Hydrologic Modelling of Salinity in the Water Resource Recovery Catchments

GOVERNMENT OF WESTERN AUSTRALIA

Volume 5: Tone and Perup River Catchments

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Water and Rivers Commission

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Cover Photograph: The Tone River at Tonebridge

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Volume 5: Tone and Perup River Catchments

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Summary

The Warren Catchment, situated 250 km south of Perth, Western Australia, is one of the five Water Resource Recovery Catchments identified in Western Australia's Salinity Action Plan (State Salinity Council, 1998). Clearing for agriculture in the upper parts of the catchment, the catchments of the Tone and Perup tributaries, has contributed to an elevation of the streamflow salinity to greater-than-desirable levels at downstream locations. An objective of the Salinity Action Plan is to prepare integrated catchment plans in partnership with catchment groups, with the target of achieving potable water supply levels by 2030.

The Water and Rivers Commission has developed a computing system 'Microstation And Geographic Information Computation' (M.A.G.I.C.) to model the hydrology of the catchments. The hydrologic analysis assists in developing plans for the catchment by improving understanding of water use and movement in the catchment, and allowing proposed actions to be tested for their likely impact on water balance. The main output of the model is an estimate of distribution and rates of steady state deep groundwater discharge associated with the type and distribution of vegetation throughout the catchment.

This report presents the models of the Tone and Perup Sub-Catchments within the Warren Catchment. It also identifies sites for tree planting (on pasture existing in 1996) to meet an estimate of a required reduction in deep groundwater discharge, with the aim of minimising the area planted, and assuming that trees can effectively use deep groundwater discharge. Results are summarised in spreadsheets and portrayed as mapsheets in Map Appendix 5 (which is unpublished and not included as part of this report). This report contains samples only of maps from Map Appendix 5. The Water and Rivers Commission should be contacted if these or any other maps are required.

1. Introduction

The Warren River Catchment is situated 250 km south of Perth, Western Australia with a catchment area of 4023 km^2. This report concentrates on the two uppermost tributaries – the Tone River and the Perup River. The Tone River has a catchment area of 1660 km^2 and the Perup River has a catchment area of 658 km^2.

In the South West of Western Australia, increased salinisation of streams and land has followed the clearing of deep-rooted natural vegetation from the land and its replacement with shallow-rooted agricultural crops and pastures. The forests drew most of the water from the soil, allowing very little to recharge deep aquifers, but accumulating within the soil some of the salt carried in the rainfall. Removal of forests increases recharge to deep groundwater, leading to rising groundwater tables and eventual discharge of deep groundwater containing high salt concentrations (Peck and Williamson, 1987).

The Western Australian Government extended the Country Areas Water Supply Act in 1978, introducing clearing controls legislation for the Warren River Catchment Area (among other south west catchments) to prevent additional clearing of native forest that would lead to increases in salinity. In 1978 the government also introduced legislation preventing further alienation of Crown land (Warren River Water Reserve Alienation Control 1978). In the Salinity Action Plan initiated in 1996, the Warren Catchment has been designated a Water Resource Recovery Catchment 'with the target of achieving potable water supply levels by 2030'. This is to be achieved by preparing and implementing integrated catchment plans 'in partnership with catchment groups according to management principles established by recovery teams' (State Salinity Council 1998).

Salinity of streamflows and areas of salt affected land in the Warren catchment have increased since 1978 due to earlier clearing. Stream salt load has increased over that period (Davies and Bari, 1995), with the Tone and Perup Catchments contributing a significant proportion. The Warren River is classified as a long term water resource for the future (Stokes *et al.*, 1995), and is one of the largest potable resources of the south west river basins (Schofield *et al.*, 1988). Currently, it is the relatively fresh runoff from the other tributaries of the Warren that are diluting the salt load from the Tone and Perup. Reducing the saline seepage from the Tone and Perup catchments will require revision of agricultural systems to maintain or increase productivity as well as conserve the water resource.

The Water and Rivers Commission has developed a computing system 'MicroStation And Geographic Information Computation' (M.A.G.I.C.) to model the hydrology of the catchments. The hydrologic analysis assists in developing plans for the catchment by improving understanding of water use and movement in the catchment, and allowing proposed actions to be tested for their likely impact on water balance. The main output of the model is an estimate of distribution and rates of steady state deep groundwater discharge associated with the type and distribution of vegetation throughout the catchment

The objective of this study was to use M.A.G.I.C. to develop hydrological models of the Tone and Perup catchments. Initially, the modelling makes an assessment of the catchments in January 1996, with tree densities and distribution interpreted from Landsat TM data recorded at that date. It then identifies sites for tree planting (on pasture existing in 1996) to meet an estimate of a required reduction in deep groundwater discharge, with the aim of minimising the area planted, and assuming that trees can effectively use deep groundwater discharge. The methods of analysis and results of the model are outlined in this report. This process was previously applied to the Upper Denmark (Mauger, 1994), Wellington (Arumugasamy and Mauger, 1994), Kent (Mauger, 1996a) and the Helena (Dixon, 1996) catchments. Maps have been produced for the Tone and Perup catchments that show the distribution and estimated rates of deep groundwater discharge, and the identified sites for planting trees. These maps can be used as a guide when planning tree layouts in farm plans.

2. Description of catchment

The Warren River basin forms part of the southern extremity of the Darling Plateau. The geomorphology of the catchment can be described as undulating plateau with moderately incised valleys, with bauxitic laterite soils over Archaean granitic and metamorphic rocks, and some areas of swampy flats (PWD, 1984). The annual average rainfall of the catchment varies from 520 mm in the east of the Tone catchment to 810 mm in the west of the Perup catchment to 940 mm in the south of the Tone catchment.

A laterite plateau landform exists over approximately two thirds of the Tone and Perup catchments. These laterite uplands are chiefly massive, with overlying pisolitic gravels and minor lateritized sands over mottled clays. A third of the Tone catchment occurs as dissected laterites and colluvium. Rolling country with mainly yellow mottled soils and gravely ridges, including valleyfill deposits, variably lateritized and podzolized (GSWA, 1985). In the Perup catchment, 15% of the area exists as incised valleys, with moderate to steep slopes with yellow podzolic soils and red earths. The remaining area exists as swampy flats. Here there are shallow drainage lines, with leached alluvial sands and podzolic soils (JDA, 1995). In scattered areas over the upper catchment, granite and adamellite can also be found in the surface layers.

A high percentage of the Tone catchment above the Bullilup gauging station near Tonebridge has been cleared for agricultural use. By 1965, 45% of the catchment had been cleared (PWD, 1984). This figure had increased to 70% in 1980. Since the clearing control legislation was put in place in 1978 and reforestation introduced, overall catchment forest cover has increased. In 1993, 64% was still cleared (Davies and Bari, 1995). From 1996 satellite data, it was estimated that only 56% of the catchment was still in a cleared state.

Below the gauging station a large percentage remains uncleared. It is only in the eastern part of the catchment towards the Unicup Lakes that clearing has occurred. From the 1996 satellite data clearing in this section of the catchment is about 20%.

In contrast to the Tone catchment, only a small percentage of the Perup catchment has been cleared. It was estimated that 18% of the catchment had been cleared by 1980. By 1993 this figure had been reduced to 16%, and from the 1996 satellite data, clearing is now estimated at 13%.

Of the remaining native vegetation, approximately two thirds of the area is jarrah-marri forest, with some wandoo. These forest areas generally lie along minor valleys. A further 20% of the vegetation is marri-wandoo woodlands, existing on the dissected laterites. The remaining area is classed as low woodlands, with paperbark woods on the swampy flats.

The Perup is dominated by jarrah-marri forest, accounting for 90% of the vegetated area, with the remaining area being low woodlands. In the upper Tone the jarrah-marri forest covers only half the vegetated area, with marri-wandoo woodlands covering a further third, and low woodlands the remainder.

3. Model of catchment

The personal-computer based M.A.G.I.C. modelling system was used to model the Tone and Perup subcatchments of the Warren River. Mauger (1996b) outlines the principles used in the hydrologic assessment of vegetation in catchments affected by dryland salinity in South Western Australia. A Geographic Information System approach was used in the development of the model. The resulting process can provide information at a scale of tens of metres, useful for planning on farms, while effects can be integrated for the whole catchment with areas up to hundreds of square kilometres. To help data management while computing, and to allow summary results to be distributed throughout the catchments, the catchments were divided into subcatchments, each with an average area of about 20 km^2.

Each subcatchment is modelled by a two-layer groundwater simulation, with inputs of rainfall and evapotranspiration, which is executed using the raster processing system, RASCAL. The soil profile was represented as two layers of equal slope to the surface slope. Soil depths and permeabilities have been assumed constant in the absence of maps that could indicate how values should vary (Mauger 1996b). The model was run in monthly time steps for a three year period. The first year ran the shallow groundwater simulation as a preliminary analysis to get an estimate of the initial water storage in each cell. The lower groundwater level was a "steady state" analysis, ie. the average over a long period of time assuming vegetation cover remained the same throughout. The shallow groundwater simulation was run for the next two years using the storage loss from the previous year. Ideally, after the third year the final water storage in each cell should have equalled the initial water storage.

Quantities needed as input into the model of the catchment were computed using RASCAL. Gridded elevation cells were generated from contour linework in MicroStation PC (geographical information drawing software package) format. Slope and drainage distribution information was generated from the elevation map in each RASCAL project. Average Annual Pan Evaporation Isopleths and Average Annual Rainfall Isohyets (1926-81) polygons in MicroStation PC format were converted into Rascal maps in each project.

Native vegetation cover across the catchments is derived from Landsat Thematic Mapping data, captured in January 1996. In rural land, most of the pixels (the area of land that is recorded as a single data point in a Landsat scene) contain a mixture of four components that can be identified using Bands 3, 4 and 5 of the Landsat TM data: green leaves, dead vegetation, sandy soil and shaded areas. An index referred to as the 'greenness', a percentage of pure green component, was computed by the method outlined in Appendix A of Mauger (1988). This was used to give an indication of the tree density in the catchment. Pixels comprising mostly open water or bare clay are also distinguished using a classification process.

The natural 'greenness' of the vegetation was assumed to be 0.0087*Rainfall + 0.0051*Evaporation +35.85. The coefficients for the natural 'greenness' formula were obtained from Mauger (1994). The transpiration rate from trees in any cell was computed as:

$$\frac{\text{(actual greenness)}}{\text{('natural' greenness)}} \times \text{('natural' transpiration rate)}$$

where ('natural' transpiration rate) is proportional to annual rainfall. (Mauger, 1996b)

If the natural greenness was overestimated, the transpiration rate from the trees would be underestimated leading to an over-estimation of streamflow.

Pasture transpiration was the product of the leaf area, pan evaporation and a pan to leaf evaporation coefficient. Pasture LAI was varied according to the month of the year.

The details of the computing processes used for the Tone and Perup catchments are documented in Appendix A. The computing processes used in these catchments are similar to those used for the other modelled catchments, documented in the Volume of Appendices in Mauger (1996a).

For the modelling of the Tone River, the catchment was separated into two smaller areas. The catchment above the Bullilup gauging station (s607007) at Tonebridge was one area, with the catchment below the gauging station the second. The Tone above Tonebridge was subdivided into forty nine sub-catchments of areas from nine to thirty three square kilometres. The Tone below Tonebridge was subdivided into thirty three sub-catchments of areas from eight to sixty five square kilometres. The Perup catchment above the Quabicup Hill gauging station (s607004) was subdivided into thirty seven sub-catchments of areas from nine to twenty seven square kilometres. Each sub-catchment was placed into a Rascal project consisting of separate maps comprised of 25 x 25 m cells.

The catchment boundaries, identifying numbers of each sub-catchment and directions of outflow are illustrated in Figure 1. Gauging stations recording streamflow and salinity at the outlet of the Perup and Tonebridge catchments are also shown on this figure. Spreadsheet 1 details the AMG coordinates of outlet locations in the sub-catchments (ie. points at which totals are reported).

The results of the model for each sub-catchment are relayed in Spreadsheets 2-4. Each spreadsheet has the sums for isolated individual catchments and aggregates for sub-catchments including all the upstream catchments.

Spreadsheet 2 contains all of the area statistics, such as catchment area (km^2), average rainfall (mm), cleared areas (km^2 & % of catchment), forest without upstream clearing (km^2 & % of catchment). The average flows to be expected with clearing as in 1996 are in Spreadsheet 3. This includes streamflow (m^3 & mm [m^3/m^2 of catchment]) and deep groundwater discharge ('seepage') (m^3 & mm).

In Spreadsheet 4, the model minimum tree planting for a 45% reduction in seepage at gauging station S607007 is reported for each sub-catchment. This includes the predicted and review seepages and streamflows that would occur if the trees were planted.

4. Modelling parameters

The Tone above Tonebridge was used as the calibration catchment. The model was calibrated by aggregating streamflow and deep groundwater discharge for the catchment and comparing them with historical data at the Bullilup gauging station at the catchment outlet (S607007). The annual average streamflow at the gauging station is 30.20 x 10^6 m^3. The groundwater seepage arriving at the outlet was estimated to be 10.66 x 10^6 m^3. The calibrated model parameters would then be applied to the Tone below Tonebridge and Perup catchments.

The bottom soil layer permeability is usually set by calibrating modelled deep groundwater discharge outside of the forest to the value estimated by dividing gauged salt flux by typical deep groundwater salinity (Mauger 1996b). Seepage from forested areas is not counted in contributing to salt output. In order to separate seepage originating from pasture areas from seepage generated within forested areas, a map was generated in which cells were marked as 'outside forest' if more than 2% of the catchment area upstream from them was pasture. Only seepage from 'outside forest' cells was assumed to carry salt.

An initial run was performed using the 1926-81 average annual rainfall isohyets and the following pasture and aquifer properties:

- Cleared areas were used for annual pasture with a peak Leaf Area Index (LAI) of 2.1.
- The topsoil layer throughout the catchment was taken to be 1.5 metres deep with a permeability of 30 m/month/unit hydraulic gradient and a porosity of 0.2.
- The bottom soil layer was 20 metres deep with a permeability of 3 m/year/unit hydraulic gradient.

The initial run did not take into account lake evaporation. Streamflow and seepage was found to be a third higher than the gauged average record.

Streamflow output from the model was reduced then by subtracting annual evaporation from lakes at the end of each year in the modelling process. The amount of evaporation removed from the lakes was 0.7 times the pan evaporation. The factor 0.7 is the assumed lake to pan correction factor (AWRC 1970).

Additionally, the rainfall data used in the model was changed to a set which had the average annual rainfall patterns for the period 1980 - 1995 (BOM, 1996). This data was considered more relevant than the long-term data set because the streamflow from the Tone catchment has only been recorded between 1978 and 1993. Over this period, average annual rainfall has been lower than earlier this century, and so will be expected to yield lower streamflow volume. The monthly coefficients for rainfall and pan evaporation were those used in the Kent, Denmark and Wellington catchments.

The model was re-run with the changed data, and the resulting streamflow and salt load was found to compare well with the recorded data. The modelled annual average streamflow was 27.26 x 10^6 m^3 and the deep discharge outside the forested areas was 9.55 x 10^6 m^3.

The above model parameters were then used to model the Perup and Tone below Tonebridge catchments. Of these two catchments, only the Perup is gauged. The computed annual average streamflow for the Perup was 22.34 x 10^6 m^3 and the average annual deep discharge outside the forested areas was 2.01 x 10^6 m^3. This compares with 13.90 x 10^6 m^3 and 3.16 x 10^6 m^3 respectively from the historical data. A sensitivity test on a fully forested subcatchment showed that streamflow varied almost proportionally to the topsoil layer permeability. Further calibration was not attempted because the volume difference was small in the overall water balance and accurate simulation of forest performance was not critical in predicting tree planting. The lower Tone catchment had a computed annual average streamflow of 24.04 x 10^6 m^3 and the deep discharge outside the forested areas was 1.97 x 10^6 m^3.

Saltfall decreases with the distance from the coast and is estimated to range between 24 mg/L over the lower Warren catchment and 20 mg/L over the Tone and Perup catchments in the upper Warren catchment. The salt concentration in the rain used in Table 1 was assumed to be proportional to the aggregate average rainfall for the sub-catchment and all upstream sub-catchments as shown in Spreadsheet 1.

In Table 1, a typical deep groundwater salinity of 9000 mg/L was used. Not many deep groundwater salinities have been measured throughout the catchment.

It was assumed that 25% of the salt from rainfall infiltrates into the bottom soil layer, thus not entering streamflow in the immediate future. This assumption is supported by a salt balance calculation on large sections of gauged catchments that are practically completely forested i.e. Kent River between Rocky Glen and Styx Junction guages, Bingham River, and Warren River at Wheatley Farm gauge less upstream gauges (as shown in Table 1). The flow weighted mean salt concentration was assessed from streamflow records. The total amount of salt resulting from the seepage of cleared land in the catchment was estimated by subtracting from the stream's salt load an estimate of the salt contributed directly by rainfall.

Maps showing the location of predicted deep groundwater discharge (seepage), classed by rate of discharge are in Map Appendix 5A. Also shown on the maps is native forest and scattered trees as interpreted from the Landsat MSS data for January 1996; streamlines, property information and contours taken from planimetric maps. A sample of the map is shown in Figure 2.

5. Seepage reduction objectives

The salt load from seepage can be calculated using streamflow salt records. Salt leaving the catchment can have two sources - groundwater seepage and rainfall. It is assumed that 75% of salt in rainfall leaves the catchment, with the remainder becoming part of the recharge to deep groundwater. Subtracting rainfall derived salt load from the streamflow salt load leaves salt contained in seepage which occurs as a result of clearing.

An analysis can be done to calculate the required reduction in seepage to reduce salt so that the annual flow weighted salinity is within potable limits. In the case of the Tone and Perup catchments, a gauging station downstream on the Warren River (Barker Rd Crossing) was used for the target salt concentration. The percentage reduction in current seepage salt load gives the target for the percentage reduction in the volume of seepage from cleared land. In this calculation, it was assumed that tree planting to reduce seepage would also reduce streamflow by 10%.

Table 1 shows the calculations required. Five gauging stations are referred to. The Tone River (Bullilup - S607007), Perup River (Quabicup Hill - S607004) and Wilgarup River (Quintarrup - S607144) each drain into the Warren River, upstream of the Wheatley Farm gauging station (S607003). The Barker Rd Crossing gauging station (S607220) is located further downstream towards the ocean outlet. Catchment streamflows, salt load and rainfall were averaged over a standard period (1979-1993). A target of 500 mg/L for the flow weighted average salinity at the Barker Rd station resulted in a target reduction of seepage of 45% from cleared land.

6. Tree planting to reduce seepage

In order to identify sites and areas to be indicated for tree planting, the following criteria were used:

- minimise the areas to be planted in order to reduce seepage to the required degree
- plant in areas currently not native forest

The computer analyse process selected the areas of highest seepage rate first, and then progressively lower seepage rates until the total reduction in seepage target was met. Cells with deep groundwater discharge rates in the bottom soil layer that exceeded 32 mm/year were selected to be planted. The results of the analysis are presented as 'denoted sites for trees' as shown in the mapsheets titled 'Recommended sites for tree planting' in Map Appendix 5B. A sample of one of these maps is shown in Figure 3. The principles outlined in Appendix A result in a pattern of tree planting in belts of trees being situated in zones where deep groundwater discharge is to be utilised.

The numerical results of the analysis are tabled in Spreadsheets 4. Firstly, an estimate was made of the effect the tree planting would have on the seepage. The results are under the heading 'PREDICTED SEEPAGE'. The density of planting to achieve the predicted seepage is also estimated. The review process then puts the planted trees in the model, and the steady state modelling of the streamflow and seepage is re-analysed. The results are labelled 'REVIEW STREAMFLOW' and 'REVIEW SEEPAGE'. The review streamflow was used as an estimate of the effect of planting on the mean streamflow in Table 1.

The reviewed seepage was used to confirm the predicted seepage estimate. The average Review / Predicted seepage was 103% for the upper Tone, 102% for the lower Tone and 97% for the Perup catchment. The reviewed streamflow was 53% of the 1996 streamflow for the upper Tone, 85% for the lower Tone and 74% for the Perup catchment. Over the cleared areas, predicted seepage was reduced to 48% of the 1996 seepage for the upper Tone, 64% for the lower Tone and 34% for the Perup catchment. The corresponding areas to be planted were 15% of the cleared area in the upper Tone, 10% in the lower Tone and 23% in the Perup catchment. Practical plans for planting trees to achieve the same seepage reduction would require greater area because seepage location and rate is not precisely known. The predicted seepage should be used as the guide when estimating the reduction in seepage that would result from the tree planting, since the reviewed estimate may not be that precise.

7. Field work

On the 17th of September 1997, the Tone and Perup catchments were visited, to compare the results of the mapsheets of Map Appendix 5B with the field situation.

It was found that generally the modelling predicted the location of groundwater seepages very well. However, occasionally the model predicted high rates of discharge where in reality there was little or no discharge, and, to a lesser degree, the model predicted little or no discharge where there was high discharge in reality.

It must be remembered that the model has been calibrated to the catchment scale using constant aquifer parameters and so may not be fully accurate in sections of the catchment. When dealing with smaller scale areas within the catchment, such as farm plans, more detailed knowledge of the geology of the site is required, so that more accurate plans can be derived.

8. Conclusion

The hydrological modelling of the Tone and Perup Catchments (total area 2318 km^2) identified the saline seepage resulting from pasture existing in 1996. The results from this process are portrayed as mapsheets in Map Appendix 5A.

It was estimated that the saline seepage from the 1996 pasture needs to be reduced by 45% on average to meet the target flow weighted average salinity of 500 mg/L at Barker Rd gauging station. The model was re-run with the suggested trees planted, and the resulting seepage volume was compared to the target reduction in seepage volume. This comparison suggested that the initial criteria chosen for tree planting was appropriate. Trees need to be planted where the seepage exceeds 32 mm/year (based on a bottom soil layer permeability of 3 m/year/unit hydraulic gradient and a peak pasture LAI of 2.1) to meet the target. The area covered by planted trees amounts to 15% of the cleared pasture areas in the upper Tone, 10% in the lower Tone and 23% in the Perup catchment. The results of the predicted sites of tree planting are portrayed as map sheets in Map Appendix 5B. If all of the suggested trees were planted, it was estimated that a decrease in streamflow at the gauging station of 30% would result.

The map sheets in Map Appendix 5B can be used as a guide when planning tree layouts in farm plans. Actual plans should also incorporate farm objectives and operational constraints. If farm plans are prepared, then their effectiveness in reducing salinity should be reviewed by modelling them.

Future inclusion of catchment spatial variations in hydrogeological parameters such as layer thicknesses and soil permeabilities will also improve accuracy in smaller scale areas such as the case of farm plans, or for larger scale areas such as future revisions of the full catchment.

This report contains only samples of the maps from Map Appendix 5, as Figures 2 and 3. If a full set, or a map of any particular area, is required, please contact the Water and Rivers Commission to obtain a copy.

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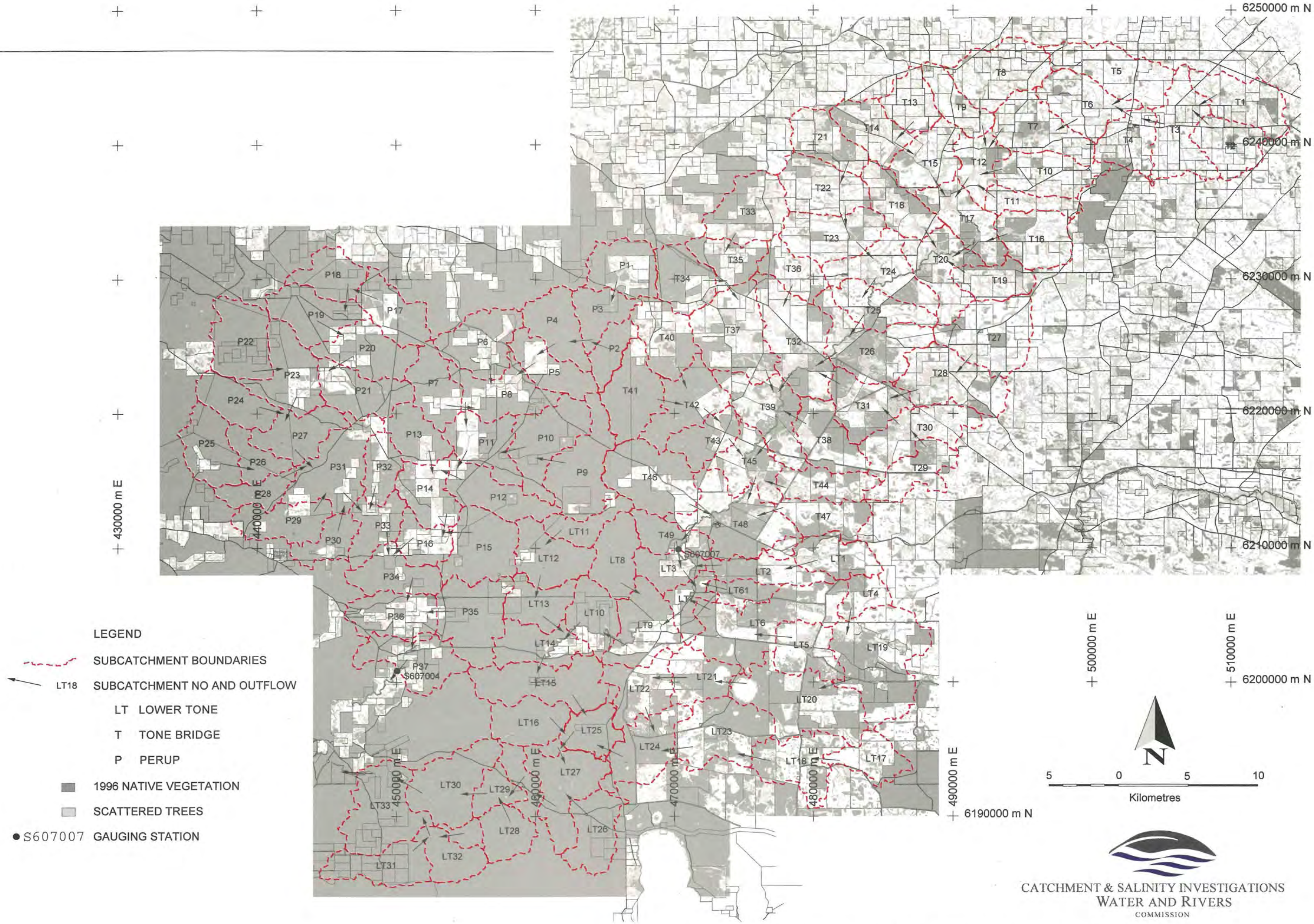

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Figure 1. Subcatchments of the Tone and Perup rivers showing catchment numbers and gauging stations.

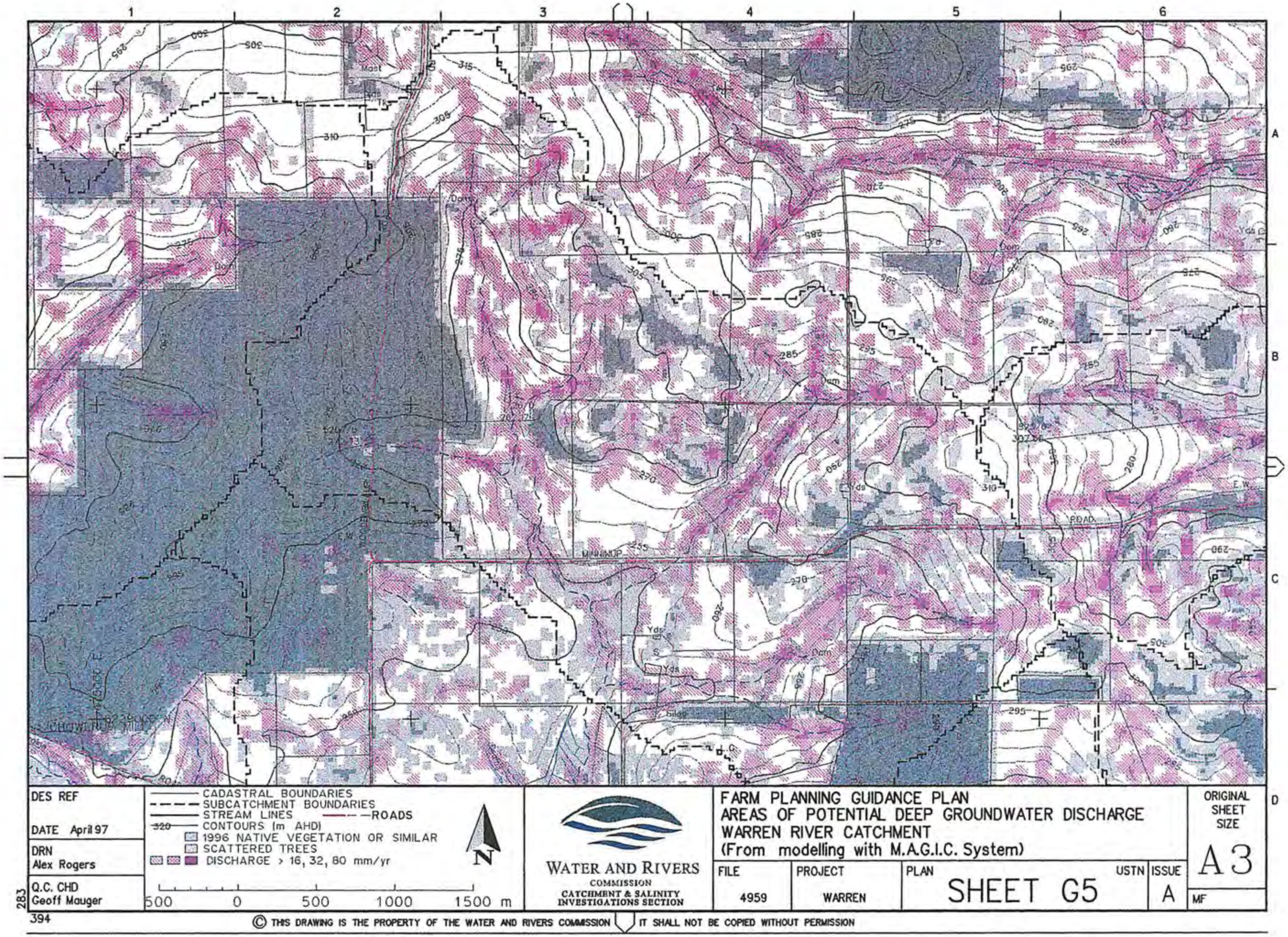


Figure 2. Sample of map from Map Appendix 5A.

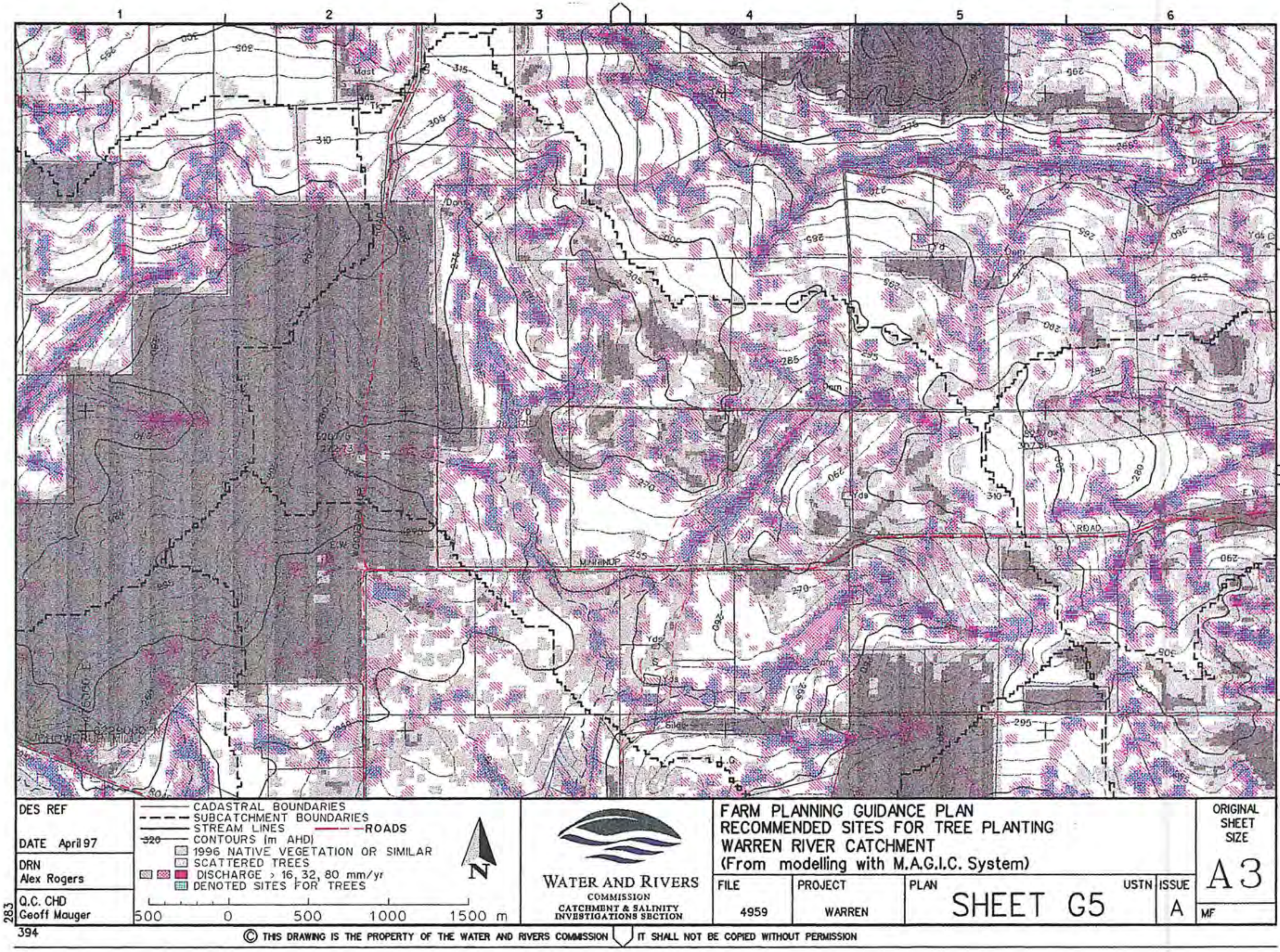


Figure 3. Sample of map from Map Appendix 5B.

Table 1. Calculation of salinity reduction targets

RAIN

CATCHMENT	Area	Volume		Salt	
	sq.km	$m^3 \times 10^6$	mm	mg/l	tonnes
Tone (Bullilup)	987	623	631	20	12456
Perup (Quabicup Hill)	658	503	765	20	10067
Wilgarup (Quintarrup)	461	422	915	24	10124
Warren (Wheatley Farm)	2991	2198	735	20	43968
Warren less (Tone, Perup, Wilgarup)	885	650	735	20	11321
Lower Tone (Bullilup to Perup confluence)	658	503	764	20	10054
Warren (Barker Rd)	4022	3089	768	24	72589
Barker Rd-Wheatley Farm	1031	891	864	30	26715

STREAM

	Before treatment					After treatment				
	Volume			Salt		Volume			Salt	
	Model	Record		mg/l	tonnes	Model	Estimate		mg/l	tonnes
	$m^3 \times 10^6$	$m^3 \times 10^6$	mm			$m^3 \times 10^6$	$m^3 \times 10^6$	mm		
Tone (Bullilup)	27.26	30.20	31	3487	105309	14.39	15.10	15	3256	49165
Perup (Quabicup Hill)	22.34	13.90	21	2591	36008	16.51	12.51	19	1548	19360
Wilgarup (Quintarrup)		28.00	61	969	27144		25.20	55	623	15706
Warren (Wheatley Farm)		87.10	29	1997	173953		67.81	23	1349	91477
Warren less (Tone, Perup, Wilgarup)		15.00	17	366	5492		15.00	17	483	7246
Lower Tone (Bullilup to Perup confluence)	23.74					20.20				
Warren (Barker Rd)		262.90	65	825	216775		243.61	61	**500**	121805
Barker Rd-Wheatley Farm		175.80	171	244	42822		175.80	204	173	30328

SEEPAGE (SALT LOAD = SALT IN STREAM - 75% SALT IN RAIN)

	Before treatment						After treatment				
	Volume			Salt		Reduce seepage to	Volume			Salt	
	Model	Record		mg/l	tonnes		Model	Estimate		mg/l	tonnes
	$m^3 \times 10^6$	$m^3 \times 10^5$	mm				$m^3 \times 10^6$	$m^3 \times 10^6$	mm		
Tone (Bullilup)	9.55	10.66	11	9000	95967		4.58	4.42	4	9000	39823
Perup (Quabicup Hill)	2.01	3.16	5	9000	28457		0.68	1.31	2	9000	11809
Wilgarup (Quintarrup)		2.17	5	9000	19551			0.90	2	9000	8113
Warren (Wheatley Farm)		15.66	5	9000	140977			6.50	2	9000	58501
Warren less (Tone, Perup, Wilgarup)		-0.33	0	9000	-2999			-0.14	0	9000	-1244
Lower Tone (Bullilup to Perup confluence)	1.93						1.23				
Warren (Barker Rd)		18.04	4	9000	162333	41%		7.48	2	9000	67363
Barker Rd-Wheatley Farm		2.53	2	9000	22786			0.22	0	9000	1993

Note: Estimate 50% streamflow reduction at Bullip after treatment. 10% at other sites.
'Treatment' includes any actions taken in the catchment to reduce the discharge of deep groundwater discharge and the salt it contains.

Plates

Taken 28/11/96 in Warren Catchment

1. Tone River catchment looking south from Tone River Rd (Water accumulating areas sustain green pasture longer into summer)

2. Dry bed of Tone River downstream of Hillier Rd

3. Tone River upstream from Mullidup Rd crossing

4. Small lake (approx 5500 mg/L TDS) by Mullidup Rd (near Mobrup Rd)

5. Tone River at Tonebridge

6. Waterlogging near break of slope where seepage expected off Tone Rd (near Forrester Rd) in Tone River catchment

7. Drain west of Pindicup Lake in lower Tone catchment (approx 1300 mg/L TDS)

8. Tree planting in the Perup River catchment near Badon Scott Rd

Spreadsheet 1

Locations and Sizes of Rascal Projects for Sub-Catchments

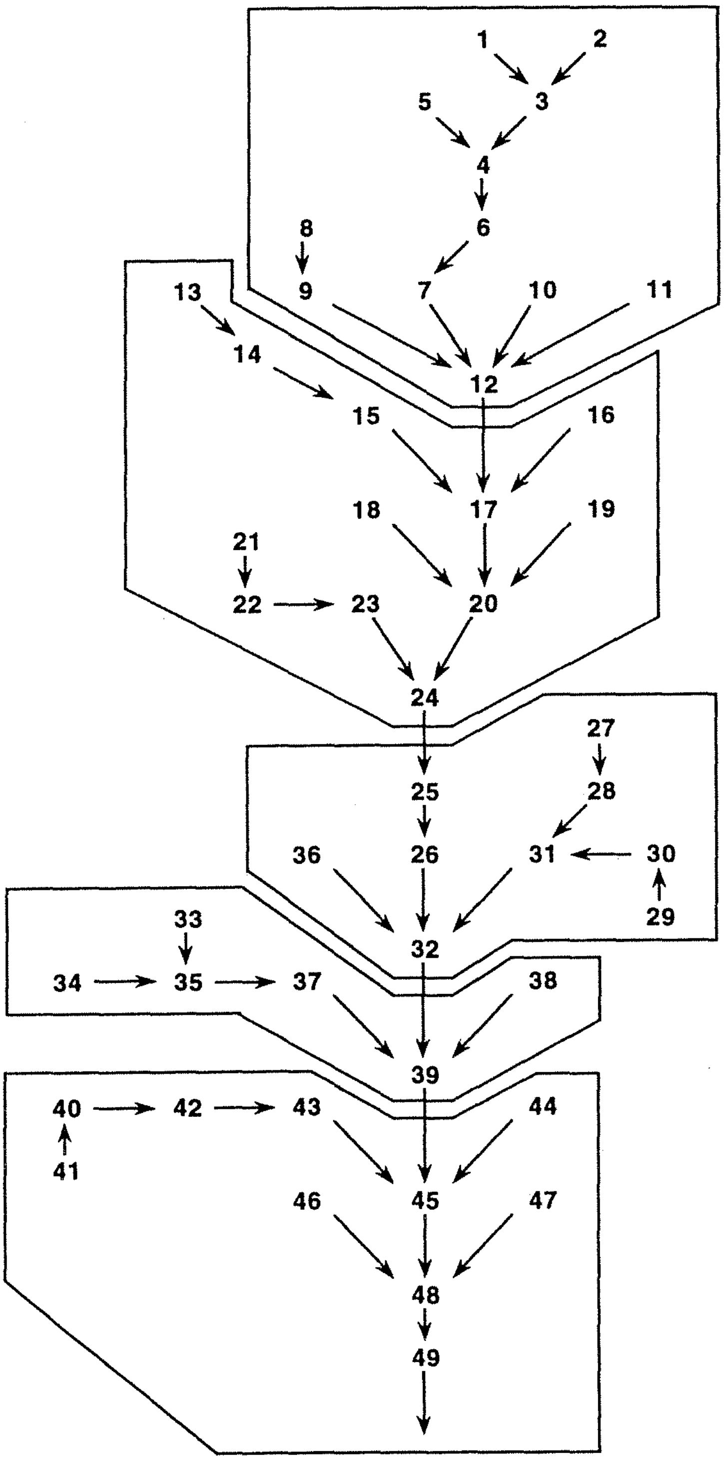
TONE ABOVE TONEBRIDGE CATCHMENT

Project	SW Corner		NE Corner		Rows	Columns	Cell	Catchment	Gauging Point	
	Easting	Northing	Easting	Northing			Length	Number	Easting	Northing
TONE01	506500	6240000	514800	6246000	240	332	25	1	508352	6242912
TONE02	506500	6236800	513500	6245300	340	280	25	2	507762	6241662
TONE03	503700	6236500	510500	6246500	400	272	25	3	504612	6241562
TONE04	499700	6237000	505100	6243200	248	216	25	4	502462	6242287
TONE05	496100	6242200	506500	6248400	248	416	25	5	502562	6243287
TONE06	495500	6239500	504200	6246100	264	348	25	6	498162	6241537
TONE07	492400	6237900	500800	6245000	284	336	25	7	492987	6240662
TONE08	489000	6242000	498000	6248500	260	360	25	8	492012	6242712
TONE09	487200	6240000	493500	6246500	260	252	25	9	492412	6240887
TONE10	492500	6235500	502400	6240000	180	396	25	10	492987	6238187
TONE11	492000	6234000	500000	6237500	140	320	25	11	492487	6236437
TONE12	489500	6234500	494800	6241800	292	212	25	12	490687	6237012
TONE13	484100	6240500	489700	6246300	232	224	25	13	486662	6241137
TONE14	480700	6237700	488400	6244000	252	308	25	14	486487	6239662
TONE15	484700	6235700	491300	6242700	280	264	25	15	488987	6236987
TONE16	492000	6230100	499200	6235700	224	288	25	16	493362	6233212
TONE17	486900	6230500	494500	6238100	304	304	25	17	491037	6232262
TONE18	482900	6232500	489900	6239300	272	280	25	18	488212	6233262
TONE19	489200	6227900	496500	6232100	168	292	25	19	490237	6230862
TONE20	485900	6226100	493000	6234600	340	284	25	20	487237	6230462
TONE21	477900	6237200	484600	6243400	248	268	25	21	482087	6238087
TONE22	477000	6234200	484700	6240000	232	308	25	22	482387	6234862
TONE23	477000	6230200	485800	6235900	228	352	25	23	483412	6231837
TONE24	480200	6226700	489500	6234300	304	372	25	24	484187	6229487
TONE25	480700	6223900	489400	6230600	268	348	25	25	483662	6226412
TONE26	479600	6221600	489300	6230000	336	388	25	26	481162	6224287
TONE27	488100	6222200	496300	6229500	292	328	25	27	490862	6223962
TONE28	485400	6219500	494600	6225600	244	368	25	28	486962	6221537
TONE29	482800	6213000	490900	6218700	228	324	25	29	488187	6218187
TONE30	482700	6214400	494000	6221700	292	452	25	30	485812	6219712
TONE31	480600	6217300	488700	6224000	268	324	25	31	481362	6222612
TONE32	475000	6220500	482400	6231000	420	296	25	32	477837	6222637
TONE33	471600	6231400	478800	6238600	288	288	25	33	473862	6233037
TONE34	467800	6226900	473600	6233100	248	232	25	34	473012	6229787
TONE35	470200	6228500	477300	6233700	208	284	25	35	473937	6229312
TONE36	475500	6227500	481700	6234000	260	248	25	36	478162	6229137
TONE37	470500	6221700	478100	6230800	364	304	25	37	476787	6222637
TONE38	477800	6215000	484700	6221800	272	276	25	38	478462	6219362
TONE39	472200	6215200	480500	6223800	344	332	25	39	476487	6218187
TONE40	466400	6221900	472400	6229300	296	240	25	40	470587	6222887
TONE41	464000	6217000	470000	6226000	360	240	25	41	469262	6221187
TONE42	466500	6216500	474700	6225000	340	328	25	42	472812	6219887
TONE43	468900	6215100	475400	6221100	240	260	25	43	474287	6217637
TONE44	476600	6212800	485300	6217100	172	348	25	44	477362	6214712
TONE45	471500	6212900	478300	6220300	296	272	25	45	475487	6214887
TONE46	464300	6211800	472400	6218600	272	324	25	46	471562	6212837
TONE47	476400	6209900	484900	6214400	180	340	25	47	477112	6212862
TONE48	468700	6208700	479900	6216400	308	448	25	48	471037	6211362
TONE49	466500	6208600	473400	6213500	196	276	25	49	470237	6209887

Notes:
1.Bullilup Gauging Station (S607007) corresponds to the outlet point of TONE49
2.TONE49 discharges into TONEL03 of 'Tone below Tonebridge' group

1. Locations and Sizes of Rascal Projects for Sub-Catchments (cont.)

TONE ABOVE TONEBRIDGE CATCHMENT MAP



Note: Enclosed groups correspond to printing pages in Spreadsheets 2-4.

1. Locations and Sizes of Rascal Projects for Sub-Catchments (cont.)

TONE BELOW TONEBRIDGE CATCHMENT

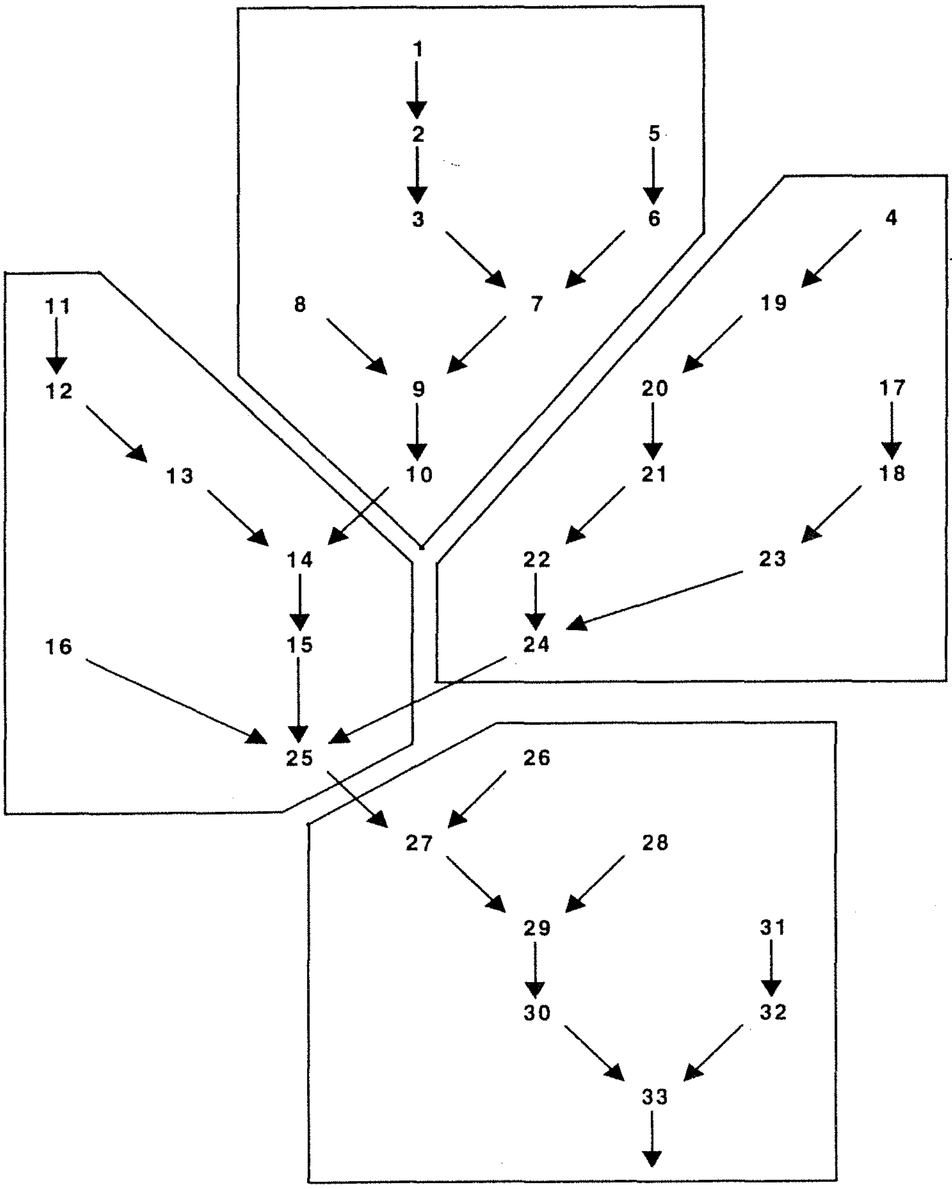
Project	SW Corner		NE Corner		Rows	Columns	Cell	Catchment	Gauging Point	
	Easting	Northing	Easting	Northing			Length	Number	Easting	Northing
TONEL01	478100	6207000	485600	6211600	184	300	25	1	478712	6209012
TONEL02	471800	6206600	482000	6211400	192	408	25	2	472312	6208687
TONEL03	466600	6205700	472800	6210700	200	248	25	3	471137	6207612
TONEL04	481200	6204000	486200	6208600	184	200	25	4	482537	6204537
TONEL05	476600	6199500	482600	6205000	220	240	25	5	477312	6203412
TONEL06	470500	6199800	483000	6208200	336	500	25	6	471662	6205962
TONEL07	468500	6201000	474500	6209000	320	240	25	7	469987	6204737
TONEL08	463300	6205700	468300	6213500	312	200	25	8	467062	6206887
TONEL09	464400	6200600	471400	6208400	312	280	25	9	465787	6203237
TONEL10	461700	6201000	466700	6208500	300	200	25	10	462437	6203887
TONEL11	460000	6209500	467600	6214500	200	304	25	11	461162	6210862
TONEL12	457700	6206500	464900	6213000	260	288	25	12	460112	6207112
TONEL13	457700	6203200	463500	6208200	200	232	25	13	461512	6204087
TONEL14	454800	6200500	465300	6205300	192	420	25	14	460812	6201312
TONEL15	454600	6197200	465800	6202200	200	448	25	15	463487	6197837
TONEL16	456200	6194800	463000	6199600	192	272	25	16	461912	6196387
TONEL17	480200	6191800	487700	6196800	200	300	25	17	480787	6194337
TONEL18	475000	6190200	483000	6196800	264	320	25	18	475562	6194337
TONEL19	480500	6196000	488500	6206200	408	320	25	19	481562	6199987
TONEL20	473400	6194800	484400	6202800	320	440	25	20	474012	6199962
TONEL21	469000	6197400	475500	6203200	232	260	25	21	469787	6200312
TONEL22	464000	6196000	470500	6203000	280	260	25	22	468162	6197187
TONEL23	469500	6192900	477700	6199500	264	328	25	23	469937	6195037
TONEL24	464000	6191300	471800	6198800	300	312	25	24	465312	6194737
TONEL25	461000	6193800	467000	6200300	260	240	25	25	461987	6195362
TONEL26	461200	6185100	467200	6192600	300	240	25	26	462762	6191262
TONEL27	458700	6187200	465500	6196200	360	272	25	27	460537	6191187
TONEL28	455000	6186100	463000	6191500	216	320	25	28	457687	6190962
TONEL29	455000	6189500	461000	6196100	264	240	25	29	455587	6191687
TONEL30	450200	6188700	458200	6196200	300	320	25	30	450887	6192437
TONEL31	444100	6184100	453100	6188700	184	360	25	31	452112	6187987
TONEL32	450700	6184600	457200	6190600	240	260	25	32	452087	6189287
TONEL33	445300	6186600	453300	6194800	328	320	25	33	447212	6193237
TONEL61								61	472412	6207337

Notes:

1. TONEL61 located within the TONEL06 project
   TONEL03 receives outflow from TONE49 of 'Tone above Tonebridge' group

1. Locations and Sizes of Rascal Projects for Sub-Catchments (cont.)

TONE BELOW TONEBRIDGE CATCHMENT MAP



Note: Enclosed groups correspond to printing pages in Spreadsheets 2-4.

1. Locations and Sizes of Rascal Projects for Sub-Catchments (cont.)

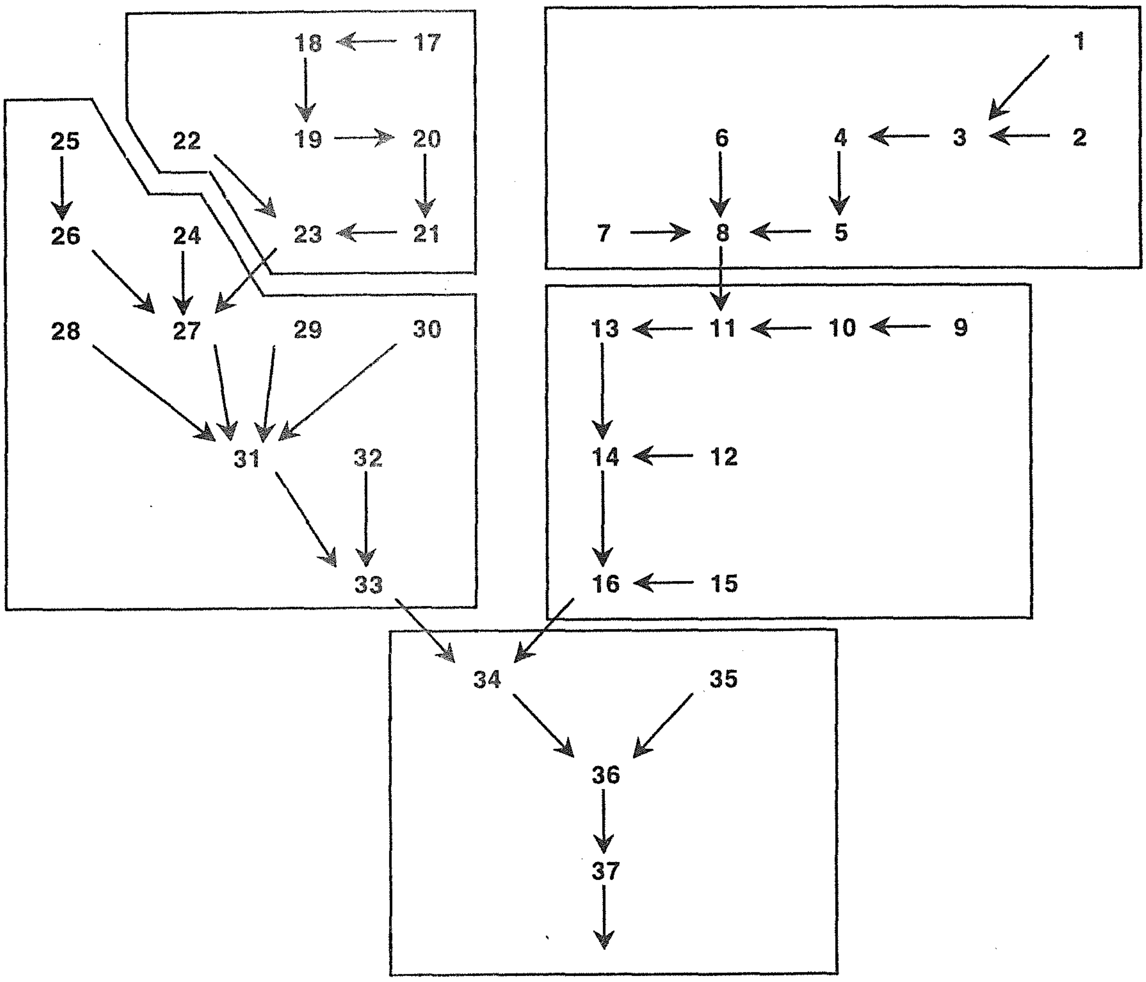
PERUP CATCHMENT

Project	SW Corner		NE Corner		Rows	Columns	Cell	Catchment	Gauging Point	
	Easting	Northing	Easting	Northing			Length	Number	Easting	Northing
PERUP01	463000	6228000	469500	6233600	224	260	25	1	465512	6229287
PERUP02	463200	6221000	467700	6227600	264	180	25	2	464362	6225212
PERUP03	462100	6224000	467900	6230000	240	232	25	3	463412	6225462
PERUP04	458500	6222500	464500	6230200	308	240	25	4	460887	6224837
PERUP05	457500	6220500	465000	6227000	260	300	25	5	459287	6223287
PERUP06	452200	6222000	459700	6228300	252	300	25	6	456762	6222537
PERUP07	450000	6218200	455500	6226000	312	220	25	7	454712	6220512
PERUP08	453000	6218800	463000	6225200	256	400	25	8	454987	6220187
PERUP09	460000	6212000	466600	6222200	408	264	25	9	461187	6216562
PERUP10	457500	6213000	464500	6222200	368	280	25	10	458087	6217037
PERUP11	452800	6214200	459600	6220700	260	272	25	11	454912	6216387
PERUP12	453000	6211500	462500	6217700	248	380	25	12	453812	6215487
PERUP13	448700	6215600	454700	6223100	300	240	25	13	452437	6216237
PERUP14	449400	6211000	455400	6217500	260	240	25	14	453537	6211687
PERUP15	453000	6206600	459800	6213800	288	272	25	15	454062	6211337
PERUP16	449500	6208200	454500	6213600	216	200	25	16	450262	6209887
PERUP17	446700	6224500	453200	6231500	280	260	25	17	447237	6229087
PERUP18	441500	6228000	448500	6233200	208	280	25	18	446362	6228412
PERUP19	440000	6224500	448600	6230200	228	344	25	19	445862	6225987
PERUP20	443400	6222000	452400	6227800	232	360	25	20	445812	6223862
PERUP21	444000	6219000	451500	6224800	232	300	25	21	444462	6222462
PERUP22	436000	6222000	441800	6229500	300	232	25	22	441212	6223262
PERUP23	438000	6219200	445500	6227700	340	300	25	23	442512	6220287
PERUP24	435000	6218200	442500	6223700	220	300	25	24	441612	6220162
PERUP25	434000	6214000	439500	6221500	300	220	25	25	438812	6216062
PERUP26	437200	6214200	443200	6219700	220	240	25	26	442562	6216387
PERUP27	438800	6215600	449800	6221100	220	440	25	27	443412	6216512
PERUP28	436600	6212400	443400	6216600	168	272	25	28	442862	6215887
PERUP29	438200	6210000	446000	6214200	168	312	25	29	444837	6213712
PERUP30	441500	6208000	448000	6213200	208	260	25	30	446212	6212612
PERUP31	441200	6212000	448400	6219500	300	288	25	31	446787	6213112
PERUP32	447000	6212600	451000	6219400	272	160	25	32	448187	6213362
PERUP33	445800	6208000	451300	6215000	280	220	25	33	449437	6210387
PERUP34	446000	6206000	455000	6211000	200	360	25	34	450987	6206662
PERUP35	452400	6201200	459600	6208600	296	288	25	35	452962	6205537
PERUP36	445800	6202500	453400	6207500	200	304	25	36	451287	6203412
PERUP37	445700	6198500	455700	6204300	232	400	25	37	450062	6200837

Note: Quabicup Gauging Station (S607004) corresponds to the outlet point of PERUP37.

1. Locations and Sizes of Rascal Projects for Sub-Catchments (cont.)

PERUP CATCHMENT MAP



Note: Enclosed groups correspond to printing pages in Spreadsheets 2-4.

Spreadsheet 2

Areas for Subcatchments

1. Areas for Subcatchments of the Tone above Tonebridge Catchments

Subcatchment	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Drains to	3	3	4	6	6	7	12	9	12	12	12	17
SUMS FOR ISOLATED SUBCATCHMENTS												
Areas (km^2)	20.66	16.86	24.66	15.58	25.24	21.12	23.12	25.81	12.83	20.32	9.66	13.27
Rainfall (mm)	528	520	521	533	530	529	534	536	540	548	557	543
AS AT 1996												
Cleared area (km^2)	15.45	12.94	21.10	12.08	22.30	17.84	16.08	19.94	9.91	14.86	7.66	8.58
Clearing (%)	75%	77%	86%	77%	88%	84%	70%	77%	77%	73%	79%	65%
Forest w/o u/s Clearing	2.22	1.33	0.87	1.96	1.45	1.74	3.15	1.62	0.97	2.64	0.54	2.75
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS												
Areas (km^2)	20.66	16.86	62.18	77.76	25.24	124.12	147.24	25.81	38.64	20.32	9.66	229.14
Rainfall (mm)	528	520	523	525	530	527	528	536	537	548	557	533
AS AT 1996												
Cleared area (km^2)	15.45	12.94	49.49	61.57	22.30	101.71	117.80	19.94	29.85	14.86	7.66	178.74
Clearing (%)	75%	77%	80%	79%	88%	82%	80%	77%	77%	73%	79%	78%
Forest w/o u/s Clearing	2.22	1.33	4.42	6.38	1.45	9.57	12.72	1.62	2.60	2.64	0.54	21.25

2. Areas for Subcatchments of the Tone above Tonebridge Catchments

Subcatchment	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Drains to	17	14	15	17	17	20	20	20	24	22	23	24	25
SUMS FOR ISOLATED SUBCATCHMENTS													
Areas (km^2)	13.27	13.29	17.05	18.25	19.71	19.48	16.46	13.51	21.11	16.51	21.91	22.85	22.21
Rainfall (mm)	543	550	565	550	561	557	564	584	575	596	600	595	583
AS AT 1996													
Cleared area (km^2)	8.58	10.89	9.76	13.07	13.09	10.70	9.28	8.42	12.46	8.88	14.54	15.36	15.41
Clearing (%)	65%	82%	57%	72%	66%	55%	56%	62%	59%	54%	66%	67%	69%
Forest w/o u/s Clearing	2.75	0.64	4.26	2.42	3.56	5.73	4.42	3.01	4.62	4.55	3.69	3.57	3.06
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS													
Areas (km^2)	229.14	13.29	30.35	48.59	19.71	316.92	16.46	13.51	367.99	16.51	38.42	61.27	451.47
Rainfall (mm)	533	550	559	556	561	540	564	584	545	596	598	597	554
AS AT 1996													
Cleared area (km^2)	178.74	10.89	20.65	33.72	13.09	236.25	9.28	8.42	266.42	8.88	23.42	38.78	320.61
Clearing (%)	78%	82%	68%	69%	66%	75%	56%	62%	72%	54%	61%	63%	71%
Forest w/o u/s Clearing	21.25	0.64	4.90	7.32	3.56	37.86	4.42	3.01	49.91	4.55	8.24	11.81	64.78

Abbreviations:

w/o = without

u/s = upstream

Spreadsheet 2. Areas for Subcatchments (cont.)

3. Areas for Subcatchments of the Tone above Tonebridge Catchments

Subcatchment	24	25	26	27	28	29	30	31	36	32
Drains to	25	26	32	28	31	30	31	32	32	39
SUMS FOR ISOLATED SUBCATCHMENTS										
Areas (km²)	22.21	15.87	28.37	29.41	27.37	15.80	23.45	19.91	13.04	33.19
Rainfall (mm)	583	592	604	596	603	633	629	637	610	624
AS AT 1996										
Cleared area (km²)	15.41	10.40	13.24	21.87	17.97	9.86	15.91	6.93	8.22	18.67
Clearing (%)	69%	66%	47%	74%	66%	62%	68%	35%	63%	56%
Forest w/o u/s Clearing	3.06	2.97	10.56	3.78	4.62	3.25	3.86	9.74	3.27	9.99
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS										
Areas (km²)	451.47	467.33	495.70	29.41	56.78	15.80	39.25	115.94	13.04	657.87
Rainfall (mm)	554	555	558	596	599	633	631	616	610	572
AS AT 1996										
Cleared area (km²)	320.61	331.01	344.24	21.87	39.84	9.86	25.77	72.54	8.22	443.67
Clearing (%)	71%	71%	69%	74%	70%	62%	66%	63%	63%	67%
Forest w/o u/s Clearing	64.78	67.75	78.31	3.78	8.40	3.25	7.11	25.26	3.27	116.83

4. Areas for Subcatchments of the Tone above Tonebridge Catchments

Subcatchment	32	33	34	35	37	38	39
Drains to	39	35	35	37	39	39	45
SUMS FOR ISOLATED SUBCATCHMENTS							
Areas (km²)	33.19	23.28	17.11	14.06	30.98	18.95	24.79
Rainfall (mm)	624	621	650	632	650	647	642
AS AT 1996							
Cleared area (km²)	18.67	10.55	3.53	5.95	15.84	6.39	10.08
Clearing (%)	56%	45%	21%	42%	51%	34%	41%
Forest w/o u/s Clearing	9.99	9.01	12.38	6.32	10.12	10.91	11.33
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS							
Areas (km²)	657.87	23.28	17.11	54.45	85.44	18.95	787.04
Rainfall (mm)	572	621	650	633	639	647	584
AS AT 1996							
Cleared area (km²)	443.67	10.55	3.53	20.03	35.88	6.39	496.02
Clearing (%)	67%	45%	21%	37%	42%	34%	63%
Forest w/o u/s Clearing	116.83	9.01	12.38	27.70	37.82	10.91	176.90

Abbreviations:
w/o = without
u/s = upstream

Spreadsheet 2. Areas for Subcatchments (cont.)

5. Areas for Subcatchments of the Tone above Tonebridge Catchments

Subcatchment	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**
Drains to	45	42	42	43	45	45	48	48	48	49	
SUMS FOR ISOLATED SUBCATCHMENTS											
Areas (km^2)	24.79	19.53	22.13	21.09	13.55	14.71	17.59	28.43	15.36	32.69	11.96
Rainfall (mm)	642	671	697	683	676	665	658	712	669	674	701
AS AT 1996											
Cleared area (km^2)	10.08	7.68	1.54	2.98	2.46	7.04	9.06	7.06	7.30	13.54	1.27
Clearing (%)	41%	39%	7%	14%	18%	48%	52%	25%	48%	41%	11%
Forest w/o u/s Clearing	11.33	9.69	20.29	17.49	10.49	5.16	5.52	20.60	6.24	15.62	10.24
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS											
Areas (km^2)	787.04	19.53	22.13	62.75	76.30	14.71	895.64	28.43	15.36	972.11	984.07
Rainfall (mm)	584	671	697	684	683	665	595	712	669	602	603
AS AT 1996											
Cleared area (km^2)	496.02	7.68	1.54	12.20	14.66	7.04	526.78	7.06	7.30	554.69	555.96
Clearing (%)	63%	39%	7%	19%	19%	48%	59%	25%	48%	57%	56%
Forest w/o u/s Clearing	176.90	9.69	20.29	47.47	57.96	5.16	245.54	20.60	6.24	288.00	298.23

6. Areas for Subcatchments of the Tone below Tonebridge Catchments

Subcatchment	**1**	**2**	**3**	**5**	**6**	**7**	**8**	**9**	**10**
Drains to	2	3	7	6	7	9	9	10	14
SUMS FOR ISOLATED SUBCATCHMENTS									
Areas (km^2)	15.30	14.01	11.55	16.72	46.72	19.42	16.80	23.36	15.87
Rainfall (mm)	679	687	705	713	701	714	725	729	737
AS AT 1996									
Cleared area (km^2)	8.01	5.72	2.48	9.02	13.05	5.10	0.00	6.81	1.53
Clearing (%)	52%	41%	21%	54%	28%	26%	0%	29%	10%
Forest w/o u/s Clearing	5.32	6.94	8.17	4.14	27.37	12.05	16.80	14.66	13.77
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS									
Areas (km^2)	15.30	29.31	40.86	16.72	63.44	123.72	16.80	163.88	179.75
Rainfall (mm)	679	682	689	713	704	700	725	707	710
AS AT 1996									
Cleared area (km^2)	8.01	13.73	16.21	9.02	22.08	43.39	0.00	50.19	51.73
Clearing (%)	52%	47%	40%	54%	35%	35%	0%	31%	29%
Forest w/o u/s Clearing	5.32	12.26	20.43	4.14	31.51	63.99	16.80	95.45	109.22

Abbreviations:
w/o = without
u/s = upstream

Spreadsheet 2. Areas for Subcatchments (cont.)

7. Areas for Subcatchments of the Tone below Tonebridge Catchments

Subcatchment	10	24	11	12	13	14	15	16	25
Drains to	14	25	12	13	14	15	25	25	27
SUMS FOR ISOLATED SUBCATCHMENTS									
Areas (km²)	15.87	22.31	10.45	19.31	14.53	17.24	28.70	16.51	12.36
Rainfall (mm)	737	788	721	734	746	760	775	788	787
AS AT 1996									
Cleared area (km²)	1.53	4.14	0.37	0.88	0.36	2.31	0.01	0.02	0.00
Clearing (%)	10%	19%	4%	5%	2%	13%	0%	0%	0%
Forest w/o u/s Clearing	13.77	15.78	9.87	18.15	13.86	14.03	28.66	16.33	12.34
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS									
Areas (km²)	179.75	207.50	10.45	29.75	44.29	241.28	269.97	16.51	506.34
Rainfall (mm)	710	739	721	730	735	718	724	788	734
AS AT 1996									
Cleared area (km²)	51.73	77.00	0.37	1.25	1.61	55.65	55.66	0.02	132.68
Clearing (%)	29%	37%	4%	4%	4%	23%	21%	0%	26%
Forest w/o u/s Clearing	109.22	100.63	9.87	28.02	41.88	165.13	193.79	16.33	323.08

8. Areas for Subcatchments of the Tone below Tonebridge Catchments

Subcatchment	4	17	18	19	20	21	22	23	24
Drains to	19	18	23	20	21	22	24	24	25
SUMS FOR ISOLATED SUBCATCHMENTS									
Areas (km²)	8.44	12.84	21.77	42.53	37.78	15.49	18.48	27.85	22.31
Rainfall (mm)	686	748	764	696	732	739	760	752	788
AS AT 1996									
Cleared area (km²)	5.02	7.65	11.15	17.76	11.13	4.89	6.40	8.88	4.14
Clearing (%)	59%	60%	51%	42%	29%	32%	35%	32%	19%
Forest w/o u/s Clearing	2.28	3.51	6.23	18.40	21.12	8.53	9.94	14.83	15.78
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS									
Areas (km²)	8.44	12.84	34.61	50.97	88.75	104.24	122.73	62.46	207.50
Rainfall (mm)	686	748	758	695	710	715	722	755	739
AS AT 1996									
Cleared area (km²)	5.02	7.65	18.80	22.78	33.90	38.79	45.18	27.68	77.00
Clearing (%)	59%	60%	54%	45%	38%	37%	37%	44%	37%
Forest w/o u/s Clearing	2.28	3.51	9.74	20.68	41.81	50.33	60.28	24.57	100.63

Abbreviations:
w/o = without
u/s = upstream

Spreadsheet 2. Areas for Subcatchments (cont.)

9. Areas for Subcatchments of the Tone below Tonebridge Catchments

Subcatchment	25	26	27	28	29	30	31	32	33
Drains to	27	27	29	29	30	33	32	33	
SUMS FOR ISOLATED SUBCATCHMENTS									
Areas (km^2)	12.36	18.21	25.31	12.75	8.61	26.29	18.27	13.17	28.70
Rainfall (mm)	787	848	822	854	830	838	938	893	894
AS AT 1996									
Cleared area (km^2)	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.14
Clearing (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%
Forest w/o u/s Clearing	12.34	18.19	25.19	12.73	8.56	26.23	18.16	13.16	28.36
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS									
Areas (km^2)	506.34	18.21	549.86	12.75	571.23	597.52	18.27	31.44	657.66
Rainfall (mm)	734	848	742	854	745	750	938	919	764
AS AT 1996									
Cleared area (km^2)	132.68	0.01	132.70	0.00	132.71	132.72	0.01	0.02	132.87
Clearing (%)	26%	0%	24%	0%	23%	22%	0%	0%	20%
Forest w/o u/s Clearing	323.08	18.19	366.46	12.73	387.76	413.99	18.16	31.32	473.66

10. Areas for Subcatchments of the Perup Catchments

Subcatchment	1	2	3	4	5	6	7	8
Drains to	3	3	4	5	8	8	8	11
SUMS FOR ISOLATED SUBCATCHMENTS								
Areas (km^2)	18.71	9.81	13.12	17.55	15.77	21.86	16.42	20.62
Rainfall (mm)	658	686	672	674	686	680	698	691
AS AT 1996								
Cleared area (km^2)	4.88	0.43	0.19	0.03	3.66	4.64	2.93	4.87
Clearing (%)	26%	4%	1%	0%	23%	21%	18%	24%
Forest w/o u/s Clearing	12.41	9.23	12.76	17.48	11.36	15.57	13.05	14.55
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS								
Areas (km^2)	18.71	9.81	41.64	59.19	74.96	21.86	16.42	133.86
Rainfall (mm)	658	686	669	670	674	680	698	680
AS AT 1996								
Cleared area (km^2)	4.88	0.43	5.50	5.53	9.19	4.64	2.93	21.63
Clearing (%)	26%	4%	13%	9%	12%	21%	18%	16%
Forest w/o u/s Clearing	12.41	9.23	34.40	51.88	63.24	15.57	13.05	106.41

Abbreviations:
w/o = without
u/s = upstream

Spreadsheet 2. Areas for Subcatchments (cont.)

11. Areas for Subcatchments of the Perup Catchments

Subcatchment	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Drains to	11	10	11	14	14	14	16	16	34
SUMS FOR ISOLATED SUBCATCHMENTS									
Areas (km²)	20.62	26.86	24.61	18.90	19.22	14.44	16.54	24.37	11.58
Rainfall (mm)	691	710	703	702	717	723	729	736	738
AS AT 1996									
Cleared area (km²)	4.87	0.84	0.04	4.45	1.41	2.17	6.92	0.76	5.49
Clearing (%)	0.24	3%	0%	24%	7%	15%	42%	3%	47%
Forest w/o u/s Clearing	14.55	25.43	24.41	13.54	17.44	11.44	7.36	23.16	4.65
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS									
Areas (km²)	133.86	26.86	51.47	204.23	19.22	14.44	254.43	24.37	290.38
Rainfall (mm)	680	710	707	689	717	723	696	736	701
AS AT 1996									
Cleared area (km²)	21.63	0.84	0.88	26.96	1.41	2.17	37.47	0.76	43.72
Clearing (%)	0.16	3%	2%	13%	7%	15%	15%	3%	15%
Forest w/o u/s Clearing	106.41	25.43	49.84	169.78	17.44	11.44	206.02	23.16	233.83

12. Areas for Subcatchments of the Perup Catchments

Subcatchment	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Drains to	18	19	20	21	23	23	27
SUMS FOR ISOLATED SUBCATCHMENTS							
Areas (km²)	17.16	14.04	19.80	20.27	19.25	22.53	22.80
Rainfall (mm)	694	692	716	708	718	782	743
AS AT 1996							
Cleared area (km²)	3.32	0.61	0.97	4.17	3.45	0.08	3.56
Clearing (%)	19%	4%	5%	21%	18%	0%	16%
Forest w/o u/s Clearing	12.66	13.19	18.52	15.28	14.64	22.24	18.25
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS							
Areas (km²)	17.16	31.19	50.99	71.26	90.51	22.53	135.84
Rainfall (mm)	694	694	702	704	707	782	726
AS AT 1996							
Cleared area (km²)	3.32	3.93	4.89	9.06	12.51	0.08	16.15
Clearing (%)	19%	13%	10%	13%	14%	0%	12%
Forest w/o u/s Clearing	12.66	25.85	44.37	59.65	74.28	22.24	114.78

Abbreviations:

w/o = without

u/s = upstream

U/S = upstream

Spreadsheet 2. Areas for Subcatchments (cont.)

13. Areas for Subcatchments of the Perup Catchments

Subcatchment	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
Drains to	27	27	26	27	31	31	31	31	33	33	34
SUMS FOR ISOLATED SUBCATCHMENTS											
Areas (km²)	22.80	15.12	18.58	9.94	17.61	9.45	17.21	10.79	27.65	11.38	14.01
Rainfall (mm)	743	802	836	802	750	805	795	780	747	735	758
AS AT 1996											
Cleared area (km²)	3.56	0.15	1.04	0.00	0.00	0.01	1.81	0.41	4.84	2.72	1.56
Clearing (%)	0.16	1%	6%	0%	0%	0%	11%	4%	18%	24%	11%
Forest w/o u/s Clearing	18.25	14.78	17.23	9.94	17.61	9.39	14.26	9.84	21.00	7.73	11.48
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS											
Areas (km²)	135.84	15.12	18.58	28.52	197.09	9.45	17.21	10.79	262.19	11.38	287.59
Rainfall (mm)	726	802	836	824	748	805	795	780	754	735	754
AS AT 1996											
Cleared area (km²)	16.15	0.15	1.04	1.04	17.34	0.01	1.81	0.41	24.41	2.72	28.69
Clearing (%)	0.12	1%	6%	4%	9%	0%	11%	4%	9%	24%	10%
Forest w/o u/s Clearing	114.78	14.78	17.23	27.17	174.33	9.39	14.26	9.84	228.83	7.73	248.03

14. Areas for Subcatchments of the Perup Catchments

Subcatchment	**16**	**33**	**34**	**35**	**36**	**37**
Drains to	34	34	36	36	37	
SUMS FOR ISOLATED SUBCATCHMENTS						
Areas (km²)	11.58	14.01	16.78	26.99	19.21	20.87
Rainfall (mm)	738	758	774	765	777	798
AS AT 1996						
Cleared area (km²)	5.49	1.56	1.53	0.67	6.43	3.82
Clearing (%)	0.47	0.11	9%	2%	33%	18%
Forest w/o u/s Clearing	4.65	11.48	14.72	25.95	10.31	15.18
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS						
Areas (km²)	290.38	287.59	594.75	26.99	640.95	661.83
Rainfall (mm)	701	754	728	765	731	734
AS AT 1996						
Cleared area (km²)	43.72	28.69	73.94	0.67	81.04	84.86
Clearing (%)	0.15	0.10	12%	2%	13%	13%
Forest w/o u/s Clearing	233.83	248.03	496.58	25.95	532.84	548.01

Abbreviations:
w/o = without
u/s = upstream

Spreadsheet 3

Average flows for clearing as in 1996

1. Flows for 1996 clearing for Subcatchments of the Tone above Tonebridge Catchments

Subcatchment	1	2	3	4	5	6	7	8	9	10	11	12
Drains to	3	3	4	6	6	7	12	9	12	12	12	17
SUMS FOR ISOLATED SUBCATCHMENTS												
Stream flow (m^3)	256202	243773	265993	227824	531740	434822	462586	648505	314054	492989	214887	281501
Stream flow (mm)	12.40	14.46	10.79	14.62	21.07	20.59	20.01	25.13	24.48	24.26	22.24	21.21
Seepage (m^3)	260886	229556	288172	191591	367724	308576	339995	399131	206228	308790	136387	185984
Seepage (mm)	12.63	13.62	11.69	12.29	14.57	14.61	14.71	15.47	16.07	15.19	14.12	14.01
Seepage/stream flow (%)	102%	94%	108%	84%	69%	71%	73%	62%	66%	63%	63%	66%
Seepage inside forest (m^3)	13338	8414	4193	8221	4267	6795	37018	7681	8400	26046	3276	28054
Seepage inside forest (mm)	6.01	6.32	4.82	4.20	2.94	3.90	11.75	4.74	8.62	9.87	6.11	10.19
Seepage outside forest (m^3)	247548	221142	283979	183369	363457	301781	302977	391451	197828	282744	133111	157930
Seepage outside forest (mm)	13.42	14.25	11.94	13.46	15.28	15.57	15.17	16.18	16.69	15.99	14.59	15.01
Seepage loss (m^3)	-58552	-43917	-59599	-33730	-40278	-20223	-81119	-40570	-24767	-73657	-28719	-67033
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS												
Stream flow (m^3)	256202	243773	765968	993792	531740	1960354	2422940	648505	962559	492989	214887	4374877
Stream flow (mm)	12.40	14.46	12.32	12.78	21.07	15.79	16.46	25.13	24.91	24.26	22.24	19.09
Seepage (m^3)	260886	229556	778614	970205	367724	1646505	1986500	399131	605359	308790	136387	3223020
Seepage (mm)	12.63	13.62	12.52	12.48	14.57	13.27	13.49	15.47	15.67	15.19	14.12	14.07
Seepage/stream flow (%)	102%	94%	102%	98%	69%	84%	82%	62%	63%	63%	63%	74%
Seepage inside forest (m^3)	13338	8414	25946	34167	4267	45229	82246	7681	16081	26046	3276	155703
Seepage inside forest (mm)	6.01	6.32	5.87	5.36	2.94	4.73	6.47	4.74	6.19	9.87	6.11	7.33
Seepage outside forest (m^3)	247548	221142	752668	936038	363457	1601276	1904254	391451	589279	282744	133111	3067317
Seepage outside forest (mm)	13.42	14.25	13.03	13.11	15.28	13.98	14.16	16.18	16.35	15.99	14.59	14.75
Seepage loss (m^3)	-58552	-43917	-162068	-195798	-40278	-256300	-337419	-40570	-65337	-73657	-28719	-572164

Assumptions:

Lower soil layer 20m deep with permeability 3m/yr/unit hydraulic gradient

Peak leaf area index for pasture = 2.1

Spreadsheet 3. Average flows for clearing as in 1996 (cont.)

2. Flows for 1996 clearing for Subcatchments of the Tone above Tonebridge Catchments

Subcatchment	12	13	14	15	16	17	18	19	20	21	22	23	24
Drains to	17	14	15	17	17	20	20	20	24	22	23	24	25
SUMS FOR ISOLATED SUBCATCHMENTS													
Stream flow (m^3)	281501	405164	454210	454778	566300	484697	341668	368056	530972	598092	808653	769329	631681
Stream flow (mm)	21.21	30.48	26.63	24.92	28.73	24.88	20.76	27.25	25.15	36.22	36.91	33.68	28.44
Seepage (m^3)	185984	220898	231776	280238	296059	267298	208638	177349	268317	238380	316668	295111	298444
Seepage (mm)	14.01	16.62	13.59	15.36	15.02	13.72	12.68	13.13	12.71	14.44	14.45	12.92	13.44
Seepage/stream flow (%)	66%	55%	51%	62%	52%	55%	61%	48%	51%	40%	39%	38%	47%
Seepage inside forest (m^3)	28054	1737	18325	14201	38189	59346	39317	26685	46365	32137	17450	15404	22543
Seepageinside forest (mm)	10.19	2.71	4.30	5.87	10.72	10.35	8.89	8.87	10.04	7.06	4.73	4.32	7.38
Seepage outside forest (m^3)	157930	219161	213452	266037	257870	207953	169321	150664	221952	206243	299218	279707	275901
Seepage outside forest (mm)	15.01	17.32	16.68	16.81	15.97	15.13	14.07	14.35	13.46	17.24	16.43	14.51	14.40
Storage loss (m^3)	-67033	-20352	-23825	-38915	-61215	-104101	-67777	-53914	-94399	-36218	-22580	-39223	-53248
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS													
Stream flow (m^3)	4374877	405164	859374	1314152	566300	6740025	341668	368056	7980721	598092	1406745	2176075	10788476
Stream flow (mm)	19.09	30.48	28.32	27.04	28.73	21.27	20.76	27.25	21.69	36.22	36.61	35.52	23.90
Seepage (m^3)	3223020	220898	452674	732912	296059	4519289	208638	177349	5173593	238380	555048	850160	6322197
Seepage (mm)	14.07	16.62	14.92	15.08	15.02	14.26	12.68	13.13	14.06	14.44	14.45	13.88	14.00
Seepage/stream flow (%)	74%	55%	53%	56%	52%	67%	61%	48%	65%	40%	39%	39%	59%
Seepage inside forest (m^3)	155703	1737	20061	34263	38189	287500	39317	26685	399867	32137	49587	64992	487402
Seepageinside forest (mm)	7.33	2.71	4.10	4.68	10.72	7.59	8.89	8.87	8.01	7.06	6.02	5.50	7.52
Seepage outside forest (m^3)	3067317	219161	432613	698650	257870	4231789	169321	150664	4773726	206243	505461	785168	5834795
Seepage outside forest (mm)	14.75	17.32	17.00	16.93	15.97	15.16	14.07	14.35	15.01	17.24	16.75	15.88	15.09
Storage loss (m^3)	-572164	-20352	-44177	-83092	-61215	-820572	-67777	-53914	-1036662	-36218	-58798	-98021	-1187931

3. Flows for 1996 clearing for Subcatchments of the Tone above Tonebridge Catchments

Subcatchment	24	25	26	27	28	29	30	31	36	32
Drains to	25	26	32	28	31	30	31	32	32	39
SUMS FOR ISOLATED SUBCATCHMENTS										
Stream flow (m^3)	631681	626401	632711	611499	597441	656281	559524	564388	459518	727022
Stream flow (mm)	28.44	39.48	22.30	20.80	21.83	41.55	23.86	28.34	35.24	21.91
Seepage (m^3)	298444	243036	280791	316311	272588	170096	210664	133338	172017	245604
Seepage (mm)	13.44	15.32	9.90	10.76	9.96	10.77	8.98	6.70	13.19	7.40
Seepage/stream flow (%)	47%	39%	44%	52%	46%	26%	38%	24%	37%	34%
Seepage inside forest (m^3)	22543	20929	67803	23439	27984	11489	15939	52983	9296	56161
Seepageinside forest (mm)	7.38	7.04	6.42	6.19	6.06	3.53	4.13	5.44	2.84	5.62
Seepage outside forest (m^3)	275901	222107	212988	292872	244604	158607	194725	80355	162721	189444
Seepage outside forest (mm)	14.40	17.23	11.96	11.43	10.75	12.64	9.94	7.90	16.66	8.17
Storage loss (m^3)	-53248	-53876	-207394	-88219	-108102	-69873	-74573	-95499	-11572	-129042
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS										
Stream flow (m^3)	10788476	11414877	12047588	611499	1208940	656281	1215805	2989133	459518	16223261
Stream flow (mm)	23.90	24.43	24.30	20.80	21.29	41.55	30.98	25.78	35.24	24.66
Seepage (m^3)	6322197	6565233	6846024	316311	588899	170096	380760	1102997	172017	8366642
Seepage (mm)	14.00	14.05	13.81	10.76	10.37	10.77	9.70	9.51	13.19	12.72
Seepage/stream flow (%)	59%	58%	57%	52%	49%	26%	31%	37%	37%	52%
Seepage inside forest (m^3)	487402	508331	576134	23439	51424	11489	27428	131834	9296	773425
Seepageinside forest (mm)	7.52	7.50	7.36	6.19	6.12	3.53	3.86	5.22	2.84	6.62
Seepage outside forest (m^3)	5834795	6056902	6269890	292872	537476	158607	353332	971163	162721	7593217
Seepage outside forest (mm)	15.09	15.16	15.02	11.43	11.11	12.64	11.00	10.71	16.66	14.03
Storage loss (m^3)	-1187931	-1241808	-1449202	-88219	-196321	-69873	-144446	-436266	-11572	-2026082

Assumptions:

Lower soil layer 20m deep with permeability 3m/yr/unit hydraulic gradient

Peak leaf area index for pasture = 2.1

Spreadsheet 3. Average flows for clearing as in 1996 (cont.)

4. Flows for 1996 clearing for Subcatchments of the Tone above Tonebridge Catchments

Subcatchment	**32**	**33**	**34**	**35**	**37**	**38**	**39**
Drains to	39	35	35	37	39	39	45
SUMS FOR ISOLATED SUBCATCHMENTS							
Stream flow (m^3)	727022	607465	493871	484064	1216143	652938	989243
Stream flow (mm)	21.91	26.09	28.87	34.42	39.25	34.46	39.90
Seepage (m^3)	245604	210287	119577	141998	318715	160629	257782
Seepage (mm)	7.40	9.03	6.99	10.10	10.29	8.48	10.40
Seepage/stream flow (%)	34%	35%	24%	29%	26%	25%	26%
Seepage inside forest (m^3)	56161	21152	46565	18088	35353	40546	60491
Seepage inside forest (mm)	5.62	2.35	3.76	2.86	3.49	3.71	5.34
Seepage outside forest (m^3)	189444	189136	73011	123910	283362	120083	197291
Seepage outside forest (mm)	8.17	13.25	15.43	16.00	13.58	14.95	14.66
Storage loss (m^3)	-129042	-20738	-12418	-11815	-46491	-28283	-111800
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS							
Stream flow (m^3)	16223261	607465	493871	1585399	2801543	652938	20666984
Stream flow (mm)	24.66	26.09	28.87	29.11	32.79	34.46	26.26
Seepage (m^3)	8366642	210287	119577	471862	790577	160629	9575630
Seepage (mm)	12.72	9.03	6.99	8.67	9.25	8.48	12.17
Seepage/stream flow (%)	52%	35%	24%	30%	28%	25%	46%
Seepage inside forest (m^3)	773425	21152	46565	85805	121158	40546	995620
Seepage inside forest (mm)	6.62	2.35	3.76	3.10	3.20	3.71	5.63
Seepage outside forest (m^3)	7593217	189136	73011	386057	669419	120083	8580010
Seepage outside forest (mm)	14.03	13.25	15.43	14.43	14.06	14.95	14.06
Storage loss (m^3)	-2026082	-20738	-12418	-44971	-91462	-28283	-2257627

5. Flows for 1996 clearing for Subcatchments of the Tone above Tonebridge Catchments

Subcatchment	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**
Drains to	45	42	42	43	45	45	48	48	48	49	
SUMS FOR ISOLATED SUBCATCHMENTS											
Stream flow (m^3)	989243	818228	490807	521819	336599	556342	661232	1064348	592651	1437273	119398
Stream flow (mm)	39.90	41.90	22.18	24.74	24.85	37.81	37.60	37.44	38.59	43.97	9.98
Seepage (m^3)	257782	207407	99028	156974	84470	150654	154656	153202	119702	256551	60890
Seepage (mm)	10.40	10.62	4.47	7.44	6.24	10.24	8.79	5.39	7.79	7.85	5.09
Seepage/stream flow (%)	26%	25%	20%	30%	25%	27%	23%	14%	20%	18%	51%
Seepage inside forest (m^3)	60491	52791	69362	105729	49243	16981	24582	40912	10034	63182	37046
Seepage inside forest (mm)	5.34	5.45	3.42	6.05	4.69	3.29	4.45	1.99	1.61	4.05	3.62
Seepage outside forest (m^3)	197291	154616	29666	51245	35227	133673	130075	112290	109668	193369	23844
Seepage outside forest (mm)	14.66	15.71	16.13	14.22	11.53	13.99	10.78	14.35	12.03	11.33	13.80
Storage loss (m^3)	-111800	-40802	-6783	-44543	-24043	-18293	-56252	-10533	-9587	-151229	-7775
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS											
Stream flow (m^3)	20666984	818228	490807	1830854	2167454	556342	24052011	1064348	592651	27146283	27265682
Stream flow (mm)	26.26	41.90	22.18	29.18	28.41	37.81	26.85	37.44	38.59	27.93	27.71
Seepage (m^3)	9575630	207407	99028	463409	547879	150654	10428818	153202	119702	10958274	11019164
Seepage (mm)	12.17	10.62	4.47	7.38	7.18	10.24	11.64	5.39	7.79	11.27	11.20
Seepage/stream flow (%)	46%	25%	20%	25%	25%	27%	43%	14%	20%	40%	40%
Seepage inside forest (m^3)	995620	52791	69362	227882	277125	16981	1314307	40912	10034	1428435	1465481
Seepage inside forest (mm)	5.63	5.45	3.42	4.80	4.78	3.29	5.35	1.99	1.61	4.96	4.91
Seepage outside forest (m^3)	8580010	154616	29666	235527	270754	133673	9114511	112290	109668	9529838	9553683
Seepage outside forest (mm)	14.06	15.71	16.13	15.41	14.76	13.99	14.02	14.35	12.03	13.93	13.93
Storage loss (m^3)	-2257627	-40802	-6783	-92128	-116171	-18293	-2448343	-10533	-9587	-2619692	-2627467

Assumptions:

Lower soil layer 20m deep with permeability 3m/yr/unit hydraulic gradient

Peak leaf area index for pasture = 2.1

Spreadsheet 3. Average flows for clearing as in 1996 (cont.)

6. Flows for 1996 clearing for Subcatchments of the Tone below Tonebridge Catchments

Subcatchment	**1**	**2**	**3**	**5**	**6**	**7**	**8**	**9**	**10**
Drains to	2	3	7	6	7	9	9	10	14
SUMS FOR ISOLATED SUBCATCHMENTS									
Stream flow (m^3)	726782	462790	428440	835776	1584180	268667	496347	1141287	680929
Stream flow (mm)	47.50	33.02	37.10	50.00	33.91	13.84	29.54	48.86	42.90
Seepage (m^3)	160278	94186	84618	111602	289955	79179	48852	153385	51135
Seepage (mm)	10.48	6.72	7.33	6.68	6.21	4.08	2.91	6.57	3.22
Seepage/stream flow (%)	22%	20%	20%	13%	18%	29%	10%	13%	8%
Seepage inside forest (m^3)	7226	22484	29974	12700	111676	33043	48852	58275	29531
Seepage inside forest (mm)	1.36	3.24	3.67	3.07	4.08	2.74	2.91	3.98	2.15
Seepage outside forest (m^3)	153052	71701	54644	98902	178279	46136	0	95110	21604
Seepage outside forest (mm)	15.33	10.14	16.18	7.86	9.21	6.26	0.00	10.93	10.26
Storage loss (m^3)	-10876	-35416	-5081	-54200	-150952	-13882	867	-21680	-4333
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS									
Stream flow (m^3)	726782	1189572	1618012	835776	2419956	4306636	496347	5944270	6625200
Stream flow (mm)	47.50	40.58	39.60	50.00	38.15	34.81	29.54	36.27	36.86
Seepage (m^3)	160278	254464	339082	111602	401557	819819	48852	1022056	1073191
Seepage (mm)	10.48	8.68	8.30	6.68	6.33	6.63	2.91	6.24	5.97
Seepage/stream flow (%)	22%	21%	21%	13%	17%	19%	10%	17%	16%
Seepage inside forest (m^3)	7226	29710	59684	12700	124377	217103	48852	324230	353762
Seepage inside forest (mm)	1.36	2.42	2.92	3.07	3.95	3.39	2.91	3.40	3.24
Seepage outside forest (m^3)	153052	224754	279398	98902	277181	602715	0	697825	719429
Seepage outside forest (mm)	15.33	13.18	13.68	7.86	8.68	10.09	0.00	10.20	10.20
Storage loss (m^3)	-10876	-46292	-51373	-54200	-205152	-270407	867	-291220	-295553

7. Flows for 1996 clearing for Subcatchments of the Tone below Tonebridge Catchments

Subcatchment	**10**	**24**	**11**	**12**	**13**	**14**	**15**	**16**	**25**
Drains to	14	25	12	13	14	15	25	25	27
SUMS FOR ISOLATED SUBCATCHMENTS									
Stream flow (m^3)	680929	1015128	207022	432372	365803	683654	808847	254910	377869
Stream flow (mm)	42.90	45	19.82	22.39	25.17	39.66	28.19	15.44	30.58
Seepage (m^3)	51135	115247	49051	71871	29564	57520	6133	39897	25846
Seepage (mm)	3.22	5	4.70	3.72	2.03	3.34	0.21	2.42	2.09
Seepage/stream flow (%)	8%	11%	24%	17%	8%	8%	1%	16%	7%
Seepage inside forest (m^3)	29531	49245	39510	64669	23135	19491	6116	38718	25769
Seepage inside forest (mm)	2.15	3	4.00	3.56	1.67	1.39	0.21	2.37	2.09
Seepage outside forest (m^3)	21604	66002	9542	7202	6428	38030	18	1179	77
Seepage outside forest (mm)	10.26	10	16.61	6.22	9.54	11.84	0.55	6.31	5.84
Storage loss (m^3)	-4333	-40772	-3858	-10813	-5853	-7056	-3275	-6361	-5447
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS									
Stream flow (m^3)	6625200	9152158	207022	639395	1005197	8314051	9122898	254910	18907835
Stream flow (mm)	36.86	44	19.82	21.49	22.70	34.46	33.79	15.44	37.34
Seepage (m^3)	1073191	1474675	49051	120922	150486	1281198	1287331	39897	2827749
Seepage (mm)	5.97	7	4.70	4.06	3.40	5.31	4.77	2.42	5.58
Seepage/stream flow (%)	16%	16%	24%	19%	15%	15%	14%	16%	15%
Seepage inside forest (m^3)	353762	335540	39510	104179	127315	500567	506683	38718	906711
Seepage inside forest (mm)	3.24	3	4.00	3.72	3.04	3.03	2.61	2.37	2.81
Seepage outside forest (m^3)	719429	1139135	9542	16743	23172	780631	780648	1179	1921038
Seepage outside forest (mm)	10.20	11	16.61	9.66	9.63	10.25	10.25	6.31	10.48
Storage loss (m^3)	-295553	-444861	-3858	-14671	-20524	-323133	-326408	-6361	-783077

Assumptions:

Lower soil layer 20m deep with permeability 3m/yr/unit hydraulic gradient

Peak leaf area index for pasture = 2.1

Spreadsheet 3. Average flows for clearing as in 1996 (cont.)

8. Flows for 1996 clearing for Subcatchments of the Tone below Tonebridge Catchments

Subcatchment	**4**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Drains to	19	18	23	20	21	22	24	24	25
SUMS FOR ISOLATED SUBCATCHMENTS									
Stream flow (m^3)	404981	894636	1590630	1781736	597046	-3464	984501	1886965	1015128
Stream flow (mm)	48.01	69.68	73.06	41.89	15.80	-0.22	53.26	67.76	45.50
Seepage (m^3)	88045	114690	203564	298717	272353	102766	92529	186764	115247
Seepage (mm)	10.44	8.93	9.35	7.02	7.21	6.63	5.01	6.71	5.17
Seepage/stream flow (%)	22%	13%	13%	17%	46%	-2967%	9%	10%	11%
Seepage inside forest (m^3)	2814	3235	17154	61312	89101	33949	26693	52038	49245
Seepage inside forest (mm)	1.23	0.92	2.75	3.33	4.22	3.98	2.68	3.51	3.12
Seepage outside forest (m^3)	85231	111454	186410	237406	183253	68816	65836	134726	66002
Seepage outside forest (mm)	13.84	11.94	11.99	9.84	11.00	9.88	7.71	10.35	10.11
Storage loss (m^3)	-7859	-11367	-31784	-140606	-94473	-34070	-30059	-53871	-40772
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS									
Stream flow (m^3)	404981	894636	2485265	2186718	2783764	2780300	3764801	4372230	9152158
Stream flow (mm)	48.01	69.68	71.80	42.90	31.37	26.67	30.68	70.00	44.11
Seepage (m^3)	88045	114690	318253	386763	659116	761882	854410	505017	1474675
Seepage (mm)	10.44	8.93	9.19	7.59	7.43	7.31	6.96	8.09	7.11
Seepage/stream flow (%)	22%	13%	13%	18%	24%	27%	23%	12%	16%
Seepage inside forest (m^3)	2814	3235	20389	64126	153227	187176	213869	72427	335540
Seepage inside forest (mm)	1.23	0.92	2.09	3.10	3.67	3.72	3.55	2.95	3.33
Seepage outside forest (m^3)	85231	111454	297864	322637	505889	574706	640542	432590	1139135
Seepage outside forest (mm)	13.84	11.94	11.97	10.65	10.78	10.66	10.26	11.42	10.66
Storage loss (m^3)	-7859	-11367	-43151	-148465	-242938	-277008	-307067	-97022	-444861

9. Flows for 1996 clearing for Subcatchments of the Tone below Tonebridge Catchments

Subcatchment	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
Drains to	27	27	29	29	30	33	32	33	
SUMS FOR ISOLATED SUBCATCHMENTS									
Stream flow (m^3)	377869	329510	651873	367252	344576	896360	553467	453386	1238902
Stream flow (mm)	30.58	18.10	25.75	28.80	40.00	34.09	30.30	34.42	43.17
Seepage (m^3)	25846	37734	73799	21490	18557	43732	10304	29561	37541
Seepage (mm)	2.09	2.07	2.92	1.69	2.15	1.66	0.56	2.24	1.31
Seepage/stream flow (%)	7%	11%	11%	6%	5%	5%	2%	7%	3%
Seepage inside forest (m^3)	25769	37573	73300	21360	18155	43535	10052	29514	33822
Seepage inside forest (mm)	2.09	2.07	2.91	1.68	2.12	1.66	0.55	2.24	1.19
Seepage outside forest (m^3)	77	161	499	130	401	197	252	48	3719
Seepage outside forest (mm)	5.84	8.57	4.03	7.43	7.83	3.09	2.37	3.17	10.80
Storage loss (m^3)	-5447	-6036	-12151	-4621	-2945	-7377	-719	-1642	-8042
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS									
Stream flow (m^3)	18907835	329510	19889217	367252	20601045	21497405	553467	1006853	23743160
Stream flow (mm)	37.34	18.10	36.17	28.80	36.06	35.98	30.30	32.03	36.10
Seepage (m^3)	2827749	37734	2939282	21490	2979329	3023061	10304	39865	3100467
Seepage (mm)	5.58	2.07	5.35	1.69	5.22	5.06	0.56	1.27	4.71
Seepage/stream flow (%)	15%	11%	15%	6%	14%	14%	2%	4%	13%
Seepage inside forest (m^3)	906711	37573	1017584	21360	1057100	1100635	10052	39565	1174022
Seepage inside forest (mm)	2.81	2.07	2.78	1.68	2.73	2.66	0.55	1.26	2.48
Seepage outside forest (m^3)	1921038	161	1921698	130	1922229	1922426	252	300	1926445
Seepage outside forest (mm)	10.48	8.57	10.48	7.43	10.48	10.47	2.37	2.47	10.47
Storage loss (m^3)	-783077	-6036	-801265	-4621	-808830	-816207	-719	-2361	-826610

Assumptions:

Lower soil layer 20m deep with permeability 3m/yr/unit hydraulic gradient

Peak leaf area index for pasture = 2.1

Spreadsheet 3. Average flows for clearing as in 1996 (cont.)

10. Flows for 1996 clearing for Subcatchments of the Perup Catchments

Subcatchment	1	2	3	4	5	6	7	8
Drains to	3	3	4	5	8	8	8	11
SUMS FOR ISOLATED SUBCATCHMENTS								
Stream flow (m^3)	448536	134464	253128	247628	509061	662009	610227	797489
Stream flow (mm)	23.98	13.71	19.29	14.11	32.28	30.28	37.17	38.67
Seepage (m^3)	130574	49014	54382	35673	113406	129225	78429	144903
Seepage (mm)	6.98	5.00	4.14	2.03	7.19	5.91	4.78	7.03
Seepage/stream flow (%)	29%	36%	21%	14%	22%	20%	13%	18%
Seepage inside forest (m^3)	34209	43155	49648	35359	21394	14426	9285	23377
Seepage inside forest (mm)	2.76	4.68	3.89	2.02	1.88	0.93	0.71	1.61
Seepage outside forest (m^3)	96365	5858	4735	314	92012	114799	69144	121526
Seepage outside forest (mm)	15.31	10.11	12.91	4.29	20.87	18.23	20.54	20.02
Storage loss (m^3)	-5326	-6240	-2304	-1689	1246	3192	-2787	-4688
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS								
Stream flow (m^3)	448536	134464	836128	1083756	1592817	662009	610227	3662542
Stream flow (mm)	23.98	13.71	20.08	18.31	21.25	30.28	37.17	27.36
Seepage (m^3)	130574	49014	233970	269643	383048	129225	78429	735605
Seepage (mm)	6.98	5.00	5.62	4.56	5.11	5.91	4.78	5.50
Seepage/stream flow (%)	29%	36%	28%	25%	24%	20%	13%	20%
Seepage inside forest (m^3)	34209	43155	127012	162371	183765	14426	9285	230853
Seepage inside forest (mm)	2.76	4.68	3.69	3.13	2.91	0.93	0.71	2.17
Seepage outside forest (m^3)	96365	5858	106958	107271	199284	114799	69144	504752
Seepage outside forest (mm)	15.31	10.11	14.78	14.67	17.00	18.23	20.54	18.38
Storage loss (m^3)	-5326	-6240	-13870	-15558	-14312	3192	-2787	-18595

11. Flows for 1996 clearing for Subcatchments of the Perup Catchments

Subcatchment	8	9	10	11	12	13	14	15	16
Drains to	11	10	11	14	14	14	16	16	34
SUMS FOR ISOLATED SUBCATCHMENTS									
Stream flow (m^3)	797489	391606	399955	851143	350481	496157	1120331	590865	874423
Stream flow (mm)	38.67	14.58	16.25	45.04	18.24	34.35	67.75	24.24	75.52
Seepage (m^3)	144903	117877	90440	155235	95749	61599	195748	69575	145715
Seepage (mm)	7.03	4.39	3.67	8.22	4.98	4.26	11.84	2.85	12.58
Seepage/stream flow (%)	18%	30%	23%	18%	27%	12%	17%	12%	17%
Seepage inside forest (m^3)	23377	102980	88804	37445	61614	8658	10920	56863	6908
Seepage inside forest (mm)	1.61	4.05	3.64	2.77	3.53	0.76	1.48	2.46	1.48
Seepage outside forest (m^3)	121526	14897	1636	117790	34135	52941	184828	12712	138807
Seepage outside forest (mm)	20.02	10.42	8.00	21.99	19.17	17.63	20.14	10.45	20.04
Storage loss (m^3)	-4688	-32649	-9977	-4184	-10227	-6383	-11851	-29862	-14568
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS									
Stream flow (m^3)	3662542	391606	791560	5305246	350481	496157	7272215	590865	8737503
Stream flow (mm)	27.36	14.58	15.38	25.98	18.24	34.35	28.58	24.24	30.09
Seepage (m^3)	735605	117877	208317	1099157	95749	61599	1452253	69575	1667543
Seepage (mm)	5.50	4.39	4.05	5.38	4.98	4.26	5.71	2.85	5.74
Seepage/stream flow (%)	20%	30%	26%	21%	27%	12%	20%	12%	19%
Seepage inside forest (m^3)	230853	102980	191784	460082	61614	8658	541274	56863	605045
Seepage inside forest (mm)	2.17	4.05	3.85	2.71	3.53	0.76	2.63	2.46	2.59
Seepage outside forest (m^3)	504752	14897	16533	639075	34135	52941	910980	12712	1062498
Seepage outside forest (mm)	18.38	10.42	10.12	18.55	19.17	17.63	18.82	10.45	18.79
Storage loss (m^3)	-18595	-32649	-42626	-65405	-10227	-6383	-93867	-29862	-138296

Assumptions:

Lower soil layer 20m deep with permeability 3m/yr/unit hydraulic gradient

Peak leaf area index for pasture = 2.1

Spreadsheet 3. Average flows for clearing as in 1996 (cont.)

12. Flows for 1996 clearing for Subcatchments of the Perup Catchments

Subcatchment	17	18	19	20	21	22	23
Drains to	18	19	20	21	23	23	27
SUMS FOR ISOLATED SUBCATCHMENTS							
Stream flow (m³)	286663	153840	402029	693580	575270	615121	1182837
Stream flow (mm)	16.71	10.96	20.31	34.21	29.89	27.30	51.89
Seepage (m³)	71288	35020	37309	107861	117815	9402	107928
Seepage (mm)	4.15	2.49	1.88	5.32	6.12	0.42	4.73
Seepage/stream flow (%)	25%	23%	9%	16%	20%	2%	9%
Seepage inside forest (m³)	23402	23791	20774	13546	32997	8477	9150
Seepage inside forest (mm)	1.85	1.80	1.12	0.89	2.25	0.38	0.50
Seepage outside forest (m³)	47886	11228	16535	94315	84817	925	98777
Seepage outside forest (mm)	10.65	13.30	12.97	18.87	18.38	3.20	21.75
Storage loss (m³)	-6977	-3534	-3212	-1704	-28803	-2195	446
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS							
Stream flow (m³)	286663	440502	842531	1536111	2111380	615121	3909339
Stream flow (mm)	16.71	14.12	16.52	21.56	23.33	27.30	28.78
Seepage (m³)	71288	106308	143617	251478	369293	9402	486622
Seepage (mm)	4.15	3.41	2.82	3.53	4.08	0.42	3.58
Seepage/stream flow (%)	25%	24%	17%	16%	17%	2%	12%
Seepage inside forest (m³)	23402	47194	67968	81514	114511	8477	132138
Seepage inside forest (mm)	1.85	1.83	1.53	1.37	1.54	0.38	1.15
Seepage outside forest (m³)	47886	59114	75649	169964	254782	925	354484
Seepage outside forest (mm)	10.65	11.06	11.43	14.63	15.70	3.20	16.83
Storage loss (m³)	-6977	-10512	-13724	-15428	-44230	-2195	-45979

13. Flows for 1996 clearing for Subcatchments of the Perup Catchments

Subcatchment	23	24	25	26	27	28	29	30	31	32	33
Drains to	27	27	26	27	31	31	31	31	33	33	34
SUMS FOR ISOLATED SUBCATCHMENTS											
Stream flow (m³)	1182837	680489	729468	385536	791237	175327	458124	-1133	1226152	679535	591578
Stream flow (mm)	51.89	44.99	39.25	38.79	44.93	18.54	26.63	-0.10	44.35	59.70	42.22
Seepage (m³)	107928	5407	31508	4865	23791	21500	75704	30806	153936	82701	63596
Seepage (mm)	4.73	0.36	1.70	0.49	1.35	2.27	4.40	2.85	5.57	7.27	4.54
Seepage/stream flow (%)	9%	1%	4%	1%	3%	12%	17%	-2719%	13%	12%	11%
Seepage inside forest (m³)	9150	2472	4544	4856	23729	20608	41333	21331	49755	9174	26704
Seepage inside forest (mm)	0.50	0.17	0.26	0.49	1.35	2.20	2.90	2.17	2.37	1.19	2.33
Seepage outside forest (m³)	98777	2935	26963	9	62	892	34371	9475	104180	73527	36892
Seepage outside forest (mm)	21.75	8.55	19.93	13.87	24.61	13.46	11.69	9.99	15.66	20.12	14.56
Storage loss (m³)	446	-2119	-806	-1320	-3842	-1293	-15470	-7585	-20489	-2501	-3685
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS											
Stream flow (m³)	3909339	680489	729468	1115004	6496069	175327	458124	-1133	8354539	679535	9625652
Stream flow (mm)	28.78	44.99	39.25	39.09	32.96	18.54	26.63	-0.10	31.86	59.70	33.47
Seepage (m³)	486622	5407	31508	36373	552193	21500	75704	30806	834138	82701	980436
Seepage (mm)	3.58	0.36	1.70	1.28	2.80	2.27	4.40	2.85	3.18	7.27	3.41
Seepage/stream flow (%)	12%	1%	4%	3%	9%	12%	17%	-2719%	10%	12%	10%
Seepage inside forest (m³)	132138	2472	4544	9401	167740	20608	41333	21331	300768	9174	336647
Seepage inside forest (mm)	1.15	0.17	0.26	0.35	0.96	2.20	2.90	2.17	1.31	1.19	1.36
Seepage outside forest (m³)	354484	2935	26963	26972	384453	892	34371	9475	533370	73527	643789
Seepage outside forest (mm)	16.83	8.55	19.93	19.92	16.89	13.46	11.69	9.99	15.99	20.12	16.28
Storage loss (m³)	-45979	-2119	-806	-2126	-54067	-1293	-15470	-7585	-98904	-2501	-105090

Assumptions:

Lower soil layer 20m deep with permeability 3m/yr/unit hydraulic gradient

Peak leaf area index for pasture = 2.1

Spreadsheet 3. Average flows for clearing as in 1996 (cont.)

14. Flows for 1996 clearing for Subcatchments of the Perup Catchments

Subcatchment	**16**	**33**	**34**	**35**	**36**	**37**
Drains to	34	34	36	36	37	
SUMS FOR ISOLATED SUBCATCHMENTS						
Stream flow (m^3)	874423	591578	698671	369268	1322242	1588167
Stream flow (mm)	75.52	42.22	41.63	13.68	68.82	76.08
Seepage (m^3)	145715	63596	52616	93858	168754	98318
Seepage (mm)	12.58	4.54	3.14	3.48	8.78	4.71
Seepage/stream flow (%)	17%	11%	8%	25%	13%	6%
Seepage inside forest (m^3)	6908	26704	11963	81029	7935	6095
Seepage inside forest (mm)	1.48	2.33	0.81	3.12	0.77	0.40
Seepage outside forest (m^3)	138807	36892	40653	12829	160819	92223
Seepage outside forest (mm)	20.04	14.56	19.69	12.37	18.06	16.18
Storage loss (m^3)	-14568	-3685	-1146	-24517	-7932	-595
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS						
Stream flow (m^3)	8737503	9625652	19061826	369268	20753336	22341502
Stream flow (mm)	30.09	33.47	32.05	13.68	32.38	33.76
Seepage (m^3)	1667543	980436	2700594	93858	2963206	3061524
Seepage (mm)	5.74	3.41	4.54	3.48	4.62	4.63
Seepage/stream flow (%)	19%	10%	14%	25%	14%	14%
Seepage inside forest (m^3)	605045	336647	953655	81029	1042619	1048714
Seepage inside forest (mm)	2.59	1.36	1.92	3.12	1.96	1.91
Seepage outside forest (m^3)	1062498	643789	1746939	12829	1920587	2012811
Seepage outside forest (mm)	18.79	16.28	17.79	12.37	17.76	17.69
Storage loss (m^3)	-138296	-105090	-244532	-24517	-276981	-277576

Assumptions:

Lower soil layer 20m deep with permeability 3m/yr/unit hydraulic gradient

Peak leaf area index for pasture = 2.1

Spreadsheet 4

Model minimum tree planting

Target: 50% reduction in seepage
Criteria: Plant on pasture land where seepage > 20mm/yr
Allow draw to 30% depth of bottom soil layer

1. Model minimum tree planting for Subcatchments of the Tone above Tonebridge Catchments

Subcatchment	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Drains to	3	3	4	6	6	7	12	9	12	12	12	17
SUMS FOR ISOLATED SUBCATCHMENTS												
Area planted (km²)	2.06	2.09	2.24	1.54	3.53	2.79	2.69	3.67	1.90	2.71	1.31	1.30
Planted/cleared area (%)	13%	16%	11%	13%	16%	16%	17%	18%	19%	18%	17%	15%
Predicted seepage (cu.m)	144145	107800	161006	99724	151779	134572	177174	157720	84946	142233	58121	101615
" out. for. seepage (cu.m.)	133176	101383	159099	94542	149543	130787	144912	154559	79136	120059	55801	76550
% of 1996 seepage	55%	47%	56%	52%	41%	44%	52%	40%	41%	46%	43%	55%
% of 1996 out. for. seepage	54%	46%	56%	52%	41%	43%	48%	39%	40%	42%	42%	48%
Review seepage	139767	105381	157088	97521	145496	127819	168849	145969	81755	137111	56411	100420
Review streamflow	71547	59892	73470	70902	120537	101820	183161	156025	70498	157780	49806	117835
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS												
Area planted (km²)	2.06	2.09	6.39	7.93	3.53	14.26	16.94	3.67	5.56	2.71	1.31	27.84
Planted/cleared area (%)	13%	16%	13%	13%	16%	14%	14%	18%	19%	18%	17%	16%
Predicted seepage (cu.m)	144145	107800	412951	512676	151779	799027	976201	157720	242666	142233	58121	1520836
" out. for. seepage (cu.m.)	133176	101383	393657	488199	149543	768528	913440	154559	233695	120059	55801	1399545
% of 1996 seepage	55%	47%	53%	53%	41%	49%	49%	40%	40%	46%	43%	47%
% of 1996 out. for. seepage	54%	46%	52%	52%	41%	48%	48%	39%	40%	42%	42%	46%
Review seepage	139767	105381	402236	499757	145496	773072	941920	145969	227724	137111	56411	1463586
Review streamflow	71547	59892	204908	275811	120537	498168	681329	156025	226523	157780	49806	1233272

2. Model minimum tree planting for Subcatchments of the Tone above Tonebridge Catchments

Subcatchment	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Drains to	17	14	15	17	17	20	20	20	24	22	23	24	25
SUMS FOR ISOLATED SUBCATCHMENTS													
Area planted (km²)	1.30	2.30	2.08	2.62	2.32	1.81	1.51	1.36	1.80	1.93	2.95	2.61	2.49
Planted/cleared area (%)	15%	21%	21%	20%	18%	17%	16%	16%	14%	22%	20%	17%	16%
Predicted seepage (cu.m)	101615	69197	97065	117621	150347	157838	115928	95164	158087	107506	127925	133368	139346
" out. for. seepage (cu.m.)	76550	68020	81936	106424	116595	103572	79569	71206	115057	79681	114866	121156	118618
% of 1996 seepage	55%	31%	42%	42%	51%	59%	56%	54%	59%	45%	40%	45%	47%
% of 1996 out. for. seepage	48%	31%	38%	40%	45%	50%	47%	47%	52%	39%	38%	43%	43%
Review seepage	100420	67028	92981	112674	145651	154396	114013	93128	157001	102226	119824	128516	136153
Review streamflow	117835	58247	150012	109362	223050	246234	120583	158832	253877	247207	273711	284297	193173
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS													
planted (km²)	27.84	2.30	4.37	6.99	2.32	38.95	1.51	1.36	43.63	1.93	4.88	7.50	53.62
Planted/cleared area (%)	16%	21%	21%	21%	18%	16%	16%	16%	16%	22%	21%	19%	17%
Predicted seepage (cu.m)	1520836	69197	166262	283883	150347	2112905	115928	95164	2482084	107506	235431	368799	2990229
" out. for. seepage (cu.m.)	1399545	68020	149955	256379	116595	1876091	79569	71206	2141923	79681	194547	315703	2576244
% of 1996 seepage	47%	31%	37%	39%	51%	47%	56%	54%	48%	45%	42%	43%	47%
% of 1996 out. for. seepage	46%	31%	35%	37%	45%	44%	47%	47%	45%	39%	38%	40%	44%
Review seepage	1463586	67028	160009	272682	145651	2036316	114013	93128	2400457	102226	222050	350565	2887176
Review streamflow	1233272	58247	208260	317622	223050	2020179	120583	158832	2553471	247207	520918	805215	3551859

Abbreviations:
out. for. = outside forest

Spreadsheet 4. Model minimum tree planting (cont.)

Target: 50% reduction in seepage
Criteria: Plant on pasture land where seepage > 20mm/yr
Allow draw to 30% depth of bottom soil layer

3. Model minimum tree planting for Subcatchments of the Tone above Tonebridge Catchments

Subcatchment	24	25	26	27	28	29	30	31	36	32
Drains to	25	26	32	28	31	30	31	32	32	39
SUMS FOR ISOLATED SUBCATCHMENTS										
Area planted (km²)	2.49	2.20	1.61	2.09	1.50	1.41	1.47	0.45	1.64	0.90
Planted/cleared area (%)	16%	21%	12%	10%	8%	14%	9%	6%	20%	5%
Predicted seepage (cu.m)	139346	105943	185879	194455	185692	82750	121908	106809	69595	193909
" out. for. seepage (cu.m.)	118618	89120	125029	174880	161184	74776	108220	57678	61823	142083
% of 1996 seepage	47%	44%	66%	61%	68%	49%	58%	80%	40%	79%
% of 1996 out. for. seepage	43%	40%	59%	60%	66%	47%	56%	72%	38%	75%
Review seepage	136153	103362	183871	188841	183201	80209	210664	106031	66865	245604
Review streamflow	193173	213653	350399	279243	304886	330167	559524	458115	115602	727022
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS										
Area planted (km²)	53.62	55.82	57.42	2.09	3.59	1.41	2.88	6.92	1.64	66.88
Planted/cleared area (%)	17%	17%	17%	10%	9%	14%	11%	10%	20%	15%
Predicted seepage (cu.m)	2990229	3096172	3282051	194455	380147	82750	204658	691613	69595	4237168
" out. for. seepage (cu.m.)	2576244	2665364	2790393	174880	336065	74776	182996	576739	61823	3571037
% of 1996 seepage	47%	47%	48%	61%	65%	49%	54%	63%	40%	51%
% of 1996 out. for. seepage	44%	44%	45%	60%	63%	47%	52%	59%	38%	47%
Review seepage	2887176	2990538	3174409	188841	372041	80209	290873	768946	66865	4255824
Review streamflow	3551859	3765512	4115911	279243	584129	330167	889692	1931936	115602	6890470

4. Model minimum tree planting for Subcatchments of the Tone above Tonebridge Catchments

Subcatchment	32	33	34	35	37	38	39
Drains to	39	35	35	37	39	39	45
SUMS FOR ISOLATED SUBCATCHMENTS							
Area planted (km²)	0.90	1.57	0.72	1.26	2.56	1.08	1.75
Planted/cleared area (%)	5%	15%	20%	21%	16%	17%	17%
Predicted seepage (cu.m)	193909	112792	75434	60835	158487	96406	148954
" out. for. seepage (cu.m.)	142083	95133	30086	46064	128954	59140	95517
% of 1996 seepage	79%	54%	63%	43%	50%	60%	58%
% of 1996 out. for. seepage	75%	50%	41%	37%	46%	49%	48%
Review seepage	245604	106792	73988	57811	318715	95639	147479
Review streamflow	727022	294274	329196	200409	1216143	376351	554146
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS							
Area planted (km²)	66.88	1.57	0.72	3.55	6.10	1.08	75.81
Planted/cleared area (%)	15%	15%	20%	18%	17%	17%	15%
Predicted seepage (cu.m)	4237168	112792	75434	249061	407548	96406	4890076
" out. for. seepage (cu.m.)	3571037	95133	30086	171283	300237	59140	4025931
% of 1996 seepage	51%	54%	63%	53%	52%	60%	51%
% of 1996 out. for. seepage	47%	50%	41%	44%	45%	49%	47%
Review seepage	4255824	106792	73988	238590	557305	95639	5056247
Review streamflow	6890470	294274	329196	823879	2040023	376351	9860990

Abbreviations:
out. for. = outside forest

Spreadsheet 4. Model minimum tree planting (cont.)

Target: 50% reduction in seepage
Criteria: Plant on pasture land where seepage > 20mm/yr
Allow draw to 30% depth of bottom soil layer

5. Model minimum tree planting for Subcatchments of the Tone above Tonebridge Catchments

Subcatchment	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**
Drains to	45	42	42	43	45	45	48	48	48	49	
SUMS FOR ISOLATED SUBCATCHMENTS											
Area planted (km²)	1.75	1.29	0.25	0.48	0.22	1.01	0.90	1.01	0.76	1.26	0.12
Planted/cleared area (%)	17%	17%	16%	16%	9%	14%	10%	14%	10%	9%	9%
Predicted seepage (cu.m)	148954	126012	83999	127796	71956	90124	98308	87538	73029	183410	53029
" out. for. seepage (cu.m.)	95517	75743	16047	23325	24384	76250	77798	48545	65248	126852	16696
% of 1996 seepage	58%	61%	85%	81%	85%	60%	64%	57%	61%	71%	87%
% of 1996 out. for. seepage	48%	49%	54%	46%	69%	57%	60%	43%	59%	66%	70%
Review seepage	147479	122233	83643	127402	72116	87423	97036	86492	71043	180747	51684
Review streamflow	554146	486312	426164	393192	275503	283415	407153	708866	377229	1081124	86624
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS											
Area planted (km²)	75.81	1.29	0.25	2.02	2.24	1.01	79.96	1.01	0.76	83.00	83.11
Planted/cleared area (%)	15%	17%	16%	17%	15%	14%	15%	14%	10%	15%	15%
Predicted seepage (cu.m)	4890076	126012	83999	337807	409763	90124	5488270	87538	73029	5832248	5885276
" out. for. seepage (cu.m.)	4025931	75743	16047	115114	139498	76250	4319477	48545	65248	4560122	4576818
% of 1996 seepage	51%	61%	85%	73%	75%	60%	53%	57%	61%	53%	53%
% of 1996 out. for. seepage	47%	49%	54%	49%	52%	57%	47%	43%	59%	48%	48%
Review seepage	5056247	122233	83643	333278	405394	87423	5646101	86492	71043	5984383	6036066
Review streamflow	9860990	486312	426164	1305668	1581171	283415	12132729	708866	377229	14299947	14386571

6. Model minimum tree planting for Subcatchments of the Tone below Tonebridge Catchments

Subcatchment	**1**	**2**	**3**	**5**	**6**	**7**	**8**	**9**	**10**
Drains to	2	3	7	6	7	9	9	10	14
SUMS FOR ISOLATED SUBCATCHMENTS									
Area planted (km²)	1.40	0.44	0.43	0.44	0.92	0.27	0.00	0.58	0.11
Planted/cleared area (%)	17%	8%	17%	5%	7%	5%	0%	9%	7%
Predicted seepage (cu.m)	71883	67940	55722	86807	234629	61770	48634	115975	43575
" out. for. seepage (cu.m.)	67334	47731	27936	78190	137444	32278	0	62247	16337
% of 1996 seepage	45%	72%	66%	78%	81%	78%	100%	76%	85%
% of 1996 out. for. seepage	44%	67%	51%	79%	77%	70%	0%	65%	76%
Review seepage	129833	88068	53828	85874	232501	58721	48852	112227	40267
Review streamflow	483748	382230	317613	733463	1349139	191840	496347	977838	646843
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS									
Area planted (km²)	1.40	1.83	2.26	0.44	1.36	3.89	0.00	4.47	4.57
Planted/cleared area (%)	17%	13%	14%	5%	6%	9%	0%	9%	9%
Predicted seepage (cu.m)	71883	139823	195544	86807	321436	578751	48634	743360	786935
" out. for. seepage (cu.m.)	67334	115065	143001	78190	215634	390913	0	453161	469497
% of 1996 seepage	45%	55%	58%	78%	80%	71%	100%	73%	73%
% of 1996 out. for. seepage	44%	51%	51%	79%	78%	65%	0%	65%	65%
Review seepage	129833	217902	271729	85874	318375	648825	48852	809905	850171
Review streamflow	483748	865979	1183592	733463	2082602	3458034	496347	4932219	5579062

Abbreviations:
out. for. = outside forest

Spreadsheet 4. Model minimum tree planting (cont.)

Target: 50% reduction in seepage
Criteria: Plant on pasture land where seepage > 20mm/yr
Allow draw to 30% depth of bottom soil layer

7. Model minimum tree planting for Subcatchments of the Tone below Tonebridge Catchments

Subcatchment	**10**	**24**	**11**	**12**	**13**	**14**	**15**	**16**	**25**
Drains to	14	25	12	13	14	15	25	25	27
SUMS FOR ISOLATED SUBCATCHMENTS									
Area planted (km²)	0.11	0.41	0.03	0.00	0.02	0.31	0.00	0.00	0.00
Planted/cleared area (%)	7%	10%	7%	0%	4%	14%	0%	0%	0%
Predicted seepage (cu.m)	43575	91228	47211	71556	28652	36164	6106	39860	25836
" out. for. seepage (cu.m.)	16337	46303	10979	7415	6864	18497	16	1586	97
% of 1996 seepage	85%	79%	96%	100%	97%	63%	100%	100%	100%
% of 1996 out. for. seepage	76%	70%	115%	103%	107%	49%	89%	135%	126%
Review seepage	40267	90347	47314	71708	28737	34628	6133	39895	25841
Review streamflow	646843	886527	199779	431399	362465	578111	808847	254879	377857
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS									
Area planted (km²)	4.57	7.86	0.03	0.03	0.05	4.93	4.93	0.00	12.79
Planted/cleared area (%)	9%	10%	7%	2%	3%	9%	9%	0%	10%
Predicted seepage (cu.m)	786935	995505	47211	118767	147419	970518	976624	39860	2037825
" out. for. seepage (cu.m.)	469497	711913	10979	18394	25259	513253	513268	1586	1226865
% of 1996 seepage	73%	68%	96%	98%	98%	76%	76%	100%	72%
% of 1996 out. for. seepage	65%	62%	115%	110%	109%	66%	66%	135%	64%
Review seepage	850171	969771	47314	119022	147759	1032558	1038692	39895	2074198
Review streamflow	5579062	6781061	199779	631178	993642	7150815	7959662	254879	15373460

8. Model minimum tree planting for Subcatchments of the Tone below Tonebridge Catchments

Subcatchment	**4**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Drains to	19	18	23	20	21	22	24	24	25
SUMS FOR ISOLATED SUBCATCHMENTS									
Area planted (km²)	0.69	0.87	1.49	1.45	1.30	0.52	0.27	0.87	0.41
Planted/cleared area (%)	14%	11%	13%	8%	12%	11%	4%	10%	10%
Predicted seepage (cu.m)	45918	65122	112354	208757	192878	70628	76355	132265	91228
" out. for. seepage (cu.m.)	44550	63644	101763	159541	116063	40682	51941	87426	46303
% of 1996 seepage	52%	57%	55%	70%	71%	69%	83%	71%	79%
% of 1996 out. for. seepage	52%	57%	55%	67%	63%	59%	79%	65%	70%
Review seepage	43406	61874	107722	203812	187969	70301	75437	128902	90347
Review streamflow	214173	609408	1121877	1400730	234205	-167629	896393	1585376	886527
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS									
Area planted (km²)	0.69	0.87	2.35	2.14	3.44	3.95	4.23	3.23	7.86
Planted/cleared area (%)	0.10	11%	13%	9%	10%	10%	9%	12%	10%
Predicted seepage (cu.m)	45918	65122	177476	254675	447553	518181	594536	309742	995505
" out. for. seepage (cu.m.)	44550	63644	165407	204091	320154	360836	412776	252833	711913
% of 1996 seepage	72%	57%	56%	66%	68%	68%	70%	61%	68%
% of 1996 out. for. seepage	64%	57%	56%	63%	63%	63%	64%	58%	62%
Review seepage	43406	61874	169596	247218	435187	505488	580925	298498	969771
Review streamflow	214173	609408	1731285	1614902	1849108	1681479	2577872	3316661	6781061

Abbreviations:
out. for. = outside forest

Spreadsheet 4. Model minimum tree planting (cont.)

Target: 50% reduction in seepage
Criteria: Plant on pasture land where seepage > 20mm/yr
Allow draw to 30% depth of bottom soil layer

9. Model minimum tree planting for Subcatchments of the Tone below Tonebridge Catchments

Subcatchment	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
Drains to	27	27	29	29	30	33	32	33	
SUMS FOR ISOLATED SUBCATCHMENTS									
Area planted (km²)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Planted/cleared area (%)	0%	12%	5%	0%	5%	0%	0%	0%	19%
Predicted seepage (cu.m)	25836	37563	73603	21477	18430	43610	10268	29397	35495
" out. for. seepage (cu.m.)	97	108	456	173	489	191	208	0	1989
% of 1996 seepage	100%	100%	100%	100%	99%	100%	100%	99%	95%
% of 1996 out. for. seepage	126%	67%	91%	133%	122%	97%	83%	0%	53%
Review seepage	25841	37581	73730	21466	18480	43729	10294	29537	35223
Review streamflow	377857	328693	651828	367096	344326	896334	553015	452901	1231690
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS									
Area planted (km²)	12.79	0.00	12.79	0.00	12.79	12.79	0.00	0.00	12.82
Planted/cleared area (%)	10%	12%	10%	0%	10%	10%	0%	0%	10%
Predicted seepage (cu.m)	2037825	37563	2148992	21477	2188899	2232510	10268	39665	2307670
" out. for. seepage (cu.m.)	1226865	108	1227429	173	1228091	1228282	208	208	1230479
% of 1996 seepage	72%	100%	73%	100%	73%	74%	100%	99%	74%
% of 1996 out. for. seepage	64%	67%	64%	133%	64%	64%	83%	70%	64%
Review seepage	2074198	37581	2185510	21466	2225457	2269186	10294	39831	2344239
Review streamflow	15373460	328693	16353981	367096	17065403	17961737	553015	1005915	20199342

10. Model minimum tree planting for Subcatchments of the Perup Catchments

Subcatchment	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Drains to	3	3	4	5	8	8	8	11
SUMS FOR ISOLATED SUBCATCHMENTS								
Area planted (km²)	0.88	0.01	0.01	0.00	1.09	1.31	0.73	1.35
Planted/cleared area (%)	18%	3%	6%	0%	30%	28%	25%	28%
Predicted seepage (cu.m)	75934	48306	53697	35519	40223	46041	27541	54890
" out. for. seepage (cu.m.)	44289	6332	5058	259	20935	34043	18905	34788
% of 1996 seepage	58%	99%	99%	100%	35%	36%	35%	38%
% of 1996 out. for. seepage	46%	108%	107%	83%	23%	30%	27%	29%
Review seepage	72323	48321	53968	35673	39447	43576	26565	50798
Review streamflow	248593	131138	251947	247628	232196	350497	392391	451465
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS								
Area planted (km²)	0.88	0.01	0.91	0.91	1.99	1.31	0.73	5.38
Planted/cleared area (%)	18%	3%	17%	16%	22%	28%	25%	25%
Predicted seepage (cu.m)	75934	48306	177937	213457	253680	46041	27541	382153
" out. for. seepage (cu.m.)	44289	6332	55679	55938	76873	34043	18905	164609
% of 1996 seepage	58%	99%	76%	79%	66%	36%	35%	52%
% of 1996 out. for. seepage	46%	108%	52%	52%	39%	30%	27%	33%
Review seepage	72323	48321	174611	210284	249731	43576	26565	370670
Review streamflow	248593	131138	631678	879306	1111502	350497	392391	2305855

Abbreviations:
out. for. = outside forest

Spreadsheet 4. Model minimum tree planting (cont.)

Target: 50% reduction in seepage
Criteria: Plant on pasture land where seepage > 20mm/yr
Allow draw to 30% depth of bottom soil layer

11. Model minimum tree planting for Subcatchments of the Perup Catchments

Subcatchment	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Drains to	11	10	11	14	14	14	16	16	34
SUMS FOR ISOLATED SUBCATCHMENTS									
Area planted (km²)	1.35	0.05	0.00	1.31	0.40	0.53	1.92	0.08	1.29
Planted/cleared area (%)	0.28	6%	6%	29%	28%	24%	28%	11%	24%
Predicted seepage (cu.m)	54890	114631	90076	60236	68873	22792	54218	64413	48435
" out. for. seepage (cu.m.)	34788	15221	1507	25011	8002	15991	45988	9541	43944
% of 1996 seepage	38%	97%	100%	39%	72%	37%	28%	93%	33%
% of 1996 out. for. seepage	29%	102%	92%	21%	23%	30%	25%	75%	32%
Review seepage	50798	114550	90158	58437	68716	22070	50609	64580	43156
Review streamflow	451465	374760	399395	453563	237138	339860	545076	569086	472396
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS									
Area planted (km²)	5.38	0.05	0.05	6.74	0.40	0.53	9.59	0.08	10.97
Planted/cleared area (%)	0.25	6%	6%	25%	28%	24%	26%	11%	25%
Predicted seepage (cu.m)	382153	114631	204707	647096	68873	22792	792978	64413	905825
" out. for. seepage (cu.m.)	164609	15221	16728	206347	8002	15991	276329	9541	329813
% of 1996 seepage	52%	97%	98%	59%	72%	37%	55%	93%	54%
% of 1996 out. for. seepage	33%	102%	101%	32%	23%	30%	30%	75%	31%
Review seepage	370670	114550	204708	633815	68716	22070	775209	64580	882946
Review streamflow	2305855	374760	774155	3533572	237138	339860	4655646	569086	5697128

12. Model minimum tree planting for Subcatchments of the Perup Catchments

Subcatchment	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Drains to	18	19	20	21	23	23	27
SUMS FOR ISOLATED SUBCATCHMENTS							
Area planted (km²)	0.38	0.07	0.13	1.05	0.81	0.00	1.03
Planted/cleared area (%)	12%	12%	13%	25%	24%	0%	29%
Predicted seepage (cu.m)	48810	31132	28776	40971	60943	9343	27024
" out. for. seepage (cu.m.)	26491	8567	8395	30367	30364	1155	20093
% of 1996 seepage	68%	89%	77%	38%	52%	99%	25%
% of 1996 out. for. seepage	55%	76%	51%	32%	36%	125%	20%
Review seepage	48579	31114	28599	39355	57221	9402	23881
Review streamflow	189158	137199	366080	425200	354217	615121	836188
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS							
Area planted (km²)	0.38	0.45	0.58	1.63	2.44	0.00	3.48
Planted/cleared area (%)	0.25	12%	12%	18%	20%	0%	22%
Predicted seepage (cu.m)	48810	79942	108718	149689	210632	9343	246999
" out. for. seepage (cu.m.)	26491	35058	43453	73820	104184	1155	125432
% of 1996 seepage	54%	75%	76%	60%	57%	99%	51%
% of 1996 out. for. seepage	31%	59%	57%	43%	41%	125%	35%
Review seepage	48579	79693	108293	147648	204869	9402	238152
Review streamflow	189158	326357	692437	1117637	1471854	615121	2923164

Abbreviations:
out. for. = outside forest

Spreadsheet 4. Model minimum tree planting (cont.)

Target: 50% reduction in seepage
Criteria: Plant on pasture land where seepage > 20mm/yr
Allow draw to 30% depth of bottom soil layer

13. Model minimum tree planting for Subcatchments of the Perup Catchments

Subcatchment	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
Drains to	27	27	26	27	31	31	31	31	33	33	34
SUMS FOR ISOLATED SUBCATCHMENTS											
Area planted (km²)	1.03	0.01	0.33	0.00	0.00	0.00	0.24	0.04	0.90	0.77	0.32
Planted/cleared area (%)	0.29	9%	31%	0%	41%	10%	13%	9%	18%	28%	20%
Predicted seepage (cu.m)	27024	4659	10239	4864	23768	21309	60573	28677	94997	27111	40394
" out. for. seepage (cu.m.)	20093	2233	7101	10	42	931	22054	9409	50311	19827	15929
% of 1996 seepage	25%	86%	32%	100%	100%	99%	80%	93%	62%	33%	64%
% of 1996 out. for. seepage	20%	76%	26%	110%	69%	104%	64%	99%	48%	27%	43%
Review seepage	23881	4479	9295	4865	23781	21288	59219	28609	92263	25415	38713
Review streamflow	836188	677308	615764	385536	791209	174275	394486	-7440	964467	433552	490236
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS											
Area planted (km²)	3.48	0.01	0.33	0.33	3.82	0.00	0.24	0.04	4.98	0.77	6.07
Planted/cleared area (%)	0.22	9%	31%	31%	22%	10%	13%	9%	20%	28%	21%
Predicted seepage (cu.m)	246999	4659	10239	15103	290529	21309	60573	28677	496084	27111	563590
" out. for. seepage (cu.m.)	125432	2233	7101	7111	134817	931	22054	9409	217522	19827	253277
% of 1996 seepage	51%	86%	32%	42%	53%	99%	80%	93%	59%	33%	57%
% of 1996 out. for. seepage	35%	76%	26%	26%	35%	104%	64%	99%	41%	27%	39%
Review seepage	238152	4479	9295	14159	280572	21288	59219	28609	481951	25415	546079
Review streamflow	2923164	677308	615764	1001300	5392980	174275	394486	-7440	6918768	433552	7842556

14. Model minimum tree planting for Subcatchments of the Perup Catchments

Subcatchment	**16**	**33**	**34**	**35**	**36**	**37**
Drains to	34	34	36	36	37	
SUMS FOR ISOLATED SUBCATCHMENTS						
Area planted (km²)	1.29	0.32	0.39	0.11	1.49	0.89
Planted/cleared area (%)	0.24	0.20	26%	16%	23%	23%
Predicted seepage (cu.m)	48435	40394	23642	86882	59330	22031
" out. for. seepage (cu.m.)	43944	15929	12869	7696	53196	18268
% of 1996 seepage	33%	64%	45%	93%	35%	22%
% of 1996 out. for. seepage	32%	43%	32%	60%	33%	20%
Review seepage	43156	38713	21521	86470	52331	20050
Review streamflow	472396	490236	574755	337116	838798	1221350
AGGREGATES FOR SUBCATCHMENTS AND ALL UPSTREAM SUBCATCHMENTS						
Area planted (km²)	10.97	6.07	17.43	0.11	19.03	19.91
Planted/cleared area (%)	0.25	0.21	24%	16%	23%	23%
Predicted seepage (cu.m)	905825	563590	1493057	86882	1639269	1661300
" out. for. seepage (cu.m.)	329813	253277	595960	7696	656852	675120
% of 1996 seepage	54%	57%	55%	93%	55%	54%
% of 1996 out. for. seepage	31%	39%	34%	60%	34%	34%
Review seepage	882946	546079	1450546	86470	1589346	1609396
Review streamflow	5697128	7842556	14114439	337116	15290353	16511703

Abbreviations:
out. for. = outside forest

Appendix A
Details of Computing Processes

1. Introduction

The basic process to analyse a catchment was reported in Mauger (1994). That paper showed the major stages of the process and listed the RASCAL maps, which were the principal products of each stage. Since then, there have been changes to the process to incorporate more hydrologic functions, and to improve the computing procedure. The rationale for the changes is included in the report on the Kent River Catchment (Volume 3 in the series of reports on the Clearing Control Catchments). However, due to the extent of the changes, a complete revision of this appendix has been necessary, compared to that published with Volumes 1 and 2 for the Upper Denmark and Wellington Catchments respectively. Reprocessing those catchments with the revised procedure has negligible impact on their results.

This appendix gives details of each stage in the process in a top-down hierarchical style, based on the computing commands and input data files needed to execute the processes using the M.A.G.I.C. system.

Most of the files used in the modelling process are the same for both Tone catchments as well as the Perup catchment. Therefore, just one of these, the Tone above Tonebridge catchment, was used as an example throughout the appendix. Where the Tone below Tonebridge and Perup catchments differ from this one, the different files are included.

2. Conventions

The following typographical conventions are used within this appendix:

- User inputs of a definite form in **BOLD** + **CAPITALS** or **lowercase.**
- User inputs of a variable form in *CAPITALS* + *ITALICS*.
- Output from computer in `Courier` font.

User inputs that are program, command and file names are in capitals. File names are identified by having an extension (eg EXAMPLE.TXT).

Files with extensions ".IN" are used as a substitute for console input when programs are run from batch files or when otherwise convenient .

Section numbers in [ ] show where more instructions or contents of data files are to be found within this appendix. In sections giving contents of files, '[ ]' references and comments in normal type on the same lines as computer inputs are not included in the actual file contents.

In the M.A.G.I.C. system, the command HOW *TOPIC* writes text to the computer screen which gives background information and details of how to use *TOPIC*. To follow up references made in this appendix, the user will need access to a copy of the MAGIC system.

A map numbering convention has been established to give some structure to the storage of maps in the RASCAL projects, and to enable command files to work on any project without the need to modify map numbers. Table A1 shows the categories of maps, and Table A2 shows a normal assignment of maps to map numbers.

Table A1: Map categories

Map number range	Map category	Notes
1-100	Raw data	Stored in project from external source
101-200	Derived data	Basic data computed from raw data or derived data
201-300	Catchment model	Result maps of shallow and deep groundwater modelling
301-400	Planting prediction	Result maps of predicting tree planting
401-510	Scratch maps	Maps only needed temporarily while modelling

Table A2: Map number assignments

Raw Data	Derived data	Catchment Model	Planting Prediction	Scratch Maps
1 TM BAND 1 2 TM BAND 2 3 TM BAND 3 4 TM BAND 4 5 TM BAND 5 6 TM BAND 6 7 TM BAND 7 8 9 10 11 RAINFALL 12 PAN EVAPORATION 13 : 20 21 ELEVATION 22 LAKE=10 23 SOIL TYPE 24 25 26 FARM PROPERTIES 27 28 29 30 DIGITISED CLEARING 31 32 ,33 PLANNED PERENNIAL PASTURE 34 : 49 50 GAUGING LOCATIONS 51 : 54 55 PLANNED PLANTING 56 100	101 102 ASPECT 103 PLAN CURVATURE 104 SLOPE CURVATURE 105 DRAIN REDUCED SLOPE 106 107 SLOPE 108 : 115 LAKE=0, OTHER=1 116 DRAINAGE DIRECTIONS 117 DISPERSED DRAINAGE 118 119 NOS OF CELLS 120 GREENNESS 121 122 123 GREENNESS > 0 124 FULL PASTURE LAI=2.7 125 NEGLIGIBLE PASTURE UPSTREAM = 1 126 : 129 130 SMOOTHED INFIL RATE 131 : 149 150 CATCHMENTS 151 : 200	201 CUMULATIVE RUN-OFF 202 TOTAL PASTURE ET 203 STREAMFLOW 204 MINIMUM SHALLOW+DEEP STORE 205 STORAGE LOSS 206 FINAL SHALLOW STORAGE 207 FINAL DEEP STORE 208 : 210 211 NET RECHARGE 212 FINAL DEEP DRAINAGE 213 THROUGHFLOW 214 SURPLUS RECHARGE 215 SMOOTHED SEEPAGE VOLUME 216 SMOOTHED DEEP DISCHARGE 217 SMOOTHED THROUGHFLOW 218 SMOOTHED SURPLUS RECHARGE 219 SEEPAGE AREA [*MAPS 201-219 ARE SAVED RESULTS FROM INITIAL ANALYSIS*] 220 : 240 241 CUMULATIVE RUN-OFF 242 TOTAL PASTURE ET 243 STREAMFLOW 244 MINIMUM SHALLOW+DEEP STORE 245 STORAGE LOSS 246 FINAL SHALLOW STORAGE 247 FINAL DEEP STORE 248 : 250 251 NET RECHARGE 252 FINAL DEEP DRAINAGE 253 THROUGHFLOW 254 SURPLUS RECHARGE 255 SMOOTHED SEEPAGE VOLUME 256 SMOOTHED DEEP DISCHARGE 257 SMOOTHED THROUGHFLOW 258 SMOOTHED SURPLUS RECHARGE 259 SEEPAGE AREA [*MAPS 241-259 ARE RESULTS FROM LAST ANALYSIS*] 260 : 300	301 302 303 TREE GREENNESS FOR CURRENT MODEL 304 ANNUAL PASTURE FOR CURRENT MODEL 305 : 330 331 DEEP G/W DRAWN BY PLANTED TREES 332 PLANTED DISCHARGE 333 PLANTED TREE GREENNESS 334 335 % PLANTING OVER NATIVE DENSITY 336 : 400	401 : 409 410 POSSIBLE PASTURE OVERDRAW 411 412 CURRENT SHALLOW STORE 413 RUN-OFF 414 INFILTRATION 415 : 419 420 CURRENT DEEP STORE 421 CURRENT PASTURE ET, OR ASEARCH CELL COUNT 422 SURPLUS DEEP STORE 423 NET RECHARGE TO DEEP STORE 424 REQUIRED DEEP DRAINAGE 425 : 435 436 ANNUAL TREE TRANSPIRATION (MM) 437 438 PERENNIAL PASTURE TRANSPIRATION (MM) 439 PASTURE MAX. TRANSPIRATION (MM) 440 INITIAL STORAGE LOSS 441 CURRENT DEEP STORE, NET RECHARGE TO DEEP G/W 442 POTENTIAL RECHARGE & DISCHARGE 443 : 446 447 FINAL +VE DEEP DRAINAGE 448 449 INTEGRATED STORAGE LOSS 450 : 510

3. Major stages of analysis

3.1 CONVERT RAW DATA TO EQUIVALENT MAPS IN A RASCAL PROJECT

A.PREPARE RASCAL PROJECTS TO RECEIVE DATA

RASCAL < RASCAL.IN	[5.1]	Create a series of 4 RASCAL projects to hold basic maps of TM data and ground elevation. Also create a low resolution project (cell side length = 200m) that covers the whole catchment to hold maps of annual rainfall and pan evaporation.

B.GENERATE DATA BY INTERPOLATION BETWEEN LINES OF EQUAL VALUE

Used to create elevation from contours, annual rainfall from isohyets, and pan evaporation from annual isopleths. Using elevation as the example:

USTATION	[5.2]	Identify contours in design file and export contours to text file
GRIDSF < GRIDSF.IN	[5.3]	Generate elevations in grid cells
RASCAL < STORE.IN	[5.4]	Import elevations to RASCAL project

C. GENERATE GRIDDED THEMATIC MAPS FROM DIGITISED POLYGONS

Used to define areas planned for treatment in farm plans, lakes, and mapping of soil types (soil type data has not been used in the project to date).

USTATION	[5.2]	Prepare data in polygon form and export polygons to text file
LISTIN < LISTIN.IN	[5.5]	Import polygons to POLYANA file format
LNKEND < LNKEND.IN	[5.6]	Join lines into polygons if a polygon is represented by more than 1 line
POL2RAS < POL2RAS.IN	[5.7]	Generate gridded thematic maps in RASCAL project

D. LOAD LANDSAT THEMATIC MAPPER DATA FROM BULK SOURCE

LSDEX < LSDEX.IN	[5.8]	Extract TM bands from bulk TM data
RASCAL < STORETM.IN	[5.9]	Import TM data into RASCAL project

3.2 COMPUTE MAPS REQUIRED AS INPUT TO THE HYDROLOGIC MODEL

A. PREPARE BASE MAPS

PREMODEL TONEALL/	[6.1]	Determine vegetation from TM data in base projects Repeat for each of 4 base projects.

B. PREPARE SUB-CATCHMENT PROJECTS

B. PREPARE SUB-CATCHMENT PROJECTS

Generation of drainage data is best done on relatively small areas due to the search for drainage outlets when sinks are identified. The small areas are complete subcatchments that will be used to report results of modelling, generally having areas of about 30 sq. km. Before the drainage is analysed, boundaries of subcatchments will only be known approximately by inspecting contour data. The recommended process described here is to create an over-sized RASCAL project for each subcatchment so that the boundary will not fall outside the project limits. After the boundary has been defined by analysis, a smaller project that fully contains the subcatchment can be specified. The smaller project is created and all the maps from the larger project copied to it so that surplus computing in the modelling process will be minimised. If the subcatchment mapped in the larger project lies within 2 cells of the project boundary at any point, the subcatchment could actually extend beyond the project. In such cases, the process should be repeated using a new project with more clearance on that side.

RASCAL < RASCAL.IN	[5.1]	Create a RASCAL project for each subcatchment that has generous margins around the actual subcatchment boundary
LOADSC	[6.2]	Load base maps from projects with basic maps into subcatchment projects
INIT *TONE1*	[6.3]	Batch run to prepare initial maps for each subcatchment project
SEERAS *TONE1*	[6.4]	Manually edit blank map to define outlets of subcatchments
RASCAL < CATCH.IN	[6.5]	Generate subcatchment map from drainage data and outlet position
RASCAL < TRIM.IN	[6.6]	Mark cells outside catchment to limit drainage integration
SEERAS *TONE1*	[6.4]	View the generated catchment (map 150) and note the limits of a project that has a narrow margin (1 or 2 cells) around the subcatchment
RASCAL < RASCAL.IN	[5.1]	Create a RASCAL project for each subcatchment using the limits noted in the previous step

At this stage, each subcatchment project contains the following maps:

3 TM BAND 3
4 TM BAND 4
5 TM BAND 5
11 RAINFALL
12 PAN EVAPORATION
21 ELEVATION
22 LAKE=10
50 GAUGING LOCATIONS
102 ASPECT
103 PLAN CURVATURE
104 SLOPE CURVATURE
105 DRAIN REDUCED SLOPE
107 SLOPE
115 LAKE=0, OTHER=1
116 DRAINAGE DIRECTIONS
117 DISPERSED DRAINAGE
119 NOS OF CELLS
120 11,90,40,12,13,7,40,43,127,131,130,220
123 GREENNESS > 0
124 FULL PASTURE LAI=2.1
125 NEGLIGIBLE PASTURE UPSTREAM = 1
130 SMOOTHED INFIL RATE
150 CATCHMENTS

[Map 120 is GREENNESS based on values of TM bands 3,4,5 shown in title for pure components of greenness(11,90,40), shade(12,13,7), dead pasture(40,43,127) and bare soil(131,130,220)]

3.3 PERFORM HYDROLOGIC MODELLING ON EACH SUBCATCHMENT

To automate the processing of all subcatchments, the batch file RUNRUN.BAT combines the functions of initial modelling, planting and reviewing [7.2, 7.3, 7.4]. It includes labelling output files with the subcatchment id number, and compressing the RASCAL projects to remove scratch maps and archive the final files. RUNRUN processes one subcatchment whose id no. is the parameter. A higher level batch file, RUNALL.BAT, runs RUNRUN for all subcatchments.

RUNALL	[7.1]	Execute RUNRUN

3.4 PREPARE DATA FOR PRESENTATION OF OUTPUT

A. CLASSIFY RASTER MAPS

RASCAL < CLASS.IN	[8.1]	Generate maps of: • 3 rates of seepage (10, 20 & 50 cu.m/yr) • Native forest and scattered trees • Proposed sites for planted trees • Major streams

B. CONVERT RASTER MAPS TO POLYGONS FOR PRESENTATION IN MICROSTATION

RASCAL < *MAP.IN*	[8.2]	Generate output files of polygon coordinates
USTATION	[8.3]	Import polygons to design file as linework, generate polygons, pattern the polygons, and plot maps of results.

C. OUTPUT DATA FOR TABLES [8.4]

TABLALL	[8.4.1]	Collect data from output files from hydrological modelling and summarize into text files.
DATAIN	[8.4.2]	Read summarized text files into EXCEL spreadsheets.
PRINTALL	[8.4.3]	Print EXCEL spreadsheets.

4. Flow of map generation in Rascal Projects

The following table summarises the maps required as input and the maps produced as output for the processes involving RASCAL projects:

Input Maps	Process	Ref	Output Maps
	Interpolate from isolines		
	USTATION	[5.2]	11 Rainfall
	GRIDSF	[5.3]	12 Pan Evaporation
	STORE	[5.4]	21 Elevation
	Grid polygon themes		
	USTATION	[5.2]	22 Lakes
	LISTIN	[5.5]	
	LNKEND	[5.6]	
	POL2RAS	[5.7]	
	Load Landsat TM data		
	LSDEX	[5.8]	3 TM Band 3
	STORE	[5.9]	4 TM Band 4
			5 TM Band 5
	Prepare base maps		
	PREMODEL	[6.1]	
3 TM Band 3 4 TM Band 4 5 TM Band 5	**GREEN96**	[6.1.1]	120 Greenness labelled by coords of pure components, i.e. 11 90 40, 12 13 7, 40 43 127, 131 130 220
4 TM Band 4 5 TM Band 5 11 Rainfall 12 Pan Evaporation 120 Greenness	**GRNWAR96**	[6.1.2]	303 Green > 0 304 Full Pasture LAI = 2.1
	Prepare subcatchments		
	INIT	[6.3]	
21 Elevation	TERRAIN	[6.3.1]	102 Aspect 103 Plan Curvature 105 Slope
21 Elevation 102 Aspect	**DRAIN**	[6.3.2]	116 Drainage Directions
102 Aspect 103 Plan Curvature 116 Drainage Directions	**DISPER**	[6.3.3]	117 Dispersed Drainage
105 Slope 116 Drainage Directions 117 Dispersed Drainage	**INFRATE**	[6.3.4]	130 Smoothed Infiltration Rate 107 Actual Slope 105 Drain Reduced Slope
116 Drainage Directions	**INTDRA**	[6.3.5]	119 Drain Integral of Nos of Cells
116 Drainage Directions 304 Full Pasture LAI = 2.1	**RELG**	[6.3.6]	125 Negligible Pasture Upstream = 1

Input Maps	Process	Ref	Output Maps
	BLANK	[6.3.7]	50 Blank Map for Gauging Locations
	SEERAS	[6.4]	50 Gauging Locations
116 Drainage Directions 50 Gauging Locations	**CATCH**	[6.5]	150 Catchments
116 Drainage Directions 117 Dispersed Drainage 150 Catchments	**TRIM**	[6.6]	116 Drainage Directions 117 Dispersed Drainage
	Hydrologic modelling **GWMODEL**	[7.1]	
As Above	**GRNWAR96**	[6.1.2]	As Above
11 Rainfall 12 Pan Evaporation 105 Drain Reduced Slope 116 Drainage Directions 117 Dispersed Drainage 150 Catchments 303 Green > 0 304 Full Pasture LAI=2.1	**GWMLYS**	[7.2.1]	253 Deep Throughflow 254 Surplus Recharge to deep 411 Rain Minus ET 412 Final Shallow Storage 413 Run-off 414 Infiltration to Deep in Month 421 Pasture ET in Month 436 Annual Tree Transpiration 439 Pasture Max. Transpiration 441 Net Recharge to Deep 442 Potential Recharge, Discharge
As for GWMLYS Plus: 412 Final Shallow Storage 436 Annual Tree Transp. 439 Pasture Max. Transp. 442 Deep Recharge,	**GWMLY2**	[7.2.2]	As for GWMLYS Plus: 241 Run-off adjusted for Lakes 242 Total Pasture ET 243 Streamflow 244 Minimum Storage 245 Storage Loss 251 Total Net Recharge to Deep 252 Final Deep Drainage 420 Current Deep Store 422 Surplus Deep Store 423 Net Recharge in Month 440 Initial Storage Loss 447 Final +ve Deep Drainage 449 Integrated Storage Loss
As for GWMLY2	**GWMLY3**	[7.2.3]	As for GWMLYS Plus: 246 Final Shallow Store 247 Final Deep Store
252 Final Deep Drainage 253 Deep Throughflow 254 Surplus Recharge to deep	**SMDISCH**	[7.2.4]	255 Smoothed Seepage Volume 256 Smoothed Deep Discharge 257 Smoothed Throughflow 258 Smoothed Surplus Recharge 259 Seepage area

Input Maps	Process	Ref	Output Maps
241 Run-off adj. for Lakes	**SAVORIG**	[7.2.5]	201 Run-off adj. for Lakes
242 Total Pasture ET			202 Total Pasture ET
243 Streamflow			203 Streamflow
244 Minimum Storage			204 Minimum Storage
245 Storage Loss			205 Storage Loss
251 Total Net Rech. to Deep			211 Total Net Rech. to Deep
252 Final Deep Drainage			212 Final Deep Drainage
253 Deep Throughflow			213 Deep Throughflow
254 Surplus Recharge to deep			214 Surplus Recharge to deep
255 Smoothed Seepage Vol.			215 Smoothed Seepage Vol.
256 Smoothed Deep Disch.			216 Smoothed Deep Disch.
257 Smoothed Throughflow			217 Smoothed Throughflow
258 Smoothed Surplus Rech.e			218 Smoothed Surplus Rech.e
303 Green > 0			123 Green > 0
304 Full Pasture LAI=2.1			124 Full Pasture LAI=2.1
11 Rainfall	**PLANT**	[7.3]	331 Deep G/W Drawn by Planted Trees
12 Pan Evaporation			332 Smoothed Planted Discharge
105 Drain Reduced Slope			333 Planted Tree Greenness
117 Dispersed Drainage			421 Planted Tree Criterion
123 Green > 0			
124 Full Pasture LAI=2.1			
125 Neg. Past. U/s = 1			
201 Run-off adj. for Lakes			
202 Total Pasture ET			
212 Final Deep Drainage			
213 Deep Throughflow			
214 Surplus Recharge to deep			
216 Smoothed Deep Disch.			
	REVIEW	[7.4]	
123 Green > 0	**NEWPAST**	[7.4.1]	303 Green > 0
124 Full Pasture LAI=2.1			304 Full Pasture LAI=2.1
333 Planted Tree Greenness			
As Above	**GWMLYS**	[7.2.1]	As Above
	GWMLY2	[7.2.2]	
	GWMLY3	[7.2.3]	
	SMDISCH	[7.2.4]	
	Make maps for plotting		
119 Drain Int. of Nos of Cells	**CLASS**	[8.1]	425 Classed Seepage Rates
123 Green > 0	MAP		
227 Smoothed Deep Disch.	USTATION	[8.2]	426 Original Tree Cover
333 Planted Tree Greenness		[8.3]	427 Proposed Sites for Planting
			428 Streams with Catch. > 100ha

5. Convert raw data to equivalent maps in a Rascal Project

5.1 RASCAL.IN — INPUT FILE TO CREATE RASCAL PROJECT

TONEALL1
Y
462500 6207975 830 1050 25
N

Defines the location and size of the project named 'TONEALL1'. [ref HOW RASCAL]. Vary name and data for other projects.

5.2 USTATION - EXPORT DIGITISED LINES REQUIRED FOR GRIDDING

Open the MicroStation design file containing the data which is to be gridded. Discern at which level the lines are currently residing by using the 'ANALYSE' function. When the gridding is to be interpolation between lines such as contours, then it may be more efficient to export the required region to a new design file first, if the region to be gridded is only a small subset of the contours. It should be noted that an edge strip should be allowed beyond the immediate gridding region such that at least two contours are cut when crossing the strip at any location.

Special functions have been developed by the Computer Services Section of the Water Resources Directorate for use within MicroStation. The functions are referred to as MDL's because they are written in the MicroStation Development Language.

Use the Polygon Utility MDL DGN2ASC to export the lines into the text format which can be read by M.A.G.I.C. programs. The text format is described in HOW LISTIN. Before executing DGN2ASC, make sure contours are either in a 3D design file or have been 'tagged' with the ground level using the MDL TAGGING. Polygons must be 'tagged' with a value which represents the theme that is mapped by the polygon.

5.3 GRIDSF.IN

GRID.DAT	[5.3.1]	
OUT.PRN		File for messages generated by program
EXAMPLE.TXT		*File exported from MicroStation design file*
EXAMPLE.GRD		*Output file for input to RASCAL project*
Y		

For further details of running program refer to manual [ref HOW GRIDSF]

5.3.1 CONTENTS OF GRID.DAT

METHOD,ICONTR,RADIUS,QUAD,EDGE	
2 0 .F. .T. *1300*	Consider data within 1300m of gridding area
NWX,NWY,WCS,NPTGL,NPTGQ	
0 0 *7000* 6 10	Set basic 'window' over gridding point to 7000m
FMT, SING,SURF,WIND	
'(2F10.0,F10.4)' .F. .F. 0	Set output format and options for program reports
200 800	
463512.5 6227987.5 468487.5 6227987.5	
468487.5 6208012.5 463512.5 6208012.5	

The last 3 lines define centers of cells for gridding positions in GRIDL1. See "Quad Option" in HOW GRIDSF. Two numbers on 3rd last line are number of columns and rows respectively. Sequence of corner coordinates must be NW, NE, SE, SW to generate rows scanning West to East from North to South. Computed values of -99 indicate failure to calculate elevation, possibly due to lack of data in the vicinity. More data may be made available by increasing the EDGE value (1300 in above example). Increasing the window size (WCS) may solve the problem in some situations. Refer [HOW GRIDSF] for further information.

5.4 CONTENTS OF STORE.IN

TONEALL1		RASCAL project to receive data
STORE.DAT	[5.4.1]	
OUT.PRN		File for messages generated by program
Y		Extra data file to be nominated
EXAMPLE.GRD	[5.3]	Name of extra data file
Y		Update default filenames

Imports the list of gridded values into the RASCAL project 'TONETM1'.

5.4.1 CONTENTS OF STORE.DAT

*21*STORER4	1	*ELEVATION*
(20X,F10.0)		
END		

Specifies that the gridded data is to be stored in map 21 as 4-byte Real values. The input data has '20x,F10.0' format and is located in a separate file. Refer [HOW STORE] for further information.

5.5 CONTENTS OF LISTIN.IN

WARLAKE.ASC	Text format file created by DGN2ASC
WARLAKE.PAN	POLYANA file of same data
OUT.PRN	File for messages generated by program
Y	Update default filenames

Refer HOW LISTIN.

5.6 CONTENTS OF LNKEND.IN

WARLAKE.PAN	Input POLYANA file
WARLAKEL.PAN	Output POLYANA file
N	All records processed
5000	Consider joining if distance between ends<5000m
Y	Update default filenames

Example taking output of [5.5] and generating new, linked file WARLAKEL.PAN. Refer HOW LNKEND.

5.7 CONTENTS OF POL2RAS.IN

P	Gridding polygons
WARLAKEL.PAN	Input POLYANA file
TONEALL1	Receiving RASCAL project
OUT.PRN	File for messages
22	Map no. for output
LAKE = 10	Title of output map
I2	Data type of output map
99	Map no. for recording irregular results
ERROR MAP	Title of map " " "
I2	Data type of map " " "
N	All polygons to be gridded
N	No more selection criteria
Y	Update default filenames

Refer HOW POL2RAS for more information.

5.8 CONTENTS OF LSDEX.IN

EXAMPLE.TM	TM data source file
EXAMPLE	Name for output data files
4000 25 4096 24.91	Size of source data
6200000 450000 7	Location of NW corner, # of bands of source
3 3 4 5	# of bands to output, list of band nos to output
6162000 6183000 492000 512000	Bounds of area to output
25 25	Cell dimensions in output
Y	Update default filenames

The above is an example of LSDEX.IN contents. The actual file contents depends on the source of TM data. Program LSDEX may need to be run on different computers which can use the hardware which stores the TM data, e.g. magnetic tapes or cartridges. Program modifications may be needed to do this. Output files would then be transferred to the PC running RASCAL.

Output data is a separate file for each band at the specified spatial extent and resolution. The names of the files have extensions .LSn where 'n' is the band numbers. The above example would generate 3 output files: EXAMPLE.LS3, EXAMPLE.LS4 and EXAMPLE.LS5. Refer to [HOW LSDEX] for further information.

5.9 STORETM.IN

EXAMPLE		RASCAL project name
STORETM.DAT	[5.9.1]	
OUT.PRN		File for messages
Y		Extra data file to be given
EXAMPLE.LS3	[5.8]	File generated by LSDEX
Y		Update default filenames

5.9.1 STORETM.DAT

*3*STORE	2	*TM BAND 3*
END		

Imports the Thematic mapping data from the file 'EXAMPLE.LS3' into the project "EXAMPLE'. Refer [HOW STORE] for further information.

6. Compute maps required as input to the hydrologic model

6.1 CONTENTS OF PREMODEL.BAT

```
CALL PMIN GREEN96.DAT DUMMY %1      [6.1.1]  Make greenness from Warren TM data
RASCAL < PMIN.DAT                   [6.1.3]
CALL PMIN GRNWAR96.DAT DUMMY %1     [6.1.2]  Interpret tree greenness and pasture LAI
RASCAL < PMIN.DAT
```

'CALL PMIN' will execute the batch file PMIN.BAT [6.1.3] which contains the commands used to generate a file called 'PMIN.DAT' [6.1.3.1] containing appropriate keyboard responses to run RASCAL. The file 'PMIN.DAT' is used as input to RASCAL on the subsequent line ('RASCAL < PMIN.DAT'). Parameter DUMMY has no effect in these RASCAL runs.

6.1.1 CONTENTS OF GREEN96.DAT

```
120EXPR R4                    11 90 40,12 13 7,40 43 127,131 130 220
100/(((13-43)*(7-220)-(7-127)*(13-130))*(11-12) :
   +((7-127)*(12-131)-(12-40)*(7-220))*(90-13) : GREEN PT TO PLANE
   +((12-40)*(13-130)-(13-43)*(12-131))*(40-7)) :
*(((13-43)*(7-220)-(7-127)*(13-130))*(M3-12) :
  +((7-127)*(12-131)-(12-40)*(7-220))*(M4-13) : DATA PT TO PLANE
  +((12-40)*(13-130)-(13-43)*(12-131))*(M5-7))
  END
```

Generates the greenness map. Map title records values of TM data in Bands 3, 4 and 5 corresponding to pure green leaf, shade, dead vegetation and bare soil respectively. Formula computes % of green leaf in cell assumed to contain a mixture of these components. Refer (Mauger 1994).

Refer [HOW EXPR] for details about writing an expression.

6.1.2 CONTENTS OF GRNWAR96 .DAT

```
303EXPR R4                    GREEN > 0
IF(M4<35*.6+8.4 | M120<6.5 | M5>140,0, : WATER, PASTURE OR CLAY
M120 : NATIVE VEGETATION
)
304EXPR R4                    FULL PASTURE LAI = 2.1
IF(M4<35*.6+8.4 | M5<115*.71+3 | M120<-10 ,0, : WATER OR CLAY
: PASTURE LAI=2.1 WITH NO TREES
2.1*(1 - M303 / (.0087*M11-.0051*M12+35.85)): COMBINATION OF PASTURE AND TREES
)
304EXPR R4                    FULL PASTURE LAI = 2.1
IF(M304<0,0,M304)
  END
```

Generates the greenness > 0 of native vegetation, and the peak leaf area index of pasture.

6.1.3 CONTENTS OF PMIN.BAT

```
ECHO %3 > PMIN.DAT
ECHO %1 >> PMIN.DAT
ECHO OUT.PRN >> PMIN.DAT
ECHO Y >> PMIN.DAT
ECHO %2 >> PMIN.DAT
ECHO Y >> PMIN.DAT
```

Parameter %1 is the name of the RASCAL input command file. %2 is the name of the extra data file for RASCAL. If none of the commands in the command file use an extra data file, the name used is immaterial. %3 is the name of the RASCAL project (i.e. name of file without extension .RAS).

6.2 CONTENTS OF LOADSC.BAT

CALL COPYBASE TONE1	Load maps into subcatchment project TONE1

Repeat this line in file LOADSC.BAT, changing the number in the subcatchment project name each time, so that the command is performed on every subcatchment.

6.2.1 CONTENTS OF COPYBASE.BAT

CALL COPYIN %1 TONEALL1	Prepare input file for COPYRAS, to copy from the
COPYRAS < COPYRAS.IN	first 'base project'. Then execute COPYRAS.
CALL COPYIN %1 TONEALL2	Repeat for each base project, including low resolution
COPYRAS < COPYRAS.IN	project
CALL COPYIN %1 TONEALL3	
COPYRAS < COPYRAS.IN	
CALL COPYIN %1 TONEALL4	
COPYRAS < COPYRAS.IN	

6.2.1.1 CONTENTS OF COPYIN.BAT

ECHO %2 > COPYRAS.IN	Donor project name
ECHO %1 >> COPYRAS.IN	Project receiving maps
ECHO OUT.PRN >> COPYRAS.IN	Output file for messages
ECHO N >> COPYRAS.IN	Take value of 'nearest neighbour' cell
ECHO ALL >> COPYRAS.IN	Copy to whole area of receiving maps
ECHO 1 200 >> COPYRAS.IN	Copy maps numbered 1 through to 200
ECHO 1 >> COPYRAS.IN	Map numbers of copies to start at 1
ECHO 2 1 >> COPYRAS.IN	No more ranges of map numbers to copy
ECHO Y >> COPYRAS.IN	Update default file names from this run

Refer [HOW COPYRAS] for details of running program COPYRAS.

6.3 CONTENTS OF INIT.BAT

CALL PMIN TERRAIN.DAT *DUMMY* %1	[6.3.1] Make slope etc from elevation
RASCAL < PMIN.DAT	
CALL PMIN DRAIN.DAT *DUMMY* %1	[6.3.2] Make simple, sink-free drainage directions
RASCAL < PMIN.DAT	
CALL PMIN DISPER.DAT *DUMMY* %1	[6.3.3] Make dispersed drainage codes
RASCAL < PMIN.DAT	
CALL PMIN INFRATE.DAT *DUMMY* %1	[6.3.4] Infiltration rate to bottom soil layer
RASCAL < PMIN.DAT	
CALL PMIN INTDRA.DAT *DUMMY* %1	[6.3.5] # cells in catchment from simple drainage
RASCAL < PMIN.DAT	
CALL PMIN RELG.DAT *DUMMY* %1	[6.3.6] Cells with negligible upstream clearing
RASCAL < PMIN.DAT	
CALL PMIN BLANK.DAT *DUMMY* %1	[6.3.7] Make blank map for catchment outlets
RASCAL < PMIN.DAT	

'CALL PMIN' will execute the batch file PMIN.BAT [6.1.3]

6.3.1 CONTENTS OF TERRAIN.DAT

*21*TERRAR4*105102103*
 END

Generates slopes, aspect and plan curvature. Refer [HOW TERRA] for further information.

6.3.2 CONTENTS OF DRAIN.DAT

*117*DRAINI2*116*
 21 102
 END

Generates drainage (116) and trace (117) maps. Refer [HOW DRAIN] for further information.

6.3.3 CONTENTS OF DISPER.DAT

```
117DISPEI2102103116
  END
```

Generates dispersed drainage map (117). Overwrites trace map from DRAIN which is not needed. Refer [HOW DISPER] for more explanation.

6.3.4 CONTENTS OF INFRATE.DAT

```
:Start by putting the original slope map in map 107 so that modified map can be stored in map 105
105SWAP   107
: Add 'water' in excess of saturation
130EXPR                                    INITIAL CELL STATE
  1000
: Allow flow as per shallow groundwater
: (hence answer depends on soil values of permeability, depth, porosity)
: Aspect map 102 in INTDR command invokes slope modification, storing results in map 105
130INTDRR4130117107      11102105
30 .2  0  0  0  0
: subtract original vol. (+= convergence, -=divergence)
130EXPR R4                                 FLOW CONVERGENCE
  M130-1000
: apply regression found from net recharge under native forest
130EXPR R4                                 INFIL RATE EX CONVERGENCE
  18-.63*M130
: average result over adjacent cells
130ASEARR4130     421                      SUMMED INFIL RATE EX CONVERG
130EXPR R4                                 SMOOTHED INFIL RATE EX CONVERG
  M130/M421
: set any negative values to zero
130EXPR R4                                 SMOOTHED INFIL RATE EX CONVERG
  IF(M130<0,0,M130)
  END
```

Generates a map containing cell infiltration rates calculated using balanced infiltration rates and convergence.

6.3.5 CONTENTS OF INTDRA.DAT

```
119INTDRI4   116
   END
```

Generates map (119) of nos. of cells integrated along drainage paths. Each cell thus contains a number equal to the catchment area draining to that cell, in units of nos. of cells. Refer [HOW INTDRA] for more explanation.

6.3.6 CONTENTS OF RELG.DAT

```
125INTDRI4304116                           clearing in path
125EXPR                                    NEGLIGIBLE PASTURE UPSTREAM = 1
: cleared area = M125/LAI. If clearing <~2% of total area, mark as neg. u/s pasture
IF( M125<M119*.05, 1,0)
  END
```

6.3.7 CONTENTS OF BLANK.DAT

```
50EXPR                              GAUGING LOCATIONS
0
   END
```

Sets all cell values in map 50 to zero.

6.4 USE OF SEERAS FOR MANUAL MAP EDITING AND VIEWING

SEERAS is the program which displays maps from a RASCAL project on the computer screen. For its operation, refer [HOW SEERAS].

To generate maps of catchment areas, one cell at the outlet of each catchment needs to be given a value which identifies the catchment. If the outlet is a gauging station, its coordinates may be known, and when the map is displayed, the cursor could be placed at those coordinates. However it is essential that the cell chosen is one through which all drainage paths from within the catchment will pass. Such cells are easiest identified by displaying the map of integrated numbers of cells (map 119) [6.3.5] which looks like a drainage network. Consequently, to set the outlet cell values, display map 119 and the blank map 50 [6.3.8] together. Locate the cell closest to the desired coordinates which is also on the main drainage path. Then change the value of that cell in map 50. Saving the changes in map 50 creates the map required as input to catchment area generation [6.5].

To define a smaller rectangular area to be used as the border of a new project, first ensure the display of the map showing features to guide the area is zoomed 'in' (i.e. press 'I'). Then move the cursor to the row or column that will form the new border. Note that the coordinate shown in the detail panel is the cell centre. When creating the new project with RASCAL, the outside edge of the southwest cell must be given, i.e. half a cell width to the south and west. RASCAL also asks for the number of rows and columns in the project. These numbers must be calculated from the coordinates of the northen and eastern extremities.

6.5 CONTENTS OF CATCH.IN

CALL PMIN CATCH.DAT *DUMMY* %1 RASCAL < PMIN.DAT	[6.5.1]	Catchment map generation

'CALL PMIN' will execute the batch file PMIN.BAT [6.1.3]

6.5.1 CONTENTS OF CATCH.DAT

*50*CATCH 116 50	*CATCHMENTS*
END	

Generates catchment map. Refer [HOW CATCH] for further information.

6.6 CONTENTS OF TRIM.IN

CALL PMIN TRIM.DAT *DUMMY* %1 RASCAL < PMIN.DAT	[6.6.1]	Mark cells outside catchment to limit drainage integration

6.6.1 CONTENTS OF TRIM.DAT

116EXPR	DRAINAGE DIRN TRIMMED
IF(M150>0,M116,-99)	
117EXPR	DISP DRAINAGE TRIMMED
IF(M150>0,M117,-99)	
END	

7. Hydrologic modelling

7.1 CONTENTS OF RUNALL.BAT

CALL RUNRUN 01	[7.1.1]	Repeat this line in RUNALL.BAT, changing the subcatchment id no. for all subcatchments to be run.

7.1.1 CONTENTS OF RUNRUN.BAT

CALL GWML TONE %1	[7.2]	Perform modelling, renaming and COMPRAS
COPY *.Y? RESULTS		Archive output files,
COPY *.SM RESULTS		
COPY *.OVR RESULTS		
DEL *.Y?		Delete redundant files
DEL *.SM		
DEL *.OVR		
DEL TONE%1.MAP		
DEL TONE%1.RAS		
PKZIP TONE1%1 TONE1%1.*		
PKZIP2EXE TONE1%1		
DEL TONE1%1.MAP		
DEL TONE1%1.RAS		
DEL TONE1%1.ZIP		

7.2 CONTENTS OF GWML.BAT

CALL PMIN GRNWAR96.DAT DUMMY %1	[6.1.2]	Native forest and pasture density
RASCAL < PMIN.DAT		(needed if changing pasture LAI)
CALL PMIN GWMLYS.DAT DUMMY %1	[7.2.1]	Start all cells saturated, simulate 1
RASCAL < PMIN.DAT		year to get initial cell soil moisture & estimate net recharge to deep
CALL PMIN GWMLY2.DAT DUMMY %1	[7.2.2]	Simulate 1 year with deep g/w
RASCAL < PMIN.DAT		flow to improve initial moistureand net recharge estimates
CALL PMIN GWMLY3.DAT DUMMY %1	[7.2.3]	Simulate final year to estimate
RASCAL < PMIN.DAT		deep g/w discharge & streamflow
CALL PMIN SMDISCH.DAT DUMMY %1	[7.2.4]	'Smooth' deep g/w output maps
RASCAL < PMIN.DAT		
CALL PMIN SAVORIG.DAT DUMMY %1	[7.2.5]	Save output maps from simulations
RASCAL < PMIN.DAT		
CALL PMIN PLANT.DAT Y2.OUT %1%2	[7.3]	Nominate tree planting to meet
RASCAL < PMIN.DAT		deep groundwater use criteria
COPY ??.Y? ??BS%2.Y?		Rename OVROUT output files to
COPY ??.SM ??BS%2.SM		include subcatchment id no.
COPY ??.OVR ??BS%2.OVR		
CALL REVIEW %1%2	[7.4]	Batch run to review modelling after nominated tree planting
COPY ??.Y? ??TR%2.Y?		
COPY ??.SM ??TR%2.SM		
CALL COMPRIN %1 %2	[7.5]	Eliminate scratch maps
COMPRAS < COMPRIN.DAT		(map no.>400)

Refer to section [6.1.3] for explanation of 'CALL PMIN'. Parameter %1 is name of project for a subcatchment.

7.2.1 CONTENTS OF GWMLYS.DAT

```
:RUN SHALLOW GROUNDWATER SIMULATION FOR 12 MONTHS AS A PRELIMINARY
:ANALYSIS TO GET ESTIMATE OF INITIAL WATER STORAGE FOR PROJECTS
:WHICH CONTAIN LAKES.
SET CELLSIZE 25
SET FACTOR CELLSIZE^2/625
SET DRY 20*FACTOR
SET DEPTH 1.5
SET K 30
SET POROSITY .2
SET WATERST POROSITY*DEPTH*CELLSIZE^2
:304COPY   124
```

```
:303COPY   123
:Convert pan evap and LAI to transpiration. PAN/LEAF = .352
439EXPR R4                       PASTURE MAX. TRANSPIRATION(MM)
  .352*M12*M304
436EXPR R4                       ANNUAL TREE TRANSPIRATION (MM)
: NET RAIN / NATURAL GREENNESS       * ACTUAL GREENNESS
   1.33 *.85*M11 / (.0087*M11-.0051*M12+35.85) *   M303
412EXPR R4                       INITIAL WET STORAGE
 WATERST
441EXPR R4                       INITIAL DEEP STORAGE
 0
PROC MONTH RAIN EVAP GROWTH
412EXPR R4                       ADD RAIN
        M412 + M11*RAIN*FACTOR
421EXPR R4                       PASTURE ET
: PASTURE ET CANNOT CAUSE STORE TO BECOME LESS THAN -DRY
        MAX(0, MIN(M412+ DRY, EVAP*FACTOR*GROWTH*M439))
412EXPR R4                       SHALLOW STORE - PASTURE - TREES
        M412 - M421 -  EVAP*FACTOR*1.0*M436
412INTDRR4412117105       11
 1.5 30 .2  0  0  0  0
414EXPR R4                       INFILTRATION
        MAX(0,MIN(M412,M130))
441EXPR R4                       DEEP STORE
: OLD STORE + INFILTRATION + .6 OF EXCESS ET ON SHALLOW STORE
      M441 +M414  + .6 * MIN(0,M412+DRY)
412EXPR R4                       STORAGE AFTER INFILT & ET
        MAX(-DRY , M412 - M414)
413EXPR R4                       RUN-OFF
        IF(M412>WATERST,M412-WATERST,0)
412EXPR R4                       FINAL STORAGE
        M412 - M413
ENDPROC
PROC MARCHAPRIL RAIN EVAP NAME
412EXPR R4                       ADD RAIN
        M412 + M11*RAIN*FACTOR
412EXPR R4                       SHALLOW STORE - TREES
        M412 - EVAP*FACTOR*1.0*M436
412INTDRR4412117105       11
 1.5 30 .2  0  0  0  0
414EXPR R4                       INFILTRATION
        MAX(0,MIN(M412,M130))
441EXPR R4                       DEEP STORE
: OLD STORE + INFILTRATION + .6 OF EXCESS ET ON SHALLOW STORE
      M441 +M414  + .6 * MIN(0,M412+DRY)
412EXPR R4                       STORAGE AFTER INFILT & ET
        MAX(-DRY , M412 - M414)
413EXPR R4                       RUN-OFF
        IF(M412>WATERST,M412-WATERST,0)
412EXPR R4                       FINAL STORAGE
        M412 - M413
ENDPROC
 MONTH                           .049 ; .036 ;  1  ;   SEPTEMBER
 MONTH                           .033 ; .054 ;  1  ;   OCTOBER
 MONTH                           .013 ; .066 ; .93 ;   NOVEMBER
 MONTH                           .008 ; .086 ; .74 ;   DECEMBER
 MONTH                           .005 ; .091 ; .37 ;   JANUARY
 MONTH                           .007 ; .079 ; .07 ;   FEBRUARY
 MARCHAPRIL                      .012 ; .070 ;         MARCH
 MARCHAPRIL                      .028 ; .041 ;         APRIL
 MONTH                           .075 ; .029 ; .07 ;   MAY
 MONTH                           .112 ; .022 ; .37 ;   JUNE
 MONTH                           .106 ; .023 ; .74 ;   JULY
 MONTH                           .083 ; .027 ; .93 ;   AUGUST
```

```
442INTDRR4441117105      12      INITIAL DEEP DRAINAGE
20. 3 0 0 0 0
253 254
: COMPUTE CAPACITY OF SITE TO ACCEPT INFILTRATION IF NOT DISCHARGE
442EXPR R4                       POTENTIAL RECHARGE & DISCHARGE
: DISCH<=0, SURP RECH - NET RECH + (-VE) DISCH, ELSE +VE DISCH
 IF(M442<=0,M254 - M441 + M442 , M442)
150OVROUT 442                    DD.Y1
150OVROUT 441                    NR.Y1
  END
```

7.2.2 CONTENTS OF GWMLY2.DAT

```
SET CELLSIZE 25
SET FACTOR CELLSIZE^2/625
SET DRY 20*FACTOR
SET DEPTH 1.5
SET K 30
SET POROSITY .2
SET WATERST POROSITY*DEPTH*CELLSIZE^2
440EXPR I2                       INITIAL STORAGE LOSS
 WATERST - M412
420EXPR R4                       INITIAL DEEP STORE
 0
251COPY  420                     CUM. NET RECHARGE
241COPY  420                     INITIAL CUMULATIVE RUN-OFF
242COPY  420                     INITIAL PASTURE ET TOTAL
442EXPR R4                       MONTHLY DISCHARGE
        M442/12
PROC MONTH RAIN EVAP GROWTH
420EXPR R4                       ADD DISCHARGE TO DEEP STORE
        MIN(0,M420) + M442
422EXPR R4                       SURPLUS DEEP STORE
        MAX(0,M420)
412EXPR R4                       ADD RAIN & +VE DISCHARGE
        M412+ M422 + M11*RAIN*FACTOR
421EXPR R4                       PASTURE ET
: PASTURE ET CANNOT CAUSE STORE TO BECOME LESS THAN -DRY
        MAX(0, MIN(M412+DRY, EVAP*FACTOR*GROWTH*M439))
242EXPR R4                       TOTAL PASTURE ET
       M242 + M421
412EXPR R4                       SHALLOW STORE - TREES
        M412 - M421 - EVAP*FACTOR*M436
412INTDRR4412117105      11
 1.5 30 .2  0  0  0  0
414EXPR R4                       INFILTRATION
        MAX(0,MIN(M412,M130))
423EXPR R4                       NET RECHARGE
: INFILTRATION + .6 OF EXCESS ET ON SHALLOW STORE
        M414  + .6 * (MIN(0,M412+DRY))
420EXPR R4                       DEEP STORE
      M420 + M423 -M422
251EXPR R4                       CUM. NET RECHARGE
      M251 + M423
412EXPR R4                       STORAGE AFTER INFILT & ET
        MAX(-DRY , M412 - M414 + MAX(0,M420))
413EXPR R4                       RUN-OFF
        IF(M412>WATERST,M412-WATERST,0)
241EXPR R4                       CUMULATIVE RUN-OFF LESS EVAP
        M241 + MAX(M413-M115*MAX(.7*EVAP*FACTOR*M12-M421,0),0)
412EXPR R4                       FINAL STORAGE
        M412 - M413
 ENDPROC
PROC MARCHAPRIL RAIN EVAP NAME
```

```
420EXPR R4                    ADD DISCHARGE TO DEEP STORE
      MIN(0,M420) + M442
422EXPR R4                    SURPLUS DEEP STORE
      MAX(0,M420)
412EXPR R4                    ADD RAIN MARCH
      M412+ M422 + M11*RAIN*FACTOR
412EXPR R4                    SHALLOW STORE - TREES MARCH
      M412 - EVAP*FACTOR*M436
412INTDRR4412117105     11
 1.5 30 .2  0  0  0  0
414EXPR R4                    INFILTRATION
      MAX(0,MIN(M412,M130))
423EXPR R4                    NET RECHARGE
: INFILTRATION + .6 OF EXCESS ET ON SHALLOW STORE
      M414  + .6 * (MIN(0,M412+DRY))
420EXPR R4                    DEEP STORE
    M420 + M423 -M422
251EXPR R4                    CUM. NET RECHARGE
    M251 + M423
412EXPR R4                    STORAGE AFTER INFILT & ET
      MAX(-DRY , M412 - M414 + MAX(0,M420))
413EXPR R4                    RUN-OFF
      IF(M412>WATERST,M412-WATERST,0)
241EXPR R4                    CUMULATIVE RUN-OFF LESS EVAP
      M241 + MAX(M413-M115*MAX(.7*EVAP*FACTOR*M12-M421,0),0)
412EXPR R4                    FINAL STORAGE
      M412 - M413
 ENDPROC
 MONTH                        .049 ; .036 ;  1  ;   SEPTEMBER
 MONTH                        .033 ; .054 ;  1  ;   OCTOBER
 MONTH                        .013 ; .066 ; .93 ;   NOVEMBER
 MONTH                        .008 ; .086 ; .74 ;   DECEMBER
 MONTH                        .005 ; .091 ; .37 ;   JANUARY
 MONTH                        .007 ; .079 ; .07 ;   FEBRUARY
 MARCHAPRIL                   .012 ; .070 ;         MARCH
 MARCHAPRIL                   .028 ; .041 ;         APRIL
245COPY  412                                        END OF APRIL SHALLOW STORAGE
 MONTH                        .075 ; .029 ; .07 ;   MAY
 MONTH                        .112 ; .022 ; .37 ;   JUNE
 MONTH                        .106 ; .023 ; .74 ;   JULY
 MONTH                        .083 ; .027 ; .93 ;   AUGUST
241EXPR R4                    RUN-OFF ADJUSTED FOR LAKES
:For cells in lakes, & major streams remove annual evaporation
   M241-CELLSIZE/1000*.7*M12*M23
:sum run-off over catchment and print to file SF.Y2
150OVROUT 241                 SF.Y2
244EXPR R4                    STORAGE LOSS
    WATERST - M440 - M412
150OVROUT 244                 SL.Y2
252INTDRR4251117105     12    FINAL DEEP DRAINAGE
20. 3 0 0 0 0
253 254
447EXPR R4                    FINAL +VE DEEP DRAINAGE
     IF(M252>0,M252,0)
150OVROUT 251                 NR.Y2
150OVROUT 447                 DD.Y2
  END
```

7.2.3 CONTENTS OF GWMLY3.DAT

Because the storage loss in the year 2 simulation is usually significant, a third year is simulated with soil moisture starting at the final values for year 2. The storage loss in the year 3 simulation is usually acceptably small, as reported in file SL.Y3. The third year simulation of deep groundwater discharge is practically the same as for the second year, but streamflow is markedly different. If further convergence to the steady state was required, GWMLY3.DAT should be run again.

```
SET CELLSIZE 25
SET FACTOR CELLSIZE^2/625
SET DRY 20*FACTOR
SET DEPTH 1.5
SET K 30
SET POROSITY .2
SET WATERST POROSITY*DEPTH*CELLSIZE^2
: COMPUTE CAPACITY OF SITE TO ACCEPT INFILTRATION IF NOT DISCHARGE
442EXPR R4                    POTENTIAL RECHARGE & DISCHARGE
: DISCH<=0, SURP RECH - NET RECH + (-VE) DISCH, ELSE +VE DISCH
 IF(M252<=0,M254 - M251 + M252 , M252)
440EXPR I2                    INITIAL STORAGE LOSS
     WATERST-M412
420EXPR R4                    INITIAL DEEP STORAGE
 0
251COPY  420                  CUM. NET RECHARGE
241COPY  420                  INITIAL CUMULATIVE RUN-OFF
242COPY  420                  INITIAL PASTURE ET TOTAL
442EXPR R4                    MONTHLY DISCHARGE
     M442/12
PROC MONTH RAIN EVAP GROWTH
420EXPR R4                    ADD DISCHARGE TO DEEP STORE
     MIN(0,M420) + M442
422EXPR R4                    SURPLUS DEEP STORE
     MAX(0,M420)
412EXPR R4                    ADD RAIN & +VE DISCHARGE
     M412+ M422 + M11*RAIN*FACTOR
421EXPR R4                    PASTURE ET
: PASTURE ET CANNOT CAUSE STORE TO BECOME LESS THAN -DRY
     MAX(0, MIN(M412+DRY, EVAP*FACTOR*GROWTH*M439))
242EXPR R4                    TOTAL PASTURE ET
    M242 + M421
412EXPR R4                    SHALLOW STORE - TREES
     M412 - M421 - EVAP*FACTOR*M436
412INTDRR4412117105     11
 1.5 30 .2 0 0 0 0
414EXPR R4                    INFILTRATION
     MAX(0,MIN(M412,M130))
423EXPR R4                    NET RECHARGE
: INFILTRATION + .6 OF EXCESS ET ON SHALLOW STORE
     M414 + .6 * (MIN(0,M412+DRY))
420EXPR R4                    DEEP STORE
    M420 + M423 -M422
251EXPR R4                    CUM. NET RECHARGE
    M251 + M423
412EXPR R4                    STORAGE AFTER INFILT & ET
     MAX(-DRY , M412 - M414 + MAX(0,M420))
413EXPR R4                    RUN-OFF
     IF(M412>WATERST,M412-WATERST,0)
241EXPR R4                    CUMULATIVE RUN-OFF LESS EVAP
     M241 + MAX(M413-M115*MAX(.7*EVAP*FACTOR*M12-M421,0),0)
412EXPR R4                    FINAL STORAGE
     M412 - M413
 ENDPROC
PROC MARCHAPRIL RAIN EVAP NAME
420EXPR R4                    ADD DISCHARGE TO DEEP STORE
     MIN(0,M420) + M442
422EXPR R4                    SURPLUS DEEP STORE
     MAX(0,M420)
412EXPR R4                    ADD RAIN MARCH
     M412+ M422 + M11*RAIN*FACTOR
412EXPR R4                    SHALLOW STORE - TREES MARCH
     M412 - EVAP*FACTOR*M436
412INTDRR4412117105     11
```

```
 1.5 30 .2  0  0  0  0
414EXPR R4                     INFILTRATION
       MAX(0,MIN(M412,M130))
423EXPR R4                     NET RECHARGE
: INFILTRATION + .6 OF EXCESS ET ON SHALLOW STORE
       M414  + .6 * (MIN(0,M412+DRY))
420EXPR R4                     DEEP STORE
     M420 + M423 -M422
251EXPR R4                     CUM. NET RECHARGE
     M251 + M423
412EXPR R4                     STORAGE AFTER INFILT & ET
       MAX(-DRY , M412 - M414 + MAX(0,M420))
413EXPR R4                     RUN-OFF
       IF(M412>WATERST,M412-WATERST,0)
241EXPR R4                     CUMULATIVE RUN-OFF LESS EVAP
       M241 + MAX(M413-M115*MAX(.7*EVAP*FACTOR*M12-M421,0),0)
412EXPR R4                     FINAL STORAGE
       M412 - M413
 ENDPROC
 MONTH                         .049 ; .036 ;  1  ;   SEPTEMBER
 MONTH                         .033 ; .054 ;  1  ;   OCTOBER
 MONTH                         .013 ; .066 ; .93 ;   NOVEMBER
 MONTH                         .008 ; .086 ; .74 ;   DECEMBER
 MONTH                         .005 ; .091 ; .37 ;   JANUARY
 MONTH                         .007 ; .079 ; .07 ;   FEBRUARY
 MARCHAPRIL                    .012 ; .070 ;         MARCH
 MARCHAPRIL                    .028 ; .041 ;         APRIL
245COPY   412                                        END OF APRIL SHALLOW STORAGE
 MONTH                         .075 ; .029 ; .07 ;   MAY
 MONTH                         .112 ; .022 ; .37 ;   JUNE
 MONTH                         .106 ; .023 ; .74 ;   JULY
 MONTH                         .083 ; .027 ; .93 ;   AUGUST
: SAVE FINAL SHALLOW STORE
246SWAP   412
241EXPR R4                     RUN-OFF ADJUSTED FOR LAKES
:For cells in lakes & major streams, remove annual evaporation
     M241-CELLSIZE/1000*.7*M12*M23
150OVROUT 241                  SF.Y3
243INTDRI4241117    0    10    STREAMFLOW
243INTDRI4243118    0    0     STREAMFLOW
244EXPR R4                     STORAGE LOSS
     WATERST - M440 - M246
150OVROUT 244                  SL.Y3
252INTDRR4251117105      12    FINAL DEEP DRAINAGE
20. 3 0 0 0 0
253 254
447EXPR R4                     FINAL +VE DEEP DRAINAGE
      IF(M252>0,M252,0)
150OVROUT 251                  NR.Y3
150OVROUT 447                  DD.Y3
  END
```

7.2.4 CONTENTS OF SMDISCH.DAT

This command file 'smooths' maps by assigning to each cell the average of itself plus any adjacent cells that contain valid data. ASEAR (refer HOW ASEARCH) puts sum of valid cells in map 422, and no. of those cells in map 421. Next EXPR calculates positive averages. OVROUT then calculates sum within catchments and writes the sum to a text file.

```
422ASEARR4447     421                SUMMED ADJACENT
256EXPR R4                           SMOOTHED DEEP DISCHARGE
 IF(M422>0,M422/M421,0)
150OVROUT 256                        DS.SM
422ASEARR4253     421                SUMMED ADJACENT
257EXPR R4                           SMOOTHED THROUGHFLOW
```

```
IF(M422>0,M422/M421,0)
150OVROUT 257                        TF.SM
422ASEARR4254     421                SUMMED ADJACENT
258EXPR R4                           SMOOTHED SURPLUS RECHARGE
IF(M422>0,M422/M421,0)
255INTDRR4256116          0          SMOOTHED SEEPAGE VOLUME
150OVROUT 125     1256               PS.SM
259EXPR I2                           SEEP AREA
IF(M256>=7.5 & M125=0,1,0)
150OVROUT 128     1259               SA.SM
259INTDRI4259116                     SEEP AREA INTEGRATED
END
```

7.2.5 CONTENTS OF SAVORIG.DAT

This command file is used to copy maps that will be changed in 'PLANT.DAT' [7.3] and 'REVIEW.BAT' [7.4], enabling comparisons to be made before and after reforestation.

```
303SWAP  123
:TREES GREEN>0
304SWAP  124
:PASTURE LAI=2.7
241SWAP  201
:CUMULATIVE RUN-OFF LESS EVAP
242SWAP  202
:TOTAL PASTURE ET
243SWAP  203
:STREAMFLOW
244SWAP  204
:MINIMUM SHALLOW+DEEP
245SWAP  205
:STORAGE LOSS
246SWAP  206
:FINAL SHALLOW STORE
247SWAP  207
:FINAL DEEP STORE
251SWAP  211
:NET RECHARGE
252SWAP  212
:FINAL DEEP DRAINAGE
253SWAP  213
:THROUGHFLOW
254SWAP  214
:SURPLUS RECHARGE
255SWAP  215
:SMOOTHED SEEPAGE VOLUME
256SWAP  216
:SMOOTHED DEEP DRAINAGE
257SWAP  217
:SMOOTHED THROUGHFLOW
258SWAP  218
:SMOOTHED SURPLUS RECHARGE
  END
```

7.3 CONTENTS OF PLANT.DAT

Commands used to estimate the amount of reforestation required to minimise discharge and predict their location in the catchment.

:USE MAPS FROM 'SAVE ORIGINAL' POSITIONS
: To get good correspondence between predicted discharge and reviewed discharge, calculated :greenness must be based on unsmoothed deep groundwater maps.
: To avoid over-fragmenting recommended sites for planting, constrain planting to areas where :smoothed discharge exceeds a specified value, then use unsmoothed maps to plant trees wherever :unsmoothed discharge is greater than zero in the constrained areas.

```
: PLANT CELLS THAT ARE PASTURE AND WHERE SMOOTHED DISCHARGE > 12.5
421EXPR I2                              PLANTED TREE CRITERION
 IF(M124=0 OR M216<20,0,1)
: tree planting criteria are 'cells where map 421>0, unsmoothed discharge > 0, rooting depth .3 of :bottom soil layer thickness'
332INTDRR4212117105      13             PLANTED DISCHARGE
20. 3  0 .3  0 0 0 0
213 214 421 331
333EXPR R4                              PLANTED TREE GREENNESS
:Tree must use required g/w + total pasture ET + run-off
 IF(M331>0,(M331+M202+M201) :
:compare to use by nat. veg i.e. total rain less interception less summer stress
 /(.5*M11) :
: greenness relative to natural veg  LESS tree greenness already on cell
  *(.0087*M11-.0051*M12+35.85) - M123,0)
: Report predicted discharge in and out of native forest
150OVROUT 125    1332                   PD.OVR
150OVROUT 333                           PG.OVR
150OVROUT 421                           PA.OVR
END
```

7.4 CONTENTS OF REVIEW.BAT

```
CALL PMIN NEWPAST.DAT DUMMY %1      [7.4.1]  Add planted trees to existing trees and
RASCAL < PMIN.DAT                            adjust pasture accordingly
CALL PMIN GWMLYS.DAT DUMMY %1       [7.2.1]
RASCAL < PMIN.DAT
CALL PMIN GWMLY2.DAT DUMMY %1       [7.2.2]
RASCAL < PMIN.DAT
CALL PMIN GWMLY3.DAT DUMMY %1       [7.2.3]
RASCAL < PMIN.DAT
CALL PMIN SMDISCH.DAT Y2.OUT %1     [7.2.4]
RASCAL < PMIN.DAT
```

Refer to section [6.1] for explanation of 'CALL PMIN'.

7.4.1 CONTENTS OF NEWPAST.DAT

```
303EXPR R4                          GREEN WITH PLANTED TREES
  M333 + M123
304EXPR R4                          PASTURE LEFT AFTER PLANTING
  IF(M333>0,0,                      : ZERO WHERE NEW TREES PLANTED
  M124                              : AS BEFORE ELSE WHERE
  )
  END
```

7.5 CONTENTS OF COMPRIN.BAT

This batch file creates COMPRIN.DAT to copy maps (disregarding scratch maps) into TONEI1 from TONE1.

```
ECHO %1%2 > COMPRIN.DAT
ECHO %1I%2 >> COMPRIN.DAT
ECHO OUT.PRN >> COMPRIN.DAT
ECHO 1,333 >> COMPRIN.DAT
ECHO 1 >> COMPRIN.DAT
ECHO 2,1 >> COMPRIN.DAT
ECHO Y >> COMPRIN.DAT
```

8. Convert raster maps to polygons for presentation in microstation

8.1 CONTENTS OF CLASS.IN

TONE11		Subcatchment project being processed
CLASS.DAT	[8.1.1]	For use with subcatchment projects (Seepage & Sites for Planting)
OUT.PRN		File for messages
N		Extra file is not needed
Y		Update default file names from this run

8.1.1 CONTENTS OF CLASS.DAT

```
425EXPR                                   CLASSED SEEPAGE
IF(M216>10 & M216<=20,1,        :SEEPAGE 10-20 CU.M/YR
IF(M216>20 & M216<=50,2,        :SEEPAGE 20-50 CU.M/YR
IF(M216>50,3,                   :SEEPAGE >50 CU.M/YR
-99)))
426EXPR                                   ORIGINAL TREE COVER
IF(M303>0 & M304=0,1,           :NATIVE FOREST
IF(M303>0 & M304>0,2,           :SCATTERED PADDOCK TREES
-99))
427EXPR                                   PROPOSED SITES FOR PLANTING
IF(M333>0,1,-99)
  END
```

8.2 CONTENTS OF MAP.IN

TONE11		Subcatchment project being processed
MAP.DAT	[8.2.1]	Generate polygons
OUT.PRN		File for messages
Y		Extra file is needed for polygon output
MAP.ASC		Name of extra file
Y		Update default file names from this run

When using command MAP, the file *MAP*.LAB is generated containing the polygon labels, as well as *MAP.ASC*. Polygons can only be generated from one map in one run of RASCAL due to the need to name the extra file for output.

8.2.1 CONTENTS OF MAP.DAT

To output polygons and labels:

```
425MAP     -1                  [HOW MAP]
   END
```

To output drainage lines:

```
428INTD    428      -1         [HOW INTDRA]
   END
```

8.3 USTATION

Use the Polygon Utility ASC2DGN MDL to load polygons into a Microstation design file. First set the 'active level' to the level where the lines are to be stored. Then use the ASC2DGN option 'import to active level' (not the alternative 'read levels from file'). Even though the data represents complete polygons, it should be read as linestrings, not polygons, so that Polygon Utility's polygon shading process can be used. It is advisable to use a new design file for each subcatchment if patterning is to be generated. After creation, the pattern files may be amalgamated into one file.

If the polygons are to be patterned, load the polygon labels. First make 'active' the level where the labels are to be stored. Next set appropriate text attributes such as size and colour. Then type on the command line:

@MAP.LAB

To pattern the polygons, the POLYGON UTILITY MDL is used. The first step is to run 'Line Break'. Then omit 'Line Check' and proceed with 'Polygon Create' and 'Load Poly Id'. At this point check that the pattern definition file is correct for the polygons to be patterned. The name of the pattern definition file may have to be altered from the default to achieve this.

8.3.1 CONTENTS OF MICROSTATION MACRO TO PLOT MAPS OF RESULTS

Two macros are used to create the maps of results in MicroStation. These are ALLDRAW1.BAS (Tone above Tonebridge catchment) and ALLDRAW2.BAS (Tone below Tonebridge and Perup catchments). These macros are run in the design file 'W3BASE.DGN' to create a series of plots for Maps Appendix 5A and 5B. All the correct reference files levels and displays must be turned on in View 5 before running. It is important to close all tool boxes before running this macro, otherwise it may not run properly.

ALLDRAW1.BAS

```
Dim startPoint As MbePoint
' Initialise fence lock and DOS subdirectory for plot files
   MbeSendCommand "LOCK FENCE VOID OUTSIDE "
'   MbeSendKeyin "%c:"
'   MbeSendKeyin "%cd\ustn55\out\plot"
'   Coordinates are in master units

   startPoint.x = 482000.000000#
   startPoint.y = 6245000.000000#
   startPoint.z = 0.000000#
   plotpair "h1", "2", startPoint
   startPoint.x = 489000.000000#
   startPoint.y = 6245000.000000#
   startPoint.z = 0.000000#
   plotpair "i1", "1", startPoint
   startPoint.x = 496000.000000#
   startPoint.y = 6245000.000000#
   startPoint.z = 0.000000#
   plotpair "j1", "2", startPoint
   startPoint.x = 503000.000000#
   startPoint.y = 6245000.000000#
   startPoint.z = 0.000000#
   plotpair "k1", "1", startPoint
   startPoint.x = 475000.000000#
   startPoint.y = 6241000.000000#
   startPoint.z = 0.000000#
   plotpair "g2", "3", startPoint
   startPoint.x = 482000.000000#
   startPoint.y = 6241000.000000#
   startPoint.z = 0.000000#
   plotpair "h2", "4", startPoint
   startPoint.x = 489000.000000#
   startPoint.y = 6241000.000000#
   startPoint.z = 0.000000#
   plotpair "i2", "3", startPoint
   startPoint.x = 496000.000000#
   startPoint.y = 6241000.000000#
   startPoint.z = 0.000000#
   plotpair "j2", "4", startPoint
   startPoint.x = 503000.000000#
   startPoint.y = 6241000.000000#
   startPoint.z = 0.000000#
   plotpair "k2", "3", startPoint
   startPoint.x = 510000.000000#
   startPoint.y = 6241000.000000#
   startPoint.z = 0.000000#
   plotpair "l2", "4", startPoint
   startPoint.x = 475000.000000#
   startPoint.y = 6237000.000000#
   startPoint.z = 0.000000#
   plotpair "g3", "1", startPoint
   startPoint.x = 482000.000000#
   startPoint.y = 6237000.000000#
   startPoint.z = 0.000000#
   plotpair "h3", "2", startPoint
   startPoint.x = 489000.000000#
   startPoint.y = 6237000.000000#
   startPoint.z = 0.000000#
   plotpair "i3", "1", startPoint
   startPoint.x = 496000.000000#
   startPoint.y = 6237000.000000#
   startPoint.z = 0.000000#
   plotpair "j3", "2", startPoint
   startPoint.x = 503000.000000#
   startPoint.y = 6237000.000000#
   startPoint.z = 0.000000#
   plotpair "k3", "1", startPoint
   startPoint.x = 510000.000000#
   startPoint.y = 6237000.000000#
   startPoint.z = 0.000000#
   plotpair "l3", "2", startPoint
   startPoint.x = 468000.000000#
   startPoint.y = 6233000.000000#
   startPoint.z = 0.000000#
   plotpair "f4", "4", startPoint
   startPoint.x = 475000.000000#
   startPoint.y = 6233000.000000#
   startPoint.z = 0.000000#
   plotpair "g4", "3", startPoint
   startPoint.x = 482000.000000#
   startPoint.y = 6233000.000000#
   startPoint.z = 0.000000#
   plotpair "h4", "4", startPoint
   startPoint.x = 489000.000000#
   startPoint.y = 6233000.000000#
   startPoint.z = 0.000000#
   plotpair "i4", "3", startPoint
   startPoint.x = 496000.000000#
   startPoint.y = 6233000.000000#
   startPoint.z = 0.000000#
   plotpair "j4", "4", startPoint
   startPoint.x = 468000.000000#
   startPoint.y = 6229000.000000#
   startPoint.z = 0.000000#
   plotpair "f5", "2", startPoint
   startPoint.x = 475000.000000#
   startPoint.y = 6229000.000000#
   startPoint.z = 0.000000#
   plotpair "g5", "1", startPoint
   startPoint.x = 482000.000000#
   startPoint.y = 6229000.000000#
   startPoint.z = 0.000000#
   plotpair "h5", "2", startPoint
   startPoint.x = 489000.000000#
   startPoint.y = 6229000.000000#
   startPoint.z = 0.000000#
   plotpair "i5", "1", startPoint
   startPoint.x = 496000.000000#
   startPoint.y = 6229000.000000#
   startPoint.z = 0.000000#
   plotpair "j5", "2", startPoint
   startPoint.x = 461000.000000#
```

```
startPoint.y = 6225000.000000#
startPoint.z = 0.000000#
plotpair "e6", "3", startPoint
startPoint.x = 468000.000000#
startPoint.y = 6225000.000000#
startPoint.z = 0.000000#
plotpair "f6", "4", startPoint
startPoint.x = 475000.000000#
startPoint.y = 6225000.000000#
startPoint.z = 0.000000#
plotpair "g6", "3", startPoint
startPoint.x = 482000.000000#
startPoint.y = 6225000.000000#
startPoint.z = 0.000000#
plotpair "h6", "4", startPoint
startPoint.x = 489000.000000#
startPoint.y = 6225000.000000#
startPoint.z = 0.000000#
plotpair "i6", "3", startPoint
startPoint.x = 461000.000000#
startPoint.y = 6221000.000000#
startPoint.z = 0.000000#
plotpair "e7", "1", startPoint
startPoint.x = 468000.000000#
startPoint.y = 6221000.000000#
startPoint.z = 0.000000#
plotpair "f7", "2", startPoint
startPoint.x = 475000.000000#
startPoint.y = 6221000.000000#
startPoint.z = 0.000000#
plotpair "g7", "1", startPoint
startPoint.x = 482000.000000#
startPoint.y = 6221000.000000#
startPoint.z = 0.000000#
plotpair "h7", "2", startPoint
startPoint.x = 489000.000000#
startPoint.y = 6221000.000000#
startPoint.z = 0.000000#
plotpair "i7", "1", startPoint
startPoint.x = 461000.000000#
startPoint.y = 6217000.000000#
startPoint.z = 0.000000#
plotpair "e8", "3", startPoint
startPoint.x = 468000.000000#
startPoint.y = 6217000.000000#
startPoint.z = 0.000000#
plotpair "f8", "4", startPoint
startPoint.x = 475000.000000#
startPoint.y = 6217000.000000#
startPoint.z = 0.000000#
plotpair "g8", "3", startPoint
startPoint.x = 482000.000000#
startPoint.y = 6217000.000000#
startPoint.z = 0.000000#
plotpair "h8", "4", startPoint
startPoint.x = 489000.000000#
startPoint.y = 6217000.000000#
startPoint.z = 0.000000#
plotpair "i8", "3", startPoint
startPoint.x = 461000.000000#
startPoint.y = 6213000.000000#
startPoint.z = 0.000000#
plotpair "e9", "1", startPoint
startPoint.x = 468000.000000#
startPoint.y = 6213000.000000#
startPoint.z = 0.000000#
plotpair "f9", "2", startPoint
startPoint.x = 475000.000000#
startPoint.y = 6213000.000000#
startPoint.z = 0.000000#
plotpair "g9", "1", startPoint
startPoint.x = 482000.000000#
startPoint.y = 6213000.000000#
startPoint.z = 0.000000#
plotpair "h9", "2", startPoint
startPoint.x = 489000.000000#
startPoint.y = 6213000.000000#
startPoint.z = 0.000000#
plotpair "i9", "1", startPoint
startPoint.x = 461000.000000#
startPoint.y = 6209000.000000#
startPoint.z = 0.000000#
plotpair "e10", "3", startPoint
startPoint.x = 468000.000000#
startPoint.y = 6209000.000000#
startPoint.z = 0.000000#
plotpair "f10", "4", startPoint
startPoint.x = 475000.000000#
startPoint.y = 6209000.000000#
startPoint.z = 0.000000#
plotpair "g10", "3", startPoint
startPoint.x = 482000.000000#
startPoint.y = 6209000.000000#
startPoint.z = 0.000000#
plotpair "h10", "4", startPoint
End Sub

sub plotpair(sheet as string, layer as string,startPoint As MbePoint)
   Dim point As MbePoint
'  Turn on levels in wfram2.dgn for series 1
   MbeSendKeyin "reference levels off"
   MbeSendKeyin "frames"

   MbeSendKeyin "1-63"

'  Send a data point to the current command
   point.x = startPoint.x
   point.y = startPoint.y
   point.z = startPoint.z
   MbeSendDataPoint point, 1%
'  Turn on levels in wfram2.dgn for series 1
   MbeSendKeyin "reference levels on"
   MbeSendKeyin "frames"
   MbeSendKeyin layer + "0," + layer + "3," + layer + "4"

'  Send a data point to the current command
   point.x = startPoint.x
   point.y = startPoint.y
   point.z = startPoint.z
   MbeSendDataPoint point, 1%

'  Clip boundaries for sheet, then set fence for plot
   setclip startPoint

   MbeSendKeyin "reference display off plant"
'  Turn on levels in wfram2.dgn for series 1
   MbeSendKeyin "reference levels on"
   MbeSendKeyin "frames"

   MbeSendKeyin layer + "1"

'  Send a data point to the current command
   point.x = startPoint.x
   point.y = startPoint.y
   point.z = startPoint.z
   MbeSendDataPoint point, 1%

   MbeSendKeyin "uc=c:\warren\dgn\ucm\autoplot"
  FileCopy "c:\plots\w3base.000", "s:\rid\csi\warren\dgn\" + sheet
+ "d.000"

'  Turn on levels in wfram2.dgn for series 1
   MbeSendKeyin "reference levels off"
   MbeSendKeyin "frames"
```

```
   MbeSendKeyin layer + "1"

'  Send a data point to the current command
   point.x = startPoint.x
   point.y = startPoint.y
   point.z = startPoint.z
   MbeSendDataPoint point, 1%
'  Turn on levels in wfram2.dgn for series 1
   MbeSendKeyin "reference levels on"
   MbeSendKeyin "frames"

   MbeSendKeyin layer + "2"

'  Send a data point to the current command
   point.x = startPoint.x
   point.y = startPoint.y
   point.z = startPoint.z
   MbeSendDataPoint point, 1%

   MbeSendKeyin "reference display on plant"
   MbeSendKeyin "uc=c:\warren\dgn\ucm\autoplot"
  FileCopy "c:\plots\w3base.000", "s:\rid\csi\warren\dgn\" + sheet
+ "p.000"
end sub
sub setclip(startPoint As MbePoint)
   Dim point As MbePoint, point2 As MbePoint

   MbeSendCommand "PLACE FENCE"

   point.x = startPoint.x - 437.000000#
   point.y = startPoint.y - 427.000000#
   point.z = startPoint.z
   MbeSendDataPoint point, 1%

   point.x = startPoint.x + 7437.000000#
   point.y = startPoint.y + 4427.000000#
   point.z = startPoint.z
   MbeSendDataPoint point, 1%
   MbeSendKeyin "REFERENCE CLIP BOUNDARY forest"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 22291se"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 22291sw"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 22291nw"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 22293ne"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 22294ne"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 22294se"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 22294sw"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 22294nw"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 22291ne"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 22302sec"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 22302sep"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 22302swc"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 22302swp"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 22303sec"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 22303sep"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 23294_c"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 23303_c"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY 23303_p"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY wbndy"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY disch"
   MbeSendKeyin "REFERENCE CLIP BOUNDARY plant"

   MbeSendCommand "PLACE FENCE"
   point.x = startPoint.x - 840.000000#
   point.y = startPoint.y - 1370.000000#
   point.z = startPoint.z
   MbeSendDataPoint point, 1%

   point.x = startPoint.x + 7560.000000#
   point.y = startPoint.y + 4570.000000#
   point.z = startPoint.z
   MbeSendDataPoint point, 1%
End Sub
```

ALLDRAW2.BAS

```
' choose levels to show drawing, create plot file, ' step through all
drawing positions
Sub main
   Dim startPoint As MbePoint
' Initialise fence lock and DOS subdirectory for plot files
   MbeSendCommand "LOCK FENCE VOID OUTSIDE "
'   MbeSendKeyin "%c:"
'   MbeSendKeyin "%cd\ustn55\out\plot"
'  Coordinates are in master units

   startPoint.x = 433000.000000#
   startPoint.y = 6221000.000000#
   startPoint.z = 0.000000#
   plotpair "a7", "1", startPoint
   startPoint.x = 433000.000000#
   startPoint.y = 6213500.000000#
   startPoint.z = 0.000000#
   plotpair "a9", "1", startPoint
   startPoint.x = 433000.000000#
   startPoint.y = 6209500.000000#
   startPoint.z = 0.000000#
   plotpair "a10", "3", startPoint
   startPoint.x = 440000.000000#
   startPoint.y = 6229000.000000#
   startPoint.z = 0.000000#
   plotpair "b5", "2", startPoint
   startPoint.x = 440000.000000#
   startPoint.y = 6225000.000000#
   startPoint.z = 0.000000#
   plotpair "b6", "4", startPoint
   startPoint.x = 441000.000000#
   startPoint.y = 6221000.000000#
   startPoint.z = 0.000000#
   plotpair "b7", "2", startPoint
   startPoint.x = 440000.000000#
   startPoint.y = 6217000.000000#
   startPoint.z = 0.000000#
   plotpair "b8", "4", startPoint
   startPoint.x = 440000.000000#
   startPoint.y = 6213000.000000#
   startPoint.z = 0.000000#
   plotpair "b9", "2", startPoint
   startPoint.x = 440000.000000#
   startPoint.y = 6209000.000000#
   startPoint.z = 0.000000#
   plotpair "b10", "4", startPoint
   startPoint.x = 447000.000000#
   startPoint.y = 6225000.000000#
   startPoint.z = 0.000000#
   plotpair "c6", "3", startPoint
   startPoint.x = 447000.000000#
   startPoint.y = 6217000.000000#
   startPoint.z = 0.000000#
   plotpair "c8", "3", startPoint
   startPoint.x = 447000.000000#
   startPoint.y = 6213000.000000#
   startPoint.z = 0.000000#
   plotpair "c9", "1", startPoint
   startPoint.x = 447000.000000#
   startPoint.y = 6209000.000000#
   startPoint.z = 0.000000#
   plotpair "c10", "3", startPoint
   startPoint.x = 447000.000000#
   startPoint.y = 6205000.000000#
   startPoint.z = 0.000000#
   plotpair "c11", "1", startPoint
```

```
startPoint.x = 447000.000000#
startPoint.y = 6201000.000000#
startPoint.z = 0.000000#
plotpair "c12", "3", startPoint
startPoint.x = 447000.000000#
startPoint.y = 6197000.000000#
startPoint.z = 0.000000#
plotpair "c13", "1", startPoint
startPoint.x = 447000.000000#
startPoint.y = 6193000.000000#
startPoint.z = 0.000000#
plotpair "c14", "3", startPoint
startPoint.x = 454000.000000#
startPoint.y = 6225000.000000#
startPoint.z = 0.000000#
plotpair "d6", "4", startPoint
startPoint.x = 454300.000000#
startPoint.y = 6221000.000000#
startPoint.z = 0.000000#
plotpair "d7", "2", startPoint
startPoint.x = 454000.000000#
startPoint.y = 6217000.000000#
startPoint.z = 0.000000#
plotpair "d8", "4", startPoint
startPoint.x = 454000.000000#
startPoint.y = 6213000.000000#
startPoint.z = 0.000000#
plotpair "d9", "2", startPoint
startPoint.x = 454000.000000#
startPoint.y = 6205600.000000#
startPoint.z = 0.000000#
plotpair "d11", "2", startPoint
startPoint.x = 461000.000000#
startPoint.y = 6229000.000000#
startPoint.z = 0.000000#
plotpair "e5", "1", startPoint
startPoint.x = 461000.000000#
startPoint.y = 6225000.000000#
startPoint.z = 0.000000#
plotpair "e6", "3", startPoint
startPoint.x = 461000.000000#
startPoint.y = 6213000.000000#
startPoint.z = 0.000000#
plotpair "e9", "1", startPoint
startPoint.x = 461000.000000#
startPoint.y = 6201000.000000#
startPoint.z = 0.000000#
plotpair "e12", "3", startPoint
startPoint.x = 461000.000000#
startPoint.y = 6197000.000000#
startPoint.z = 0.000000#
plotpair "e13", "1", startPoint
startPoint.x = 468000.000000#
startPoint.y = 6209000.000000#
startPoint.z = 0.000000#
plotpair "f10", "4", startPoint
startPoint.x = 468000.000000#
startPoint.y = 6205000.000000#
startPoint.z = 0.000000#
plotpair "f11", "2", startPoint
startPoint.x = 468000.000000#
startPoint.y = 6201000.000000#
startPoint.z = 0.000000#
plotpair "f12", "4", startPoint
startPoint.x = 468000.000000#
startPoint.y = 6197000.000000#
startPoint.z = 0.000000#
plotpair "f13", "2", startPoint
startPoint.x = 468000.000000#
startPoint.y = 6192700.000000#
startPoint.z = 0.000000#
plotpair "f14", "4", startPoint
startPoint.x = 475000.000000#
startPoint.y = 6209000.000000#
startPoint.z = 0.000000#
plotpair "g10", "3", startPoint
startPoint.x = 475000.000000#
startPoint.y = 6205000.000000#
startPoint.z = 0.000000#
plotpair "g11", "1", startPoint
startPoint.x = 475000.000000#
startPoint.y = 6201000.000000#
startPoint.z = 0.000000#
plotpair "g12", "3", startPoint
startPoint.x = 475000.000000#
startPoint.y = 6197000.000000#
startPoint.z = 0.000000#
plotpair "g13", "1", startPoint
startPoint.x = 475000.000000#
startPoint.y = 6193000.000000#
startPoint.z = 0.000000#
plotpair "g14", "3", startPoint
startPoint.x = 475000.000000#
startPoint.y = 6189000.000000#
startPoint.z = 0.000000#
plotpair "g15", "1", startPoint
startPoint.x = 482000.000000#
startPoint.y = 6209000.000000#
startPoint.z = 0.000000#
plotpair "h10", "4", startPoint
startPoint.x = 482000.000000#
startPoint.y = 6205000.000000#
startPoint.z = 0.000000#
plotpair "h11", "2", startPoint
startPoint.x = 482000.000000#
startPoint.y = 6201000.000000#
startPoint.z = 0.000000#
plotpair "h12", "4", startPoint
startPoint.x = 482000.000000#
startPoint.y = 6197000.000000#
startPoint.z = 0.000000#
plotpair "h13", "2", startPoint
startPoint.x = 482000.000000#
startPoint.y = 6193000.000000#
startPoint.z = 0.000000#
plotpair "h14", "4", startPoint


end sub
sub plotpair(sheet as string, layer as string,startPoint As MbePoint)
   Dim point As MbePoint
'  Turn on levels in wfram2.dgn for series 1
   MbeSendKeyin "reference levels off"
   MbeSendKeyin "frames"

   MbeSendKeyin "1-63"

'  Send a data point to the current command
   point.x = startPoint.x
   point.y = startPoint.y
   point.z = startPoint.z
   MbeSendDataPoint point, 1%
'  Turn on levels in wfram2.dgn for series 1
   MbeSendKeyin "reference levels on"
   MbeSendKeyin "frames"

   MbeSendKeyin layer + "0," + layer + "3," + layer + "4"

'  Send a data point to the current command
   point.x = startPoint.x
   point.y = startPoint.y
   point.z = startPoint.z
   MbeSendDataPoint point, 1%
'  Clip boundaries for sheet, then set fence for plot
```

```
    setclip startPoint

    MbeSendKeyin "reference display off plant"
  ' Turn on levels in wfram2.dgn for series 1
    MbeSendKeyin "reference levels on"
    MbeSendKeyin "frames"

    MbeSendKeyin layer + "1"

  ' Send a data point to the current command
    point.x = startPoint.x
    point.y = startPoint.y
    point.z = startPoint.z
    MbeSendDataPoint point, 1%

    MbeSendKeyin "uc=c:\warren\tonel\dgn\autoplot"
    FileCopy "c:\plots\w3base.000", "c:\plots\" + sheet + "d.000"

  ' Turn on levels in wfram2.dgn for series 1
    MbeSendKeyin "reference levels off"
    MbeSendKeyin "frames"

    MbeSendKeyin layer + "1"

  ' Send a data point to the current command
    point.x = startPoint.x
    point.y = startPoint.y
    point.z = startPoint.z
    MbeSendDataPoint point, 1%
  ' Turn on levels in wfram2.dgn for series 1
    MbeSendKeyin "reference levels on"
    MbeSendKeyin "frames"

    MbeSendKeyin layer + "2"

  ' Send a data point to the current command
    point.x = startPoint.x
    point.y = startPoint.y
    point.z = startPoint.z
    MbeSendDataPoint point, 1%

    MbeSendKeyin "reference display on plant"
    MbeSendKeyin "uc=c:\wrc\ucm\autoplot"
    FileCopy "c:\plots\w3base.000", "c:\plots\" + sheet + "p.000"
end sub
sub setclip(startPoint As MbePoint)
    Dim point As MbePoint, point2 As MbePoint

    MbeSendCommand "PLACE FENCE"

    point.x = startPoint.x - 437.000000#
    point.y = startPoint.y - 427.000000#
    point.z = startPoint.z
    MbeSendDataPoint point, 1%

    point.x = startPoint.x + 7437.000000#
    point.y = startPoint.y + 4427.000000#
    point.z = startPoint.z
    MbeSendDataPoint point, 1%
    MbeSendKeyin "REFERENCE CLIP BOUNDARY forest"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 21291ne"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 21291nw"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 21291se"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 21291sw"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 21292ne"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 21292nw"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 21292se"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 21292sw"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 22291sw"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 22292nw"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 22292sw"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 22293ne"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 22293nw"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 22293se"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 22293sw"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 22294ne"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 22294nw"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 22294se"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY 22294sw"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY bndy"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY disch"
    MbeSendKeyin "REFERENCE CLIP BOUNDARY plant"

    MbeSendCommand "PLACE FENCE"
    point.x = startPoint.x - 840.000000#
    point.y = startPoint.y - 1370.000000#
    point.z = startPoint.z
    MbeSendDataPoint point, 1%

    point.x = startPoint.x + 7560.000000#
    point.y = startPoint.y + 4570.000000#
    point.z = startPoint.z
    MbeSendDataPoint point, 1%

End Sub
```

8.4 OUTPUT OF DATA FOR TABLES BASED ON CATCHMENT AREAS

Basic data to prepare tables of quantities within catchment areas are obtained by overlaying the catchment map (map 150) on a map of data, using command OVROUT [ref HOW OVROUT]. All of the required OVROUT commands are performed in GWML.BAT [7.2] while the modelling is proceeding.
A file produced by OVROUT may be imported into a spreadsheet for reporting and computing other derived quantities. To reduce the manual operations involved in preparing the spreadsheet, program TABLIST [ref HOW TABLIST] is provided to reformat the output files from OVROUT. Batch file TABALL.BAT [8.4.1] automatically runs TABLIST for all the OVROUT files required after modelling. A macro [8.4.2] then automatically loads the data into the spreadsheet ready for printing.

Alternatively, if the basic data has been integrated along drainage lines, the aggregate for the catchment can be read by displaying the integrated map using program SEERAS [ref HOW SEERAS], and positioning the cursor on the cell which is the outlet of the catchment. The value would then be manually copied into the spreadsheet. This method is not recommended where data is required from many subcatchments.

8.4.1 CONTENTS OF TABLALL.BAT

CALL TABIN CA OVR 1	[8.4.1.1]	Cleared Area
TABLIST < TABIN.DAT		
CALL TABIN FC OVR 1	[8.4.1.1]	Forest Without Upstream Clearing (One way table)
TABLIST < TABIN.DAT		
CALL TABIN RAIN OVR 1	[8.4.1.1]	Total Rainfall (One way table)
TABLIST < TABIN.DAT		
CALL TABIN DSBS SM 1	[8.4.1.1]	Smoothed Deep Discharge Base (One way table)
TABLIST < TABIN.DAT		
CALL TABIN PSBS SM 2	[8.4.1.1]	Pasture / Forest Discharge Base (Two way table)
TABLIST < TABIN.DAT		
CALL TABIN SFBS Y3 1	[8.4.1.1]	Streamflow Base (One way table)
TABLIST < TABIN.DAT		
CALL TABIN DDBS Y3 1	[8.4.1.1]	Deep Discharge Base (One way table)
TABLIST < TABIN.DAT		
CALL TABIN TFBS SM 1	[8.4.1.1]	Throughflow Base (One way table)
TABLIST < TABIN.DAT		
CALL TABIN SLBS Y3 1	[8.4.1.1]	Storage Loss Base (One way table)
TABLIST < TABIN.DAT		
CALL TABIN NRBS Y3 1	[8.4.1.1]	Natural Recharge Base (One way table)
TABLIST < TABIN.DAT		
CALL TABIN PD20 OVR 2	[8.4.1.1]	Estimated Planted Discharge (Two way table)
TABLIST < TABIN.DAT		
CALL TABIN PG20 OVR 1	[8.4.1.1]	Planted Tree Greenness (One way table)
TABLIST < TABIN.DAT		
CALL TABIN PA20 OVR 1	[8.4.1.1]	Planted Tree Area (One way table)
TABLIST < TABIN.DAT		
CALL TABIN DSTR SM 1	[8.4.1.1]	Smoothed Deep Discharge Treated (One way table)
TABLIST < TABIN.DAT		
CALL TABIN PSTR SM 2	[8.4.1.1]	Pasture / Forest Discharge Treated (Two way table)
TABLIST < TABIN.DAT		
CALL TABIN SFTR Y3 1	[8.4.1.1]	Streamflow Treated (One way table)
TABLIST < TABIN.DAT		
CALL TABIN DDTR Y3 1	[8.4.1.1]	Deep Discharge Treated (One way table)
TABLIST < TABIN.DAT		
CALL TABIN TFTR SM 1	[8.4.1.1]	Throughflow Treated (One way table)
TABLIST < TABIN.DAT		
CALL TABIN SLTR Y3 1	[8.4.1.1]	Storage Loss Treated (One way table)
TABLIST < TABIN.DAT		
CALL TABIN NRTR Y3 1	[8.4.1.1]	Natural Recharge Treated (One way table)
TABLIST < TABIN.DAT		

8.4.1.1 CONTENTS OF TABIN.BAT

Prepares input data file and runs program TABLIST

ECHO %1#.%2 > TABIN.DAT	The template for OVROUT file names
ECHO WRNSC.DAT >> TABIN.DAT	[8.4.1.2]

```
ECHO %1.TXT >> TABIN.DAT        Output filename to be read by Excel
ECHO %3 >> TABIN.DAT            Select one-way or two-way table
ECHO Y >> TABIN.DAT             Update default file names
TABLIST < TABIN.DAT
```

8.4.1.2 CONTENTS OF WRNSC.DAT

This file lists subcatchment order for the Tone above Tonebridge catchment. In the actual file, each entry is on a new line. The number sequence is that used in the spreadsheet, that reflects the drainage structure of the catchment. XX provides a break between data for different sheets within the spreadsheet workbook.

1 2 3 4 5 6 7 8 9 10 11 12 XX 13 14 15 16 17 18 19 20 21 22 23 24 XX 25 26 27 28 29 30 31 36 32 XX 33 34 35 37 38 39 XX 40 41 42 43 44 45 46 47 48 49

8.4.1.3 CONTENTS OF TONELSC.LST

Similar to WRNSC.DAT above, this file is used for the subcatchments of the Tone below Tonebridge catchment.

01 02 03 05 06 07 08 09 10 XX 11 12 13 14 15 16 25 XX 04 17 18 19 20 21 22 23 24 XX 26 27 28 29 30 31 32 33

8.4.1.4 CONTENTS OF PRPSC.LST

Similar to WRNSC.DAT above, this file is used for the subcatchments of the Perup catchment.

01 02 03 04 05 06 07 08 XX 09 10 11 12 13 14 15 16 XX 17 18 19 20 21 22 23 XX 24 25 26 27 28 29 30 31 32 33 XX 34 35 36 37

8.4.2 CONTENTS OF EXCEL MACRO 'DATAIN'

```
'
' datain Macro
' Macro recorded 27/3/96 by Geoff Mauger
' Modified 17/7/96 by Renee Dixon
' Modified 17/4/97 by Alex Rogers
' load data from text file generated by program TABLIST (in RASCAL\EXE)
'
' Keyboard Shortcut: Ctrl+d
'
Sub all()
  txtdir = "S:\RID\CSI\WARREN\MDL\RAS\APR9RSLT\"
'  txtfile = "area.TXT"
'  load2 txtdir & txtfile, 2
'    storeOne txtfile, "B", 138
  txtfile = "ca.TXT"
  load2 txtdir & txtfile, 2
    storeOne txtfile, "D", 139
  txtfile = "fc.TXT"
  load2 txtdir & txtfile, 2
    storeOne txtfile, "D", 140
  txtfile = "sfbs.TXT"
  load2 txtdir & txtfile, 2
    storeOne txtfile, "D", 141
  txtfile = "psbs.TXT"
  load2 txtdir & txtfile, 3
    storeOne txtfile, "D", 144
    storeOne txtfile, "E", 143
  txtfile = "slbs.TXT"
  load2 txtdir & txtfile, 2
    storeOne txtfile, "D", 145
 txtfile = "rain.TXT"
   load2 txtdir & txtfile, 2
   storeOne txtfile, "D", 155
   storeOne txtfile, "C", 138
  txtfile = "pa20.TXT"
   load2 txtdir & txtfile, 2
```

```
  storeOne txtfile, "D", 147
 txtfile = "pd20.TXT"
   load2 txtdir & txtfile, 3
   storeOne txtfile, "D", 149
   storeOne txtfile, "E", 150
 txtfile = "sftr.TXT"
 load2 txtdir & txtfile, 2
   storeOne txtfile, "D", 154
 txtfile = "pstr.TXT"
 load2 txtdir & txtfile, 3
   storeOne txtfile, "D", 152
   storeOne txtfile, "E", 153

End Sub
Sub storeOne(ByVal txtfile As String, ByVal scol As String, orow)
   cutpaste txtfile, "1-12", scol, 1, 12, "B", orow
   cutpaste txtfile, "12-24", scol, 14, 25, "C", orow
   cutpaste txtfile, "24-32", scol, 27, 35, "C", orow
   cutpaste txtfile, "32-39", scol, 37, 42, "C", orow
   cutpaste txtfile, "39-49", scol, 44, 53, "C", orow

End Sub
Sub load2(ByVal strFileName As String, strw)
    Workbooks.OpenText Filename:=strFileName, Origin:= _
      xlWindows, StartRow:=strw, DataType:=xlDelimited, TextQualifier _
      :=xlNone, ConsecutiveDelimiter:=True, Tab:=False, Semicolon _
      :=False, Comma:=False, Space:=True, Other:=False, FieldInfo _
      :=Array(Array(1, 1), Array(2, 1), Array(3, 1), Array(4, 1))
 End Sub
Sub cutpaste(ByVal txtfile As String, ByVal xlsheet As String, _
         ByVal scol As String, srow1, srowl, ocol As String, orow)
   Windows(txtfile).Activate
   Range(Cells(srow1, scol), Cells(srowl, scol)).Select
   Selection.Copy
   Windows("WRNTABLE.XLS").Activate
   Sheets(xlsheet).Select
   Range(ocol & orow).Select
    Selection.PasteSpecial Paste:=xlAll, Operation:=xlNone, SkipBlanks _
      :=False, Transpose:=True
End Sub
```

8.4.3 CONTENTS OF EXCEL MACRO 'PRINTALL'

```
' Macro1 Macro
' Macro recorded 27/3/96 by Geoff Mauger
' Modified 24/9/96 by Renee Dixon
' Modified 17/4/96 by Alex Rogers
'
Sub printall()
   printtabl ("a1:n36")
   printtabl ("a39:m74")
   printtabl ("a77:m112")
End Sub
Sub Print2(ByVal cat As String, ByVal table As String)
   Sheets(cat).Select
   Range(table).Select
   Selection.PrintOut Copies:=1
End Sub
Sub printtabl(ByVal table As String)
   Print2 "1-12", table
   Print2 "12-24", table
   Print2 "24-32", table
   Print2 "32-39", table
   Print2 "39-49", table
End Sub
```