FIELD DAY TO

SALINITY RESEARCH PROJECTS IN

THE WELLINGTON DAM CATCHMENT

28 August 1978

Sponsored by
Lions Club of Collie

FIELD DAY PAPERS

Salinity Research Projects in

the Wellington Dam Catchments

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Sponsored by Lions Club of Collie in
conjunction with Department of Agriculture,
Public Works Department, Forests Department
and CSIRO

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PROGRAMME

10.00 a.m.	Assembly at Recreation Grounds, Prinsep Street, Collie
	Introductory Comments - Field Day Chairman
	Speakers: Problem Identification : Farmers' Problem in Salinity Control by Peter Piavanini : Introduction to Research and Investigation Programmes Aimed at Controlling Stream Salinity in the Collie Catchment by Ian Loh (Public Works Department)
10.30 a.m.	Leave Collie
11.15 a.m.	Arrive Lemon Catchment Weir Site
	Speakers: Causes of Salinity by Clive Malcolm (Department of Agriculture) : Catchment Studies by David Williamson (CSIRO)
11.45 a.m.	Leave Lemon Catchment
12.00 a.m.	Arrive Dons Catchment
	Speakers: Clearing Strategies by Adrian Peck (CSIRO) : Agricultural Management of Cleared Areas by Rudolph Sprivulis (Department of Agriculture)
12.40 a.m.	Leave Dons Catchment
1.10 p.m.	Arrive Stene's Demonstration Area
	LUNCH (included in registration fee)
1.40 p.m.	Official Opening - Mr. G. MacKinnon, M.L.C.
1.50 p.m.	Equipment Demonstration - Trees as Water Pumps by Eric Greenwood (CSIRO)
2.10 p.m.	Speakers: Management Strategies for Stream Rehabilitation by Ian Loh (Public Works Department) : Cultural Techniques in Reafforestation by Drew Haswell (Forests Department)
2.45 p.m.	Catchment Studies and Salinity Control - A Summary by Clive Malcolm (Department of Agriculture)
3.00 p.m.	Leave for Collie
3.30 p.m.	Field Day ends at Recreation Grounds, Collie

FIGURE 1

LOCALITY PLAN OF LAND USE & WATER QUALITY STUDIES IN WELLINGTON DAM CATCHMENT

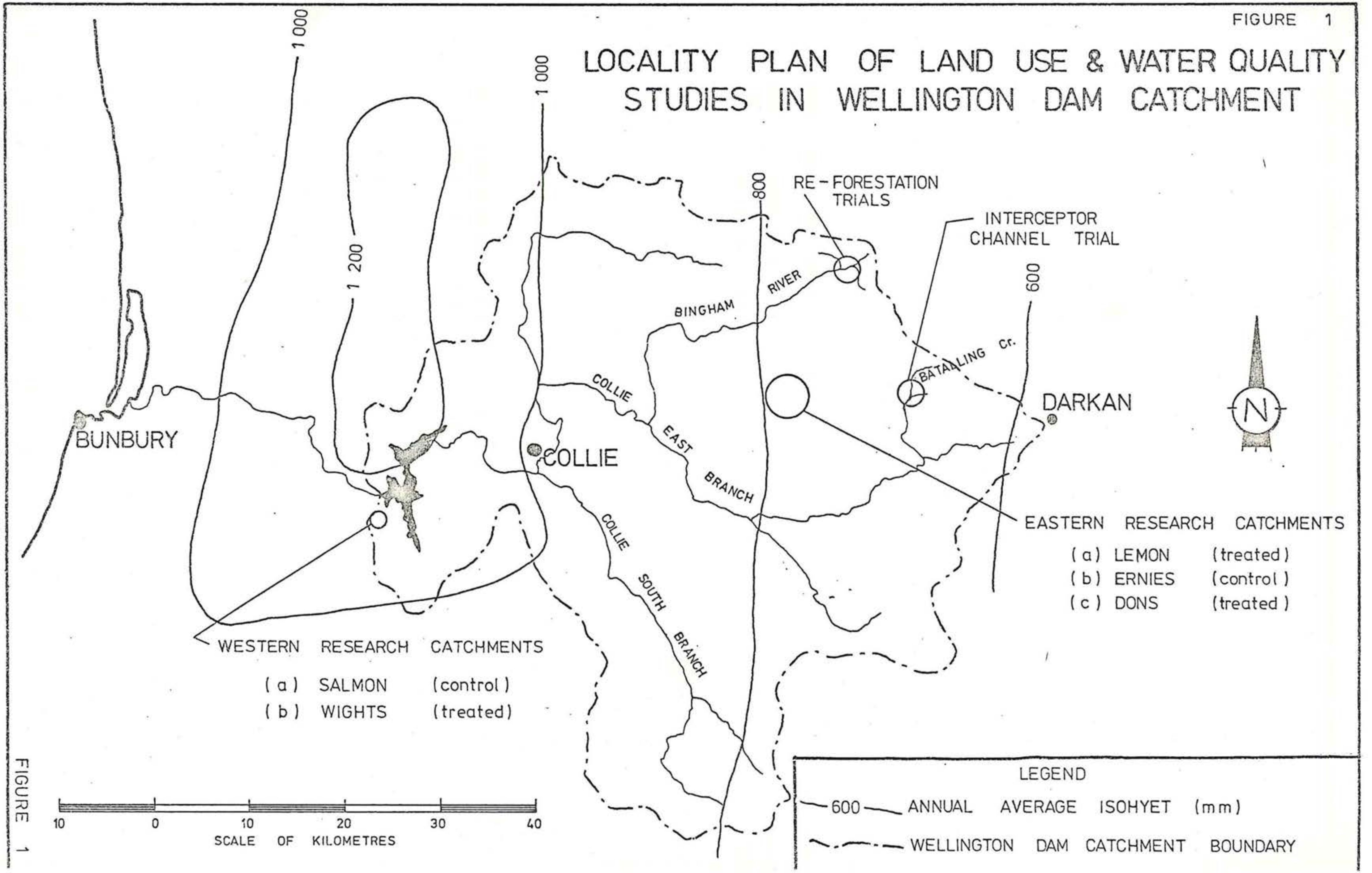


FIGURE 1

FARMERS PROBLEMS IN SALINITY CONTROL

Peter Piavanini - Collie

Actual salinity problems on farmers' properties are not a major problem to most farmers in the catchment area, although there are a few who are affected by actual salt encroachment. Their main concerns are

1. the uncertainty of the future development of their individual property due to imposed restrictions, and

2. the lack of liaison with the Public Works Department.

State Government Departments and some members of the general public seem to be under the impression that farmers are up in arms about not being able to clear land in the catchment area. As a person who has had a long association with farmers in this area, I do not believe farmers feel that way. The majority of farmers agree that clearing does cause salinity. However, they should not have to carry the financial burden of this problem, because water is a national resource.

Every farmer in the catchment is faced with his own individual problem.

1. The farmer who is fully cleared does not know if there will be a reafforestation program on his property.

2. The farmer who wants to sell his property meets buyer resistance. As an estate agent who operates in this area, I have found that buyers do not want to know about farms in the catchment area. There is a great deal of buyer resistance to farms in the area which is affecting values dramatically.

3. The farmer with two-thirds of his property cleared cannot clear any more thus making a potentially viable property not viable.

4. Most farmers owning land adjoining the town area, with the potential to subdivide the land, feel they have been poorly treated.

The Government has put the restrictions on to farmers' land but the farmers have to go to the Public Works Department, cap-in-hand, for any information regarding procedures related to these restrictions. I think it is high time the Government appointed a full-time liaison officer in the area who would go to the farmers rather than the farmers having to take the initiative.

INTRODUCTION TO RESEARCH AND INVESTIGATION PROGRAMMES AIMED AT CONTROLLING STREAM SALINITY ON THE COLLIE CATCHMENT

I. Loh - Public Works Department, West Perth

1. BACKGROUND

Clearing for Agriculture throughout much of the south-west of Western Australia has caused major increases in the salinity of streams draining the region. The increase in salinity of inflow to Wellington reservoir over the last thirty years is a classical example. In the late 1940's when only 5% of the catchment area was cleared, average inflow salinities were approximately 250 mg/l TDS. By the mid-1970's when clearing had reached 23%, average inflow salinities were around 750 mg/l TDS. Inflow salinities have not increased uniformly over time, however. Different sequences of floods and droughts have caused major fluctuations in salinities from year to year which have far out-weighed the gradual yearly increase in salinity caused by clearing. This has made the identification of the effects of clearing particularly difficult in the past.

Short term variations in inflow salinities also occur, which together with temperature variations, give rise to density (temperature and salinity) layering in the reservoir. From detailed research work by the University of Western Australia on the water mixing processes within the reservoir, new operating policies to minimise the build up of salt in the reservoir have been developed. The new policies are expected to improve the supply salinity by about 10% but long term solutions to the problem lie in improved catchment management aimed at reducing the inflow salinities.

The first catchment management strategy aimed at salinity control was introduced in the early 1960's. No further crown land was released for agricultural development in Wellington Dam catchment after 1962. However clearing of existing privately owned land continued through the 1960's and early 1970's. In November 1976, legislation was passed to control further clearing on the catchment including clearing on the remaining privately owned land as yet uncleared.

There is a considerable delay (sometimes tens of years) between the actual clearing and its full effect on the surface stream system. It has been estimated that without further action salinities of inflow could reach 1100 mg/l TDS as the full effect of clearing prior to the legislation control develops. If this inflow salinity develops application of the new reservoir procedures should result in an average reservoir salinity of about 1000 mg/l TDS with some 5% of years (drought years) being over 1400 mg/l TDS. It is clear, therefore, that it is not sufficient to control further clearing. Rehabilitation techniques need to be actively researched and field tested so that land management programs can be developed which protect water quality but minimise the disruption to agricultural practices.

2. WELLINGTON RESERVOIR SALINITIES

Figure 1 shows the great variability in the salinities of inflow to Wellington Reservoir, both the long term and short term.

These salinity changes together with temperature variation cause salinity layering within the reservoir. (See Figure 2) By careful manipulation of the scour values during the winter saline water can be selectively removed without affecting the current supply requirements from the reservoir.

New operating policies to carry out this procedure have been in operation since September 1976. However the scouring technique is only likely to improve average reservoir salinities by about 10%. Solutions to the salinity problem in the long term involves better methods of land management which reverse the adverse hydrologic changes which have occurred following clearing. The partial reforestation trial along the Bingham Valley is one such trial.

MONTHLY SALINITIES AND INFLOWS INTO WELLINGTON RESERVOIR (1963 -1977)

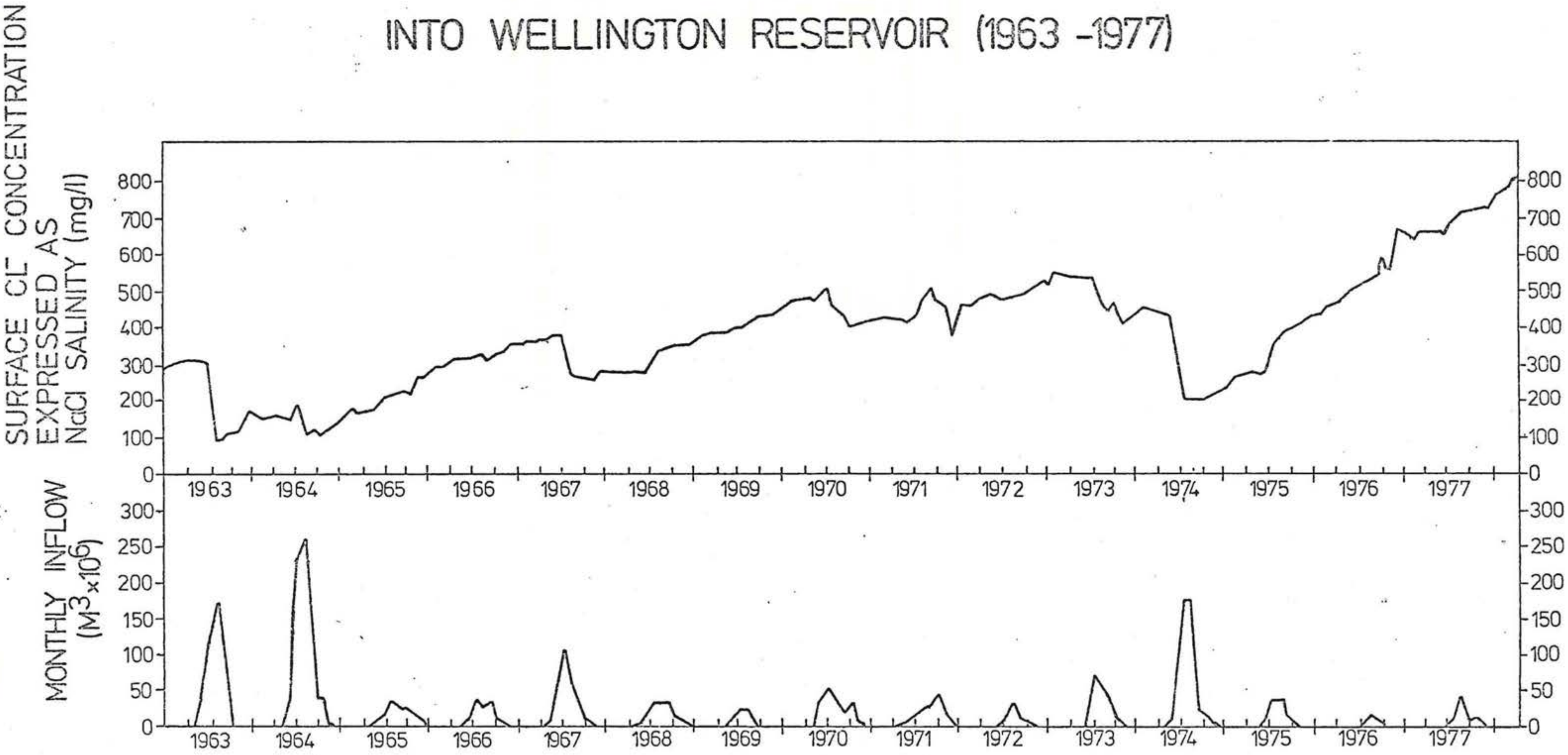
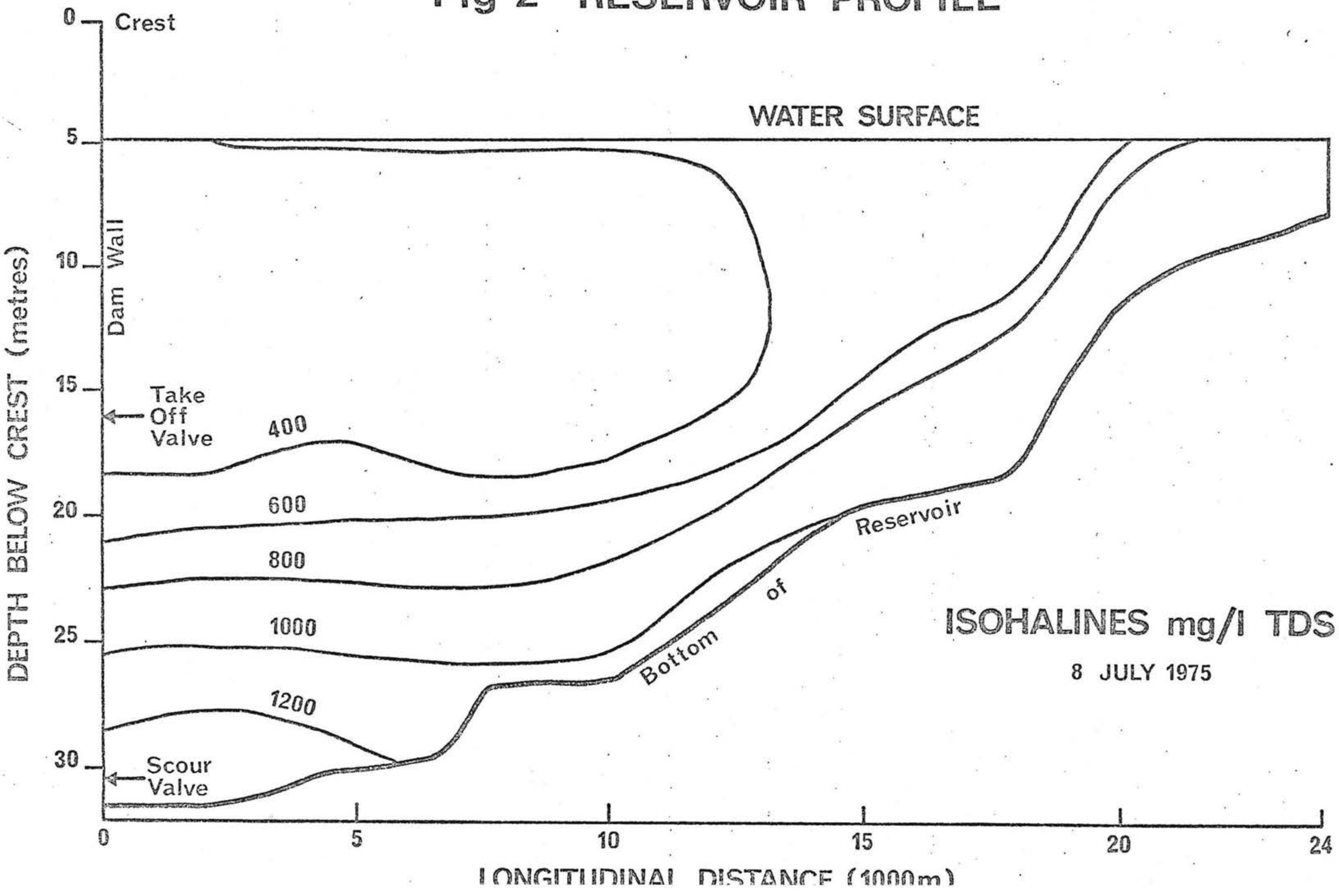


Figure 1

Fig 2 RESERVOIR PROFILE



WHY DOES LAND CLEARING TURN OUR STREAMS AND SOILS SALINE?

C.V. Malcolm - Department of Agriculture, South Perth

The fresh rainwater brings with it each year a small, harmless amount of salt, about 50-100 kilograms per hectare. Some of the salt returns to the sea in rivers but some is left behind in the soil. Over thousands of years the amount of salt stored in the deep clay subsoils and groundwaters has built up to tonnes or even hundreds of tonnes per hectare. The most salt is stored in the deepest clay subsoils.

While the forest remains, and uses a large proportion of the rain each year, there is insufficient water moving through the soil to wash the salt out into the natural drains (rivers). When the forest is disturbed by logging, dieback, mining or agriculture, less rainfall is used. Some of the unused water drains deep into the soil and joins the groundwater. On its way it washes salt from the soil and carries it to the groundwater. The extra water raises groundwater levels causing an increase in seepage flowing into the streams. Because the seepage flow is saltier than surface runoff an increase in seepage causes an increase in stream salinity unless it is diluted by extra runoff.

Even if the groundwater does not flow into streams it may come close enough to the surface to cause a soil salinity problem.

To prevent or minimise salt problems we need to stop the stored salt from being moved. It may be possible to avoid clearing those parts of catchments where the most salt is stored, or to plant species which will use more water. A more hazardous alternative is to increase runoff so that the seepage flows are diluted by more fresh water from overland flow.

The overall principles that I have outlined are well proved. The experimental programme that you are to see today is designed to answer questions such as: how much clearing is possible; which soils can be cleared with least salt output; how long does the salt take to wash out of the landscape; how much replanting of trees is needed; and on which areas should replanting be done?

CATCHMENT STUDIES

D.R. Williamson - CSIRO Division of Land Resources Management

The CSIRO and Public Works Department, with co-operation from the Forests Department and Department of Agriculture are conducting experiments in small representative catchments to develop a detailed understanding of the effects of clearing the forest for agricultural use.

The aim of the catchment studies is to determine the size of all components of the hydrologic cycle and the salt cycle both before and after clearing. Five catchments have been instrumented, two west of Collie on the Salmon Brook and three east of Collie on tributaries of the Bingham River and Pollard Brook. Details of the catchments are given in Table 1. The paired catchment technique is being used which involves keeping one catchment uncleared to provide an estimate of the water and salt balance of the cleared catchment if it had not been cleared. This helps to overcome the effect of differences in the amount of rainfall from one year to the next. The catchment studies are providing data to test the effect of changes in land use.

CATCHMENT INSTRUMENTATION

The instrumentation is similar in each of the five catchments, except that there are more groundwater wells in the cleared catchments. The instrumentati in Lemon Catchment is a useful example to show what is being measured (see Figure 1). The storage raingauges provide both a measurement of the quantity of rainfall and a sample which is analysed for the salt content of the rain. The pluviometer provides a continuous record of the rainfall from which hourly (and hence daily) values may be obtained.

There are five water balance sites on each catchment. These are areas of 1/10th ha (1/4 acre) in which the water content of the soil is measured down to a depth of 5.7 m (19 ft). There is also a well for measuring the depth to groundwater in the deeper clay soil, and a well for measuring any perched groundwater in the surface sandy or gravelly soil.

A grid of wells spaced 400 m apart have been installed to measure the level of the groundwater in the clays. In addition, there is a group of wells installed in part of the catchment to observe when there is a perched groundwater in the gravelly soils overlying the clays.

The stream flow is measured using a V-notch weir, and daily samples of water are taken automatically. These are analysed for their salt and sediment content.

The salt content of the soil from the ground surface down to the basement rock has been determined using samples obtained at five sites with a Gemco drilling rig. Ten sampling sites were selected at the time the catchment was cleared. Some are in areas which could be expected to become saline. Measurements of the salt content in the top 2 m (6½ ft) are being made at least every two years to observe the changes in salt content of the soil.

In the Ernies catchment, the PWD have a climate station measuring temperature, wind, incoming solar radiation and pan evaporation. This is useful basic information for estimating evaporation from pasture, crop and forest.

Detailed soil maps have been determined for all catchments.

CLEARING ACTIVITIES

Agricultural-type clearing has been carried out in one western catchment (Wights) and one eastern catchment (Lemon), although clearing has been more complete than is usual for land to be used for crop or pasture. Table 2 gives the areas of clearing in each of the five catchments. On Lemon catchment the clearing is across the catchment including both valley and slopes to provide data on the major intake areas for the groundwater. Dr. Peck will explain the clearing strategies on Don's catchment later today.

This clearing program has been necessary because we need to study the catchments both before and after clearing. These studies could not be made on existing cleared land.

SOME RESULTS OF STUDIES

The quantity of salt stored in the soil under the forest varies from about 70 tonnes/ha (28 tons/acre) in western catchments (Wights) to over 300 tonnes/h (120 tons/acre) in the eastern catchments (Lemon). At least 70% of this salt is stored in the soil above the deep groundwater.

Under forest vegetation, the streamflow in the eastern catchments has been small or negligible, though of very good quality. The broad flat valley generates more streamflow on Lemon catchment than for the other catchments which do not have this feature. The annual streamflow from the two western catchments has been very similar varying from 2% to 27% of the rainfall before clearing. But in the first year after clearing, the streamflow increased by about 120% in Wights catchment compared to what the streamflow would have been if clearing had not occurred.

Prior to clearing the total salt content of the streams in the western catchments over 1000 mg/l (70 grains/gallon) in the early autumn falling to 100 mg/l (7 grains/gallon) in the wettest months. In the eastern catchments (eg. Lemon) the total salt content was always low in the stream water, being always less than 200 mg/l (14 grains/gallon). The data is still being processed for the salt content of streams since clearing. Studies of the chemistry of rain and stream water suggests that a significant amount of the streamflow has come from either a perched or deep groundwater system.

In the western catchments, the deep groundwater table extends across about 90% of the area, has an average depth of about 13 m below ground level with the annual fluctuation of the water table being about 2 m (6½ ft). The salt content is in the range 500 mg/l (35 grains/gallon) and 3500 mg/l (245 grains/gallon). In the drier eastern catchments (eg. Lemon), the deep groundwater table occurs in only 10% of the catchment, has an average depth of 10 m below ground level with an annual fluctuation of the water table of about 1 m (3 ft). The salt content is in the range 1000 mg/l (70 grains/gallon and 2500 mg/l (175 grains/gallon). The changes in groundwater levels due to the clearing should become more obvious after about three or four years of observations. On average, a molecule of water will travel a horizontal distance of less than 250 mm/year in the deep groundwater aquifer of these catchments.

Perched groundwaters have been observed in the gravelly surface soils but have been very seasonal. Increases in the quantity of water moving in the perched groundwater is expected in cleared catchments.

TABLE 1. General details of the catchments.

Catchment Group	Catchment Name	Area hectares	Estimated Av. Annual Rainfall mm	Starting date for measurements				Period of Clearing
				Streamflow	Rainfall	Soil Water	Groundwater	
Western Catchments	Wights	93.8	1150	April 74	Sept 73	Jan 74	April 73 Feb 74	Dec 76 to June 77
	Salmon	81.8	1150	April 74	Sept 73	Jan 74	April 73	Not cleared
Eastern Catchments	Dons	350	750	April 74	Sept 73	Dec 73	Nov 72 May 76 Aug 77	Oct 76 to June 77
	Ernies	270	750	April 74	Sept 73	Dec 73	Nov 72 Feb 73	Not cleared
	Lemon	344	800	April 74	Sept 73	Dec 73	Jan 73 May 76	Oct 76 to June 77

TABLE 2. Areas of clearing in catchment studies

CATCHMENT NAME	CLEARING STRATEGY	AREA CLEARED ha
Western Catchment		
Wights	completely cleared	93.8
Salmon	not cleared (control)	nil
Eastern Catchments		
Lemon	lower half cleared	184.0
Earnies	not cleared (control)	nil
Dons	parkland	14.2
	strip clearing	69.5
	clearing ridges	17.5
	clearing lower slopes	31.5

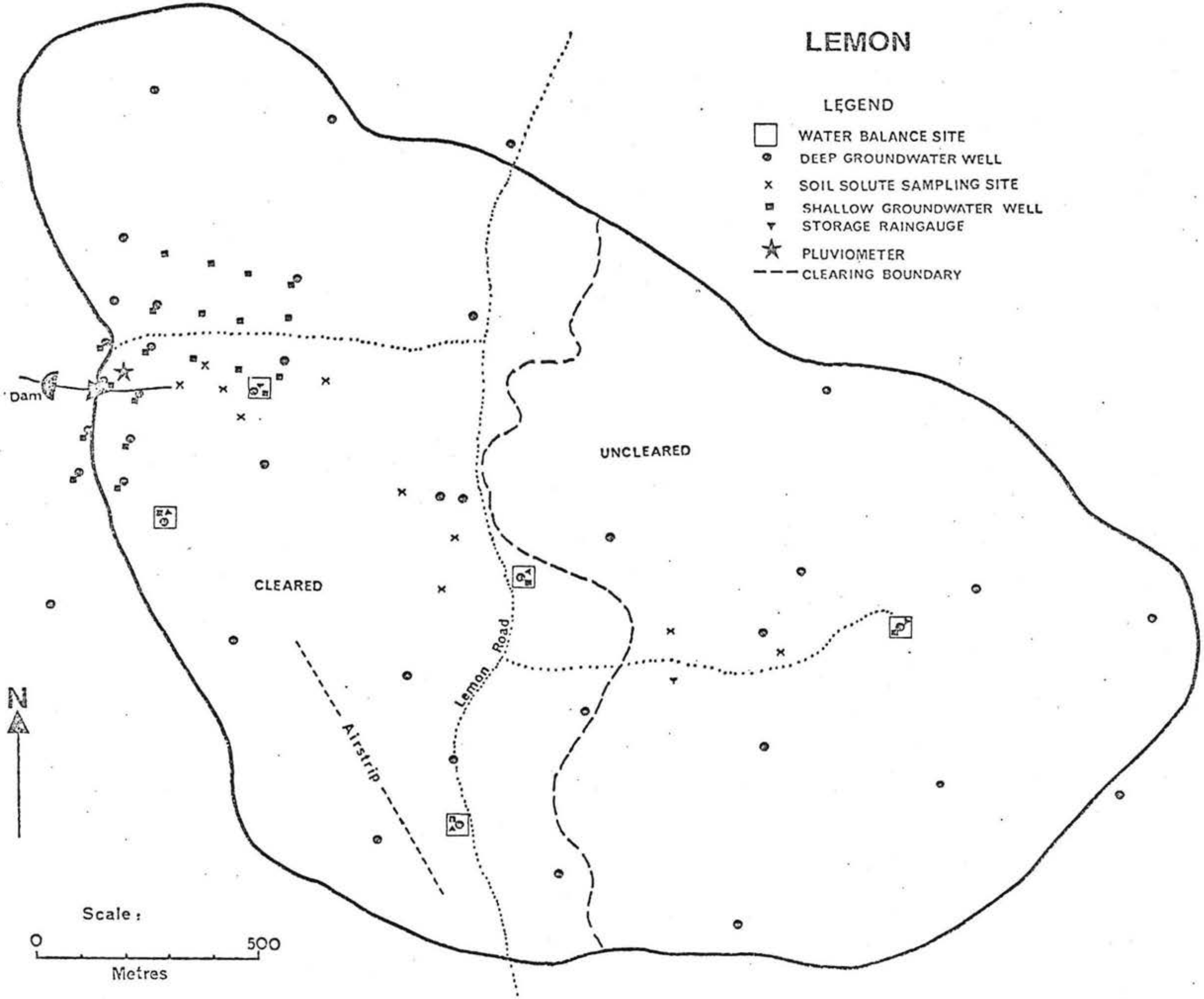


Figure 1. Instrumentation of the Lemon catchment

CLEARING STRATEGIES ON DONS CATCHMENT

A.J. Peck - CSIRO Division of Land Resources Management

Saline seepages affect cropland and pastures over a large area of the Great Plains in North America - Montana, North Dakota and South Dakota in the United States, and Alberta, Saskatchewan and Manitoba in Canada. Both the soils and the climate there are very different from what we experience in Southern Australia, but there are many similarities between their salinity problem and ours.

The North Americans have successfully reclaimed saline seepages by careful attention to water management on the farm. They drain surface water from areas where it tends to accumulate, avoid leaving land under fallow, and plant deep-rooted, water-loving varieties of crops and pastures near saline seeps.

The experiments in Dons Catchment are designed to determine the effectiveness of native trees in holding the water table down. It may be possible that this task can be achieved by plants which are more valuable to the farmer (e.g. pines or perennial pastures), but at this time we don't know suitable species or management for many of our areas with salinity problems.

The basic questions that we are hoping to answer with the Dons experiments are:

(i) What area of the water-loving plants is needed relative to the area of normal crop or pasture?

(ii) Whereabouts in the landscape is it best to plant the water-loving plants? and

(iii) Can the water-loving plants survive when salts begin to accumulate around their roots?

The strip clearing on Dons examines effects of the proportion of trees to crop (10%, 20% and 30%) and the width of the strips (100, 150 and 300 m). Elsewhere in this catchment we have an area of parkland clearing (25 trees/ha left), and comparisons of clearing valley and lower slope soils or the rocky laterite on upper slopes.

Many boreholes have been drilled throughout Dons Catchment. These are monitored regularly to detect any changes in the groundwater system. Because of the time taken for water to penetrate to a water table perhaps 20 m below the surface, and the fluctuations of water table height which occur even under the forest, we do not expect to be sure of any changes within about 2 years of clearing. That time is nearly up. In the next few years we may notice some changes, but it is likely to be several years before we can make any recommendations to farmers on the basis of this experiment.

LAND UTILISATION ON WIGHT'S, LEMON AND DON'S CATCHMENTS

R. Sprivulis - Agricultural Adviser,
Department of Agriculture, Bunbury

CLEARING

The bulldozing on all three blocks was preceeded by the removal of millable timber at the end of 1976 and in early 1977.

The bulldozing, wind rowing, burning and levelling of the ground was scheduled to be completed by the end of April, 1977. The contractors with the cheapest quote fell hopelessly behind the schedule and another contractor had to be engaged. This delayed the seeding until the middle of June, 1977.

SEEDING

In June the cleared ground had become too boggy for ground seeding and supering. The seed and fertiliser were applied by aerial broadcasting.

The fertiliser dressing consisted of Super, copper, zinc, molybdenum Mix No. 2 applied at 350 kg/ha.

The pasture seed was sown at the following rates:

Wight's Block (Rainfall 1150 mm/annum)	kg/ha	Lemon and Don's Blocks (Rainfall 800 mm/annum)	kg/ha
Woogenellup	4.5	Daliak	4.5
Dinninup	4.5	Seaton Park	4.5
Mt. Barker	4.5	Dinninup	4.5
Total Sub-clover	13.5	Total Sub-clover	13.5
Wimmera Ryegrass	4.5	Wimmera Ryegrass	4.5

All clover seed was inoculated and lime pelleted.

The winter of 1977 was abnormally dry and this reduced the strike of the seed sown.

In the autumn of 1978 the poorly covered spots were reseeded with Dinninup at an overall rate of 7 kg/ha. All areas received plain super at 200 kg/ha.

PROJECTED LAND MANAGEMENT

The Wight's and Lemon blocks of 94 ha and 187 ha, respectively, have been fenced, provided with water and will be utilised as grazing leases.

The 134 ha of Don's block, because of its clearing strategy and the presence of Heart Leaf poison has been leased for cropping. This year it has been planted to Fest lupins and West oats.

MANAGEMENT STRATEGIES FOR STREAM REHABILITATION

I. Loh - Public Works Department, West Perth

1. REFORESTATION TRIALS ALONG THE BINGHAM RIVER VALLEY

The Public Works Department purchased a large farming property in the north eastern section of Wellington Dam catchment some time before legislation to control further clearing on the catchment was proclaimed. The property flanked the upper sections of the Bingham River Valley, a major tributary of the Collie River. An arrangement was made with Mr. Roff Stene (a previous part owner) to lease the majority of the cleared areas of the property from the Public Works Department while co-operating with the Department on reforestation trials on the remaining cleared areas. A 140 ha experimental area was selected in 1976 to carry out strip reforestation of approximately 20% of the area. Co-operation was sought from the Forest Department to plant and manage the reforestation. Guidance and assistance from other government departments and CSIRO has also been provided. This study represents one of a number of investigations into the role of reforestation on both stream water quality and salt affected land. The approach assumes that changes in the deep saline groundwater system following clearing is the dominant mechanism causing the salinity problem and that by strategically placing strips of trees, groundwater levels can be lowered locally around drainage lines to minimise the discharge of salts to the stream system.

It is hoped that the trial will show that partial reforestation is compatible with continued farming practice, to show the effect of existing and recently planted vegetation on the groundwater table, and to study the suitability of different tree species for reforestation in the eastern section of Wellington Dam catchment.

A trial of reforesting approximately 20% of the cleared area upslope from salt affected land was commenced in 1976. Plantings continued in 1977 and additional plantings are planned for this year (1978). The general layout is based on the premise that, by strategically placing belts of trees to intersect groundwater seepage, much of the harmful discharge of saline groundwater to the surface stream system can be stopped.

Groundwaters are being monitored under reforestation, the adjacent pasture and forest (see Figure 2 and Figure 3). Changes of 11 m in the groundwater levels following clearing have been inferred from control bores in a forested valley downstream. From assumed pre-clearing groundwater levels and an aquifer storage coefficient, predictions of the additional groundwater recharge following clearing at the reforestation site were made. These did not contradict previous recharge estimates based on catchment salt and water balances. Some additional confidence can therefore be placed on the existing predictions of the effects of additional clearing on stream water quality in the low rainfall areas (800 mm per annum).

Over fifteen different species have been planted from possible commercial species such as Pinus radiata to salt tolerant species such as Tamarix and Eucalyptus camaldulensis (River Red Gum). Seedling survival following planting (establishment) and subsequent tree growth has been good on upslope sites but poor establishment caused by site preparation difficulties in the wetter salt affected lower slopes have occurred. In addition to planting one or two year seedling stock, small scale trials of direct seeding of eucalypts were carried out following some success with the technique in the rehabilitation of bauxite mined areas.

Germination has been satisfactory and it appears a cheap and effective means of establishing trees on farmland. Larger scale trials will be carried out this year. Additional time for tree growth is required before significant changes in the groundwater levels beneath reforested strips could be expected.

While the results show that a natural mature forest can maintain a low water table level as groundwaters rise under adjacent pasture, this does not mean that trees can recover an initially disturbed situation sufficiently to halt all undesirable saline groundwater discharge. Long term monitoring of the groundwater under the reforested plots is required before any conclusions can be made about the success of the trial.

2. INTERCEPTOR CHANNEL TRIAL ON BATALLING CREEK

Unfortunately, there is not sufficient time available during this field day to make an inspection of this trial. However, the following details are given for general information.

The Department has recently commenced an investigation of a surface drainage scheme suggested by Mr. Whittington as a technique for rehabilitation of salt affected streams. Mr. Whittington has claimed considerable success with a similar (but not precisely the same) technique for rehabiliation of salt affected land on his property at Brookton. Interceptor channels have been constructed under Mr. Whittington's supervision upstream of a previous gauging station on Batalling Creek, a tributary of the Collie River East Branch. The flow and salinity of one drain or interceptor channel is being directly monitored together with the shallow and deep groundwater beneath. The concept behind the scheme is that the interceptor channels will intersect shallow fresh subsurface flow and pass it more directly to the stream system. That is, by harnessing this fresher water, seepage to the valley is reduced, evaporation is therefore reduced and salts do not concentrate in the soil surface in the valley. Mr. Whittington's scheme assumes that deep groundwater is not a major factor in the salinity problem.

No conclusions can be expected of the effect of the whole scheme on the streamflow draining the area for a number of years. It is hoped, however, that by measuring flows in the drain this year estimates of the magnitude of the schemes likely affect on the general streamflow will be possible within a much shorter time scale.

Initial results from the groundwater drilling and monitoring indicates that shallow subsurface flow occurs during winter but that deep saline groundwater is also contributing to the salt affected valley. The study is now awaiting completion of the winter period and an assessment of the quantity and quality of flow in the drain relative to the total streamflow.

MAP OF REFORESTATION LAYOUT AND BOREFIELD

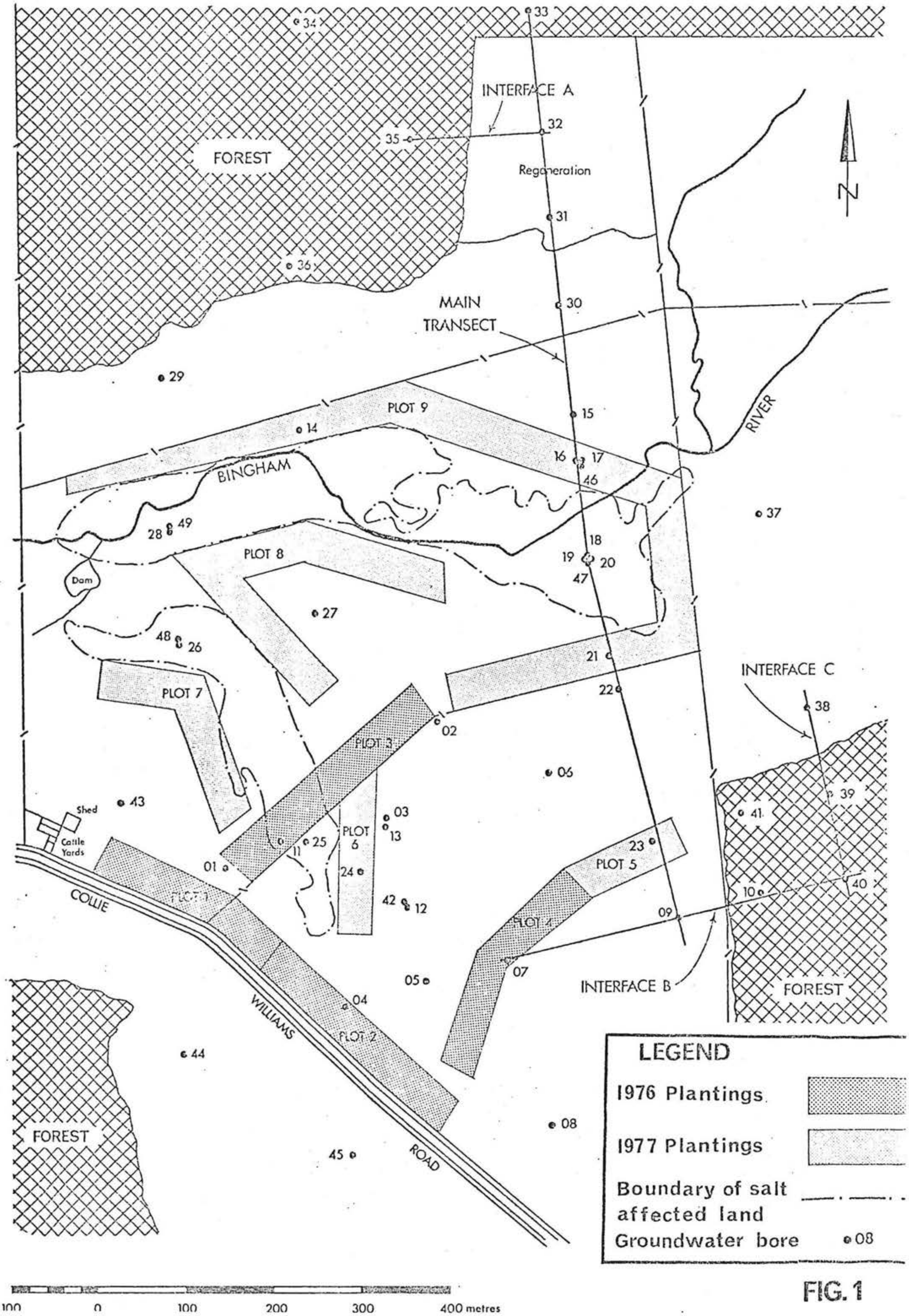


FIG. 1

VEGETATION AND GROUNDWATER PROFILE OF MAIN TRANSECT

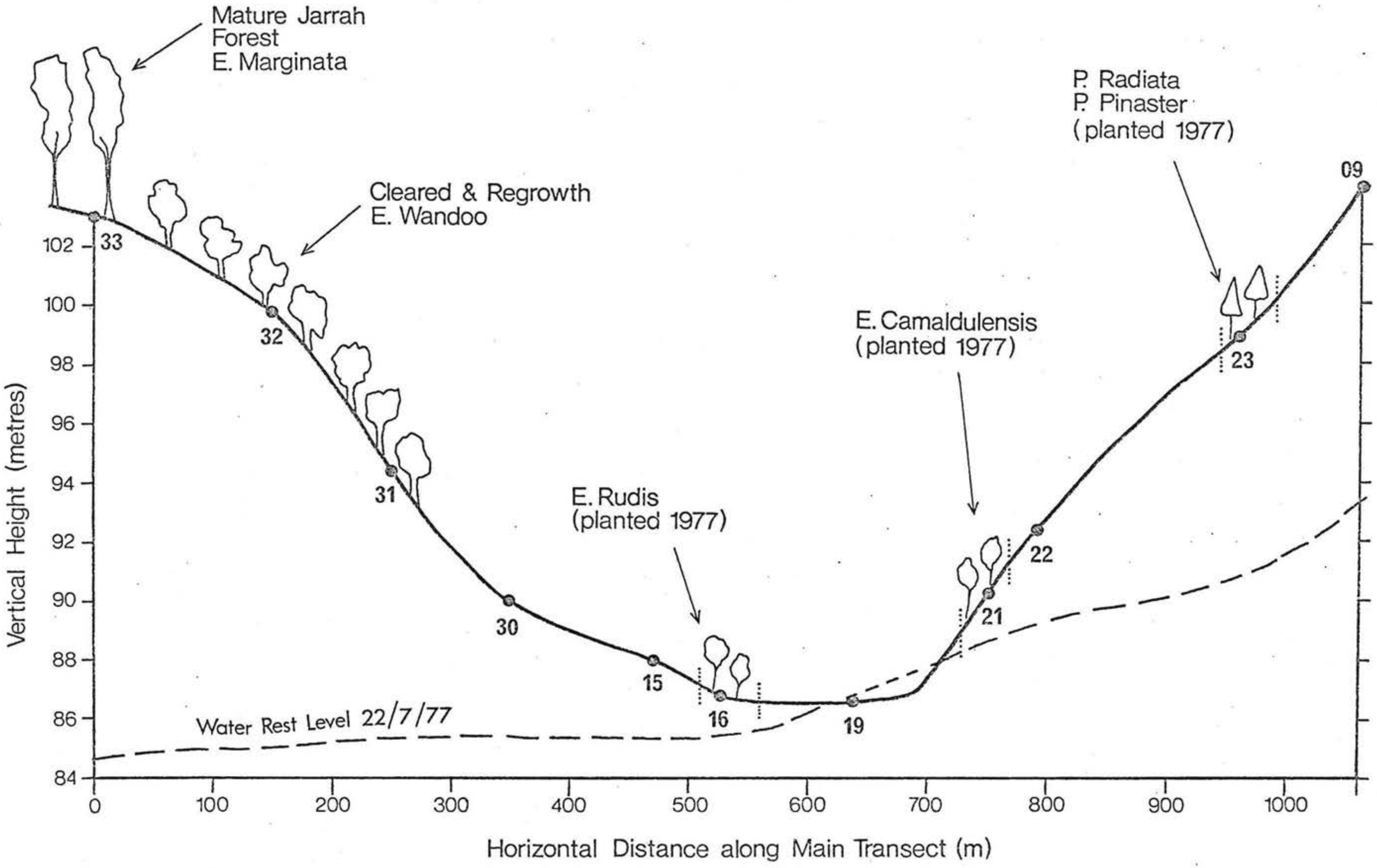


FIG. 2

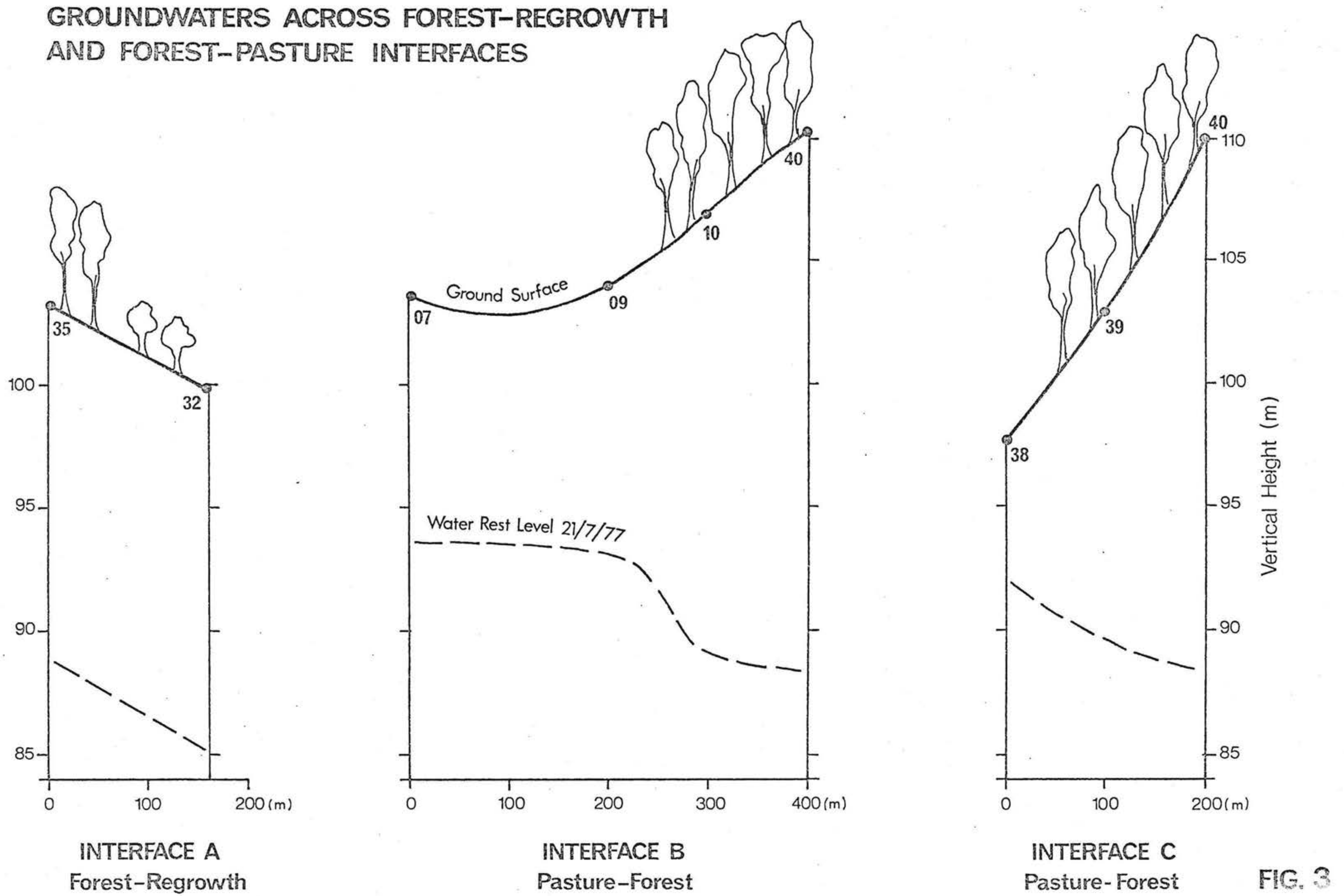

GROUNDWATERS ACROSS FOREST-REGROWTH
AND FOREST-PASTURE INTERFACES
Ground Surface
Water Rest Level 21/7/77
35
32
07
09
10
40
38
39
40
100
95
90
85
110
105
100
95
90
85
Vertical Height (m)
0
100
200 (m)
0
100
200
300
400 (m)
0
100
200 (m)
INTERFACE A
Forest-Regrowth
INTERFACE B
Pasture-Forest
INTERFACE C
Pasture-Forest

FIG. 3

CULTURAL PRACTISES EMPLOYED FOR THE REFORESTATION OF SALT AFFECTED FARMLAND

D.A. Haswell - Forests Department, Collie

INTRODUCTION

The reforestation programme at Stenes property north-east of Collie has been in progress for the past three years. The initial aims were:

1. To identify tree species which would tolerate the specific saline conditions at Stenes.

2. To establish cultural techniques for tree establishment.

3. To identify problems associated with tree establishment.

During Year 1, tree plantings on mid and upper slopes were generally successful. Problems first became evident for plantings in Year 2, which extended into waterlogged, saline sites where tree mortality became very high.

Modifications to planting techniques were carried out in Year 3 and it now appears likely that greater success may be expected. The following outlines cultural practises for strip reforestation out at Stenes.

SITE PREPARATION

Because of the high water yield on cleared areas following autumn rains, all ground preparatory work must be commenced early to avoid bogging. The following sequences are recommended.

1. Burning of the areas should be carried out in late November. The aim of this operation is to incinerate annual rye and barley grass seed. In general, the hotter the burn, the greater will be the incineration of seed.

2. Site demarcation. If it is intended to graze adjacent paddocks, the planting site must be fenced.

3. The planting area must be ploughed in April, primarily to increase water infiltration and to stimulate annual grass germination.

4. All low lying sites, plus a proportion of bottom slopes, must be mounded at right angles to the main stream flow.

5. Mid slope areas should be ripped to a depth of 0.3 m with a multi-tyned ripper.

6. Upslope areas should be deep ripped to a depth of 0.6 m with a single tyned rabbit ripper.

7. Entire area must be sprayed with a herbicide such as Vorox AA, at the rate of 5 litres/ha, using a Terra spray jet.

All tractor operations must be completed in the mounded areas by early June, to avoid bogging.

PLANTING

With the exception of mounded areas, planting commences in early June and can proceed to the end of July using open rooted seedling stock. The use of Jiffy or other forms of containerised stock can extend planting to the beginning of August. On mounded areas in low lying sites, water availability is not a problem and planting can be delayed to the end of August. Planting must not commence until winter rains are assured and saturation of the soil profile has occurred to a depth of 1 m. It is necessary to establish soil moisture depth by digging test holes. The following sequences then apply:

1. Visually divide the site into:

   High salt zones - waterlogged areas, non-mounded
   moderate salt zones - mid slopes
   low salt zones - upper slopes and ridges

2. In these eastern areas, species suitable for the above salt zones are as follows:

   High salt zone - E. sargentii, rudis, camaldulensis
   Moderate salt zone - E. rudis, camaldulensis, patens
   Low salt zone - E. camaldulensis, calophylla, wandoo, accedens, marginata
   P. radiata (deep soils only)

   In selecting species, preference should be given to species local to the area, which have shown a high capacity to draw and release water to the atmosphere. Of the above species, E. camaldulensis, wandoo, patens, marginata and P. radiata have commercial significance.

3. Planting should commence on upslope areas first and proceed downslope eventually to the mounded areas. These latter areas should be left to the end of August to allow for maximum salt leaching of the soil in the mounds.

4. Planting should be carried out to a spacing of 4 m x 2 m which will provide a stocking of 1250 seedlings per ha. This should reduce to the desired final stocking of 1000 seedlings per ha through normal planting mortality.

5. Methods of planting vary, but the best is to use a mattock (container stock), or wedge shaped planting spear (open rooted stock). When planting:

   a. Seedlings must be firm in the ground. It should not be possible to pull them out with the forefinger and thumb using light pressure.

   b. Elimate all air pockets in the soil by double spearing and firming in with the boot heel.

   c. Seedlings must be planted 3 cm below nursery depth and no roots should bend upwards.

   d. Seedlings must be erect.

   e. Discard inferior seedlings and only plant those with good vigor.

f. Do not expose seedling roots under any circumstances. In particular, open rooted seedlings must be kept wrapped in moist hessian bags and must be heeled in overnight. They should be discarded if more than 24 hours old.

g. Seedlings must be planted either on mounds or in the ripped lines.

h. Do not transport plants in an open vehicle, as this will rapidly dry out the young seedlings.

FERTILISER APPLICATION

Fertiliser is required to improve the chances of seedling establishment and then to provide rapid growth to overcome competition from annual grasses. Fertiliser regimes are selected to suit the saline classification of the area, as follows:

High salt zone - superphosphate only, at the rate of 90 g/tree
Moderate salt zone - Agras 2, at the rate of 60 g/tree
Low salt zone - Agras 2, at the rate of 60 g/tree

1. Fertiliser should not be placed on the young seedling under any circumstances.

2. The best method is to spear fertiliser in by creating a vee-notch to a depth of 0.2 m on the downslope side of the seedling. The notch should be approximately 0.3 m away from the base of the seedling. Fertiliser is then placed in the vee-notch, which may be left open.

3. A subsequent application of fertiliser may be made at age six months.

4. For P. radiata, all fertiliser quantities should be doubled. Additionally a foliar spray of 2% manganese, copper and zinc should be applied at age one year for maximum result.

PROBLEMS

1. Vermin. Rabbits etc., must be totally excluded from the planting area. Local control can be effectively achieved by the ripping of warrens and subsequent fumigation of new holes as they appear.

2. Stock. Sheep and cattle must be totally excluded, as seedlings will be either eaten or trampled.

3. Annual Grass Control. Areas that have been exposed to intensive grazing, generally have a vigorous germination of both annual rye and barley grasses. Control before planting occurs must be carried out, if tree planting programmes are to succeed. The Forests Department has demonstrated that burning of the seed bearing heads in late November, followed by chemical control is very effective. However, cultural control by double ploughing may be appropriate. Whichever method is used, success must be guaranteed, or tree plantings will certainly fail.

4. Severe Salt Scalded Areas. At this stage it is not possible to expect major success of tree plantings in severe salt scalded areas. These areas will only become suitable for tree stocking, when adjacent plantings depress the water table and when a redistribution of surface and soil salt occurs.

FUTURE REFORESTATION TECHNIQUES

Direct Seeding. This technique, either by broadcast or spot sowing, is favoured when extensive areas are required for reforestation at a low establishment cost.

Seed supplied are, however, expensive to purchase due to the relative seed shyness of many eucalypts and the labour intensive nature of collection.

Broadcast techniques guarantee full stocking, but requires up to 1 kg seed/ha. Spot sowings may only require ¼ kg seed/ha, but cannot guarantee full stocking to the same extent.

Seed sowing may be carried out between April and June. It should not proceed beyond June, as the ground temperature is not suitable to break seed dormancy. It is a good idea to dust seed with a suitable insecticide and bulk up with a granulated fertiliser.

Mechanical planting. Equipment such as the Lowther and Quickwood planting machines have been developed, which increase the productivity of planting by a factor of 3.

These machines are drawn by a normal farm tractor using a 3-point linkage and can plant either container or open rooted stock. Adaptions have been recently made which allow for simultaneous fertiliser application.

SUMMARY

Successful tree planting on reclaimed farmland must be carefully planned and carried out using the correct techniques.

It is important, if reforestation programmes are to succeed, that in excess of 80% survival rate occurs each year.

The above procedures, if followed, should achieve these objectives.

MONITORING SALT SEEPS

A practical method is required for defining the salt seep boundaries, plus the direction of general recharge discharge channels.

By the time a saline seep becomes visible, the land has already been damaged, hence detection of encroaching saline water is necessary before any reclamation process is commenced.

PROBLEM

1. To accurately define the boundaries of surface salinity;
2. to define the below surface boundaries to a depth of 1 metre;
3. to define the recharge and discharge channels;
4. to plot annually the increase or decrease of the saline seep.

Abstract

A practical technique for defining saline seep boundaries, utilising earth resistance methods.

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The principle involved requires that a block of earth of approximately one metre^3 be measured for electrical resistance. In normal sites (pasture land) the resistance would be high, i.e. hundreds of ohms, but with the addition of soluble salts the earth resistance drops dramatically to below 5 ohms.

OHMS CALIBRATION

METER READING	SOIL SALINITY
3-5	SEVERE SALT
5-20	SALTY - BARLEY GRASS
20-40	MID SLOPE
40+	NO SALT EFFECT.

PRINCIPLES OF SOIL ELECTRICAL RESISTANCE

All soils can be considered as conductors or insulators of electrical current.

Most growing soils are high in electrical resistance, irrespective of moisture content. But with the addition of soluble salts, the resistance changes and the soils become conductors.

The fact can be used to advantage in defining of saline seeps, where the interest is not in the laboratory type analysis of accurate salt content but in the more general aspect of is it salty or fresh?

The method of measurement is to inject an electrical current into the soil via two probes, then measuring the current flow across two other probes. This principle is known as the

WENNER FOUR ELECTRODE SYSTEM

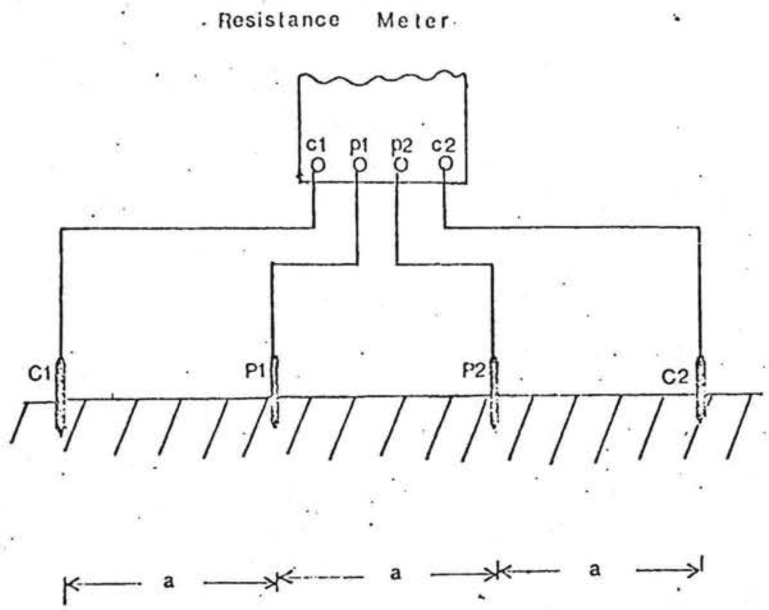
This system requires a group of four probes (stainless steel rods of 10 mm dia. by 400 mm long) be inserted into the ground approximately 50 mm or sufficient to make electrical contact. The probes are placed in line, with equal separation between each, the two outer probes are used to inject an electrical current into the ground, the two inner probes are used to measure the current flow and convert to resistance. Using this method, a block of earth approximately the size of 1½ times ("a" fig. 1) is being measured for E.C.

The depth of penetration is equal to each probe separation ("a" fig. 1).

Using the normal Wenner technique, the probe separation is increased progressively in half metre stages, eventually a change in readings indicates, either groundwater or bedrock.

WENNER TECHNIQUE

EARTH RESISTANCE MEASUREMENTS



PRINCIPLE

FOUR PROBES IN LINE and IN CONTACT WITH EARTH

EQUIDISTANT PROBE SPACING

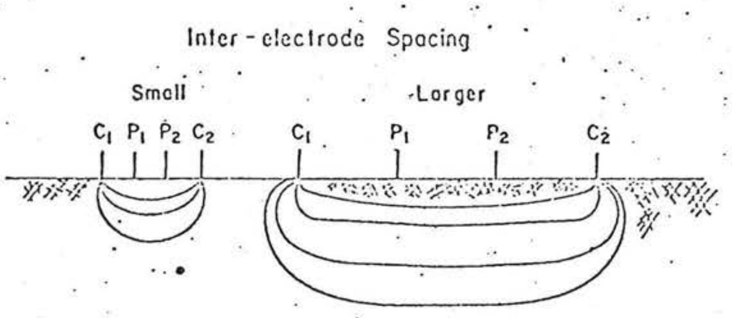
OUTER PROBES CI and C2 TO GENERATOR

ELECTRICAL RLSISTANCE MEASURED BETWEEN INNER

PROBES P1 and P2

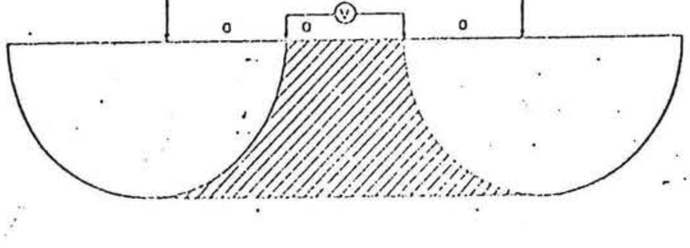
SEPERATION MEASURMENT of PROBES EQUALS

DEPTH PENETRATION



VOLUME of EARTH BLOCK EQUALS SEPARATION

of PROBES CUBED



EARTH RESISTANCE TRANSECT

Taken alongside a paddock fence using the fence posts as markers

RESISTANCE IN OHMS
AT 50 cm SPACING

No 1

6·5
6·5
9
8
9
8
6·5
4·5
3
5
7·5
5
10
9
9
12
18
45
120
240
800
700
820
950

No 2

10
10
8
9
3
4
4·5
8
8
18
30

For the purpose of measuring saline seeps the area of interest would be the first 50 cm from surface, as this could be considered to be the crop growing depth.

By taking measurements across a transact using a fixed 50 cm probe separation, a plot of high-low readings will present a picture of saline - non-saline areas. A number of transacts will give a complete map of the saline seep.

Moisture content of the soil becomes most important to the passage of electrical current, and vary the readings considerably. The ideal time to take measurements is when the soil is at field capacity of water content. Readings taken at other than the ideal time would still give high-low results but on a much higher plain.

Temperature is normally important in taking salinity readings, but in the case of E.R. the parts per million (P.P.M.) of salt content is not so important as a high-low reading.

Suitable earth resistivity meters are obtainable from:

U.K.	-	"MEGGER" INSTRUMENTS
U.S.A.	-	"BISON" INSTRUMENTS
	-	"SOIL TEST" INC.

To speed up the taking of measurements, all equipment was built on a small trolly, this enabled the coverage of a 1 ha plot in the time of three to four hours.

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