NRA Anglian 154

DEPARTMENT OF CIVIL ENGINEERING

Water Resources Research Group

Software Profile

A User Manual for QUANTARE

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QUANTARE
(Quantitative Areal Rainfall Estimation)

A program for displaying spatial rainfall and computing areal rainfall totals for pre-defined catchments from point raingauge rainfall data, utilising two-dimensional interpolation algorithms.

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1. Introduction

This manual is a report in a series of Technical Reports produced by the Water Resources Research Group at the Department of Civil Engineering, University of Salford.

The manual is a reference to the software package known as QUANTARE (Quantitative Areal Rainfall Estimation), a program for displaying spatial rainfall fields and computing quantitative areal rainfall totals for pre-defined catchments, from point raingauge rainfall data. The report begins by stating the software specification and goes on to discuss the input files required. The structure of QUANTARE is described and illustrated with a flowchart and an example run-time session described. Annotated samples of the input datafiles are included. Whilst the report concentrates on a single example (National Rivers Authority, Anglian Region, Northern Area), QUANTARE has been designed and structured so that customisation and implementation in other areas is straightforward and a chapter is dedicated to this.

The Appendices provide a source listing of the program together with hard copy listings of example input and output datafiles. The datafiles accompany the program on the distribution disk and may be used to replicate the run-time example in the report main body. User input datafiles should exactly replicate the format of the example datafiles.

This manual is not a definitive guide to the interpolation routines used. Further information can be found in the references listed in the bibliography.

The Water Resources Research Group would welcome any comments on this Software Profile. Please contact Professor Ian Cluckie at the address on the front of the report.

2. Typography and Flow Chart Symbols

The body of this manual is printed in a normal (Times font) typeface; other typefaces have special meanings.

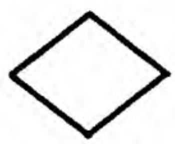
`Courier` is used for the listings of the program, datafiles and screen output. **`Bolded courier`** represents interactive user keyboard input whilst annotated comments of source code and datafile listings are made in **bolded times**.

The program structure is illustrated by a flowchart and described (summarised) textually. Algorithms are described in terms of steps such as input, output and computations. Decisions are made by testing Boolean expressions that are evaluated to be true or false. The flowchart symbols for these processes, along with a symbol to indicate beginning and end are:

Assignments or computations

Input or output

Boolean expressions



Start or stop

3. Software Specification and System Requirements

QUANTARE is an interactive, graphically based FORTRAN program. The software is coded in ANSI FORTRAN 77 and has been developed on a Digital Electronic Company (DEC) MicroVAX II minicomputer using VMS v5.4 and VAX FORTRAN 77 v5.5. The code utilises some VAX FORTRAN 77 implementations (extensions) and this should be considered before attempting to port the code to a different environment.

The two-dimensional interpolation and surface fitting algorithms are part of the Numerical Algorithms Group (Mark 14) Fortran Library[1].

Graphics play an integral role in the presentation of results in QUANTARE and are facilitated by UNIRAS Graphics Software[2] package (Version 6.0). UNIRAS graphics modules are upwardly compatible with subsequent releases of UNIRAS. UNIRAS graphics modules are machine independent and can be implemented on a wide range of machines. A menu of devices for which the graphics elements of the software have already been implemented prompt the user to indicate the device on which the software is running enabling the correct device driver to be software selected. Implementation for new devices is straightforward if a UNIRAS driver for the device is available. It is envisaged that incorporation of an alternative graphics package (capable of producing two-dimensional colour or black-and-white surface plots) into QUANTARE would be straightforward.

1 Numerical Algorithms Group Ltd, Wilkinson House, Jordan Hill Road, Oxford, OX2 8DR, UNITED KINGDOM
NAG Inc, 1400 Opus Place, Suite 200, Downers Grove, IL 60515-5702, USA.

2 UNIRAS A.S.,376 Gladsaxevej, DK-2860 Søborg, DENMARK
UNIRAS Ltd, Ambassador House, 181 Farnham Road, Slough, SL1 4XP, UNITED KINGDOM.

4. Areal Rainfall Estimation

Water resource management usually requires estimates of areal rainfall rather than point rainfall estimates. In particular, an accurate assessment of areal rainfall is a necessary basic input to rainfall-runoff models (perhaps the most substantial user of real-time rainfall data), especially conceptual models which utilise a water balance approach. Numerous methods of determining areal rainfall from point raingauge measurements have been proposed (e.g. see the review conducted by Hall and Barclay, 1975, and the objective comparisons of Creutin and Obled, 1982) and the techniques proposed vary greatly in terms of complexity, from the simplest deterministic methods, (e.g. nearest neighbour method, arithmetic mean, Thiessen, subjective isohyetal) to the more sophisticated stochastic methods such as bicubic-spline surfaces, optimal interpolation, and kriging.

The report is not judgmental and does not state the accuracy, reliability, shortcomings or advantages of one interpolation technique over another, or any other procedure over interpolation.

4.1. Spatial Rainfall Fields and Catchment Totals from Sparse Raingauge Data

QUANTARE derives a representation of the spatial rainfall field and estimates areal rainfall depths over predefined catchments. This is achieved by interpolating irregularly distributed point raingauge rainfall depths to a (5 km) regular grid, the grid nodes being used to construct the spatial rainfall field and to compute catchment rainfall.

Each phase in the process is shown schematically in figure 1.

4.2. Two-Dimensional Interpolation

This section introduces the two-dimensional interpolation algorithms supported by QUANTARE. The algorithms work with irregularly distributed data (although many solutions to related problems in two-dimensional interpolation have been in long use, interpolation functions making an exact fit for irregularly spaced data are rare [when the data points are on a regular grid, many solutions are possible]). The choice regarding the interpolation algorithm used by QUANTARE is made by the user at run-time.

The fundamental problem that any interpolation procedure for two-dimensional data scattered in the plane addresses is the following (after Renka and Cline, 1984):

> '...given a set of nodes (abscissae) $(x_i, y_i,)$ arbitrarily distributed in the x-y plane, with

corresponding ordinates z_i, $i=1,2,\ldots,M$, construct a bivariate function $F(x,y)$ which interpolates/fits a surface to, the data values, i.e., $F(x_i,y_i)=z_i$, $i=1,2,\ldots,M$...'.

A smooth interpolatory surface is often desired when a visual impression of a three dimensional process/field is required. The problem arises in the case of raingauge rainfall estimates where the information usually derives from points whose locations are determined logistically rather than as a result of network optimisation considerations. Thus, in practice most existing operational raingauge networks can be considered as randomly distributed as regards the observed rainfall process. The main requirements for an interpolation scheme are (Shepherd, 1968):

- the two dimensional interpolation function is to be 'smooth'.
- the interpolated surface must pass exactly through the specified data points.
- the interpolated surface should meet the user's intuitive expectations (about the phenomenon under investigation).

Regardless of the algorithm used, a satisfactory fit cannot be expected if the number and arrangement of the data points do not adequately represent the character of the underlying relationship. Ideally data points should extend over the whole domain of interest of the independent variable and extrapolation outside the data ranges is unwise and can result in large errors. It is advantageous to have additional points near the boundaries of the estimation domains, and also in special interest, high priority regions.

Two interpolation procedures are described and either can be used in QUANTARE. The description will aid any choice in the routine used, though personal preference established from trial and error will inevitably also play a role in algorithm selection.

Interpolation methods may be either local or global. In a global method the interpolant is dependent on all the data points regardless of their distance from the interpolation point, whereas in a local method, the interpolant does not depend on data points more than a certain distance from the interpolation point. Often a local method is used to avoid prohibitive computation time, although for rainfall, especially localised convective storms, a global method would not be appropriate.

4.2.1. Renka and Cline Method

This routine constructs an interpolating surface $F(x,y)$ through a set of M scattered data points (x_r,y_r,f_r), for $r=1,2,\ldots M$, using a method due to Renka and Cline. In the (x,y) plane, the data points must be distinct. The constructed surface is continuous and has continuous first order derivatives.

The method involves firstly creating a triangulation with all the (x,y) data points as nodes, the triangulation being as nearly equi-angular as possible (Cline and Renka, 1984). Then gradients in the x- and y-directions are estimated at node r, for $r=1,2,...,M$, as the partial derivatives of a quadratic function of x and y which interpolates the data value f_r and which fits the data values at nearby nodes (those within a certain distance chosen by the algorithm) in a weighted least square sense. The weights are chosen such that closer nodes have more influence than more distant nodes on derivative estimates at node r. The computed partial derivatives, with the f_r values, at the three nodes of each triangle define a piecewise polynomial surface of certain form which is the interpolant on that triangle. More detailed information on the algorithm is provided in Renka and Cline (1984), Lawson (1977), and Renka (1984).

The interpolant $F(x,y)$ can be subsequently evaluated at any point (x,y) inside or outside the domain of the data in the second stage routine (see below). Points outside the domain of the data are determined by extrapolation.

The second stage routine computes the interpolant for a specified grid. The routine takes as input the parameters defining the interpolant $F(x,y)$ of a set of scattered data points (x_r,y_r,f_r), for $r=1,2,...M$, and evaluates the interpolant at the point (px,py). If (px,py) is equal to (x_r,y_r) for some value of r, the returned value will be equal to fr. If (px,py) is not equal to (x_r,y_r) for any r, the derivatives passed to the routine are used to compute the interpolant. A triangle is sought which contains the point (px,py), and the vertices of the triangle along with the partial derivatives and f_r values at the vertices are used to compute the value $F(px,py)$. If the point (px,py) lies outside the triangulation defined by the input parameters, the returned value is obtained by extrapolation. In this case, the interpolating function F is extended linearly beyond the triangulation boundary.

4.2.2. Modified Shepherd Method

This routine constructs an interpolating surface $F(x,y)$ through a set of M scattered data points (x_r,y_r,f_r), for $r=1,2,...M$, using a modification of Shepherd's method. The surface is continuous and has continuous first derivatives.

The basic Shepherd method, described in Shepherd (1968), interpolates the input data with the weighted mean:

$$F(x,y) = \frac{\sum_{r=1}^{M} w_r(x,y)\, f_r}{\sum_{r=1}^{M} w_r(x,y)} \quad \text{where } w_r(x,y) = \frac{1}{d^2} \text{ and } d_r^r = (x-x_r)^2 + (y-y_r)^2$$

(eq. 4.3)

The basic method is global in that the interpolated value at any point depends on all the data, but the method uses a modification due to Franke and Neilson (1980), whereby the method becomes local by adjusting each $w_r(x,y)$ to be zero outside a circle with centre (x_r,y_r) and some radius R_w. Also, to improve the performance of the basic method, each f_r above is replaced by a function $f_r(x,y)$ which is a quadratic fitted by weighted least-squares to data local to (x_r,y_r) and forced to interpolate (x_r,y_r,f_r). In this context, a point (x,y) is defined to be local to another point if it lies within some distance R_q of it. Computation of these quadratics constitutes the main work done by this routine. If there are less than five other points within distance R_q from (x_r,y_r) the quadratic is replaced by a linear function. In cases of rank deficiency, the minimum norm solution is computed.

The values for R_w and R_q can be specified explicitly but it is usually easier to choose instead two integers N_w and N_q from which the routine computes R_w and R_q These integers can be thought of as the average number of data points lying within distances R_w and R_q respectively from each node. Default values are utilised by the procedure.

The timing of the routine is approximately proportional to the number of data points M, provided that N_q is of the same order as its default vale (18). If N_q is increased so that the method becomes more global, the time taken becomes approximately proportional to M^2.

The radii R_w and R_q are computed as:

$$\frac{D}{2}\sqrt{\frac{N_w}{M}} \text{ and } \frac{D}{2}\sqrt{\frac{N_q}{M}} \qquad \text{(eq. 4.4)}$$

where D is the maximum distance between any pairs of data points.

Default values N_w=9 and N_q=18 work quite well when the data points are fairly uniformly distributed. However, for data having some regions with relatively few points or for small data sets (M<25), a larger value of N_w may be needed. This is to ensure a reasonable number of data points within a distance R_w of each node, and to avoid some regions in the data area being left outside all the discs of radius R_w on which the weights $w_r(x,y)$ are non-zero. Maintaining N_q approximately equal to $2.N_w$ is usually an advantage. Increasing N_w and N_q does not improve the quality of the interpolant in all cases: it does increase the computational time and makes the method less local.

The interpolant $F(x,y)$ can be subsequently evaluated at any point (x,y) inside or outside the domain of the data in the second stage routine (see below).

The second stage routine computes the interpolant for a specified grid. The routine takes as input the parameters defining the interpolant $F(x,y)$ of a set of scattered data points (x_r,y_r,f_r) for $r=1,2,\ldots,M$, and evaluates the interpolant at the point (px,py). If (px,py) is equal to (x_r,y_r) for some value of r, the returned value will be equal to f_r. If (px,py) is not equal to (x_r,y_r) for any r, all points that are within a prescribed distance of (px,py), along with the corresponding nodal functions will be used to compute a value of the interpolant.

4.3. Other Information

Figure 2 shows the interpolation domain used for the National Rivers Authority, Northern Area.

The boundaries of the rectangular interpolation domain should be set-up so that interpolation takes place over the entire area of interest (regions are invariably not rectilinear but tend to follow political or natural boundaries) Setting up the domain so that it includes the entire area of interest has the advantage of ensuring that the domain remains constant even though the number and locations of raingauge data available may vary.

5. Program Structure and Data Requirements

This chapter describes the structure of QUANTARE, and the input datafiles it uses.

5.1. Structure

The program consists of small main segment, with most data handling, interaction and graph drawing being handled by subroutines. A full source code listing of QUANTARE is provided in Appendix 1. The program flowchart in figure 3 illustrates the program structure which is also outlined below:

- Character and array initialisation
- Welcome message
- Run-time Options
- Establishment of estimation time period.
- Read and process raingauge rainfall data
- Data processing and interpolation domain set-up
- Main loop
    - Raingauge rainfall data processing
    - Interpolation of raingauge rainfall data
    - Graphical presentation
- End of main loop
- Write catchment totals to an output file (if required).
- Graphical display of cumulated rainfall fields.

5.2. Input and Output Datafiles

The program utilises raingauge rainfall and catchment input datafiles, and files holding coastline and political boundary data.

The format of the raingauge rainfall input datafile is shown in figure 4, (an example is listed in Appendix 2) and the format of a catchment input file is shown in figure 5 (example listed in Appendix 3).

Essentially the raingauge file comprises of 15 minute rainfall depths for a 24 hour period, for all available raingauges in the region. The file has a ten line header block which records the nature of the data, the date, number of stations, data time period, and data interval. Rainfall data for each raingauge follows sequentially, raingauge after raingauge. Each raingauge has a two line sub-header which shows the raingauge reference code, and the gauge location in national grid coordinates.

The catchment inputfile comprises a three-line header block, followed by a catchment number indicator, and then (repeated for each catchment on the datafile), a catchment sub-header (text), catchment node number indicator, and catchment node NGR coordinates.

QUANTARE produces two output files, of which only one is of direct concern. The results output datafile consists of hourly and total rainfall totals for each predefined catchment for the estimation period specified at run-time (see Appendix 5). In addition, the interpolation algorithms sends warning messages to a second output file (for010.dat) when interpolation is taking place for points more than a certain distance from raingauge locations (extrapolation). The messages can be safely ignored (as long as the user is aware of the consequences of extrapolating raingauge data by an interpolating surface) and is advised to delete this file regularly, since it can reach sizable proportions.

5.3. Include File

In order to simplify the program structure, introduce generality, and make application to different areas as straightforward as possible, all the major program parameters are held in a subsidiary include file 'quantare.inc' (see Appendix 2 for an example). When QUANTARE is being used for the Northern Area referred to throughout this report, the user need only ensure that the correct value of *nstat* is used (this value can be changed by editing the include file) and should always be checked before running QUANTARE. Further information on the parameters held in the include file and application of RADGAP to other areas can be found in Chapter 7.

5.4. Presentation of Results

The spatial rainfall field is presented by QUANTARE in the form of two-dimensional colour or black-and-white filled contour plots. The interpolated raingauge rainfall field has depth units (mm).

The rainfall field can be drawn each hour, at the end of the estimation period (or both), the choice being made by the user at run-time. If hourly graphical output is required, two operational modes are accommodated. In the first the user is required to press the return key at the end of each hour before QUANTARE interpolates and displays data for the next hour, alternatively an auto-refresh option is available whereby the program continues automatically until the end of the estimation period is reached.

6. Running the Program

This chapter describes run-time execution of QUANTARE. A run-time listing of the program user-interface during run-time is provided in Appendix 6. QUANTARE is straightforward to use and the information required of the user at run-time is limited to a selection of certain run-time options, and the time of the estimation period. Referral to the program flow chart (figure 3) may aid the reader.

6.1. Device Type

At present about five devices are supported by QUANTARE for graphical output (i.e. the device names appear in a program menu). However the machine independency of UNIRAS coupled with the large number of device drivers available means that QUANTARE will run on many different device types. If you wish to run QUANTARE on a device not displayed on the program menu contact the Water Resources Research Group indicating the UNIRAS (GROUTE) driver name for the device. This will then be incorporated in the code for a subsequent release version. See Appendix 7 for a list of the devices currently supported.

6.2. Option Menu

There is some flexibility in graphical output produced by QUANTARE. The interpolated rainfall field can be displayed for each hour, or just at the end of the estimation period. If both are required, the user can specify auto refresh whereby the graphical output is automatically updated as data are adjusted. Alternatively, the user is required to press the return key at the end of each hour for the program to continue to the next adjustment hour.

6.3. Adjustment Date

The user enters the date for which adjustment is required (in the form YYMMDD). From this information QUANTARE constructs the name of the raingauge input filename. The estimation period can be of any duration within the 24 hours of the date selected.

6.4. Rainfall Scale Slicing

The user interactively controls the rainfall scale used for the graphical presentation of the interpolated rainfall field. If the hourly graphics option is selected, QUANTARE prompts the user to enter a value for the maximum hourly rainfall depth, and likewise for the final cumulated rainfall field at the end of the estimation period. This value corresponds to the top of the rainfall depth scale. From this, QUANTARE computes the scale slice range and sets up the slicing array. A linear rainfall slicing scheme used with a total of seven rainfall levels. Thus the slice range is computed as the maximum value divided by seven. For example, if the user enters a value of 70 (mm) the rainfall scale will have the values 0-7, 7-14, 14-21,...,63-70. QUANTARE also provides a final 'catch-all' class of >maximum value. When drawing the final cumulated rainfall field a loop option exists whereby the field can be replotted thereby enabling the user to select a different maximum value (and therefore different slice range).

6.5. Compiling and Linking RADGAP

When QUANTARE is compiled, the include file is automatically compiled at the same time. It should be ensured that both the main module (quantare.for) and the include file (quantare.inc) are in the same directory. In addition, the interpolation subroutines are held in an object module (alg.obj) which must be linked with the compiled version of QUANTARE.

6.6. Running QUANTARE

The program is invoked by entering `Run QUANTARE`. After each response the return (enter) key is pressed, the display scrolls and the next prompt is displayed. The reader is referred to Appendix 6 for the run-time listing.

6.7. Example Run-Time Session

The session shown in the example run-time listing in Appendix 5 is described below.

RUN QUANTARE

Laserwriter output device selected.

Graphics options settings changed so that graphics are not produced every hour.

Auto-refresh selected so that the programs continues automatically until the end of the estimation period.

Default interpolation algorithm used (Renka and Cline).

Black-and-white graphical output selected.

The date selected for adjustment is 7th July 1989.

The adjustment period selected is from 00:00-24:00.

Maximum rainfall depth selected for graphics scale is 56 (mm). (This will result in the rainfall scale having the values 0-8, 8-16,16-24,...,48-56, greater than 56).

STOP

7. Customised Implementation of QUANTARE

QUANTARE has been designed and structured so that application to other areas is straightforward. As mentioned in section 5.3, this has been achieved largely through the use of a FORTRAN include module ('quantare.inc'). This subsidiary piece of code contains all the major program parameters and enables customisation to be made without altering the code of QUANTARE. The reader should refer to figure 5 for an explanation of the terms and parameters used in this section.

The include file contains a total of 16 parameters and two arrays. An explanatory list of these follows:

cell:	interpolation grid size (km)
ngr_lef_id:	ngr coordinates left-side of sub-region
ngr_rig_id:	ngr coordinates right-side of sub-region
ngr_top_id:	ngr coordinates of top of sub-region
ngr_bot_id:	ngr coordinates of bottom of sub-region
nx:	dimension of sub-region (x-axis)
ny:	dimension of sub-region (y-axis)
xlo:	lower bound of sub-region (x-axis)
xhi:	upper bound of sub-region (x-axis)
ylo:	lower bound of sub-region (y-axis)
yhi:	upper bound of sub-region (y-axis)
idom:	number of points outside adjustment domain (ie in mask)
start,stop:	start and end cells of adjustment domain
nstat:	number of raingauge stations
mmax:	total number of data points (=nstat+idom)
num_cmt:	number of pre-defined catchments
max_nodes:	maximum number of nodes allowed in any catchment

The majority of these parameters are self-determining (i.e. they are computed from other parameters entered by the user), and QUANTARE customisation requires only seven of the parameters on the parameter listing shown above to be amended.

Firstly, the parameter *cell* should be set. The default and recommended value for this is 5 km, though this can be changed if a finer or coarser interpolation mesh is required.

The second phase entails setting up a rectangular sub-region. This should be chosen so that there is adequate space for a mask having a depth of not less than least two-cells all the way around the interpolation domain, i.e.

the area in which interpolation will take place. When the sub-region has been defined the following parameters: *ngr_lef_id*, *ngr_rig_id*, *ngr_top_id*, and *ngr_bot_id* (i.e. the 8-figure NGR coordinates of the left and right sides, top and bottom of the sub-region) are set (see figure 7).

The third phase sets up the actual interpolation domain, i.e. the area inside of the sub-region for which a representation of the spatial raingauge field is derived. The variables determining the domain are held in the two arrays *start* and *stop*. Before these values can be set, it is recommended that a figure similar to figure 2 or figure 6 be produced. Once a similar figure is available it is straightforward to customise the *start* and *stop* values. In the example shown in figure 6, *nx=16*, *ny=18*, and the *start* and *stop* values in the include file would be set as follows:

```
data start / 1, 1, 3, 2, 2, 2, 2, 2, 2, 3, 3, 4, 4, 4, 4, 5, 1, 1, 1 /
data stop  / 1, 1, 8, 9, 11, 12, 13, 14, 15, 15, 15, 14, 14, 14, 14, 11, 1, 1, 1 /
```

It should be noted that the first and two and last three values of start and stop arrays are set to 1. Values of unity indicate to QUANTARE that the interpolation domain does not extend into the sub-region at these points.

Finally, the number of cells falling outside of the interpolation domain (i.e. inside the mask), parameter *idom* is determined. In simple cases where there are not many cells, this can be achieved simply by counting the cells manually, however in more complex cases, it is advisable to use the utility program 'set_idom'. The program is listed in Appendix 8. Before running the user needs to set values *nx* and *ny*, and change the *start* and *stop* array values held in the data statement (as described above for the include file). The program simply counts the cells inside the interpolation domain and when completed writes the required value of *idom* to the screen. Once *idom* has been determined, it should be set in the include file.

If all these stages has been carried out correctly, QUANTARE has been successfully customised.

Postscript to Customisation:

In addition to the above changes, the names of the raingauge input files will need to be changed. In addition, the subroutines for drawing the coastline and political boundaries will also require some additional work. As a short-term solution, the subroutines ANGLIAN2 and COAST2 can be omitted, and reinstated when the required boundaries have been digitised.

8. Conclusions

This report is a users guide to the FORTRAN software package QUANTARE, a program for displaying the spatial rainfall field and quantitatively estimating areal rainfall over pre-defined catchments from a network of ground-based raingauges. The report contains listings of full source code and input datafiles; all of which are contained on the software distribution disk.

QUANTARE is an interactive, user-friendly program featuring user selected options and graphical results presentation. The structure of the program has been described and illustrated using flowchart representation. Data requirements and input file formats are explicitly described. In addition, full details on customised implementation of QUANTARE to different areas are provided.

A runtime listing is provided and described in the text, and the user options are described.

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Creutin J.D., and Obled, C. (1982) 'Objective analyses and mapping techniques for rainfall fields: an objective comparison, *Water Res. Research*, **18(2)**, 413-431.

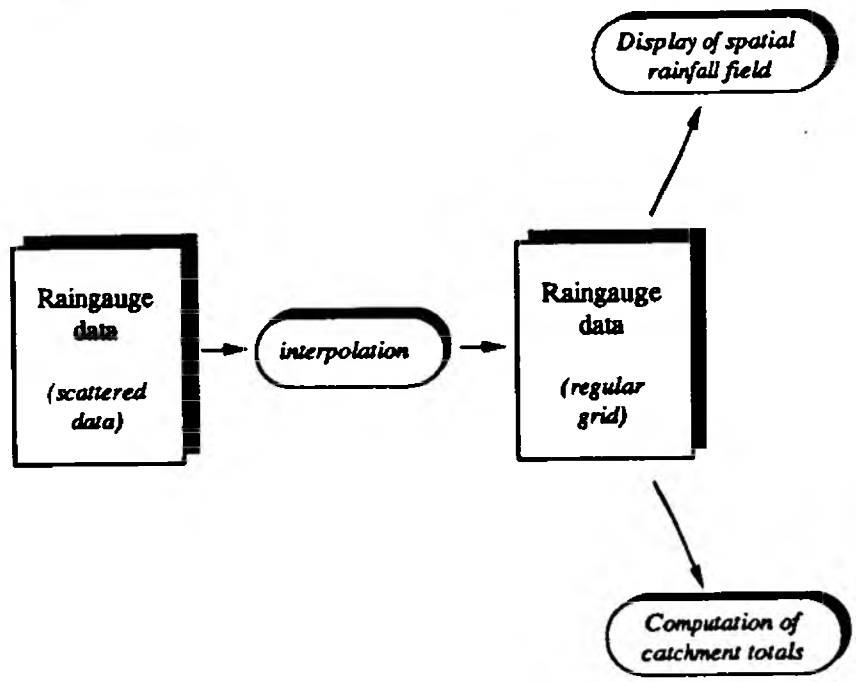
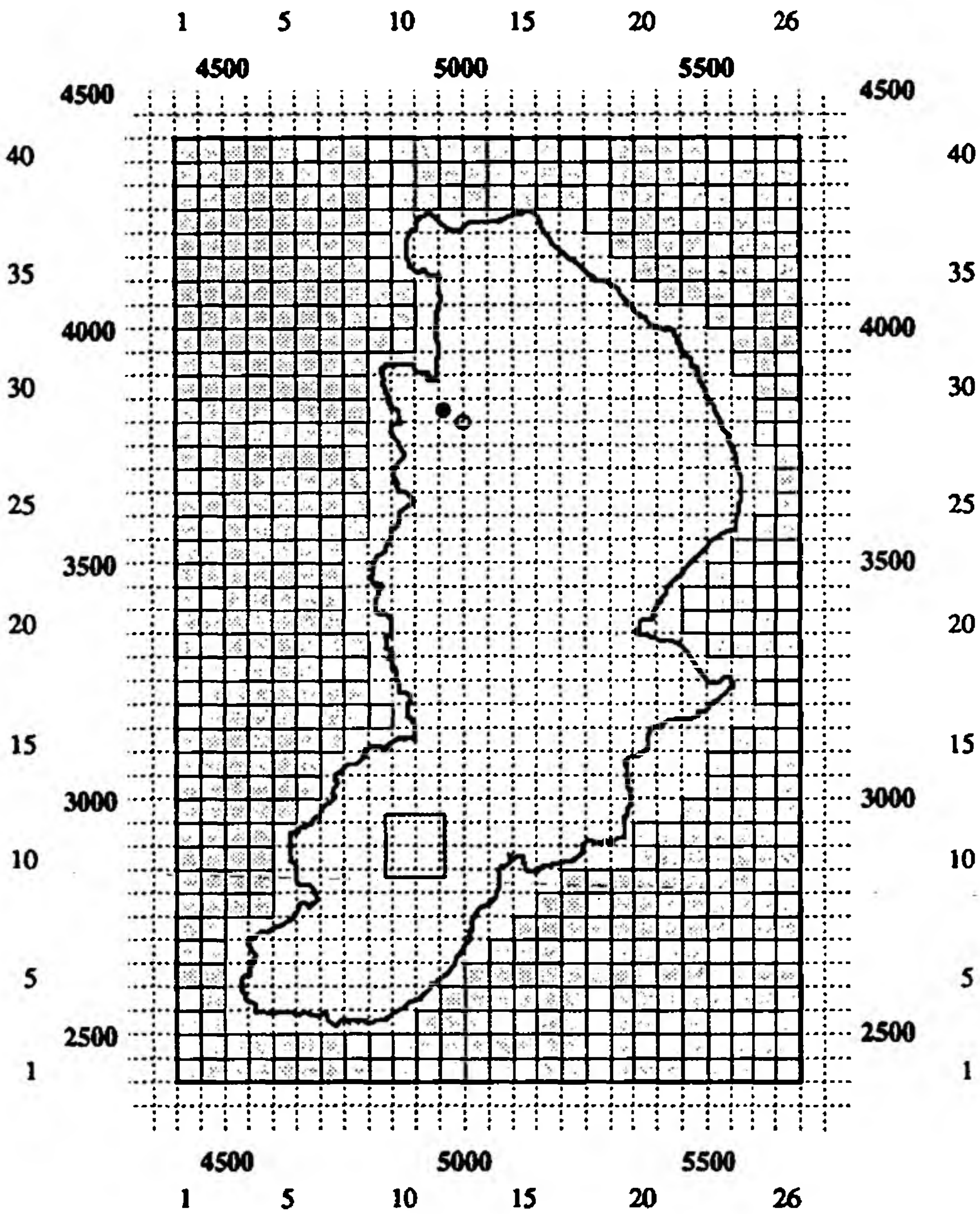


Figure 1: Schematic representation of the display of spatial rainfall patterns and the computation of catchment areal rainfall totals



Key			
● Radar site ○ Radar grid centre ▦ Rainfall field not drawn	**National Grid Coordinates** Interpolation domain coordinates	0 km 20	N

Figure 2: <u>Interpolation Domain (Northern Area, National Rivers Authority, Anglian Region) showing Test Catchment</u>

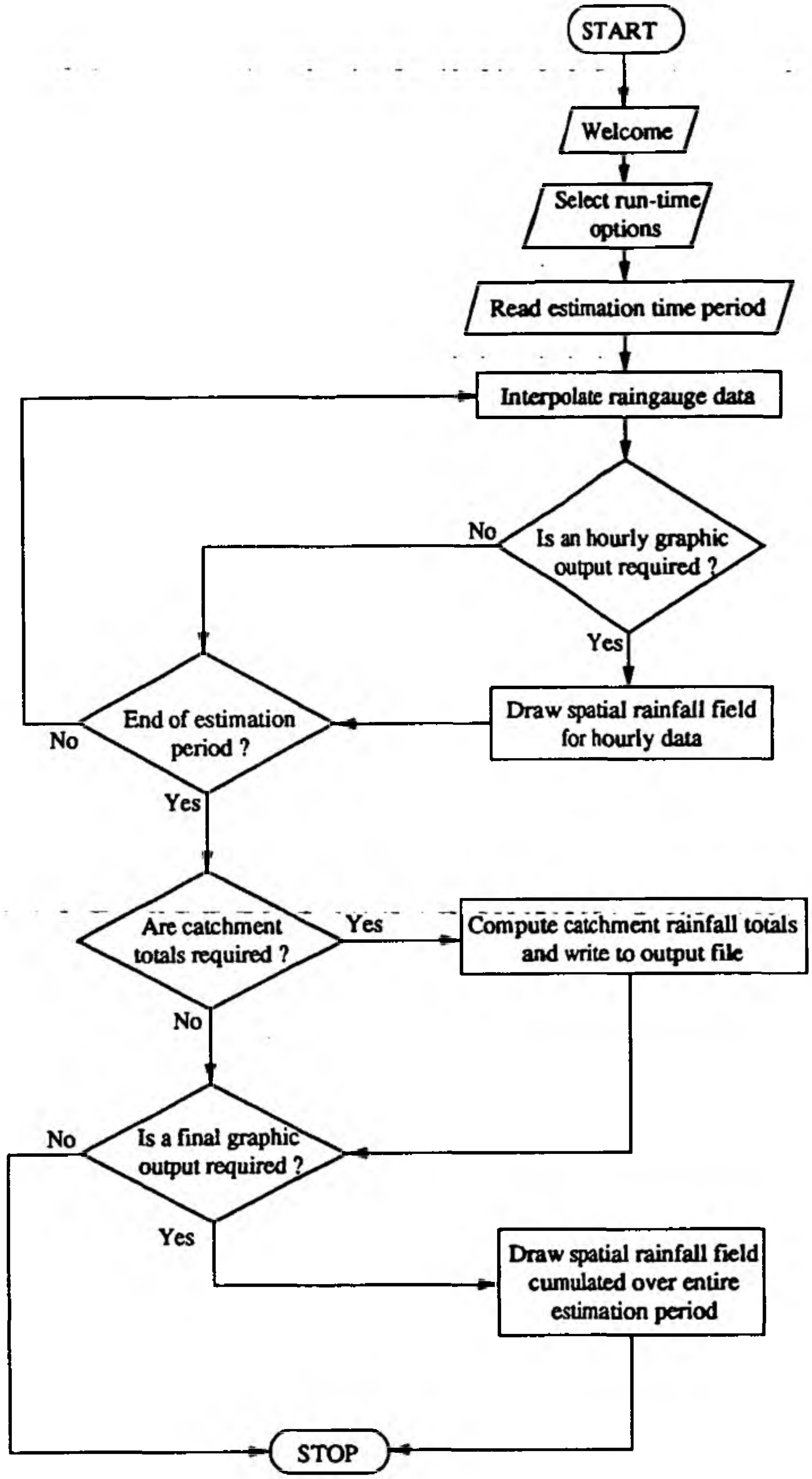


Figure 3: Program Flow Chart

Header block

Read as 25x, i2

```
----------------------------------------------------------------------

Raingauge rainfall datafile
14 december   1989
Number of stations  66
Data from 00:00 (first datum) to 23:45 (last datum)
15 minute data interval

----------------------------------------------------------------------
```

Sub-header block

Read as 21x, a3

Read as 20x, f6.1, 1x, f6.1

Read as 3x, 12f5.1

Data block

```
Gauge reference 802
Gauge location  5552.0 3586.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  1.0  0.5  0.5  0.0
  0.5  0.5  0.5  0.5  0.5  0.0  0.5  0.0  0.0  0.5  0.5  0.0
  0.5  0.0  0.5  0.0  0.0  0.0  1.5  2.5  2.5  1.5  1.0  0.5
  0.0  0.5  0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.5  0.0  0.0
  0.0  0.0  0.0  1.0  0.5  0.5  1.0  0.5  0.0  0.0  0.0  0.5
  0.5  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference 803
Gauge location  5106.0 3698.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.5  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.5  0.0  0.5  0.5
  0.5  0.5  0.5  0.0  0.5  0.5  1.0  0.0  0.5  0.5  0.5  0.5
  1.0  0.0  0.5  0.0  0.5  0.0  0.0  0.0  1.0  0.0  0.0  0.5
  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0
  0.0  0.0  0.5  0.5  1.0  0.5  0.5  0.5  1.0  0.5  0.5  0.5
  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
```

96 15 minute rainfall totals per raingauge

Figure 4: Example rainfall datafile (items read by QUANTARE in bold)

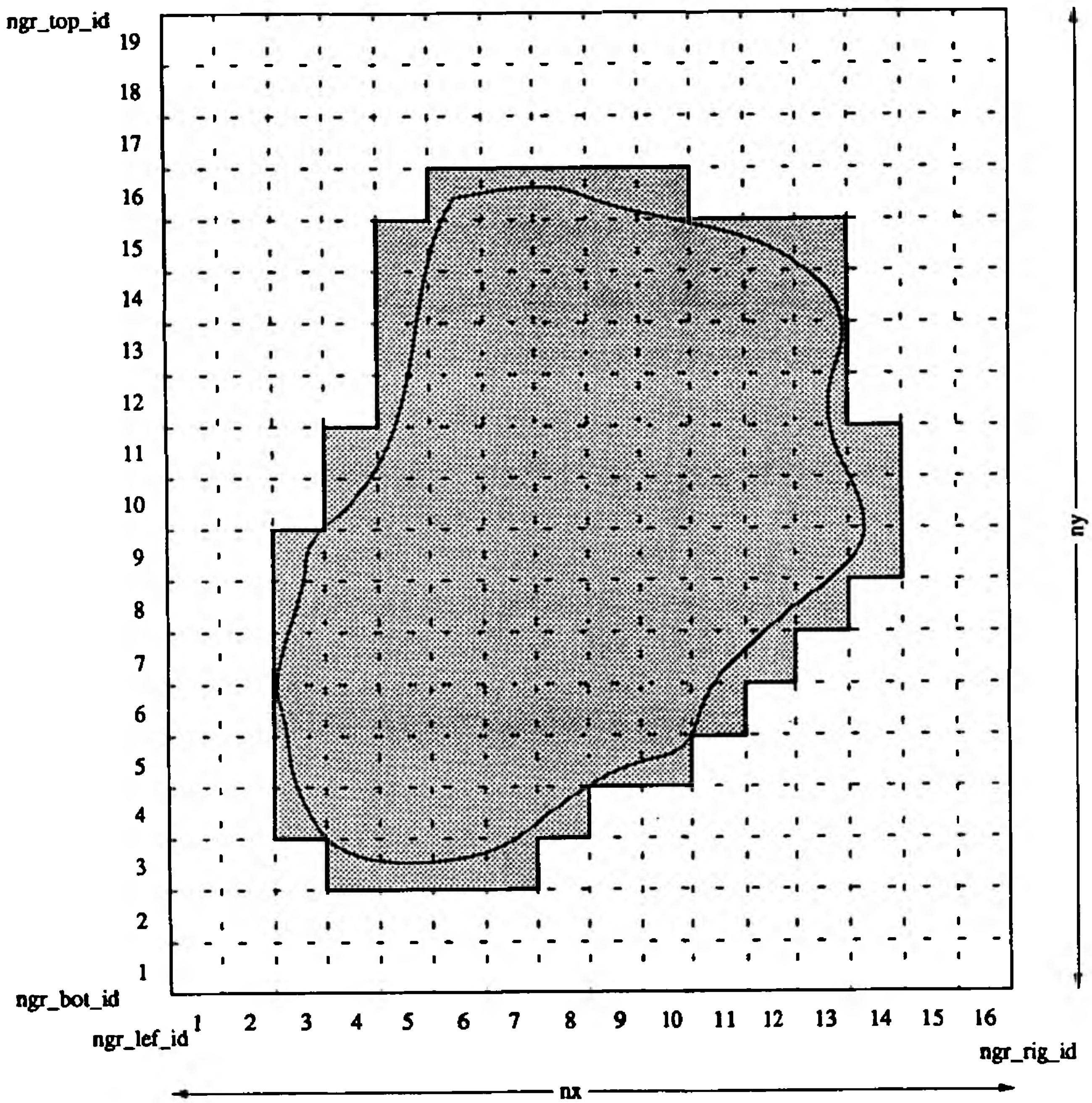


Figure 5: Sub-Region and Interpolation Domain

Appendices

Appendix 1: Source Code Listing

```
c
c
c     ------------------------------------------------------------------------
c
c                              PROGRAM QUANTARE
c
c     A program for estimating areal rainfall depths from point raingauge
c     rainfall data. The irregularly distributed raingauge rainfall amounts
c     are interpolated to a regular (5 km * 5km) grid by a sophisticated
c     two-dimensional interpolation algorithm.
c
c         Water Resources Research Group
c         Department of Civil Engineering
c         University of Salford
c         SALFORD
c         M5 4WT
c
c         For further information contact:
c                 Prof. Ian Cluckie
c
c     ------------------------------------------------------------------------
c
c
c
       program quantare
c
c     IMPORTANT, before running check settings of parameters in include file
c     'quantare.inc', especially snstat (number of raingauges).
c
       include 'quantare.inc'
c
       real rg_interp(nx,ny),cum_rg_interp(nx,ny)
       real x(nstat),y(nstat),f(nstat),cum_rg(nstat),value(nstat,96)
       real px(nx),py(ny)
       real fnodes(5*nstat),wrk(6*nstat)
       real out(nx,ny),array(nx,ny)
       character*3 gr(nstat)
       character*1 opt1,opt2,opt3,opt4,opt6,replot
       character*6 day
       integer kh,istart_hour,iend_hour,idev,icount,icol
c
       real cmt_x(num_cmt),cmt_y(num_cmt)
       integer icmt_x(num_cmt,max_nodes),icmt_y(num_cmt,max_nodes)
       integer nnodes(max_nodes)
       real cmt_hour_rf(num_cmt,24)
       character*60 cmt_name(num_cmt)
c
       icount=1
c
c
c     ---------------------------------------------------------------------
c
c     type welcome message
c
       call welcome
c
c     ---------------------------------------------------------------------
c
c     get graphics device and other options
```

```
c
      call options(idev,opt1,opt2,opt3,opt4,icol,opt6)
c
c  -----------------------------------------------------------------------
c
c  call subroutine to read and process raingauge data
c
      call rg_read(day,x,y,value,gr,cum_rg,istart_hour,iend_hour)
c
c  -----------------------------------------------------------------------
c
c  call subroutine to read catchment data
c
      if (opt6.eq.'Y') then
         call cmt_read(ncat,nnodes,icmt_x,icmt_y,cmt_name)
         do j=1,ncat
            do i=1,24
               cmt_hour_rf(j,i)=0.0
            end do
         end do
      end if
c
c  -----------------------------------------------------------------------
c
c  call subroutine to determine adjustment domain
c
      call setup_domain(px,py)
c
c  -----------------------------------------------------------------------
c
c
c  main loop
c
c ======================================================================
      do kh=istart_hour,iend_hour
c ======================================================================
c
c
c  -----------------------------------------------------------------------
c
c  set 'f' array to have rainfall data for correct hour inside
c
         do kk=1,nstat
            f(kk)=0.0
         end do
         jj=((kh-1)*4)+1
         do kk=1,nstat
            do i=jj,jj+3
               f(kk)=f(kk)+value(kk,i)
            end do
         end do
c
c  -----------------------------------------------------------------------
c
         if (kh.eq.istart_hour) then
            write(*,*)
            write(*,*)' ----------------------------------------------
     #------------------------'
            write(*,*)
            write(*,*)'                        Computation segment'
            write(*,*)
            write(*,*)' ----------------------------------------------
```

```
     #-----------------------'
             write(*,*)
          end if
          write(*,*)
          write(*,*)' Computing for hour ',kh
          write(*,*)' ----------------------------------------'
c
c ----------------------------------------------------------------------
c
c  two algorithms are available to interpolate raingauge data to a
c  regular grid.
c
          if (opt4.eq.'A') call
     #        rg_interpolate1(x,y,f,px,py,rg_interp)
          if (opt4.eq.'B') call
     #        rg_interpolate2(x,y,f,px,py,rg_interp)
c
c --------------------------------------------------------------------
c
c  compute hourly catchment rainfall totals
c
          if (opt6.eq.'Y') then
             do j=1,ncat
                do i=1,nnodes(j)
                   cmt_hour_rf(j,kh)=cmt_hour_rf(j,kh)+
     #                                  rg_interp(icmt_x(j,i),icmt_y(j,i))
                end do
                cmt_hour_rf(j,kh)=cmt_hour_rf(j,kh)/real(nnodes(j))
             end do
          end if
c
c --------------------------------------------------------------------
c
c  update arrays for cumulating interpolated raingauge arrays
c
          do i=1,nx
             do j=1,ny
                cum_rg_interp(i,j)=cum_rg_interp(i,j)+rg_interp(i,j)
             end do
          end do
c
c --------------------------------------------------------------------
c
c  rg_interp cells outside adjustment domain are assigned
c  a value of -999.999 so that they are not plotted
c
          call outside_boundary3(rg_interp)
c
c --------------------------------------------------------------------
c
c  if required call graphics routines to plot hourly adjustment
c
          if (opt1.eq.'Y') call
     #        graphics(icount,idev,icol,kh,istart_hour,x,y,rg_interp)
c
c --------------------------------------------------------------------
c
c
          if (opt1.eq.'Y'.and.opt3.eq.'N') then
             write(*,*)' Press return to continue...'
             read(*,*)
             write(*,*)' '
```

```
            end if
c
c
c ==================================================================
        end do ! end of main loop
c ==================================================================
c
c
c
c -------------------------------------------------------------------
c
c   write catchment rainfall totals to an output file
c
        if (opt6.eq.'Y') then
           do j=1,ncat
              cmt_total=0.0
              write(9,28)cmt_name(j)
              do ihour=istart_hour,iend_hour
                 write(9,27)ihour,cmt_hour_rf(j,ihour)
                 cmt_total=cmt_total+cmt_hour_rf(j,ihour)
              end do
              write(9,29)cmt_total
              write(9,*)' '
           end do
           write(9,*)' '
           write(9,*)'  ----------------  End of file  --------------- '
        end if
 27     format(3x,i2,')',4x,f5.2)
 28     format(a60)
 29     format(3x,'Total',1x,f6.2)
c
c -------------------------------------------------------------------
c
c   if required process data and call graphics routines to plot final
c   adjustment fields
c
        call outside_boundary3(cum_rg_interp)
        write(*,*)
        write(*,*)' Please wait, preparing final graphics...'
        if (opt2.eq.'Y') then
 36        call graphics(icount,idev,icol,99,istart_hour,x,y,cum_rg_interp)
           write(*,*)' '
 13        write(*,*)' Do you wish to replot the rainfall field (Y/N) ?'
           read(*,12,err=13)replot
           if (replot.ne.'y'.and.replot.ne.'Y'.and.
     &         replot.ne.'n'.and.replot.ne.'N') goto 13
           if (replot.eq.'y'.or.replot.eq.'Y') goto 36
           write(*,*)' '
        end if
 12     format(a1)
c
c  ------------------------------------------------------------------
c
c
        write(*,*)
        write(*,*)
        write(*,*)' --------------------------- QUANTARE STOP
     & ------------------------------'
        write(*,*)
        write(*,*)
        call gclose
        end
```

```
c
c
c     ------------------------------------------------------------------------
c
c
c
c
c
c     Subroutines follow.......
c
c
c
c
c
c     ------------------------------------------------------------------------
         subroutine welcome
c     ------------------------------------------------------------------------
c
         write(*,*)
         write(*,*)
         write(*,*)'  ---------------------------------------------
     #-----------------------'
         write(*,*)
         write(*,*)'                                    QUANTARE'
         write(*,*)
         write(*,*)'  A program to estimate quantitative areal rainfall
     # amounts from'
         write(*,*)'  point raingauge rainfall data, incorporating two-
     #dimensional'
         write(*,*)'  interpolation algorithms'
         write(*,*)
         write(*,*)'  Written by:'
         write(*,*)'     Water Resources Research Group'
         write(*,*)'     University of Salford'
         write(*,*)'     Salford, M5 4WT'
         write(*,*)'     England, U.K.'
         write(*,*)
         write(*,*)'  ---------------------------------------------
     #-----------------------'
         write(*,*)
c
         write(*,*)'  IMPORTANT: Before continuing...'
         write(*,*)'     Are you sure that the parameter settings in the
     # file "quantare.inc"'
         write(*,*)'     are correct? If not, abort program and change
     # settings by editing'
         write(*,*)'     the file. If OK...'
         write(*,*)
         write(*,*)'  Hit return to continue...'
         read(*,*)
c
         return
         end
```

```
c
c
c
c
c
c     ----------------------------------------------------------------
      subroutine options(idev,set1,set2,set3,set4,icol,set6)
c     ----------------------------------------------------------------
c
      character*1 set1,set2,set3,set4,set5,set6
      integer opt,icol
c
 35   format(i1)
 45   format(a1)
c
      write(*,*)
      write(*,*)
      write(*,*)'  ---------------------------------------------
     #-----------------------'
      write(*,*)'  The UNIRAS graphics routines in this program are
     # device independent.'
      write(*,*)'  ---------------------------------------------
     #-----------------------'
      write(*,*)
 696    write(*,*)'  Please type in the integer corresponding to the
     # device required'
      write(*,*)'    (1) VAXstation       (GPX driver)'
      write(*,*)'    (2) VAXstation       (X11 driver)'
      write(*,*)'    (3) VT Emulator      (ReGIS driver)'
      write(*,*)'    (4) IBM PC           (VGA driver)'
      write(*,*)'    (5) Inkjet Printer'
      write(*,*)'    (6) Laserwriter      (Postscript)'
      write(*,*)
 31     write(*,*)'  Please type integer [1,2,3,4,5 or 6]...'
      read(*,*,err=31)idev
      if (idev.gt.6.or.idev.eq.0) goto 31
      write(*,*)
c
      set1='Y'
      set2='Y'
      set3='Y'
      set4='A'
      set5='C'
      set6='Y'
      icol=1
      write(*,*)
      write(*,*)
      write(*,*)
      write(*,*)'  ---------------------------------------------
     #-----------------------'
      write(*,*)'  Option Menu'
      write(*,*)'  ---------------------------------------------
     #-----------------------'
      write(*,*)
      write(*,*)'  Options (default in UPPER CASE)'
      write(*,*)
      write(*,*)'  1. Graphics every hour                 (Y/n)'
      write(*,*)'  2. Graphics at end of period (Y/n)'
      write(*,*)'  3. Auto refresh                        (Y/n)'
      write(*,*)'  4. Interpolation algorithm (enter a or b):'
      write(*,*)'     (a) Renka and Cline              (default)'
      write(*,*)'     (b) Modified Shepherd'
```

```
      write(*,*)'  5. Colour or black/white graphics       (C/b)'
      write(*,*)'  6. Compute catchment rainfall totals     (Y/n)'
 5    write(*,*)
      write(*,*)'  To change a default setting enter integer
     # corresponding to the setting'
      write(*,*)'  to be changed, press return key and enter y or n
     # as appropriate'
 25   write(*,*)'  [Enter 0 <rtn> to continue]...'
 26   write(*,*)
       read(*,35,err=25)opt
      if (opt.ne.1.and.opt.ne.2.and.opt.ne.3.and.opt.ne.4.
     #              and.opt.ne.5.and.opt.ne.6.and.opt.ne.0) then
        write(*,*)'  Enter integer [1,2,3,4,5,6 or 0]...'
        goto 25
      end if
       if (opt.eq.0) then
           goto 15
        else if (opt.eq.1) then
           read(*,45)set1
           if (set1.eq.'y') set1='Y'
           if (set1.eq.'n') set1='N'
        else if (opt.eq.2) then
           read(*,45)set2
           if (set2.eq.'y') set2='Y'
           if (set2.eq.'n') set2='N'
        else if (opt.eq.3) then
           read(*,45)set3
           if (set3.eq.'y') set3='Y'
           if (set3.eq.'n') set3='N'
        else if (opt.eq.4) then
           read(*,45)set4
           if (set4.eq.'a') set4='A'
           if (set4.eq.'b') set4='B'
        else if (opt.eq.5) then
           read(*,45)set5
           if (set5.eq.'c'.or.set5.eq.'C') icol=1
           if (set5.eq.'b'.or.set5.eq.'B') icol=3
        else if (opt.eq.6) then
           read(*,45)set6
           if (set6.eq.'y') set6='Y'
           if (set6.eq.'n') set6='N'
        else
           write(*,*)' Error in options module'
      end if
      goto 26
 15   continue
c
      return
      end
```

```
c
c
c
c
c  ----------------------------------------------------------------------
      subroutine cmt_read(ncat,nnodes,icmt_x,icmt_y,cmt_name)
c  ----------------------------------------------------------------------
c
      include 'quantare.inc'
      real cmt_x(num_cmt,max_nodes),cmt_y(num_cmt,max_nodes)
      integer icmt_x(num_cmt,max_nodes),icmt_y(num_cmt,max_nodes)
      integer nnodes(max_nodes)
      character*60 cmt_name(num_cmt)
c
      open(unit=8,name='quantare.cmt',status='old',readonly)
      do i=1,3
         read(8,*)
      end do
      read(8,*)ncat
      type*,ncat
      do j=1,ncat
         read(8,11)cmt_name(j)
         read(8,*)nnodes(j)
         do i=1,nnodes(j)
            read(8,*)cmt_x(j,i),cmt_y(j,i)
            icmt_x(j,i)=1+((cmt_x(j,i)-ngr_lef_id)/50.0)
            icmt_y(j,i)=1+((cmt_y(j,i)-ngr_bot_id)/50.0)
         end do
      end do
      close(unit=8)
 11   format(a60)
c
      open(unit=9,name='rainfall.out',status='new')
      write(9,*)' '
      write(9,*)'  ------------------------------------------------'
      write(9,*)'  QUANTARE Output File: Catchment rainfall totals'
      write(9,*)'  ------------------------------------------------'
      write(9,*)' '
      write(9,*)'  Hourly rainfall totals:'
      write(9,*)'  -----------------------'
      write(9,*)' '
      write(9,*)'  Hour:  Rainfall (mm):'
c
      return
      end
```

```
c
c
c
c
c
c     ----------------------------------------------------------------
      subroutine rg_read(day,x,y,value,gr,cum_rg,istart_hour,iend_hour)
c     ----------------------------------------------------------------
c
      include 'quantare.inc'
      real value(nstat,96),cum_rg(nstat),x(nstat),y(nstat)
      character*3 gr(nstat)
      character day*6
      character ifile*80
c
      write(*,*)
      write(*,*)
      write(*,*)' ---------------------------------------------
     #-----------------------'
      write(*,*)
      write(*,*)'                               Data selection routine'
      write(*,*)
      write(*,*)' ---------------------------------------------
     #-----------------------'
      write(*,*)
      write(*,*)' Enter adjustment date in the form YYMMDD...'
      write(*,*)' e.g. for 7th July 1989 enter:'
      write(*,*)' 890707  <rtn>'
      read(*,11)day
 11   format(a6)
c
      write(*,*)
      write(*,*)' To select estimation period enter start and
     # end hours required'
      write(*,*)' e.g. to adjust from 03:00 to 07:00 enter:'
      write(*,*)' 3  <rtn>'
      write(*,*)' 7  <rtn>'
      read(*,*)istart_hour,iend_hour
c
      ifile='[cluckie.tilford.raingauge_data.raw_data]'//day//'_rg.dat'
      open(unit=33,name=ifile,status='old',readonly)
      do i=1,4
         read(33,*)
      end do
c     read(33,34)nstat
      read(33,34)
 34   format(t25,i2)
      do i=1,5
         read(33,*)
      end do
      do i=1,nstat
         x(i)=0.0
         y(i)=0.0
         do j=1,96
            value(i,j)=0.0
         end do
      end do
c
      do kk=1,nstat
         read(33,30)gr(kk)
 30      format(t21,a3)
         read(33,31)x(kk),y(kk)
```

```
 31      format(t20,f6.1,1x,f6.1)
         x(kk)=(x(kk)-ngr_lef_id)/50.0
         y(kk)=(y(kk)-ngr_bot_id)/50.0
         k=1
         do i=1,96/12
            read(33,16)(value(kk,j),j=k,k+11)
            k=k+12
         end do
 16      format(3x,12f5.1)
      end do
      do kk=1,nstat
         do i=1,96
            cum_rg(kk)=cum_rg(kk)+value(kk,i)
         end do
      end do
c
      return
      end
```

```
c
c
c
c
c
c
c -------------------------------------------------------------------
      subroutine setup_domain(px,py)
c -------------------------------------------------------------------
c
      include 'quantare.inc'
      real px(nx),py(ny)
c
c evaluate the spline on a rectangular grid at npx*npy points over
c the domain (xlo to xhi) * (ylo to yhi)
c
      delta=(xhi-xlo)/(nx-1)                        ! = 1
      do i=1,nx
         px(i)=min(xlo+(i-1)*delta,xhi)
      end do
      do i=1,ny
         py(i)=min(ylo+(i-1)*delta,yhi)
      end do
c
      return
      end
```

```
c
c
c
c
c
c     ----------------------------------------------------------------
      subroutine rg_interpolate1(x,y,z,px,py,rg_interp)
c     ----------------------------------------------------------------
c
c     this routine interpolates raingauge data after a modified
c     Renka and Cline routine
c
      include 'quantare.inc'
      integer triang(7*nstat),ifail
      real grads(2,nstat),px(nx),py(ny),rg_interp(nx,ny)
      real x(nstat),y(nstat),z(nstat)
c
c
c     interpolation of raingauge data to a regular grid
c     generate triangulation and gradients
c
      ifail=0
      write(*,*)' Please wait, computing interpolating function...'
      call e01sae(nstat,x,y,z,triang,grads,ifail)
      call x04aae(1,10)
      write(*,*)' Please wait, evaluating interpolant...'
      write(*,*)' '
      do j=ny,1,-1
         do i=1,nx
            ifail=-1
            call e01sbe
     #      (nstat,x,y,z,triang,grads,px(i),py(j),rg_interp(i,j),ifail)
         end do
      end do
c
      do i=1,nx
         do j=1,ny
            if (rg_interp(i,j).lt.0.0) rg_interp(i,j)=0.0
         end do
      end do
c
      return
      end
```

```
c
c
c
c
c
c -------------------------------------------------------------------
     subroutine rg_interpolate2(x,y,z,px,py,rg_interp)
c -------------------------------------------------------------------
c
c this routine interpolates raingauge data using a modified
c Shepard routine
c
     include 'quantare.inc'
     integer ifail,minnq,nq,nw
     real rnq,rnw
     real x(nstat),y(nstat),z(nstat)
     real px(nx),py(ny),rg_interp(nx,ny)
     real fnodes(5*nstat),wrk(6*nstat)
c
c compute nodal function coefficients
c
     rnq=0.0
     nq=0
     write(*,*)' Please wait, computing nodal function...'
     ifail=0
     call e01see(nstat,x,y,z,rnw,rnq,nw,nq,fnodes,minnq,wrk,ifail)
c
c evaluate interpolant
c
     write(*,*)' Please wait, evaluating interpolant...'
     write(*,*)' '
     call x04aae(1,10)
     do i=ny,1,-1
        do j=1,nx
           ifail=-1
           call e01sfe(nstat,x,y,z,rnw,fnodes,
    &                       px(j),py(i),rg_interp(j,i),ifail)
        end do
     end do
c
     do i=1,ny
        do j=1,nx
           if (rg_interp(j,i).lt.0.0) rg_interp(j,i)=0.0
        end do
     end do
c
     return
     end
```

```
c
c
c
c
c
c
c
c  ------------------------------------------------------------------
      subroutine outside_boundary3(array)
c  ------------------------------------------------------------------
c
      include 'quantare.inc'
      real out(nx,ny),array(nx,ny)
c
      do i=1,ny
         if (.not.(start(i).eq.1.and.stop(i).eq.1)) then
               mask_stop=i+1
               goto 5
         end if
 5    end do

      do i=1,ny
         if (.not.(start(i).eq.1.and.stop(i).eq.1)) then
               mask_start=i-1
               goto 6
         end if
      end do
 6    continue
c
      do i=mask_start+1,mask_stop-1
         do j=1,start(i)
            out(j,i)=10.0
         end do
         do j=stop(i),nx
            out(j,i)=10.0
         end do
      end do
      do i=1,mask_start
         do j=1,nx
            out(j,i)=10.0
         end do
      end do
      do i=mask_stop,ny
         do j=1,nx
            out(j,i)=10.0
         end do
      end do
c
      k=1
      do i=1,nx
         do j=1,ny
            if (out(i,j).eq.10.0) array(i,j)=-999.999
         end do
      end do
c
      return
      end
```

```
c
c
c
c
c ------------------------------------------------------------------
      subroutine graphics(icount,idev,icol,kh,istart_hour,x,y,rg_interp)
c ------------------------------------------------------------------
c
      include 'quantare.inc'
      integer idev,kh,istart_hour,icount,icol
      real rg_interp(nx,ny)
      real x(nstat),y(nstat)
      real zcl(2)
c
c
      if (icount.eq.1) then
         if (idev.eq.1) call groute('select mgpx;exit')
         if (idev.eq.2) call groute('select mx11;exit')
         if (idev.eq.3) call groute('select mregis;exit')
         if (idev.eq.4) call groute('select mvga;exit')
         if (idev.eq.5) call groute('select glj250;exit')
         if (idev.eq.6) call groute('select hposta4;exit')
         call gopen
         call rorien(2)
         call grpsiz(xsi,ysi)
         xsize=0.4*xsi
         ysize=(2.0/1.3)*xsize
         height=0.03*min(xsize,ysize)
         xmax=float(nx)
         xmin=0.0
         ymax=float(ny)
         ymin=0.0
         xoff=0.35*xsi
         yoff=0.35*ysi
         xoffk=0.65*xsi
         yoffk=0.15*xsi
         call rshade(icol,0)
         call rundef(-999.999,0)
         call glimit(xmin,xmax,ymin,ymax,0.0,0.0)
         call gvport(xoff,yoff,xsize,ysize)
      end if
      icount=icount+1
c
      if (kh.eq.istart_hour) then
         write(*,*)
         write(*,*)' Hourly graphics presentation display:'
         write(*,*)'   Please enter a value for the top of the rainfall
     # slicing scale. This'
         write(*,*)'   will be used to determine an appropriate slice
     # range.'
         read(*,*)ztop
         zcl(2)=ztop/7.0
         zcl(1)=0.0
      end if
c
      if (kh.eq.99) then
         write(*,*)
         write(*,*)' Final graphics presentation display:'
         write(*,*)'   Please enter a value for the top of the rainfall
     # slicing scale. This'
         write(*,*)'   will be used to determine an appropriate slice
     # range.'
```

```
            read(*,*)ztop
            zcl(2)=ztop/7.0
            zcl(1)=0.0
         end if
c
         call rclass(zcl,8,5)
         call gcnr2s(rg_interp,nx,ny) ! interpolated raingauge
         call gscale
         call draw_axes(height)
         call raingauge(x,y,nstat)
         call coast2
         call anglian2
         if (kh.eq.istart_hour.or.kh.eq.99)
     #            call key(height,yoffk,xoffk)
         call gempty
c
         return
         end
```

```
c
c
c
c
c
c -----------------------------------------------------------------------
      subroutine draw_axes(height)
c -----------------------------------------------------------------------
c
      parameter (gundef=999.999,iundef=9999,undef=0.0)
      real north,south,east,west
      integer lenarl(4)
      character*14 texarl(4)
c
      east=5700.0
      west=4400.0
      north=4400.0
      south=2400.0
      data lenarl / 0,13,0,14 /
      data texarl / ' ','Easting (NGR)',' ','Northing (NGR)' /
      data dbl,ntick / 1000.0,4 /
c
      call glimit(west,east,south,north,0.0,0.0)
      call raxtef(6,'SWIM',1)
      call raxlfo(0,0,iundef,iundef)
      call raxbti(6,gundef,gundef,dbl)
      call raxsti(ntick)
      call raxdis(4,1,iundef)
      call raxdis(3,1,iundef)
      call raxdis(6,1,iundef)
      call raxis2(south,west,height,lenarl,texarl)
      call raxis(1,north,height,2)
      call raxdis(4,0,iundef)
      call raxis(2,east,height,2)
c
      return
      end
```

```
c
c
c
c
c
c
c  ----------------------------------------------------------------------
      subroutine coast2
c  ----------------------------------------------------------------------
c
      include 'quantare.inc'
      character*80 fname
c
      xshift=-ngr_lef_id
      yshift=-ngr_bot_id
      xdiff=ngr_rig_id-ngr_lef_id
      ydiff=ngr_top_id-ngr_bot_id
c
      fname='[cluckie.tilford.radar_data.programs]coastline.dat'
      open (unit=3,file=fname,status='old',readonly)
      call glimit(0.0,xdiff,0.0,ydiff,0.0,0.0)
      call gwicol(0.7,32)
      call gvect(xor,yor,0)
      iflag=0
      do i=1,6000
         read(3,*,end=98)ix,iy
         if ((ix.ge.ngr_lef_id.and.ix.le.ngr_rig_id).and.
     #         (iy.ge.ngr_bot_id.and.iy.le.ngr_top_id)) then
            id=1-iflag
         else if (ix.eq.32767.and.iy.eq.32767) then
            iflag=1
            goto 97
         else
            id=0
         end if
         call gvect(float(ix)+xshift,float(iy)+yshift,id)
         iflag=0
 97      continue
      end do
 98   close(unit=3)
c
 999  return
      end
```

```
c
c
c
c
c
c     ----------------------------------------------------------------
      subroutine anglian2
c     ----------------------------------------------------------------
c
      include 'quantare.inc'
      integer ix(6000),iy(6000),icolour(6000)
      real ngr_x(6000),ngr_y(6000)
      real ang_ngr_xmax(6), ang_ngr_xmin(6)
      real ang_ngr_ymax(6), ang_ngr_ymin(6)
      character*80 fname(6)
c
      xshift=-ngr_lef_id
      yshift=-ngr_bot_id
      xdiff=ngr_rig_id-ngr_lef_id
      ydiff=ngr_top_id-ngr_bot_id
c
      fname(1)='[cluckie.tilford.dig]anglian_inland_boundary.map'
      fname(2)='[cluckie.tilford.dig]lobound.map'
      fname(3)='[cluckie.tilford.dig]ocbound.map'
      fname(4)='[cluckie.tilford.dig]ncbound.map'
      fname(5)='[cluckie.tilford.dig]nor_only_bound.map'
c
      do k=1,5
         open (unit=3,file=fname(k),status='old',readonly)
         num_data=0
         ixmax=0
         iymax=0
         ixmin=10000
         iymin=10000
         do i=1,6000
            read(3,*,end=98)ix(i),iy(i),icolour(i)
            if (ix(i).gt.ixmax) ixmax=ix(i)
            if (iy(i).gt.iymax) iymax=iy(i)
            if (ix(i).lt.ixmin) ixmin=ix(i)
            if (iy(i).lt.iymin) iymin=iy(i)
            num_data=num_data+1
         end do
 98      ang_ymax=float(iymax)
         ang_ymin=float(iymin)
         ang_ngr_ymax(1)=4250.0
         ang_ngr_ymin(1)=1750.0
         ang_ngr_ymax(2)=3390.0
         ang_ngr_ymin(2)=3170.0
         ang_ngr_ymax(3)=3270.0
         ang_ngr_ymin(3)=2520.0
         ang_ngr_ymax(4)=3420.0
         ang_ngr_ymin(4)=2290.0
         ang_ngr_ymax(5)=2580.0
         ang_ngr_ymin(5)=2340.0
         ang_xmax=float(ixmax)
         ang_xmin=float(ixmin)
         ang_ngr_xmax(1)=5700.0
         ang_ngr_xmin(1)=4505.0
         ang_ngr_xmax(2)=5340.0
         ang_ngr_xmin(2)=4890.0
         ang_ngr_xmax(3)=5563.0
         ang_ngr_xmin(3)=4570.0
```

```
              ang_ngr_xmax(4)=6106.0
              ang_ngr_xmin(4)=5570.0
              ang_ngr_xmax(5)=6250.0
              ang_ngr_xmin(5)=5920.0
c
              dy=ang_ngr_ymax(k)-ang_ngr_ymin(k)
              dx=ang_ymax-ang_ymin
              ay=dy/dx
              by=ang_ngr_ymax(k)-(ay*ang_ymax)
              dy=ang_ngr_xmax(k)-ang_ngr_xmin(k)
              dx=ang_xmax-ang_xmin
              ax=dy/dx
              bx=ang_ngr_xmax(k)-(ax*ang_xmax)
              do i=1,num_data
                 ngr_x(i)=(ax*float(ix(i)))+bx
                 ngr_y(i)=(ay*float(iy(i)))+by
              end do
              call glimit(0.0,xdiff,0.0,ydiff,0.0,0.0)
              call gwicol(0.2,32)
              do i=1,num_data
               if ((ngr_x(i).ge.ngr_lef_id.and.ngr_x(i).le.ngr_rig_id).and.
     #           (ngr_y(i).ge.ngr_bot_id.and.ngr_y(i).le.ngr_top_id)) then
                   if (icolour(i).eq.0) ipen=0
                   if (icolour(i).gt.0) ipen=1
                 else
                   ipen=0
               end if
              call gvect(ngr_x(i)+xshift,ngr_y(i)+yshift,ipen)
              end do
              close(unit=3)
           end do
c
  999      return
           end
```

```
c
c
c
c
c
c
c     -----------------------------------------------------------------
      subroutine key(height,y_off,x_off)
c     -----------------------------------------------------------------
c
      integer lenar3(3)
      character*9 texar3(3)
      data lenar3 / 5,5,9 /
      data texar3 / 'Below','Above','Undefined' /
      call rtxfon('SWIM',1)
      call gscamm
      call gclopt(lenar3,texar3,height,2,0.0,1)
      call gcoscl(x_off,y_off)
      return
      end
```

```
c
c
c
c
c
c     ------------------------------------------------------------------------
      subroutine raingauge(x,y)
c     ------------------------------------------------------------------------
c
      include 'quantare.inc'
      real x(nstat),y(nstat)
c
      anx=real(nx)
      any=real(ny)
      call glimit(0.0,anx,0.0,any,0.0,0.0)
      do i=1,nstat
         call gwells(3,x(i),y(i),1.5,0.02,33)
      end do
      return
      end
```

Appendix 2: Include File

Note, that in this example, parameters for 7th August 1989 will be used (other lines commented out).

```
c
c
c    radgap.inc:  an include file used by radgap
c
c
c
c    PARAMETER NOTES
c
c    ngr_lef_id  = ngr coordinates left-side adjustment domain
c    ngr_rig_id  = ngr coordinates right-side adjustment domain
c    ngr_top_id  = ngr coordinates of top of adjustment domain
c    ngr_bot_id  = ngr coordinates of bottom of adjustment domain
c    nx          = dimension of interpolation domain (x-axis)
c    ny          = dimension of interpolation domain (y-axis)
c    xlo         = lower bound of interpolation domain (x-axis)
c    xhi         = upper bound of interpolation domain (x-axis)
c    ylo         = lower bound of interpolation domain (y-axis)
c    yhi         = upper bound of interpolation domain (y-axis)
c    idom        = number of points outside  interpolation domain (ie in
mask)
c    start,stop  = start and end cells of interpolation domain
c    nstat       = number of raingauge stations
c    mmax        = total number of data points (=nstat+idom)
c    num_cmt     = number of predefined catchments
c    max_nodes   = maximum number of nodes in any catchment
c
c
c
c    PARAMETER DATA TYPES
c
       integer nx,ny,nstat,idom,max_nodes,num_cmt
       integer mask_start,mask_stop
       real xlo,xhi,ylo,yhi,delta,cell
       real ngr_lef_id,ngr_rig_id,ngr_top_id,ngr_bot_id
c
c
c    PARAMETER STATEMENTS
c
       parameter (cell=5.0)
       parameter (num_cmt=10,max_nodes=50)
       parameter (ngr_lef_id=4400.0,ngr_rig_id=5700.0)
       parameter (ngr_bot_id=2400.0,ngr_top_id=4400.0)
c
       parameter (nx=(ngr_rig_id-ngr_lef_id)/(cell*10.0) )
       parameter (ny=(ngr_top_id-ngr_bot_id)/(cell*10.0) )
c
       parameter (xlo=1.0,xhi=real(nx),ylo=1.0,yhi=real(ny))
c
       parameter (idom=522)
       integer start(ny),stop(ny)
c
       data start /  1, 1, 2, 2, 2, 2, 2, 2, 3, 3,
     #                3, 4, 5, 6, 7, 7, 7, 7, 7, 7,
     #                7, 7, 7, 7, 7, 7, 7, 7, 7, 7,
     #                7, 7, 7, 7, 7, 7, 7, 1, 1, 1 /
       data stop /   1, 1,11,12,13,14,15,16,16,17,
```

```
     #              20,22,23,23,24,25,25,25,25,25,
     #              25,25,25,25,25,25,25,25,25,25,
     #              24,24,23,21,20,19,18, 1, 1, 1 /
c
c  NOTE: use correct value of nstat for data (if necessary uncomment
c        appropriate line, and comment out others)
c
c  use these settings for 891218
c    parameter (nstat=68)
c  use these settings for 891214
c    parameter (nstat=66)
c  use these settings for 890729
c    parameter (nstat=63)
c  use these settings for 890707
     parameter (nstat=58)
c  use these settings for 890627
c    parameter (nstat=66)
c  use these settings for 890320
c    parameter (nstat=49)
c  use these settings for 881129
c    parameter (nstat=64)
c
     parameter (mmax=nstat+idom)
c
c
```

Appendix 3: Example Raingauge Rainfall Inputfile

```
----------------------------------------------------------------

Raingauge rainfall datafile
27 June       1989
Number of stations  66
Data from 00:00 (first datum) to 23:45 (last datum)
15 minute data interval

----------------------------------------------------------------

Gauge reference S02
Gauge location  5552.0 3586.0
 0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.5  0.5  0.0  0.0  0.5
 0.0  0.5  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  1.0  0.0
 1.0  0.5  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0  1.0
 0.0  0.5  0.5  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference S03
Gauge location  5106.0 3698.0
 0.0  0.0  0.0  0.0  0.0  0.5  0.5  0.0  0.5  0.0  0.0  0.5
 0.0  0.5  0.5  0.0  0.0  2.5  2.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0
 1.0  0.0  1.0  1.0  0.0  0.0  2.0  1.0  0.5  0.0  0.0  0.0
 0.5  0.0  0.0  0.0  1.0  0.5  0.0  1.0  1.0  0.5  1.0  0.5
 0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  1.5  0.5  0.0  0.0
 0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference S04
Gauge location  5241.0 3611.0
 0.0  0.0  0.0  0.0  1.0  0.5  0.5  0.5  0.5  0.0  0.5  0.0
 0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  1.0  0.0  0.0  0.0  0.5  0.0  0.5  1.5  1.0  0.0  0.5
 0.0  2.0  1.0  0.0  0.0  0.0  0.0  1.5  1.5  0.0  0.5  0.5
 0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0
 0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference S05
Gauge location  5222.0 3740.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.5  0.5  0.0  0.0  0.5
 0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.5  0.0  1.0  0.5  0.5  2.5  0.0  1.0  0.5  0.0
 0.5  0.0  0.0  0.0  0.0  0.0  0.5  0.5  1.0  0.5  1.0  1.0
 0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference S06
Gauge location  5203.0 3826.0
 0.0  0.0  0.0  0.0  0.5  0.0  0.5  0.5  0.5  0.5  0.0  0.0
 0.0  0.0  0.5  0.5  0.5  0.0  0.5  1.5  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  1.5  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0
 0.0  0.5  0.0  0.5  0.5  2.0  5.0  0.5  1.5  0.5  0.0  0.0
```

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	2.0	2.0	0.5
0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference S07
Gauge location 5296.0 3754.0

0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.5	0.0	0.5	0.0	0.0
0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0	0.5	0.0	0.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5
0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference S11
Gauge location 5319.0 3859.0

0.0	0.0	0.0	0.0	0.5	1.0	0.5	0.5	0.0	0.5	0.5	0.0
0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.5	1.5	0.0
0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference S13
Gauge location 4985.0 3756.0

0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	0.0	0.0	0.0
1.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	0.5
1.0	3.5	1.0	0.0	0.0	1.0	1.5	1.0	0.5	0.0	0.0	0.0
0.0	0.5	0.5	0.5	0.5	0.0	1.0	0.5	0.0	0.0	0.5	0.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference S14
Gauge location 5405.0 3730.0

0.0	0.0	0.0	0.0	0.5	0.5	0.5	1.0	0.5	0.5	0.0	0.5
0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0	3.0	0.5
0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	0.5
1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference S16
Gauge location 4996.0 4053.0

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
0.0	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference S17
Gauge location 5174.0 3356.0

0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.0	0.5	0.5	0.5	0.0
0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	0.5	0.5	1.0	0.5	1.0	1.0	0.5	0.5	0.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

```
 0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference S18
Gauge location  5324.0 3445.0
 0.0  0.0  0.0  0.0  0.5  0.5  0.5  0.5  0.0  0.5  0.5  0.0
 0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  1.0
 0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.5  0.0  1.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference T01
Gauge location  4861.0 2831.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.5  1.5  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  3.5  1.0  0.5  0.5  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference T02
Gauge location  4838.0 3065.0
 0.0  0.0  0.0  0.0  0.5  0.5  0.0  0.0  0.5  0.5  0.5  0.5
 0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference T03
Gauge location  5124.0 2982.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  1.0
 0.5  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  2.5  0.5  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.5  0.5
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference T05
Gauge location  4627.0 2607.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference T07
Gauge location  5013.0 2975.0
 0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  1.0  1.5
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.5  1.5  0.5  0.0  0.5  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference T10
```

```
Gauge location  4867.0 2574.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.5  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference U01
Gauge location  5109.0 3202.0
 0.0  0.0  0.0  0.0  0.5  0.5  0.5  0.5  0.0  0.0  0.0  0.0
 1.5  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0
 0.0  0.0  0.0  1.5  1.0  0.0  0.0  0.0  0.0  0.0  0.5  0.5
 0.0  0.0  0.0  0.0  0.0  1.5  1.0  0.5  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference U04
Gauge location  4992.0 3247.0
 0.0  0.0  0.0  0.0  0.5  0.5  0.0  0.5  0.5  0.0  0.0  0.0
 0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  1.0  1.5  0.5  0.0  0.0  0.5  0.5  0.5  0.5  1.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference U05
Gauge location  5246.0 3091.0
 0.0  0.0  0.0  0.0  0.5  0.0  0.5  0.0  0.0  0.0  0.0  0.0
 0.5  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  2.5  0.5  0.5  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.5
 0.0  0.0  0.0  0.5  0.0  0.0  2.0  1.0  0.5  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference U06
Gauge location  5272.0 3993.0
 0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.5  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5
 0.0  0.0  0.5  0.0  0.0  0.0  0.0  2.0  1.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference U07
Gauge location  5143.0 3051.0
 0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.5  1.5
 0.0  0.5  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.5  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0
 0.5  0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference U08
Gauge location  5177.0 3008.0
 0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.5
```

1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 6.0 0.0 0.5 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.5 0.0
0.0 0.5 0.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
Gauge reference U10
Gauge location 5358.0 3258.0
0.0 0.0 0.0 0.0 0.5 0.5 0.5 0.0 0.0 0.0 0.5 0.0
0.0 0.5 0.5 0.5 0.5 0.5 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.5 0.5 0.0 0.0 0.0 0.5 0.5 1.0 0.5 0.0 0.0
0.0 0.0 0.0 0.0 0.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
Gauge reference U11
Gauge location 5067.0 3164.0
0.0 0.0 0.0 0.0 0.5 0.0 0.5 0.0 0.5 0.5 0.5 0.0
0.0 0.0 0.0 2.0 0.5 0.0 0.5 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.5 0.0 0.0 0.0 0.0 0.0
0.0 0.5 0.0 0.0 0.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
Gauge reference U13
Gauge location 5201.0 2984.0
0.0 0.0 0.0 0.0 0.0 0.5 0.0 0.0 0.0 0.0 0.0 0.0
0.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.5 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.5 0.0
0.0 0.5 0.0 0.0 0.0 0.0 0.0 0.5 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
Gauge reference U14
Gauge location 5201.0 3003.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.5
0.0 0.0 0.0 0.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 3.5 3.5 0.0 0.0 0.5 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.5
0.0 0.5 0.5 0.0 0.0 0.0 0.0 0.5 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
Gauge reference U15
Gauge location 5193.0 2986.0
0.0 0.0 0.0 0.0 0.0 0.5 0.0 0.0 0.0 0.0 0.0 0.0
0.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 1.5 1.0 0.5 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.5
0.0 0.5 0.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
Gauge reference U17
Gauge location 5001.0 3336.0
0.0 0.0 0.0 0.0 0.5 0.5 0.0 0.5 0.0 0.5 0.0 0.0
0.5 0.5 0.0 0.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

```
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.5  0.5  0.5  1.0  0.0
 0.5  0.0  0.0  0.0  4.0  2.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference U18
Gauge location  4946.0 3081.0
 0.0  0.0  0.0  0.0  0.5  0.5  0.5  0.0  0.5  0.0  0.5  0.5
 0.5  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  1.5  1.0  0.5  0.0  0.0  0.5  0.5  0.5  1.0  0.0
 0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference U19
Gauge location  5262.0 3251.0
 0.0  0.0  0.0  0.0  0.5  0.0  0.5  0.5  0.0  0.5  0.0  0.0
 0.5  1.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0
 0.0  0.5  0.0  1.5  1.0  0.5  0.5  1.0  0.5  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference U21
Gauge location  5476.0 3201.0
 0.0  0.0  0.0  0.0  0.5  0.0  0.5  0.0  0.5  0.0  0.0  0.0
 0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.5  0.5  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.5
 0.0  0.5  0.0  0.0  0.5  0.0  0.0  0.5  0.0  0.5  0.5  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference U22
Gauge location  5183.0 3029.0
 0.0  0.0  0.0  0.0  1.0  0.0  0.5  0.0  0.5  0.0  0.0  0.0
 0.0  0.0  0.5  1.5  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.5  1.5  0.5  0.0  0.0  0.5
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference U23
Gauge location  5460.0 3140.0
 0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.5  0.0  0.5  0.0  0.0
 0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.5  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.5  0.5  0.0  0.0  0.0  0.0  0.5
 0.0  0.0  0.5  1.0  0.0  0.0  0.0  1.0  1.5  1.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference U25
Gauge location  5274.0 3962.0
 0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.5
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.5  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0
```

```
 0.0  0.0  1.5  0.0  0.0  0.0  0.0  0.5  0.5  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference V01
Gauge location  4760.0 2647.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  2.5  0.5  0.5  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  1.0  1.0  1.5  1.0  0.5  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference V02
Gauge location  4902.0 2593.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  2.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  2.0  1.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference V03
Gauge location  4948.0 2847.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.5  1.0  1.5
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  4.5  1.5  2.5  0.5  0.0  0.5  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference V04
Gauge location  5000.0 3024.0
 0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.5  2.0  0.5
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.5  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.5  0.5  1.0  0.0  0.5
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference V05
Gauge location  4861.0 2888.0
 0.0  0.0  0.0  0.0  0.5  0.0  0.5  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0
 0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.5
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference V06
Gauge location  5148.0 2946.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.5
 0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.5  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  1.0  1.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
```

```
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference V07
Gauge location  4584.0 2619.0
 0.0  0.0  0.0  1.0  0.0  0.0  2.5  1.5  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.5  0.5  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference V08
Gauge location  4774.0 2867.0
 0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  1.5  3.5  0.5  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.5  4.5  1.0  0.5  0.5  0.0  0.5  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference V09
Gauge location  4754.0 2768.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  2.5  0.5  0.5  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.5  0.5  0.5  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference V10
Gauge location  4729.0 2596.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.5  0.0  0.5  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.5  0.0  0.0  0.5  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference V11
Gauge location  4882.0 2619.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.5  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.5  2.0  0.0  0.0  0.5  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference V12
Gauge location  4879.0 2642.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.0  0.0  0.5
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.5  0.5  1.5  0.5  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
Gauge reference V13
```

Gauge location 4854.0 2962.0

0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference V14
Gauge location 4795.0 2959.0

0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	1.0	0.5	0.0	0.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.5	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference V16
Gauge location 4645.0 2847.0

0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.0	1.5	1.0	0.5	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	1.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference V18
Gauge location 4691.0 2936.0

0.0	0.0	0.0	0.0	0.5	0.0	0.0	1.5	0.5	0.5	0.5	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.5	0.5	2.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference V19
Gauge location 4624.0 2551.0

0.0	0.0	0.0	0.0	0.0	0.0	4.5	4.5	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	2.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference V20
Gauge location 4727.0 2869.0

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0	0.0	0.0	0.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	8.0	0.0	0.5	0.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference V21
Gauge location 5042.0 2883.0

0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	1.5	0.0

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.5
0.0 0.0 0.0 0.0 0.5 1.5 0.5 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
Gauge reference V22
Gauge location 5038.0 2897.0
0.0 0.0 0.0 0.0 0.0 0.5 0.0 0.0 0.0 0.0 0.5 1.0
0.0 0.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 1.0 0.5 0.0 0.5 0.0 0.5 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
Gauge reference V23
Gauge location 4757.0 2688.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.5 2.5 2.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.5 0.5 0.0 0.0 0.0 0.5 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
Gauge reference V24
Gauge location 4567.0 2545.0
0.0 0.0 0.0 0.0 0.0 0.0 2.0 1.5 0.5 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 3.0 0.5 0.0 0.5 0.0 0.5 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
Gauge reference V25
Gauge location 4826.0 2807.0
0.0 0.0 0.0 0.0 0.5 0.0 0.0 0.0 0.5 1.5 1.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.5 1.0 0.5 0.5 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
Gauge reference V26
Gauge location 4946.0 2675.0
0.0 0.0 0.0 0.0 0.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 1.0 0.0 0.0 1.0 0.5 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.5 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
Gauge reference V27
Gauge location 4691.0 2823.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.0 1.0 0.5 0.5 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.0	0.0	0.0	4.5	1.5	1.0	0.5	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference V28

Gauge location 5090.0 2962.0

0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	1.5
0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5	1.5
1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference V29

Gauge location 4768.0 2616.0

0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.5	0.5	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference V30

Gauge location 4760.0 3005.0

0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5	0.0	0.5	0.0	0.0
1.5	1.0	0.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0	2.0	0.0	0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference V31

Gauge location 4877.0 2994.0

0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	1.5	1.0	0.5
0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gauge reference V32

Gauge location 4908.0 2674.0

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.5	0.0	0.5	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix 4: Example Catchment Inputfile

This catchment file contains data for one catchment and contains node co-ordinates for all nodes falling within the catchment in NGR coordinates (5 km grid resolution).

```
Catchment datafile for use with QUANTARE
File contains ngr's of points falling within pre-defined catchments
Example catchment datafile
1
Test catchment: 100 sq km (10 km * 10 km)
9
4850.0  2850.0
4900.0  2850.0
4950.0  2850.0
4950.0  2900.0
4950.0  2950.0
4900.0  2950.0
4850.0  2950.0
4850.0  2900.0
4900.0  2900.0
```

Appendix 5: Example Outputfile

```
----------------------------------------------
QUANTARE Output File: Catchment rainfall totals
----------------------------------------------

Hourly rainfall totals:
-----------------------

Hour:  Rainfall (mm):
Test catchment: 100 sq km (10 km * 10 km)
 1)     0.00
 2)     0.00
 3)     0.00
 4)     0.00
 5)     0.25
 6)     7.72
 7)     3.20
 8)     0.79
 9)     9.37
10)     0.14
11)     1.51
12)     0.65
13)     0.00
14)     0.00
15)     0.00
16)     0.44
17)     1.38
18)     4.55
19)     0.93
20)     0.00
21)     0.00
22)     0.05
23)     0.00
24)     0.00
Total   30.99


---------------- End of file ---------------
```

Appendix 6: Runtime Listing of QUANTARE

The following is a runtime listing of QUANTARE as described in chapter 6 of the main report.

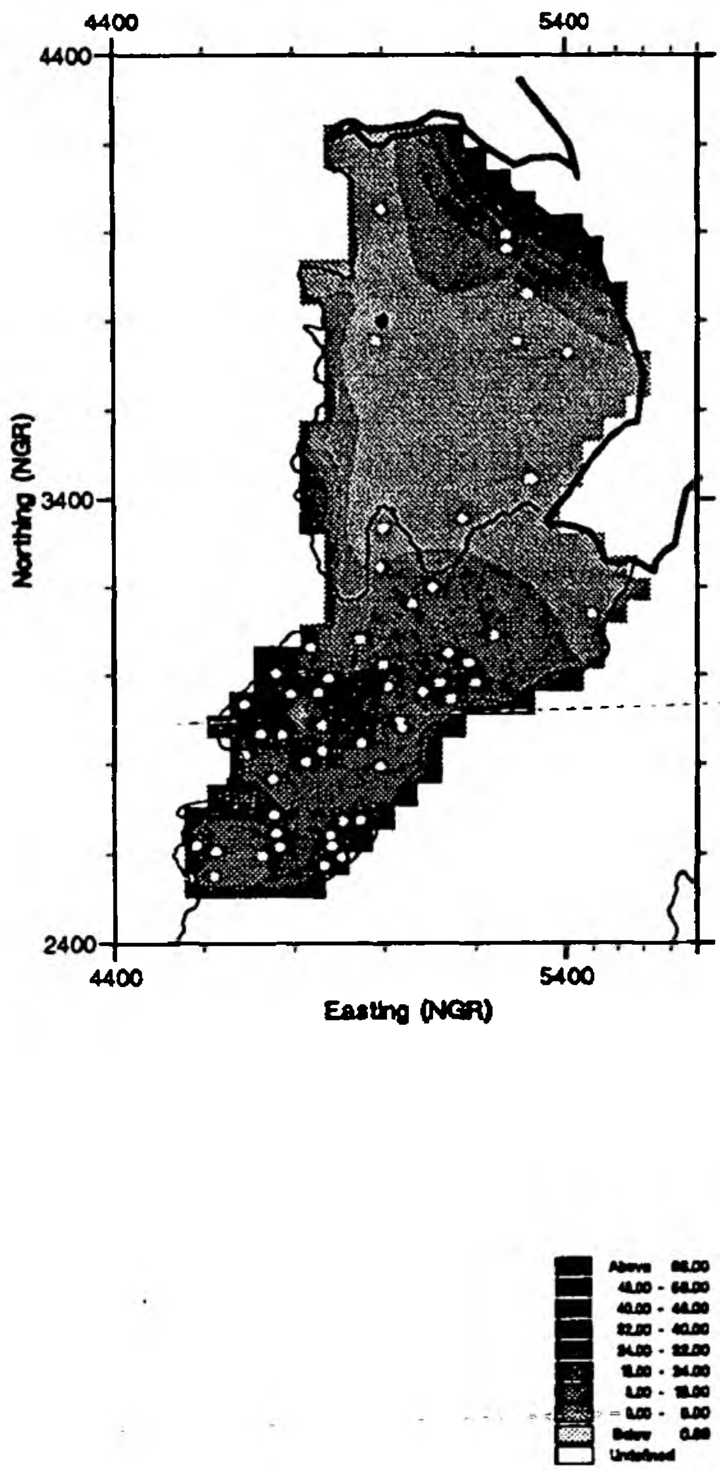
Bolded text indicates user input.

```
$run quantare

 -----------------------------------------------------------------------

                              QUANTARE

 A program to estimate quantitative areal rainfall amounts from
 point raingauge rainfall data, incorporating two-dimensional
 interpolation algorithms

 Written by:
    Water Resources Research Group
    University of Salford
    Salford, M5 4WT
    England, U.K.

 -----------------------------------------------------------------------

 IMPORTANT: Before continuing...
    Are you sure that the parameter settings in the file "quantare.inc"
    are correct? If not, abort program and change settings by editing
    the file. If OK...

 Hit return to continue...



 -----------------------------------------------------------------------
 The UNIRAS graphics routines in this program are device independent.
 -----------------------------------------------------------------------

 Please type in the integer corresponding to the device required
   (1) VAXstation       (GPX driver)
   (2) VAXstation       (X11 driver)
   (3) VT Emulator      (ReGIS driver)
   (4) IBM PC           (VGA driver)
   (5) Inkjet Printer
   (6) Laserwriter      (Postscript)

 Please type integer [1,2,3,4,5 or 6]...
6



 -----------------------------------------------------------------------
 Option Menu
 -----------------------------------------------------------------------

 Options (default in UPPER CASE)
```

```
  1. Graphics every hour                    (Y/n)
  2. Graphics at end of period            (Y/n)
  3. Auto refresh                           (Y/n)
  4. Interpolation algorithm (enter a or b):
     (a) Renka and Cline                  (default)
     (b) Modified Shepherd
  5. Colour or black/white graphics         (C/b)
  6. Compute catchment rainfall totals      (Y/n)

  To change a default setting enter integer corresponding to the setting
  to be changed, press return key and enter y or n as appropriate
  [Enter 0 <rtn> to continue]...

1
n

5
b

0


  --------------------------------------------------------------------

                      Data selection routine

  --------------------------------------------------------------------

 Enter adjustment date in the form YYMMDD...
 e.g. for 7th July 1989 enter:
 890707  <rtn>
890707

 To select estimation period enter start and end hours required
 e.g. to adjust from 03:00 to 07:00 entor:-
 3  <rtn>
 7  <rtn>
1
24

  --------------------------------------------------------------------

                     Computation segment

  --------------------------------------------------------------------


 Computing for hour            1
 ---------------------------------------
 Please wait, computing interpolating function...
 Please wait, evaluating interpolant...

 Computing for hour            2
 ---------------------------------------
 Please wait, computing interpolating function...
 Please wait, evaluating interpolant...

 Computing for hour            3
 ---------------------------------------
 Please wait, computing interpolating function...
 Please wait, evaluating interpolant...

 Computing for hour            4
```

```
--------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour             5
--------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour             6
--------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour             7
--------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour             8
--------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour             9
--------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour             10
--------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour             11
--------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour             12
--------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour             13
--------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour             14
--------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour             15
--------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour             16
--------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...
```

```
Computing for hour              17
---------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour              18
---------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour              19
---------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour              20
---------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour              21
---------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour              22
---------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour              23
---------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Computing for hour              24
---------------------------------------
Please wait, computing interpolating function...
Please wait, evaluating interpolant...

Please wait, preparing final graphics...

 Final graphics presentation display:
   Please enter a value for the top of the rainfall slicing scale. This
   will be used to determine an appropriate slice range.
56

Do you wish to replot the rainfall field (Y/N)
n

--------------------------- QUANTARE STOP -------------------------


$
```


4400
5400
4400
3400
2400
Northing (NGR)
4400
5400
Easting (NGR)
Above 56.00
48.00 - 56.00
40.00 - 48.00
32.00 - 40.00
24.00 - 32.00
16.00 - 24.00
8.00 - 16.00
0.00 - 8.00
Below 0.00
Undefined

Appendix 7: Devices Supported

The following devices are explicitly supported by QUANTARE.

DEC VAXstations (GPX driver)
DEC VAXstations (X11 driver)
VAX Terminal Emulators (ReGIS driver)
DEC Ink Jet Printer
Laserwriter (Postscript Driver)

Appendix 8: Utility Program Source Listing (set idom)

```
c
        program set_idom
c
c   this routine determines the correct setting for the parameter
c   idom (i.e. the number of cells falling outside of the adjustment
c   boundary. Use this if the boundary has been changed or if a new
c   adjustment boundary is being defined.
c
c   before running enter correct values for the adjustment domain
c   dimensions (i.e. nx and ny)
c
        integer nx,ny
        parameter (nx=26,ny=40)
        integer start(ny),stop(ny)
c
c
c   'straight-edge' anglian region, northern area boundary
c
        data start /  1, 1, 2, 2, 2, 2, 2, 2, 3, 3,
     #                3, 4, 5, 6, 7, 7, 7, 7, 7, 7,
     #                7, 7, 7, 7, 7, 7, 7, 7, 7, 7,
     #                7, 7, 7, 7, 7, 7, 7, 1, 1, 1 /
        data stop /   1, 1,11,12,13,14,15,16,16,17,
     #               20,22,23,23,24,25,25,25,25,25,
     #               25,25,25,25,25,25,25,25,25,25,
     #               24,24,23,21,20,19,18, 1, 1, 1 /
c
c
        ic=0
        do i=3,37
           do j=start(i)+1,stop(i)-1
           ic=ic+1
           end do
        end do
        ic=(nx*ny)-ic
        write(*,*)
        write(*,*)'  Parameter idom should be set to the following value
',ic
c
        end
```