DEPARTMENT OF PRIMARY INDUSTRY FISHERIES AND ENERGY

WATER RESOURCES DIVISION

HUON RIVER FLOOD PLAIN STUDY

STAGE 2 REPORT

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DEPARTMENT OF PRIMARY INDUSTRY FISHERIES AND ENERGY

WATER RESOURCES DIVISION

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EXECUTIVE SUMMARY

This report details Stage 2 of the Huon River Flood plain study at Huonville.

Twelve survey cross sections were used to set up a water surface profile computer model. The model was calibrated by adjusting roughness coefficients to reproduce the observed May 1975 flood levels.

Peak design flood discharges allow for storm rainfall excess, base flow and tidal effects, with rainfall excess discharges from runoff-routing methods used in Stage 1 of this study. The corresponding flood levels were computed by using these discharges in a HEC-2 hydraulic model of the river.

A 1:5000 scale flood map was produced showing flood extents of the 100 year and 20 year ARI floods.

It is recommended that this map be used as the basis for developing an overall flood management strategy for the flood area.

It is also recommended that a flood study of the Mountain River be carried out to complete flood contours in the study area and to address the control of future development along the entire Mountain River.

Future floods should be monitored to supplement observed data and improve the reliability of predicted flood behaviour.

DEPARTMENT OF PRIMARY INDUSTRY FISHERIES AND ENERGY

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JUNE 1992
321-2101-4101

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Glossary of Abbreviations Used

AEP	Annual Exceedance Probability (Expressed as a Percentage)
ARI	Average Recurrence Interval (Expressed in Years)
RSWC	Rivers and Water Supply Commission Water Resources Division of Department of Primary Industry Fisheries & Energy
HEC	Hydro-Electric Commission
B of M	Bureau of Meteorology
IFD	Rainfall Intensity - Frequency - Duration Data
ARR	'Australian Rainfall and Runoff' (Institution of Engineers, Australia, 1987).
RORB	Name of Runoff Routing Computer Programme
HEC-2	Name of Backwater Profile Computer Programme
IL	Initial Loss (mm)
CL	Continuous Loss (mm/hr)
k_c, m	RORB Calibration Parameters

DEPARTMENT OF RESOURCES AND ENERGY

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HUON RIVER FLOOD PLAIN STUDY

STAGE 2 REPORT

CHAPTER 1 - INTRODUCTION

Huonville is a rural town of some 3 700 inhabitants, serving as the business centre for the Municipality of Huon, situated about 40 km south-west of Hobart.

Gutteridge Haskins & Davey Pty Ltd (GHD), was commissioned by the Rivers and Water Supply Commission in March 1991, to conduct a study into the flooding of the Huon River at Huonville. The study was jointly funded by State and Federal Government funds managed by the Water Resources Division of the Department of Primary Industry, Fisheries and Energy, and the Municipality of Huon.

The ultimate aim of the study is to produce flood plain maps for the township of Huonville showing the extent of the 1% and 5% annual exceedance probability (AEP) flood inundation and flood levels for the 1%, 2% and 5% AEP events. Such maps will provide vital assistance to the Municipality in planning and controlling future land development in the Huonville area, and assessing existing flood plain management issues.

The complete study was undertaken in two (2) stages:

Stage 1

The establishment of river flows through Huonville for design storm events, including the collection of hydrologic data, flood frequency analysis, establishment and calibration of a hydrologic model, determination of the 1%, 2% and 5% (AEP) flood flows in Huonville, cross sectional survey and establishment of a hydraulic model for subsequent flood profile investigations.

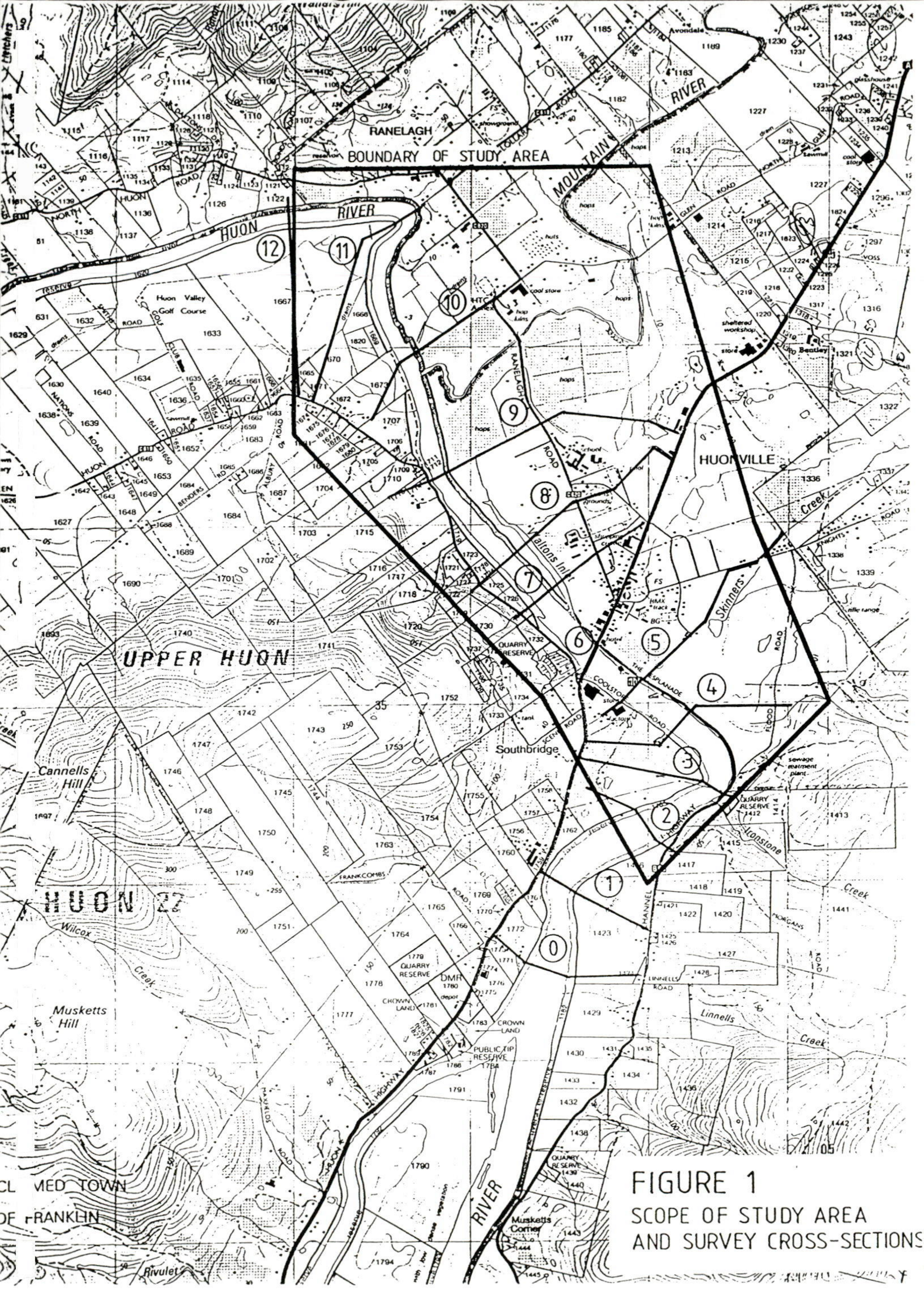


FIGURE 1
SCOPE OF STUDY AREA
AND SURVEY CROSS-SECTIONS

A report summarising the Stage 1 investigations was completed in July 1991.

- *Stage 2*

  The collection of available historic flood level data, calibration of the hydraulic model, determination of the 1%, 2% and 5% flood profiles and flood extent mapping.

This report presents the investigations undertaken for Stage 2 of the study and is intended to be read in conjunction with the Stage 1 report. The study area is generally defined as the reach of the Huon River from Ranelagh downstream to Egg Islands, and is shown in Figure 1, along with the survey cross sections used in the hydraulic model.

Stage 2, then, essentially comprised the following tasks:

- Data collection of available historic flood data and tidal information.
- Calibration of the hydraulic model, HEC-2, to observed floods.
- Prediction of flood profiles for the selected probabilistic events.
- Mapping of areas liable to flooding for the selected events.

These tasks and the findings which result are described in the following chapters of this report.

CHAPTER 2 - DESIGN FLOOD FLOWS

2.1 Catchment Hydrology Studies

Stage 1 investigations aimed to produce a flood frequency curve of river flow (m^3/sec) for the Huon River. This stage of the study included hydrologic modelling of the Huon catchment.

Calibration of the runoff routing computer programme (RORB) for six (6) flood events at the gauging station upstream of Frying Pan Creek, led to the adoption of the following calibration parameters for the whole catchment:

k_c = 40.0
m = 0.8
Initial Loss (IL) = 10 mm

With reference to a flood frequency analysis, the continuing loss was estimated to vary from 1.4 mm/hr for a 2 year ARI design flood to 4.2 mm/hr for 100 years ARI.

The resulting flood frequency curve for the gauging station upstream of Frying Pan Creek is shown in Figure 2.

Resulting design river floods at Huonville derived from the rainfall/runoff model are as shown in Table 1. It is not possible to produce a rating curve for this section of the river due to tidal variations in river level. These flows are very close to the flood frequency curve in Figure 2, illustrating a slight attenuation of flow between Frying Pan Creek and Huonville.

Several of the historical floods on the Huon River, namely the May 1975 and May 1948 floods, are recorded to be partially attributable to melting snow from peaks within the catchment. The effect of melted snow cannot be readily accounted for in the RORB model.

Records of snowfall in the remote areas of the catchment are sparse and it is outside the scope of this study to make a quantitative assessment of the contribution of snow to river flow or to undertake a probability analysis of the likelihood of high rainfall following snowfalls. Nevertheless, the flood frequency curve derived in Stage 1 of this study, whereby continuing losses in the RORB model were varied to match flood frequency results from historical floods, makes an implicit allowance for the component of snow in recorded flood discharges.

2.2 Other Contributions to Design Flows

The peak flow estimates for the flood events greater than the 5% AEP event are based on RORB modelling and, accordingly, are estimates of rainfall excess. There is likely to be a small additional contribution of base flow to this figure.

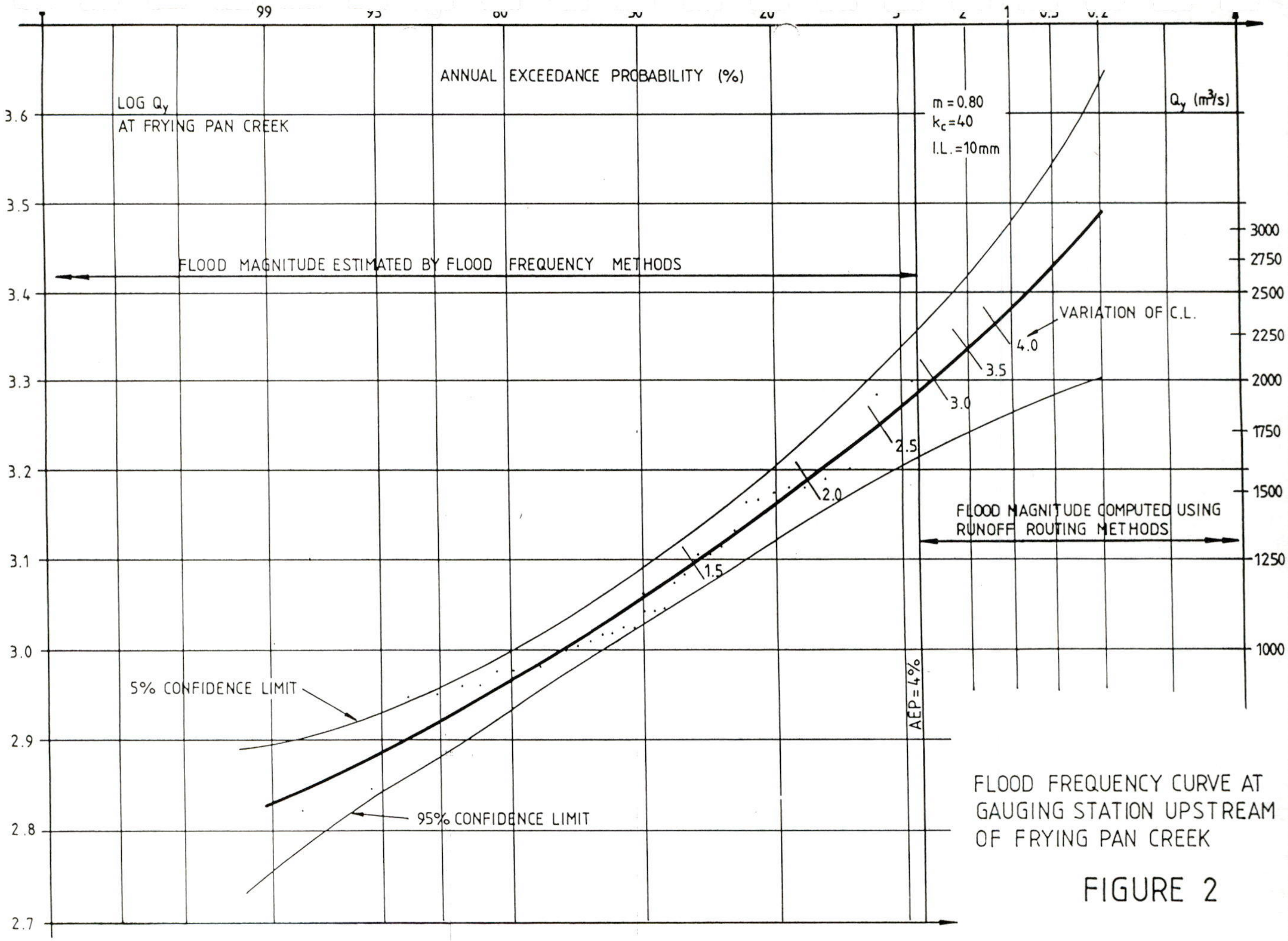
Because the river at Huonville is tidally influenced, the catchment flood flows are superimposed upon an incoming or outgoing tidal flow, depending on the relative occurrence in time of the flood hydrograph with the tidal cycle. However, because flood hydrographs can span several tidal cycles, the most effective means of including the hydraulic effect of tides in the HEC-2 model is to add a net tidal outflow contribution to the catchment peak flood flow.

The estimated combined contribution of base flow and tidal outflow amounts to an additional 40 to 80 m^3/s upon the peak rainfall excess figure computed in Stage 1. Table 1 below summarises the resulting design flow figures used for the hydraulic modelling described later in this report.

TABLE 1

Design Floods at Huonville

ARI (Years)	**Peak Flood Flow** (Rainfall Excess from Stage 1) (m^3/s)	**Design Flows for use in HEC-2 Model** (m^3/s)
2	1090	1130
5	1440	1480
10	1595	1635
20	1875	1955
50	2100	2180
100	2375	2455



FLOOD FREQUENCY CURVE AT GAUGING STATION UPSTREAM OF FRYING PAN CREEK

FIGURE 2

CHAPTER 3 - HISTORICAL FLOOD LEVEL DATA

3.1 Historical Floods

Some of the significant floods through Huonville in the last 80 years are listed in Table 2 below.

TABLE 2

Major Floods of Record

Date	Peak Flow (m^3/s) at Frying Pan Creek Gauging Station	Estimated ARI at Gauging Station (Years)	Approximate Time of Peak in Huonville
3 July 1990	1463	5.3	~ 14:00 Hours
14 August 1980	1553	6.7	~ 23:45 Hours
28 August 1975	1528	6.2	~ 22:50 Hours
18 May 1975	1990	26	~ 17:30 Hours
10 December 1968	1355	3.5	~ 17:20 Hours
22 April 1960	1924	25	After 18:00 Hours
24 June 1952	1853	20	~ 18:00 Hours
28 May 1948	2223	56	~ 16:30 Hours
16 June 1947	* 1888		
17 May 1935	* 1829		
16 July 1921	* 1700		
? 1914	** Approx 1990		

* Flood peaks measured at Judbury gauge (from HEC Report 1981).

** From RWSC 1988 as referenced in Section 3.2.

(i) As discussed in the Stage 1 Report, there is considerable difficulty in extrapolating these flows from the upstream gauging stations to the peak floods which passed through Huonville. The six (6) floods since 1960 listed were used in the Stage 1 runoff routing analysis because of the availability of rainfall and stream flow records, and therefore give an estimate of river flows through Huonville.

(ii) The present Huon River bridge was built in 1960 before the April flood. The effect of this bridge structure has been modelled in the HEC-2 calibration model. From 1922 to 1960, a timber truss bridge existed, records of which are stored in the Archives of the State Library.

(iii) A river level gauge was installed on the downstream side of the new bridge late in 1960, probably as a result of the April flood. These level data give a useful starting point for establishing historical flood levels since this date. The gauge was not operational between 12 July 1983 and 25 May 1987.

For the reasons stated above, the floods since 1960 were the primary source for level information to calibrate the HEC-2 model. In any event, the amount of anecdotal and photographic evidence increased generally for the more recent events. There was also a tendency for some confusion between the earlier floods (e.g., between the 1947, 1948 and 1952 floods). Any level information for pre-1960 floods is, nevertheless, useful for qualitative analysis. Changes in land use since these floods, such as replacement of orchards with pasture, would also affect the calibrated roughness coefficients for these early floods.

3.2 Sources of Data

Sources for historical flood levels were generally confined to the following:

- Newspaper reports from 'The Mercury' and 'Huon News'.
- Photographs, both personal and from newspapers.
- Anecdotal flood level points from long term residents.
- Tidal gauge board at the Huon Bridge.
- HEC Report 'Huon River Power Development - Flood Study' by M Williams and A Nazarow of July 1981 (reference Nº 9).
- Unpublished RWSC report (1988) by G Katona on surveyed flood levels from anecdotal evidence by Mr Jim Skinner.

Level data researched on each flood since 1947 is listed in Table 3.

Table 3 summarises significant flood level data for post-1947 floods and their sources. Exhaustive efforts were made to collect historic flood level data. Placement of two advertisements for information in the Huon News produced a minimal response. Nevertheless, the number of flood marks was felt to be sufficient to calibrate the model. It is recommended that peak flood levels from future flood events be surveyed and recorded to improve the present level data base. All levels are to Australian Height Datum (AHD).

3.3 Summary of Flood Levels

TABLE 3

Summary of Historic Flood Level Data

Date of Flood	Site of Flood Survey Point	Source	RL AHD (m)	Uncertainty (+/-)
3 July 1990	Golf Course	Anecdotal - Groundsman	4.3	0.3
	Golf Club	Photo - Council	5.0	0.3
	K Pitt Pumphouse CS12	Mark on Well	5.2	*
	Ranelagh Sewerage Ponds	Photo - P Francombe	2.9	0.2
	Ranelagh Church	Photo - P Francombe	3.0	0.2
	K Pitt Hayshed CS8	Photo - Council	2.2	0.2
	5 Wilmot Road	Photo - Council	2.1	0.1
	Tidal Gauge at Bridge	3.345 m Record	1.89	0.05
14 August 1980	K Pitt Pumphouse	Mark on Well	5.36	*
	Tidal Gauge at Bridge	11.25 ft Record	1.98	0.05
28 August 1975	Tidal Gauge at Bridge	11.3 ft Record	1.99	0.05
18 May 1975	Golf Course	Anecdotal - Groundsman	5.6	0.2
	J Skinner Residence - Between CS8 & 9	RWSC Report	4.8	0.3
	Post at Larratt Property CS9	Anecdotal - B Larratt	4.16	0.3
	K Pitt Hayshed CS8	Anecdotal - K Pitt	3.7	0.3
	Tidal Gauge at Bridge	13.9 ft Record	2.78	0.05
	Crown of Cygnet Road N° 7	Anecdotal - S Page	2.74	0.1
10 December 1968	Tidal Gauge at Bridge	9.9 ft Record	1.57	0.05
22 April 1960	Golf Course	Anectodal - Groundsman	5.6	0.4
	Francombe Pumphouse - Above Top of Motor	Anecdotal - P Francombe	> 5.4	
	Ranelagh Road	Photo - Council	5.7	0.3
	Larratt Residence - Floor Level CS9	Anecdotal - B Larratt	6.1	0.3
	Skinner Residence - Between CS8 & 9	RWSC Report	4.37	0.1
	Short Street House	Photo - A Eaton	3.6	0.2
	Wilmot Street	Photo - A Eaton	3.5	0.2
	Main Road - w'board house now AMP	Photo (B/W) - A Eaton	3.06	0.1
	Newsagency Window Sill	Photo (B/W) - A Eaton	3.15	0.1
	Caltex Station	Anecdotal - B Larratt	2.94	0.2
	N° 7 Cygnet Rd Doorstep	Anecdotal - S Page	3.08	0.1
	Linnell Property	Mark on Shed	1.91	0.1
24 June 1952	4 ft Water over Low Point of Cygnet Road CS4	'The Mercury'	2.3	0.3
16 June 1947	N° 11 Wilmot Street - McMullen House	Photograph - 'The Mercury'	2.9	0.2

* These levels, from marks made on the inside of a pump house, are unexpectedly high, possibly as a result of surges in the pump station.

The following notes are made regarding the summary of flood levels obtained.

- A level of accuracy has been estimated for most levels, ranging from ± 0.3 m for most anectodal marks and distant objects on photographs to +/- 0.05 m for tidal gauge levels. This enables a confidence range for each point to be used to obtain calibrated flood profiles of best fit.

- Photographs can usually enable a fairly accurate flood level to be taken, however, there is no guarantee that the photo was taken at the flood peak. It should be noted that the majority of floods listed in Table 3, peaked in Huonville after sundown when photography was not generally possible.

- The May 1975 event occurred on a Sunday afternoon without much warning to the community. The river rose rapidly supplemented by melting snow from surrounding peaks. Possibly as a result there are very few photographic records of the flood.

- The authors are unaware of any aerial photographs of the town under flood, a source often used in similar mainland studies.

CHAPTER 4 - HYDRAULIC MODELLING

4.1 River Survey

In Stage 1 of this study, survey of the flood plain between Ranelagh and the northern end of Egg Islands was carried out. To enable the construction of a HEC-2 computer model of the river, the survey was undertaken with the following steps:

(i) The flood plain was inspected in the field to assess the likely direction of overbank flow during flooding, local vegetation and other features which may affect the backwater model and to determine accessibility for survey work.

(ii) 13 cross-sections were selected and drawn, as far as possible, perpendicular to the direction of stream flow lines. It is therefore assumed in the model that the river will be at approximately the same level throughout each cross section. These cross-sections, as shown in Figure 1, generally extend to the 15 metre contour and include one section coinciding with the Huon Highway and bridge alignment. For the purposes of outlining the scope of work to the surveyor, the sections were drawn up on 1:5000 maps of the district, enabling intersection points to be set out from existing features.

An additional section across Mountain River was included to enable modelling of any breakaway flows from the main channel in extreme events.

(iii) Survey was carried out to the following requirements:

- Up to 100 survey points per cross section.
- Station elevations to be ± 0.05 m, stated to the nearest 0.05 m, levels to AHD.
- Minimum spacing of points within main channel to be 15 metres, or for maximum changes in elevation of 0.5 metres.
- Steel markers to be placed in the field to mark the extremities of each cross section at the left and right bank.
- Cross sections to use the convention of 'looking downstream', having offsets commencing from the extreme left point.
- Photographs to be taken at each cross section recording typical land use and any special features.

- Data consisting of offset and elevation of each survey point was presented in graphical, tabulated and digital format, for conversion to the HEC-2 input file.

Data for Cross Section 6 involving the highway and bridge vertical alignments was derived from copies of design drawings from the Department of Roads and Transport.

4.2 Hydraulic Model

The survey described in Section 4.1 was used to develop the HEC-2 model of the Huon River. This model requires the consideration of a number of factors, as described below.

4.2.1 *General Description*

The hydraulic model used in this study is the HEC-2 computer package developed in the United Sates by the US Army Corps of Engineers. The model is a computerised application of Bernoulli's theorem for the total energy at each cross-section and uses Manning's formula for the friction head loss between cross-sections with Standard Step Method of calculation. HEC-2 is widely used in Australia and is considered an industry standard.

Each cross-section is divided into three components; the left and right overbanks and the main channel. A value of Manning's 'n' is assigned to each segment and a weighted value of conveyance is then calculated by the model for each cross-section. The friction loss in a reach between cross-sections is then obtained by averaging the conveyances at each end of the reach. Thus, by starting at a known water level at the cross-section at the downstream boundary of the study area, the elevation at each successive cross-section upstream is computed by applying the principles outlined above.

Losses such as transition losses occurring at expansions or contractions in the stream are accounted for by a proportion of the difference in velocity head between successive cross-sections, the proportion being dependant upon the abruptness and nature of the transition. Losses in head through bridge openings (other than transition losses) are evaluated in special sub-routines which take account of the effect of the piers on the flow and flow over the road surface where it occurs.

The parameters that require calibration in the model are as follows.

Each Cross Section

- Manning's 'n' - Left Bank
- Manning's 'n' - Right Bank
- Manning's 'n' - Main Stream
- Definition of Ineffective Flow Areas - Left Bank
- Definition of Ineffective Flow Areas - Right Bank

Between Cross Sections

- Expansion Transition Co-efficient
- Contraction Transition Co-efficient

Bridges

- Pier Shape Co-efficient
- Weir Flow Co-efficient
- Orifice Flow Co-efficient

In addition, the cross-sectional (and bridge) geometry at each cross-section must be defined, as well as the discharge at each section. The selection of the correct starting level at the downstream boundary is also important.

4.2.2 *Ineffective Flow Areas*

The model presumes that the entire cross section is available to transmit flow in the downstream direction. Where this is not so, the ineffective portion of the cross section is specially defined as such in the data file. Such no-flow areas usually occur immediately upstream and downstream of embankments across the flood plains and in backwaters such as Waltons Inlet.

4.2.3 *Effect of Bridges*

The HEC-2 programme contains two alternative routines for analysing flow through bridges and culverts. The NORMAL BRIDGE routine represents the bridge across section as a normal cross section except that that part of the bridge deck and piers below water level is subtracted from the total area, and the wetted perimeter is increased accordingly.

The SPECIAL BRIDGE routine in HEC-2 uses hydraulic formulae to compute the change in energy and water surface elevation through a bridge or culvert under conditions of low flow, pressure flow, weir flow or combinations thereof. Of necessity the pressure flow calculations are restricted to one trapezoidal opening. When there are no piers, low flow is computed using the NORMAL BRIDGE routine. But when piers exist the programme undertakes a momentum balance to determine the class of flow based on a trapezoidal representation of the opening.

The bridge on the Huon River was modelled using the SPECIAL BRIDGE routine.

4.2.4 *Model Establishment*

The basic HEC-2 input was set up from the cross section data of some 1200 survey points, supplemented by additional programme 'cards' detailing preliminaries, flow conditions, extent of river channel, distance between adjacent sections and bridge geometry.

4.3 Extrapolation of Historical River Flows to Huonville

From the summary of flood levels given in Table 3, it is evident that the 1990, May 1975 and 1960 floods provide the greatest number of survey points for calibration of the HEC-2 model. These events were subsequently adopted for calibration. In order to carry out this calibration, the river flow (m^3/sec) through the model needs to be entered.

In the case of Huonville, where the river is tidal and, therefore, a local rating curve is not available for the river, the historical river flows must be extrapolated from the nearest upstream gauging station at Frying Pan Creek. Stage 1 of this study selected parameters k_c, m, initial loss and continuing loss for each calibrated storm event to match actual peak flow hydrographs with measured flows at Frying Pan Creek. Universal values of these parameters were then selected for typical design storms.

These design parameters, assuming standard temporal patterns for design storms in each sub-area, indicate a slight attenuation effect for design floods between Frying Pan Creek and Huonville. Nevertheless, in reality a storm with variations in rainfall distribution over the catchment could exhibit a significant rise in river flow between these two points. This effect is evident from the records of the April 1960 flood. The initial hydrological studies showed that flow magnitudes for the May 1975 and April 1960 floods to be similar at the Frying Pan Creek gauging station, however, the recorded 1960 flood levels in Huonville are considerably higher (see Appendix B giving details of the 1960 flood).

Extrapolation of the 1960 river discharge from Frying Pan Creek to Huonville, using the RORB model and calibrated parameters for this event gives a range of results depending upon assumptions as to variation of rainfall distribution and parameters adopted. This uncertainty is exacerbated by the lack of historical rainfall data in the catchment. Extrapolation of the May 1975 event to Huonville using calibrated RORB parameters for that particular flood, however, indicates that this flood exhibited a slight reduction in flow downstream of the gauging station. Furthermore, the increased quantity of rainfall data for this more recent event improved the reliability of the result.

Because of this perceived lack of reliability of the RORB calibration of the 1960 flood, it was considered more appropriate to calibrate the HEC-2 model by varying roughness coefficients to fit the May 1975 flood with the observed flood levels. Once the backwater model was calibrated, the model was fitted to the 1960 observed flood profile by varying discharge within a likely range based on our knowledge of the catchment and the available rainfall data. The 1990 flood data was used to verify and slightly modify the calibration parameters to the best fit for all three flood events.

4.4 Calibration of May 1975 Flood

Using RORB parameters of best fit, the May 1975 discharge was extrapolated to have a peak of approximately 1 950 m^3/s at Huonville. This corresponds to a flood of average return incidence (ARI) just over 20 years.

The starting level for the flood profile at the downstream end was estimated using the slope area method in the HEC-2 programme. The downstream observed flood point for the 1960 flood gave an indication of the initial slope of the profile. The model tended to reduce an imposed change in level at the downstream end to half its value by the bridge on Cross Section 6.

With due regard for the accuracy of the observed flood levels, the best fit flood profile resulted for the following roughness coefficients, given in Table 4. The level between Sections 8 and 9 was not included in the fitting process due to the unreliability of its source. The profile is plotted on Figure 3.

TABLE 4

Calibration of May 1975 Flood Mannings 'n'

Cross Section	**Channel**	**Left Overbank**	**Right Overbank**	**Flood Profile Level (AHD)**
0 North of Egg Island	0.037	0.12	0.12	1.50
1	0.037	0.12	0.12	1.00
2	0.040	0.12	0.12	1.82
3 Ironstone Creek	0.040	0.12	0.12	1.99
4	0.037	0.10	0.10	2.34
5	0.040	0.12	0.12	2.52
* 6 Huon Bridge	0.040	0.15	0.15	2.91
7	0.040	0.12	0.12	3.25
8	0.040	0.12	0.12	3.55
9	0.037	0.12	0.12	3.97
10 Upstream of Mountain River	0.040	0.12	0.12	4.52
11	0.055	0.15	0.15	4.87
12	0.055	0.15	0.15	5.25

* Four sections were created close to the bridge to suit SPECIAL BRIDGE function, each with separate roughness coefficients and flood level. The study area lies between Cross Sections 1 and 12.

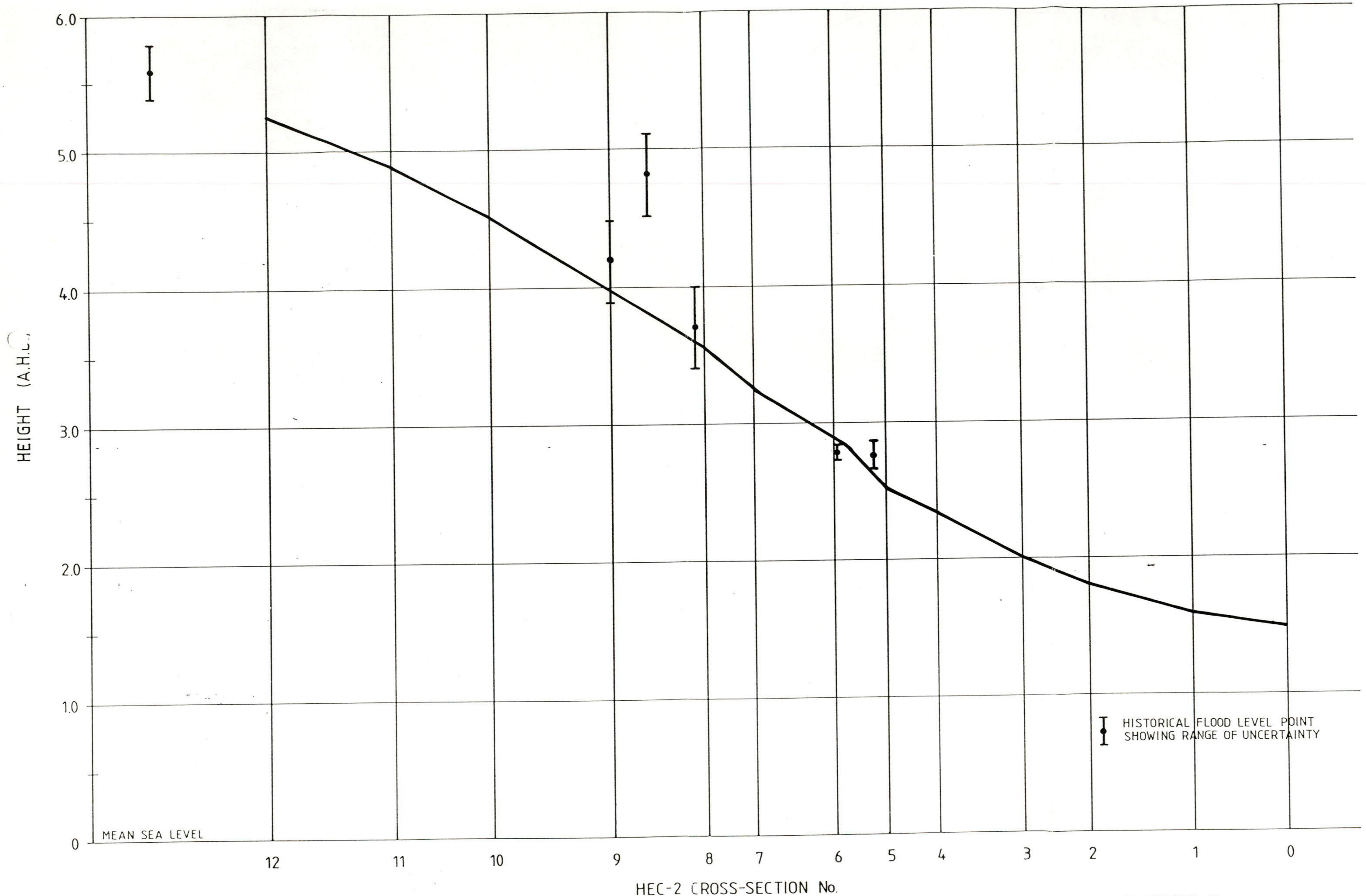


FIGURE 3
FLOOD PROFILE MAY 1975

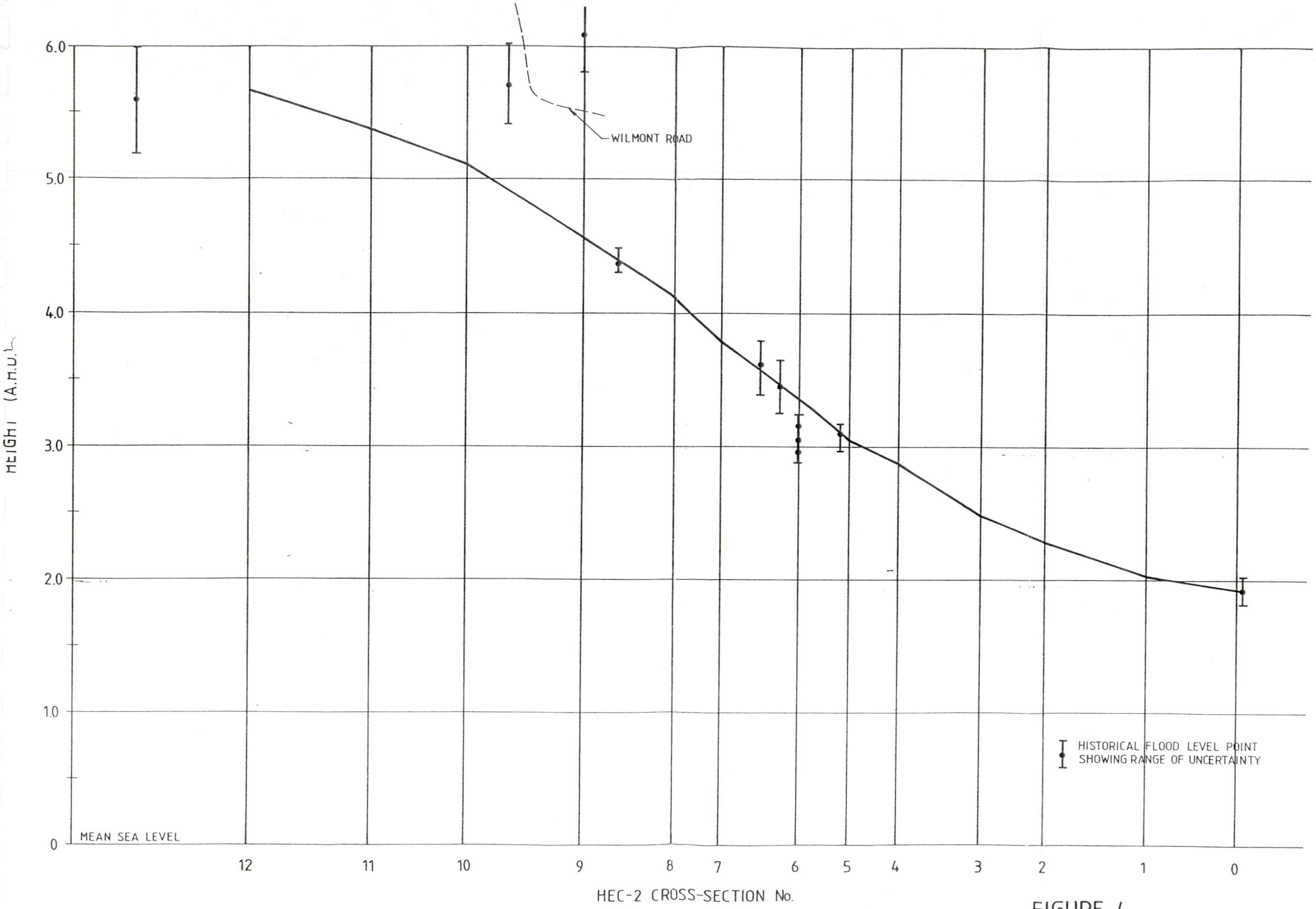


FIGURE 4
FLOOD PROFILE APRIL 1960

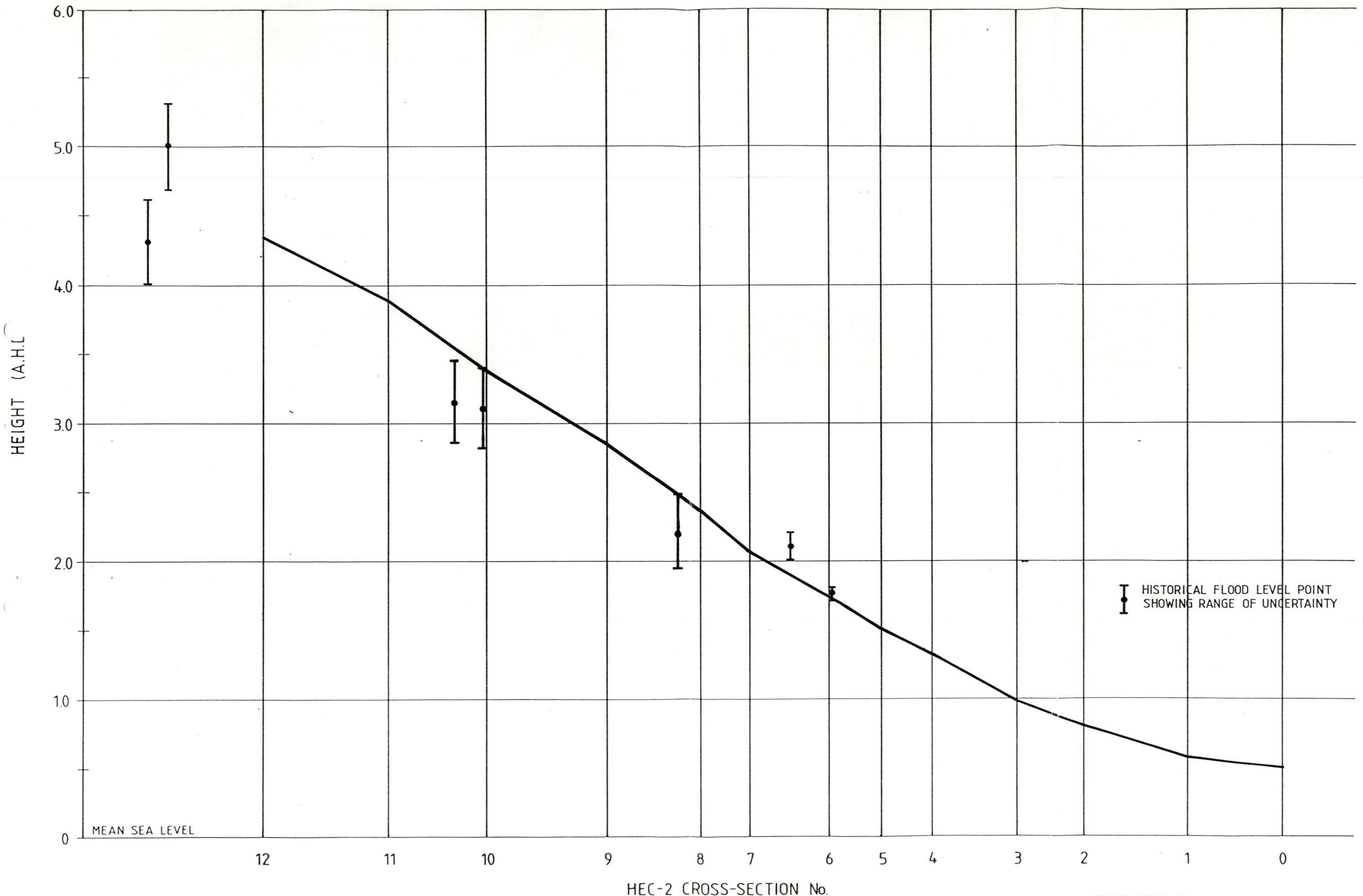


FIGURE 5
FLOOD PROFILE JULY 1991

4.5 Calibration of 1960 and 1990 Floods

As noted in Section 4.1, the Stage 1 hydrologic studies indicated that the peak flow magnitudes of the May 1975 and April 1960 floods to be similar at the gauging station. However, the recorded 1960 flood levels in Huonville are considerably higher than those of 1975.

In order to explore this observation, the river discharge and starting levels were varied in the calibrated backwater model to obtain the flood profile best fitting the observed 1960 flood levels. As shown in Figure 4, a river flow of around 2 400 m^3/s provided the best fit to observed flood levels, that is, close to the 100 year ARI flood. The river discharge was reduced to 2 100 m^3/s upstream of Mountain River to allow for tributary inflow. The two high flood points between sections 9 and 10 are considered to be due to the backing up of Mountain River at its bridge and are worthy of separate study as recommended in section 5.1 of this report. The vertical alignment of Wilmot Road which crosses the river is shown in the flood profile.

In the case of the July 1990 flood, a discharge of 1 300 m^3/s at Huonville, or some 90% of the flood peak at Frying Pan Creek, gave the best fit flood profile as shown in Figure 5. Since this flood lay largely within the river channel it was used to further adjust Mannings n in the channel of each cross section. The parameters given in Table 4 are therefore the best compromise to fit all three calibrated events.

4.6 Design Flood Profiles

Before inputting design floods to the calibrated model, other factors which have affected the physical nature of the model were considered. The adoption of the roughness coefficients from the 1975 flood calibration for present day design floods is through to be satisfactory since there have been few recent significant changes to land use or road and bridge levels. Certainly, before 1975 the main road had been raised some 0.3 metres in parts of the town and there had been a general transition from orchards to grazing in some surrounding properties.

Following completion of the calibration and verification of the hydraulic model, the flood profiles of the 20 year, 50 year and 100 year ARI flood were determined. The flood discharges in the study area were those obtained in Stage 1 of this report from runoff routing model with an allowance for base flow and tidal effects as discussed in Chapter 2. No amendments to the physical characteristics of the 1975 model have been made because those characteristics are considered largely representative of present conditions. The flood profiles summarised in Table 5 represent levels of flood inundation under existing conditions. Starting levels were obtained by interpolating starting levels versus discharge for calibrated floods. The flood profile are plotted in Figure 6.

TABLE 5

Computed Design Flood Levels (m AHD)

Cross Section	**20 Year ARI** 1955 m^3/s	**50 Year ARI** 2180 m^3/s	**100 Year ARI** 2455 m^3/s
1	1.60	1.89	2.06
2	1.82	2.09	2.33
3	2.00	2.27	2.52
4	2.35	2.64	2.93
5	2.53	2.84	3.12
6	2.91	3.14	3.43
7	3.26	3.52	3.86
8	3.56	3.84	4.18
9	3.98	4.27	4.62
10	4.53	4.84	5.20
11	4.87	5.18	5.53
12	5.26	5.55	5.89

As the river level rises during the initial stages of a flood, the HEC-2 model indicates that the river bank is over-topped first at Cross Section 12, followed by the left bank of Cross Sections 9 and 10 on either side of the mouth of Mountain River. During a 1:100 year flood the amount of flow containment within the main river channel varies from 90% for Cross Section 1 to approximately 45% at Cross Sections 10 and 12.

Velocities within the main river channel for a 1 in 100 year flood range from a maximum of 2.9 metres/second at Cross Section 9 to 1.4 metres/second at Cross Section 11 at the bend of the river near Ranelagh. The average velocity of flow in either overbank ranges to a maximum of 0.7 metres/second. Mean estimated channel and overbank velocities for the 100 year ARI flood are listed in Table 6. It is stressed that these are mean velocities. Actual local water speeds could be considerably higher, particularly through the main township where the effective flow area is reduced by large buildings.

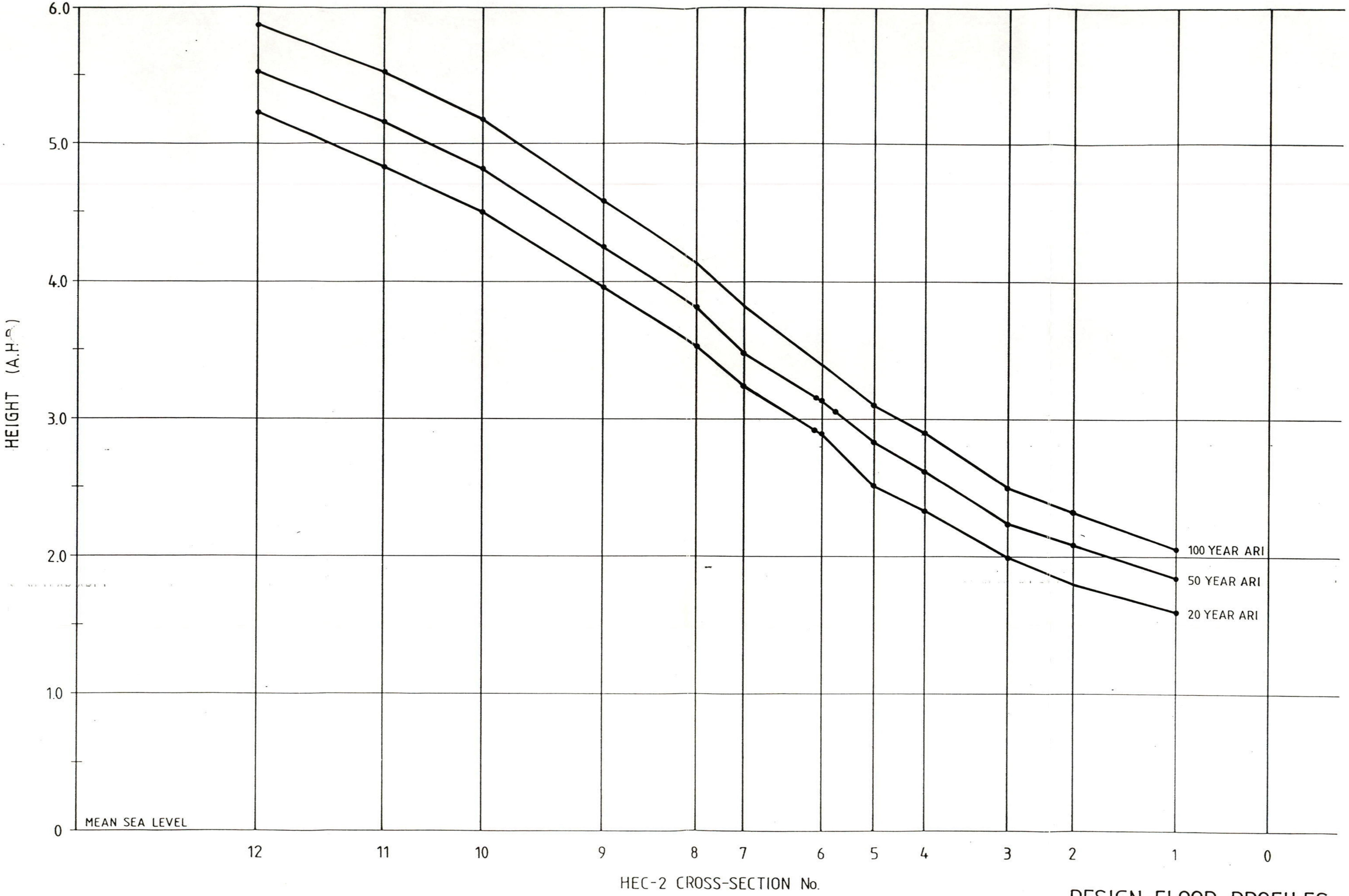
Preliminary plotting of flood levels on a base plan indicate flooding patterns of sections of the main street and town similar to those experienced in actual floods. Those areas of rural land lying in the flood plain are also clearly represented. The extents of inundation of the 100 year and 20 year ARI floods as derived from the HEC-2 analysis do not differ markedly, although the depth of the 100 year flood is some 0.6 to 0.7 metres greater than those of the 20 year event.

The secondary areas of flooding along the main street are largely ponded backwater and should not experience significant flow velocities.

TABLE 6

Computed Flood Velocities

Cross Section	**Mean Velocities (m/s)**		
	Main Channel	**Left Overbank**	**Right Overbank**
1	1.9	0.2	0.1
2	2.0	0.3	0.4
3	2.4	0.1	0.3
4	2.0	0.4	0.3
5	2.5	0.5	0.2
6	2.5	0.2	0.2
7	2.6	0.6	0.5
8	2.3	0.7	0.5
9	2.9	0.5	0.4
10	1.7	0.4	0.4
11	1.4	0.3	0.3
12	2.0	0.4	0.5



DESIGN FLOOD PROFILES
FIGURE 6

CHAPTER 5 - OTHER EFFECTS ON DESIGN FLOOD LEVELS

5.1 Mountain River

The boundary of the study area, as shown in Figure 1 of this report, includes the last three kilometres of Mountain River, which discharges into the Huon River between Cross Sections 9 and 10. A hydraulic model of the Huon River giving extents of inundation for design floods in the main channel, cannot be extended to join flood levels of a tributary without an independent rainfall/runoff and hydraulic model of that minor river. For the purpose of calibration of the Huon River in the study area, an allowance has been made in the HEC-2 model for addition of estimated Mountain River flows between Cross Sections 9 and 10. Nevertheless, extrapolation of design flood extents for Mountain River are not possible without more detailed modelling of this sub-catchment and collection of historical flood level data along the river. This problem has been identified and a separate study for the complete Mountain River has been programmed for 1992/93.

There is evidence from the 1960 flood levels that the bridge at Wilmot Road restricts flow in Mountain River, causing partial inundation of local hop fields and the school, which would not occur under flooding of the Huon River alone. Although a final flood plain map for both rivers would show 100 year ARI, say, flood levels for both rivers, these events would not necessarily be coincident due to the relatively fast peak rise of Mountain River.

5.2 Tides

Chart records from the river level gauge at the Huon bridge have not been digitised to allow calculation of mean river level and mean tidal variations. The Port of Hobart records a mean tidal variation of 0.9 metres, from 0.2 m AHD for mean maximum highwater to - 0.7 m AHD for mean minimum low water. The magnitude and timing of tidal variations at the mouth of the Huon River appear to be very close to the port of Hobart.

The effect of tidal variation upon the river levels during a major flood is relatively difficult to model. The time of hydrograph rise for the floods studied ranged from 15 to 35 hours so that there is a good chance that a tidal peak occurring every 6.5 hours, will contribute in part to a hydrograph peak. This effect is illustrated in Figure 7, showing the river level records for the December 1968 flood of 1 355 m^3/s peak.

On the other hand, since river levels during large floods are significantly higher than mean high water, a major flood may not be significantly affected by downstream tidal effects.

An evaluation of the impact of the above uncertainties can best be made by carrying out a sensitivity analysis on the effects of these variations on design flood levels.

HUON RIVER AT HUONVILLE

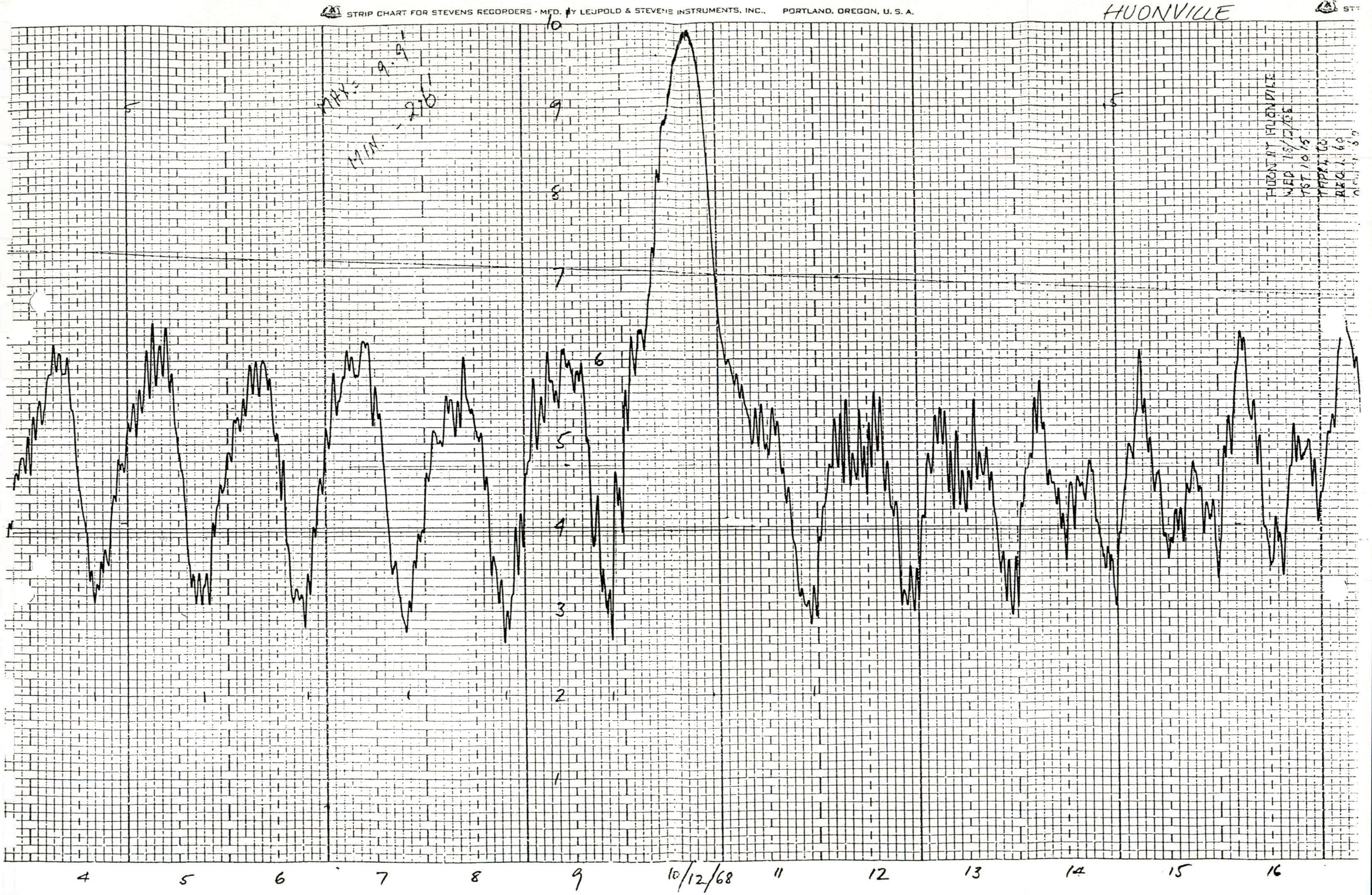


FIGURE 7

5.3 Sensitivity Analysis

Several computer runs were made on the HEC-2 model to investigate the sensitivity to changes in flow, Mannings 'n' and starting level. The 100 year design flood was used as a basis for the study.

- A 10% rise in discharge (+ 237.5 m^3/s) produced a rise in flood level up to 0.26 m at Cross Section 12. The rise at the Huon Bridge was 0.20 m.
- A 10% rise in Manning 'n' gave very similar results to those above.
- A downstream starting level set 0.3 m higher produced virtually no effect at the upstream end of the model. The rise at the bridge was less than 0.2 m.

In general it is concluded that none of these changes has a large effect on either flood level or extent of inundation of flood maps. For the purposes of allowing for base flow and tidal effects, the constant discharge of 80 m^3/s added to all design flows, is well below the variations studied above.

CHAPTER 6 - FLOOD HAZARD

6.1 A Brief Flood Damage History

In the past 50 years less than half a dozen floods have caused significant damage in the study area.

The 1947, 1948 and 1952 floods all resulted in heavy stock losses in flood plain areas of surrounding rural properties. Of these, the May 1948 flood was the highest recorded as '*the worst in 50 years*'. '*The Mercury*' reports that this flood forced the temporary evacuation of nine families, although it is unlikely that water entering houses would have exceeded 1.2 metres in depth. Some soil erosion occurred and apple tree orchards were destroyed. Several small bridges in the region were washed away and pavement erosion is also recorded. An elderly farmer in Judbury perished while trying to save stock. Several feet of water entered shops in the Huonville business area, leaving debris and mud, and cutting off vehicular access through the town but causing no permanent structural damage.

The April 1960 flood caused damage of similar magnitude though it was recorded as the '*worst flood ever*' as expected from the backwater analysis in this report. Power, water and telephone services were all disrupted by the floodwaters and agricultural damage was severe. Photographic records show that vehicular access through the town was restored within 24 hours as the flood receded.

The May 1975 flood event used for calibration of the HEC-2 model caused some inundation of water into shops, although it is unclear whether some of this was as a result of urban runoff directly from rainfall in the town. '*Thousands of dollars of damage*' resulted in the shopping centre alone. Flooding also caused the closure of the Huonville school for the following day. Since 1975, flooding of a similar magnitude sufficient to enter shops and houses has not occurred in the study area.

It is expected that the several factors would have lessened the extent of inundation and magnitude of damage over the last 50 years.

- Replacement of the low timber truss bridge over the river would cause less of a 'choke' to the river discharge.
- Replacement of surrounding bridges with higher, stronger designs.
- Improved roads and services.
- Clearing of some orchards for grazing improving flow characteristics over flood plains.
- Improved forecasting to warn landowners of impending floods.

6.2 Floodway Delineation

The floodways are those areas of the flood plain which must be kept clear to permit the unimpeded flow of floodwaters. If the floodways are blocked or partially blocked, there will be a redistribution of flood flows, causing some areas to receive deeper and/or swifter floodwaters than previously.

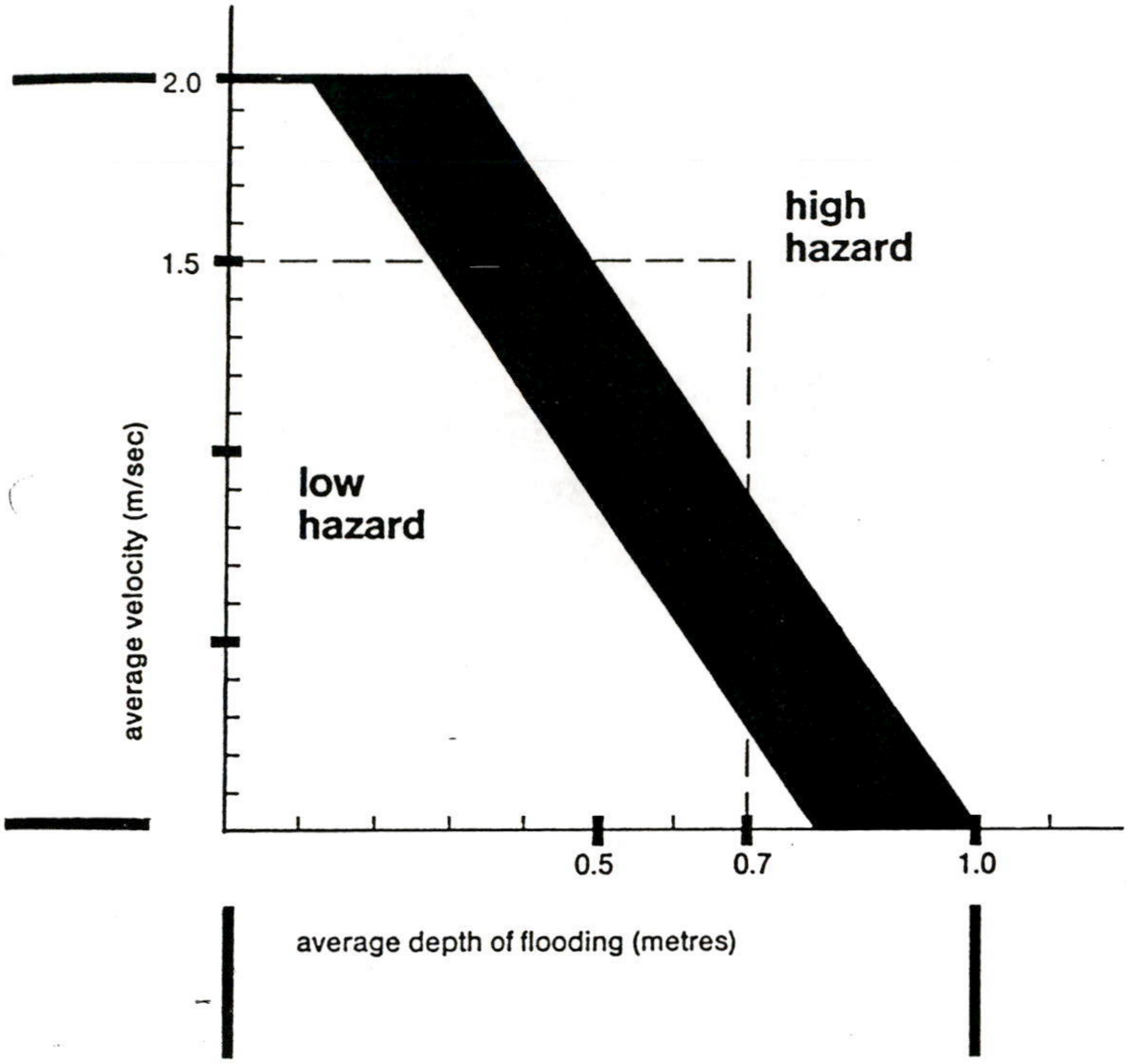
Most flood management policies draw a distinction between floodway and flood fringe areas. Within flood fringe areas Councils can approve any development consistent with the approved flood plain management plan. The only conditions attached relate to flood proofing, structural adequacy and access during flooding. However, within floodway areas, a development proposal will only be approved if it can be demonstrated that there will be no increase in flood levels, that fail safe evacuation is possible, and that the structure will be sound.

The extent of the floodway has been variously defined as the area inundated by the 1 in 20 year flood or that area left by encroaching across either flood plain towards the channel until a designated flood level has increased by a significant amount (usually 0.1 metres). The 20 year ARI flood has been adopted as the extent of the floodway for the purposes of this study and, accordingly, the flood fringe is that area between the 1 in 20 and 1 in 100 year floods. The flood standard has been selected to be the 100 year ARI flood, that is the approximate magnitude of the highest recorded flood on record.

Within the flood fringe, water depth does not exceed 0.7 metres and average overbank velocity does not exceed 0.7 metres per second during a 100 year ARI flood. In the case of Huonville the defined flood fringe is just within the low hazard category. The Flood Plain Development Manual of the NSW Department of Water Resources (1986), identifies low hazard flood areas as those with water depths less than 0.8 metres where able-bodied adults would have little difficulty wading due to relatively low flow velocities. A provisional hazard diagram is reproduced in this report as Figure 8.

Nevertheless, the location of a site within this low hazard, flood fringe area does not necessarily reduce the need for flood proofing. Development guidelines from the above mentioned Department of Water Resources report, for low hazard-flood fringe areas and high hazard-floodway areas are included in Appendix B, as an example of two extremes for flood guidelines.

FIGURE 8 Provisional Hazard Diagram



note:

The degree of hazard may be either –

- reduced by the establishment of an effective flood evacuation procedure,
- increased if evacuation difficulties exist.

Within ■ area the degree of hazard is dependent on site conditions and the nature of the proposed development.

example:

if the depth of floodwater is –	0.7 m
and the velocity of floodwater is –	1.5 m/sec

then the provisional flood hazard is **high**

6.3 Flood Mitigation

The future development of an overall management strategy for the Huon River flood plain could include a number of flood mitigation options.

Structural options include channel improvements, retarding basins, levee construction and house raising. Non-structural options are designed to lessen future flood problems place conditions on future development, and include specifying minimum flood levels, changing land use zoning or applying particular conditions to Building Regulations.

Flood warning systems should also be considered in a flood management strategy.

6.4 Future Flood Monitoring

Information from any subsequent floods can be used to test the assumptions made in this report, refine the hydraulic model and generally improve the accuracy of predicted flood levels and velocities. A larger amount of observed data will increase reliability of predicted flood behaviour.

Many useful measurements and observations which can be made by Council staff or other interested persons during future floods to supplement the information obtained from gauge records. These can include estimates of flood velocities, flow directions, locations of still water or back eddies, areas of turbulent water, rate of rise and fall in water level and, of course, maximum flood levels.

CHAPTER 7 - FLOOD EXTENT MAPPING

7.1 Base Plan

The base plan for the flood map was generated by the Department of Environment and Planning by amalgamating four (4) 1:5 000 Tasmaps, namely Huonville 21, 22, 31, 32. The maps show 5 metre topographic contours only and, as such, some supplementary survey was required to allow better interpolation of the flood contour between HEC-2 cross sections.

7.2 Mapped Events

In summary, the flood line contours shown on the map are:

- The 1% annual exceedance probability flood (or 100 year ARI).
- The 5% AEP flood (or 20 year ARI).

An 80 m^3/s allowance has been added to rainfall excess discharges in the HEC-2 model to account for base flow and tidal effects.

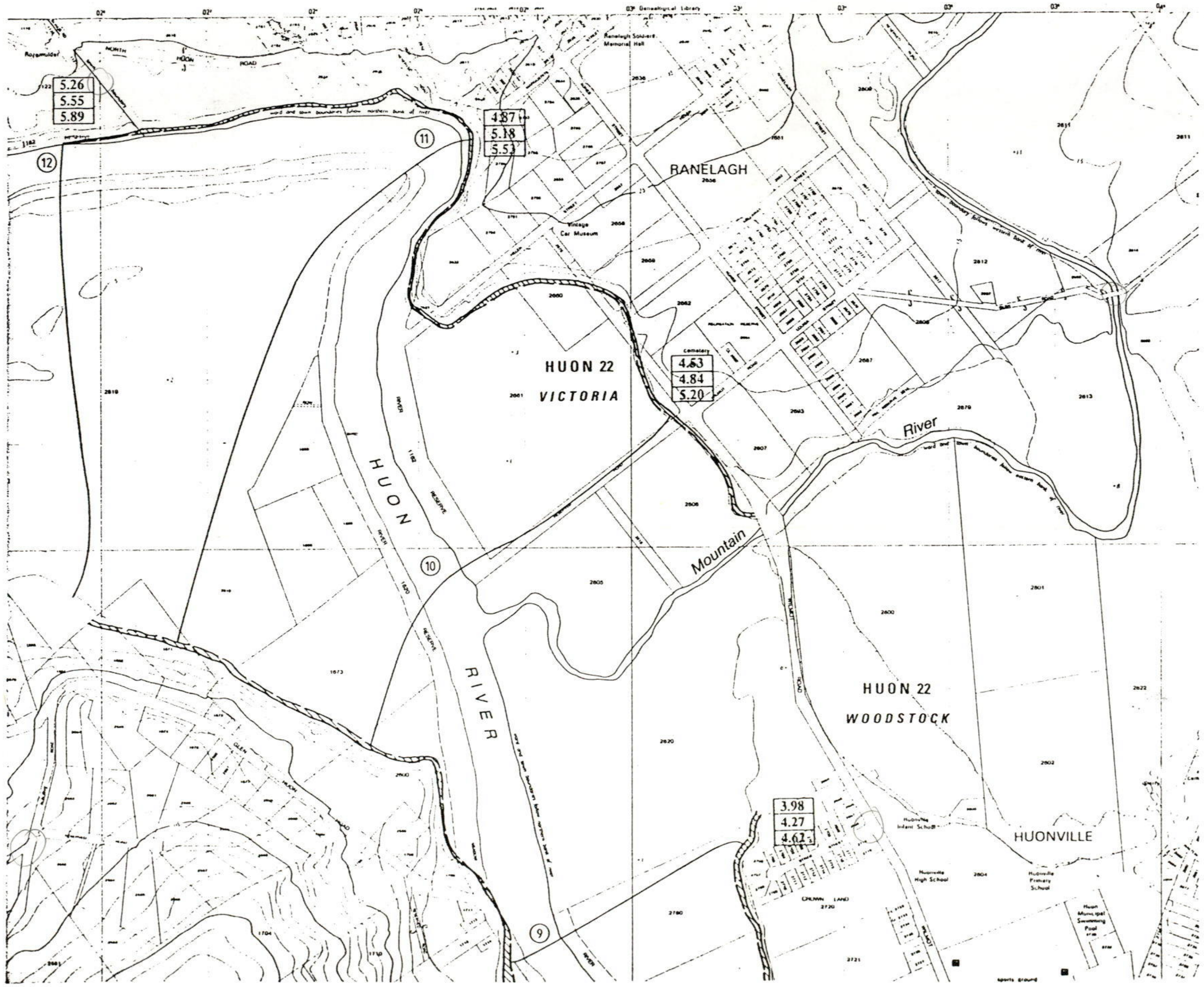
The levels of the 1%, 2% and 5% floods are given in boxes alongside each surveyed cross section. The 2% flood is not mapped because of the closeness of the flood lines. The flood fringe has been defined as that area between the 5% and 1% flood extents.

7.3 Use of the Map

A reduced copy of the map is shown overleaf in Figures 9 and 10.

It should be noted that the flood extents have only been located precisely at each surveyed cross section. The flood extents between the cross sections have been interpolated to maintain the required floodway widths and hence the required flood plain conveyance.

It should be noted that flood extents shown are approximate and the location of the flood extent at any intermediate point should be determined by field survey to determine the actual level on the property in question.



MUNICIPALITY OF HUON

DEPARTMENT OF PRIMARY INDUSTRY,FISHERIES & ENERGY
WATER RESOURCES DIVISION

HUON RIVER FLOOD PLAIN MAP

NOTES

1 Floods are defined by the Average Recurrence Interval or ARI (expressed in years). A 100 year ARI flood has a 1 in 100 chance of being equalled or exceeded in any one year.

2 Areas outside the 100 year ARI flood extent may be inundated by rarer flood events.

3 Isolated local flooding due to rainfall may occur in any area.

4 Flood levels are based on best estimates of the flood magnitudes derived from frequency analysis of data up to 1990, and runoff routing studies.

5 Extent of flooding is approximate only and is based on field surveyed cross sections carried out in May 1991, and published topographic maps. Actual extent of flooding at any particular location should be verified on site by survey.

6 Extent of flooding is for existing catchment characteristics. The extent of past floods may differ due to changed catchment and local conditions.

7 It may be necessary to review the inundation limits defined on this map following the recurrence of future floods.

8 This map details inundation from Huon River flooding only. Flooding in tributaries is not shown.

9 All levels are in metres to Australian Height Datum (AHD). 4.00 m on the bridge tidal board is equivalent to 2.545 AHD.

10 For further information, refer to 'Huon River Flood Plain Study', Stages 1 and 2, reports by Gutteridge Haskins & Davey Pty Ltd, for the Department of Primary Industry, Fisheries and Energy, Water Resources Division, 1991 and 1992.

1.60	20 year ARI
1.89	50 year ARI
2.06	100 year ARI

——— Extent of 100 Year ARI Flood
— — — Extent of 20 Year ARI Flood

10000
200 100 0 200 400m

FIGURE 9

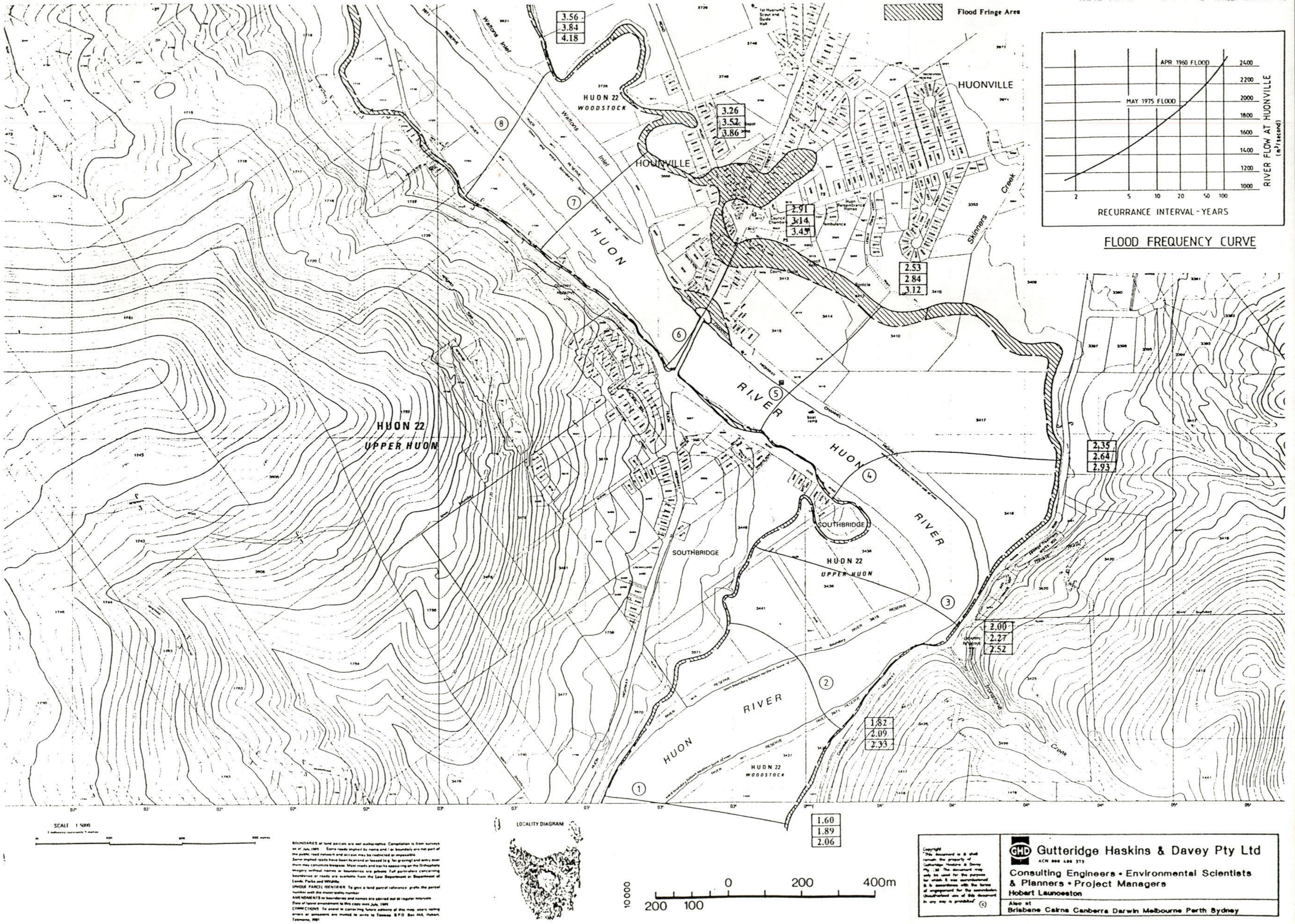


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FIGURE 10

CHAPTER 8 - RECOMMENDATIONS

8.1 Recommendations

It is recommended that:

(i) The Municipality of Huon adopt the 1:5000 flood map as the basis for assuring future development in the Huon River flood plain at Huonville. In using the predicted flood level information on this map, field survey should be undertaken to determine the actual flood extent as it may apply to a particular property under consideration.

(ii) The Municipality of Huon develop a flood plain management strategy for the Huon River flood plain at Huonville. The strategy should include:

- Policies of setting minimum levels for future developments in accordance with current regulations, including consideration of freeboard.

- Estimation of potential flood damage and assessment of possible flood mitigation options including assessment of possible improvements to existing developments in the flood plain.

The strategy should be developed in consultation with the following:

- Commissioner for Town and Country Planning
- State Emergency Service
- Water Resources Division, Department of Primary Industry, Fisheries and Energy
- Bureau of Meteorology

(iii) Future floods be monitored to obtain improved records of flood extent and behaviour. In this way the inundation limits on the flood map may be better defined.

(iv) The catchment and flood plain of Mountain River should be modelled in detail to enable the flood plain map to be extended into the lower reaches of Mountain River to upstream of Ranelagh, and as part of this study consideration should be given to undertake this flood plain mapping upstream to Grove.

8.2 Date

This report is dated 30 June 1992.

REFERENCES

1 Gutteridge Haskins & Davey Pty Ltd (1991)
Huon River Flood Plain Study Stage 1
Report to Rivers and Water Supply Commission

2 Gutteridge Haskins & Davey Pty Ltd (1982)
Geelong Flood Plain Management Study
Report to State Rivers and Water Supply Commission

3 Department of Water Resources NSW (1986)
Muswellbrook Flood Study Report

4 Department of Water Resources NSW (1987)
Yass Flood Study Report

5 Department of Water Resources NSW (1986)
Flood Plain Development Manual

6 Bureau of Meteorology (1988)
List of Pluviograph Stations Australia

7 Australian Water Resources Council (1984)
Stream Gauging Information Australian (6th Edition)

8 Hydrologic Engineering Centre vs Army Corps of Engineers (1991)
HEC-2 Water Surface Profiles User's Manual

9 Hydro-Electric Commission (1981)
Huon River Power Development Flood Study

10 Rivers and Water Supply Commission (1988)
Unpublished Internal Report on Surveyed Flood Levels in Huonville

APPENDIX A

APRIL 1960 FLOOD

APPENDIX A

APRIL 1960 FLOOD

The flooding of the Huon River in April 1960, resulted from an atypical rainfall distribution.

Probabilistic rainfall information for the catchment derived from statistical data suggests that rainfall magnitude is typically less in the eastern sub-areas. Moreover, the usual weather pattern moves across the State from west to east.

In the case of the period 21 to 23 April 1960, the attached rainfall records show that rainfall in the west was comparatively low for the first two days, whereas eastern gauges recorded 400 to 800 points (100 to 200mm) during the second day. South-eastern gauges recorded similar magnitudes into the third day. A copy of daily rainfall records are attached (note that records are in 'points' for the 24 hours prior to 9:00am on the recorded day. Four points to the millimetre).

The overall result of this weather pattern is that the eastern tributaries of the Huon River had extraordinary high flood peaks which coincided with the peak of the Huon River.

Thus, the Huon River peak discharge at Frying Pan Creek was approximately 20 year ARI but by the time the flood peak hit Huonville the magnitude approached 100 year ARI. The flood peak at Huonville also occurred at a higher than average tide peak, which effectively raised the downstream controlling level of the flood.

C ETEOROLOGY

DAILY RAINFALL IN TASMANIA

(As Compiled from Telegraphic Reports)

Prepared under instructions from the Minist . for Interior,
by Director, Bureau of Meteorology

DURING THE MONTH OF APRIL 1960

Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Prog. Total
NORTHERN																
Beaconsfield				10					15					11		36
Bridport				58					30		1			3		37
Burnie Paper Pulp ..					8				28		4			4		44
Cressy Post Office ..				3					39					7	29	78
Devonport				24	4				27			3			15	73
Erriba				10			2		35		21			11	30	109
Hampshire Hills ..				13					37					20		70
Irishtown	5			22				2	41							70
Latrobe				6					29							35
Launceston				10					13					3	22	48
Low Head				3					4	1					18	26
Meander				4					33		2			49	29	117
Redpa	7	4	8	42					42	31	1	4			29	168
Ringarooma				7					14							21
Scottsdale				5					17	1				10	36	75
Sheffield				3					35					50		88
Smithton				8					43		3		1			54
Stanley	1			12				3	23						41	80
Tagarra				11	5				13		1			6	25	61
Ulverstone (week.) ..									NIL							
Westbury				2					43					6		51
Western Junction ..				6					16	2		2		5	15	46
Wynyard Aerodrome ..				8					28	74			1		20	131
Yolla																
MOUNTAIN REGION.																
Cape Sorell	5	5	2	55	3	1		8	40	25	3	4		1	85	240
Gormanston	26	4		65	11				23		58	1	1	1	121	311
Lake Margaret	36	4		80	18	2			35		104	1	4	2	139	425
Port Davey				78		1			44	11	7	6	5		125	277
Queenstown	19	3		56	7				39		44	3	2		78	271
Rosebery	7			46	9	2			(50?)		19			4	78	165
Waratah	5	1	1	35	7				30	29	2	2		15	80	207
West Lyell	16	5		6	10				25		59		1		126	248
Zeehan	11	6		63	10	1			37	54	8				78	263
CENTRAL PLATEAU.																
Arthur Lakes	8				5				26					20	48	107
Breona			1	3					40					89	69	[illegible]
Bronte Park				5	7	1			9		8			5	30	65
Butler's Gorge	10			22	12				6	7		1			62	120
Interlaken				3	5				22		1	1		10	14	56
L. St. Clair Pump. Stn. ..	6			8	6				10	10	1			3	67	~~74~~
Liawenee				5	6				38					24	26	99
Shannon				6	8				22						22	58
Waddamana				6	3				13					4	18	44
LAKE ECHO					22				5					1	60	88
DERWENT.																
Bothwell				2							9				9	20
Hamilton																
Maydena (A.N.M.) ..	11	2		13	9						3				58	96
New Norfolk														2	19	15
Ouse "Millbrook" ..																
Tarraleah	2			11	22				7	8					37	87
[illegible]	3			5	5				6		26			24	~~[illegible]~~	116
															44	113
Avoca				16							13					~~24~~

Station	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total Added To 27th		Total Sent
NORTHERN																			
Beaconsfield	39		125		10	26	100	13				30	95		75		379	549	549
Bridport	49	63	27	25	36	25	124	23				28	160	23	24		437	644	644
Burnie Paper Pulp ..	112	54	46	2	4	31	175	54				78	125	3	41		476	645	718
Cressy Post Office ..	70		22		5	28	261	300				39	22	4	79		803	[illegible]	905
Devonport	7	82	26		6	28	168	18				38	110	4	67		446	[illegible]	635
Erriba	43	107	82	1		18	245	252			3	80	105	6	45		946	[illegible]	~~818~~
Hampshire Hills ..	66	130	103	16		20	122	223				40	90	15			820	[illegible]	833
Irishtown	56		160	8	12	18	215	106				94	42	15	153		739	[illegible]	971
Latrobe	23		96		5	27	150	42				35	105		63		413	551	551
Launceston		78	54		3	23	175	71				40	39	11	57		492	[illegible]	[illegible]
Low Head	11	33	13	3	9	33	158	11				12	183		31		289	514	539
Meander	38		133			20	214	309				44	28	4	111		875	[illegible]	[illegible]
Redpa	17	76		15	12	9	155	113	3		14	23	53	13	38		665	[illegible]	[illegible]
Ringarooma			263	3	19	27	238	23				82	53	27			676	[illegible]	[illegible]
Scottsdale	4	73	54	8	17	22	170	40				36	99	26	21		499	[illegible]	[illegible]
Sheffield	70		126		4	25	237	226				55	110		30		831	[illegible]	[illegible]
Smithton	63		133	17	5	23	216	84			1	52	39	20	155		648	[illegible]	[illegible]
Stanley	20	89	45	13	10	20	274	70 on Bulletin				93	73	12	9		644	[illegible]	[illegible]
Tagarra			162		5	35	147	42				27	89	11	74		479		[illegible]
Ulverstone (week.) ..					X							2							721
Westbury	44		184		6	39	225	126			4	20	47	4	28		729	[illegible]	[illegible]
Western Junction ..	4	82	64		4	29	290	117	2			20	18	3	42		658	[illegible]	[illegible]
Wynyard Aerodrome ..	20		112	3	5	21 ON BULLETIN	135	89				29	91	10	~~115~~		434	621	
Yolla																			
MOUNTAIN REGION.																			
Cape Sorell	15		64	28	20 ON BULLETIN	2	93	70	23			17		30	39		552	641	723
Gormanston	32	170	127	100	124	6	90	163	10	~~25~~		19	5	89	42		1157	1293 ~~1450~~	1293
Lake Margaret	30	178	132	136	87	13	81	176	25	~~29~~		18	11	94	40		1295		1450
Port Davey	60	176	64	89	67	7	60	651	95	3		6		45	5		1555	[illegible]	[illegible]
Queenstown	38	163	102	86	100	4	66	732		10		15	4	74	41		987	[illegible]	1107
Rosebery	48	109	121	60	61	11	140	283	8			1	2	46	29		997	[illegible]	[illegible]
Waratah	67	133	131	59	16	16	118	228	11	3	1	36	40	45			1026+85 1111		[illegible]
West Lyell	30	152	105	92	95	8	59	175	24	2		31		89	48		995	[illegible]	1217
Zeehan	59	152	101	41	50	4	108	144	28	26		13		56	32		994	[illegible]	1234
CENTRAL PLATEAU.																			
Arthur Lakes	56	36	92		10	8		315	11			27	12		25		662	699	1174
Breona	28	158	138	6			450	320				41	18		54		~~967~~	1414 ~~1024~~	1414
Bronte Park	52	90	92	51	4	13	332	410	4			12	3	8	15		1135	1151	1144
Butler's Gorge	52	110	123	30	27	10	279	518	23			14	6	21	15		1306	1345	1355
Interlaken	13	62	89			40	621	420	16			39					1356	[illegible]	1372
L. St. Clair Pump. Stn. ..	33	124	107	16	13	1	271	345	18			20	4	18	13		1065	1106	1091
Liawenee	15	55	56		2	30	362	303	17					3	25		937	965	1028
Shannon	24	68	158	8	1	15	440	433	~~17~~	2		25	9	2	20		1251	1292	1293
Waddamana	35	72	133		2	17	480	452	1			22	3	2	11		1264	1280	[illegible]
LAKE ECHO	18	83	166	5	12	24	414	510	6			30	3	10	15		1356		
DERWENT.																			
Bothwell	2		141	2	2	23	242	342				21		4	14		795	813 ~~799~~	[illegible]
Hamilton	21		95		5	21	128	260				17			9		[illegible]	581	585
Maydena (A.N.M.) ..				14	20	9	120	310	15	3		19	11		29		(257)	283	868
New Norfolk	19	48	63	2		13	119	299	36			13	16	7	13		(266)	651 637	637
Ouse "Millbrook" ..			126		4	13	176	196							18		(317)	337	604
Tarraleah	41	104	130	5	8	9	386	441	17 on Bulletin			17	9	14	22		1228	1284 ~~1273~~	[illegible]
~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	8	245	284	9			20	13	7	19		~~[illegible]~~	1072	960
	107	120	125	4	7													1060	
Avoca			93			28	293	295	2			46	2		37		771	~~808~~	815
Eddystone Point ..				1	31	91	879	1132				5		3			1079	1082	[illegible]

B: Ashore totals 10ths

						3										11	5	Interlaker ..	13	12	89					420	1			30							372
	lair F										0					7	7	t. Clai Stn..		4	10		13			345					41						169
CENT PLAT	Liawenee ..				5	6				38		47			24	26	99	Liawenee ..	15	55	56		2	30	362	303	17					3	25		937	965	1028
	Shannon ..				6	8				22						22	58	Shannon ..	24	68	158	8		15	440	433	~~34~~	2		25	9	2	20		1251	1292	1293
	Waddamana ..				6	3				13					4	18	46	Waddamana ..	35	72	133		2	17	480	452	1			22	3	2	11		1264	1250	123
	LAKE ECHO					22				5					1	60	88	LAKE ECHO	18	83	166	5	12	24	414	510	6			30	3	10	15		1356		
95 DERWENT.	Bothwell ..				2							9				9	20	Bothwell ..	2		141	2	2	23	242	342				21		4	14		795	813 ~~799~~	
	Hamilton ..																	Hamilton ..	21		95		5	21	128	260				17			9		592	581	595
	Maydena (A.N.M.) ..	11	2		13	9						3				58	96	Maydena (A.N.M.) ..			63	14	20	9	120	310	15	3		19	11		29		(257)	283	868
	New Norfolk ..														2	19	15	New Norfolk ..	19	48	[illegible]	2		13	119	299	36			13	16	7	13		(266) 6-	~~651~~ 637	635
	Ouse "Millbrook" ..																	Ouse "Millbrook" ..			126		4	13	176	196							18		(3191)	337	604
	Tarraleah ..	2			11	22				7	8					37	87	Tarraleah ..	41	104	130	5	8	9	386	441	17	see Bulletin		17	9	14	22		1228	1284 1273	12
	WAYATINAH	3			5	5				6		26			245	~~44~~	116	WAYATINAH	~~107~~	~~120~~	~~120~~	~~135~~	~~7~~	8	245	284	8			20	13	7	19		1033 ~~1079~~	1072	960
																44	113		107	120	125	4	7													1080	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31			
92 EASTERN.	Avoca ..				16							13					24	Avoca ..			93			28	293	295	2			46	2		37		771	~~808~~	815
	Eddystone Point ..				1				1	28	3		21	1		52	117	Eddystone Point ..	5			1	31	91	829	(132?)				5		3			1079	1082	121
	Gould's Country ..				2	14		17		34		8	2		2		79	Gould's Country ..	32		100	9	24	46	505	15	1		2	44		10	34		850	894	907
	Lake Leake ..				2												12	Lake Leake ..	15	74	38		3	~~323~~	760	295				22			45		1252	1297	1340
	Lewis Hill ..				13							10					23	Lewis Hill ..			52		3	30	408	261				36			12		813	825	838
	Mathinna ..				8			1		9		15	13		4		50	Mathinna ..	22		85		8	34	594	88			2	96	1		34		979	1013	1014
	Nugent ..				18					5		13					36	Nugent ..	13		65			16	716	633	162	15	3	50			35		1109	1744	174
	St. Helens ..				1			20		32	6		8	2	2	12	78	St. Helens ..			30		14	29	632	14	⑤			24	12		13		826	851	882
	St. Marys ..							8		19		4			11		42	St. Marys ..	11		67		14	33	567	96			5	~~42~~	11				880	854	880
	Swan Island ..									24	9	5				17	55	Swan Island ..	18	63	43	3	43	16	80		1				23	6	17		305	361	384
	Swansea ..									22	5	10	1				38	Swansea ..		30	13		4	47	285	478	3			49	1		50		947	998	1003
	Triabunna ..				4					20		18					~~38~~	Triabunna ..	9	42	30		3	30	312	215	10			31			23		~~770~~	~~773~~	807
	Upper Blessington ..				19					–							19	Upper Blessington ..	41	113	56		17	19	478	101				55	29		44		899	972	1010
	Upper Scamander ..				4			6		29							39	Upper Scamander ..		10	71		23	47	325	34				20	7		13		569	589	589
	Rossarden																																				
93 MIDLAND.	Campbell Town ..				4					28					4		36	Campbell Town ..	26		95			30	201	95			5	20	2		36		508	546	546
	Oatlands ..				2					15		3			4		24	Oatlands ..	13	50	58		3	29	201	413	10			25		4	14		826	844	855
	Ross "Ellinthorp" ..				3					32					2	15		Ross "Ellinthorp" ..	8	67	33			28	~~279~~ 281	178				42	2		39			731	731

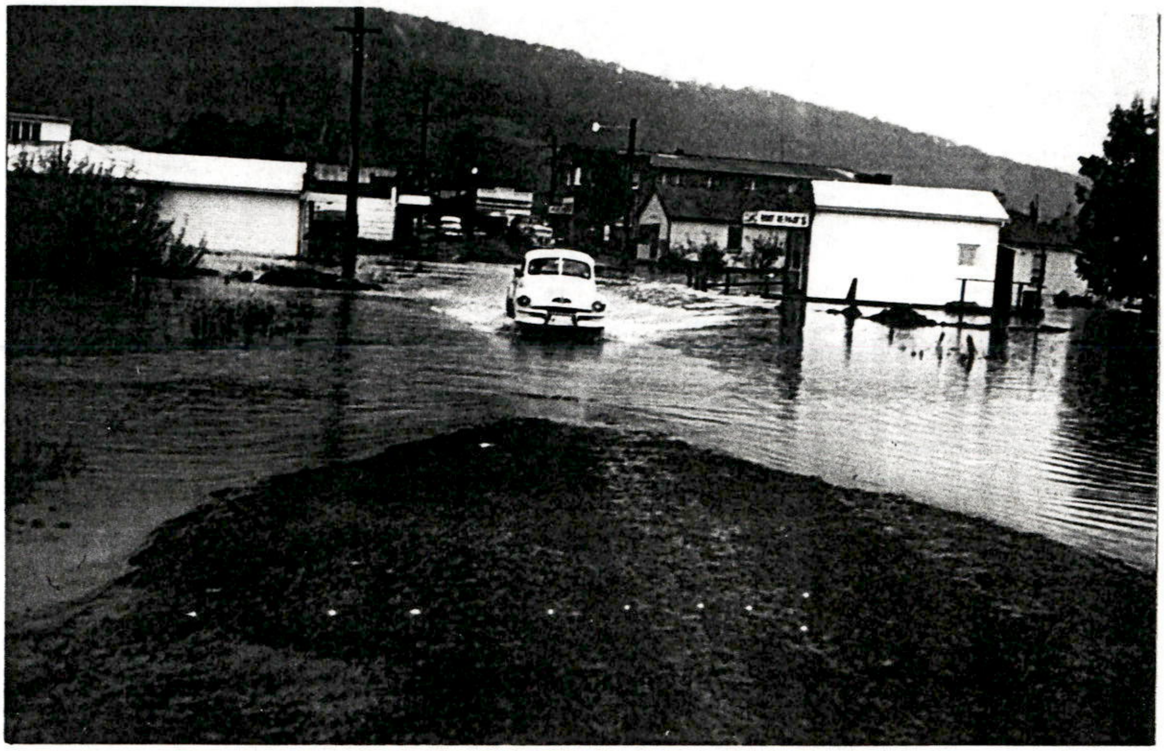
Ellinthorp—most for a month. Previously 611 Aug. 1939. Biggest flood since 1917.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			16	17	18	19	20	21	22	23	24	25	26	27	28	29	30			TOTAL (POINTS)	
94 SOUTH-EASTERN.	Bagdad Post Office ..				1					2		3					6	Bagdad Post Office ..	14		133			26	394	420	17			4	12	1	22		1014	1039	1045
	Bellerive ..				2					1		2			1	1	6	Bellerive ..	23		84		2	20	214	494	46	1	1	64	1	3	9		953	966	963
	Cape Bruni ..	6			11	25				4	1	Nil	6			7	60	Cape Bruni ..	29	66	79		6	4	62	283	(103)			37	4	11	30		(343) 774	388	~~390~~
	Franklin ..				4	2				16		2					24	Franklin ..	45		190		5	5	312	521	38			29	6	9	18		1169	1202	1202
	Glenorchy ..				1	3						1			1		3	Glenorchy ..	82		179	1	2	17	270	640	48			18	7	1	15		1260	1283	1282
	Grove ..				6	7						6			2	19	40	Grove ..	25	61	67	3	2	20	355	609	81	1		31			14		1295	1309	1330
	Hobart Aerodrome ..				6					2		7				4	19	Hobart Aerodrome ..	9	27	26		1	15	247	513	71		1	43		2	13		972	987	957
	Hobart ..				1							2			2	20	25	Hobart ..	22	56	51	2	1	15	177	525	45			44	2	1	11		963 (975)	975	975
	Hythe ..				9	12				10		10	7				48	Hythe ..	37		124		5	4	54	444				69	2	21	6		785	844	908
	Judbury ..				48												48	Judbury ..	37		121				215	513	48			29		19			1011	1030	1020
	Kempton (week.) ..																1	Kempton (week.) ..					137						875						1012	1012	1032
	Kingston ..				4							15			1		20	Kingston ..					125	50	160	& 166				60		10			1179	1089	1059
	Lenah Valley ..				2							2			3		7	Lenah Valley ..	58		130	1	2	18	252	646	36			27	3	3	18		1177	1195	119
	Lindisfarne ..																	Lindisfarne ..		Combined 232					321	645	26			45		3	10		1037	1050	1050
	Lymington ..																	Lymington ..																			
	Maatsuyker Island ..	4	6		51	8	2			65	13	14	27			92	277	Maatsuyker Island ..	28	85	86	46	46	53	89	200	31			17	42		17		(727)	1017 796	1059
	Mt. Nelson ..				4					2		37			2		45	Mt. Nelson ..	26		90	1	3	22	168	500	54			48	1	2	14		957	974	977
	Premaydena ..				19	5				5		2					31	Premaydena ..	6		48	3	7	8	183	421	133			44	3	10	18		884	909	909
	Rokeby ..				3					1		3					7	Rokeby ..	16		57		2	33	191	435	63			47	1	3	9		851	864	851
	Tasman Island ..				15	7				69		9					100	Tasman Island ..	36	5	20		14	4	46					56	10		14		(281)	305	671
	The Springs ..		1		13	3				3		40	2			34	96	The Springs ..	38	69	68	11	4	40	725	769	40		25	~~56~~	58				1885	1902	2183
	Tunnack ..									12		7				20	39	Tunnack ..		55	53			18	375	485	51			35		6			1109	1115	1115
99 FLINDERS IS.	Pat's River ..				3					3		4				26	36	Pat's River ..	32			[illegible]		11	6	8					15	33	8		246	302	303
18 NG S.	Currie ..	2	5		15					26	58					39	135	Currie ..	20																		11

APPENDIX B

PHOTOGRAPHIC RECORDS

April 1960 & July 1990



22 / 23 April 1960
Wilmot Road looking towards Huonville

22 / 23 April 1960
Main Street Huonville

22 / 23 April 1960

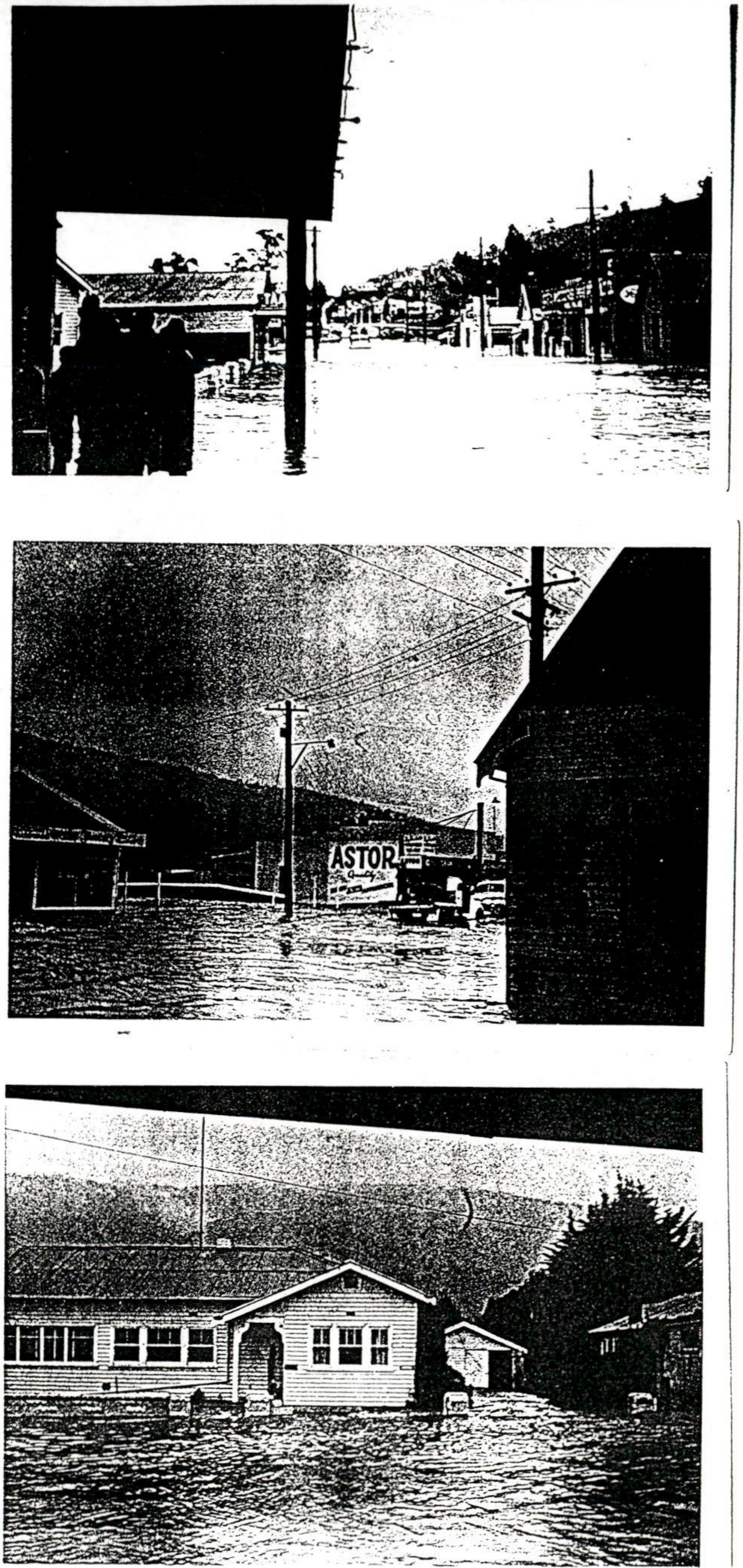
Main Street Huonville
(not at flood peak)

22 April 1960

Wilmot Road Huonville

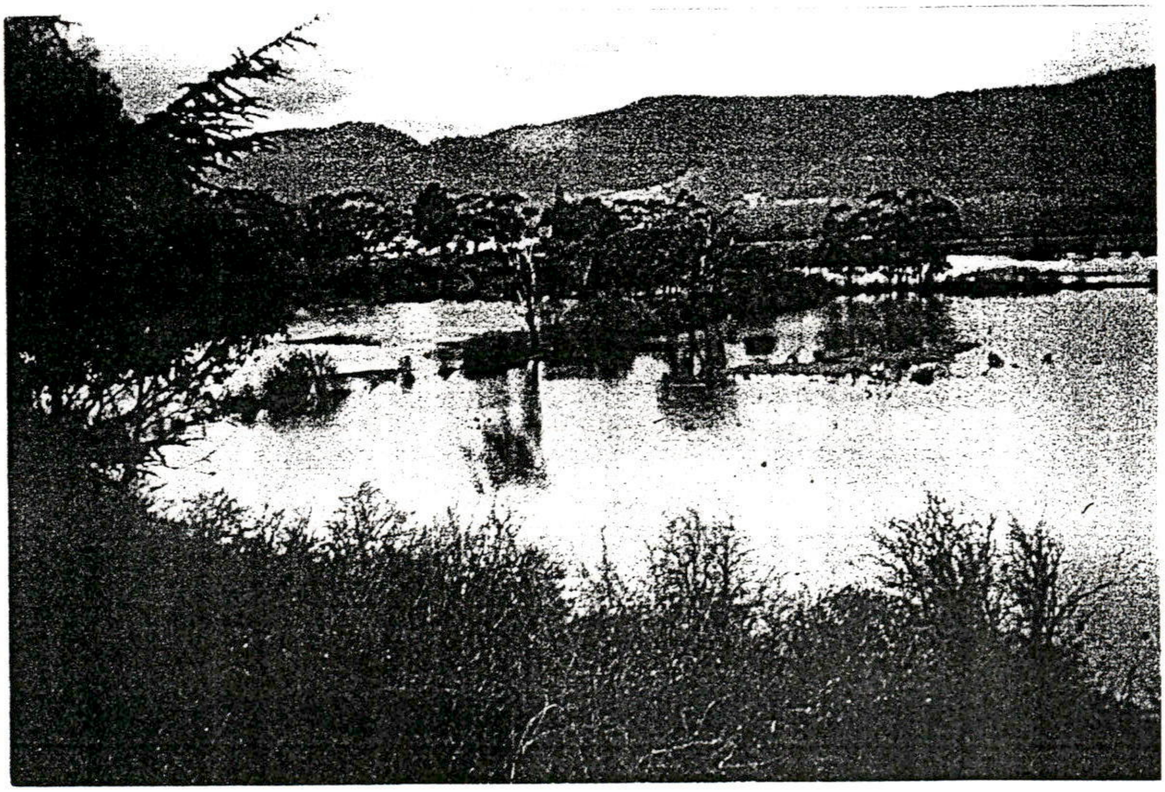
22 / 23 April 1960
House at end of Short Street

22 / 23 April 1960
Paddocks off Wilmot Road



22 April 1960

Main Street Huonville



3 July 1990

From Frankcombe property looking towards
sewage ponds and Ranelagh Church

APPENDIX C

HEC-2 FILE

100 Year ARI Flood

```
T1  HUON RIVER FLOOD PLAIN STUDY
T2  STAGE 2
T3       100 YEAR ARI FLOOD
J1    -10       0       0       0       0       1       1    2455    1.95
J2     -1       0      -1
J3     38      14      13      26       1       4      17      55
J5    -10     -10
J6      1
NC   0.12    0.12   0.037     0.1     0.3
X1      0      93     400     673
X2
X3     10
GR 15.15     97.0   14.20   111.0   13.25   122.0   12.80   126.0   12.45   132.0
GR 12.30    133.0   11.45   141.0   11.15   144.0   10.95   146.0   10.10   155.0
GR  8.80    173.0    7.70   185.0    6.65   195.0    6.45   197.0    5.50   205.0
GR  5.45    207.0    5.00   207.5    5.25   208.0    5.20   209.0    4.55   213.0
GR  4.25    215.0    3.95   217.0    3.65   218.0    3.20   221.0    2.55   228.0
GR  2.20    232.0    1.70   235.0    1.65   239.0    0.75   252.0    0.25   303.0
GR  0.45    321.0    0.75   341.0    0.30   381.0    0.90   400.0    0.35   420.0
GR  0.00    423.0   -0.35   425.0   -2.50   435.0   -2.80   444.0   -3.60   459.0
GR -4.60    474.0   -4.80   489.0   -4.90   504.0   -5.00   520.0   -4.90   535.0
GR -5.00    550.0   -5.50   565.0   -5.00   580.0   -4.80   595.0   -4.80   610.0
GR -4.90    625.0   -5.00   640.0   -4.60   655.0   -3.80   668.0   -1.00   670.0
GR  0.00    672.0    0.50   673.0    1.00   678.0    0.95   686.0    1.35   690.0
GR  2.00    693.0    2.50   695.0    2.85   699.0    3.50   702.0    3.95   706.0
GR  4.50    710.0    5.25   715.0    5.75   720.0    6.55   725.0    7.10   729.0
GR  7.85    736.0    8.50   741.0    9.05   742.0    9.40   747.0   10.05   757.0
GR 10.40    765.0   10.85   781.0   11.50   797.0   12.10   813.0   11.95   822.0
GR 11.65    824.0   11.30   829.0   11.15   839.0   11.35   855.0   12.05   879.0
GR 12.85    895.0   13.15   912.0   14.05   924.0   14.55   930.0   14.85   931.0
GR 15.05    933.0   15.40   936.0   15.85   936.4
NC   0.12    0.12   0.037
X1      1      94     487     637     460     580     540
X2
X3     10
GR 16.74      0.0   16.40     2.0   16.25     3.0   16.00     6.0   15.85     9.0
GR 15.60     12.0   15.35    14.0   15.15    16.0   14.95    18.0   14.65    20.0
GR 14.35     22.0   14.00    24.0   13.60    25.0   13.25    27.0   12.95    28.0
GR 12.60     29.0   12.25    31.0   11.85    33.0   11.45    34.0   11.00    37.0
GR 10.55     39.0   10.20    42.0    9.70    45.0    9.45    49.0    9.05    51.0
GR  8.70     54.0    8.15    57.0    7.60    60.0    7.00    63.0    6.50    66.0
GR  6.05     70.0    5.10    78.0    4.60    86.0    3.85    94.0    3.10   105.0
GR  2.20    120.0    1.40   139.0    1.00   156.0    0.55   175.0    0.40   194.0
GR  0.30    220.0    0.25   241.0    0.20   258.0    0.20   271.0    0.20   305.0
GR  0.15    327.0    0.55   349.0    0.30   381.0    0.25   414.0    0.25   423.0
GR  0.25    440.0    0.30   464.0    0.65   482.0    1.43   487.0    0.15   489.0
GR -0.90    491.0   -4.70   506.0   -5.40   521.0   -6.30   535.0   -7.40   544.0
GR -8.20    557.0   -8.80   572.0   -9.80   587.0   -9.40   597.0   -9.00   607.0
GR -4.00    622.0   -2.00   629.0    0.15   637.0    5.45   642.0    5.85   643.0
GR  7.08    644.0    7.75   646.0    8.15   648.0    8.55   649.0    9.15   652.0
GR  9.45    654.0    9.85   657.0   10.30   659.0   10.65   661.0   11.15   663.0
GR 11.50    665.0   12.00   668.0   12.45   670.0   12.80   673.0   13.15   676.0
GR 13.50    679.0   13.45   680.0   14.05   682.0   14.57   682.5   15.30   683.0
GR   15.7   683.9   16.10   684.0   16.45   685.0   16.65   686.0
NC   0.12    0.12   0.040
X1      2      95      90     289     450     580     600
X2
X3     10
GR 15.90      0.0   15.10     1.0   14.30     3.0   14.20     5.0   13.45     7.0
GR 12.40      8.0   12.00    14.0   10.85    16.0   10.45    17.0   10.05    18.0
GR  9.75     19.0    9.45    20.0    9.20    21.0    8.85    22.0    8.50    23.0
GR  7.95     24.0    7.55    25.0    7.05    27.0    6.65    28.0    6.20    29.0
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GR  5.90    30.0    5.45    31.0    5.10    33.0    4.55    34.0    4.20    35.0
GR  3.60    36.0    3.20    38.0    2.80    39.0    2.40    42.0    1.95    44.0
GR  1.45    46.0    1.00    49.0    0.90    53.0    0.70    66.0    0.80    78.0
GR  1.10    90.0    0.95   101.0    0.70   105.0    0.60   107.0    0.30   108.0
GR  0.20   108.0   -0.70   109.0   -1.70   113.0   -4.10   117.0   -7.50   130.0
GR -5.30   145.0   -4.70   160.0   -3.90   175.0   -4.00   190.0   -3.90   205.0
GR -4.30   220.0   -4.50   235.0   -3.30   251.0   -1.10   265.0    0.20   278.0
GR  0.50   287.0    1.41   289.0    0.60   293.0    0.55   306.0    0.15   323.0
GR -1.91   345.0   -0.05   365.0   -0.10   386.0   -0.10   405.0   -0.05   425.0
GR -0.05   446.0    0.10   453.0   -1.47   471.0    0.25   484.0    1.10   487.0
GR  1.75   490.0    2.50   493.0    3.20   496.0    3.85   499.0    4.40   502.0
GR  5.15   509.0    6.45   524.0    6.95   529.0    7.60   538.0    8.35   543.0
GR  9.25   549.0    9.65   552.0   10.40   558.0   10.80   564.0   11.60   570.0
GR 11.80   574.0   12.60   583.0   13.05   596.0   13.85   622.0   14.40   633.0
GR 15.30   650.0   15.90   660.0   16.90   676.0   17.90   691.0   18.20   695.0
NC  0.12    0.12   0.040
X1     3      78      37     148     450     220     430
X2
GR 20.25     0.0   19.70     1.0   10.55     8.0    9.00    10.0    7.55    12.0
GR  6.20    15.0    5.45    19.0    5.05    26.0    4.90    31.0    4.55    33.0
GR  3.60    35.0    2.80    36.0    0.30    37.0   -0.30    39.0   -3.20    43.0
GR -9.80    58.0   -9.80    67.0   -9.60    82.0   -9.40    95.0   -5.30   107.0
GR -5.10   122.0   -0.60   137.0    0.30   138.0    0.55   139.0    0.40   144.0
GR  1.05   147.0    1.35   148.0    0.90   150.0   -0.25   152.0    0.30   152.2
GR  0.55   176.0    1.15   194.0    1.65   204.0    1.30   220.0    0.75   236.0
GR  0.80   241.0    1.05   244.0    1.50   256.0    1.45   276.0    1.25   297.0
GR  1.10   317.0    1.05   336.0    0.80   357.0    0.85   377.0    1.15   407.0
GR  1.00   432.0    1.05   464.0    1.10   500.0    1.25   522.0    0.90   563.0
GR  1.45   597.0    1.00   608.0    1.35   625.0    2.10   640.0    2.80   646.0
GR  3.20   649.0    3.95   653.0    4.60   657.0    5.35   662.0    6.10   667.0
GR  6.95   673.0    7.65   677.0    8.50   683.0    9.10   688.0    9.75   692.0
GR 10.15   693.0   10.50   694.0   10.40   696.0   10.50   698.0   11.55   700.0
GR 11.95   705.0   12.65   710.0   13.30   716.0   13.85   723.0   14.20   731.0
GR 14.20   743.0   14.70   756.0   15.20   768.0
NC  0.10    0.10   0.037
X1     4      95     558     767     550     150     500
X2
X3    10
GR 15.30     0.0   14.40     3.0   13.50     7.0   12.50    12.0   11.65    19.0
GR 12.05    25.0   10.95    30.0   10.00    31.0   10.45    42.0    9.75    45.0
GR  8.95    57.0    7.70    72.0    6.95    81.0    6.25    90.0    5.70    98.0
GR  5.00   116.0    4.30   122.0    3.70   128.0    3.25   132.0    2.60   149.0
GR  1.95   166.0    1.40   184.0    0.80   210.0    0.65   218.0    0.35   221.0
GR  0.80   222.0    0.80   238.0   -0.50   240.0    0.55   244.0    0.90   246.0
GR  0.55   261.0    0.65   289.0    0.55   314.0    0.70   337.0    0.25   360.0
GR  0.50   379.0    0.85   436.0    1.05   503.0    1.55   558.0    1.45   588.0
GR  1.30   607.0    1.00   608.0    0.35   610.0   -0.10   611.0   -2.40   614.0
GR -3.00   625.0   -3.50   640.0   -2.50   655.0   -2.70   670.0   -3.10   685.0
GR -3.20   700.0   -3.70   715.0   -3.80   730.0   -3.90   745.0   -4.00   760.0
GR -0.50   766.0    0.35   767.0    0.35   769.0    0.80   770.0    0.95   770.0
GR  1.85   786.0    2.30   787.0    2.35   792.0    2.75   797.0    3.65   811.0
GR  4.35   823.0    4.60   826.0    5.25   836.0    5.85   842.0    6.00   847.0
GR  5.65   857.0    5.15   862.0    4.35   866.0    3.95   868.0    3.55   870.0
GR  3.10   873.0    2.65   875.0    2.15   878.0    1.80   882.0    1.60   888.0
GR  2.00   891.0    2.70   900.0    3.40   927.0    3.15   977.0    3.25  1021.0
GR  3.75  1026.0    4.15  1029.0    4.65  1032.0    5.80  1041.0    7.00  1057.0
GR  8.15  1068.0    9.50  1077.0   10.55  1084.0   11.35  1087.0   12.35  1094.0
NC  0.12    0.12   0.040
X1     5      95    1141    1328     400     200     280
X2
X3    10
GR 13.25    70.0   12.95   102.0   11.40   141.0   11.15   195.0   10.75   203.0
```

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GR 11.45    211.0    10.85    244.0    10.40    277.0     9.60    309.0     8.85    342.0
GR  8.35    370.0     7.75    379.0     7.40    405.0     7.30    421.0     6.65    460.0
GR  7.35    492.0     6.70    532.0     6.35    565.0     5.65    595.0     4.50    617.0
GR  4.65    661.0     4.85    699.0     4.75    726.0     4.15    732.0     4.15    739.0
GR  3.95    746.0     3.85    755.0     4.15    767.0     4.25    780.0     4.05    805.0
GR  3.80    820.0     3.20    854.0     2.70    885.0     2.40    909.0     2.20    928.0
GR  1.85    942.0     1.30    953.0     0.85    961.0     0.60    979.0     0.75    991.0
GR  0.30    991.2     0.70    991.5     0.85   1018.0     1.60   1027.0     1.80   1081.0
GR  0.85   1087.0     0.35   1102.0     0.00   1103.0     0.50   1105.0     0.50   1124.0
GR  1.95   1129.0     2.80   1141.0     1.95   1147.0     2.15   1153.0     2.50   1158.0
GR  2.75   1164.0     2.15   1170.0     1.70   1179.0     1.15   1186.0     0.90   1191.0
GR  0.35   1192.0    -0.60   1193.0    -1.80   1196.0    -2.80   1201.0    -1.50   1211.0
GR -2.00   1221.0    -2.70   1231.0    -2.70   1246.0    -2.80   1261.0    -3.40   1276.0
GR -5.10   1291.0    -3.90   1306.0    -2.90   1324.0     0.35   1328.0     2.40   1329.0
GR  3.05   1338.0     3.40   1359.0     3.85   1367.0     4.30   1375.0     4.75   1391.0
GR  5.40   1406.0     6.45   1415.0     7.00   1421.0     7.85   1427.0     8.85   1433.0
GR  9.40   1435.0     9.95   1438.0    10.60   1441.0    11.10   1443.0    11.60   1446.0
GR 12.15   1448.0    12.75   1450.0    12.30   1453.0    13.85   1456.0    14.40   1461.0
NC  0.15     0.15    0.040      0.3      0.5
X1    61       85   1412.9     1572      320      200      210
X2
GR 17.69        0    17.11       20    16.74       40    16.44       60    16.15       80
GR 15.88      100    15.51      120    15.18      140    14.83      160    14.39      180
GR 13.89      200    13.37      220    12.99      240    12.56      260    12.07      280
GR 11.53      300    11.26      320    10.99      340    10.78      360    10.52      380
GR  10.2      400     9.98      420     9.75      440     9.46      460     9.12      480
GR  8.87      500     8.56      520     8.20      540     7.84      560     7.54      580
GR  7.37      600     7.16      620     7.03      640     6.84      660     6.77    690.5
GR  6.56      721     6.34    751.4     6.13    781.9     6.05    812.4     5.94    842.9
GR  5.54    873.4      5.1    903.8     4.67    934.3     4.23    964.8     3.80    995.3
GR  3.44   1025.8     3.61   1056.2     4.31   1086.7     4.62   1117.2     4.24   1147.7
GR  3.90   1169.0     3.42   1199.5     3.07   1230.0     2.92   1260.5     2.81   1290.9
GR  2.69   1321.4     2.64   1336.7     2.97     1361     3.30     1386     4.37   1412.9
GR  4.35     1413     0.25     1415    -0.50     1416    -3.00     1426    -2.80     1437
GR -2.70     1449    -3.60     1460    -2.40     1471    -2.70     1483    -2.60     1494
GR -2.30     1506    -3.10     1516    -3.20     1529    -3.30     1539    -3.20     1552
GR -3.90     1561     -1.0     1570     0.25     1572     7.55     1576     7.80     1604
GR  8.80     1625     8.85     1654    10.10     1679    10.60     1698    10.85     1712
NC  0.15     0.15    0.040      0.5      0.8
X1    62                                  80       80       80
X2
X3    10                                                             2.6     7.48
SB  1.25      1.6      1.4        0    160.0      8.4     1133        0        0        0
X1    63                                  10       10       10
X2     0        0        1     6.30     2.64
X3    10                                                             2.6     7.48
BT   -27      500     8.87               540     8.20               580     7.54
BT            620     7.16               660     6.84               721     6.56
BT          781.9     6.13               842     5.94             903.8     5.10
BT          964.8     4.23            1025.8     3.44            1086.7     4.31
BT           1147     4.24            1199.5     3.42            1260.5     2.92
BT         1321.4     2.69              1361     2.97              1386     3.30
BT           1417     4.37              1439     4.89              1462     5.38
BT           1485     5.85              1508     6.30              1531     6.72
BT           1554     7.11              1577     7.48              1604     7.80
X1    64                                  20       20       20
X2
X3    10
NC  0.12     0.12    0.040      0.1      0.3
X1     7       95      713      829      280      420      400
X2
X3    10
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GR  6.85     0.0    6.75     7.0    6.90    54.0    6.60    66.0    6.40   107.0
GR  5.80   164.0    5.60   215.0    5.30   264.0    5.45   276.0    5.40   287.0
GR  4.85   295.0    5.00   309.0    4.35   331.0    4.45   369.0    4.55   372.0
GR  4.10   381.0    3.55   384.0    3.80   400.0    4.15   409.0    4.00   425.0
GR  4.00   440.0    4.20   453.0    4.45   463.0    4.35   478.0    4.30   493.0
GR  4.45   505.0    4.15   516.0    3.35   539.0    2.65   558.0    2.10   571.0
GR  1.60   582.0    1.10   594.0    1.00   596.0    1.05   611.0    1.00   618.0
GR  0.75   620.0   -0.25   621.0   -1.05   622.0   -3.75   640.0   -0.95   657.0
GR -0.25   658.0    0.25   658.0    0.65   671.0    1.25   684.0    1.75   697.0
GR  1.85   713.0    1.75   724.0    0.40   725.0   -0.30   725.0   -1.10   726.0
GR -4.50   739.0   -4.50   755.0   -4.20   769.0   -3.60   789.0   -2.20   813.0
GR -0.45   822.0    0.40   823.0    0.50   824.0    0.90   829.0    0.65   834.0
GR  0.50   840.0    0.40   850.0    0.45   857.0    0.65   871.0    0.60   879.0
GR  0.65   887.0    0.30   896.0   -0.05   897.0    0.40   899.0    0.60   902.0
GR  0.75   908.0    0.70   909.0    1.15   910.0    1.55   911.0    2.05   912.0
GR  2.65   913.0    2.90   918.0    2.65   923.0    2.35   924.0    2.80   928.0
GR  3.40   929.0    3.90   929.3    4.50   930.0    5.65   931.0    5.75   932.0
GR  6.55   934.0    7.45   935.0    7.95   936.0    8.53   937.0    9.90   939.0
GR 10.45   939.0   11.20   940.0   11.70   941.0   12.65   942.0   13.65   943.0
NC  0.12    0.12   0.040
X1     8      95    1131    1277     320     290     280
X2
X3    10
GR 11.60     0.0   11.40     6.0   11.35    52.0   11.95    87.0   11.80   134.0
GR 11.10   144.0   10.75   170.0   10.40   207.0   10.05   219.0    9.85   228.0
GR  9.50   252.0    9.10   269.0    8.50   287.0    8.20   306.0    7.90   324.0
GR  7.95   380.0    7.80   381.0    7.40   391.0    7.10   396.0    6.75   466.0
GR  7.00   515.0    7.25   571.0    6.85   626.0    6.70   645.0    6.20   670.0
GR  5.85   677.0    5.45   678.0    5.05   710.0    4.95   711.0    5.10   712.0
GR  5.25   757.0    5.50   802.0    5.40   862.0    5.35   902.0    5.20   945.0
GR  5.05   947.0    5.30   953.0    5.25   967.0    5.10   990.0    4.80   996.0
GR  4.55  1002.0    4.30  1006.0    3.95  1008.0    3.60  1011.0    3.25  1014.0
GR  2.50  1019.0    1.75  1023.0    1.25  1030.0    0.75  1038.0    0.50  1045.0
GR -0.20  1045.0   -2.60  1047.0   -3.90  1061.0   -1.10  1072.0   -0.20  1073.0
GR  0.70  1075.0    1.15  1101.0    1.60  1116.0    2.05  1131.0    2.00  1150.0
GR  1.20  1168.0    0.40  1168.0   -0.80  1169.0   -2.00  1182.0   -3.20  1197.0
GR -3.30  1214.0   -3.20  1230.0   -3.30  1244.0   -3.60  1257.0   -0.70  1272.0
GR  0.40  1273.0    0.65  1274.0    1.10  1275.0    1.55  1277.0    1.35  1305.0
GR  0.90  1324.0    0.45  1363.0    0.20  1367.0    0.60  1372.0    1.10  1397.0
GR  1.50  1409.0    1.90  1420.0    2.55  1426.0    3.05  1429.0    3.65  1434.0
GR  2.95  1437.0    4.10  1439.0    4.35  1441.0    4.70  1442.0    5.30  1443.0
GR  5.70  1444.0    6.20  1445.0    7.30  1448.0    8.00  1451.0    9.40  1453.0
NC  0.12    0.12   0.037
X1     9      95    1427    1512     550     680     640
X2
X3    10                   929.0    6.35
GR 14.95     0.0   14.95     3.0   16.40    16.0   17.30    28.0   18.30    43.0
GR 19.20    54.0   20.25    67.0   20.60    70.0   19.60    87.0   18.85   109.0
GR 17.50   161.0   17.30   161.5   16.45   166.0   15.70   168.0    6.15   185.0
GR  8.40   212.0   10.45   216.0   10.00   221.0    9.50   227.0    8.75   236.0
GR  8.10   239.0    7.50   239.4    5.75   247.0    6.10   260.0    5.90   283.0
GR  5.25   285.0    5.80   296.0    6.35   303.0    6.65   333.0    5.80   342.0
GR  5.40   389.0    5.45   435.0    5.45   493.0    5.20   557.0    4.85   557.2
GR  5.40   558.0    5.00   579.0    4.75   653.0    4.35   702.0    3.90   750.0
GR  3.75   792.0    4.60   817.0    5.35   821.0    5.68   826.0    5.35   831.0
GR  4.80   833.0    5.15   835.0    5.60   850.0    6.15   882.0    6.35   929.0
GR  5.85  1007.0    5.20  1014.0    4.90  1021.0    4.45  1027.0    3.80  1032.0
GR  2.70  1039.0    1.77  1048.0    1.95  1082.0    1.45  1147.0    2.30  1191.0
GR  1.85  1232.0    1.10  1243.0    0.45  1250.0    1.05  1264.0    1.05  1314.0
GR  1.70  1377.0    1.30  1385.0    1.80  1396.0    2.20  1427.0    1.75  1434.0
GR  1.39  1437.0    1.00  1439.0    0.35  1439.0   -0.40  1440.0   -3.50  1455.0
GR -4.00  1465.0   -5.80  1481.0   -5.90  1495.0   -2.60  1507.0   -0.70  1511.0
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GR  0.35  1512.0    0.80  1517.0    1.45  1520.0    2.15  1521.0    3.29  1523.0
GR  3.70  1524.0    4.35  1534.0    4.70  1583.0    5.10  1599.0    5.85  1616.0
GR  6.75  1630.0    7.45  1642.0    8.20  1650.0    8.90  1655.0    9.85  1671.0
NC  0.12    0.12   0.040
X1    10      95     653     796     700     500     650
X3    10
GR 15.85     0.0   15.25    38.0   15.00    51.0   14.55    65.0   14.15    81.0
GR 13.80    95.0   13.40   141.0   13.15   178.0   12.50   181.0   11.90   184.0
GR 11.30   187.0   10.55   190.0   10.20   192.0    9.75   194.0    9.20   195.0
GR  8.80   196.0    8.30   198.0    7.80   199.0    7.25   201.0    6.80   202.0
GR  6.30   204.0    5.75   206.0    5.10   209.0    4.80   211.0    4.20   212.0
GR  3.40   214.0    2.90   216.0    2.60   241.0    2.30   308.0    1.90   349.0
GR  1.65   393.0    1.45   474.0    1.55   501.0    2.00   534.0    1.50   554.0
GR  2.00   589.0    2.00   643.0    2.50   653.0    2.45   667.0    1.90   673.0
GR  1.50   676.0    1.30   680.0    0.85   682.0    0.35   685.0   -0.50   686.0
GR -2.00   692.0   -2.50   704.0   -2.10   718.0   -2.80   733.0   -3.20   753.0
GR -3.50   767.0   -2.80   781.0    0.35   783.0    1.00   785.0    1.30   786.0
GR  1.90   789.0    2.40   790.0    2.90   792.0    2.95   796.0    2.80   813.0
GR  2.40   834.0    1.85   856.0    1.90   875.0    1.70   896.0    1.70   918.0
GR  1.65   942.0    1.50   962.0    1.55   986.0    1.20  1018.0    0.60  1019.0
GR -0.25  1019.4    0.55  1022.0    1.35  1032.0    1.60  1040.0    2.05  1089.0
GR  2.50  1091.0    3.20  1094.0    3.65  1095.0    4.25  1097.0    4.75  1098.0
GR  5.30  1099.0    5.75  1101.0    6.45  1102.0    7.20  1104.0    7.75  1105.0
GR  8.25  1106.0    9.10  1108.0    9.65  1109.0   10.25  1110.0   11.20  1112.0
GR 11.50  1113.0   11.80  1113.6   12.35  1114.0   12.95  1116.0   13.45  1118.0
NC  0.15    0.15   0.055
X1    11      95      23     166     840     450     900
X2
X3    10
GR 17.60     0.0   15.30     3.0   14.30     4.0   13.45     5.0   12.70     6.0
GR 11.70     7.0   10.60     8.0    9.75     9.0    8.95    10.0    7.95    11.0
GR  6.85    13.0    6.00    14.0    5.25    15.0    4.15    17.0    3.05    18.0
GR  2.20    20.0    1.45    22.0    0.60    23.0   -0.70    25.0   -2.50    38.0
GR -8.60    56.0   -6.80    79.0   -4.40    92.0   -2.50   112.0    0.30   134.0
GR  0.60   135.0    0.85   136.0    1.25   137.0    1.70   139.0    2.25   143.0
GR  2.80   146.0    3.30   149.0    3.50   154.0    4.00   166.0    3.40   212.0
GR  3.15   229.0    2.60   261.0    2.75   323.0    2.65   355.0    2.25   397.0
GR  1.60   409.0    2.25   424.0    2.30   460.0    2.15   471.0    2.50   502.0
GR  2.10   548.0    1.50   550.0    0.85   553.0    1.45   556.0    1.90   558.0
GR  2.40   560.0    2.70   580.0    2.35   595.0    1.65   597.0    2.10   599.0
GR  2.45   605.0    2.35   622.0    2.65   643.0    3.50   669.0    3.40   711.0
GR  2.90   752.0    2.60   801.0    2.55   831.0    2.25   859.0    2.55   909.0
GR  1.80   915.0    2.20   917.0    2.35   917.0    2.45   918.0    2.45   937.0
GR  2.90   955.0    2.60   991.0    2.20  1008.0    2.00  1038.0    2.30  1073.0
GR  2.10  1113.0    2.35  1141.0    2.90  1155.0    4.05  1171.0    4.95  1179.0
GR  5.60  1184.0    5.95  1186.0    6.30  1188.0    6.60  1190.0    6.90  1192.0
GR  7.25  1194.0    7.55  1197.0    7.90  1200.0    8.40  1204.0    9.05  1205.0
GR  9.40  1207.0    9.80  1208.0   10.30  1210.0   10.75  1212.0   11.20  1214.0
NC  0.15    0.15   0.055
X1    12      90    24.0     128     740     360     670
X2
GR 11.75     8.0   11.45     8.3   10.95     9.0   10.10    11.0    9.50    12.0
GR  8.85    13.0    7.45    14.0    7.05    15.0    6.40    15.7    5.20    15.9
GR  4.80    16.0    4.20    17.0    3.60    20.0    2.80    20.4    2.05    22.0
GR  0.75    24.0    0.65    24.0   -1.10    25.0   -2.40    39.0   -3.50    54.0
GR -3.20    64.0   -3.40    72.0   -3.00    79.0   -0.70    94.0    0.65    95.0
GR  1.55    96.0    2.35    97.0    2.60    98.0    3.25   100.0    3.50   102.0
GR  3.90   104.0    4.15   114.0    4.55   128.0    3.85   150.0    2.95   159.0
GR  2.10   180.0    1.50   192.0    1.55   251.0    1.20   266.0    0.85   268.0
GR  1.15   271.0    1.55   282.0    2.05   284.0    2.35   286.0    2.85   290.0
GR  3.25   291.0    3.65   294.0    4.20   298.0    4.10   329.0    3.60   354.0
GR  3.90   382.0    3.25   414.0    2.80   425.0    3.10   445.0    2.60   463.0
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GR  3.20    474.0    3.75    482.0    3.60    509.0    3.20    544.0    2.80    563.0
GR  3.25    595.0    2.85    620.0    2.25    664.0    2.35    730.0    2.20    796.0
GR  1.95    797.0    2.30    798.0    2.55    832.0    2.05    834.0    2.55    836.0
GR  2.60    862.0    3.60    899.0    4.40    921.0    4.00    923.0    4.35    926.0
GR  4.60    951.0    5.95    968.0    6.60    972.0    7.15    974.0    7.60    977.0
GR  8.00    978.0    8.50    980.0    8.95    982.0    9.40    985.0    9.90    986.0
GR 10.50    987.0   10.95    989.0   11.40    990.0   11.90    991.0   12.30    992.0
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