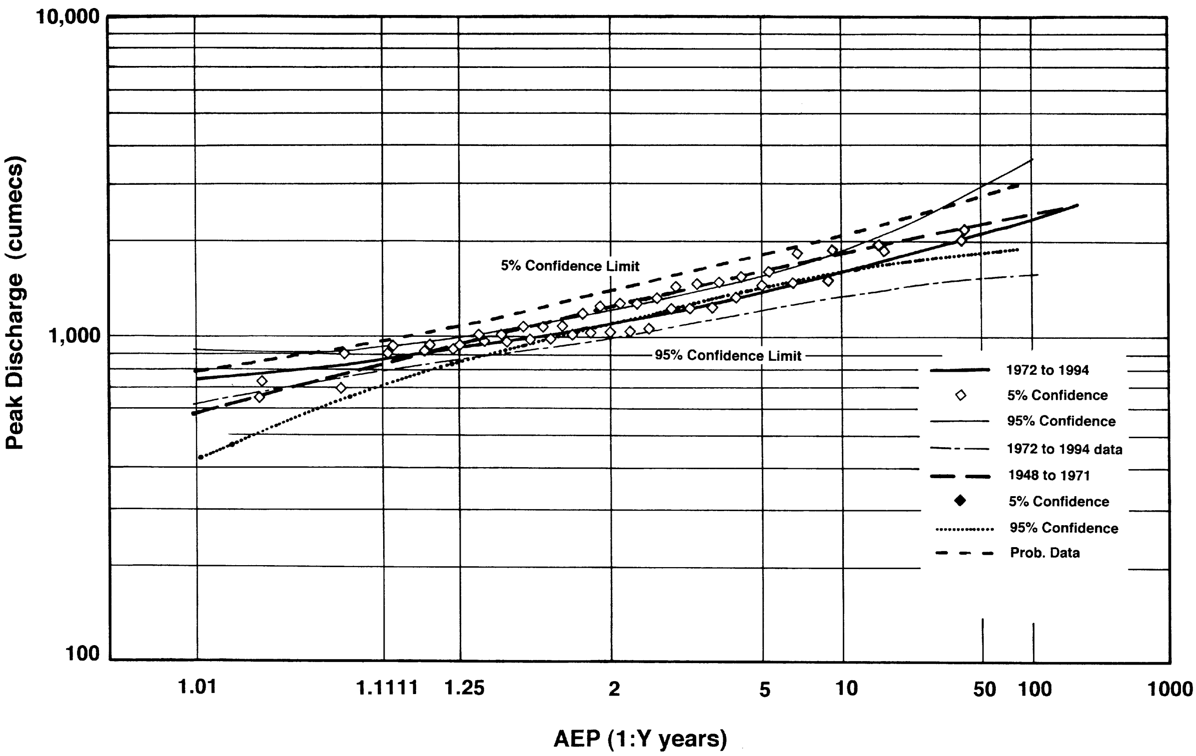

Figure 10: Huon River above Frying Pan Creek: pre- and post-dam flood frequency.

	Raw Data			Log Normal			Positive Skew		
ARI Years	**1948-71** cumecs	**ratio of post-dam to pre-dam**	**1972-94** cumecs	**1948-71** cumecs	**ratio of post-dam to pre-dam**	**1972-94** cumecs	**1948-71** cumecs	**ratio of post-dam to pre-dam**	**1972-94** cumecs
2	1278	88%	1125	1264	92%	1164	1238	92%	1145
5	1646	86%	1412	1641	88%	1437	1628	88%	1428
10	1867	87%	1626	1882	85%	1604	1902	85%	1619
20	2066	89%	1848	2107	83%	1757	2177	83%	1804
50	2308	94%	2165	2392	81%	1946	2552	80%	2051
100	2479	98%	2426	2603	80%	2084	2849	79%	2241
Skew	**-0.21**		**+0.86**	**0.0**		**0.0**	**+0.4**		**+0.4**

Table 4: Frequency and size of pre- and post-dam floods. Note: "ARI" = Average Recurrence Interval

Time	**1948 - 71**			**1972 - 94**		
	5%	50%	95%	5%	50%	95%
2 yr.	1387	1238	1105	1258	1145	1043
5 yr.	1863	1628	1423	1595	1428	1279
10 yr.	2253	1902	1606	1860	1619	1408
20 yr.	2707	2177	1750	2159	1804	1508
50 yr.	3432	2552	1897	2617	2051	1607
100 yr.	4093	2849	1984	3019	2241	1664

Table 5: Confidence limits: pre- and post-dam flood frequency analysis

is a 10% chance that the flood lies outside the band enclosed by the 5% and 95% confidence limits. The adopted skew for Table 5 is positive 0.4.

The 2, 5, 10 and 20 year ARI flood estimates are the most reliable, and the most likely post-dam values of these floods are similar to the 95% confidence limit of the pre-dam floods. While it is still statistically possible that the reduction in the size and frequency of Huon River floods is due to other factors the magnitude of the reduction, the timing of the reduction and the consistency with the general "rule of thumb" outlined above means that we can conclude Scotts Peak Dam has significantly reduced flooding in the Huon River.

Huonville Flood Levels

Gutteridge Haskins & Davey (1993) examined flooding in Huonville. The Huon River at Huonville is tidal and the cycle of tides can increase the heights, and thus the effects of flooding in Huonville. This increase in flooding by tides has been estimated to increase floodpeak levels by amounts equivalent to a 40 to 80 cumecs increase in flood flow. This is insignificant for major floods.

The approximate 10% increase in Huon River floods that would follow the removal of Scotts Peak Dam would increase the level of the 100 year flood in Huonville by about 200mm.

Alternatively the 10% increase would change a 20 year flood into a 50 year flood or a 50 year flood into a 100 year flood.

OTHER FLOODING ISSUES

A number of paired catchment studies associated with clearing land for forestry or agriculture (Nandakumar & Mein 1993) have shown that cleared catchments initially produce higher catchment yields and higher flood peaks. Yields and flood peaks then reduce as the vegetation returns. Lake Pedder lies in an area of consistent high rainfall and a drained lake would expose large areas with no live vegetative cover to this high rainfall.

A recent example of the flooding produced by the lack of live vegetative cover occurred in the Whyte River catchment north of the Pieman River in March 1982. A severe fire in February 1982 burnt large parts of the Whyte River catchment exposing the soil. A moderate rainfall in March 1982 that would be expected to occur several times each year produced the largest recorded flood in the Whyte River. Whyte River records began in 1961 and based on these records the March 1982 flood was estimated have a 50 year Average Recurrence Interval (Figure 11). The bare hills of Queenstown are a well-known example of the effects of high Tasmanian rainfall on exposed soil. Flash flooding from the exposed rock, soil and tailings near Queenstown is more severe than from nearby catchments with deeper soils and vegetative cover.

A drained Lake Pedder would have no protecting vegetative cover to intercept rainfall and any storm that occurs soon after draining would produce above average flood peaks, as occurred in the Whyte River catchment in 1982. The erosive power of large flood peaks is much greater than the small floods that occur several times each year. The size, frequency and erosive effects of the above average floods that would occur from a drained Lake Pedder catchment need further study.

FLOW DURATION PATTERNS

The construction of Gordon, Serpentine, Scotts Peak and Edgar dams and the subsequent power station operations have altered the flow regime in the lower Huon and Gordon rivers. Draining Lake Pedder would alter the flow regimes again.

Huon River flow duration

Figures 12 and 12a are flow duration curves for the *Huon above Frying Pan Creek*; about 12% of the catchment area of this streamflow station was diverted by the closure of Scotts Peak Dam in June 1972. The pre-dam median flow was 48.5 cumecs while the post-dam median flow is 41.1 cumecs, a reduction of 15% in median streamflow. For lower flows the reduction in stream flows since diversion is smaller. Post-dam flows exceeded 90% and 95% of the time are only 8% less than the corresponding pre-dam flows.

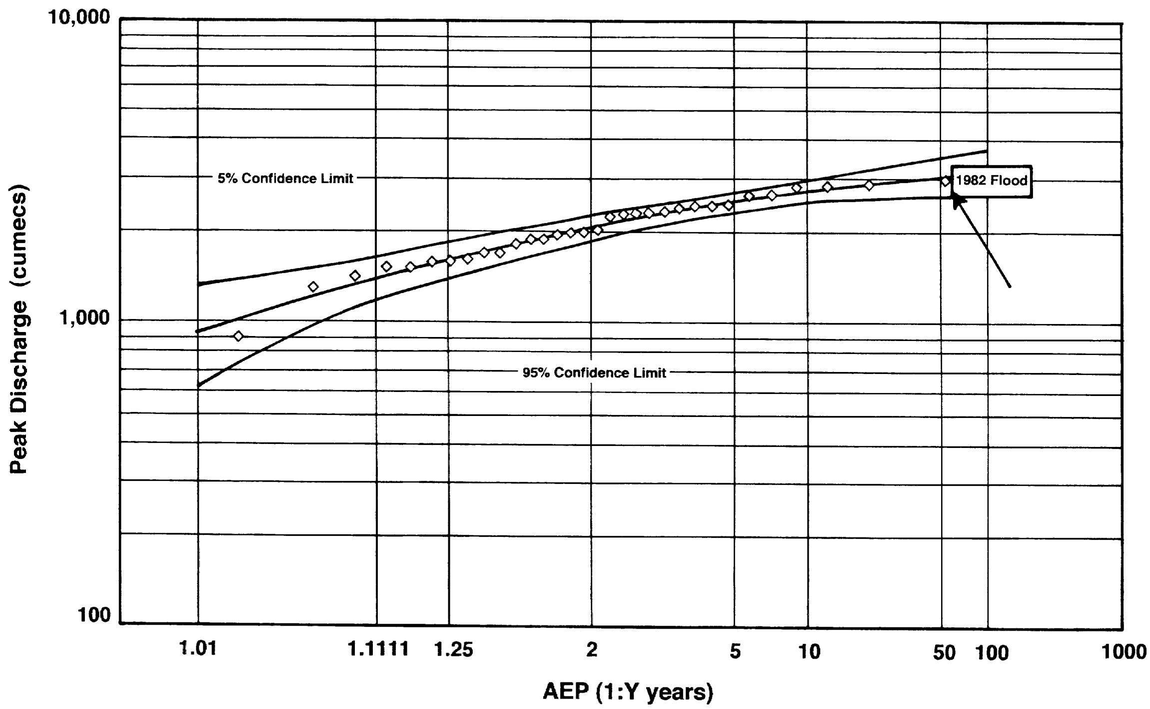

Figure 11: Whyte River above Rocky Creek: flood frequency analysis.

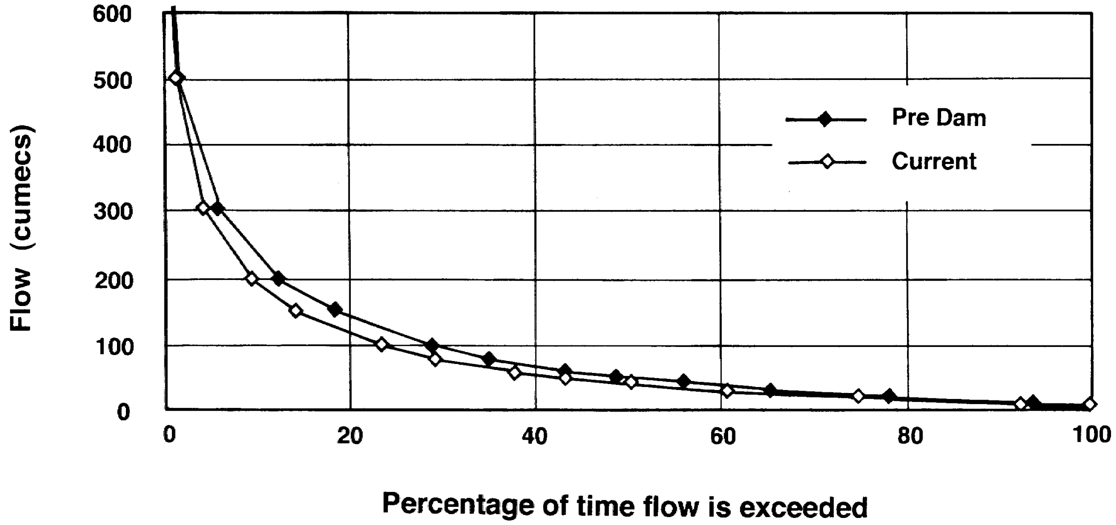

Figure 12: Huon River above Frying Pan Creek: pre- and post-dam flow duration curves.

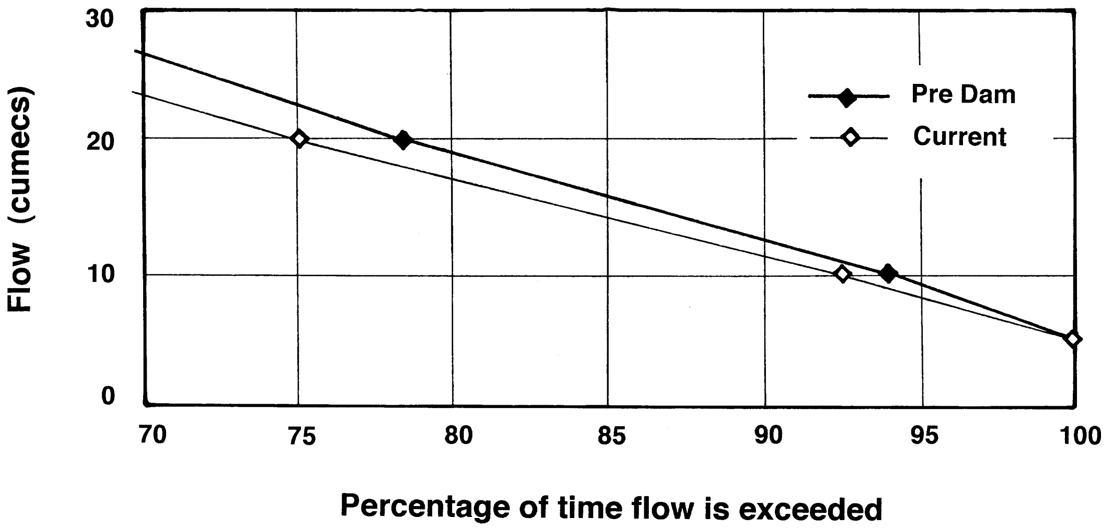

Figure 12a: Low flow expansion of Huon River above Frying Pan Creek: pre- and post-dam flow duration curves.

A reduction in median streamflow larger than the reduction in area was expected as the part of the Huon River catchment diverted has a relatively high rainfall. This causes a runoff per unit area higher than the rest of the Huon catchment, increasing the effect of the diversion on median flows. The lower streamflows that are typically exceeded 90% or 95% of the time are maintained by groundwater and discharge from swamps and storages in the catchment. The diversion of the upper Huon has had a smaller effect on these low flows.

If Scotts Peak Dam is breached to drain Lake Pedder then flows in the Huon River would revert to the pre-dam conditions.

Gordon River flow duration

There is no single streamflow station that can be used to examine changes in the flow regime in the lower Gordon River and it is necessary to estimate flow duration curves by scaling and summing curves from other stations. For this paper, flow duration curves that describe the pre-dam, post-dam and no-Pedder flow regime in the Gordon River below the Franklin River junction were estimated as follows:

Pre-dam	*Gordon River above Franklin* (1958 to 72) plus *Franklin River at Mt. Fincham* (1953 to 94) * **2.22**

Post-dam	*Gordon Power Station outflow* (simulated 1924 to 91) plus *Gordon River above Franklin* (April 1974 to Dec. 77) plus *Franklin River at Mt. Fincham* (1953 to 94) *** 2.22**
No Lake Pedder	*Gordon Power Station outflow* (simulated 1924 to 91) *** 0.6** plus *Gordon River above Franklin* (April 1974 to Dec. 77) plus *Franklin River at Mt. Fincham* (1953 to 94) *** 2.22** plus *Serpentine River above Gordon* (1961 to 72)

Gordon Dam was closed April 8th 1974 and the power station did not begin regular operations until January 1978. Hence, streamflow data for *Gordon River above Franklin* (April 74 to Dec. 77) is a direct measure of the pickup below Gordon Dam. Streamflow data for *Franklin River at Mt. Fincham* was scaled by the ratio of catchment areas to give the flow in the Franklin River above the junction with the Gordon River. The catchment area of the *Franklin River at Mt. Fincham* is 757 km^2 while the total catchment area of the Franklin River above its junction with the Gordon River is 1684 km^2 giving a pick up ratio of 2.22.

Because different periods of record were used the flow data was scaled to approximate long-term average values.

Figure 13 illustrates the changes to Lower Gordon flow regime that resulted from the construction and operation of the Gordon River Power Development. Lower Gordon River flows in the mid range now occur much more often than for the natural catchment. Flows above this range are less common because the high flows are stored and released to generate power when required. Although the median flow is similar, a flow of 300 cumecs is now exceeded 36% of the time compared to 29% for the natural catchment.

Low flows are also more common than for pre-dam conditions. Lake Gordon is a major system storage and hence Gordon Power Station does operate during periods when runoff is low elsewhere in the HEC system. Hence, at times, operation of Gordon Power Station will increase flows in the Lower Gordon River above natural conditions. However as Gordon Power Station is based on a major system storage it tends to be one of the last power stations chosen to produce energy. If capacity is available elsewhere other power stations will be used in preference to Gordon Power Station in order to preserve as much water as possible in Lake Gordon. Hence, at times, Gordon Power Station will be turned off during periods of low runoff causing flows in the Lower Gordon River to be lower than naturally occurring low flows. This is demonstrated in Figure 13a, an expansion of the lower flow section of Figure 13.

To estimate the No-Pedder case the percentage of time that the current Gordon Power Station exceeds various flows was scaled by 0.6; this is an over-simplification of the likely operating rules but it does illustrate possible changes to the downstream flow regime. If Lake Pedder water is not diverted into Lake Gordon (the No-Pedder case) then the relative balance of the two major system storages, Lake Gordon and Great Lake, would need to be re-optimised.

In the No-Pedder case the frequency of low flows is very similar to the current situation; the loss of the water from upper Huon River diversion is not apparent in this analysis. High flows would still be stored but the reduction in storage and the increase in the proportion of natural catchment means that the size and frequency of high flows would be closer to the natural catchment situation. Mid- and high-range behaviour is different to both the pre - dam case and current situation with the reduced operation of Gordon Power Station and the increased uncontrolled pick-up changing the shape of the duration curve. For the No-Pedder case the frequency of mid-range flows decreases while higher flows would be more frequent.

Circulation patterns in Macquarie Harbour are particularly important to the aquaculture industry because of the problems with Queen River sediments and acid mine drainage. The effect, of reducing Gordon River mid-range flows or increasing the frequency of higher flows, on the circulation patterns and water quality in Macquarie Harbour has not yet been determined. Following the changes to the operation of the Mt. Lyell mine, the hydrology, sediment movement and chemistry of the King River and parts of Macquarie Harbour are being studied (Locher 1994). The results of this current study and further work being scoped at present may provide insight into the effect of draining Lake Pedder on the Lower Gordon River and Macquarie Harbour.

Lower Gordon floods were not examined but the catchment area scaling to the power 0.8 that was confirmed for the Huon catchment would also apply to the Gordon catchment.

CONCLUSIONS

Using the additional rainfall data that is now available and a re-estimation of rainfall distribution in Tasmania's South West confirmed that Lake

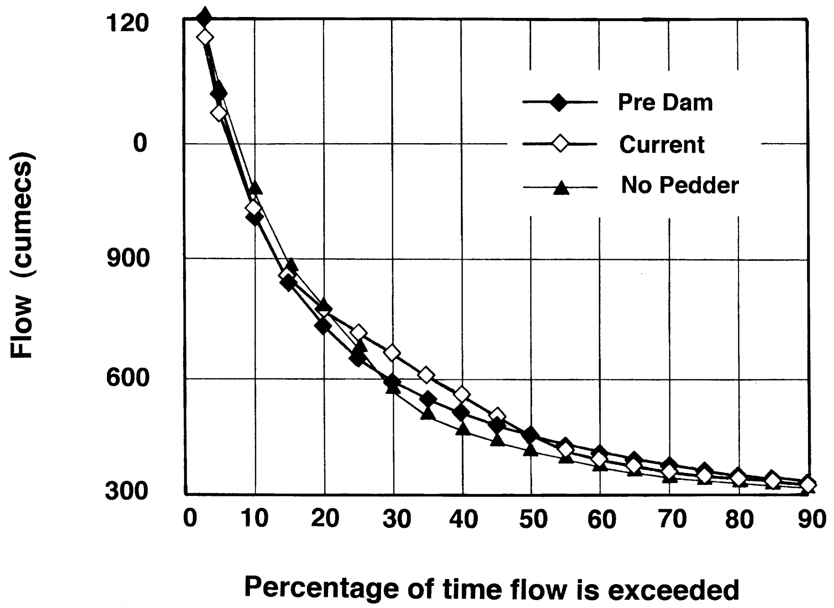

Figure 13: Estimated flow duration curves for Gordon River below Franklin River junction.

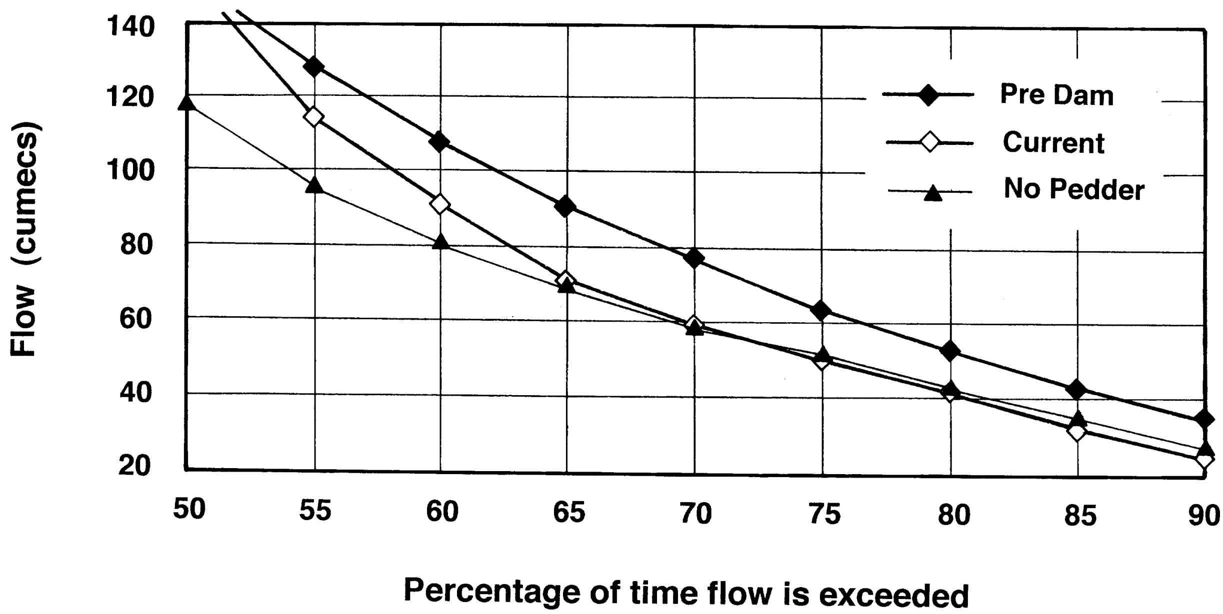

Figure 13a: Low flow expansion of estimated Gordon river below Franklin River junction flow duration curves.

Pedder contributes approximately 40% of the rainfall volume falling on the catchments contributing to Gordon Power Station. Based on stream flow and changes in lake storage volumes the average inflow to Lake Pedder is estimated to be 42.7 cumecs. Approximately 14.5 cumecs of the total Lake Pedder inflow is from the upper Huon catchment diversion. This Lake Pedder inflow is 42.5% of the estimated inflow to Gordon Power Station. A streamflow based estimate 2.5% more than the rainfall based estimate is consistent with a higher runoff to rainfall ratio for the wetter Lake Pedder catchment.

Based on the Lake Pedder storage curves, the hydraulic characteristics of outlet structures, the bathometric shape of the storage and estimated Lake Pedder inflows a simulation of Lake Pedder draining showed that:

- The small riparian outlet in Edgar Dam cannot drain the Huon River section of Lake Pedder because the invert of the outlet is above the level of the Huon/Serpentine saddle and because upper Huon River flows exceed the capacity of the Edgar Dam riparian outlet.

- The Serpentine Dam outlet can drain Lake Pedder in about 12 months with average inflows during the drainage period but it cannot keep the level behind Serpentine Dam below the level of the old Lake Pedder if water from the Upper Huon catchment is diverted into the Serpentine River catchment.

To drain Lake Pedder and prevent upper Huon River water flowing across the Huon/Serpentine saddle, Scotts Peak Dam must be removed. If Scotts Peak Dam is removed and Serpentine Dam is not removed water levels behind the Serpentine Dam would regularly rise 10 kilometres up the Serpentine Valley creating a large area of mud flats. With no Lake Gordon spill through McPartlan Pass and no increased runoff from the drained area the water level behind Serpentine Dam would remain below the level of the old Lake Pedder.

Flow regimes in the Gordon and Huon Rivers would be altered if Lake Pedder was drained. Huon River flows would revert to pre-1972 conditions if Scotts Peak Dam was removed. In the Lower Huon River median flows would increase by about 15% and low flows would increase by about 8%. The size of floods with the same frequency would increase in proportion of the catchment area ratio raised to the power 0.8, that is, by about 10%. The frequency of low flows in the lower Gordon River would not change significantly but the frequency of mid-range flows would decrease while the frequency of higher flows would increase.

Several areas require further study:

- The effect of changes in the Lower Gordon River flow regime on water quality and circulation in Macquarie Harbour is still being investigated and it is too early to draw firm conclusions.

- The area currently covered by the water of the enlarged Lake Pedder would have no live vegetative cover if the lake was drained. This would increase both the frequency and severity of flood peaks. The effect of these enhanced floods on erosion and sediment movement in the drained area and downstream rivers requires further study.

- The loss of the Lake Pedder diversion into Lake Gordon, one of two major system storages, would significantly alter the operation of the HEC power generation system. Much more work is required to quantify changes to any No-Pedder system operating rules, and estimates used in this paper are necessarily only approximate.

ACKNOWLEDGEMENTS

This paper was originally produced as Attachment 1 to the April 1995 Hydro-Electric Commission submission to the House of Representatives Standing Committee on Environment, Recreation and the Arts Inquiry into the Proposal to Drain and Restore Lake Pedder, entitled *HEC Response to Questions Raised by the Committee on February 1995 and Supplementary Information.*

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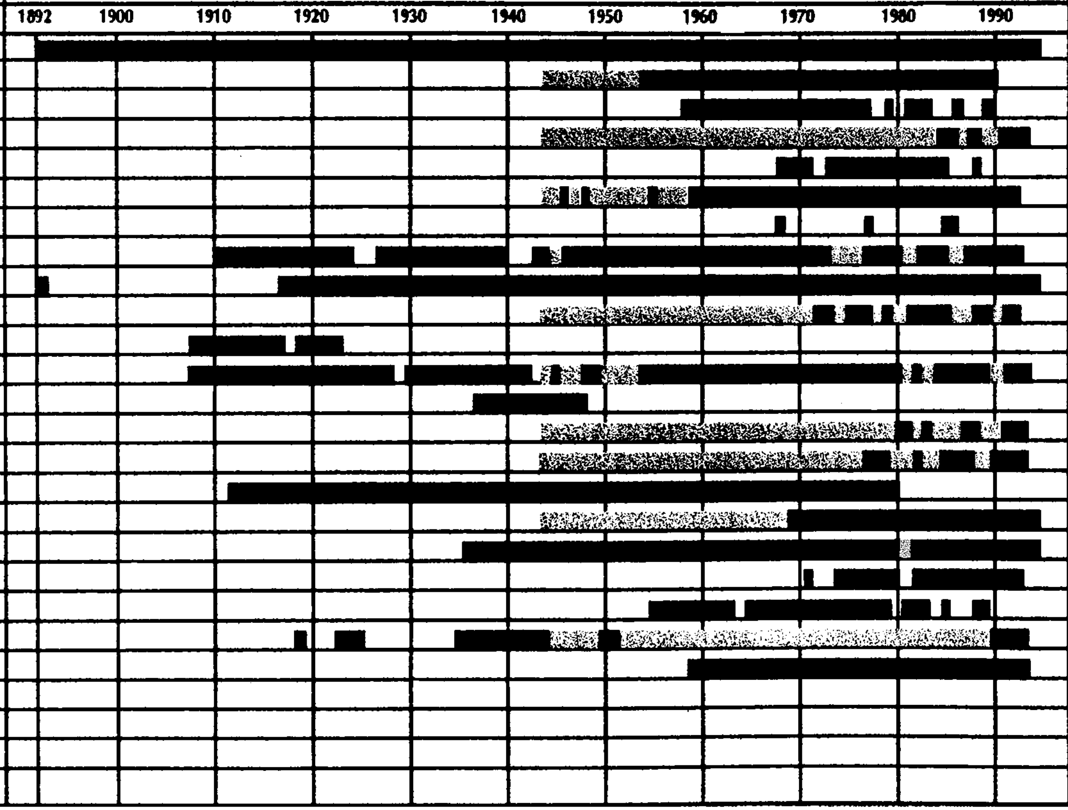
APPENDIX 1:

RAINFALL RECORDING LEVELS FROM RECORDING SITES IN SOUTH WEST TASMANIA

South West Tasmania Rainfall

Rainfall Recording Sites	Site No	BOM No	Rainfall Ave. 1961 to 1990	Count 1961 - 1990	Rainfall Ave. 1892 to 1994	Count 1892 - 1994
Arve Valley		97045	1382	23	1398	30
Butlers George	881	96003	1599	30	1654	52
Cape Sorell	121	97000	1481	10	1353	71
Cardigan Hats	884	97032	2776	30	2834	49
Davey bl crossing	473	97070	2310	30	2320	40
Florentine River	886	595000	1635	30	1673	47
Franklin bl Jane	183		2499	5	2499	5
Franklin Track Hill 4	914	97051	2811	30	2865	49
Franklin @ Mt. Fincham	145		2842	30	2898	50
Glenrowan	1976	95021	794	30	810	54
Gordon/Sir Johns Falls	1041	597002	2293	30	2359	53
Gormanston	276	97003	2836	15	2963	80
Hermit Hut	953	97038	0	0	1350	22
Hastings Chalet	1842	94027	1362	30	1393	50
Judy's Marsh	1993	95038	1263	19	1263	19
Jungle	1994	95039	1133	16	1133	16
King River at Crotty	78		2898	30	2962	47
King William Creek	957		2190	30	2246	49
Lake Echo PS	975	96014	989	30	999	50
Lake Fenton	1965	95010	1465	28	1524	50
Lake Margaret Dam	370	97006	3448	30	3581	81
Lake Margaret PH	4082	97020	2896	30	2956	51
Lake Pedder	978	597005	1753	3	1753	3
Lake Pedder/Double Pk	979	97069	3044	3	3044	3
Lake St. Clair	131	96015	1529	30	1516	53
Liapootah P.S.	981	95027	1100	28	1098	31

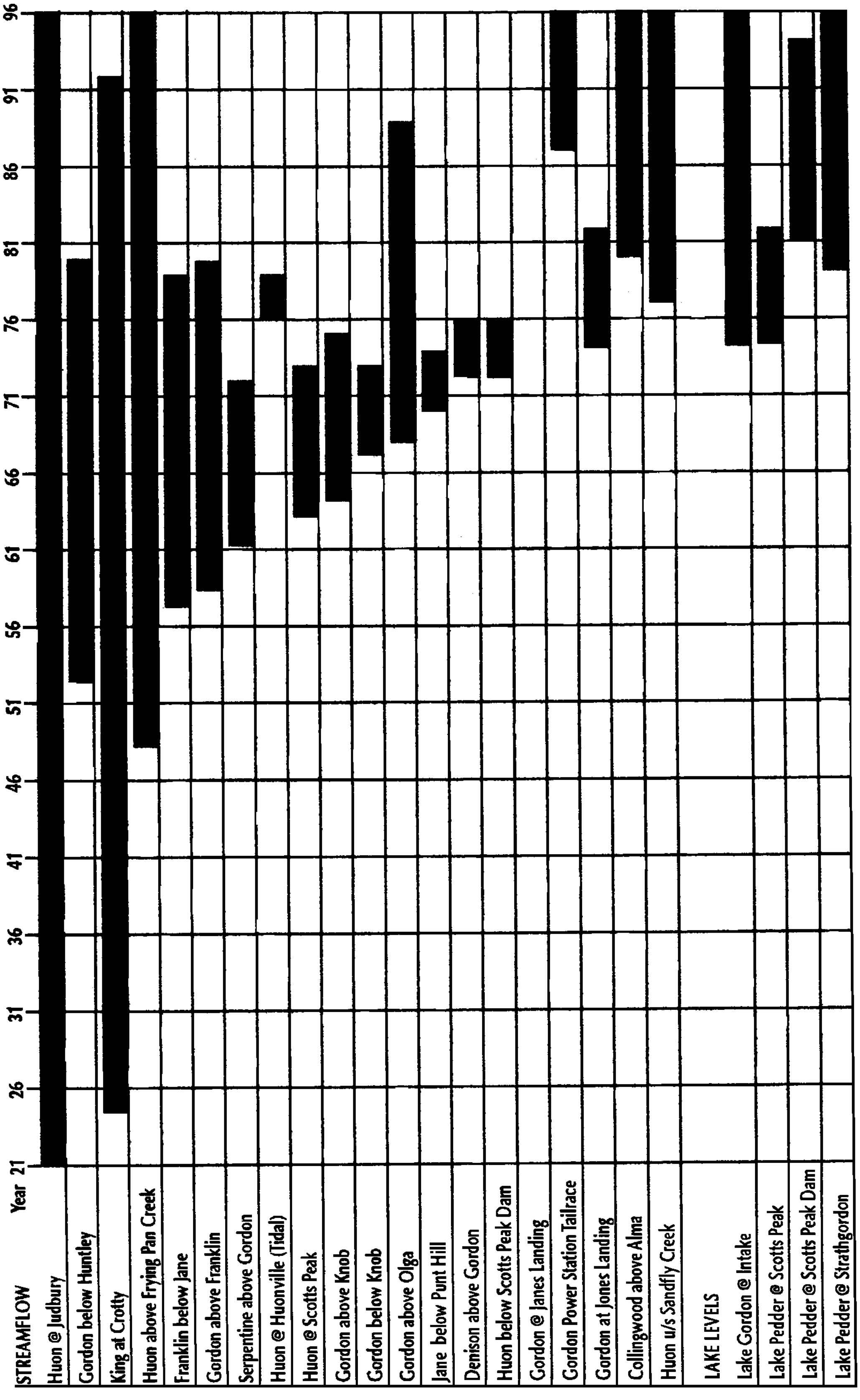
South West Tasmania Rainfall



Rainfall Recording Sites	Site No	BOM No	Rainfall Ave. 1961 to 1990	Count 1961 - 1990	Rainfall Ave. 1892 to 1994	Count 1892 - 1994
Maatsuker Island	1856	94041	1458	30	1256	103
Maydena	1966	95011	1200	30	1212	47
Settlement	1978	95023	1190	23	1199	26
McPartlan Pass	991	97052	1861	30	1891	50
Mt Wedge	4116	97055	1722	18	1722	18
N.P. Forestry	1969	95014	894	30	890	49
Olga Camp	1003	97050	2302	4	2302	4
Osterly	1971	95016	663	30	704	78
Ouse at Millbrook	382	95012	534	30	549	79
Picton Plains	4125	97065	1298	30	1281	49
Pillinger	4118	97057	0	0	1964	15
Queenstown	1026	97008	2474	30	2515	83
Rasselas Vale	4071	97009	0	0	1909	12
Sandfly Creek	1030	597009	1835	30	1866	50
Scotts Peak	1033	597008	1919	30	1942	50
Sharpes Siding	1972	95017	1083	20	1046	69
Strathgordon Met.	1046	97053	2383	20	2478	51
Tarraleah - Village	1049	95018	1138	1	1174	59
The Knob	4122	97061	3058	17	3064	19
Tim Shea	1975	95020	1438	24	1444	30
Tyenna River	299		952	1	959	63
Wayatinah P.S.	940	95026	945	30	928	35
Marker						
Estimates						
Pluviograph or Daily Read						

APPENDIX 2:

STREAMFLOW AND LAKE LEVEL DATA FROM GORDON RIVER AND HUON RIVER CATCHMENTS



APPENDIX 3:

HUON RIVER FLOOD DATA

Year	Month	Day	Height metres	Flow cumecs	Comments
1948	May	28	9.278	2223	Record began 2 April. 1948 flood quoted as "worst for 50 years", flood lapped decks of original wooden bridges at Judbury and Huonville. Water 3' 6" in Huonville shops. 18" above 1947 flood.
1949	July	7	5.904	1044	
1950	October	28	4.712	702.9	
1951	April	13	7.279	1496	
1952	June	24	8.361	1881	Water entered houses in Huonville
1953	July	22	7.212	1472	
1954	June	7	6.099	1105	
1955	August	12	6.087	1101	
1956	June	29	6.642	1280	
1957	December	3	7.544	1588	
1958	August	20	7.343	1518	
1959	June	12	6.712	1303	
1960	April	23	8.84	1924	
1961	June	27	5.535	932.4	
1962	June	16	8.514	1937	
1963	September	14	4.56	663.7	
1964	August	5	7.739	1657	
1965	May	23	6.727	1308	
1966	May	28	5.581	946	
1967	November	27	5.462	910.9	
1968	December	10	6.867	1355	
1969	June	30	6.13	1114	
1970	September	17	6.434	1212	
1971	October	28	5.95	1058	
1972	September	19	5.465	911.8	9th June 1972: Scotts Peak Dam closed
1973	May	3	7.333	1514	
1974	July	22	6.629	1276	
1975	May	18	8.66	1990	Mercury 19/5/75: Huonville main centre under 4 feet of water.
1976	December	4	6.569	1256	
1977	April	30	5.897	1042	
1978	May	27	5.939	1055	
1979	December	10	5.828	1008	
1980	August	14	7.519	1553	
1981	November	12	8.944	2078	
1982	September	8	5.803	1000	
1983	September	20	5.664	959.6	
1984	December	25	5.619	1022	
1985	March	5	5.422	967.6	
1986	October	25	5.414	955.4	
1987	January	9	6.402	1244	
1988	October	4	5.873	1093	
1989	September	15	5.756	4060 (?)	?? Others at similar stage ≈ 1000 cumecs
1990	July	3	7.239	1495	
1991	August	15	6.8	1361	
1992	July	3	4.587	744	
1993	June	21	5.513	993	Missing record in October
1994	September	18	5.778	1066	December
1995					

Annual Flood Peaks - Huon River above Frying Pan Creek

Year	Month	Day	Height metres	Flow cumecs	Comments
1921	July	16	7.31	1830	Record began 21 Feb. Annual peak OK. Mercury 19/7/21:- River overflowed banks and water rose to doorstops but did not enter houses as had previous floods.
1922	November	-	5.49	1115	Missing June and July - Annual Peak OK
1923	December	-	5.59	1149	
1924	June	-	6.8	1327	
1925	October	-	4.55	777	
1926	October	-	4.95	917	
1927	May	-	5.15	989	
1928	October	-	5.18	1000	
1929	April	-	4.99	928	Missing May
1930	August	-	5.6	1156	Missing May and June
1931	March	-	5.72	1202	
1932	April	-	4.29	686	
1933	March	-	5.39	1074	
1934	July	-	5.33	1055	
1935	May	17	7.14	1765	Mercury 20 May:- first flood in 14 years to cover main road in Huonville, water entered Nettlefold's garage.
1936	August	-	5.48	1111	Missing Jan., Feb., Mar. and April
1937	-	-	Missing	-	*King at Crotty Peak* in May; no May data available.
1938	July	-	4.78	857	Missing December
1939	April	-	4.97	924	*King at Crotty Peak* in April; missing August - October.
1940	March	-	4.79	860	
1941	December	-	5.9	1271	
1942	April	-	4.83	874	
1943	June	-	5.6	1156	
1944	September	-	4.87	888	
1945	March	-	5.23	1018	
1946	July	-	5.28	1037	
1947	June	17	7.58	1345	Little mention of this flood in Mercury
1948	May	29	8.17	2188	Quoted as "worst for 50 years", flood lapped decks of original wooden bridges at Judbury and Huonville. Water 3' 6" in Huonville shops. 18" above 1947 flood.
1949	July	-	4.44	1115	
1950					

Annual Flood Peaks - Huon River at Judbury

Year	Month	Day	Height metres	Flow cumecs	Comments
1901	October	28	-	3100	Based on pegged flood level and revised 1948 flood. Mercury 29/10/1901:- "heaviest rain for 17 years...road between Hobart and P.O. completely blocked...houses submerged...still raining". Mercury 1/11/1901:- "...the flood in the Huon district is the highest for 40 years - probably the highest ever remembered". Extensive damage to orchards and stock.
1914	-	-	-	2360	Flood levels available in Huonville also.

Historic Flood Peaks - Huon River at Hermitage