WATER AUTHORTY
of Western Australia

Projected Inflow Salinities to and Supply Salinities from Wellington Reservoir, Western Australia

Appendix M
Harris Dam Project
Environmental Review and
Management Programme

Report No WH4
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APPENDIX M

WATER QUALITY DETERIORATION

1. EFFECT OF CATCHMENT CLEARING ON INFLOW SALINITIES

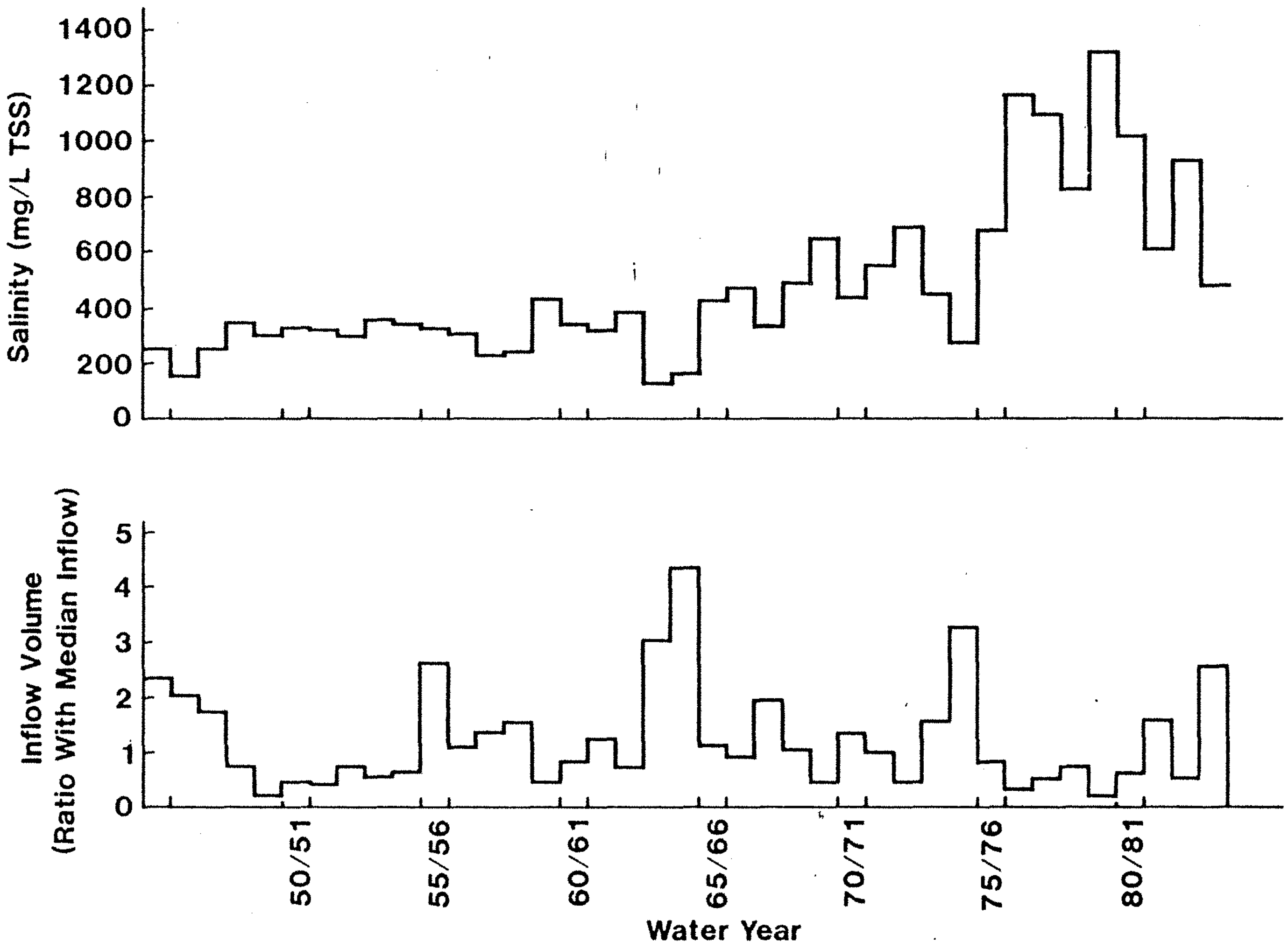
The impact of agricultural development on the inflow salinity to Wellington Reservoir is clearly depicted in Figures 1 and 2. While large variations in inflow salinity occur from year to year as a result of variations in the volume of streamflow to the reservoir, a clear trend of deteriorating water quality is apparent. The salinity of median inflow for 1945 has been estimated to be about 280 mg/L TSS. By 1984 the salinity of a year of median inflow had deteriorated to 850 mg/L TSS and is continuing to deteriorate at a current rate of 30 mg/L per year.

Salinities in dry years can be 50% to 100% higher than values in average years. The current estimate of the salinity in a dry year (defined here as a year in which the annual inflow is exceeded in 90% of years) is 1370 mg/L.

The distribution of inflow salinities within years is extremely complex (Loh and Stokes, 1981) and can give rise to very high daily inflow salinities (often in excess of 2500 mg/L TSS). These variations have important implications for reservoir operations and water supply salinities and are discussed in Section 2.4 below.

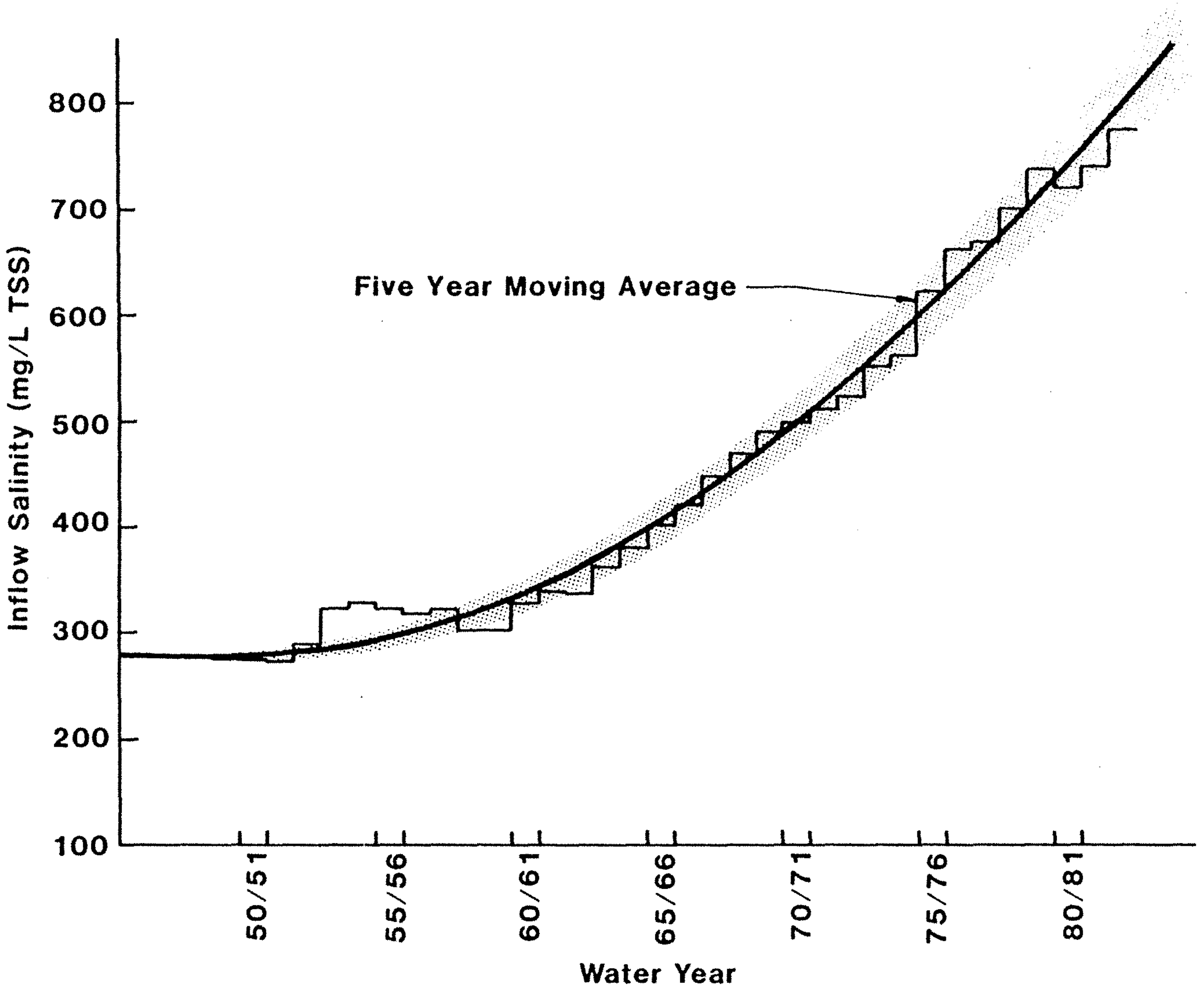
2. CAUSES OF THE INCREASE IN SALINITY

Removal of deep rooted forest vegetation and its replacement with shallow rooted crops and pastures has resulted in additional water passing the root zone of the vegetation and thereby recharging the groundwater system. As groundwaters rise, some of the salts stored in the soil profile are mobilised, and eventually additional salts and groundwater discharge to the surface stream



Inflow Salinities And Flow Volumes
To Wellington Reservoir

Figure 1



Average Inflow Salinity To Wellington Reservoir

Figure 2

system. Major increases in stream salinities result in areas where there is a large store of salts in the landscape. This generally occurs where annual rainfall is less than 900 mm per annum. Streams draining agricultural land in these regions commonly have average salinities in excess of 3000 mg/L. In higher rainfall areas, particularly over 1000 mm per annum, where salt storage is much lower, and where clearing results in additional fresh surface and shallow subsurface water, increases in streamflow salinity are much smaller and can often be difficult to detect (Loh et al, 1983).

The distribution of rainfall, salt storage and agricultural clearing results in a highly variable spatial distribution of stream salinities across the Wellington Reservoir catchment. Over 80% of the salts inflowing to the reservoir come from the eastern and southern subcatchments where rainfalls are less than 900 mm per annum and most of the agricultural development has occurred. In contrast only 20% of salts and over 50% of streamflow comes from the remaining higher rainfall and predominantly forested northern and western portions of the catchment (Barrett and Loh, 1982). The catchment of the proposed Harris River storage is located in this region of fresh streamflow.

The quantities of additional water recharging the groundwater following clearing are relatively small (less than 10% of annual rainfall) and the groundwater system transports water extremely slowly. Consequently, there is a long delay between initial clearing and the time when the additional groundwater discharge reaches its maximum. In the more saline sections of the catchment this delay is invariably in excess of 20 years.

3. CLEARING CONTROLS AND THE EFFECT OF PAST CLEARING

Realising the seriousness of the then current salinity levels and recognising that the full effect of past clearing was not yet reflected in the inflow salinity at that time, the State

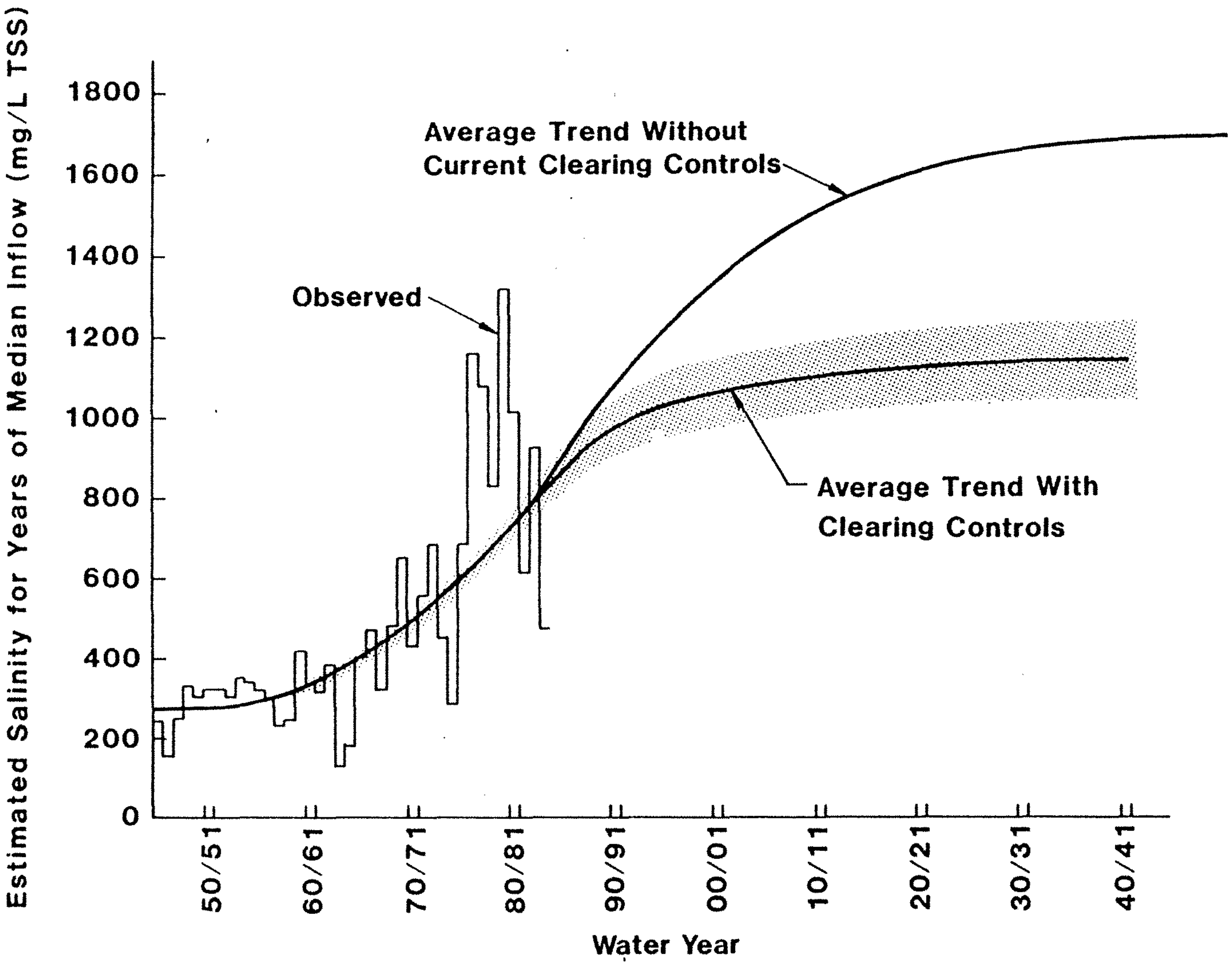
Government introduced legislation to control further agricultural development in November, 1976. The Country Areas Water Supply Act was amended to prohibit unlicenced clearing on the catchment. While small scale essential clearing is licenced, large scale agricultural development is not permitted. Farmers affected can claim compensation for their inability to further develop their farm enterprise.

Application of the legislation has effectively held the level of clearing to 64 000 ha or 23% of the total catchment and has avoided the expansion of agriculture to a possible 100 000 ha or 35% of the total catchment.

Prediction at the time indicated that if the level of clearing was maintained at the 1976 level the salinity of inflow in a median year would ultimately reach about 1100 mg/L TSS. Subsequent detailed groundwater simulation studies have been carried out on subcatchments in the extreme eastern portion of the catchment which suggest that the original estimates are of the correct order. If the catchment as a whole is similar to the areas studied in detail then salinities observed to date reflect about two-thirds of the full effect of past clearing. The ultimate salinity of a median inflow year could range from 1050 to 1250 mg/L but the best estimate is considered to be approximately 1150 mg/L TSS. The groundwater simulations indicate the salinity of inflow discharge will approach 1100 mg/L in about the year 2010 when 95% of the full effect of previous clearing should have developed. Ultimate equilibrium is approached slowly and should be achieved about 2040.

The estimated future inflow salinities resulting from past clearing are shown in Figure 3 for years of median inflow.

Most importantly, however, are the likely salinity levels in dry years. While dry year estimates are subject to considerable uncertainty, it has been estimated that for an annual inflow



Observed And Projected Inflow Salinities To Wellington Reservoir

Figure 3

volume likely to be exceeded in 90% of years the inflow salinity in 2010 would be approximately 1800 mg/L, approaching 1880 mg/L TSS by 2040.

Figure 3 also shows the trend in salinities of median inflow years if the clearing control legislation had not been imposed and clearing had continued to its potential of 100 000 ha by 1990. Ultimate salinity in a year of median flow would have reached 1700 mg/L TSS, while in a dry year (90% probability of exceedance) salinity would have approached 3000 mg/L TSS.

4. REFORESTATION

While the clearing control legislation has had a major effect in minimising further deterioration in reservoir salinity levels, estimates of the full effect of clearing current at the time of the legislation indicated the quality of both town water and irrigation supplies would eventually become unacceptable, particularly in dry years. In addition the deterioration would limit the future utility of the presently uncommitted yield from Wellington Reservoir. Consequently reforestation of cleared farmland in the drier, high salt-yielding parts of the catchment was commenced in 1979.

The reforestation programme was initially proposed to run for six to ten years with an annual replanting target of 2000 ha. The actual planting rate achieved has varied between 700 and 800 ha per year, with a total of 3 370 ha having now been reforested. The reforestation strategy involved planting along the valley bottoms and lower side-slopes, the remaining mid- and upper slopes providing viable strips of cleared farmland which could then be exchanged for lower slope land areas on adjacent farmland to further extend the area of reforestation.

By September 1984 sufficient land had been purchased to enable approximately 8000 ha to be planted. When planting of this area is complete, the total costs of reforestation are expected to be $13 million. This reforestation, which will take several years to complete, will in the longer term exert some control of salt discharges from 18 500 ha of the 51 000 ha of cleared farmland in the highly salt susceptible zones of the catchment. There is however, considerable uncertainty in assessing the magnitude of the salinity reductions which will be achieved by the present reforestation programme.

Despite the difficulties in reliably estimating the effects of reforestation, calculations can be made using knowledge of the distribution of water and salt discharge across the catchment and by assuming various levels of effectiveness of the reforestation in controlling saline groundwater discharge. Estimates of the time scale for reforestation to reduce groundwater levels has been based on the groundwater simulation studies noted above. Assuming the current replanting programme is moderately effective (reducing groundwater discharges by 70%) then long-term salinities of inflow will ultimately reach about 950 mg/L TSS in a median year. The current reforestation programme should therefore reduce the expected level in 2010 (1100 mg/L TSS) by about 150 mg/L, equivalent to a long-term deterioration of about 100 mg/L TSS over current levels.

However an important limitation on the usefulness of reforestation is the slow rate at which trees become effective in reducing the discharge of saline groundwaters to the surface stream system. The problem is further compounded by the present rate of planting, which is significantly below the rate initially envisaged. Reforestation is not achieving the required salinity reductions quickly enough to meet the needs of the Great Southern Towns Water Supply.

While the reforestation programme will limit the rate of rise of inflow salinity during the 1980's present knowledge suggests that trees will not significantly reduce inflow salinities until the mid- to late-1990's. Peak inflow salinities can therefore be expected in the early to mid-1990's.

The inflow salinity in a median year in the mid-1990's is expected to be about 1005 mg/L and reach approximately 1610 mg/L in a dry year.

Table 1 summarises the estimated inflow salinities for different land use conditions discussed above. It should be remembered that the values are sensitive to the assumptions of the effectiveness of reforestation. If the current reforestation programme were 100% effective, median year inflow salinities would reach about 970 mg/L in the mid-1990's and reduce to about 850 mg/L by the year 2010. Therefore the programme would in the longer term roughly maintain the current inflow salinity levels. If reforestation was only 50% effective median inflow salinities would reach about 1020 mg/L in the mid-1990's and reduce to only 1000 mg/L in 2010.

Figure 4 shows the estimated effect of the current reforestation programme on inflow salinities in a median year.

TABLE 1
BEST ESTIMATES OF INFLOW
SALINITIES TO WELLINGTON RESERVOIR

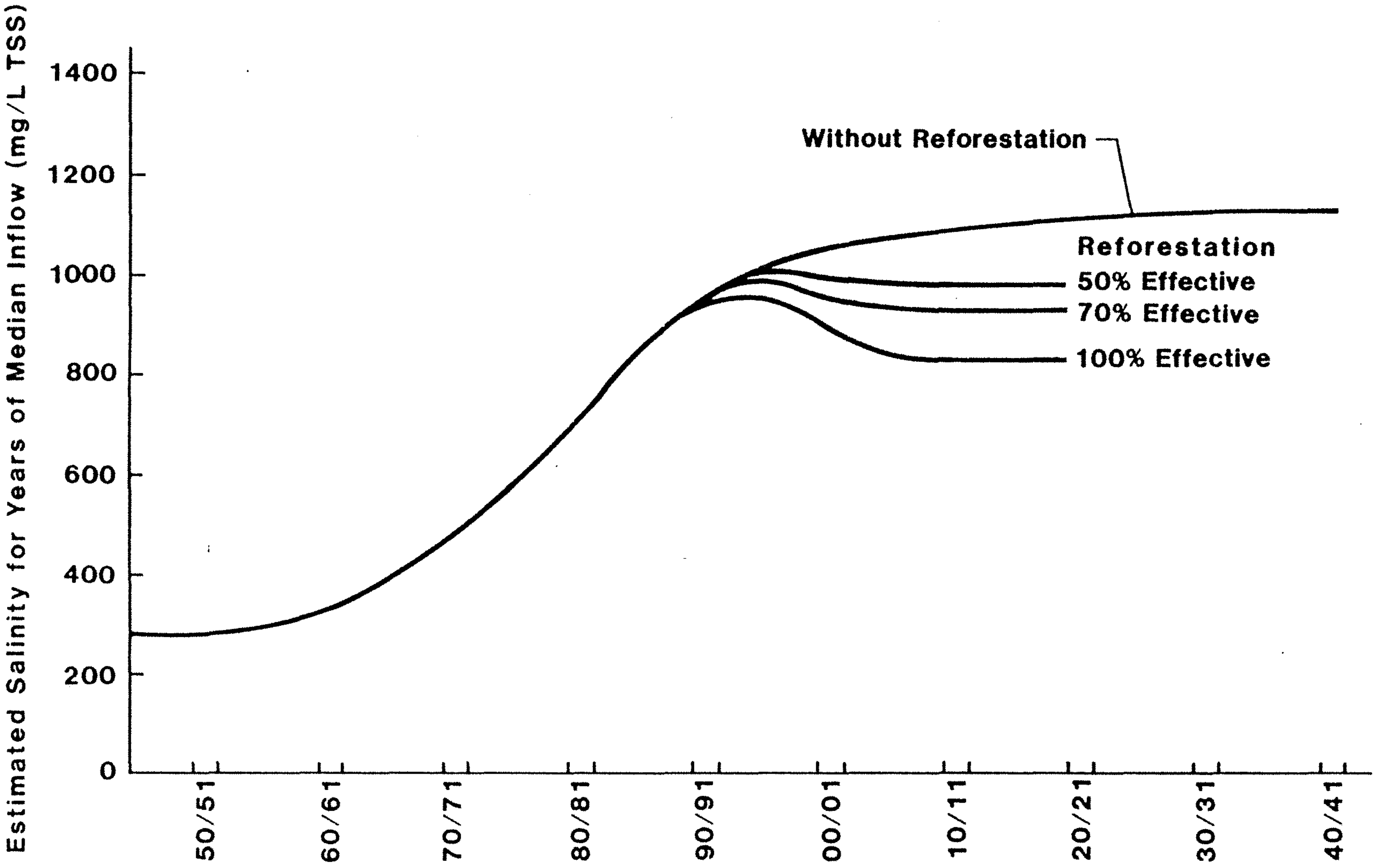
LAND USE CONDITION	YEAR	INFLOW SALINITY FOR AVERAGE (1) CONDITIONS	INFLOW SALINITY FOR DRY (2) CONDITIONS
Current Situation	1984	850	1330
If all private land had been cleared by 1990	2020	1620	2830
	2050	1700	3000
Clearing Controlled to 1976 Level by Legislation	2010	1100	1800
	2040	1150	1880
Completion of the Current Reforestation by the Early 1990's (70% effective)	mid-1990's	1005	1610
	2010	950	1510
	2040	950	1510

(1) Average Conditions - A year of median inflow volume
(2) Dry Conditions - A year with an inflow volume exceeded in 90% of years

5. RESERVOIR OPERATION AND WATER SUPPLY QUALITY

While the quality of supply from Wellington Reservoir is dominated by the quality of inflow there is scope to operate the reservoir in such a way as to minimise the salinity of supply to the Great Southern Towns Water Supply Scheme.

Results from a research project on the water mixing processes in Wellington Reservoir (Imberger and Hebbert, 1980) first identified strong seasonal layering of salinity in the reservoir in 1975. Initial flows from the eastern portion of the catchment at the start of each winter are cold and highly saline, often over 3000 mg/L TSS. As this inflow is more dense than the stored water, it underflows the waterbody and lodges at the base of the reservoir. By selectively releasing this saline water during early winter and also by supplying summer irrigation water from the base of the



Effect Of Current Reforestation Programme On Average Inflow Salinities

Figure 4

reservoir, improvements in the town water supply quality are possible. A new operating policy based on these concepts was introduced in 1976 and has been working effectively since.

The benefits obtained have been studied in detail using the most recent version of a complex reservoir simulation programme which takes into account all the main mixing processes in Wellington Reservoir (Meares, Jokela and Patterson, 1985). Daily simulations of the salinity and temperature structure and daily predictions of the salinity of both town water supply and irrigation releases have been made for an eight year study period from 1974 to 1982 (Hookey and Loh, 1985).

Table 2 presents the results of the average, 50th (median) and 95th percentiles of supply salinities for both the previous and current operational procedures over the eight year study period.

TABLE 2
SUPPLY SALINITIES OVER EIGHT YEAR SIMULATION PERIOD

	OPERATIONAL PROCEDURES	
	Previous Method (1)	Current Method (2)
INFLOW SALINITY		
Total Salt/Total Water (4)	619	619
Equivalent Median Year Salinity	741	741
MEAN SUPPLY SALINITY		
Town Water	768	693 (10%)
Irrigation Water	764	733 (4%)
MEDIAN SUPPLY SALINITY		
Town Water	860	770 (10%)
Irrigation Water	830	790 (5%)
95TH PERCENTILE SUPPLY SALINITY		
Town Water	1045	980 (6%)
Irrigation Water	1060	1040 (2%)

Notes : (1) Previous method - No winter scour, irrigate through hydroelectric station offtake at mid-level of the dam wall.

(2) Current method - Early winter scour, irrigate from base of the reservoir.
(3) Values in brackets are the percent improvements due to the new operational procedures over the previous method.
(4) Total salt load divided by the total volume of streamflow over the eight year study period.

Average improvements in salinity of approximately 10% and 5% have been estimated for town water and irrigation supplies respectively. Smaller percentage improvements occur in times of high salinity. While the percentage improvements are relatively small they have been achieved at little or no cost and have been important in limiting the salinity of supply through a very dry period in the late 1970's when salinities reached their highest levels yet recorded.

On the basis of the salinities of inflow in a median year results of the current operation simulations over the eight year period have been scaled up to estimate the supply salinities for the range of land use conditions discussed in sections 3 and 4. The results are presented in Table 3. These form the base set of supply salinities from which to compare the effect of various options for improving the supply to the Great Southern.

The results indicate that with a moderately effective (70%) reforestation programme and the application of suitable reservoir operating procedures, the mean town water supply salinity will ultimately approach 890 mg/L TSS but could still approach 1250 mg/L TSS in a run of dry years similar to the late 1970's. Irrigation supply salinities will average approximately 940 mg/L but could exceed 1330 mg/L in a run of dry years. However before the full effects of reforestation become apparent mean town water and irrigation supply salinities could reach 940 mg/L and 990 mg/L in the mid-1990's respectively.

TABLE 3

PREDICTED FUTURE WATER SUPPLY SALINITIES FROM WELLINGTON RESERVOIR

Land Use Condition	Current Condition	Without any Reforestation	If All Private Land Had Been Cleared	Completion of Current Reforestation by early 1990's 70% effective		Completion of Current Reforestation by early 1990's 100% effective	
Date	1984	2040		Mid 1990's	2010	Mid 1990's	2010
INFLOW SALINITY							
Total Salt/Total Flow	710	960	1420	839	793	810	710
Median Year Salinity	850	1150	1700	1005	950	970	850
MEAN SUPPLY SALINITY							
Town Water	795	1076	1590	940	888	907	795
Irrigation Water	841	1138	1682	994	940	960	841
MEDIAN SUPPLY SALINITY							
Town Water	883	1196	1766	1044	987	1008	883
Irrigation Water	906	1226	1812	1071	1013	1034	906
95TH PERCENTILE SUPPLY SALINITY							
Town Water	1124	1521	2248	1329	1256	1283	1124
Irrigation Water	1193	1614	2386	1410	1333	1361	1193
YEARLY AVERAGE SUPPLY SALINITY AT END OF DROUGHT SEQUENCE (1980/81)							
Town Water	1109	1534	2218	1311	1240	1266	1109
Irrigation Water	1105	1527	2209	1306	1235	1261	1105

If a run of dry years similar to those experienced in the late 1970's again occurred in the mid-1990's, supply salinities in excess of 1330 and 1410 mg/L for town water and irrigation supplies could be expected.

While the long term salinities would be similar to the current levels if reforestation were 100% effective, mean levels of 910 and 960 mg/L would still be reached in the mid-1990's. These could exceed 1280 mg/L and 1360 mg/L if dry conditions were experienced at that time.

In view of the estimates in Table 3, coupled with the current chloride limits on drinking water of 1100 mg/L TSS, and the likelihood of more stringent standards being set for sodium levels in the near future, it is clear that a satisfactory supply to the Great Southern Towns Water Supply scheme cannot be guaranteed in the future even with the current reforestation programme operating effectively and application of the recently improved reservoir operational procedures.

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TREE WATER USAGE ABOVE SHALLOW SALINE GROUNDWATER
- Water News Article

1. INTRODUCTION

Land and stream salinisation caused by agricultural development is now recognised as a major national water resources issue. In the recent Commonwealth Government Perspectives in Australia's water resources to the year 2000 (Water 2000) the current damage costs of salinisation was estimated to total $93 million per year at 1982 prices. Approximately $50 million per year of this cost is directly related to the impact on water resources and water supplies. Over the period to the year 2000 the expected cost of salinity management will almost double.

The impact of agricultural development on the salinity of water resources in the south-west of Western Australia has been particularly dramatic. Recent updating of the water resources inventory of Western Australia (WAWRC, 1984) indicates 35.3% of the divertible surface water resources of the South-West Drainage Division of Australia have salinities in excess of 1 000 mg/L TSS (brackish or saline). A further 16.0% is of marginal quality (500 to 1 000 mg/L TSS). Prior to agricultural development virtually all the divertible surface water resources of the region were believed to be fresh. A major research thrust should therefore be to find the least cost solutions to stream salinity problems.

Engineering solutions to protect or to rehabilitate saline river systems are extremely expensive in both capital and operating costs. Moreover, they do not address the real cause of the problem - the additional recharge to and subsequent discharge from saline groundwater system to surface stream systems. It is for this reason that there is growing interest in biological solutions such as various agronomic treatments which minimise groundwater recharge and different agro-forestry strategies which aim to reduce groundwater discharge and/or recharge.

The Commonwealth Government has been assisting the Western Australian Government under the National Water Programme in a reforestation scheme to reduce the salinity of inflow to Wellington Reservoir, the largest single developed water resource in the south-west of Western Australia. The programme represents the first large scale tree planting project for salinity control and therefore has an active research component. Long term monitoring studies have been established to evaluate the effect of the tree plantings on both surface and groundwater hydrology. As the project has progressed a major need developed to quantify the tree water use characteristics of individual species to assist in the species selection and design of reforestation strategies.

The species used in salinity control projects have been selected in the past on a number of factors including suitability for soil type, tolerance to disease, insect attack and climate as well as salt tolerance. Little has been directly known about the specific transpiration characteristics of the species being used. While salt tolerance is clearly an important characteristic it is possible that many trees may be salt tolerant because they restrict or stop their transpiration when only saline water is available. If trees are to be used as pumps to lower water tables it is essential to know their seasonal water usage and to determine their ability to draw water from a saline water table.

It was for these reasons that the former Department of Forests and Public Works, now the Department of Conservation and Land Management and the Water Authority of Western Australia, requested funds under the AWRC research programme and embarked on AWRC project 84/166.

2. AIMS OF PROJECT

The original aims of the project were to determine the leaf water conductance characteristics of approximately 10 eucalypt species growing within four metres of a saline water table in the 600 to 800 mm rainfall region of south-western Australia. The programme aimed to:

(i) define the leaf conductance-vapour pressure deficit response of each species at four or five different soil moisture conditions throughout the spring to autumn drying cycle.

(ii) relate the seasonal changes in the leaf conductance-vapour pressure deficit to the seasonal soil moisture regime and the proximity of a saline groundwater.

(iii) define the leaf conductance-radiation response function for each species.

(iv) determine seasonal leaf area changes and girth growth rates and relate these to observed tree water use characteristics.

Screening of additional species will also be carried out, although less intensively and probably only once through the year.

While minor changes have been made as the project has developed the objectives effectively remain the same. The study is part of a wider programme of reforestation research in which it is hoped to compute the water use of different species throughout the dry summer period. In this way it is hoped to identify those species which continue to transpire through the summer and actively extract water from the capillary fringe of saline water tables.

3. APPROACH

In the late 1970's it was decided to establish a series of species selection arboreta to provide basic information of the growth performance of a wide range of eucalypts likely to be suitable for rehabilitation of disturbed areas following bauxite mining, agricultural clearing and other diseased forest areas Bartle et al (1978). Replicate plantings of some 70 eucalypt species were located so as to adequately cover the major environments and types of disturbance requiring reforestation. Species plots were made as large as practical (0.5ha), a size large enough to provide an inner core reasonably representative of a whole forest. The objective was to provide a base from which the growth and transpiration potential for any species for any location could be inferred.

Because of the area and time scales within which this work had to proceed the Penman-Monteith equation was chosen as an appropriate model by which to evaluate transpiration. The conductance of the leaf surface to the passage of water vapour is a major Penman-Monteith parameter. In conjunction with light intensity the major short term control of leaf conductance is vapour pressure deficit (VPD). This response was first described by Schultze et al (1974) and has since been shown to be the major short term mechanism regulating conductance in woody plants. The response to soil water availability is a longer term constraint on conductance. Cowan (1984) has drawn these two mechanisms together into a comprehensive theory on the optimization of water loss and carbon gain. He sees the former mechanism as a 'feedforward' sensing of atmospheric drought to meter out water loss for a better carbon gain, the latter being a feedback response to eventual soil drought.

With the aim of this project being to define conductance relationships for the most promising species at one arboretum site, the Bingham River Arboretum was selected for the detailed monitoring. This is located in a 750mm rainfall zone and is situated on a valley bottom site, previously farmland affected by secondary salinity. (See photo A). It is on the Wellington Reservoir catchment and is representative of the land being selected for reforestation.

It is planned to extend data collection over two summers. In the first summer (1984/85) now complete, some 19 species were subject to intensive leaf conductance measurement. Measurement technique was designed to provide representative whole canopy estimates of conductance. Concurrently, relevant atmospheric, soil water and plant parameters were recorded.

Two operators were equipped with LiCor 1600 porometers with cassette tape data recorders. (See Photo B). Access to tree canopies was gained using trailer mounted hydraulic elevators able to reach to 14m. (See Photo C). Within the arboretum area an automatic weather station at canopy top height continuously recorded temperature, humidity, solar radiation and wind run (three levels). The depletion of soil water through the dry summer period was quantified by gravimetric analysis of shallow (0-6m) soil cores taken bi-monthly from eight locations. Tree water potential was measured immediately pre-dawn with a pressure bomb on the day of conductance measurement of any species.

Conductance measurements were taken for each species on a 1-2 week cycle from a representative canopy volume at a fixed location. Leaves were visually stratified into three vertical and two aspect classes, each class being of approximately equal leaf area. On a measurement day for any species, random samples of 6-10 leaves per class were taken in as brief a period as possible (30-40 minutes). This was repeated regularly through the day. A mean conductance was computed from the 48-60 individual leaf values to give a single observation for that species at that time.

Seasonal changes in leaf area are being recorded using the Lange Light Interception Method.

4. INITIAL RESULTS

For each species all conductance observations have been plotted against VPD. To provide some resolution on the effect of water potential the observations are flagged for both period of collection (i.e. any one of five data collection periods) and for time of day. Observations taken at marginal radiation intensities (i.e. less than 200 W/m^2) were omitted to remove complications associated with light limitation. Plots of this form for Eucalyptus globulus, E.mannifera and E.sideroxylon are presented in Fig. 1 (a) to (c). Several preliminary conclusions are possible from the data collected to date.

(i) All species display a negative sloping relationship of conductance with VPD.

(ii) Most species exhibit a marked reduction in conductance from spring to autumn for any level of VPD, apparently a response to the seasonal decline in soil water availability.

(iii) Very large differences in conductance values at any level of VPD are apparent between species. This can be observed by comparing Figure 1(a) (E.globulus)) and Figures 1(b) and 1(c) (E.mannifera and E.sideroxylon). Given that these three species have similar growth performance and leaf area, similar depth to water table and comparable site conditions, the observed differences indicate substantial difference in transpiration potential.

(iv) Some species exhibit a progressive decline in conductance through the day in the summer to autumn period irrespective of VPD. The nature of this effect is not yet apparent. It may be a response to local soil water depletion or local accumulation of soil salinity in the root zone.

(v) The response to a large autumn rainfall event (62mm from April 9-11) took up to 3 weeks to become apparent in conductance levels.

Detailed studies of the relationship between leaf conductance and VPD and other variables such as leaf water potential, soil water and salinity profiles soil salinity and soil water potential have yet to carried out. Nevertheless the results are sufficiently varied to indicate very different patterns of water use between species.

It is clear that although E.globuuls has a high leaf area its transpiration rates are low throughout most of the summer. In contrast E.sideroxylon, although reducing its transpiration rate through the drying period, still maintained significant water usage well into the autumn period. This was supported by gravimetric moisture content measurements that indicated reductions in soil moisture at increasing depths as the soils dried out.

Although not part of the actual AWRC research project approximate computations of actual transpiration using the leaf conductance-VPD relationships, crude leaf area estimates and climaticalogical data have been made using the Penman-Monteith equation. Initial results indicate that early summer transpiration can exceed pan evaporation rates by well over 50% for the better performing species reducing to about a third of pan evaporation by April.

5. SUMMER 1985/86 PROGRAMME

Five species have been identified for further detailed study to improve the prediction of transpiration and enable comprehensive study of all the factors affecting leaf conductance, in accordance with the original objectives. Additional piezometers have been established at these sites and will be monitored to note changes in soil moisture, depth to water table and salinity of groundwater measured at the mid point of each period of leaf conductance measurement. In addition to predawn leaf water potentials, mid morning, noon, mid afternoon and dusk potentials will be recorded on each day of detailed measurement. Table 1 lists species to be studied in detail.

A further 15 species will also be sampled less intensively to develop quantitive rankings of transpiration behaviour and highlight additional species for subsequent detailed study. Emphasis will be placed on recording the conductance of exposed leaves in the upper one third of the canopy unaffected by light limitations. Table 2 lists the species for this less detailed study. The two tiered approach to the sampling is hoped to cover the dual objectives of providing enough detail to adequately define the factors affecting leaf conductance and cover the widest range of species for screening purposes.

6. RELATED WORK

One of the major criticisms of porometry has been the problem of integrating up the behaviour of individual leaves to whole forest communities.

Comparative studies of tranpiration of E.marginata (Jarrah) using the project's porometry sampling strategy and a ventilated chamber suggest that simple addition of the unit leaf conductance provides a good estimate of total tree transpiration. Studies are continuing on species with stomata on both sides of their leaves.

Another concern relates to the problem that leaf conductance may not be the only significant factor in controlling water vapour flux from a forest community. In dense forests subject to high relative humidity conditions the micrometeorological conditions may also limit the transfer of water vapour to the external atmosphere. Fortunately the reforestation stands being studied are well ventilated and are exposed to low relative humidities for a large proportion of the summer drying cycle.

The initial calculations of actual water use by the various tree species are therefore considered to be of the correct order.

Considerable support for this has been gained from the independent measure of groundwater levels across the arboretum site. Those species which have shown the highest leaf conductance characteristics at the end of summer and shown the highest computed tree water usage have been located where the largest reductions in groundwater levels have been observed.

The project is to continue through the 1985/86 summer period.

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TABLE 1
SUMMARY OF SPECIES TO BE STUDIED INTENSIVELY

E.sideroxylon
E.microcarpa
E.woolsiana
E.melliodora
E.saligna

TABLE 2
SUMMARY OF SPECIES TO BE STUDIED EXTENSIVELY

E.polyanthemos
E.globulus
E.mannifera
E.viminalis
E.leucoxylon
E.botryoides
E.wandoo
E.largiflorens
E.resinifera
E.globulus
E.camaldulensis
E.occidentalis
E.huberana
E.macroryncha
E.albens

Leaf Conductance - Vapour Pressure Deficit Relationships for Selected Eucalypt Species

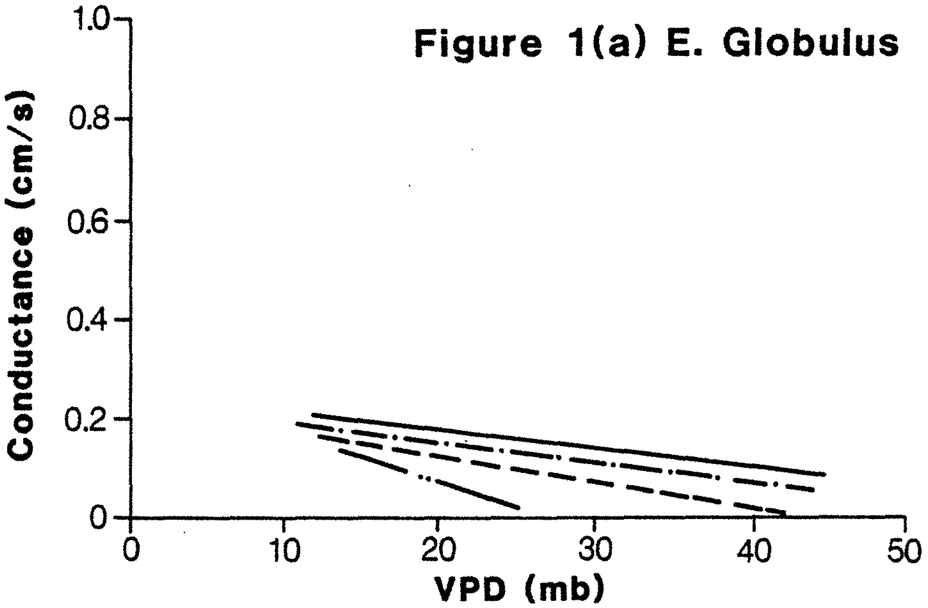


Figure 1(a) E. Globulus

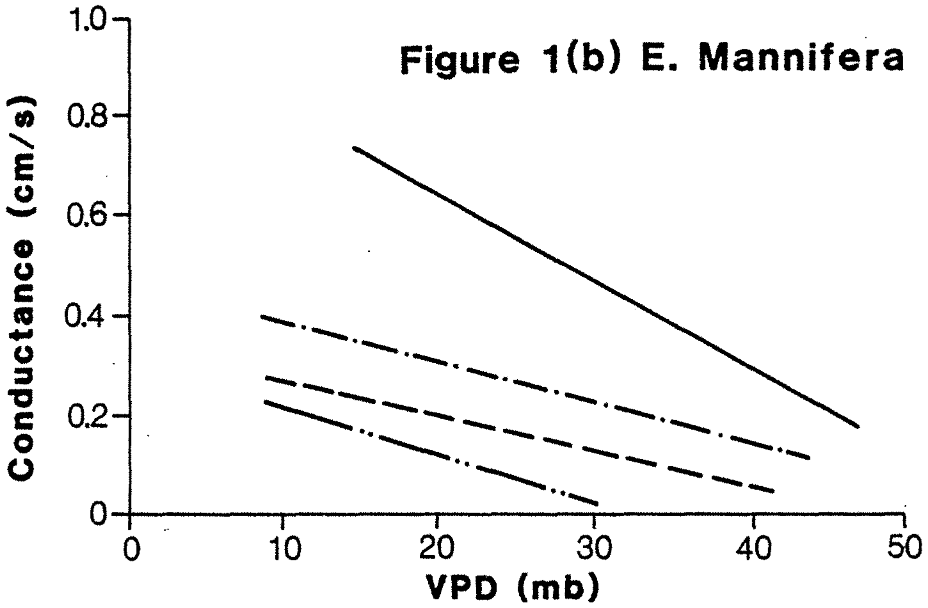


Figure 1(b) E. Mannifera

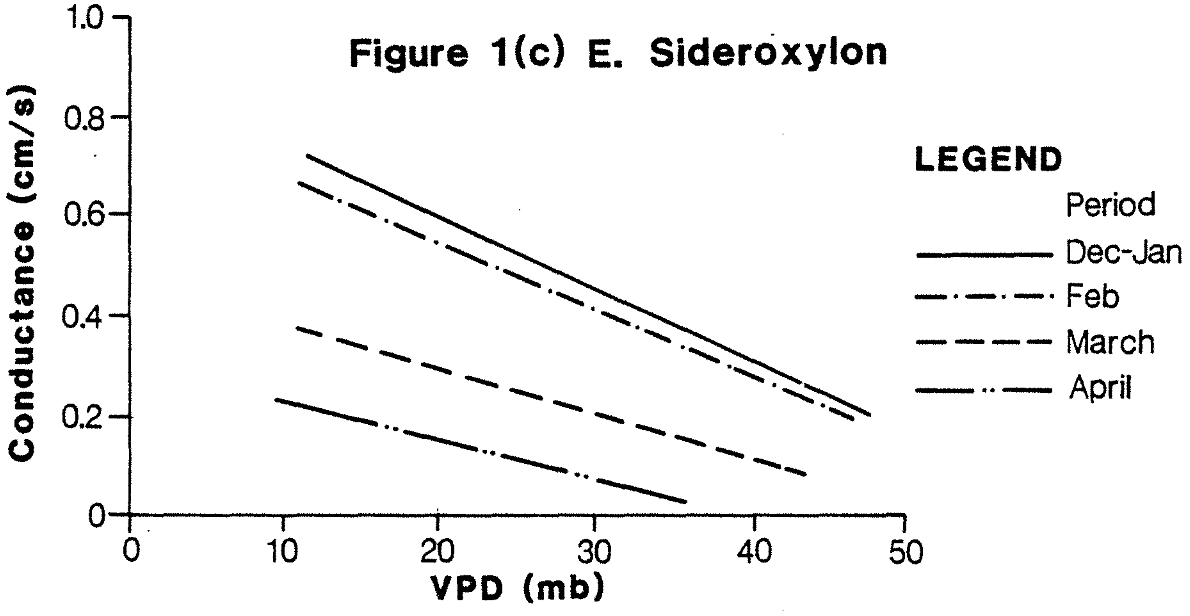


Figure 1(c) E. Sideroxylon

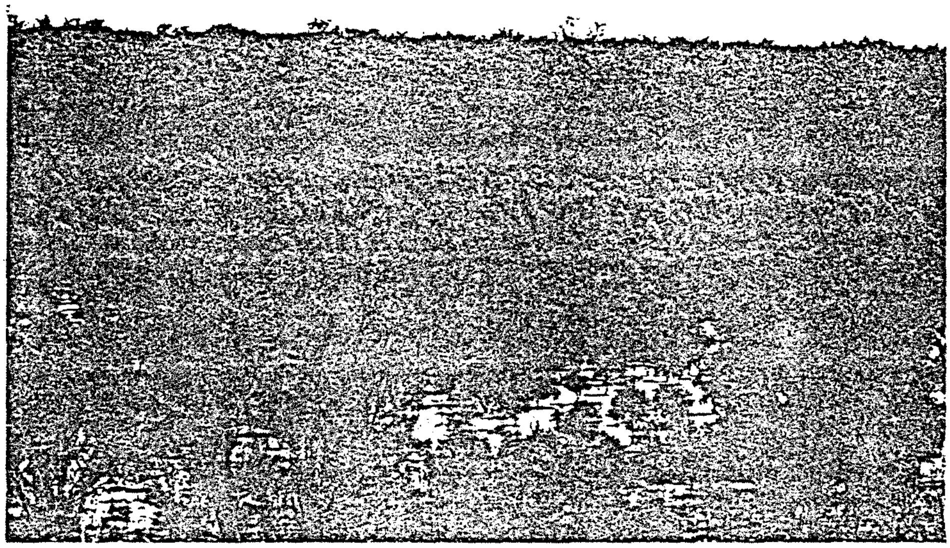


Photo A

Photo B

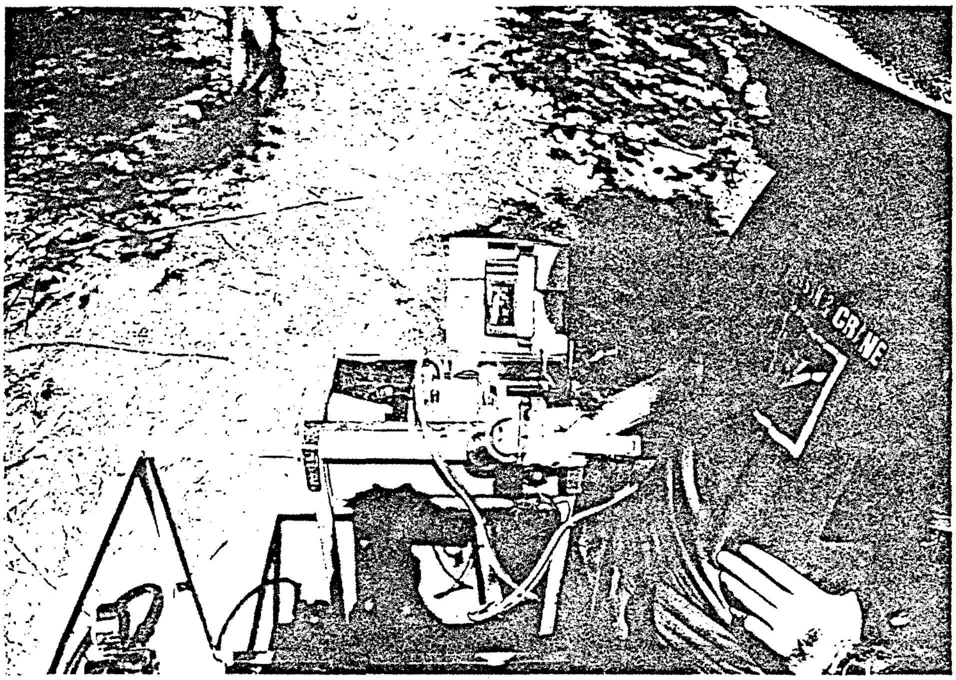
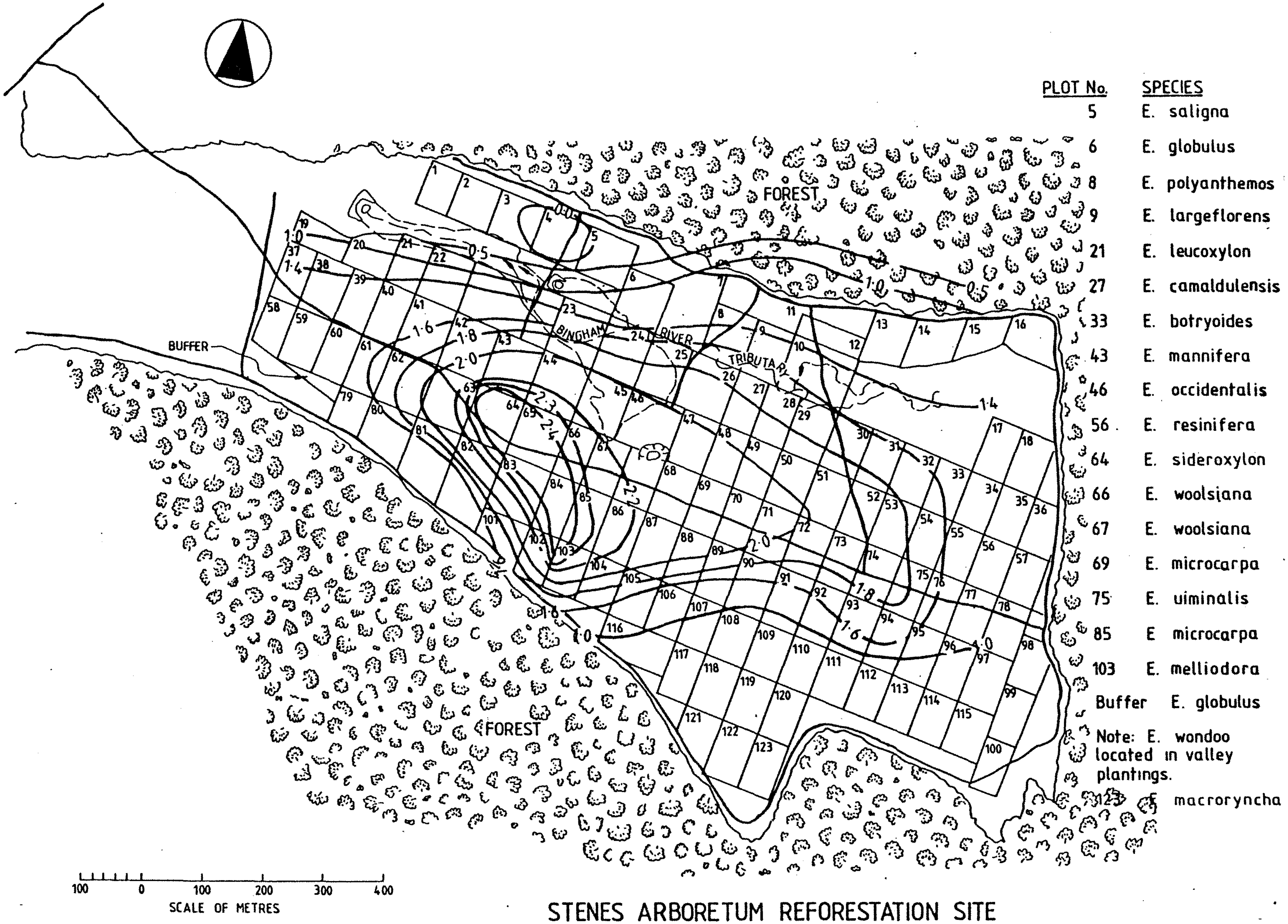


Photo C.

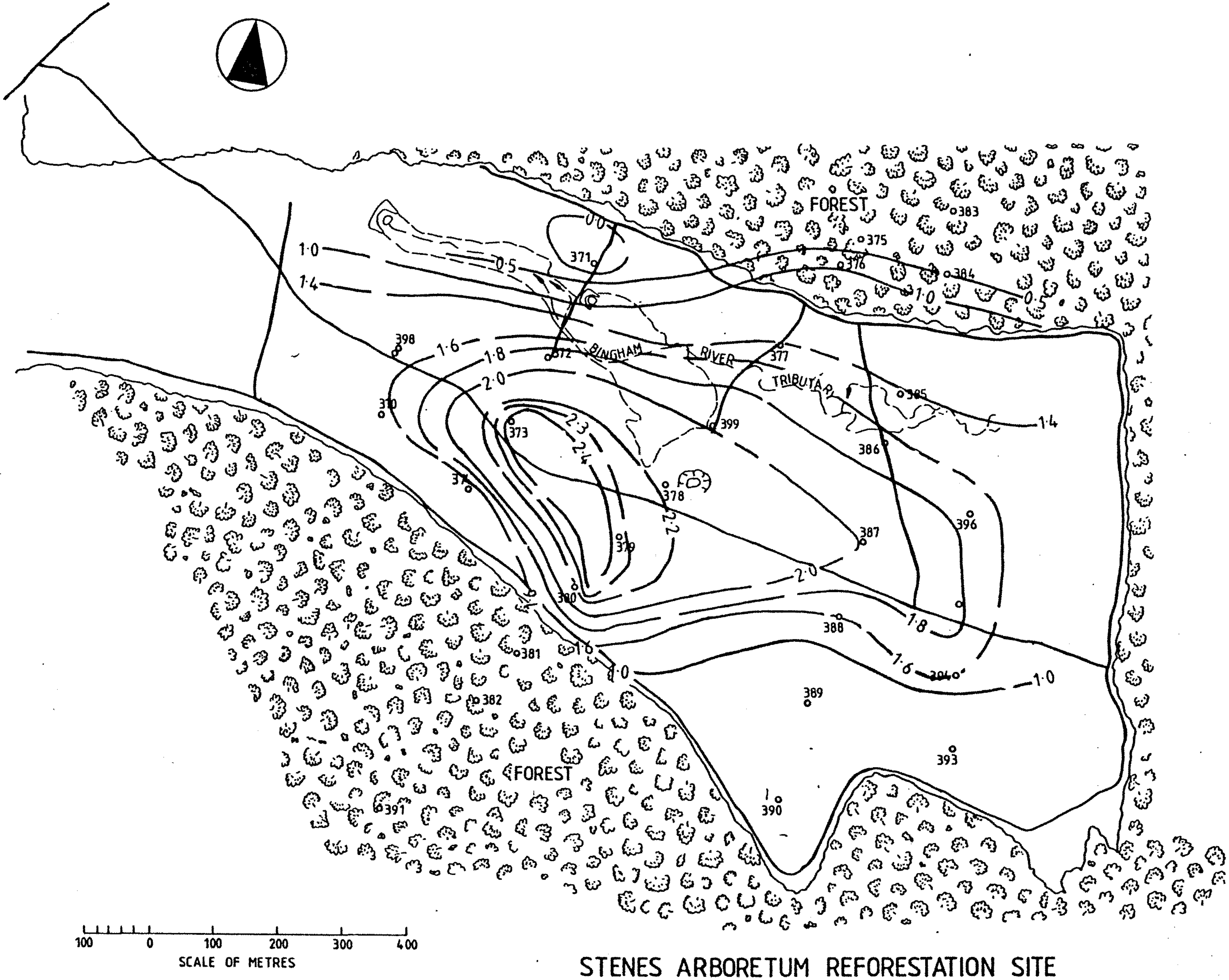


PLOT No.	SPECIES
5	E. saligna
6	E. globulus
8	E. polyanthemos
9	E. largeflorens
21	E. leucoxylon
27	E. camaldulensis
33	E. botryoides
43	E. mannifera
46	E. occidentalis
56	E. resinifera
64	E. sideroxylon
66	E. woolsiana
67	E. woolsiana
69	E. microcarpa
75	E. uiminalis
85	E microcarpa
103	E. melliodora
Buffer	E. globulus

Note: E. wondoo located in valley plantings.

123	E macroryncha

STENES ARBORETUM REFORESTATION SITE
ABSOLUTE REDUCTION IN BORE WATER LEVELS FROM MAY, 1979 TO MAY, 1985



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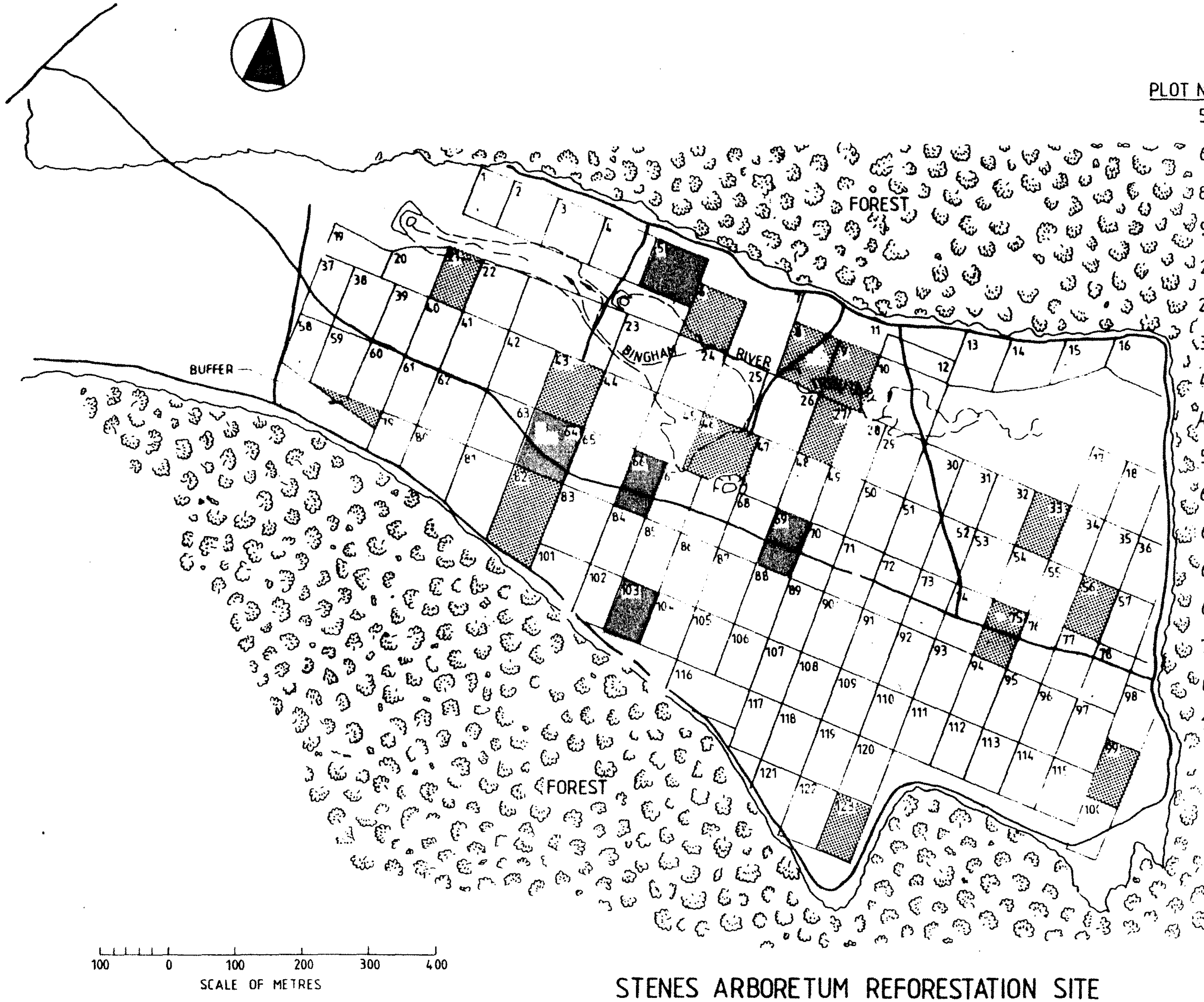
ABSOLUTE REDUCTION IN BORE WATER LEVELS FROM MAY, 1979 TO MAY, 1985



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67	E. woolsiana
69	E. microcarpa
75	E. viminalis
85	E. microcarpa
103	E. melliodora
Buffer	E. globulus

Note E. wandoo located in valley plantings

123 E. macro[illegible]

STENES ARBORETUM REFORESTATION SITE