RIVER TAY CATCHMENT STUDY

Report to Ove Arup and Partners

by

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1993/042

Foreward

The River Tay Catchment Study was commissioned by Tayside Regional Council after a series of major flood events caused extensive damage throughout the region. The Study was centred around the development of two computational models: one an hydrological model of the Tay and Earn basins and the other an hydraulic model of the most flood prone areas. The models would be used to test the sensitivity of flood water levels to a range of environmental changes and flood alleviation options. A wide range of data was required for the modelling from a series of flood events.

This report has been prepared by the Institute of Hydrology (IH) for Ove Arup and Partners as a sub-contract within the River Tay Catchment Study. The Terms of Reference (see below) asked for three reports to be prepared by IH:

Report 1 Methodology for estimating sub-catchment precipitation.

A methodology was to be developed for estimating hourly rainfall data for ten selected flood events. It was expected that the method would derive relationships between rainfall and topography which could be applied to the physical characteristics of each sub-catchment within the Tay and Earn river basins.

Report 2 Flood event screening

Ten flood events in the Tay and Earn catchments were to be selected which could be used in a subsequent modelling exercise to test the sensitivity of the flood water levels to a range of environmental changes.

Report 3 Flood event data.

Data for each of the ten events were to be obtained from all available sources to include: rainfall, snow cover, river flow and water levels in the lochs and reservoirs. These data were to be presented either in tabular form or in a suitable computer compatible form.

This is the final report for the work carried out by IH and is a compilation of Reports 1, 2 and 3.

Terms of Reference

RIVER TAY CATCHMENT STUDY

DATA COLLECTION FOR HISTORICAL STORM AND FLOOD EVENTS
BY THE INSTITUTE OF HYDROLOGY (SCOTLAND)

1. Objective

1.1 The objective of the work is to provide a data base of precipitation, including any available information on snowfall and snow accumulation, and of gauged flows for ten flood events in the Tay River Basin from which data will be selected for the calibration and verification of hydrological and hydraulic models.

1.2 Separate precipitation estimates are required for around 35 sub-catchments of the Tay and Earn catchments. The sub-catchments are provisionally indicated on Drawing 46769 S-04 and are listed in Tables 1 and 2. Flood flows are required for all available river gauging stations.

1.3 The work comprises three parts;

a) a study to develop a method of estimating hourly storm rainfall over each sub-catchment;

b) a screening study of historical flood events from which ten will be recommended for detailed data collection;

c) the collection of data for the ten agreed events.

2. Spatial storm rainfall estimates

2.1 A study shall be undertaken of the spatial distribution of storm precipitation for selected storm events, using information on the relationships between precipitation and topography obtained from the Balquhiddar catchments and elsewhere as may be available. The output shall be a recommended method best suited in the opinion of the IH(S) for the estimation of hourly storm precipitation for defined sub-catchments of the Tay river basin.

2.2 In so far as the method of estimation of spatial rainfall distribution requires the measurement of catchment characteristics such as elevation, slope and apsect from topographical maps, this shall be undertaken.

2.3 Preference shall be given to methods which allow flexibility in the final selection of sub-catchments. Thus a method which gives estimates of hourly rainfall on a grid square basis is preferable to one which provides only lumped estimates for pre-defined sub-catchments. An indication shall be given of the likely order of uncertainty of the individual sub-catchment hourly and storm total precipitation values when using the recommended method.

2.4 The results of the study shall be presented in a report (Report 1). The method shall be described in sufficient detail to enable the sub-catchment or grid point storm precipitation data eventually presented with Report 3 (see section 4 below) to be checked.

3. Preliminary screening of flood events

3.1 A preliminary screening shall be carried out covering historical flood events, with the aim of selecting the ten events for which detailed data collection will be carried out. The screening shall take account of the following requirements:

a) in general, preference should be given to events for which the maximum amount of precipitation and river flow data is likely to be available, that is generally to the more recent events;

b) the selected events shall include the two major events of January 1993 and February 1990;

c) with model calibration in view, the selected events should aim to include at least two for which water levels were bankfull or above in the flood-prone reaches but not high enough to cause widespread failure of flood banks and flooding of the adjacent land;

d) the selected events should include some for which there is unlikely to have been significant snowmelt contribution;

e) the selected events should include, if possible, one or two from the time before the completion of the Tummel/Garry and Breadalbane hydro-electric schemes.

3.2 The results of the screening shall be presented, with recommendations for the ten events, in a brief report (Report 2). The report shall indicate the broad characteristics of each proposed event, and shall also indicate the number and type of rainfall and the number river gauging stations for which it is believed data will be available. Subject to Ove Arup and Partners' agreement to the ten events recemmended, IH(S) will proceed to the data collection for the events.

4. Data collection for the selected ten flood events

4.1 The data to be collected for each event by the Institute of Hydrology (Scotland) shall include, if available:

a) daily (rain day) rainfall, and any available hourly rainfall totals, covering a period which is sufficient to determine both the total event rainfall and the $API5_d$, from gauges:

(i) within the subcatchments listed in Tables 1 and 2, which make up the whole of Hydrometric Areas 0150 and 0160;

(ii) from any adjacent parts of Hydrometric Areas 0080, 0120, 0132,0141, 0142, 0171, 0180, 0850, 0890, 0901 and 0902 where the gauges are near enough to be of assistance in estimating spatial rainfall over the sub-catchments.

b) estimates of snow cover and of the rate of snow melt for any events for which there are appropriate quantitative or qualitative data from the Balquhiddar catchments, from ski companies, from the Tay River Purification Board or from other sources;

c) flood flow figures at time intervals apropriate for the definition of complete flow hydrographs from all river gauging stations for which such hydrographs are available or can be extracted. The hydrographs shall cover a period of time sufficient for the determination of the quick response runoff as defined in the Flood Studies Report.

d) information on the water levels in lochs and reservoirs within the Tay and Earn river basins during the passage of the flood event. The information shall be confined to the major water bodies which are listed in Table 3.

4.2 The precipitation and river flow data for each event shall be presented in suitable computer-compatible form, the details of which shall be agreed with the firm responsible for the modelling (Binnie and Partners). The precipitation data shall be in the form of hourly sub-catchment precipitation, or of hourly grid square precipitation, or both.

4.3 The original daily and hourly rainfall data, and river flow data shall also be made available to Ove Arup and Partners.

4.4 Any information on snow cover and snow melt, on water levels in lochs and reservoirs, shall be presented in tabular form in a report (Report 3) which shall accompany the precipitation and river flow data.

5. Programme

5.1 Reports and flood event data shall be submitted on or before the following dates, or such other dates as may be agreed in writing:

Report	Subject	Submission date
1	Methodology for estimating sub-catchment precipitation	3 September 1993
2	Flood event screening	19 August 1993
3	Flood event data	30 September 1993

RIVER TAY CATCHMENT STUDY

REPORT 1:

METHODOLOGY FOR ESTIMATING SUB-CATCHMENT RAINFALL

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1 Introduction

The spatial and temporal distributions of rainfall in the River Tay and Earn basins have been studied to develop a methodology for estimating sub-catchment rainfall during storm events. Rainfall is highly variable over large river basins in Scotland and is dominated by orographic effects. The problem is to derive catchment mean rainfall amounts over different time intervals from relatively sparse networks of gauges, usually located in the low altitude areas of the basin. The River Tay catchment study is currently developing a computer model of the runoff response of the catchment and requires rainfall inputs, averaged over each of the 37 sub-catchments, in hourly time increments for 10 historical flood events.

The purpose of the hydrological modelling is to test the sensitivity of flood water depths at critical points in the Tay and Earn catchments to a range of environmental change scenarios. These scenarios include climate change, snow, forestry, land drainage and flood banks. Ten contrasting flood events were selected by the Institute of Hydrology (Black and Johnson, 1993) for use in the study, these were:

30 January	1975
24 August	1985
7 February	1989
5 February	1990
6 March	1990
2 January	1991
2 January	1992
17 January	1993
30 March	1993
17 May	1993

The study area has been divided into 37 sub-catchments on the basis of topography, land use and the presence of river gauging stations, Fig.1. The sub-catchments are divided into six groups determined by the main rivers within the basin: Tay, Earn, Lyon, Tummel, Garry and Isla.

This report is intended to provide details of the proposed methodology for deriving hourly sub-catchment mean rainfall estimates for the 10 selected storm events. Rainfall data are available from gauge sites throughout the Tay basin in monthly, daily and hourly time intervals but cannot be simply applied to the sub-catchments because of the widespread topographic influences on the spatial and temporal distributions of rainfall. A summary of possible methodologies extracted from the literature is given with a discussion on their applicability to the Tay catchment. The recommended method is developed from this and summarised in a series of procedural steps.

2 Available Rainfall Data

In the Tay and Earn river basins monthly, daily and hourly rainfall data were obtained from the Meteorological Office (MO) and the Tay River Purification Board (TRPB) archives. The locations of all gauge sites are shown in Figs. 2 (monthly), 3 (daily) and 4 (hourly). The number of gauges used during this study were:

Monthly gauges:	113
Daily gauges:	71
Hourly gauges:	20 (7 outside the catchment area)

Unfortunately data from all gauge sites in the area were not available for each event; changes have occurred in the networks and some gauge readings rejected during the MO quality control procedure. Although it would be preferable to use the same groups of gauges for each event, the procedure developed here aims to minimise the inaccuracies due to this.

3 Development of Methodology

Throughout the literature the most common analysis of the spatial distribution of rainfall in a catchment is the relationship with altitude. Ballantyne (1983) and Hovind (1965) used annual and storm precipitation totals respectively to demonstrate that windward and leeward slopes have contrasting rainfall - altitude gradients. Harrison (1986) found seasonal differences in the rainfall gradient while Goh Kim Chuan and Lockwood (1974) used both annual and seasonal rainfall totals to show that the altitude factor is better described by a mean altitude within an 8km radius of the gauge. Differences in the rainfall gradient for a range of synoptic situations were found by Smithson (1969) while Sutcliffe (1966) concluded that the rainfall gradient for individual storms can be very different but smoothed out when looking at annual totals. These results are fairly conclusive that topography is a prime control on the distribution of rainfall in mountain areas but there is unlikely to be a simple relationship between rainfall and altitude.

Several methods are available for deriving areal mean rainfall totals from point source measurements. Thiessen (1911) proposed the polygon method where each gauge total is considered to represent an area surrounding the gauge extending to the neighbouring gauges' areas; this method is un-suitable for catchments with high relief. Jones (1983) developed a method which was intended for widespread computer application and so possibly not the most appropriate for individual storms in specific catchments. The method uses neighbouring gauges to estimate the rainfall at grid points and the time distribution but considers the eventuality of variations in raingauge availability. The third possible method is the isohyetal method, a

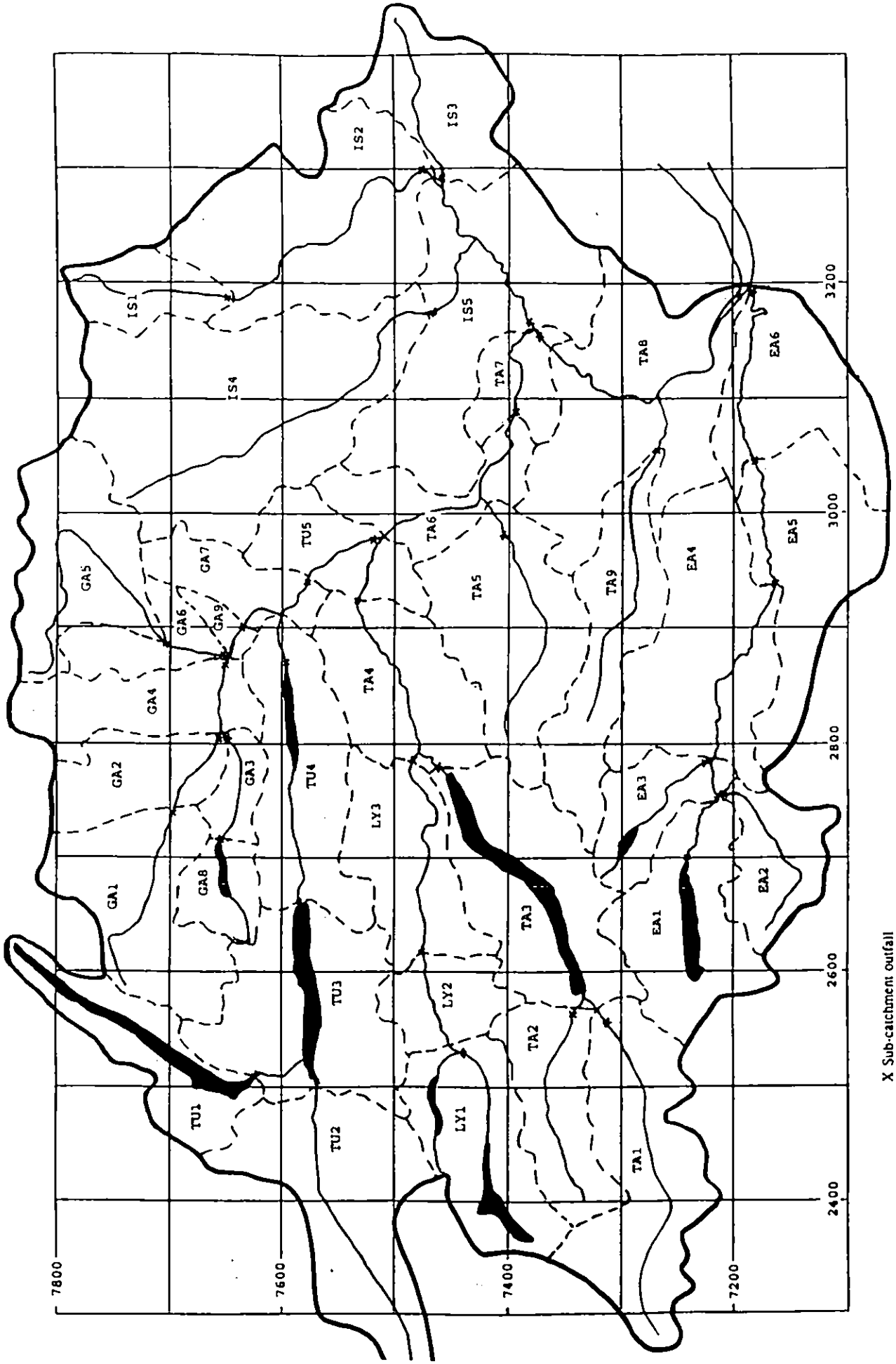

Figure 1 Sub-catchments within the Tay and Earn river basins

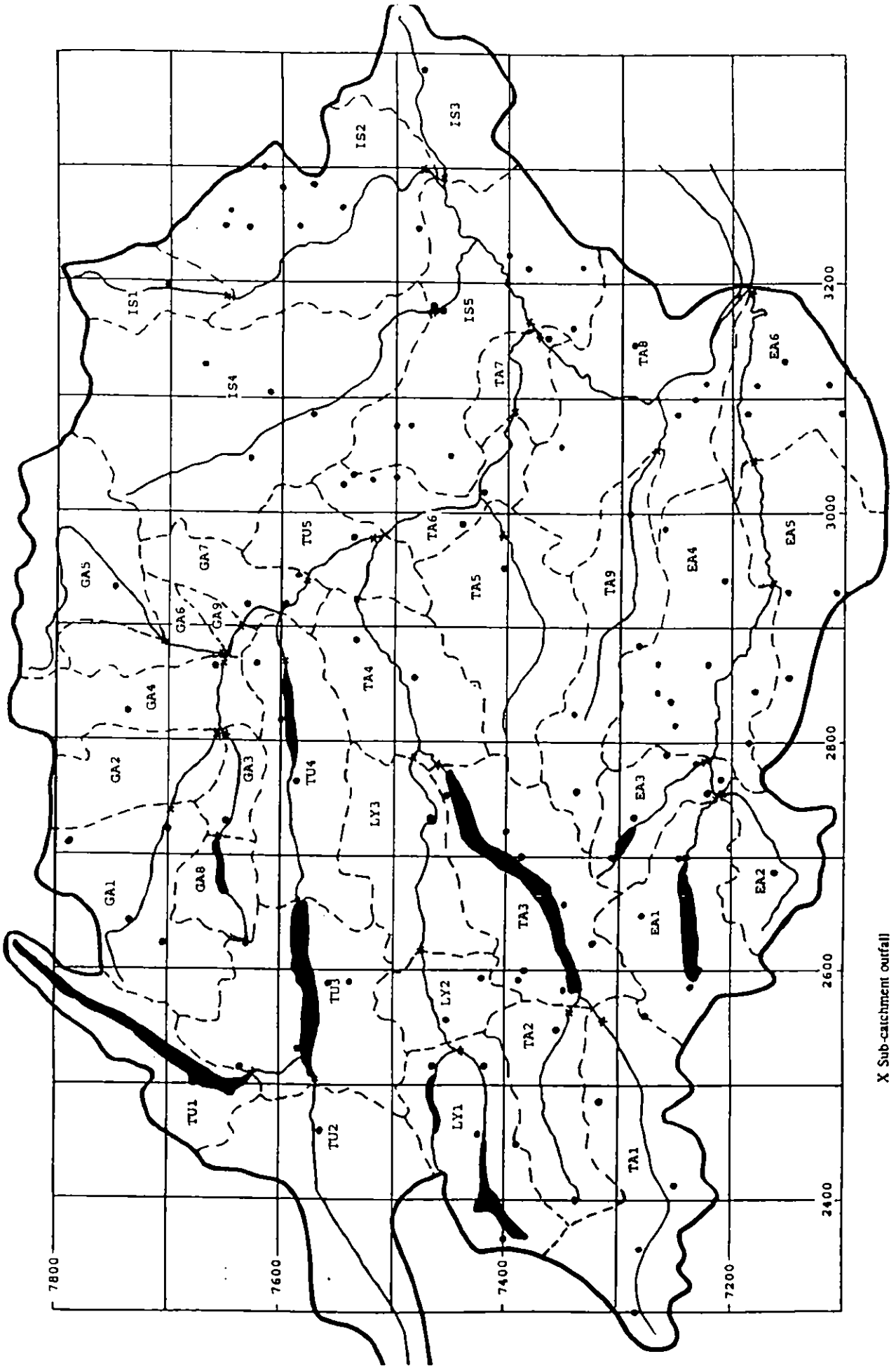

Figure 2 *Location of monthly raingauge sites in the Tay and Earn catchments*

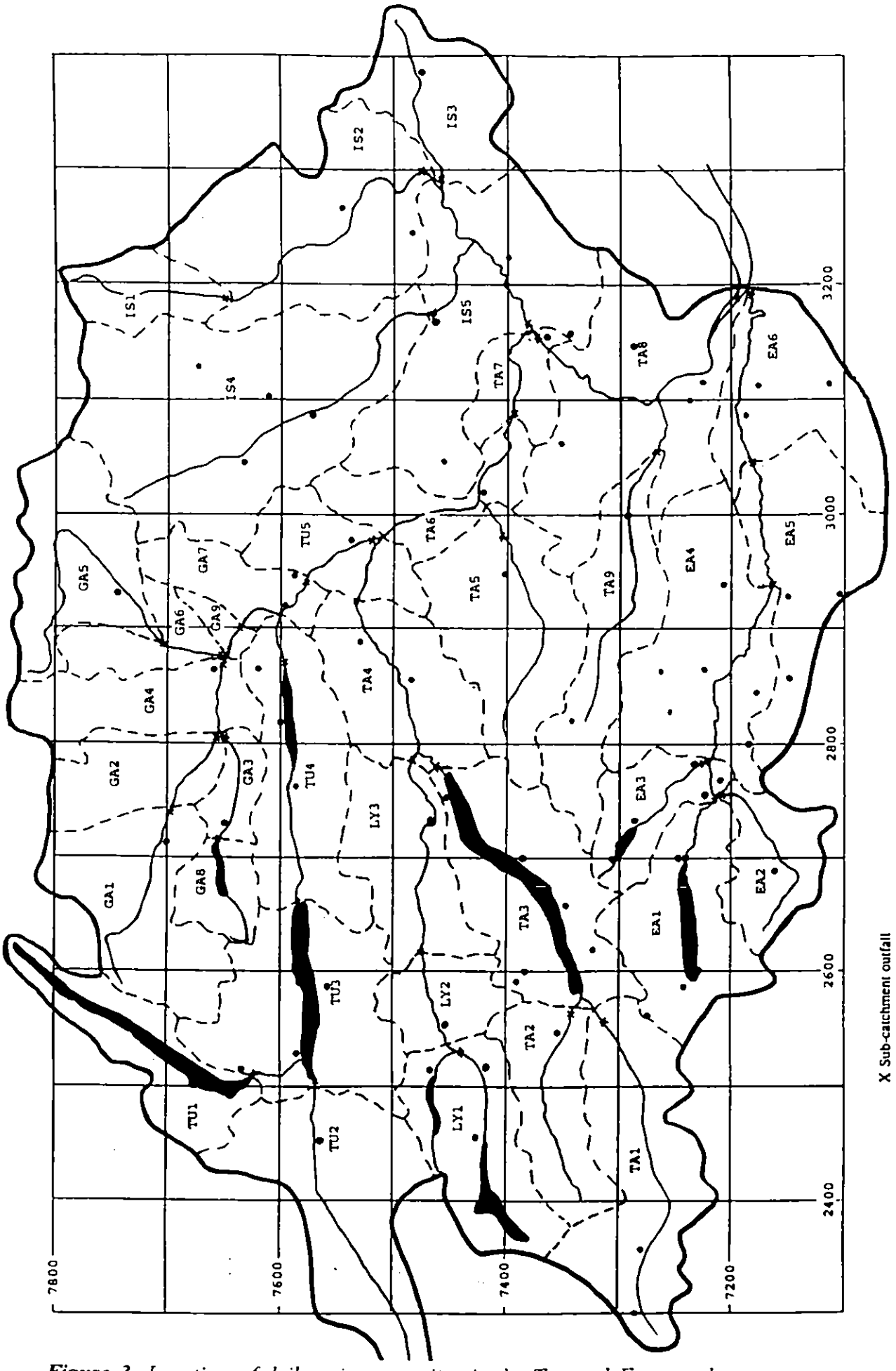

Figure 3 *Location of daily raingauge sites in the Tay and Earn catchments*

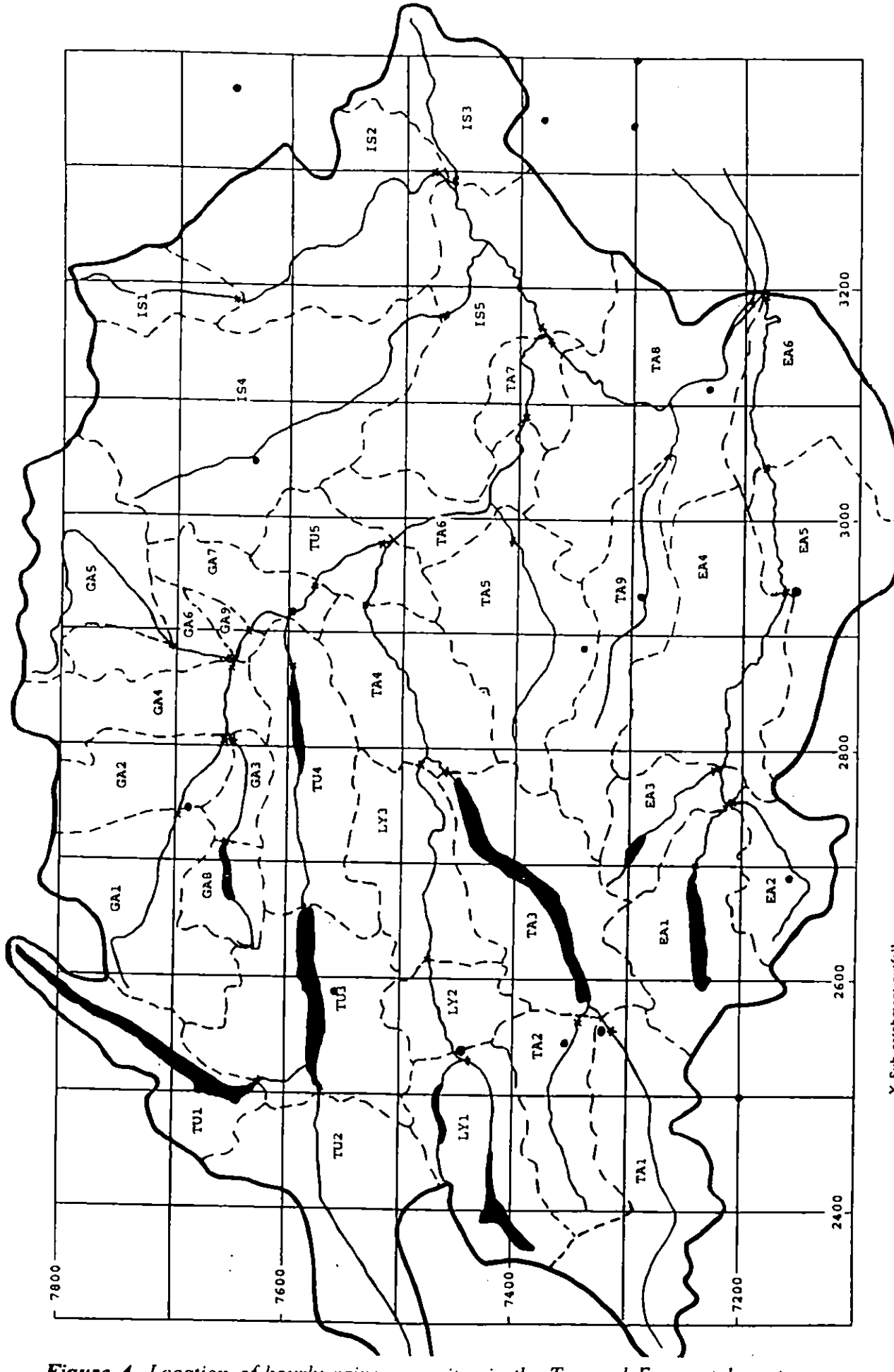

Figure 4 *Location of hourly raingauge sites in the Tay and Earn catchments*

subjective method in which an interpolation is carried out between the lines to determine the rainfall at an ungauged point; being subjective it is a method especially open to a wide range of interpretation in mountain areas.

Most of these methods rely on the relationship between neighbouring gauges but do not consider the extreme situations of sparse gauge networks in areas of rugged topography where the surrounding areas are often considerably different to the relatively ideal site for the raingauge location. It was considered that the above methods were not suitable for the Tay basin and a method should be developed which was based on topography but flexible enough to change for each of the ten storm events. The main problems were considered to be:

- regional variations in rainfall - annual totals of rainfall vary from over 3500mm in the west of the area to some 500mm in the east reflecting the contrasts in regional topography;

- differences between storm events - although the synoptic conditions for the majority of the selected storm events were broadly similar the gauge catches were not;

- variability within individual storm events - rainfall distributions within each event showed significantly different spatial patterns;

- distribution of gauges in sub-catchments - the distribution of gauges between sub-catchment was not uniform, 5 had no monthly read gauges, 6 no daily gauges and 25 no hourly gauges;

- location of gauges in deep valleys or on lower slopes - the medium and high altitude ranges are undersampled.

To overcome these problems a different method has been developed using inter-site relationships, derived from selected raingauges' locations and altitude for each event, and applied to ungauged points in each sub-catchment. The method starts with the rainfall, for the month in which the flood event occurred, from lowland and valley bottom locations and develops the best fit equation relating rainfall to longitude, latitude and altitude. Only lowland and valley sites are used as the aim is to apply the equations to the outfalls from each sub-catchment which are similarly low lying. Due to the complex nature of the spatial distribution of rainfall in each month the area usually has to be split into several zones with the division being determined by a step-wise repetition of the regression analysis. The aim in each relationship is to achieve a coefficient of determination of greater than 0.9. For each event the equation(s) are applied to the site data of the sub-catchment outfalls to derive the estimated monthly rainfall at that location.

The monthly rainfall estimates are time distributed into daily values using the daily rainfall data. Due to the complex relationships between topography and daily rainfall it was considered that the production of daily isohyetal maps would be too

subjective for this study but a more conservative term could be used. The term recommended for use is the percentage of the month's total rainfall which fell on each day. These percentages are plotted on catchment maps and isopleths drawn. An example is shown in Fig.5 which illustrates the results for the 14th January 1993. The most reassuring result from all 10 events was the lack of an apparent link with topography. Therefore even though this method is still open to personal interpretation there are regular regional patterns which emerge. Daily percentages for each sub-catchment outfall are extracted from the maps and applied to the monthly rainfall totals for that location determined in the previous step.

Daily rainfall totals are time distributed into hourly values using the hourly raingauge data. At each hourly raingauge site the percentages of the day's rainfall which fell in each hour are derived. This was found to be an even more conservative factor than the daily percentages and although mapping was tried the use of the nearest gauge(s) was considered appropriate. If possible the average of the closest three gauges should be used for each location. The hourly percentages of the daily rainfall are then applied to the days rain determined in the previous step.

The final step is to apply the hourly time series from each sub-catchment outfall to the remainder of the sub-catchment to derive a mean catchment rainfall. The method of accomplishing this was developed at the Balquhidder research catchments operated by the Institute of Hydrology where networks of automatic weather stations (AWS) have been operating since 1982 (Johnson and Simpson, 1991). For each of the storm events an altitude relationship was developed between the two extreme Balquhidder sites (Tulloch Farm and Kirkton High). This relationship is then applied to a 2x2km grid of locations in each sub-catchment where the altitude had been extracted from the 1:50,000 OS maps. Although this assumes that the Balquhidder relationship can be applied to the whole of the Tay basin there are no other suitable pairs of AWS close to the basin. As the grid has a regular spacing over each sub-catchment the calculation of the areal mean is carried out by an arithmetic mean of all grid point estimates for each hour.

A fundamental result from this study has been to find how, in each individual storm, there are relatively small areas within the basin which have significantly higher rainfall than other areas. For the 10 events selected for this study these areas are always in the higher mountain areas where runoff response is rapid and a high proportion of the rainfall. These centres are therefore likely to be the key generating areas for the flood event and so it is suggested that the rainfall estimates for these mountain areas need to be more precise than the remaining areas where the runoff is a relatively minor contribution to the flood volume.

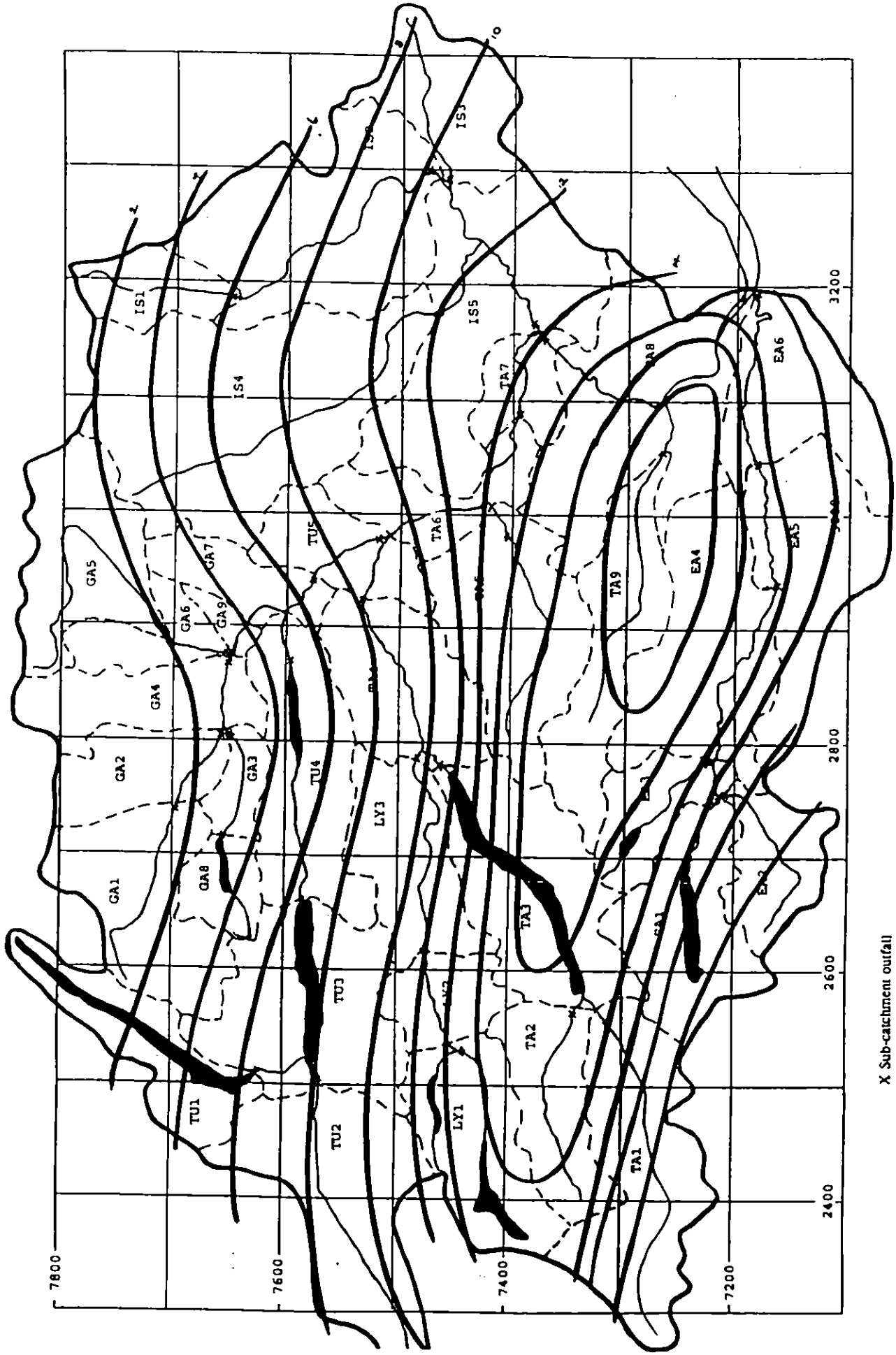

Figure 5 Percentage of the month's rainfall which fell on 14th January 1993

4 Summary of Recommended Methodology

The recommended method of deriving mean sub-catchment hourly rainfall data for the 10 events is summarised below:

a. Derive multiple regression relationships between rainfall and the location and altitude of the gauges for all valley bottom monthly gauges operating during that storm. Location is defined in longitude and latitude coordinates. Apply this relationship to the location and altitude of the sub-catchment outfalls to estimate monthly rainfall at those points;

b. For each valley bottom site with daily rainfall determine the percentage of the monthly rainfall total which fell on that day. Plot these results on a catchment map and draw isopleths. Interpolate between the isopleths to determine the percentage figure at each sub-catchment outfall. Apply this percentage to the monthly rainfall total derived in step (a) to derive a daily rainfall total at those points.

c. For each site with hourly rainfall data transform the 24 hourly values into percentages of the days rainfall which fell in that hour. From each sub-catchment outfall determine the closest hourly rainfall stations (if possible three stations) and derive a mean of the hourly percentages through the 24 hours. Apply this distribution to the day's rain derived in section (b) to derive hourly rainfall at the catchment outfall.

d. Using a 2x2km grid which corresponds to the OS national grid, determine the ground surface altitude at the intersection of each grid line.

e. For each storm event derive a simple mean hourly rainfall-altitude relationship derived from two Balquhidder experimental catchment automatic weather stations. Apply this relationship to the hourly rainfall for each sub-catchment outfall and the altitude of each grid line intersection in each sub-catchment to determine the hourly rainfall at all grid points.

f. Calculate the arithmetic mean of all grid point hourly rainfall values to derive the mean sub-catchment hourly rainfall.

Acknowledgements

The authors are grateful for the assistance given by the Tay River Purification Board, Scottish Hydro Electric and the Meteorological Office in supplying the rainfall data used in this study.

References

Ballantyne,C.K. 1983. Precipitation gradients in Wester Ross, North West Scotland. Weather 38, 379-387.

Black,A.R. & Johnson,R.C. 1993. River Tay Catchment Study: Report 2: Flood Event Screening. Contract Report to Ove Arup and Partners, August 1993.

Goh Kim Chuan & Lockwood,J.G. 1974. An assessment of topographical controls on the distribution of rainfall in the central Pennines. Met. Mag., 103, 275-287.

Harrison,S.J. 1986. Spatial and temporal variations in the precipitation-elevation relationship in the maritime uplands of Scotland. Proc. International symposium on topoclimatology and its applications, March 1985. Presses Universities, University de Liege, 117-133.

Hovind,E.L. 1965. Precipitation distribution around a windy mountain peak. J. Geophysical Research, vol.70, no.14, 3271-3278.

Johnson,R.C. & Simpson,T.K.M. 1991. The automatic weather station network in the Balquhidder catchments, Scotland. Weather, 46, 47-50.

Jones,S.B. 1983. The estimation of catchment average point rainfall profiles. Institute of Hydrology Report no. 87.

Smithson,P.A. 1969. Effects of altitude on rainfall in Scotland. Weather, 24, 370-376.

Sutcliffe,J.V. 1966. The assessment of random errors in areal rainfall estimation. Bulletin of the IASH, 3, 35-42.

Thiessen,A.H. 1911. Precipitation for large areas. Monthly weather review, 39, 1082-1084.

RIVER TAY CATCHMENT STUDY:

REPORT 2:

FLOOD EVENT SCREENING

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1 Introduction

This report is prepared under contract to Ove Arup and Partners as part of the River Tay Catchment Study commissioned by Tayside Regional Council. It makes recommendations for the selection of ten flood events to be used in modelling the hydrological and hydraulic behaviour of the Tay and Earn catchments. A description is given of the meteorological and hydrological characteristics of each event. Methods used in selecting the events are outlined, and the rainfall and flow data thought to be available for each event are indicated. Finally, a brief summary is given demonstrating the strengths of the data set recommended and its suitability for the modelling studies to which it is to be put.

2 Methodology

Event selection was governed by the five requirements set out in the terms of reference, namely that preference should be given to those events with the most data available; that the major events of February 1990 and January 1993 should be included; that at least two events should be included in which levels reached bank-full in vulnerable reaches without causing widespread flooding; that some events selected should have little or no snowmelt contribution; and that, if possible, one or two events should pre-date completion of the Tummel/Garry and Breadalbane hydro-electric schemes. In seeking to identify a suitable set of events, reference was made to the Institute of Hydrology's National River Flow Archive, in which monthly maximum instantaneous flows are recorded for each gauging station available. Complete listings of these values were obtained, and used to produce a list of varied floods conforming to the requirements set.

Peak values were sorted in order to identify the largest few events at each station. It was first ensured that all large floods in the downstream section of the Tay were included in the data set. Beyond the required major floods of February 1990 and January 1993 it was felt important that the 30 January 1974 event should also be included, as its peak is far greater than any of the remaining others, and can therefore be regarded as a useful additional moderately large event. Beyond these three events, there are many others recording peaks of over 1000 m^3/s at Caputh gauging station and/or 1100 m^3/s at Ballathie. It was therefore decided to focus attention on other criteria.

It was felt important to identify events where no snowmelt contribution to runoff was present. The lack of comprehensive snow cover data available suggested that use of summer events was the only sure means of identifying snowmelt-free events.

However, Weather Log (Royal Meteorological Society) and newspaper weather reports were checked as a means of verification. Use of summer events enhances the data set by virtue of the fact that summer rainfall has rather different spatial and temporal characteristics to that in winter, and such storms are known to be capable of producing high levels in Perth - the flood of 29 August 1910 has a level of 5.61 m OD recorded on Smeaton's Bridge. The flood of 24 August 1985 was selected on the basis of producing the second largest flood peak on record at Wester Cardean, the largest being the January 1993 event, and a modest peak at Ballathie. The flood of 17 May 1993 was also selected as it is known to have only a small snowmelt contribution, and also produced a modest peak at Ballathie, but with the maximum number of gauging station records.

Bearing in mind the ultimate purpose of the event data for modelling studies, no event predating completion of the Tummel/Garry and Breadalbane hydro-electric schemes is recommended for inclusion because of the scarcity of data from that period. Even by 1958, by which time most of the Tummel/Garry scheme was complete and in operation, only eleven flow gauges had been established, including four in the headwaters of the Isla sub-catchment. Moreover the raingauge network in the 1950s is rather sparse, particularly in relation to autographic gauges, so the catchment rainfall estimates which could be produced would be subject to a very large error. Prior to 1954 hourly data are known to be available only from Leuchars Met Office site (outside the catchment), and even that is of limited utility owing to its location; in 1954 and 1955 records begin at Mylnefield (also outwith the catchment) and Lochay Power Station respectively. The value of collecting data from this period is thought to be of extremely limited value, and would do nothing to help determine the effect of the hydro-electric schemes on the runoff response of the catchments.

Notwithstanding the above, if an event for the 'pre-hydro' period is to be used, that of 5 November 1951 is recommended, as it achieved a high peak of 1850 m^3/s at Ballathie (Tay RPB estimate). The peak of 17 February 1950 is slightly higher at Ballathie (TRPB estimate of 1890 m^3/s) and provides the added benefit of a peak level for Loch Tay, but unlike the 1951 event there is no hydrograph available from Caputh. There is no hydrograph available at Ballathie for either of these events.

The remaining events listed in the following section all derive from the recent period, 1989-1993, and as such offer a much larger amount of data both in terms of rainfall and runoff. While the range of peak values at Ballathie is quite restricted, 944 - 1171 m^3/s, it will be seen that these events differ both in their synoptic origins and hydrological characteristics. Combining these lesser floods with the two major events of 1990 and 1993 where, particularly in the latter case the great majority of rivers in the two basins were at or near their highest levels in 40 years, it is ensured that for all parts of the river network, a wide range of high flows are included in the data set - generally from levels of historic note to levels which caused little overbank inundation.

3 Recommended events

The ten recommended events are listed in chronological order, with notes on their meteorological and hydrological characteristics. The numbers of flow and rainfall stations indicated are based on known periods of record for each station; they do not take into account gaps which may exist in records so the actual numbers of stations available may be slightly less than those shown in some cases. Conversely, it may be possible to obtain data from sources as yet not positively identified, in which case additional data may be provided for some events. Raingauges have been located by reference to the Meteorological Office Rainmaster catalogue of gauges, through discussion with Tay River Purification Board staff, and with those in other boards in adjacent areas. Comprehensive data from the Institute of Hydrology's experimental sites at Balquhidder are available for the events listed from 1985. Numbers of daily read raingauges include those read only 5 or 6 times per week, of limited use for events which occurred at week-ends.

30 January 1974

A moderately large peak on the lower Tay (1570 m^3/s at Ballathie), with a large input from the Isla such that the Ballathie peak was substantially larger than that at Caputh (1193 m^3/s). The flood followed another peak, slightly smaller in the lower Tay, on the 18th which caused floodplain inundation in many parts of the catchments, and was thus partly attributable to very wet antecedent conditions.

Flow stations		15
Rainfall stations	- hourly	3
	- daily	+52
	- monthly	+55

24 August 1985

Notable peak on River Isla (150 m^3/s, exceeded only by January 1993 peak of 159 m^3/s in a record commencing in 1972), though rather less exceptional in other parts of the catchments. The flood was preceded by peaks on the 14th/16th at least in the western areas. The peak flow recorded at Ballathie was 740 m^3/s; there was definitely no snowmelt component.

Flow stations		16
Rainfall stations	- hourly	7
	- daily	+48
	- monthly	+46

7 February 1989

A moderate flood on the lower Tay with the great bulk of the runoff originating in the north-west part of the area. Pitnacree and Port-na-Craig peaks were broadly similar (544 and 676 m^3/s respectively), but both were well below maxima recorded in 1993. In the lower river, inflows from the Braan and Almond are both known to have been relatively low, as well as the Isla; the peak at Ballathie (1168 m^3/s) was measured to be 3 m^3/s less than that at Caputh.

Flow stations		18
Rainfall stations	- hourly	7
	- daily	+44
	- monthly	+44

5 February 1990

A major flood in many parts of both the Tay and Earn catchments, resulting from a combination of snowmelt and heavy rainfall. Flows in the upper part of the Tay sub-catchment marginally exceed those recorded in January 1993. The peaks generated in the rivers Tummel and Tay were coincident as they met at Logierait, producing a very large flood wave to travel down the lower river. However runoff from the Isla sub-catchment, peaking ahead of the main wave, was modest and there are reports not only of the Isla backing up, but also of water from the Tay actually flowing upstream in the Isla. Major floodplain inundation occurred and, despite the magnitude of the flood wave, produced significant attenuation. It was the largest recorded event on the Earn at the time (both Forteviot Bridge and Kinkell Bridge gauging stations), subsequently eclipsed by the 1993 event.

Flow stations		19
Rainfall stations	- hourly	6
	- daily	+46
	- monthly	+44

6 March 1990

A broadly similar event to that of February 1989, but slightly smaller, following just a month after the major February flood which caused much floodplain inundation and damage to flood banks, and with a rise in peak discharge between Caputh and Ballathie (1014 to 1101 m^3/s). Very modest response on the Earn (Forteviot Bridge peak 132 m^3/s) and in the lower/eastern tributaries of the Tay.

Flow stations		19
Rainfall stations	- hourly	6
	- daily	+46
	- monthly	+44

2 January 1991

Another modest peak in the lower Tay (1042 m^3/s at Ballathie and only 744 m^3/s at Caputh), but deriving much more of its flow from its lower tributaries than others. Peaks in some headwater rivers, eg Lyon and Dochart, were quite modest (223 and 211 m^3/s at Comrie Bridge and Killin respectively) but more significant contributions accrued from small, lower tributaries, eg 121 m^3/s at Hermitage and 125 m^3/s at Almondbank. A moderately large peak of 201 m^3/s was recorded on the Earn at Kinkell Bridge. More than 250 sheep were lost in various parts of Perthshire, including the Earn and Isla valleys, so considerable floodplain inundation must have occurred.

Flow stations		26
Rainfall stations	- hourly	9
	- daily	+46
	- monthly	+44

2 January 1992

This is the smallest winter peak amongst the ten selected events, registering 944 m^3/s at Ballathie. Moderately heavy rainfall over a 24-hour period in western areas combined with some snowmelt. Out-of bank flooding was reported in the lower Tummel below Pitlochry and on the Tay between Kenmore and Dalguise. However, there were only modest contributions from the lower Tay tributaries, including the Isla

Flow stations		28
Rainfall stations	- hourly	10
	- daily	+44
	- monthly	+43

17 January 1993

This major event is thought to be the largest flood on the Tay at Perth since 1814, and was also very large on the Earn. Major inundation occurred in Perth, Bridge of Earn and, to a lesser extent, other settlements in both catchments as well as further afield. An estimated 66 km^2 of inundation occurred in the two catchments combined. An exceptionally deep snowpack had accumulated, even at low altitudes, when two fronts crossed the area, causing a significant rise in temperature and heavy rainfall. Rivers throughout the area reached extreme levels, and the coincidence of peaks on the Tay system, including a major peak from the Isla, caused a huge flood estimated at 2269 m^3/s at Ballathie to pass through Perth causing widespread damage. The Earn peak was 358 m^3/s at Kinkell Bridge.

Flow stations		28
Rainfall stations	- hourly	11
	- daily	+44
	- monthly	+43

30 March 1993

Snow showers several days before the 17th may have been responsible for a minor snowmelt component to this flood, but most runoff must have originated from rainfall. Rain seems to have been heavy only in the west of the Tay and Earn catchments, with very low totals in the east of the Tay being recorded. High flow peaks therefore occurred only in western tributaries: the peak at Ballathie was 1106 m^3/s.

Flow stations		28
Rainfall stations	- hourly	11
	- daily	+44
	- monthly	+43

17 May 1993

Another flood following snowfall after a few days, but again believed to have little snowmelt in the flow peak. Rainfall appears to have been heaviest in the south-west part of the two catchments, and very light in the east. The peak of 820 m^3/s achieved at Ballathie is the second smallest of the ten recommended events, and adds diversity to the data set as a whole. Again, little runoff was received from the eastern side of the Tay catchment. The moderate Kinkell Bridge peak of 151 m^3/s is almost identical to that of the March 1993 flood.

Flow stations		28
Rainfall stations	- hourly	11
	- daily	+44
	- monthly	+43

4 Summary

The ten events listed above incorporate a great diversity of characteristics and are recommended as the optimal set for the modelling work required. They include the two major events of February 1990 and January 1993 which caused the most widespread floodplain inundation and damage in the Tay and Earn catchments. Two

events, 24 August 1985 and 17 May 1993, are included from the summer half-year in order to guarantee no significant snowmelt contribution, and serve a secondary role in providing the overall data set with events which were quite modest in the downstream reaches of the two main rivers.

All but two of the events date from the five years since 1989 and are thus rich in data; indeed three are from 1993 at which time there is the maximum amount of river flow data available. Though the number of daily and monthly read raingauges in recent years has been slightly less than in 1974, this is more than adequately compensated for by the increase in numbers of hourly raingauges and river gauging stations. The events identified have differing spatial characteristics, such that some registered particularly high flows in some sub-catchments where others did not, also temporal differences in runoff ensure that there are differences in the flood routing of the events. These differences, and the inclusion of two relatively small summer floods, ensure that the overall data set includes events where peak levels are not particularly high (and inundation is limited) throughout the two catchments. No event is recommended for the pre-hydroelectric period as it is felt that the rainfall estimation, attempted flood routing and subsequent model calibration using such an event would be subject to very large errors as a result of the limited data available from the period.

Having considered all major floods in the period of instrumental records, it is recommended that the ten set out above are adopted on the basis of the selection criteria for the modelling work proposed.

5 Acknowledgements

The Tay River Purification Board is gratefully thanked for cooperation in providing details of data availability and much further information covering many other aspects of flooding in its area. Additional assistance in identifying sources of rainfall data was provided by the Meteorological Office in Edinburgh.

RIVER TAY CATCHMENT STUDY

REPORT 3:

FLOOD EVENT DATA

by

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1 Introduction

This report is the third in a series of three reports by the Institute of Hydrology to Ove Arup and Partners for the Tay Catchment Study. Report 3 presents all available data for the ten flood events selected in Report 2. The data are in four sections:

- Rainfall — daily and hourly measured rainfall and the hourly sub-catchment totals derived using the methodology developed in Report 1;
- Snow — depths of snow and rates of melt;
- Flow — hourly flow data;
- Water levels — loch and reservoir water levels.

2. Rainfall data

Rainfall data have been obtained from the Meteorological Office, Tay River Purification Board, Scottish Hydro Electric plc and the Institute of Hydrology. Data are available in three time series: monthly, daily and hourly. The rainfall stations in operation vary for each of the ten events, details of the availability of rainfall data and the stations' locations and altitudes are shown in Appendix 1.

The objective of this work was to derive hourly mean rainfall for each of the 37 sub-catchments in the Tay and Earn river basins. Physical details of each sub-catchment are shown in Appendix 2.

2.1 MONTHLY DATA

The rainfall data for the month in which each flood event occurred are used to develop intersite relationships for each event, Appendix 3, using the three site parameters altitude, longitude and latitude for each station. The relationships are applied to each sub-catchment outfall to derive the monthly rainfall totals shown in Appendix 4.

2.2 DAILY DATA

Daily rainfall data for the day of each event and, where possible, the preceding and following days are shown in Appendix 5. The proportion of the months rainfall which fell on each of these days was calculated and used to derive the daily rainfall totals for each sub-catchment outfall, Appendix 6.

2.3 HOURLY DATA

Relatively few hourly rainfall stations exist in comparison to the monthly and daily gauges. Data from these stations was used to time distribute the daily rainfall totals for each sub-catchment outfall into an hourly time series. The variation of hourly rainfall intensity over each sub-catchment is the final step and this was achieved by using a relationship developed from the intense network of hourly raingauges in the Balquhidder research catchments, operated by the Institute of Hydrology. The relationship could only be a simple gradient of intensity with altitude and when applied to the 2x2km network of spot altitudes in each sub-catchment was found to make very little difference, usually less than 10%. The hourly mean sub-catchment rainfall for the events were supplied to Ove Arup and Partners on computer diskette.

3. Snow data

Information on the depth and extent of snow was obtained from the Meteorological Office and ski companies and is presented in three parts.

3.1 SNOW DEPTH

Snow depth measurements are routinely made at Meteorological Office climatological stations at 0900 GMT. Observers complete returns to the Meteorological Office and the data thus compiled can then be supplied to other organisations.

Data were obtained for the eight events for which a snowmelt contribution to runoff was thought to be possible. These depths are tabulated in Appendix 7. For the first five of these eight events, no differentiation was made between zero depth and missing values (both are denoted by blanks unless no data were available for the whole of the period requested), but missing data are understood to be rare, and reference to data from other sites still enables a general picture of the snow characteristics of each event to be obtained. The appendix shows a marked contrast between the great snow depths involved in the events of January 1993 and to a

lesser extent January 1991 and the other events in which there was little snow at the climatological stations prior to the floods. The altitudes and grid references of these stations are given below in Table 1.

Table 1 *Climatological stations recording snow depth data*

Station	Easting	Northing	Altitude (m AMSL)
Dalwhinnie	2639	7855	351
Perth Aerodrome	3155	7280	118
Strathallan School	3090	7185	41
Drummond Castle	2841	7177	113
Dall, Rannoch School	2593	7562	232
Faskally	2918	7599	94
Ardtalnaig	2702	7394	130
Kindrogan	3054	7629	259
Loch Venachar	2598	7063	84
Aberfoyle	2530	7004	28

3.2 SNOWLINE OBSERVATIONS

The Meteorological Office annual publication Snow Survey of Great Britain (Meteorological Office 1975 *et seq*) tabulates a range of indices of snow depth and snow cover at a network of sites across Great Britain, as well as giving a textual commentary on the conditions encountered in each winter month. Figure 2 of these publications is of particular interest in the context of this study, showing the height each day of the snow line at a number of near-mountain stations. Data extracted from this figure are presented in Appendix 8 for three stations within or adjacent to the Tay catchment, the details of these being given in table 2. The reader is referred to these Meteorological Office publications for further information on snow cover and depths.

Table 2 *Snow survey or climatological stations with snowline altitude data*

Station	**Mountain**	**Alt. range (m)**	**Grid Reference**
Fersit	Creag Meagaidh	259-1130	NN351782
Loch Arklet	Ben Vane	146-916	NN376096
Ardtalnaig	Ben Lawers	130-1214	NN702394

3.3 INFORMATION FROM SKI COMPANIES

White Corries Limited, operator of the Glencoe ski area, and Cairngorm Chairlift Company, operator of the Cairngorm ski area, both provided information on snow depths and weather conditions for their respective areas. In both cases, copies of log sheets were provided and these are presented in Appendix 9. Providing information from just beyond the north-west and north-east extremes of the Tay catchment, these logs provide a useful supplement to the quantitative rainfall and snow data described in the preceding sections. Changes in the weather can also be understood from the logs in more qualitative terms than would otherwise be the case. Neither record covers all ten of the events identified for the purposes of this study.

4 River flow data

All river gauging station data supplied with this report were collected by the Tay River Purification Board (TRPB). In late 1990 the Board commissioned a new hydrological data management system, HYDROLOG, for the routine storage and processing of all stage, flow, rating and rainfall data. River flow data for all events from January 1991 have therefore been extracted directly from this system, along with stage data for a few stations for which flows are not routinely computed. This latter group of stations comprises those where tidal effects preclude the derivation of a stage-discharge calibration, along with some flood warning stations where channel conditions and/or the lack of a cableway prevent discharges being estimated at anything other than low flows.

Prior to 1991, the majority of stage data was recorded on charts, with flow data being derived after digitising and the application of an appropriate rating. However, only daily mean and peak instantaneous flows were routinely archived, making it necessary to re-digitise charts in order to obtain flow hydrographs for the events of interest in this study. This was a very laborious process, undertaken by TRPB, the data obtained again being stored, processed , and output by the HYDROLOG system. Charts from 10 stations had already been digitised by the Institute of Hydrology for the February 1990 flood as part of an earlier study (Houghton-Carr and Boorman, 1993); these data were made available for this study.

For each event, data are given from the recession prior to the event of interest until the river is clearly in recession after it. Often there are a number of peaks within the period covered, corresponding to series of rainstorms which often characterise periods of major flooding on the Tay. Typically two to three weeks of data are presented.

The gauging stations for which data are presented are listed in Appendix 10, giving details of the station number, river, name and national grid reference of each. Appendix 11 then shows the stations for which data have been obtained for each event. In a few cases, records are not continuous throughout the period of interest.

The output from HYDROLOG is not suitable for entry to spreadsheet software packages, and to cater for this the files have been reformatted using a purpose-written program HlogFlow, to give a vertical, comma-delimited format which is suitable for spreadsheet use. These files are provided on two floppy disks accompanying this report and, as ASCII text, can be read with any normal text editor. The data are all at hourly intervals, with the first line of each file giving the measurement units, filename (derived from station number) and name. A separate file is provided for each gauging station, the files for each flood being grouped within directories named by the flood date. Table 3 shows a typical page of output.

5. Reservoir level data

5.1 SCOTTISH HYDRO ELECTRIC PLC

Reservoir level data were obtained with the assistance of Scottish Hydro-Electric plc from their Tummel Valley and Breadalbane control centre logs. These are maintained for operational rather than archiving purposes, and it was for this reason that some of the logs relating to flood periods could not be found. Most of the information recorded in the logs relates to power generation at and within each of the power stations in the groups, but hydraulic information is vital to the efficient operation of the schemes, so for this reason reservoir level data are recorded. At least one level reading per day is normally taken for each reservoir, and levels for most are routinely recorded on a more frequent basis. However, this has been done more consistently in the past for the main Tummel scheme reservoirs than for those in the Breadalbane scheme, and there are still some reservoirs today for which only daily values are made. Appendix 12 shows the information obtained for each reservoir.

For those reservoirs for which provision is made for several level observations to be made per day, the frequency of recording is highly variable. A higher frequency of logging is generally maintained during periods of flooding, reflecting more rapid level changes, but the demands on control engineers can result in less information being recorded than might be desirable for the purposes of a historical study such as this. While it was regarded as ideal that levels should be extracted at regular time intervals through each event, this irregular recording regime sometimes results in this being impossible; in such cases, all

Table 3 *Sample output from HlogFlow: Station 15007 Tay at Pitnacree, January 1991 event.*

m3/s ,015007.lis,Pitnacree	First line of output:
01/01/91, 9:00, 97.309	measurement unit, filename,
01/01/91,10:00, 96.614	station
01/01/91,11:00, 96.475	
01/01/91,12:00, 96.614	
01/01/91,13:00, 96.614	All subsequent lines: date
01/01/91,14:00, 96.891	(mm/dd/yy), time, value in
01/01/91,15:00, 96.753	units specified above
01/01/91,16:00, 98.425	
01/01/91,17:00, 103.954	
01/01/91,18:00, 116.536	
01/01/91,19:00, 136.510	
01/01/91,20:00, 167.859	
01/01/91,21:00, 217.029	
01/01/91,22:00, 257.837	
01/01/91,23:00, 286.451	
01/01/91, 0:00, 317.202	
01/01/91, 1:00, 340.184	
01/01/91, 2:00, 358.419	
01/01/91, 3:00, 368.124	
01/01/91, 4:00, 376.749	
01/01/91, 5:00, 388.041	
01/01/91, 6:00, 393.969	
01/01/91, 7:00, 398.733	
01/01/91, 8:00, 399.689	
01/02/91, 9:00, 397.779	
01/02/91,10:00, 392.781	
01/02/91,11:00, 385.915	
01/02/91,12:00, 373.711	
01/02/91,13:00, 361.644	
01/02/91,14:00, 338.154	
01/02/91,15:00, 318.967	
01/02/91,16:00, 304.075	
01/02/91,17:00, 290.288	
01/02/91,18:00, 281.363	
01/02/91,19:00, 271.700	
01/02/91,20:00, 264.840	
01/02/91,21:00, 257.018	
01/02/91,22:00, 253.341	
01/02/91,23:00, 246.649	
01/02/91, 0:00, 243.828	
01/02/91, 1:00, 237.823	
01/02/91, 2:00, 235.039	
01/02/91, 3:00, 231.871	
01/02/91, 4:00, 228.521	

data have been extracted for whatever times were available. Where values for the 3- or 6-hourly time intervals typically used were not available, simple linear interpolation has been employed in periods of steady or steadily changing levels to provide the data required; however this was not done in periods when a flood wave was passing through a reservoir, as the hydraulic behaviour of the system could not be confidently predicted.

Levels shown on the log sheets are derived in a number of ways. Most direct of these is a visual level observation by an engineer at the dam, which is then passed on to the control centre. At other times, levels can be found from the control centre displays showing pressure transducer readings of water depth. Prior to updating control centre displays, these instruments were interrogated with the use of tele-talk devices. Both types of value are presented in the appendices of this report, but inconsistencies arise as a result of pressure transducers wandering from their correct values. Actual (dam) values are therefore shown in bold in the tables for sub-daily data, with the remaining majority being based on pressure transducer data; in the tables for daily data the values are assumed to be for dam observations or 'good estimates' based on known transducer errors, unless shown in italics, used to indicate an uncorroborated transducer reading.

The times of daily observations are not exactly known although the observer making dam readings normally follows a set routine. Table 4 shows typical observation times at dams of the two hydro systems based on present practices. The suitability of applying these times to early event data, particularly 1974, is unknown.

Data recorded on the log sheets are in various units, reflecting changes in technology used and operating practices. At installation, pressure transducers were calibrated either in feet and inches above Ordnance Datum (OD) or feet and tenths above OD. These units are translated directly onto the log sheets without conversion. More recently, logging has been switched to metres above or below dam spill level, adding a third measurement unit, and some log sheets show metric and imperial units together. To avoid confusion, all data were converted to metres OD as they were extracted from the log sheets. However, it is likely that the mixture of units has led to some minor errors in those presented, particularly as some older sheets appear to show levels at some reservoirs both in feet and inches and feet and tenths within the same day. The maximum error likely to arise from this type of error is 45.7mm. Transcription errors, such as reservoir levels changing by tens or hundreds of feet in an hour, have been corrected wherever apparent.

A final point in relation to the log sheets is that gate openings at Kinloch Rannoch, controlling flow into Dunalastair Water, are normally recorded in the Loch Rannoch column. These data have been included with the level data presented here, copied in the form a x b, where a gives the number of gates opened and b their opening in the units given. A travel time of 1 - 1.5 hours between Kinloch Rannoch and Dunalastair Dam is normal for the water thus transferred.

All level data is presented on floppy disk in Lotus 1-2-3 .WK3 files, complete with italicised/emboldened values where appropriate. Daily data are in files

TV_DAILY.WK3 and BR_DAILY.WK3 and are also given in paper form as Appendix 13. Sub-daily data constitute Appendix 14 and are too voluminous to print. These files are labelled *MMYYSS*HR.WK3 where *MM* and *YY* denote the month and year of the flood respectively, and *SS* denotes the scheme, either TV (Tummel Valley) or BR (Breadalbane).

Table 4 *Typical times of manual reservoir level readings 1993*

Tummel Valley scheme	
Tummel	0900
Faskally	0900
Eigheach	0900
Ericht	1100
(others varied)	
Breadalbane scheme	
Lednock	0900
Earn	1000
Lyon	1000
Stronuich	1030
Lairige	1100
Breachlaich	1100
Daimh	1130

5.2 TAYSIDE REGIONAL COUNCIL

Tayside Regional Council operates the Backwater and Lintrathen Reservoirs in the hills north of Alyth. Observations of reservoir level are taken daily by the Council and have been provided for inclusion in Appendix 13 of this report. The top water levels of the reservoirs are 37.0m and 7.67m respectively, measured against local datum levels; all values are expressed in metres. Data are held in file TR_DAILY.WK3.

References

Meteorological Office. 1975 ... *Snow Survey of Great Britain*, Meteorological Office: Bracknell.

Houghton-Carr,H.A. & Boorman,D.B. 1993. The Flood of February 1990 on the Tay River System, Perthshire. Report to MAFF.

Acknowledgements

This report, with its supporting appendices on disk and paper, is the end product of a large amount of cooperation between many individuals and organisations throughout the Tayside area and the authors. It is therefore important to gratefully acknowledge their help, without which scarcely any of these data could have been collected.

The Tay River Purification Board has been involved in a large amount of work digitising chart records and collating computer data, so special thanks are due to all staff of the hydrology department at TRPB. Beyond their specific help in relation to compiling data for this report, John Anderson and his team have enthusiastically provided a great amount of information about floods and the general characteristics of the Tay and Earn basins since the events which prompted the commissioning of this study.

At Scottish Hydro-Electric plc David Lee, Peter Donaldson and James Clark have all been very helpful in making daily control log sheets available, and interpreting their contents. Sandra Macintyre and Neil Baxter of White Corries Ltd and Cairngorm Chairlift Co Ltd respectively have both assisted with the provision of snow and other meteorological data, and at Tayside Regional Council Water Services Dept, Alec Rae and Mr McRobbie have been helpful in providing reservoir level, rainfall and runoff data collected in relation to the council's water supply undertakings. Many thanks to all of these.

Many thanks, too, to all those others within IH and beyond who have assisted the authors in bringing together all the data used in the preparation of this report.

APPENDIX 1

Availability of rainfall data for each storm event

M = Monthly data available
D = Daily data available
H = Hourly data available

	Storm events									
Station	74	85	89	2/90	3/90	91	92	1/93	3/93	5/93
852069	-	-	-	-	-	H	H	-	-	-
855xxx	-	-	-	-	-	-	H	H	H	H
(Gella Bridge, NO372653)										
857789	-	-	-	-	-	-	H	H	H	H
858300	M	M	M	M	M	M	M	M	M	-
858310	M	M	M	M	M	M	M	M	M	-
858673	H	H	-	-	-	-	-	-	-	-
859312	-	-	-	H	H	H	-	H	-	-
859814	D	M	M	MD	MD	M	D	-	MD	MD
860007	-	-	-	-	-	-	MD	MD	MD	MD
860141	M	M	M	M	M	M	M	M	M	M
860481	M	M	M	M	M	M	-	-	M	M
860623	MD	M	M	M	MD	M	D	-	M	MD
860733	-	M	M	M	M	-	-	M	M	M
860882	M	M	M	M	M	-	-	M	M	M
861125	D	MH	MD	H	D	MH	DH	M	M	MD
861xxx	-	-	-	-	-	-	-	H	H	H
(Killin, NN564320)										
861244	M	M	M	M	M	-	D	M	M	MD
861305	M	M	M	M	MD	M	D	M	M	MD
861356	-	M	M	-	-	-	D	M	M	MD
861364	M	M	M	-	D	M	D	M	M	MD
861538	-	-	-	-	-	-	MD	M	M	MD
861812	MD	M	MD	MD	MD	M	M	MD	MD	MD
861824	M	M	M	M	M	M	M	M	M	M
862053	MD	M	M	M	MD	M	MD	M	MD	M
862169	M	M	M	M	M	M	-	M	M	M
862411	MD	M	M	M	M	M	-	M	M	MD
862523	M	M	M	M	M	-	D	M	M	MD
862675	M	M	M	M	M	-	-	M	M	MD
862xxx	-	-	-	-	-	-	H	H	H	H
(Moar, NN535451)										
862984	-	-	M	M	M	M	-	M	M	M
863336	MD	MD	M	MD	MD	M	-	-	-	-
863911	M	M	M	M	M	M	MD	-	MD	-
865046	M	M	M	M	M	M	D	-	M	-
865921	M	M	M	M	M	M	D	-	M	M

866079	MD	M	M	M	MD	M	D	-	MD	M
866475	MD	MD	MDH	MDH	MDH	MH	MDH	-	MD	MD
866546	M	M	M	M	M	M	M	M	M	M
866625	M	M	M	M	M	M	M	M	M	M
867133	MD	MD	MD	M	MD	M	MD	-	MD	-
867488	MD	MD	MD	MD	MD	MD	MD	M	MD	MD
867739	M	M	M	M	M	-	M	-	M	M
867886	M	M	M	M	M	-	-	M	M	M
86xxxx							H	H	H	H
(Dalnamein, NN747694)										
868055	M	M	M	M	M	M	-	-	M	M
868163	-	M	M	M	M	M	-	M	M	M
868847	MD	M	M	M	MD	M	D	-	M	MD
869222	M	M	M	M	M	M	-	-	M	M
869440	-	MD	M	MD	MD	MD	M	M	M	MD
870020	-	MD	MD	MD	MD	M	MD	-	MD	M
870595	M	M	M	M	M	M	M	M	M	-
870623	MD	MDH	MDH	MDH	MDH	MH	MDH	MDH	MDH	MDH
870928	M	MD	MD	MD	MD	M	MD	M	MD	MD
871092	-	M	M	M	M	M	M	M	M	-
871106	M	M	M	M	M	-	-	M	M	-
871122	M	M	M	M	M	-	M	M	M	-
871211	M	M	M	M	M	M	M	M	-	-
871225	M	M	MD	-	D	M	M	-	M	M
871811	-	-	MD	MD	MD	MD	MD	-	MD	MD
872568	M	-	M	M	M	M	M	M	M	-
873073	-	M	M	-	-	-	-	-	M	-
873096	-	M	M	M	M	M	-	M	M	-
873112	M	M	M	M	M	M	M	M	M	-
873180	M	M	M	M	M	M	M	M	M	-
873233	M	M	M	M	M	M	M	M	M	-
873264	-	M	M	M	M	M	M	M	M	-
873295	M	M	M	M	M	M	M	M	M	-
873322	M	M	M	MD	M	M	-	-	-	-
873677	-	M	M	M	M	M	M	MD	M	MD
873817	M	M	M	M	M	M	M	M	M	M
874358	M	-	M	M	M	-	-	M	M	M
875211	-	MD	MD	MD	MD	MD	MD	MD	MD	MD
875920	MDH	MH	MDH	MDH	MDH	MH	MH	MDH	MDH	MDH
876513	M	M	M	M	M	M	-	M	M	-
876516	M	M	M	M	M	M	M	M	-	-
876627	-	M	MD	MD	MD	MD	MD	MD	MD	MD
876633	D	M	M	M	M	M	M	M	MD	-
876839	MD	M	M	M	M	M	M	M	MD	MD
876858	M	M	M	M	M	M	M	M	M	-
877132	-	M	M	M	M	M	M	M	M	-
877314	-	M	M	MD	M	MD	M	MD	MD	M
877337	-	-	MD	MD	MD	M	MD	M	MD	MD
877408	M	M	M	M	M	-	M	M	M	-

877464	M	M	M	MD	M	M	M	M	MD	M
877590	-	M	MD	MD	M	M	M	M	MD	MD
878230	M	M	M	M	M	M	-	M	M	M
878339	-	D	MDH	MD	MD	MH	MD	MD	MDH	MDH
878553	H	H								
878561	-	M	M	M	M	M	-	M	M	M
878841	M	M	M	M	M	M	-	-	M	M
879009	-	MD	M	M	M	M	M	M	MD	MD
879211	D	MH	MH	M	M	M	M	MD	M	-
879495	M	M	MD	MD	MD	MD	MD	MD	MD	MD
879830	-	M	M	M	M	M	-	M	M	M
880078	-	-	-	MD	MD	MD	MD	MD	MD	-
880275	-	MD	MD	MD	MD	MD	MDH	MDH	MDH	MDH
880513	-	M	M	M	M	M	-	M	M	M
880560	M	MD	M	M	MD	M	D	M	M	MD
880730	-	M	M	M	M	M	-	M	M	M
880817	-	M	M	M	M	M	-	-	M	M
881005	MD	MD	M	MD	MD	M	D	MD	MD	MD
881029	-	M	M	M	M	M	-	M	M	M
881069	-	M	M	M	M	M	-	-	M	M
881185	M	MD	M	MD	MD	M	MD	MD	MD	M
881231	M	M	MD	MD	MD	M	MD	MD	MD	MD
881495	-	-	-	-	-	-	-	M	MD	MD
881784	M	MD	MD	MD	MD	MD	MD	MD	MD	MD
881880	-	-	-	MH	MH	MH	MD	M	MD	D
88xxxx	-	-	-	-	-	-	-	H	H	H
(Kinkell Bridge, NN933167)										
882052	-	-	MD	MD	MD	M	MD	-	MD	-
882517	M	M	M	M	M	M	M	-	M	M
882543	M	M	M	M	M	M	M	-	M	M
882741	MD	MD	M	M	M	M	M	MD	MD	MD
882817	-	-	M	M	M	M	M	MD	M	MD
882856	-	M	M	M	M	M	M	M	M	-
882897	MD	MD	M	M	M	M	M	-	M	M

Note
This table includes H codes for all events where hourly data have been collected, irrespective of whether or not they have been used.

Daily raingauge locations and altitude in the Tay and Earn catchments

Easting	Northing	Altitude (m)
2702	7394	130
2457	7417	312
2734	7472	130
2593	7562	232
2770	7590	148
2725	7649	262
2865	7662	149
2932	7742	305
2918	7599	94
2979	7532	107
2948	7402	230
3199	7704	396
3275	7540	210
3250	7478	91
3382	7485	67
3131	7674	335
3054	7629	259
3175	7466	78
3051	7452	107
3223	7405	55
3157	7334	130
3067	7356	91
2819	7336	305
3091	7255	30
3113	7226	4
2587	7231	107
2757	7220	62
2693	7158	225
2835	7248	232

2867	7223	122
2841	7177	113
2861	7138	168
2932	7163	35
2929	7110	120
3090	7185	41
3108	7178	30
3111	7108	166
3313	7225	47
3422	7274	30
3183	7093	95
3332	7147	46
3306	7144	64
3362	7145	42
3366	7078	154
3468	7209	10
3501	7159	26
3478	7114	146
3590	7133	23

APPENDIX 2

Sub-catchment physical details

Sub-catchment	Longitude	Latitude	Outfall altitude (m)	Mean altitude (m)
EA1	2700	7240	100	361
EA2	2760	7200	70	385
EA3	2780	7220	50	460
EA4	2930	7170	20	185
EA5	3040	7180	10	151
EA6	3200	7190	0	58
TA1	2560	7320	130	430
TA2	2570	7340	110	484
TA3	2780	7470	100	424
TA4	2920	7540	50	359
TA5	2980	7410	70	400
TA6	3090	7390	40	242
TA7	3150	7370	30	67
TA8	3200	7190	0	107
TA9	3070	7260	20	394
LY1	2530	7450	250	581
LY2	2620	7480	180	520
LY3	2790	7490	100	492
TU1	2510	7630	350	528
TU2	2510	7570	400	412
TU3	2660	7580	190	418
TU4	2880	7600	140	426
TU5	2980	7510	70	293
GA1	2740	7690	260	590
GA2	2810	7650	150	495
GA3	2810	7650	150	335

GA4	2870	7650	130	499
GA5	2890	7710	230	642
GA6	2870	7650	130	581
GA7	2930	7570	110	444
GA8	2710	7660	290	504
GA9	2900	7640	120	334
IS1	3190	7650	290	638
IS2	3300	7470	50	299
IS3	3290	7460	50	131
IS4	3170	7470	50	456
IS5	3160	7380	30	153

APPENDIX 3

Intersite relationships for monthly rainfall in the 10 flood events using site Longitude (Lon), Latitude (Lat) and Altitude (Alt):

January 1974:

North of latitude 7565
Log(Rain) = -1.22 - .00034(Lon) + .00060(Lat) + .00021(Alt)

South of latitude 7565
Log(Rain) = 1.07 - .00064(Lon) + .00043(Lat) + .00028(Alt)

August 1985:

North of latitude 7500, West of longitude 2900
Log(Rain) = 2.25 - .00032(Lon) + .00010(Lat) + .00031(Alt)

North of latitude 7500, East of longitude 2900
Log(Rain) = -2.29 + .00004(Lon) + .00059(Lat) + .00101(Alt)

South of latitude 7500, West of longitude 2900
Log(Rain) = 7.21 - .00060(Lon) - .00045(Lat) + .00031(Alt)

South of latitude 7500, East of longitude 2900
Log(Rain) = 0.16 - .00053(Lon) + .00049(Lat) + .00031(Alt)

February 1989:

Log(Rain) = 5.26 - .00090(Lon) - .00007(Lat) + .00052(Alt)

February 1990:

North of latitude 7500
Log(Rain) = 3.66 - .00049(Lon) + .00066(Alt)

South of latitude 7500
Log(Rain) = 5.58 - .00085(Lon) - .00010(Lat) + .00018(Alt)

March 1990:

North of latitude 7475
Log(Rain) = -3.11 - .00108(Lon) + .00108(Lat) + .00068(Alt)

South of latitude 7475
Log(Rain) = 7.19 - .00148(Lon) - .00013(Lat) + .00055(Alt)

January 1991:

North of latitude 7420
Log(Rain) = 7.29 - .00051(Lon) - .00050(Lat) + .00037(Alt)

South of latitude 7420
Log(Rain) = 6.58 - .00070(Lon) - .00034(Lat) + .00051(Alt)

January 1992:

Log(Rain) = 7.07 - .00094(Lon) - .00032(Lat) + .00008(Alt)

Janaury 1993:

North of latitude 7405
Log(Rain) = 5.20 - .00034(Lon) - .00024(Lat) + .00040(Alt)

South of latitude 7405
Log(Rain) = 5.62 - .00057(Lon) - .00020(Lat) - .00010(Alt)

March 1993:

West of longitude 3250
Log(Rain) = 6.85 - .00055(Lon) - .00043(Lat) + .00053(Alt)

East of longitude 3250
No relationship - mean rainfall 124mm

May 1993:

No relationship - nearest gauge used

APPENDIX 4

Months rainfall totals at each sub-catchment outfall estimated from regression analyses

	Jan 1974	Aug 1985	Feb 1989	Feb 1990	Mar 1990	
EA1	292	231	230	387	203	
EA2	252	217	197	342	161	
EA3	246	203	184	325	146	
EA4	184	148	131	242	85	
EA5	157	130	103	194	57	
EA6	124	107	73	141	33	
TA1	395	264	314	506	332	
TA2	392	251	300	490	311	
TA3	325	163	187	314	144	
TA4	274	127	130	196	88	
TA5	247	178	120	212	72	
TA6	183	159	93	170	47	
TA7	163	143	81	151	38	
TA8	124	107	73	141	33	
TA9	163	138	96	180	51	
LY1	508	262	379	548	411	
LY2	437	213	287	443	195	
LY3	326	157	183	306	116	
TU1	399	201	432	493	488	
TU2	525	206	463	532	454	
TU3	307	157	263	326	231	
TU4	259	129	156	235	130	
TU5	247	128	118	189	72	
GA1	347	160	238	332	278	
GA2	295	138	181	259	178	
GA3	295	138	181	259	178	

GA4	279	130	156	235	148	
GA5	313	141	168	267	192	
GA6	279	130	156	235	148	
GA7	235	152	137	212	101	
GA8	346	166	264	359	291	
GA9	267	170	145	223	132	
IS1	234	265	97	209	86	
IS2	146	135	60	111	23	
IS3	147	135	61	113	23	
IS4	177	159	78	143	35	
IS5	162	143	79	147	37	

	Jan 1991	Dec 1991	Jan 1992	Jan 1993	Mar 1993	May 1993
EA1	190	115	166	420	203	135
EA2	172	103	150	398	188	135
EA3	160	96	141	386	175	135
EA4	126	75	105	326	147	109
EA5	103	62	82	282	125	108
EA6	78	47	57	228	100	108
TA1	231	144	214	483	232	140
TA2	219	137	205	474	219	140
TA3	148	91	118	321	146	112
TA4	111	66	82	264	107	98
TA5	102	66	79	276	111	112
TA6	84	53	63	238	99	104
TA7	76	48	56	222	92	101
TA8	78	47	57	228	100	108
TA9	93	57	72	260	112	98
LY1	231	166	212	453	246	124

LY2	189	130	168	389	195	118
LY3	143	89	114	315	141	112
TU1	210	180	197	457	238	78
TU2	235	198	209	496	270	124
TU3	162	118	144	360	170	105
TU4	117	77	87	286	118	85
TU5	109	62	74	261	105	112
GA1	138	108	113	340	150	79
GA2	121	85	98	297	125	99
GA3	121	85	98	297	125	99
GA4	111	75	85	278	113	81
GA5	110	81	80	291	117	81
GA6	111	75	85	278	113	81
GA7	111	69	79	272	110	98
GA8	152	120	124	364	167	116
GA9	107	71	80	271	108	83
IS1	87	56	44	251	91	111
IS2	77	37	38	204	124	75
IS3	79	38	39	206	124	75
IS4	89	46	50	225	83	85
IS5	74	47	54	218	90	101

APPENDIX 5

Measured daily rainfall for storm events

Gauge location		Date: January 1974						
Easting	Northing	27	28	29	30	31		
3383	7486	3	3	35	7	1		
3313	7225	1	3	19	1	0		
3274	7539	3	2	38	5	0		
3175	7438	4	5	29	0	0		
3174	7459	3	4	25	1	0		
3156	7278	5	3	21	1	0		
3113	7226	2	6	17	4	0		
3111	7108	2	7	33	1	0		
3101	7239	2	7	18	2	0		
3101	7613	6	2	31	17	1		
3090	7185	2	7	27	4	0		
3087	7568	6	7	34	18	1		
3054	7629	8	8	25	13	1		
3051	7452	3	5	35	15	0		
3001	7295	0	5	33	3	1		
2945	7588	8	8	22	7	1		
2931	7166	2	13	25	6	0		
2918	7599	8	15	23	5	1		
2918	7112	3	7	43	11	2		
2891	7526	13	11	23	8	0		
2871	7622	12	8	26	4	1		
2866	7268	10	22	51	70	1		
2865	7223	2	15	34	8	0		
2864	7658	14	15	22	8	0		
2854	7489	15	19	30	13	2		

2835	7248	3	9	45	17	1		
2819	7337	9	16	79	27	2		
2796	7179	3	10	39	9	1		
2770	7590	18	18	24	21	1		
2765	7215	6	22	45	18	2		
2761	7452	0	20	10	26	4		
2734	7472	12	25	27	7	1		
2729	7287	9	12	43	27	0		
2725	7649	11	22	23	10	1		
2715	7706	16	35	23	8	1		
2702	7394	25	27	39	19	4		
2696	7157	8	25	62	12	1		
2662	7342	21	34	45	16	5		
2593	7562	22	37	25	14	1		
2592	7239	8	25	33	18	4		
2575	7224	11	26	36	30	0		
2558	7281	13	38	50	44	2		
2552	7462	20	43	42	32	3		
2546	7350	13	45	31	16	2		
2531	7582	15	40	12	11	1		
2464	7572	15	31	11	12	2		
2457	7417	19	44	38	25	4		
2301	7285	21	54	55	35	5		

Gauge location					Date:	August 1985		
Easting	Northing	21	22	23	24	25		
2734	7472	3	3	12	2			
2593	7562	4	4	12	2	4		
2770	7590	3	1	16	2	5		
2871	7622	4	1	17	10			
2865	7662	3	2	17	3	5		

2932	7742	2	1	30	9	1		
2918	7599	3	0	12	4	5		
2979	7532	3	1	19	8	0		
3131	7674	3	0	28	4			
2819	7336	3	3	46	2	0		
3091	7255	3	0	16	3	0		
3155	7280	0	0	20	0	1		
3096	7233	2	0	17	3	2		
2587	3231	6	1	20	3			
2698	7241	20	2	41	1			
2693	7158	5	4	39	2	0		
2765	7215	2	1	39	1	1		
2776	7221	2	1	39	0	1		
2730	7286	25	2	51	1	3		
2835	7248	3	1	45	0	2		
2867	7223	3	0	39	1			
2861	7138	5	3	17	1			
3090	7185	3	0	15	1	2		
3111	7108	2	1	23	2	2		

Gauge location		Date: February 1989						
Easting	Northing	4	5	6	7	8		
3372	7697	6	2	2	0	1		
3175	7466	3	1	1	0	0		
3157	7334	4	3	2	0	0		
3131	7674	12	8	5	0	0		
3067	7356	5	3	7	0	1		
3054	7629	10	7	5	0	1		
3019	7423	0	10	5	0	1		
2979	7532	9	4	5	0	1		
2948	7402	8	3	14	0	1		

2932	7742	13	10	13	0	1		
2929	7110	17	6	6	0	0		
2918	7599	14	2	13	0	0		
2871	7622	10	3	11	0	0		
2861	7138	18	15	23	0	0		
2841	7177	10	12	32	0	1		
2819	7336	12	9	25	0	0		
2770	7590	17	4	6	0	1		
2702	7394	12	8	48	1	1		
2693	7158	21	26	79	1	1		
2593	7562	17	11	80	1	0		
2587	7231	18	17	62	1	1		
2546	7350	26	36	87	1	1		

Gauge location		Date: February 1990						
Easting	Northing	1	2	3	4	5	6	7
3223	7405	5	1	9	6	3	9	0
3175	7466	3	3	7	16	3	9	0
3157	7334	4	3	10	3	4	9	0
3147	7369	3	2	13	7	4	8	0
3131	7674	14	17	6	18	10	19	0
3067	7356	4	5	12	18	3	13	0
2979	7532	12	7	9	6	5	16	0
2948	7402	17	10	27	36	8	20	0
2932	7742	25	7	8	6	11	16	1
2929	7110	12	9	22	9	7	12	3
2918	7599	21	12	6	16	5	18	1
2871	7622	15	10	13	31	11	18	1
2865	7662	15	7	5	11	4	12	3
2861	7138	6	14	8	12	8	10	1
2819	7336	22	22	52	16	15	20	0

2757	7220	28	18	33	37	7	21	0
2734	7472	38	24	17	57	14	18	3
2702	7394	49	12	46	23	19	19	1
2693	7158	22	33	31	57	7	22	1
2593	7562	40	18	45	29	18	19	3
2587	7231	35	19	28	50	15	22	1
2301	7285	76	32	56	69	49	37	9
3275	7540	4	4	6	6	4	11	0
3054	7629	14	15	6	11	8	15	1
2835	7248	7	8	14	19	5	20	0
2867	7223	9	10	26	29	5	15	0
2841	7177	0	17	36	29	5	14	1

Gauge location		Date: March 1990						
Easting	Northing	1	2	3	4	5	6	7
3175	7466	0	0	0	0	1	0	0
3157	7334	0	0	0	1	0	0	3
3131	7674	0	0	2	9	23	1	1
3054	7629	1	0	3	11	22	1	3
3019	7423	0	0	0	1	6	0	0
2979	7532	0	0	4	5	8	0	2
2948	7402	1	0	2	9	1	1	2
2932	7742	3	2	4	8	28	2	2
2929	7110	0	0	8	8	9	1	0
2918	7599	1	0	1	5	17	1	1
2871	7622	1	0	3	11	18	1	3
2867	7223	0	0	2	3	9	1	0
2865	7662	0	3	2	8	13	8	3
2861	7138	1	2	14	10	16	6	3
2841	7177	0	1	8	9	10	1	2
2835	7248	0	0	0	7	21	3	1

2819	7336	0	2	9	9	27	3	6
2770	7590	5	1	4	1	51	4	1
2761	7452	10	0	8	11	27	27	4
2757	7220	0	0	8	8	26	3	1
2734	7472	3	0	9	12	33	5	6
2730	7286	2	2	0	0	24	28	5
2725	7649	1	1	11	28	55	5	9
2702	7394	1	0	8	12	27	10	6
2693	7158	0	2	16	9	44	10	7
2618	7316	1	1	14	11	31	12	7
2604	7383	1	1	7	7	17	7	4
2593	7562	9	3	10	15	65	9	13
2587	7231	2	2	18	15	43	17	14
2558	7281	1	1	16	13	38	15	10
2546	7350	1	1	9	8	21	9	5
2531	7582	3	3	12	17	45	14	16
2301	7285	8	13	59	47	70	79	28

Gauge location		Date:			January 1991			
Easting	Northing	27	28	29	30	31	1	2
3223	7405	3	3	6	1	0	16	7
3175	7466	1	8	3	1	0	16	7
3157	7369	5	3	4	0	0	15	6
3131	7674	6	15	15	26	0	33	17
3067	7336	3	6	5	2	0	30	10
2948	7402	4	8	3	11	0	44	12
2871	7622	8	13	12	15	1	26	17
2865	7662	5	12	11	15	1	25	15
2861	7138	11	8	13	3	0	41	11
2757	7220	6	24	14	10	5	54	20
2693	7158	15	27	19	11	5	83	23

2587	7231	10	22	20	9	7	51	21
Gauge location		Date: January 1992						
Easting	Northing	30	31	1	2	3	4	
3175	7466	0	3	1	4	0	0	
3157	7334	0	9	3	4	1	0	
3131	7674	0	10	7	19	4	0	
2979	7532			6	9	4	0	
2948	7402			9	15	3	0	
2932	7163			7	15	4	0	
2929	7110	1	15	7	12	7	0	
2918	7599			5	14	6	0	
2871	7622	0	19	17	16	4	0	
2867	7223			7	22	5	0	
2861	7138	1	21	18	31	6	0	
2859	7492	.		8	26	15	1	
2835	7248			23	27	5	1	
2819	7336			13	25	5	0	
2770	7590			19	34	9	1	
2761	7452			19	45	11	0	
2757	7220	3	16	17	46	9	1	
2730	7286			25	53	12	0	
2725	7649			5	7	2	0	
2703	7394			20	45	10	0	
2693	7158	1	34	52	85	18	1	
2664	7347			33	44	11	0	
2618	7316			35	48	11	0	
2604	7383		.	37	52	11	0	
2598	7392			37	52	11	0	
2593	7562			35	53	10	2	
2587	7231	5	19	46	62	17	0	

2584	7345			38	56	11	0	
2558	7281			46	63	13	1	
2546	7350			36	53	11	0	
2531	7582			39	59	32	6	
2508	7422			35	53	12	0	
2507	7627			36	54	8	2	
2464	7568			41	62	10	2	
2359	7283			92	120	12	1	
2301	7285			13	17	3	5	

Gauge location		Date: January 1993						
Easting	Northing	13	14	15	16	17	18	
3272	7538	10	31	12	11	3	12	
3250	7478	13	22	13	9	2	10	
3223	7405	5	25	9	8	5	7	
3175	7466	10	30	11	10	1	11	
3131	7674	9	22	23	22	5	10	
3113	7226	15	53	17	14	5	9	
3108	7178	6	37	16	11	5	12	
3090	7185	8	38	18	13	5	11	
3054	7629	9	22	15	19	4	9	
2918	7599	1	11	16	15	2	9	
2867	7223	7	58	15	26	5	14	
2861	7138	7	30	25	27	13	12	
2841	7177	3	54	20	35	7	17	
2835	7248	4	18	11	32	5	10	
2819	7336	18	65	14	35	5	9	
2757	7220	11	67	26	36	6	16	
2702	7394	7	62	17	36	7	8	
2693	7158	20	63	24	67	12	19	
2587	7231	17	59	27	43	13	12	

2359	7283	17	66	55	41	9	12	
Gauge location						Date:		March 1993
Easting	Northing	27	28	29	30	31		
3272	7538	0	3	21	14	41		
3223	7405	0	2	20	7	38		
3175	7466	0	3	16	18	37		
3174	7459	0	2	13	12	54		
3157	7334	1	2	21	11	41		
3155	7280	0	3	28	16	35		
3147	7369	1	1	15	9	37		
3131	7674	0	4	35	9	6		
3091	7255	2	2	20	9	42		
3090	7185	1	1	16	12	44		
3067	7356	2	3	17	11	38		
3054	7629	0	5	24	6	6		
3051	7452	1	4	22	9	31		
2979	7532	1	3	27	9	20		
2948	7402	2	5	30	11	32		
2944	7214	1	1	14	10	32		
2932	7742	1	3	23	5	9		
2932	7163	0	1	18	9	46		
2932	7163	1	1	13	8	35		
2929	7110	0	1	20	10	48		
2918	7599	0	3	14	4	3		
2871	7622	0	3	10	1	0		
2867	7223	0	1	12	13	34		
2861	7138	2	1	13	8	40		
2859	7492	0	6	28	9	12		
2841	7177	0	2	13	8	27		
2835	7248	0	3	8	16	30		

2819	7336	0	4	45	25	29		
2770	7590	0	2	21	2	1		
2761	7452	0	3	28	9	11		
2757	7220	1	3	24	8	18		
2703	7286	1	5	39	14	43		
2702	7394	0	4	32	21	36		
2693	7158	0	3	16	13	24		
2593	7562	0	3	20	5	8		
2587	7231	0	3	32	11	8		
2531	7582	0	2	13	4	9		
2359	7283	0	6	38	5	11		
2301	7285	2	6	16	2	3		

Gauge location						Date:	May 1993	
Easting	Northing	13	14	15	16	17	18	
3250	7478	3	6	6	6	8	0	
3175	7466	11	9	3	15	19	0	
3157	7334	15	12	3	13	12	1	
3131	7674	0	3	7	19	38	0	
3108	7178	20	15	2	13	7	1	
3091	7255	15	15	13	3	14	12	
3090	7185	18	16	4	12	11	4	
3067	7356	16	13	3	12	24	0	
3054	7629	1	1	8	22	35	0	
3051	7452	7	11	4	15	26	0	
2979	7532	15	5	2	13	38	1	
2948	7402	18	14	5	18	50	1	
2944	7214	19	18	3	13	16	1	
2932	7163	24	20	3	20	13	1	
2918	7599	2	3	3	12	22	1	
2918	7599	2	2	4	12	22	0	

2871	7622	1	2	3	8	17	1	
2865	7662	2	2	2	6	20	0	
2861	7138	23	22	7	21	17	3	
2841	7177	14	14	6	21	16	0	
2835	7248	19	19	29	3	23	26	
2819	7336	29	29	27	24	33	0	
2730	7286	22	22	26	7	23	48	
2725	7649	3	10	1	3	11	0	
2702	7394	31	27	4	8	33	0	
2693	7158	24	13	12	15	45	0	
2664	7347	14	8	4	12	17	0	
2618	7316	11	18	5	17	46	0	
2604	7383	10	18	4	18	42	0	
2598	7392	11	19	5	19	45	0	
2593	7562	16	19	14	14	35	0	
2587	7231	8	14	3	18	37	0	
2584	7345	11	16	4	14	34	0	
2558	7281	11	19	5	24	47	0	
2546	7350	9	17	4	16	37	0	
2510	7465	13	23	6	22	48	0	
2508	7422	12	18	5	18	44	0	
2457	7417	12	21	6	20	43	0	
2359	7283	9	10	12	21	38	1	
2301	7285	8	10	14	22	52	1	

APPENDIX 6

Daily estimates of sub-catchment rainfall for each storm event

Sub-catchment	Date: January 1993					
	13	14	15	16	17	18
EA1	12	54	25	29	8	16
EA2	11	51	23	31	7	15
EA3	11	61	23	34	7	15
EA4	9	52	19	22	6	13
EA5	8	47	16	14	5	11
EA6	6	31	13	6	4	9
TA1	14	77	28	28	9	19
TA2	14	80	28	28	9	18
TA3	9	35	19	28	6	12
TA4	7	21	15	21	5	10
TA5	8	41	16	24	5	11
TA6	7	35	14	16	4	9
TA7	6	31	13	11	4	8
TA8	6	31	13	6	4	9
TA9	7	54	15	15	5	10
Ly1	13	68	27	27	9	18
LY2	11	46	23	27	7	15
LY3	9	31	18	28	6	12
TU1	13	27	27	22	9	18
TU2	14	39	29	24	9	19
TU3	10	25	21	25	7	14
TU4	8	14	17	20	5	11
TU5	7	23	15	20	5	10
GA1	10	6	20	20	6	13
GA2	8	8	17	17	5	11
GA3	8	8	17	17	5	11

GA4	8	8	16	19	5	11
GA5	8	5	17	17	5	11
GA6	8	8	16	19	5	11
GA7	8	19	16	19	5	10
GA8	10	10	21	21	7	14
GA9	8	10	16	18	5	10
IS1	7	15	15	15	5	10
IS2	6	20	12	8	4	8
IS3	6	22	12	8	4	8
IS4	6	27	13	9	4	9
IS5	6	30	13	8	4	8
Sub-catchment	Date: December 1991 - January 1992					
	30	31	1	2	3	4
EA1	1	19	33	56	13	1
EA2	1	18	22	49	10	1
EA3	0	18	18	45	8	1
EA4	0	13	7	15	3	1
EA5	0	11	3	6	2	0
EA6	0	7	2	2	1	0
TA1	1	18	42	57	10	2
TA2	1	19	37	49	10	2
TA3	0	21	16	35	9	1
TA4	0	15	9	17	6	0
TA5	0	14	9	15	2	0
TA6	0	10	1	7	1	0
TA7	0	8	1	3	0	0
TA8	0	7	2	2	1	0
TA9	0	11	2	7	0	0
Ly1	1	25	33	48	8	2
LY2	1	24	27	48	10	1

LY3	0	21	14	35	10	1
TU1	1	32	27	41	5	1
TU2	1	33	41	62	6	2
TU3	1	25	25	43	8	1
TU4	0	18	17	20	6	0
TU5	0	13	8	15	5	0
GA1	1	27	11	13	4	1
GA2	0	21	13	5	5	0
GA3	0	21	13	19	5	0
GA4	0	18	12	17	6	0
GA5	0	17	13	17	5	0
GA6	0	17	12	17	6	0
GA7	0	15	10	16	6	0
GA8	1	30	12	22	4	1
GA9	0	15	12	16	6	0
IS1	0	6	3	11	2	0
IS2	0	4	1	3	0	0
IS3	0	4	1	2	0	0
IS4	0	3	1	5	0	0
IS5	0	4	1	3	0	0
Sub-catchment	Date: May 1993					
	13	14	15	16	17	18
EA1	14	14	9	9	27	10
EA2	17	13	9	6	33	10
EA3	16	14	10	6	35	13
EA4	18	16	2	14	10	1
EA5	19	17	2	12	11	1
EA6	19	16	2	10	8	1
TA1	12	21	5	23	53	0
TA2	12	22	5	21	53	0

TA3	17	13	4	13	23	0
TA4	9	3	2	11	27	0
TA5	8	10	3	12	30	1
TA6	16	12	3	14	22	1
TA7	15	13	3	14	17	1
TA8	19	16	2	9	8	1
TA9	15	14	2	5	15	9
Ly1	11	22	6	22	47	0
LY2	16	17	7	16	35	0
LY3	14	12	5	13	23	0
TU1	6	9	6	6	13	0
TU2	12	16	12	12	32	0
TU3	9	12	7	9	15	0
TU4	1	3	3	9	18	0
TU5	14	4	2	14	36	1
GA1	1	4	1	1	7	0
GA2	1	4	1	5	13	0
GA3	1	4	1	5	13	0
GA4	1	1	1	7	16	0
GA5	0	0	1	6	15	0
GA6	1	1	1	7	16	0
GA7	5	2	2	12	26	0
GA8	3	10	1	3	11	0
GA9	0	1	2	9	19	0
IS1	0	3	8	15	31	0
IS2	1	7	7	7	10	0
IS3	1	8	7	7	10	0
IS4	11	9	3	15	17	0
IS5	14	13	4	14	17	0

Sub-catchment	Date: March 1990					
	3	4	5	6		
EA1	8	8	24	16		
EA2	6	6	19	8		
EA3	5	5	17	7		
EA4	3	5	4	0		
EA5	1	4	1	0		
EA6	0	1	0	0		
TA1	13	9	26	13		
TA2	9	9	24	9		
TA3	5	8	20	12		
TA4	5	8	13	1		
TA5	1	5	8	0		
TA6	0	1	2	0		
TA7	0	0	0	0		
TA8	0	1	0	0		
TA9	0	3	2	0		
Ly1	12	12	37	12		
LY2	5	7	27	5		
LY3	4	6	17	9		
TU1	19	24	78	9		
TU2	18	22	54	9		
TU3	6	11	55	4		
TU4	3	13	20	5		
TU5	4	5	10	0		
GA1	5	16	47	5		
GA2	3	14	23	7		
GA3	3	14	23	7		
GA4	2	10	19	10		
GA5	3	9	26	11		
GA6	2	10	19	10		

GA7	1	10	16	2		
GA8	8	26	52	5		
GA9	1	11	21	5		
IS1	1	3	13	0		
IS2	0	0	0	0		
IS3	0	0	0	0		
IS4	0	0	1	0		
IS5	0	0	0	0		
Sub-catchment	Date: February 1989					
	5	6	7			
EA1	11	48	0			
EA2	9	37	0			
EA3	9	31	0			
EA4	5	10	0			
EA5	3	5	0			
EA6	2	1	0			
TA1	22	56	0			
TA2	21	60	0			
TA3	3	22	0			
TA4	2	9	0			
TA5	2	9	0			
TA6	2	3	0			
TA7	3	1	0			
TA8	2	1	0			
TA9	2	6	0			
Ly1	26	83	0			
LY2	11	69	0			
LY3	3	22	0			
TU1	25	103	0			
TU2	27	106	0			

TU3	7	47	0			
TU4	3	14	0			
TU5	3	5	0			
GA1	9	35	0			
GA2	5	20	0			
GA3	5	20	0			
GA4	3	14	0			
GA5	6	15	0			
GA6	3	14	0			
GA7	2	9	0			
GA8	7	39	0			
GA9	2	11	0			
IS1	3	1	0			
IS2	1	0	0			
IS3	1	0	0			
IS4	0	0	0			
IS5	2	1	0			

APPENDIX 7

Meteorological Office snow depth data

Observations made when ground more than half covered, depths in cm measured by vertically-held ruler in a space free from drifiting or scouring by the wind.

Data supplied by Meteorological Office, Edinburgh.

January/Feb 1974	**28**	**29**	**30**	**31**	**1**	**2**
Dalwhinnie		5				
Perth Aerodrome	No data					
Strathallan School						
Drummond Castle						
Dall, Rannoch School		10	2			
Faskally						
Ardtalnaig		1				
Kindrogan			3	5		
Aberfoyle		No data				

February 1989	**3**	**4**	**5**	**6**	**7**	**8**
Dalwhinnie			2			
Perth Aerodrome						
Strathallan School						
Drummond Castle						
Dall, Rannoch School						
Faskally						
Ardtalnaig						
Kindrogan				2		
Loch Venachar						
Aberfoyle						

February 1990	**3**	**4**	**5**	**6**	**7**	**8**
Dalwhinnie	1	1	1		1	1
Perth Aerodrome						
Strathallan School						
Drummond Castle						
Dall, Rannoch School						
Faskally						
Ardtalnaig						
Kindrogan						
Loch Venachar						
Aberfoyle						

March 1990	**4**	**5**	**6**	**7**	**8**	**9**
Dalwhinnie						3
Perth Aerodrome						
Strathallan School						
Drummond Castle						
Dall, Rannoch School						
Faskally						
Ardtalnaig						
Kindrogan						
Loch Venachar						
Aberfoyle						

Dec90/January 1991	**31**	**1**	**2**	**3**	**4**	**5**
Dalwhinnie	39	3	4	4	4	4
Perth Aerodrome						
Strathallan School						
Drummond Castle	6	3		<0.5	<0.5	
Dall, Rannoch School	17	16		13	9	1
Faskally			<0.5		2	<0.5
Ardtalnaig				5		
Kindrogan	34	32	26	38	36	35
Loch Venachar						
Aberfoyle						

Dec91/January 1992	29	30	31	1	2	3	4
Dalwhinnie	0	0	0	0	0	0	0
Perth Aerodrome	0	0	0	0	0	0	0
Strathallan School	0	0	0	0	0	0	0
Drummond Castle	0	0	0	0	0	0	0
Dall, Rannoch School	0	0	0	0	0	0	0
Faskally	0	0	0	0	0	0	0
Ardtalnaig	0	0	0	0	0	0	0
Kindrogan	0	0	0	0	0	0	1
Loch Venachar	0	0	0	0	0	0	0
Aberfoyle	0	0	0	0	0	0	0

January 1993	13	14	15	16	17	18	19
Dalwhinnie	7	7	0	0	0	4	0
Perth Aerodrome	10	10	5	0	0	0	0
Strathallan School	9	2	0	0	0	0	0
Drummond Castle	25	25	0	0	0	0	0
Dall, Rannoch School	21	29	16	14	0	7	2
Faskally	31	24	9	7	0	3	1
Ardtalnaig	18	10	0	0	0	1	0
Kindrogan	62	73	58	42	36	35	33
Loch Venachar	8	6	0	0	0	1	0
Aberfoyle	21	17	0	0	0	0	0

March 1993	25	26	27	28	29	30	31
Dalwhinnie	0	0	0	0	0	0	0
Perth Aerodrome	0	0	0	0	0	0	0
Strathallan School	0	0	0	0	0	0	0
Drummond Castle	0	0	0	0	0	0	0
Dall, Rannoch School	0	0	0	0	0	0	0
Faskally	0	0	0	0	0	0	0
Ardtalnaig	0	0	0	0	0	0	0
Kindrogan	0	0	0	0	0	0	0
Loch Venachar	0	0	0	0	0	0	0
Aberfoyle	0	0	0	0	0	0	0

APPENDIX 8

Snow altitude data

The following figures are all extracted from the Meteorological Office *Snow Survey of Great Britain* publications, and show daily observations of snowlines at mountain stations. Data for winter 1992/93 were not available at the time of writing.

FIGURE II DISTRIBUTION OF SNOW COVER 1973/74

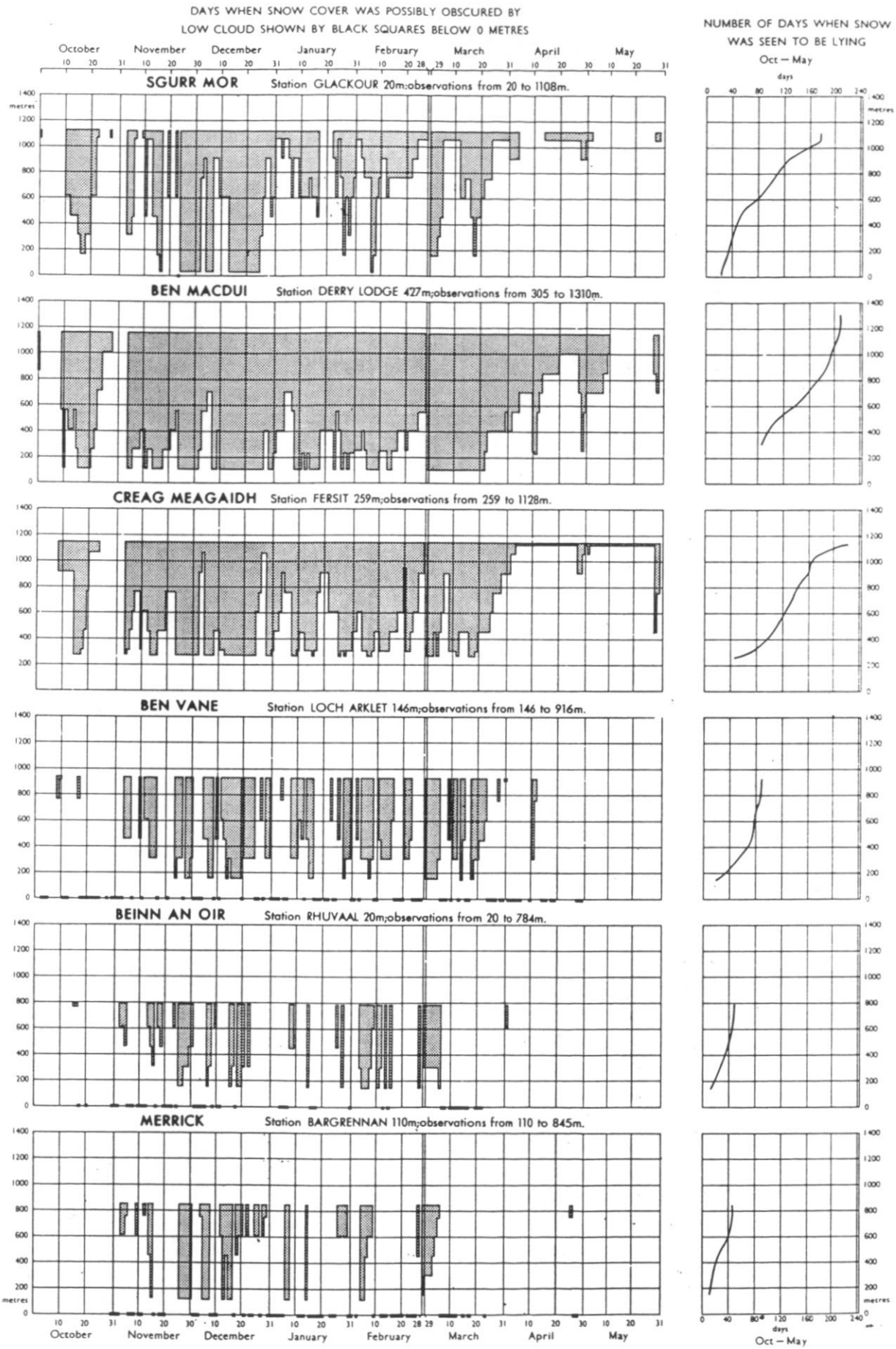


Figure 2 Distribution of snow cover 1988/89

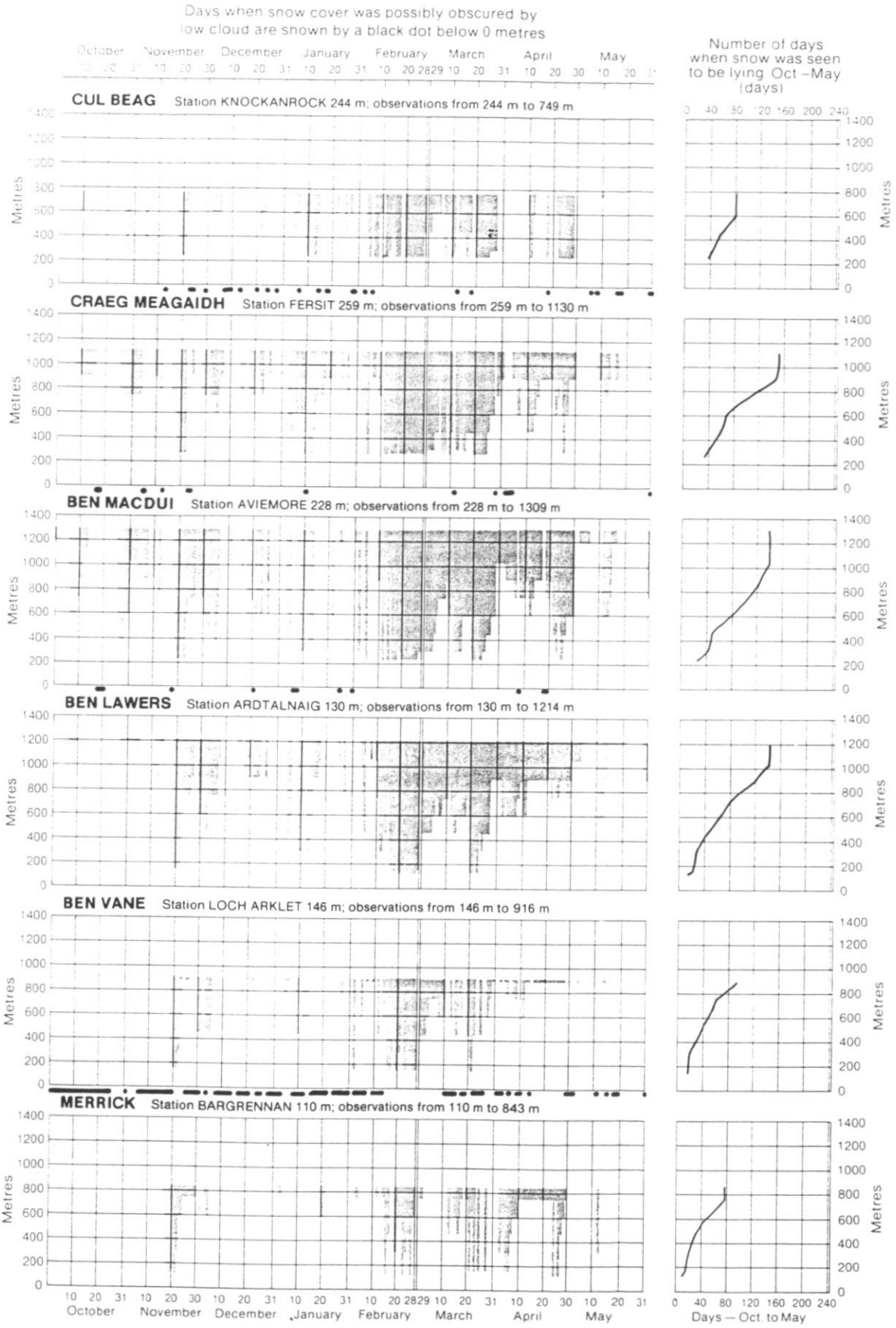


Figure 2 Distribution of snow cover 1989/90

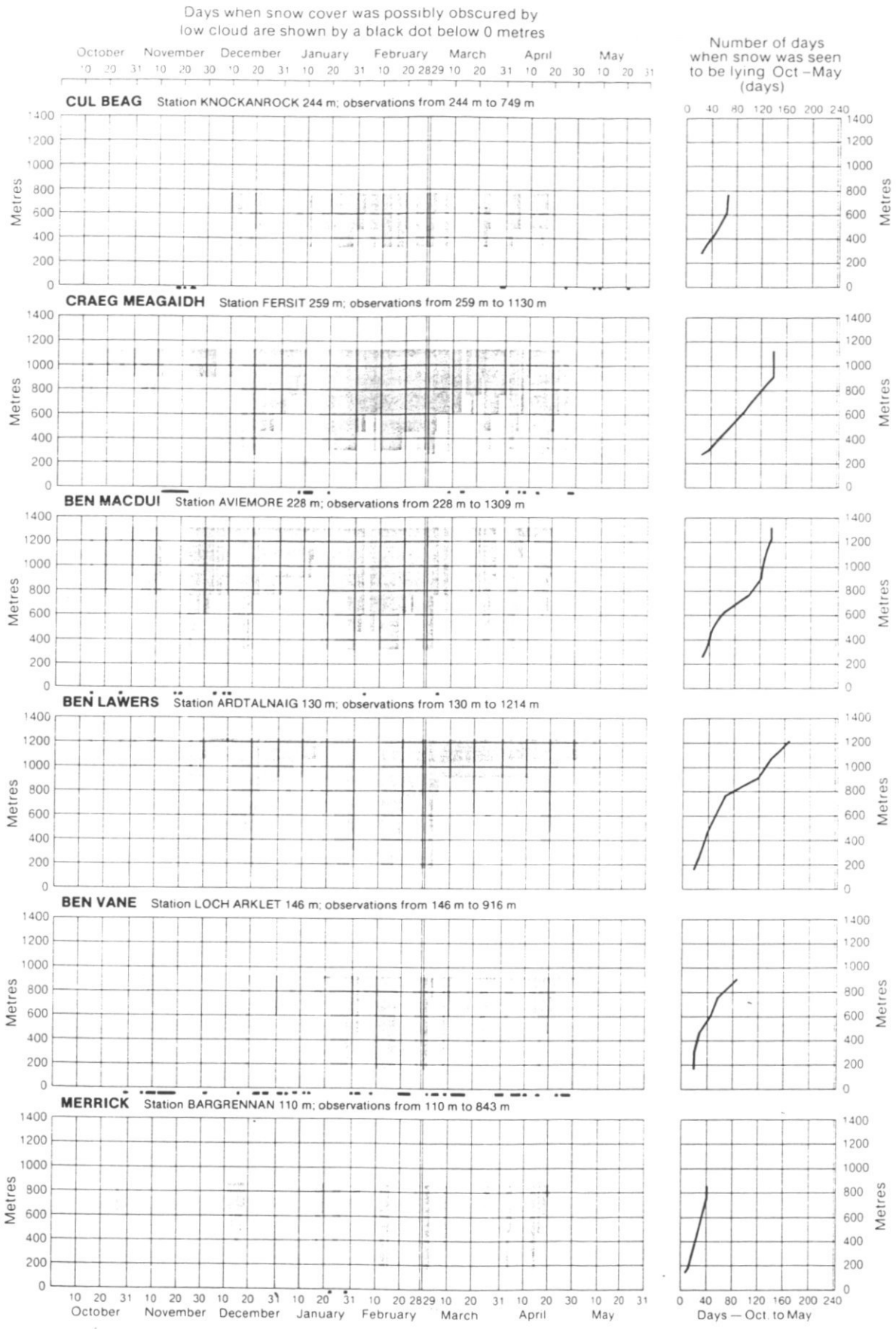


Figure 2 Distribution of snow cover 1990/91

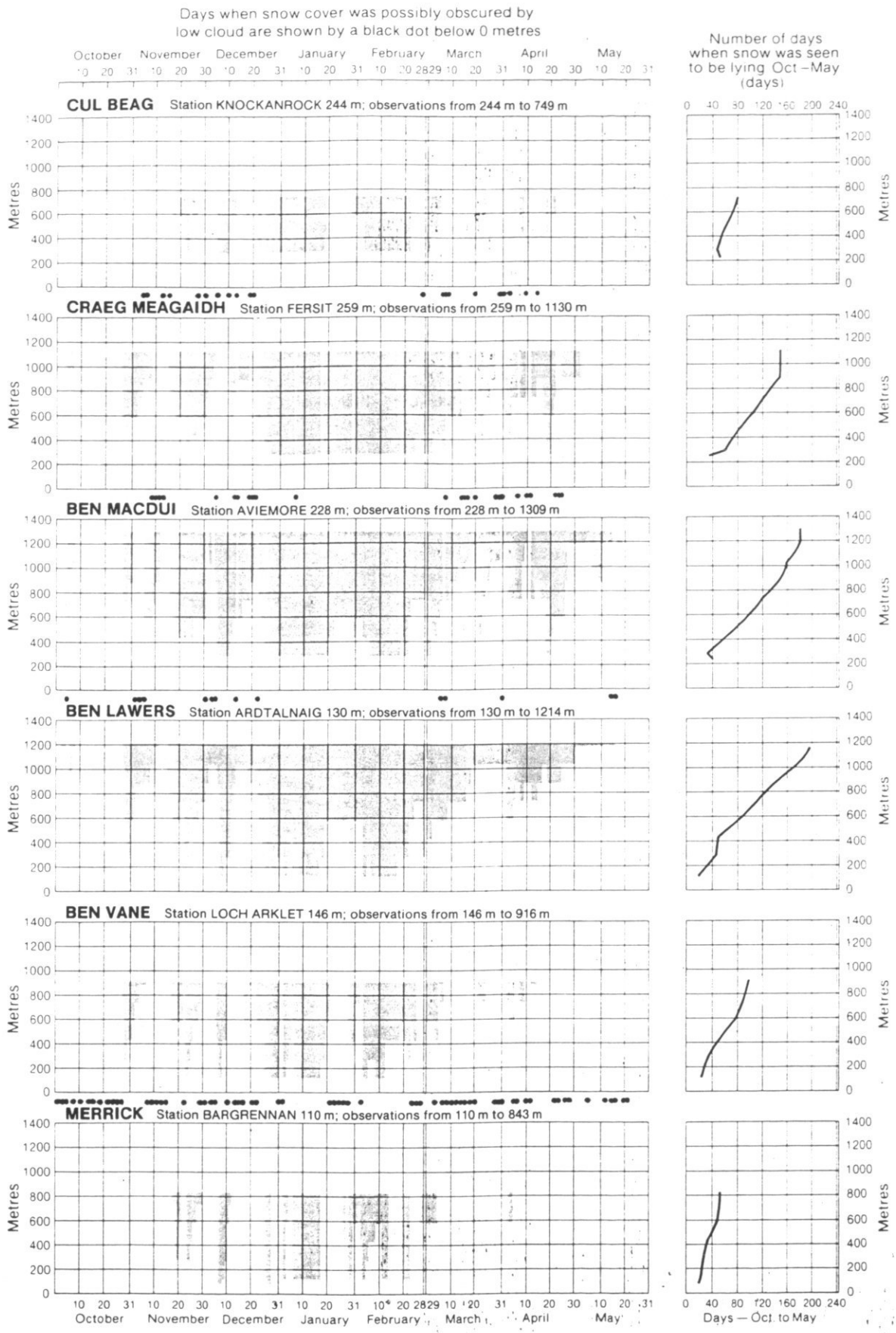
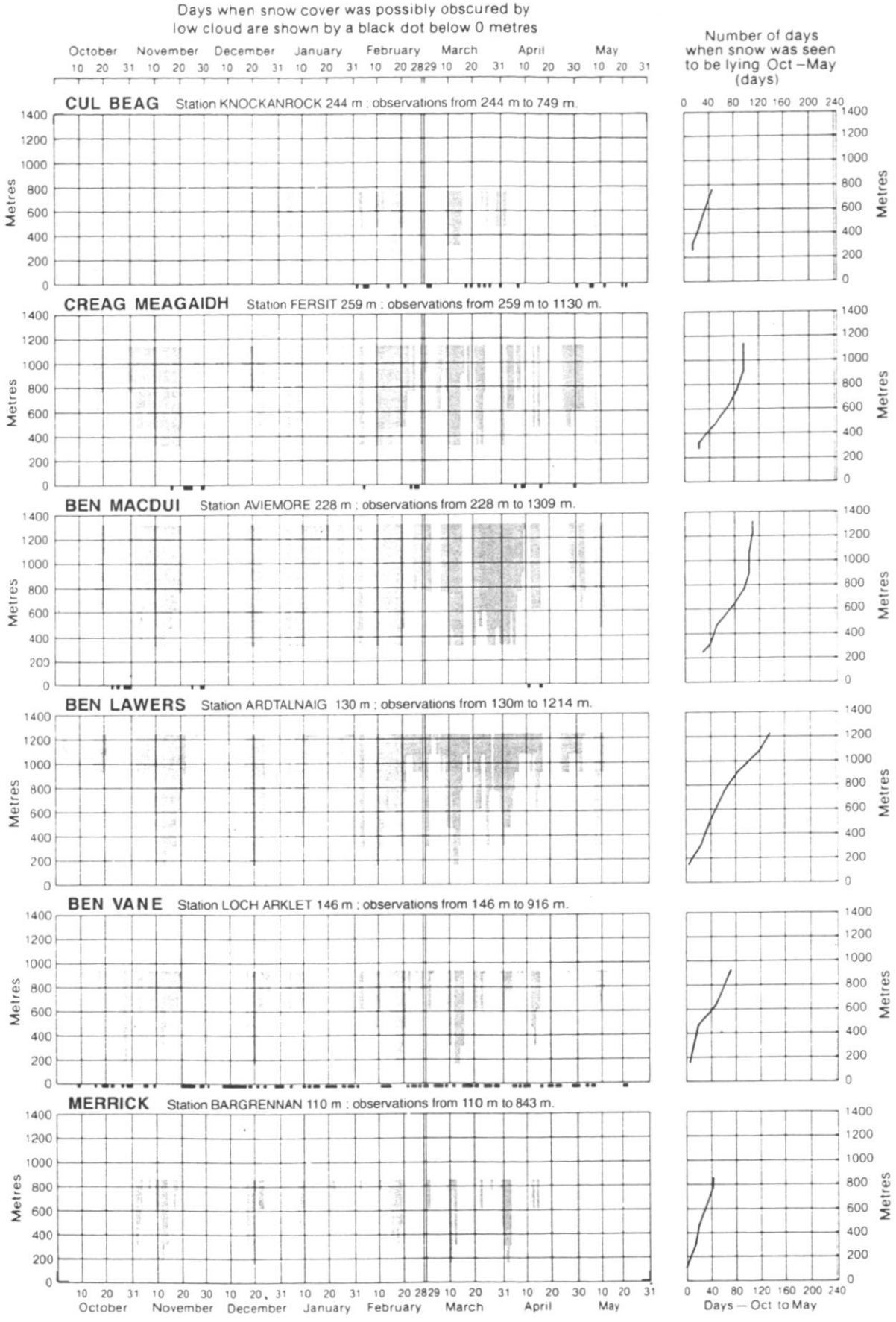


Figure 2 Distribution of snow cover 1991/92



APPENDIX 9

Information from ski companies

Information presented is copies from logs maintained by White Corries Limited (Glencoe) and Cairngorm Chairlift Company Limited. Copies of the covering letters/notes accompanying the data obtained are also presented to aid interpretation. Snow depths and information on weather conditions are likely to be of interest in both cases.

GLENCOE

DATES

30 January 1974	-	No record
7th February 1989	-	No record other than insufficient snow for skiing. Skiing began on 20th February.
5th February 1990	-	Record attached
6th March 1990	-	Record attached
2nd January 1991	-	No record as skiing did not begin until 10th January. From memory we had substantial falls of snow between Christmas and New Year and A82 was blocked for some days. On New Years eve a thaw began which caused flooding and a landslide near Glencoe on the A82 and the newly opened road was again closed for some days.
2nd January 1992	-	No record other than insufficient snow for skiing. Skiing began on 16th February. From memory there was no snow at all until into February.
17th January 1993	-	Record attached
30th March 1993	-	Record attached

Explanation of codes:

A = Alpine Weather & snow conditions
B = Good Scottish weather & snow conditions
C = Average Scottish weather and snow conditions
M = Mediocre, either weather or snow is pretty poor
Y = Very poor, had to close early or could only run minimum of lifts
Z = Stormbound, Nil return

L1 = Access lift
L2 = Cliffhanger chairlift
Neither of the above need snow as they are chairlifts

T1 = Top tow starts at 2800 feet
T2 = Lower tow starts at 2300 feet
T3 = Top tow starts at 2800 feet
T4 = Plateau tow starts at 2200 feet

On days that T4 was operating snow level was at least down to 2200 feet

8	NOV	20		2933.00	GRANT AID		
9		28		641.24	BR		
10		30		102.96	PAYMENT CLOTHING		
11	R6			3776.54			
12							
13	DEC	29		61.43	PAYMENT FOR GOODS		
14	R7			61.43			
15							
16	JAN	12		3331.00	GRANT AID		
17		22		38.96	PAYMENT CRAMPA		
18		27					
19		28	76.00			C	HEAVY SNOW SHOWERS | HIGH WINDS | GOOD SNOW
20		29	8.50			B	ALPINE AM | CLOUDY PM EXCELLENT SNOW
21	R8		84.50	3369.94		Y	HEAVY RAIN | WET SNOW
22		5	811.5				
23	FEB	1				M	GOOD SNOW | SUNNY PERIODS | VERY WINDY
24		2				Z	SEVERE GALE FORCE WINDS | SNOW "STORMBOUND"
25		3	103.50			M	WIDE CALER NEW SNOW | HIGH WINDS
26		4				Z	TORRENTIAL RAIN | HIGH WINDS "STORMBOUND"
27	1990	5				Z	TORRENTIAL RAIN | HIGH WINDS | WARM | "STORMBOUND"
28		8	13.50			M	WIND SLAB SNOW | BLUSTERY WINTER SHOWERS | HIGH WINDS
29		9	39.00			Y	WET SNOW | HIGH WINDS | SHUT DOWN | MOONIES "REFUND"
30		10	112.50			M	WET SNOW | RAIN | SNOW SHOWERS PM
31		11	53.00				VERY WINDY, HEAVY SNOWFALL "STORM WARNING FROM MET OFFICE. GEF HILL AT MOONIES "REFUND DAY"
32		12	40.00	19.00	TELEPHONE		NEW SNOW | WIDE CALER | BLUSTERY HIGH WINDS | CLIFFIE DE-RAILED
33		15	-				SUNNY PERIODS | SNOW SHOWERS HEAVY | WINDY
34		16	54.50				BLUE SKIES | LIGHT WINDS | ALPINE | CIBAB IN CAR PARK
35		17	90.50	11.00	PCs		HEAVY RAIN AM SNOW PM | WET SNOW
36	R9	18	—	6320.00	GRANT AID (CAFG)		HIGH WINDS | "STORMBOUND"
37		19					HIGH WINDS "STORMBOUND"
		HF	506.50	5350.00			

8								
9	MAR	1	–	21.28	BR	B	HY SNOW SHOWERS / SUNNY PERIODS DIG OUT ALL LIFTS	L1L2 T3T4
10		2	52.00	10.00	PCs	M	HY SNOW SHOWERS / VERY WINDY / NO TOP LIFTS	H T3T4
11		3	28-00	17.25	CAIRNGORM - POWER CURVES	Z	SEVERE SW GALES STORMBOUND	
12		4	121.50	14.00	TELE	M	HIGH WINDS / ICY SNOW / PISTA DEPAIRED / LTD OPENINGS	H T2T3
13		5	–	–		Z	HIGH WINDS / HY RAIN "STORMBOUND"	
14	1990	6		106.25	PAYMENT FOR CLOTHING		Closed on Tuesday + Wednesday	
15		7		62.00	GLEN			
16		8	–	–		C	SNOW SHOWERS / LT WINDS / NEW SNOW	L1L2 T3T4
17		9	–	–		M	HIGH WINDS AM / HY SNOW SHOWERS / CUFFIE DE-PAIRED	L1L2 T2T3T4
18		10	27.50			Z	HIGH WINDS / HY RAIN "STORMBOUND"	–
19		11	34.00	–		Z	HIGH WINDS / NOT RUNNING / STORMBOUND	–
20		12		14.00	TELE	A	LT WINDS / SUNNY	L1L2 T3T4
21		13		101.20	BR /			
22		15	18.00	43.17	NANA		HY RAIN / WET SNOW	L1L2 T3T4
23		16	24.00				HY RAIN / WET SNOW / PISTA TRACKS GONE	L1L2 T3T4
24		17	127.50	10.00	PCs		DRY AM / RAIN PM / WET SNOW / GUSTING WIND	L1L2 T1T2T3
25		18	46.00	4.03	BR		HIGH WINDS / BUTTON TRACK GONE / STORMBOUND	
26		19		314.44	CRAMPA		HIGH WINDS / SNOW SHOWERS "STORMBOUND"	
27		22	13.00	28.60	TELE		HIGH WINDS / SNOW SHOWERS / ICE ON TOP	L1 T2T3
28		23		770.00	GRANT AID (ASTE MACHINE)		HIGH WINDS / HY RAIN "STORMBOUND"	
29		24	52.50	20.00	DONATION RESCUE		HIGH WINDS / HY SNOW SHOWERS / CLOSE DOWN / LIFTS	L1 T2T3
30		25	118.00				LT WINDS / LT SNOW SHOWERS	L1L2 T1T2T3
31		26	57.50	18.44	TELE		LT WINDS / SUNNY PERIODS	L1L2 T1T3
32		R10	725.50	1554.81				
33								
34		29	52.50				LT WINDS / SUNNY PERIODS / SPRING SNOW	L1L2 T1T2
35		30	49.00				LT WINDS / SUNNY PERIODS / SPRING SNOW	L1L2 T1T2T3
36		31	188.50	49.00	CLEAN SKI (MAR)		LT WINDS / SPRING SNOW / SUNNY	L1L2 T1T2T3
37	APR	1	179.00	12.00	PCs		LT WINDS / OCCASIONAL SPRING SNOW	M L2 T1T2T3
		P/F	469.00	61.00				

WINTER 1992/93

DATE		WEATHER AND OPERATIONAL NOTES		WEATHER		LIFTS ON	CASH PAID WAGES
B.FWD							1583 84
JAN	8	Wet, Gales "STORMBOUND"			Z		
"	9	Wet, Gales "STORMBOUND"			Z		
"	10	Wet, Gales "STORMBOUND"			Z		
"	11	Heavy Snow, Severe Gales "STORMBOUND"	fresh snow		Z		1557 55
"	14	Snow Showers, Gales "STORMBOUND"	fresh snow		Z		
"	15	Wet, Gales, "STORMBOUND"	wet snow		Z		
"	16	Wet, Mild, Gales "STORMBOUND"	wet snow		Z		
1993	17	Wet, Gales "STORMBOUND"	wet snow		Z		
"	18	Wet / Snow Showers "STORMBOUND"			Z		
"	19	Snow Showers, Fresh Snow on a firm base			M	1, 2 T2, T4	1632 95
"	21	Wet / Hy Snow Showers / Gales "STORMBOUND"			Z		
"	22	Hy Snow Showers / Gales "STORMBOUND"			Z		
"	23	Good Snow Conditions, Dry a.m, Snow Showers + winds p.m			C	1, 2 1, 2, T3, T4	
"	24	Severe Gales Snow Showers "STORMBOUND"			Z		
"	25	Dry / Sunny periods a.m / Fresh snow on a firm base			M	1, 2, T2, T4	1867 22
"	27						
							1.661 54
JAN	28	Dry, Bright, Sunny periods / Hard packed snow + icy patches			C	1, 2 1, 2, T3, T4	
	29	Dry, Bright / Hard packed snow + icy patches			C	1, 2 1, 2, T3, T4	
	30	Overcast, Rain + Sleet from 2p.m / Very Icy, Top Runs Closed			M	1, 2 T2, T4	
	31	Dry, Bright, Sunny periods / Top, very icy, Middle icy patches			C	1, 2 1, 2, T3, T4	
FEB	1	Dry, Bright, Very Icy, Top Runs Closed			M	1, 2 T2, T4	2030 26
	4	Wet / Windy / Mild "STORMBOUND"	wet snow		Z		
	5	Wet / Windy / Mild "STORMBOUND"	wet snow		Z		
	6	Dry a.m / Overcast / Drizzle p.m			C	1, 2 1, T2, T3, T4	

Feb	26	Wet Day, Some Snow Showers	Icy Patches	C	L1 L2 T1, T2, T3	
"	27	Dry, Overcast, Very Icy Cold	Hard Packed, Icy Patches	S	L1 L2 T1, T2, T3	
"	28	Dry | Bright | Very Cold	Icy	B	L1, L2 T1, T2, T3	
MARCH	1	Dry | Bright | Sunny Periods | Cold	Icy Patches	B	L1 L2 T1 T2 T3	
"	4	Top Snow Showers | Lower Drizzle	Fresh Snow | Icy Patches	C	L1 L2 T1 T2 T3	2853 2
"	5	Lt Drizzle Showers | Dry | Sunny Periods	Soft Snow	C	L1 L2 T1 T2 T3	
"	6	Dry | Sunny Periods	Spring Snow	B	L1 L2 T1 T2 T3	
"	7	Sunny Periods, Light Drizzle at times	Spring Snow | Icy Patches	C	L1 L2 T1 T2 T3	
"	8	Some snow showers on top a.m | Brighter	Poor Vis Spring Snow	M	L1 L2 T1 T2 T3	2045 7
"	11	Snow Showers a.m | drizzle p.m | Poor Vis	Fresh Snow on a firm base.	M	L1 L2 T1 T2 T3	
"	12	Dry | Sunny Periods	Spring Snow	B	L1 L2 T1 T2 T3	
"	13	Wet a.m | Dry p.m | Bright	Spring Snow	M	L1 L2 T1 T2 T3	
"	14	Wet a.m | Brighter p.m	Soft Snow	M	L1 L2 T1 T2 T3	
"	15	Very wet and windy all day Poor Vis	Soft Snow	M	L1 L2 T1 T3	1982 2
"	18	Windy | Snow Showers | Hail	"STORMBOUND"	Z		
"	19	Very Windy | Rain lower | Sleet + Snow top	"STORMBOUND"	Z		
"	20	Windy | Rain lower | Sleet + Snow top	"STORMBOUND"	Z		
"	21	Sleet lower | Snow on top Cloudy		M	L1 L2 T1 T3	
"	22	Windy | Heavy Snow Showers	'STORMBOUND'	Z		
"	25	No Wind, Sunny Plateau Tow Track to Pylon 5	Fresh Snow	A	L1 L2 T1, T2, T3, T4	1843 4
"	26	Dry | Mainly Sunny Plateau Tow Track to Pylon 5	Soft Snow	B	L1 L2 T1 T2 T3 T4	
"	27	Sleet lower | Snow on top | Moderate Winds	Wet Snow	M	L1 L2 T1 T2 T3 T4	
"	28	Snow a.m | Dry + Sunny Periods p.m. Plateau Tow Track complete closed to public due to winds	Fresh Snow	C	L1 L2 T1 T2 T3 T4	
1993	29	Windy | Sleet lower | Snow on Top	Fresh Snow on a Firm Base	Y	L1 L2 T2 T4	1698 5
"	31	Closed Tuesday 30th + Weds 31st March, only open Thursday to Monday each week				
						10423 15
April	1	Overcast | Sunny Periods | Snow Showers	Fresh Snow	C	L1 L2 T1 T2 T3	
"	2	Dry | Overcast | Sunny Periods	Fresh Snow	C	L1 L2 T1 T2 T3 T4	
"	3	Overcast | Bright Periods |	Fresh Snow on top	C	L1 L2 T1 T2 T3 T4	

Cairngorm Ski Area,
Aviemore,
Inverness-shire,
PH22 1RB, Scotland.
Telephone 0479 861261
Fax 0479 861207

DEAR ANDREW

I AM AFRAID I CAN ONLY FIND 7 OUT OF 10 FIGURES YOU REQUIRED FOR BUT IF I CAN LOCATE THE BOOKS IN THE NEAR FUTURE I WILL SEND COPIES.

IN SOME SHEETS YOU WILL SEE A SNOW DEPTH BUT NO SNOW MELT READING ENTERED IN THE RAIN COLUMN. THIS IS DUE TO EITHER NOT HAVING THE TIME OR NOT BEING ABLE TO FIND THE RAIN GAUGE. HOWEVER WHEN WE DO GET A SNOW MELT READING IT IS ENTERED AS A TOTAL FOR THE PERIOD SINCE THE LAST READING WAS TAKEN

i.e. JANUARY 2ND - 17TH ALTHOUGH VARIOUS SNOW DEPTHS THERE IS ONLY A FIGURE RAIN READING AS ALL THE SNOW HAS NOT MELTED ONLY ON THE 17TH DID WE GET A FULL READING SO ALL THE READINGS WERE ADDED TOGETHER 2ND TOTALLED FOR THE PERIOD 2ND - 17TH.

HOPE THIS MAKES SENSE

YOURS SINCERELY

JANUARY 1990
17TH – 31ST

AVALANCHE RESCUE

IF YOU WITNESS AN AVALANCHE BURIAL

★ Observe the victim's progress and if possible mark the victim's point of entry and point at which last seen

Present Weather	Visibility	SCREEN Dry Bulb	SCREEN Wet Bulb	SCREEN Max.	SCREEN Min.	GRASS MIN at 09h	CONCRETE MIN at 09h	SOIL TEMPERATURES At depth 10 cm	At depth 20 cm	At depth 30 cm	At depth 50 cm	At depth 100 cm	STATE OF GROUND without snow or ice cover	STATE OF GROUND with snow or ice cover	TOTAL SNOW DEPTH at 9h	Total Amount of Rain 9h to 9h	9h-9h RUN of WIND Cup-Counter Reading Not Reported	9h-9h run of Wind diff. from prev's day	Total Sunshine for the day	(WEATHER DIARY AND R) Before 09 h GMT	
F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	
	7	0	0	0.6	-1					2.5				3	5cm				17	Strong Winds, Snow Showers	Sno
	3	-0.5	-1.0	4.0	-2.3					2.3				4	7cm	15.5	(Last two days)		18	Winds Gusting, Snow Showers, Cold	Cold
	6	0.5	0	3.8	-0.7	Windy?				2.0				2	.5cm	7.5 +			19	Windy, Hail Fog, Cold (Some Snow)	Cold
	7	3.8	2.5	9.7	-2.5	Windy				1.9				2	2cm	11.4			20	Strong Winds, Overcast, Rain	Cold
	7	6.1	5.0	8.8	3.1	Windy?				1.7				1		5.5			21	Gales Winds, Hail Fog, Mild	Cold
	3	1.5	0.1	3.2	-0.9	Windy.				2.1				1		C			22	Windy, Cold, Windy	
	6	0.5	-0.7	3	-0.6	Windy				2.0				1		16.5			23	Cold, Overcast, Windy	
	7	-2	-2.5	-1.0	-3.8					2.0				4	7				24	" " Drifting	Cold
	3	-1.1	-1.4	-0.9	-3.2					1.7				4	15				25	Snowing Windy Cold	
	7	-1.7	-1.7	1.2	-3.5					1.7				4	30cm	0.7			26	Snow Showers, Windy, Cold	
	9	-2.5	-2.5	-0.9	-2.8					1.7				4	15	Drifting off			27	Drifting Snow, Windy, Cold	
	8	-2.8	-2.7	0.2	-3.1					1.5				4	18				28	Strong Winds, Overcast, Cold	Cold
	2	0.1	-0.4	4.4	-3.9					1.4				4	16	DRIFTED OFF			29	Strong Winds, Overcast, Cold	Very
	3	1.00	0.75	2.6	+0.5					1.04				2	5cm	13.2			30	Windy Sleet Cool.	Sn
	7	0.50	-1.0	2.6	-1.0					1.00				5	10	10.5			31	Gale Cold	Sno
					-0.4																
		-0.4	0.5	-4.0																	

*These entries are 'thrown back' on Metform 32088

Cairngorm Chairlift Company, Aviemore
White Corries Ltd., Glencoe
Nevis Range Development Company, Fort William
Northern Constabulary
Grampian Police

FEBRUARY 1990
1ST – 16TH.

SCOTTISH AVALANCHE PROJECT

Wind Direction	Wind Speed	Present Weather	Visibility	Screen Dry Bulb	Screen Wet Bulb	Screen Max	Screen Min	Grass Min. at 09h	Concrete Min at 09h	Soil Temp. At depth 10 cm	At depth 20 cm	At depth 30 cm	At depth 50 cm	At depth 100 cm	State of Ground without snow or ice cover	State of Ground with snow or ice cover	Total Snow Depth at 9h	Total Amount of Rain 9h to 9h	9h-9h Run of Wind Cup-Counter Reading Not Reported	9h-9h run of Wind diff. from prev's day	Total Sunshine for the day	(Weather Diary) Before 09 h GMT
C	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	
W	40-60	02	9	0.8	-0.8	1.5?	-1.7	wind?				1.0				0						Windy, Clear, Cold Severe Winds
SW	60-90	31	3	0.0	0.0	3.3?	-0.9	wind?				1.0				8	30cm	14				~~Gale~~ DRIFTING SNOW, CO…
SSW	40-55	03	8	0.4	-0.1	4.0	-6.8	wind?				1.0				4	20cm	23.5				WINDY, COLD, CLEAR, …
SSW	50-60	64	6	3.0	2.9	8.5	+3.0?					1.3				2	10cm					Long Heavy Rain Showers, …
SW	50-70	61	6	7	6.5	9.3	+8.2?					2.5				0						Strong wind, Blown Rai…
–	–			2.0	2.0	4.8	-0.8					2.8				1		57.5				Mild, Rain Mainly…
W	20-30	02	8	0.2	-0.2	3.2	-1.1					2.8				0		0.4				Windy, Cold, Some Ra…
W	30-50	02	8	-1.0	-1.8	2.5	-1					2.7				1		1.5				" , " , Snow Sh…
SSE	50-70	70	6	3.0	.75	4.2	-2.7	wind	wind			2.5				1		~~4.5~~				Windy Snow show…
SW	20-40	65	7	2.2	1.9	3.8	-1.4	?				2.4								[illegible]		Windy. ~~Bl…~~ Heavy Rain
WSW	30-40	02	5	-3	-3.5	+1.0	[illegible]					2.1				3	6	10.2				Bright Drifting
E	25-35	70	8	-3	-3.5	-1	-2.7					2.0				4	14					Light Wind snow sh…
W	20-30	02	8	-2	-2.5	0	-3.4					2				3	14					Light Wind Clea…
NW	20	71	3	-2.1	-2.1	-0.1	-2					2				3	12					Snowing
WNW	25	02	7	-2.6	-2.6	0	-2.8					1.9				3	12					light breeze Co…
W	15-25	02	9	-2	-2	5	-2					1.9				3	12	18.8				" "

*These entries are 'thrown back' on Metform 3208B

SCOTTISH SPORTS COUNCIL

JANUARY 1991
2ND - 17TH

Year 1991 Hour	Month JAN. Date	Total Cloud	Wind Direction	Wind Speed	Present Weather	Visibility	Screen Dry Bulb	Screen Wet Bulb	Screen Max	Screen Min	Grass Min at 09h	Concrete Min at 09h	Soil at depth 10 cm	Soil at depth 20 cm	Soil at depth 30 cm	Soil at depth 50 cm	Soil at depth 100 cm	State of Ground without snow or ice cover	State of Ground with snow or ice cover	Total Snow Depth at 9h	Total Amount of Rain 9h to 9h	9h-9h Run of Wind Cup Counter Reading Not Reported	9h-9h run of Wind diff. from prev's day	Total Sunshine for the day	Be[illegible]
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U					
WED	2nd	0	[illegible]	[illegible]	70	5	0.1	0	[illegible]	[illegible]															
THU	3rd	4	[illegible]	[illegible]	[illegible]	7	1.4	-1.6	2.0	[illegible]					1.0				4	3 cm					Strong win[illegible]
FRI	4th	7	[illegible]	[illegible]	[illegible]	7	1.5	0.8	2.0	-3.1	[illegible]				1				5	5 cm	0.3				"
SAT	5th	3	SW	30-40	[illegible]	7	-1	-0.1	[illegible]	[illegible]					1.5				4	10 cm					"
SUN	6th	8	NW	25-35	70	7	0	0	1	-1.5	✓				1.5				4	9 [illegible]					
MON	7th	8	S	10-20	[illegible]	8	-2.6	-3.5	-1.[illegible]	-2.9					1.5				9	11 cm					STRONG WI[illegible]
TUE	8th	3	SW	30-40	[illegible]	8	-2.9	-3	-1.5	-4.5					1.5				8	10 [illegible]					misty
WED	9th	6	SSW	[illegible]	[illegible]	7	-2.5	-2.5	0.8	-6					1.5				7	10					Cold
THU	10th	5	SSW	35-55	02	3	-0.5	-0.5	0.1	[illegible]	-2				1.5				7	10	3.0	47.8			Cold
FRI	11th	4	W	10-25	02	8	0	0	-0	[illegible]	-1.8				1.5				7	1[illegible]					Cold windy
SAT	12th	6	NW	[illegible]	02	8	-1.5	3.6	[illegible]	-4.[illegible]					1.5				7	1[illegible]					Cold [illegible]
SUN	13th	[illegible]	S	5-10	02	3	-1	-1	1.[illegible]	-4.6									7	10					Cold light [illegible]
MON	14th	8	S	[illegible]	02	2	-1.3	-1.3	0.6	-2.9					1.5				7	10					Cold clear
TUE	15th	2	S	30-60	[illegible]	5	-2.6	-2.2	0.4	-3.[illegible]					1.5				7	0					Warm [illegible]
WED	16th	2	S	15-40	02	4	3.5	1	6.5	-2.5					1.4				3	5					Warm [illegible]
THU	17th	4	S	15-40	36	4	0.6	0	5.2	-9					1.5				2	4	7 / 37.5				Very windy / Windy, Col[illegible]

"These entries are 'thrown back' on Metform [illegible]"

DECEMBER 1991
17TH – 31ST

SCOTTISH AVALANCHE PROJECT

Visibility	SCREEN		SCREEN		GRASS MIN. at 09 h	CONCRETE MIN. at 09 h	SOIL or EARTH TEMPERATURES					STATE OF GROUND	SNOW DEPTH at 9 h	
	Dry Bulb	Wet Bulb	Max.	Min.			At depth 10 cm	At depth 20 cm	At depth 30 cm	At depth 50 cm	At depth 100 cm		Total	Fresh
G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
7	5·0	3·7	5·6	+2·9	✓				3·0			1		
6	-1·5	-2·0	4·5	-2·4	✓	(max+1·6)			3·0			2	5cm	5cm
7	1·1	0·3	1·5	-1·6	✓	(max+1·0)			2·6			1		
5	-3·5	-3·5	-0·7	-3·5	✓				2·5			8	10cm	10cm
5	-1·7	-1·5	8·0	-3·5	✓				2·5			8	15	5
6	6·5	5·5	7·9	-0·2	?	windy (max 6·5)			2·2			1		
7	-0·4	-1·5	6·5	-0·4	?				2·5			2		
7	-1·0	-1·3	4·9	-1·5	✓	(max+1·1)			2·4			6	2	2
7	2·9	2·8	7·4	-2	✓				2·2			2	1·5	
8	3·5	2·6	6·2	+2·9	?				2·4			2		
9	5·1	3·3	8·9	2·3	✓				2·6			1		
8	4·6	2·9	7·5	3·3	✓				3·3			1		
8	1·5	0·6	6·0	1·5	✓	(max+1·4)			2·7			1		
6	4·5	3·5	6·5	-1·5	✓	(max-0·5)			2·6			4		
7	3·6	2·5	8·0	-0·5	?				2·6			2		

*These entries are "thrown back" on Metform 3208B

*Total amount of Rain, 9 h-9 h	9 h-9 h RUN of WIND	9 h-9 h run of Wind diff. from prev's day*	Total Sunshine for the day	WEATHER DIARY A
	Cup-counter Reading Not Reported			Before 09 h GMT
V	W	X	Y	
17.2				WINDY SHOWERS (RAIN+HAIL) CONTINUING WIN
19.3				LIGHT WIND, SNOW, MIST, COLD WINDY SNO
				WINDY COOL - MAINLY OVERCAST CONTIN
				" COLD OVERCAST SNOW SHOWERS DURING
19.0				CONTINUED " " "
0.3				WINDY, RAINING, MILD CONTINUING
5.5				LIGHT WIND, OVERCAST, COOL LIGHT WIN
0.6				LIGHT WIND, HAIL, SNOW SHOWERS LIGHT W
0				WINDY, SCATTERED SHOWERS, MILDER REMAINI
T				STRONG WINDS, DRY BRIGHT - OVERCAST
0				LIGHT BREEZE, DRY, BRIGHT DRY, HAZ
T				WINDY, DRY, BRIGHT CONTINU
0				CALM, COOL, CLEAR LIGHT WIN
0.2				LIGHT BREEZE, CLEAR, COOL WIND INCR
19				VERY STRONG WIND, OVERCAST, DRIZZLE WINDS

JANUARY 1992
1ST – 16TH

SCOTTISH AVALANCHE PROJECT

Visibility (G)	SCREEN Dry Bulb (H)	SCREEN Wet Bulb (I)	SCREEN Max. (J)	SCREEN Min. (K)	GRASS MIN. at 09h (L)	CONCRETE MIN. at 09h (M)	SOIL or EARTH TEMPERATURES At depth 10 cm (N)	At depth 20 cm (O)	At depth 30 cm (P)	At depth 50 cm (Q)	At depth 100 cm (R)	STATE OF GROUND (S)	SNOW DEPTH at 9h Total (T)	SNOW DEPTH at 9h Fresh (U)	*Total amount of Rain 9h–9h (V)	9h–9h RUN of WIND Cup-counter Reading Not Reported (W)	9h–9h run of Wind diff. from prev's day* (X)	*Total Sunshine for the day (Y)	WEATHER DIARY AND … Before 09h GMT	
7	1.4	0.3	9.5	[illegible]					2.6			2			[illegible] ← 1.7				WINDY, OVERCAST, RAINSHOWERS	Con…
7	8.5	7.2	10.0	-9.5	?				3.4			3			31.3				Very Strong Winds, Overcast, Rain	"
5	0.3	0.3	1.1	0.3					3.?			1			8.5				Strong Winds, Overcast, Snow [illegible]	/ Windy…
6	-1.4	-1.2	0.6	-2.8					3.2			2		4cm	1.6				WINDY, OVERCAST, SNOW PERIODS	Windy …
8	-0.6	-1.0	6.0	-1.5					3.0			2			3.9				Light Wind, Cold, Clear	Continuing…
6	7.1	6.1	9.0	5.8	?	(Max 7.5)			2.9			2			15.2				Strong Winds, Rain Showers, Mild	Strong Win…
6	5.1	5.0	5.7	2.5	?				3.2			2			23.6				" " " , Cool	Wind Decr…
5	-0.8	-0.8	0.4	-1.0					3.2			3	15	15	12.4				Windy, Overcast, Snow [illegible]	Con A…
2	-2.8	-2.9	0.7	-3.4					3.0			3	14	3	0.4				Light Wind, Snowing, Cold	Becoming Lig…
8	0.5	-1.0	4.9	-7.2					2.5			3	15		0.1				Light Wind, Clear, Cold.	Wind Rising, Li…
7	4.0	3.1	4.6	0.4					2.4			1			0.3				Windy, Cool, Mainly Overcast.	Wind Dropping…
[illegible]	3.5	3.5	4.9	2.6					2.2			1			0.1				Light Drizzle Showers, Calm, Fog	Becoming…
8	2.4	0.6	6.8	0.3					2.2			0			0				Calm, Clear, Cold	Continuing…
5	1.2	0.6	6.2	0.2					2.2			0			9				" " " "	Con And…
1	5.8	1.2	6.5	-0.3					2.0			0			[illegible]				" " " Valley Fog	Continuing…
[illegible]	2.3	2.0	3.9	-2.2	?	(Max 2.1)			2.0			0			1.3				Hill Fog, Slight Drizzle, Cool, Light Wind	Wind Rising…

*These entries are 'thrown back' on Metform 3208B

JANUARY 1993

SCOTTISH AVALANCHE PROJECT

[illegible]EN Min. (K)	GRASS MIN. at 09h (L)	CONCRETE MIN. at 09h (M)	SOIL or EARTH TEMPERATURES At depth 10 cm (N)	At depth 20 cm (O)	At depth 30 cm (P)	At depth 50 cm (Q)	At depth 100 cm (R)	STATE OF GROUND (S)	SNOW DEPTH at 9h Total (T)	Fresh (U)	*Total amount of Rain 9h-9h (V)	9h-9h RUN of WIND Cup-counter Reading Not Reported (W)	9h-9h run of Wind diff. from prev's day* (X)	Total Sunshine for the day (Y)	WEATHER DIARY AND REMARKS Before 09h GMT	After 09h GMT
2.8	?X				1.3			4			4.2				Strong Gale Gusting Storm Cloud[illegible] Dry /	Con All [illegible]
3.2	?				1.3			1			0.0				Strong Breeze With Occasional Light Drizzle	
1.9					1.3			1-4			20				Strong Breeze Gusting Hale[illegible] Dry [illegible] /	Violent Storm
2.1					1.3			4	Wind [illegible]		17				Light winds, Mild, Overcast /	Becoming windier
2.3					1.3			2	8		5.5				Strong winds, heavy rain overcast	Turning to snow
[illegible]					1.3			2	2c		1.4				Snow showers in fresh breeze /	[illegible] snow showers mostly dry
[illegible]					1.3			0			5.8	+ snow 5.4			Becoming colder Near Gale winds /	wind increasing Gale Force
1					1.2			8	8		13.0				Mod snow in fresh breeze /	Con all day /
2.5	Max & Min				1.2			8	8		—				Snow showers mod winds / Storm bound	Con. all day with
3	Over Two Days				1.1			8	12	4	[illegible]				Violent Storm Gusting Hurricane Storm bound	(winds & snow)
0					1.0			8	13						Heavy snow showers / cold mod winds /	Con. all day
4	[illegible]				1.0			8	13		31.7	Snow cut			Light winds / Drifting overcast /	wind increasing [illegible]
1	?				1.0			8	13	[illegible]					Light drifting / in fresh to near gale winds /	clearing [illegible]
1	Max & Min				0.9			8	22	[illegible]					Mod snow drifting in violent storm winds /	Con all day
[illegible]	Over Two Days				0.4			1			1.8	Snow [illegible]			Continuous rain in strong to gale force winds /	Rain turning to snow [illegible]
5					0.8			4	12		63.8				Sub- [illegible] Storm Force winds /	Continuous rain in strong to [illegible]

[illegible]es are 'thrown back' on Metform 3208B

SPORTS COUNCIL

JANUARY 1993

17TH + 31ST

NTC- 947X FAWN CAVALIER

Present Weather	Visibility	SCREEN Dry Bulb	SCREEN Wet Bulb	SCREEN Max.*	SCREEN Min.	GRASS MIN. at 09h	CONCRETE MIN. at 09h	SOIL or EARTH TEMPERATURES At depth 10 cm	At depth 20 cm	At depth 30 cm	At depth 50 cm	At depth 100 cm	STATE OF GROUND	SNOW DEPTH at 9h Total	SNOW DEPTH at 9h Fresh	*Total amount of Rain, 9h-9h	9h—9h RUN of WIND Cup-counter Reading Not Reported	9h-9h run of Wind diff. from prev's day*	Total Sunshine for the day	WEATHER Before 09h GMT	WEATHER D[illegible]
F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y		
72	4	-0.7	-1.0	0.3	-6.1	[illegible]				1.7			[illegible]	[illegible]					7	Mod Snow Showers/In Heavier	- 4[illegible]
03	8	-1.4	-2.0	0.3	-3.6					1.5			2	6	3	0	Chain in container		8	DRY, COLD, MOD WINDS	CO[illegible]
03	8	-0.5	-0.7	6.0	-2.6					1.5			3	12	6	9.7			9	DRY, COLD, MOD WINDS	TWI[illegible]
02	8	4.1	2.5	5.4	-2.7	?				1.4			1				Gauge not [illegible]		10	DRY, COOL, STRONG BREEZE	RAINS
03	7	2.8	1.7	5.5	-2.0					1.2			2	12		74.8			1	DRY, COOL, GALE GUSTING V[illegible]	
77	3	-0.2	-0.2	0.9	-1.5					1.1			1	12					2	HEAVY SNOW SHOWERS/IN STRONG	
02	9	0.8	-0.5	5.0	-2					1.1			4	20		28.1	Gauge not measured		3	OVERCAST, DRY, FRESH BREEZE	WIND [illegible]
03	8	0	0	0.4	-2					1.0			4	12		1			4	" " " –	MODERATE
03	8	-6.5	-6.7	1.2	-6.5					0.9			8	16	6	0.0			5	VERY COLD, MOD WIND, OVERCAST	
03	8	1.2	0.3	1.9	-7.1	?				1.1			4	16		7.8	Snow not melted		6	DRY, COOL, FRESH BREEZE	CO[illegible]
02	9	0	-0.7	5.7	-1.2					1.1			4	16		27.4			7	" " , [illegible]	
01	9	1.5	1.0	3.0	-0.3					1.1			2	7		0			8	" " , CALM	[illegible]
02	9	0.4	-0.4	3.5	-2.7					1.1			2	7					9	" , cool, "	DRY [illegible]
02	9	0.4	-1	6.	[illegible]					1.1			2	7		0			0	DRY, WINDY, COLD	DRY TE[illegible]
01	9	0	4.5	6.5	6					1.1			1	4		0			1	DRY, COLD, CLEAR SKIES	CONT [illegible]

*These entries are 'thrown back' on Metform 3208B

SCOTTISH AVALANCHE PROJECT

AVALANCHE RESCUE

IF YOU WITNESS AN AVALANCHE BURIAL

- ★ Observe the victim's progress and if possible mark the victim's point of entry and point at which last seen.
- ★ CHECK for further avalanche danger.
- ★ Make a QUICK SEARCH of the whole debris surface

— LOOK for any signs of victims

21ST–31ST MARCH / 1ST–6TH APRIL 1993

Wind Speed	Present Weather	Visibility	Screen Dry Bulb	Screen Wet Bulb	Screen Max.*	Screen Min.	Grass Min. at 09h	Concrete Min. at 09h	Soil at depth 10 cm	Soil at depth 20 cm	Soil at depth 30 cm	Soil at depth 50 cm	Soil at depth 100 cm	State of Ground	Snow Depth at 9h Total	Snow Depth at 9h Fresh
E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
7	22	9	0	-0.3	0	-0.0					3			3	[illegible]	[illegible]
30	71	6	1.0	0.5	1.[illegible]	-1.0					3			3	1cm	1cm
25	75	[illegible]	-3.2	-3.0	0	-[illegible]					[illegible]			9	11cm	15cm
15	02	9	-0.5	-0.5	+1.1	-3.5					2.5			8	11	10cm
00	02	4	-1.2	-1.2	5.3	-4.1					2.1			8	12	1.[illegible]
09	02	9	1.5	0	4.5	-2.6					2.0			1		
[illegible]	02	6	1.7	1.0	4.3	1.5					1.0			1		
25	03	6	1.4	0.2	3.5	-1.5					2.1					
35 55	69	3	2.5	2.5	6.5	1.4					2.3			1		
40 55	65	3	5.0	5.0	6.5	2.5					2.5			2		
25	03	9	1.5	0.0	7.2	1.[illegible] [illegible]					2.5			3		
2	03	9	1.5	0.4	7.8	-1.6					2.8			2		
00	01	8	1.4	1.0	7.5	0.1					2.4			1		
22	03	8	2.3	1.2	5.1	0.5					3.0			2		
16	70	6	0.0	-0.2	5.1	-0.2					3.0			1		
48	75	3	0.2	-0.1	4.0	-1.1					2.7			1		
														12	13cm	

*These entries are 'thrown back' on Metform 3208B

*Total amount of Rain, 9h–9h	9h–9h Run of Wind: Cup-counter Reading Not Reported	9h–9h run of Wind diff. from prev's day*	Total Sunshine for the day	Weather: Before 09 h GMT	Weather
V	W	X	Y		
0.0			-	Gentle Brz, Cold, Sunny [illegible]	
0.5			2	Near gale, cold, snowing	Cold
4			3	Strong breeze, snowing	Cold
1.0	[illegible]		4	[illegible] breeze [illegible]	Low
0	Unable to [illegible] snow melt reading [illegible] 31st		5	Brz, Sunny, Cold, Cold	[illegible]
0.0			6	" " Gentle Brz	
0.7			7	Near gale [illegible]	[illegible]
			8	Near gale ~~Strong breeze~~ [illegible]	W[illegible]
			9	Gale ~~Strong~~ winds Sleet-snow	Con[illegible]
3/4	Bottle		0	Gale ~~Strong~~ winds + heavy	[illegible]
4	2 acc		1	Near gale, sunny, cloud increasing	
0.6			1	Light air, sunny, "	
0			2	Overcast, cold, some [illegible]	Fog
4.5			3	Becoming ", strong brz, cool	overcast
8.9			4	Fresh brz, light snow showers	[illegible]
34	with melt		5	Blizzard conditions	Gale force
15.1					

MAY 1993

9TH – 23RD

Speed (E)	Present Weather (F)	Visibility (G)	Screen Dry Bulb (H)	Screen Wet Bulb (I)	Screen Max (J)	Screen Min (K)	Grass Min. at 09h (L)	Concrete Min. at 09h (M)	Soil at depth 10 cm (N)	At depth 20 cm (O)	At depth 30 cm (P)	At depth 50 cm (Q)	At depth 100 cm (R)	State of Ground (S)	Snow Depth at 9h Total (T)	Fresh (U)	Total amount of 9h–9h (V)	9h–9h Run of Wind Cup-counter Reading (W)	9h–9h run of Wind diff. from prev's day* (X)	Total Sunshine for the day (Y)	Weather Before 09 h GMT
00	01	7	7.0	6.5	10.4	4.0					6.0			1							
2	03	8	5.9	4.7	11.2	0.5					5.7			1			1			8	Bought & Sunny [illegible]
2	02	8	7.8	5.7	14.7	1.0					6.0			1			0			9	BRIGHT, SUNNY, SOME CLOUD OVER T[illegible]
1	02	8	9.8	6.7	13.7	4.2					6.3			1			T			0	BRIGHT, SUNNY, COOL
[illegible]	[illegible]	3	3.5	3.4	10.6	1.3					6.3			0			0			1	BRIGHT [illegible] COOL
6	72	4	[illegible]	[illegible]	0.5	-0.2					6.2						8.9 ← 8.9			2	[illegible] Fog, [illegible]
6	71	6	0.2	[illegible]	1.8	-1.8					5.8			3	3cm	3cm	12.8 ← 12.8			3	OVERCAST [illegible] SNOW SHOWERS [illegible]
20	75	4	0.8	0.1	3.1	-1.0					5.2			3	9cm		9.3 + 8 ← 17.3			4	" [illegible]
1	70	7	1.8	1.1	8.0	-0.2					4.7			3	3cm		[illegible] ← 27.7			5	" HEAVY "
15	63	5	7.8	7.0	11.2	1.1					3.3			3	3[illegible]	[illegible]	11.1				SNOW SHOWERS, FRESH WINDS, SUN
0	50	8	5.0	3.1	10.0	3.5					5.5			1			48.9				CONTINUOUS RAIN, LOW CLOUD, [illegible] WIND, MILD
5	02	8	7.9	6.0	10.2	3.3					5.3			2			0.1				STRONG WIND, SUNNY & [illegible]
	02	9	8.1	5.2	13.2	2.1					5.1			1			TRACE				LIGHT BREEZE, OVERCAST, DRY
0	45	0	6.0	6.0	10.2	3.4					5.5			1			2.5				SUNNY, CALM, MILD, CLEAR
4	02	9	10.2	6.4	15.5	5.7					5.7			1			1.0				DENSE FOG, CALM, COOL
2	02	9	13.0	9.0	18.4	7.1					6.2			1			TRACE				CLEAR, LIGHT [illegible], MILD
														1			0				CLEAR, SUNNY, WARM, CALM.

*These entries are "thrown back" on Metform 3208B

APPENDIX 10

River gauging stations for which data are presented

No	River	Station	National Grid Reference
15001	Isla	Forter	NO187647
15003	Tay	Caputh	NO082395
15006	Tay	Ballathie	NO147367
15007	Tay	Pitnacree	NN924534
15010	Isla	Wester Cardean	NO295466
15011	Lyon	Comrie Bridge	NN786486
15012	Tummel	Port-na-Craig	NN940577
15013	Almond	Almondbank	NO067258
15014	Ardle	Kindrogan	NO056631
15016	Tay	Kenmore	NN782467
15023	Braan	Hermitage	NO014422
15024	Dochart	Killin	NN567320
15025	Ericht	Craighall	NO174472
15030	Dean Water	Dean Bridge	NO293458
15033	Lyon	Moar	NN535451
15034	Garry	Killiecrankie	NN901637
15035	Tummel	Kinloch Rannoch	NN663588
15036	Garry	Dalnamein	NN747694
15038	Tummel	Bridge of Gaur	NN497570
15039	Tilt	Marble Lodge	NN892716
15041	Lyon	Camusvrachan	NN620477
15042	Tay	Perth	NO116253
16001	Earn	Kinkell Bridge	NN933167
16002	Earn	Aberuchill	NN754216
16003	Ruchill Water	Cultybraggan	NN754216
16004	Earn	Forteviot Bridge	NO044184
16007	Ruthven Water	Aberuthven	NN975154
16012	Earn	Dalginross	NN779220
16013	Earn	Bridge of Earn	NO135184

APPENDIX 11

River flow/stage data collected

	1/74	8/85	2/89	2/90	3/90	1/91	1/92	1/93	3/93	5/93
15001							H	H	H	H
15003	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
15006	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
15007	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
15010	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
15011	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
15012		Q	Q	Q	Q	Q	Q	Q	Q	Q
15013	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
15014		Q	Q	Q	Q	Q	Q	Q	Q	Q
15016		Q	Q	Q	Q	Q	Q	Q	Q	Q
15023		Q	Q	Q	Q	Q	Q	Q	Q	Q
15024		Q	Q	Q	Q	Q	Q	Q	Q	Q
15025		Q	Q	Q	Q	Q	Q	Q	Q	Q
15030						Q	Q	Q	Q	Q
15033						H	H	H	H	H
15034						Q	Q	Q	Q	Q
15035						Q	Q	Q	Q	Q
15036						H	H	H	H	H
15038							Q	Q	Q	Q
15039							Q	Q	Q	Q
15041							Q	Q	Q	Q
15042							H	H	H	H
16001	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
16002							H	H	H	H
16003	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
16004		Q	Q	Q	Q	Q	Q	Q	Q	Q
16007						Q	Q	Q	Q	Q
16012								H	H	H
16013								H	H	H

Q: Discharge data collected
H: Stage data collected

APPENDIX 12

Reservoir level data collected

		74	85	89	90	90	91	92	939393
Tummel Valley									
Seilich		DS	D	DS	DS	DS	DS	DS	DD
Cuaich		S		S	S	S	S	S	
Ericht		D	D	DS	DS	D	D	D	DD
Garry		D	D	D	D	D	D	D	DD
Eigheach		DS	D	DS	DS	DS	DS	DS	DD
Rannoch		DS	D	DS	DS	DS	DS	DS	DD
Dunalastair		S		S	S	S	S	S	
Errochty		DS	D	DS	D	D	D	D	DD
Tummel		DS	D	DS	DS	DS	DS	DS	DD
Faskally		DS	D	DS	DS	DS	DS	DS	DD
Breadalbane									
Daimh	D	D	D		D	D	DS	D	DDS
Lyon		DS	D	D		D	D	DS	DSDDS
Stronuich	DS	D	D		D	D	DS	DS	DDS
Lairige	D	D	D		D	D	DS	D	DDS
Earn		D	D	D		D	D	DS	DSDDS
Lednock	D	D	D		D	D	D	D	DD
Breaclaich	D	D	D		D	D	D	D	DD

D: Daily levels collected, normally based on actual dam observations
S: Sub-daily levels collected, mostly based on gauged (pressure transducer) readings

APPENDIX 13

Daily reservoir level observations

Data are presented for the Tummel Valley and Breadalbane hydro systems. Files are supplied on disk in Lotus 1-2-3 .WK3 format.

Values (in metres OD) are either actual dam observations or good estimates based on known transducer correction factors, unless shown in *italics*. In this latter case, values are based on pressure transducer readings without any correction being applied.

Daily Reservoir Level Observations - Tummel Valley Scheme

Italics indicate a pressure transducer (tele-talk) reading as opposed to actual observation at dam or good estimate based on known transducer error

August 1985

Date	Seilich	Garry	Ericht	Eigheach	Rannoch	Errochty	Tummel	Faskally
22	425.4	412.42	357.96	257.12	203.71	327.51	143.56	89.002
23	425.2	412.29	358.01	257.12	203.73	327.13	143.38	90.424
24	425.41	412.88	358.04	257.61	203.63	327.28	143.61	91.542
25	425.58	413.16	358.06	257.45	203.61	327.43	143.66	90.449
26	426.21	413.64	358.19	257.1	203.53	327.74	143.71	90.221
27	426.11	413.94	358.19	256.97	203.61	327.46	143.69	90.399
28	426.49	415.06	358.37	258.19	203.73	327.51	143.69	91.44
29	426.42	414.93	358.37	258.78	203.78	327.2	143.69	90.399

February 1989

Date	Seilich	Garry	Ericht	Eigheach	Rannoch	Errochty	Tummel	Faskally
4	426.23	414.83	358.26	258.53	204.73	317.3	142.95	90.251
5	426.26	414.68	358.29	259.35	204.86	326.75	143.59	90.038
6	426.72	415.02	358.51	259.54	204.95	327.78	143.77	91.531
7	427.21	415.32	358.99	260.12	205.56	327.96	144.11	91.653
8	426.99	414.71	359.05	259.66	205.4	327.42	144.11	91.562
9	426.69	414.59	358.96	259.32	205.07	327.48	144.08	91.501
10	426.45	414.47	358.96	259.08	204.89	327.42	144.02	91.531
11	426.35	414.31	358.93	258.59	204.83	326.75	143.47	91.47
12	426.29	414.28	358.9	258.65	204.83	326.99	143.2	90.678

February 1990

Date	Seilich	Garry	Ericht	Eigheach	Rannoch	Errochty	Tummel	Faskally
2	426.38	414.58	357.59	259.57	204.83	326.44	143.68	91.531
3		414.53	357.74	259.48	204.86	326.26	143.59	91.531
4	426.42	414.65	357.77	259.45	204.89	326.2	143.1	91.531
5	427.6	415.44	358.69	260.12	205.86	327.45	144.11	91.592
6	427.51	415.14	358.84	259.84	205.74	327.57	144.14	91.562
7	427.27		358.84	259.69	205.44	326.99	144.11	91.562
8	427.09	414.83	358.69	259.35	204.89	326.47	144.05	91.531
9	426.99	414.65	358.66	259.26	204.67	326.14	143.62	91.531

March 1990

Date	Seilich	Garry	Ericht	Eigheach	Rannoch	Errochty	Tummel	Faskally
3	426.42	414.41	358.75	257.01	204.52	324.73	143.59	90.343
4	426.6	414.89	358.9	258.44	509.44	325.34	143.47	91.531
5	426.78	*414.86*	359.08	259.48	204.61	326.14	143.1	91.531
6	427.51	415.23	359.36	259.87	205.25	326.87	143.87	91.592
7	427.42	415.23	359.36	259.84	205.19	327.02	144.2	91.562
8	427.12	414.83	359.45	259.6	205.07	326.99	144.14	91.531
9	427.02	414.77	359.36	259.35	204.76	326.5	144.08	91.531
10	427.02	414.74	.359.3	259.2	204.64	326.26	143.65	91.531

January 1991

Date	Seilich	Garry	Ericht	Eigheach	Rannoch	Errochty	Tummel	Faskally
31	425.71	*411.88*	356.16	258.5	204.4	*326.32*	143.01	90.282
1	425.5	411.57	356.16	257.5	204.22	326.01	142.8	90.343
2	426.23	411.78	356.52	258.59	204.76	326.65	143.38	91.592
3	426.9	412.39	356.62	259.42	204.76	326.84	143.62	91.531
4	426.75	412.33	356.68	259.26	204.64	326.84	143.47	91.501
5	428.06	412.27	356.92	259.42	204.76	325.86	143.59	91.531
6	426.75	412.09	356.98	259.38	204.83	325.92	143.56	91.531
7	426.57	411.91	356.86	259.26	204.7	326.11	143.38	91.531

January 1992

Date	Seilich	Garry	Ericht	Eigheach	Rannoch	Errochty	Tummel	Faskally
31	425.23	412.09	357.1	257.31	203.73	326.44	143.16	89.916
1	425.59	412.39	357.1	257.37	204.03	326.62	143.38	90.282
2	426.69	412.94	357.29	259.05	204.34	*327.42*	143.41	91.166
3	427.42	415.08	357.77	259.87	205.37	328.21	143.74	91.562
4	426.93	415.08	357.9	259.54	205.25	327.2	144.11	91.562
5	426.69	414.83	358.02	259.26	204.83	326.32	144.11	91.531
6	426.38	414.68	358.14	259.08	204.58	325.31	143.62	91.531
7	427.15	414.68	358.69	259.6	204.73	325.62	143.59	91.592

January 1993

Date	Seilich	Garry	Ericht	Eigheach	Rannoch	Errochty	Tummel	Faskally
14				257.5		324.12	143.29	90.8
15				257.04		323.91	143.41	
16							143.8	
17			357.77		205.71	326.62	144.11	
18	427.06		357.93	259.6	205.34		144.11	91.592
19	428.06		358.05	259.26	204.73			
20	438.97	414.62	358.08	259.54	204.73	326.5	144.02	
21	426.96	414.56	358.05	259.45	204.67	326.75	143.65	91.531

March 1993

Date	Seilich	Garry	Ericht	Eigheach	Rannoch	Errochty	Tummel	Faskally
27	425.9	413.98	358.6	257.31	204.43	328.03	142.95	90.983
28	0	0	0	0	0	0	0	91.135
29	426.42	413.89	358.63	257.07	0	0	143.1	90.83
30	0	0	0	0	0	0	143.41	0
31	*426.99*	0	358.9	257.46	0	328.03	0	0
1	426.84	414.56	0	257.31	0	327.51	0	0
2	426.72	414.5	358.81	257.68	204.7	327.17	143.16	90.465

May 1993

Date	Seilich	Garry	Ericht	Eigheach	Rannoch	Errochty	Tummel	Faskally
14	425.44	409.5		257.04				
15	425.39	409.41	357.14	256.85	203.87	317.75	472.11	90.678
16	425.5	409.41	357.14	257.16	203.89	317.75	143.61	90.891
17	425.81	409.65	357.32	257.86	203.85	317.69	143.71	90.8
18	427.18	411.42	357.47	258.2	204.49	318.39	143.62	91.562
19	426.84	411.54	357.47	258.26	204.52	317.36	143.41	90.251
20	426.69	411.33	357.44	257.77	204.52	317.3	143.35	90.19
21	426.63	410.9	357.41	257.4	204.49	317.24	143.23	90.282

Daily Reservoir Level Observations - Breadalbane Scheme

Italics indicate a pressure transducer (tele-talk) reading as opposed to actual observation at dam or good estimate based on known transducer error

January 1974

Date	Lyon	Daimh	Stronuich	Lairige	Breaclaic	Lednock	Earn
26	343.11	432.48	*291.08*	519.07	440.44	351.59	97.14
27	343.42	432.82	*292.12*	519.71	441.05	352.41	97.292
28	343.36	432.79	*291.08*	519.44	441.2	352.32	97.323
29	343.42	432.66	*289.29*	519.07	441.35	352.2	97.323
30	343.33	432.57	*289.93*	518.92	441.5	352.04	97.506
31	343.81	432.82	292.43	518.92	442.63	352.47	97.963
1	343.51	432.82	292.18	519.38	442.75	352.2	97.749
2	343.63	432.82	292.36	519.41	442.54	352.47	116.01
3	343.51	432.42	292.36	519.32	442.87	352.35	97.688
4	343.48	432.45	289.99	519.07	443.03	352.14	97.566
5	343.05	432.42	290.11	518.62	442.54	351.89	97.384

August 1985

Date	Lyon	Daimh	Stronuich	Lairige	Breaclaic	Lednock	Earn
22	339.61	425.41	290.66	516.94	441.05	349.79	96.744
23	339.52	425.26	290.35	516.64	441.5	350	96.591
24	339.94	425.44	290.6	517	441.96	350.98	96.744
25	339.91	425.53	290.44	516.88	442.36	351.4	96.683
26	339.67	425.35	290.17	516.64	442.39	351.65	96.561
27	339.49	425.35	290.29	516.03	442.45	351.59	96.5
28	340.46	425.81	290.2	516.39	442.75	351.83	96.622
29	340.22	425.62	290.11	516.15	442.33	351.83	96.591

February 1989

Date	Lyon	Daimh	Stronuich	Lairige	Breaclaic	Lednock	Earn
4	343.45	428.95	290.99	516.79	434.04	347.17	96.561
5	343.51	429.13	290.78	516.64	434.34	347.17	96.53
6	344.06	429.62	292.3	517.55	434.34	347.44	96.622
7	344.06	430.93	292.79	519.38	435.25	348.75	97.201
8	343.66	431.23	291.94	519.07	435.35	348.94	97.201
9	346.41	431.38	289.07	518.46	435.1	348.75	97.17
10	343.08	431.2	289.56	517.58	434.71	348.51	97.079
11	342.78	430.9	289.53	516.79	434.34	348.23	97.079
12	342.66	430.9	289.99	515.97	434.04	348.08	97.109

February 1990

Date	Lyon	Daimh	Stronuich	Lairige	Breaclaic	Lednock	Earn
2							
3		**Log sheets not found**					
4							
5							
6							
7							
8							
9							

March 1990

Date	Lyon	Daimh	StronuichLairige		BreaclaicLednock		Earn
3	342.9	432.27	290.08	513.13			97.17
4	343.6	432.57	292.3	513.62			97.292
5	343.51	432.82	292.3	513.77			97.292
6	344.36	433.49	292.97	515.11	443.15	351.22	97.536
7	343.97	433.43	292.61	514.81	443.09	351.34	97.475
8	343.75	433.21	292.46	514.96	442.87	351.53	97.506
9	343.6	432.97	292.36	514.35	442.6	351.62	97.384
10	343.51	432.97	292.21	514.2	442.87	351.65	97.506

January 1991

Date	Lyon	Daimh	StronuichLairige		BreaclaicLednock		Earn
31	334.91	425.65	290.54	514.9	435.86	345.8	96.987
1	334.85	425.56	290.54	514.9	435.86	345.8	96.987
2	335.89	424.16	291.94	516.48		347.08	97.475
3	335.92	425.2	289.86	515.72	435.71	347.17	97.536
4	336.29	425.01	290.11	515.26		347.38	97.475
5	335.92	425.2	289.41	515.11	435.86	347.47	97.506
6	335.92	425.2	289.93	514.99			97.506
7	335.8	425.04	290.23	514.81		347.84	97.506

January 1992

Date	Lyon	Daimh	StronuichLairige		BreaclaicLednock		Earn
31	339.7	425.81	290.54	514 23	436.63	344.55	96.256
1	340.13	425.87	290.2	514.59	437.11	345.37	96.347
2	341.71	426.99	292.55	516.15	438.76	348.51	96.439
3	343.97	428.24	292.46	518.01	437.54	347.59	97.109
4	343.66	428.4	292.15	517.86	437.54	347.59	97.201
5	343.51	428.49	290.23	517.25	436.78	348.02	97.14
6	343.36	428.4	290.47	516.33	435.86	347.84	97.109
7	344.12	429.22	292.61	517.25	435.86	348.33	97.201

January 1993

Date	Lyon	Daimh	StronuichLairige		BreaclaicLednock		Earn
14							
15	336.19						97.353
16						345.83	97.475
17	338.99		292.36			347.5	98.207
18							97.871
19	338.48					348.08	97.658
20	339.39	427.02	291.33	513.59	437.39	348.29	97.627
21	339.39	427.02	291.08	513.44	437.39	348.9	97.536

March 1993

Date	Lyon	Daimh	StronuichLairige		BreaclaicLednock		Earn
27						350.15	96.225
28	341.44	431.2	290.66	519.38	430.26	350.52	96.225
29	341.38	431.6	289.44	519.38	434.04	350.28	96.347
30	342.21		292.46	519.84		351.37	97.201
31	342.56		290.63	520.08	433.73	351.77	97.353
1			290.54			351.53	97.262
2	342.23						

May 1993

Date	Lyon	Daimh	Stronuich	Lairige	Breaclaic	Lednock	Earn
14						345.25	96.713
15	336.56	427.72	290.17	511.8	425.01	345.25	96.7
16	336.56	427.75	290.41	512.35	425.01	345.25	96.67
17	336.56	428	291.24	512.58			96.683
18	338.21	428.98	290.02	515.2		346.92	97.079
19	337.81	428.76	290.02	515.72	425.9	346.8	97.018
20	337.63	428.55	290.49	516	425.96	346.68	96.932
21	337.29	428.46	291.1	516.21	426.02	346.59	96.835

APPENDIX 14

Sub-daily reservoir level observations
Data are presented on disk only for the Tummel Valley and Breadalbane hydro systems. Files are supplied in Lotus 1-2-3 .WK3 format.

Values (in metres OD) are normally those based on pressure transducer readings, except when actual dam readings are inserted, shown in **bold**. Small errors in transducer readings normally cause a small discrepancy between data sources. See Appendix 13 for daily level observations at most of these reservoirs.

January 1974

No data found

August 1985

Date	Backwater	Lintrathen
22	37.05	7.75
23	37.04	7.74
24		7.88
25		7.8
26	37.07	7.77
27	37.1	7.77
28	37.1	7.78
29	37.05	7.75

February 1989

Date	Backwater	Lintrathen
4		7.64
5		7.62
6	37.15	7.62
7	37.2	7.62
8	37.1	7.57
9	37.2	7.54
10	37.1	7.52
11		7.49
12		7.47

February 1990

Date	Backwater	Lintrathen
2	35	6.3
3		6.5
4		6.57
5	35.55	6.66
6	35.8	6.79
7	36	6.93
8	36.2	7.04
9	36.3	7.09

March 1990

Date	Backwater	Lintrathen
3		7.75
4		7.75
5	37.2	7.7
6	37.2	7.72
7	37.1	7.72
8	37.1	7.72
9	37.1	7.72
10		7.67

January 1991

Date	Backwater	Lintrathen
31	32.1	4.27
1	32.1	4.32
2	32.5	4.65
3	32.7	4.98
4	32.8	5.03
5		5.36
6		5.54
7	33.15	5.7

January 1992

Date	Backwater	Lintrathen
31		6.25
1		6.27
2		6.27
3	36.85	6.27
4		6.27
5		6 27
6	36.9	6.3
7	36.95	6.3

January 1993

Date	Backwater	Lintrathen
14	37.1	7.77
15	37.2	7.82
16		7.84
17		8.02
18	37.2	7.87
19	37.2	7.82
20	37.2	7.77
21	37.2	7.8

March 1993

Date	Backwater	Lintrathen
27		6.81
28		6.79
29	37.1	6.76
30	37.25	6.86
31	37.15	7.19
1	37.15	7.27
2	37.1	7.32
3		7.34

May 1993

Date	Backwater	Lintrathen
14	37	7.67
15		7.67
16		7.67
17	37.05	7.67
18	37.2	7.8
19	37.1	7.72
20	37.1	7.72
21	37.1	7.7