BAUXITE REHABILITATION MONITORING PROJECT: DOCUMENTATION AND PROCEDURES

Inventory & Planning Section, Kelmscott

065450

BAUXITE REHABILITATION MONITORING
PROJECT : DOCUMENTATION AND PROCEDURES

FORESTS DEPARTMENT OF W.A.
NORTHERN REGION INVENTORY AND PLANNING
SECTION - KELMSCOTT.

DECEMBER, 1983.

SUMMARY

This manual documents the Forests Department's Bauxite Rehabilitation Monitoring Project. The project is designed to monitor the growth and survival of bauxite rehabilitation plantings. The project will initially monitor rehabilitation at Alcoa's Jarrahdale Minesite. It will then be extended to monitor rehabilitation plantings at other minesites such as Dwellingup, Willowdale, Saddleback and Worsley and to other reforestation programmes.

For this project, monitoring involves the establishment of permanent square plots within a stratum. A stratum takes into account site preparation, planting year, species and silvicultural treatment. Some of the plots within a strata will be established at age seven, and remeasured every two years. The remainder of the plots will be established after improvement treatments (about age 7) and measured every 5 years. Policy for measurement frequency and sampling intensity will remain flexible to allow for changes in rehabilitation strategy and practices. Data from plot assessments will be processed by the Forests Department computer facilities. Analysis of the results will be undertaken by Inventory and Planning and Research Staff. Initially only basic plot data will be retrieved and analysed. Further development of computer processing facilities will allow a combination of parameters to be analysed.

Analysis of the results will provide valuable data on the success of rehabilitation techniques (at least in the short term) and will indicate areas in which to concentrate monitoring in the future. Developments of the project could include aerial photographic coverage to aid field assessment.

All office and field procedures, as well as field codes and sample field sheets are included.

B.C. Ashley,
ASSISTANT DIVISIONAL FOREST OFFICER.

DECEMBER, 1983.

CONTENTS

1. INTRODUCTION

1.1 Background

Alcoa of Australia's mineral leases cover 6940 km² of State Forest. Figure 1 shows the extent of the leases and the present minesites. Bauxite mining began at Jarrahdale in 1963.

To October 1983 some 2,200 ha have been mined and rehabilitated. Over the next 70 years, operations are expected to cover some 400,000 ha of the Northern Jarrah Forest. Operations are currently restricted to the western zone of the forest, but may be extended into the drier saline areas of the Jarrah Forest following research studies.

Bauxite mining produces a fundamental change to the landform and forest type. The longer term effects on water quality, timber production, conservation, recreation and aesthetics are at present largely unknown. This project forms a small but essential part of an overall programme devised to assess these long term effects.

1.2 Primary Objective

To establish a monitoring programme that will provide information to enable sound management of bauxite rehabilitation in accordance with land use policies.

1.3 Strategy

The strategy required to achieve the primary objective will be to:-

1. Assess the survival of rehabilitation plantings.
2. Assess the growth patterns & performance of rehabilitation plantings.
3. Monitor the changes in various site characteristics effecting the plantings.

1.4 Benefits

Using the above strategy the project will provide:-

1. Information on short and long term survival.
2. Information on short and long term growth patterns.
3. Resource information on which to base management and decisions.
4. Information which will enable site classifications to be made.
5. Improved rehabilitation records.
6. Comparisons of growth with other rehabilitation plantings.
7. Inventory techniques applicable to other areas.

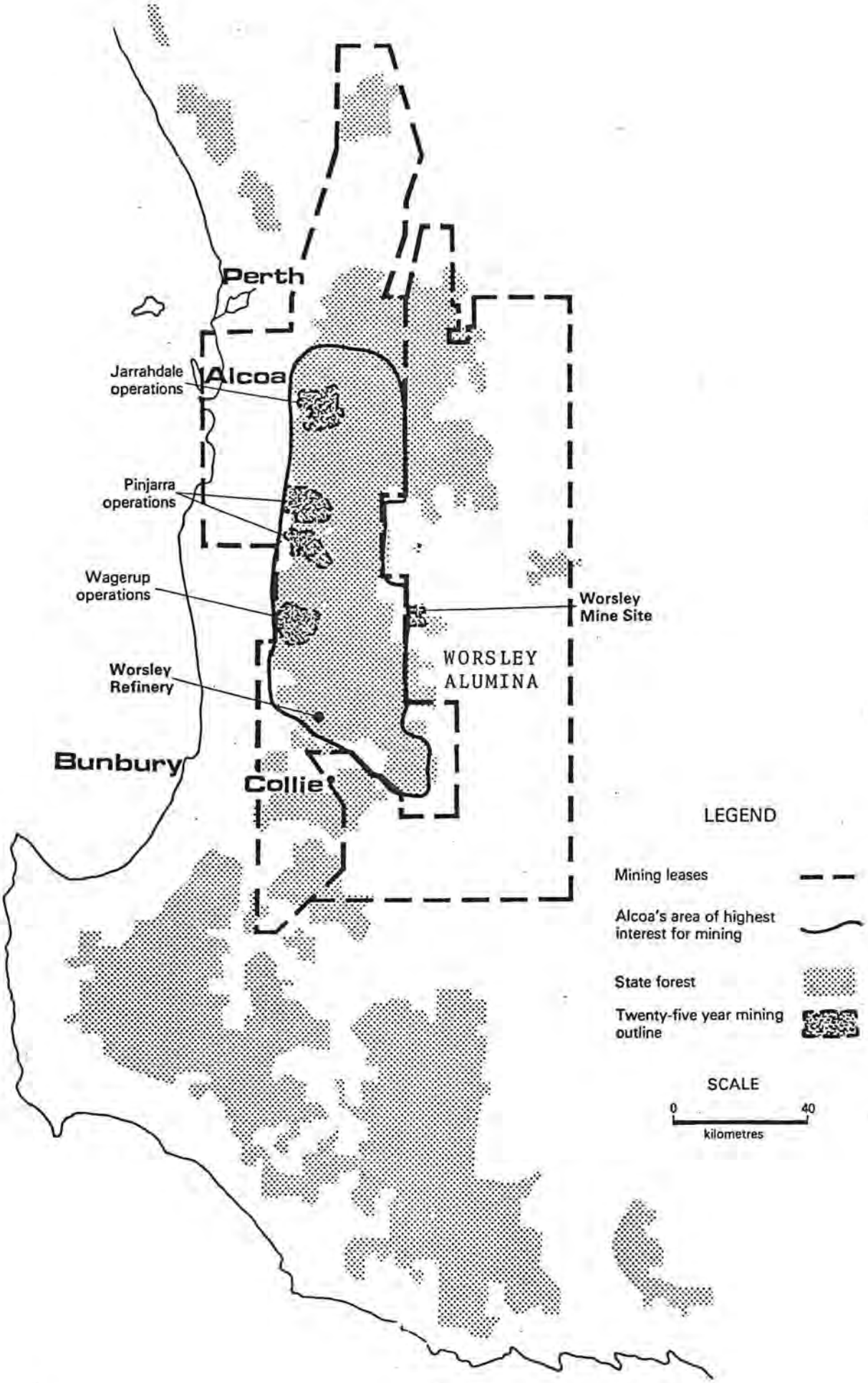
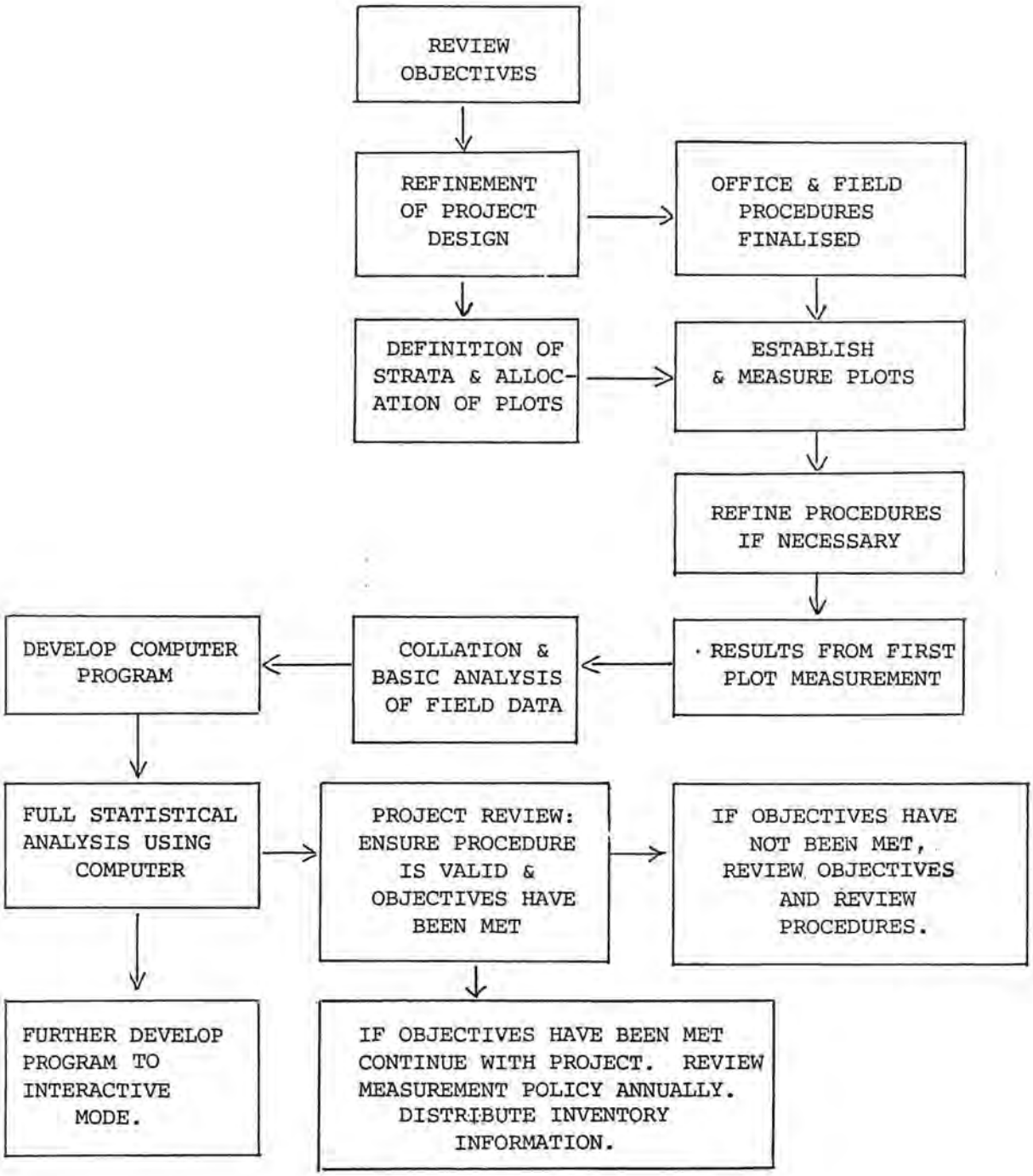


FIGURE 1. State forest in south-western Australia in relation to mining leases and mining plans. (*Source:* E.P.A. Technical Advisory Group, 1978, and Worsley E.R.M.P. Supplement, 1979.)

1.4 Strategy

In any project a strategy for successful implementation must be defined. The strategy below shows the project's development to the present and the future stages required for a full application:-



1.5 Responsibilities

Responsibility for the project rests with O.I.C. Inventory and Planning Section Northern Region. Data processing will be carried out by A.D.P. Section S.H.Q. with programming assistance from Alcoa . Analysis of the data will be carried out by O.I.C. Inventory and Planning Northern Region and Research Section Dwellingup. Recommendations stemming from the project will be dealt with at a Regional level.

When the project is expanded to cover rehabilitation plantings in the Central Region and at Mt Saddleback, these responsibilities will be reviewed.

1.6 Interactions with other Systems/Projects

The project has been designed in a manner which complements other management information systems used or being developed within the Department:-

Bauxite Register: Within a written register will be recorded site and historical information for particular bauxite pits within a minesite. All forest management activities and planting details will be recorded. It will be updated yearly.

Northern Region H.O.C.S.: An expanded Hardwood Operations Control System (H.O.C.S.) will record in a graphic form all the forest management and site information at a forest compartment level, and will record detailed bauxite rehabilitation information at a scale of 1:10,000. Location of the monitoring plots will be shown on these 1:10,000 scale compartment maps.

Graphical Computer Systems: Bauxite rehabilitation information may be incorporated into a graphical computer system (such as Intergraph) - however the exact form that such a system will take and its implementation will depend upon the outcome of the L.I.S.A.C. Rural Joint Project (in progress).

F.M.I.S.: An attribute will be coded which records the status of bauxite clearing and rehabilitation.

Dwellingup Research Section: Two research projects are being conducted - "Rehabilitation Performance Site Analysis" and "Rehabilitation Performance and Stress Monitoring". Results from the Bauxite Rehabilitation Monitoring Project will be used to pinpoint areas requiring further investigation.

Alcoa of Australia: Assistance is being provided by Alcoa of Australia for the provision of field equipment, and for the development of the computer program.

2. DESIGN OF MONITORING PROJECT

2.1 Scope

The project will commence at Alcoa's Jarrahdale minesite, and then be extended to other minesites. The monitoring technique adopted assesses both plot and tree data within a sampling framework. It is envisaged that early monitoring results will indicate failed areas requiring no further intensive monitoring. The monitoring programme would then be reduced from a broad assessment of many plantings to a more detailed assessment of successful plantings.

2.2 Stratification

Due to the large number of planting sites, areas of similar species and planting year (although in different locations within the minesite) have been amalgamated to form "strata". This applies particularly to those areas planted before 1978 where planting of single species, or similar species mixtures at various pits was carried out. A pilot assessment of pits within the Jarrahdale minesite and examination of aerial photos showed the variation within the pits was greater than variation between pits of similar planting year (or years) and species or species mixture. The delineation of pits into strata forms the basis for allocation of plots. Amalgamation within species for the following planting years has been carried out:-

1970 : No allocation at present due to small sizes of planting areas and irregularity of planting.

1970 - 73 : During these years ripping trials were carried out, but ripping was not routine.

1973 - 74 : A comprehensive ripping programme developed.

1977 : Understorey species added and deep ripping commenced.

1978 + : Species mixtures planted and rehabilitation methods standardized for all pits.

2.3 Plot Selection

Plots are randomly located within strata. If a stratum contains more than one planting year, then plots are proportionally allocated to each P.year. Plots are allocated to strata according to the following criteria:-

Stratum Size (ha)	No. of Plots	Sample %
1 - 2	2	5.3
2 - 3	3	4.8
3 - 4	4	4.6
4 - 6	5	4.0
6 - 8	6	3.4
8 - 10	7	3.1
10 +	7 - Plus 1 plot	1.8 (20 ha)
	for every 5 ha	1.2 (50 ha)
	over 10 ha	1.0 (100 ha)

2.4 Plot Type and Size

As growth responses within the mining rehabilitation areas vary in relation to specific site characteristics, discrete sampling units are required and square plots have been selected.

The plots are 20 x 20m and are permanently marked. A steel star picket locates each plot corner. A clearly visible marker (plot reference point) is placed on the boundary of the relevant pit to aid in subsequent relocation.

2.5 Measurement Policy

Establishment of all plots is scheduled at about the time of the first thinning/culling operation - this is usually at about age 7.

Following the initial establishment and assessment, the interval between measurements will be five years. However, a small sample of plots within a strata may be assessed more frequently to accurately determine growth patterns over time.

As mentioned previously, intensity and frequency of measurements will remain flexible and will be reviewd annualy as knowledge of the plantings increases. This will ensure that the establishment and remeasurement of plots is maintained at a realistic level.

2.6 Parameter to be Assessed

Parameters recorded at the time of field measurement are:-

i) Plot Data: At the top of the field sheet is recorded site and historical detail which reflect conditions for the whole of the plot. Details recorded are:-

Plot location and identification, planting year, slope, aspect, evidence of salinity, fire occurrence, silvicultural operations, tree seedling regeneration, banksia regeneration, ground cover density, erosion, whether a dieback sample has been taken, assessor and date of assessment.

ii) Tree Data: Below this plot information, the following parameters are recorded for each numbered tree:-

Stem number, species, diameter at breast height, (if over 10cm), bark thickness (if diameter is measured), total tree height, amount of seed present, presence of vines and creepers, tree class (dominance), tree health, factors which indicate a decline in vigour, tree form and crown diameter/area.

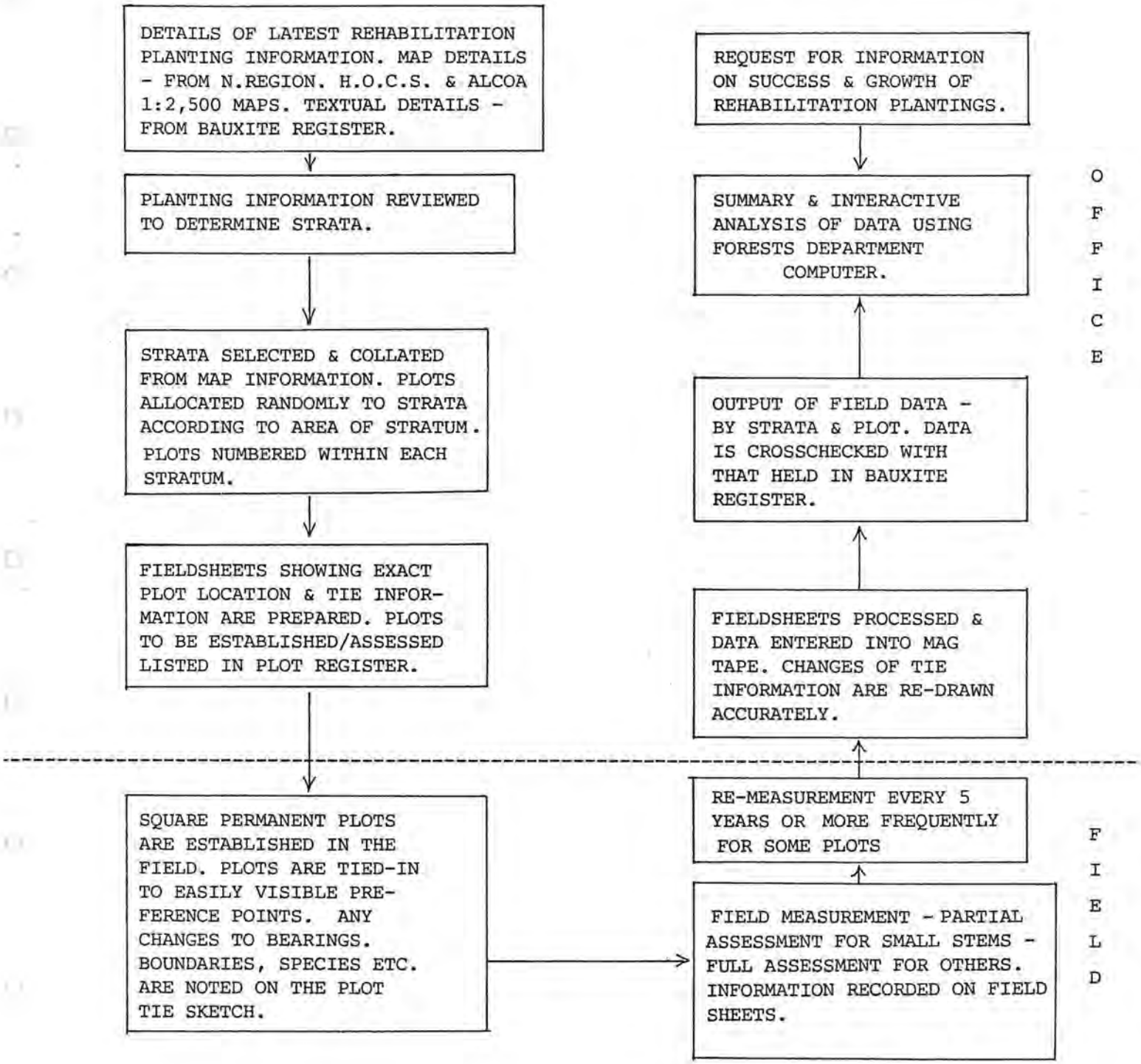
A space is included for specific comments alongside the tree data entries. General comments (including a plot diagram) are recorded on the reverse of the field sheet.

A full description of the above parameters is given in Appendix 3.3.

Site information (including forest management activities) relating to the whole of the bauxite pit is readily accessible from the Bauxtie Register (discussed previously in Section 1.6). This is made possible by overlaying the bauxite pit information with strata and plot information.

3. OFFICE & FIELD PROCEDURES

The flow chart below summarises the steps involved in the office and field procedures. Detailed Office and Field Procedures are to be found in appendices 2 and 3.



4. ANALYSIS AND DATA HANDLING

4.1 Program Type and Capabilities

A computer program will handle the processing, updating and analysis of the project data. Assistance programming is being provided by Alcoa of Australia.

Initially the program will operate in batch mode, but will eventually be operated interactively, perhaps in conjunction with graphic systems. The program will be designed to allow for:-

- Processing and editing measurement and remeasurement data.
- Providing an error report (when using batch mode).
- Storing the field data in a manner which allows ready access and provides duplicate storage of the data base for security. Some security of access should be provided.
- Providing a summary report for strata and plots within strata and for pits and sections within forest compartments.
- Being interrogated - to carry out analysis on strata and plot information using a combination of plot and tree parameters.
- Providing volume and basal area summaries for strata and plots using a volume equation and tree measurement data (diameter, bark thickness, total height and stand height).
- Integration with other systems (eg. graphics) and be able to interface with information held in the Bauxite Register (when computerised).

The program is not yet operational. In the interim simple data processing and analysis will be carried out using a programmable calculator.

4.2 Data Handling and Storage

Field sheets will be initially processed and sorted out at Kelmscott and then sent for coding. The data is then placed onto magnetic tape (or disc depending on storage capabilities). The computer program will enable error checking of the field data and provide an error report. Following editing the data will be entered into the data base in batch mode. The data base can then be manipulated using the computer program.

4.3 Output and Distribution of Results

The following reports will be required:-

1. CURRENT MEASUREMENT REPORT: A mensurational report which gives information for stratum and plot as of last measurement. Lists within each diameter class the stem no's. (stems/ha),basal area (m^3/ha) and volume (m^3/ha U.B.) for each species with the stratum. Diameter, crown diameter and height means to be given for plot/ stratum and species.

2. INCREMENT REPORT: Similar format to above, but gives either total increment between measurements or mean annual increment for the measurement interval.

3. PLOT REPORT: Gives a listing for each plot the plot attributes recorded at last assessment. These are:- Operations, Salinity, Dieback, Slope, Impact, Fire, Ground Cover, No. of Seedlings and Banksia Regeneration.

4. TREE CONDITION REPORT: Report for plot or stratum giving the percentage of trees for each species that fall within the categories for Seeding, Creepers, Class, Health, Cause of Tree Decline and Form.

5. INVENTORY SUMMARY: Gives a list of all stratum and plots and when plots were established, no. of times measured and when due for re-measurement.

6. PERIODIC INCREMENT REPORT: For each plot and stratum gives stem no., basal area, height and volume for each species and year of assessment. Used to build growth functions.

7. STATISTICAL REPORT: Gives a report on the statistical accuracy and precision for any of the reports above.

POSSIBLE REQUESTS FOR INFORMATION (WHEN USED INTERACTIVELY):

- Call up by particular species or species mixture.
- What plots and/or stratum have reached a certain mensurational criteria e.g. - basal area - for silviculture; top height - for research; volume - timber production.
- Call up by treatment (generally catered for in stratum).
- Call up by bauxite pit (using H.O.C.S. reference).
- etc.

Summarised results for the Monitoring Project will be distributed to:-

1. Forests Department - Northern Region Office
2. Forests Department - Research Section, Dwellingup
3. Forests Department - Relevant Divisions
4. Forests Department - Superintendent I & P
5. Environmental Section, Alcoa

4.4 Analysis of Results

A procedure for data analysis is not yet operational. However, for the present a simple analysis will be carried out which compares growth between pits within the same strata. This will determine the validity of grouping similar species/species mixtures, planting years and treatment into strata. Once the sampling technique has been established as being valid, analysis will compare mean total heights and diameter both between strata and within strata.

As it will be some years before remeasurement of the plots is carried out, a direct assessment of growth within a particular stratum is not possible at present. However, comparisons can be made between similar species/species mixtures planted in different years on similar sites and receiving similar treatment.

5. FUTURE DEVELOPMENTS

5.1 Refinement of Measurement Technique

(i) Investigate the use of automatic field data loggers. This equipment will record and edit field data directly for later processing.

(ii) The use of large scale colour stereo photographs (70mm). They could be used extensively in determining general tree health, stocking and crown cover. A trial run has been carried out using the Department's Hasselbald camera (70mm) - results of this photography are very promising.

5.2 Herbarium

As an aid to species identification, a field herbarium has been established. All unknown species are brought in from the field for identification and mounting.

6. REFERENCES:

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FORESTS DEPT. OF W.A. - "Land Use Management Plan - Northern Jarrah. Forest Management Priority Areas". 1980.

HARRIS J.A. - "Land Rehabilitation after Bauxite Mining in the Northern Jarrah Forest (Darling Range) of Western Australia". 1979.

INSTITUTE OF FORESTERS OF AUSTRALIA - "Bauxite Mining in the Darling Range". Report by W.A. Division, May 1980.

KERSHAW K.A. - "Quantitative and Dynamic Plant Ecology". 2nd Edition. Edward Arnold 1973.

MAJER J.D. - "The role of Invertebrates in Bauxite Mine Rehabilitation". Forests Dept. & W.A. Bulletin 93, 1981.

TECHNICAL ADVISORY GROUP - "Bauxite Mining in the Darling Range W.A.". Department of Conservation & Environment W.A. Bulletin No. 44 - 1978.

US DEPT OF AGRICULTURE - "Elementary Statistical Methods for Foresters". Agricultural Handbook 317. US Dept. of Agriculture Forest Service.

APPENDICES

1. SAFETY PROCEDURES.

   1.1 Alcoa - Jarrahdale Minesite Regulations.
   1.2 Alcoa - Jarrahdale Minesite Daily Blasting Plan.
   1.3 Forests Department - Dwellingup Safety Prescriptions.

2. OFFICE PROCEDURES.

   2.1 Before Plot Establishment & Assessment.
   2.2 Following Plot Establishment & Assessment.

3. FIELD PROCEDURES.

   3.1 Field Equipment.
   3.2 Plot Establishment.
   3.3 Plot Assessment.
   3.4 Code List.
   3.5 Dieback Sampling Procedures.

4. SAMPLE TIE SKETCH & FIELDSHEET.

APPENDIX 1.1

ALCOA AUSTRALIA

Nº 1465

JARRAHDALE MINE SITE REGULATIONS

(REVISED MAY 1981)

Please read and retain the Jarrahdale Mine Site Regulations. Raise any queries you may have with the Security Guard.

1. PERSONAL PROTECTION
When proceeding outside the office/administration area the following applies:

1.1 CONTRACTORS:
Contractors working on site must wear the same safety equipment as Jarrahdale employees, for example, safety boots, safety helmet, safety glasses plus any special safety clothing applicable to particular jobs. Do not enter the site unless you can comply with this regulation.

1.2 SHORT TERM VISITORS TO THE MINE SITE (For example less than One Day)
Visitors must wear safety helmets, safety glasses and shoes (NOT sandals or thongs). Visitors who intend to stay on a prolonged period are to wear safety boots.

1.3 GOVERNMENT OFFICIALS & EMPLOYEES WITH STATUTORY RIGHTS OF ENTRY:
For your personal protection it is recommended that you are equipped with safety helmets, approved eye protection and safety footwear.

2. HAUL ROADS & RELATED RULES
All production haul road intersections are marked with INTERSECTION signs preceding the intersection. Where service roads meet haul roads a STOP sign is installed.

2.1 At production haul road "Y" intersections:
(a) GIVE WAY TO ALL MINE PRODUCTION VEHICLES (e.g. Dump Trucks, Loaders, etc.)
(b) GIVE WAY TO THE RIGHT TO OTHER LIGHT VEHICLES (UTILITIES, FOUR WHEEL DRIVES, SEDANS, ETC.) Refer example on reverse side.

2.2 On approaching a "STOP" sign, you should stop at the intersection and GIVE WAY to ALL OTHER VEHICLES travelling along or turning from the Priority Road. (Refer example on reverse side.)

2.3 At terminating road intersections ("T" Junctions) Vehicles on the terminating road must GIVE WAY to ALL OTHER VEHICLES travelling along or turning from the Priority Road. (Refer example on reverse side.)

2.4 Overtaking is STRICTLY FORBIDDEN except in the following situations:
(a) Overtaking a Tracked Vehicle.
(b) Overtaking a Grader, GRADING a Haul Road.
(c) Overtaking a broken down vehicle or a rubber tyred vehicle which has pulled over to the left hand side of the road and STOPPED.
In the above overtaking exceptions, the Operator of the overtaking vehicle is responsible for the safe completion of the manoeuvre.

2.5 When travelling behind other vehicles keep at least 30 metres clear.

2.6 Do not stop or park on haul roads. There is insufficient width for two production trucks and a light vehicle at any point. In mining pits, do not park within 50 metres of heavy equipment.

2.7 Speed limit is 60 km.p.h. except where defined around the workshop/administration area.

2.8 You should maintain a minimum speed consistent with the general traffic flow. Remember that vehicles with a gross weight of 180 tonnes may be approaching from behind at 60 km.p.h.

2.9 The cloverleaf area leading to the truck dump bridge (circled in red and also inset on the blasting plan) is closed to vehicular traffic. Please keep clear of this area. (A plan showing this area is on reverse side).

2.10 Horn signals must be used at all times.
(a) One blast for Forward.
(b) Two blasts for Reverse.

2.11 A spotter is required for large vehicles when reversing in congested areas.

2.12 Never park in front of fire fighting equipment.

3. BLASTING OPERATIONS:

3.1 A plan showing the location and time of blasting is issued daily as required.

3.2 A siren is sounded 5 minutes before blasting time and again at the actual time of the blast.

3.3 Barricades are located at least 500 metres away from the blast area. The barricades are situated on main haul roads and forest tracks. You should move behind the barricades at least 15 minutes before the blast is timed for detonation. Do not pass BLASTING NO TRAVELLING signs. Do not smoke within 15 metres of charging operations.

3.4 Once the "all clear" has been given and on removal of the blasting barrier, it is safe to return to the area concerned.

4. CRUSHING PLANT AREA AND WORKSHOP COMPOUND:
The crushing plant area and workshop compound contain normal hazards associated with operation of large industrial machinery. For your own protection, do not enter these areas unless accompanied by mine site personnel.

Nº 1465

I have read and fully understand the Jarrahdale Minesite Regulations.
I will undertake not to drive on the Jarrahdale Minesite unless in possession of a current Drivers Licence.

Signed ..... Date .....

WUNGONG DAM

F36 G36 H36

ALBANY HIGHWAY

ORCHARD ROAD

G3621 JV409

JV309,14

FREMLIN RD

WAGTAIL RD

HAUL ROAD 1

MAGPIE RD

ROSELLA RD

NETTLETON

G3708

JV 423,24

PUMP STATION ROAD

JV 328

JV 322,26

JV427

JV403

F37 G37 H37

JV3 JV4

JW3 JW4

HAUL ROAD

Magazine

KOOKA SCENIC DRIVE

No 2 Mine Site

MINE ACCESS ROAD

Enlargement on reverse side.

HAUL ROAD

CHANDLER

WESTRAIL

CROW

WREN RD

H3805

H3813

No 1 Mine Site

Langford Park

F38 G38 H38

DOVE RD

G 3816

G 3817,18

G 3820

WESTRAIL

NETTLETON

JOHNSON ROAD

DATE .....

FIRING .....

TIME .....

APPROVED .....

..... Haul roads

..... Public roads

.....Areas cleared for mining

..... Rehabilitated areas

.....Private property

... Imperial mining sheet layout

.....Metric mining sheet layout

Scale in kilometres

1 0 1 2

1 0 1

Scale in miles

ALCOA OF AUSTRALIA LIMITED

JARRAHDALE MINING AREA

BLASTING PLAN

APPENDIX 1.3

DWELLINGUP SAFETY PRESCRIPTION NO. 1 - ALCOA MINESITE

1. INTRODUCTION

Bauxite mining involving the use of explosives and heavy machinery is currently taking place in areas of State Forest within Dwellingup Division.

In the course of their official duties all F.D. personnel are authorised to enter any mining area, however, due to the dangers associated with the mining activity the safety prescription detailed below is to be followed when entering these areas.

2. AIM

To protect from injury and accident all F.D. personnel working in Forest areas influenced by current mining operations.

3. PRESCRIPTION

3.1 Zone of influence over which this prescription is to apply is:-

3.1.1 All current mine pits ie. in the process of being
(a) Cleared.
(b) Mined.
(c) Rehabilitated.

3.1.2 All forest areas within 1km of the boundary of the areas nominated in 3.1.1.

3.2 Advice of entry into a zone of influence must be made to:-

3.2.1 Dwellingup F.D. Office for noting on the disposition board by either radio or telephone and advice of daily blasting times.

3.2.2 Alcoa Huntly and Del Park Mining Production Planning Supervisors for either Huntly (telephone Pinjarra 311 611 Mr Paul Hallam), Del Park (telephone Pinjarra 311 611 Mr Peter Heydon) depending upon area of entry direct by telephone or by radio via Dwellingup F.D. Office.

3.3 Details of advice required by Alcoa.

3.1.1 Name.

3.1.2 Job Location.

3.1.3 E.T.A. and E.T.D.

3.1.4 Communications eg. F.D. radio at personal contact if not on radio.

3.1.5 Confirmation of daily blasting times.

3.4 Alcoa minesite rules (See Appendix 1). All F.D. staff are to be familiar with the Controls placed upon Alcoa personnel. Note additional General Rules.

K.R. VEAR,
D.F.O.

Distribution: Conservator of Forests.
Supt. Central Region.
Supt. Northern Region.
O.I.C. Jarrahdale Division.
O.I.C. Dwellingup Division.
O.I.C. Northern Region.
O.I.C. I. & P. Northern Region.
Alcoa.
Issue to all Dwellingup O/S.
Issue to all F.D. authorised visitors on entry.

APPENDIX 2 - OFFICE PROCEDURES

2.1 Before Plot Establishment and Measurement

(a) Group plantings of similar species/species mixtures, planting year, site preparation and silvicultural history into sampling strata. Amalgamation should occur within the planting years 1970-73, 1974-76, as site preparation and establishment techniques were similar within each of these periods. Planting areas are not allocated to strata if by themselves less than 1.0 ha, or if less than 0.5 ha if part of an amalgamation. Thus the smallest strata size is 1.0 ha.

Colour aerial photographs (Alcoa 1:22,000 scale photography) should be consulted to ensure that survival and growth for separate planting areas within a strata have basic similarities. A separate stratum should be defined for areas which exhibit gross differences. The stratum once defined should be located on the 1:5,000 or 1:2,500 scale Alcoa rehabilitation maps. The total area of the strata should be recorded.

(b) Trace onto a sheet of tracing paper the planting areas which comprise a single strata. The planting areas should be traced so that they fit onto as compact an area as possible to facilitate random selection using a reference grid.

(c) Allocate plots to the entire strata using the following selection criteria:-

STRATUM SIZE (ha)	NO. OF PLOTS
1 - 2	2
2 - 3	3
3 - 4	4
4 - 6	5
6 - 8	6
8 - 10	7
10 +	7 - Plus 1 plot for every 5 ha over 10 ha.

If the strata is composed of a number of planting years (eg. 1970-73), the total number of plots are allocated proportionally to the area of each planting year.

(d) Randomly select the plot position with the aid of a random number table (4 figure) and a reference grid. The selected point represents the plot centre. It must be ensured that plots should not be selected systematically. If the selected point either falls within 10m of the pit boundary or within 50m of another plot, a new point is selected randomly. Random selections are made until the total number of plots for the strata have been allocated. The plot position is shown on the tracing paper by a single point.

(e) Transfer the plot position information shown on the tracing sheet onto the Plot Tie Sketch (See Appendix 4). The Plot Tie Sketch is prepared by cutting out the relevant planting area from a photocopy of the Alcoa 1:5,000 or 1:2,500 rehabilitation maps and glueing this onto the central position of the Plot Tie Sketch. This map portion should be arranged so that north is towards the top of the Plot Tie Sketch. A number of these Plot Tie Sketches will be required if the strata is composed of dispersed or very large planting areas.

The plot positions are transferred onto the Plot Tie Sketch using a light table. The plot position is shown by a blue point.

The plots are then numbered consecutively for an entire strata from north to south for each planting area. A photocopy is made of this original.

(f) Record the plot and strata details on the top of this Plot Tie Sketch Photocopy. At the bottom of this copy is shown the Plot Tie information. This shows the distance, route to and location of the Plot Reference Point (P.R.P.), as well as the bearing and the distance to the S.W. corner of the plot.

Latest colour aerial photography should be consulted to determine the best access to the pit and for the location of the P.R.P. (which is a white painted wood survey peg). This should be supplemented with current field knowledge if available.

(g) This copy of the Plot Tie Sketch is to be used as a draft field copy. Any additions or alterations to the route traversed, tie or bearing should be made on this sheet. A revised Plot Tie Sketch is made after field establishment.

(h) Record details of each strata and the plots selected for establishment in the plot register.

(i) Prior to re-measurement of a plot, a copy of the fieldsheet is made and attached to the Plot Tie Sketch. Re-measurement of the plot is recorded in the Plot Register.

2.2 Following Plot Establishment and Measurement

(a) Accurately transfer onto the Plot Tie Sketch original, all the tie details recorded on the draft Plot Tie Sketch.

(b) Collate all fieldsheets for a particular strata and store with the relevant Plot Tie Sketch in a plastic wallet. Care must be taken to ensure that if there is a second page of a fieldsheet that it is not separated from page 1. The field sheets should be checked for any ommisions or obvious errors. A photocopy is made of all the fieldsheets - the originals are then sent to A.D.P. Como for processing.

(c) Update the Plot Register to record all plot establishment, measurement and remeasurement. The plot Register should indicate when a particular plot is due for remeasurement.

(d) Store originals and copies of fieldsheets and Plot Tie Sketches within plastic wallets in lever arch files.

APPENDIX 3 - FIELD PROCEDURES

3.1 Field Equipment

The following equipment is required for plot establishment/assessment:-

1. Minesite Blasting Plan showing location of blasting area and a copy of the Minesite Regulations.

2. Plot Tie Sketches for relevant planting area.

3. Supply of Field Measurement Sheets or last Measurement sheet if applicable.

4. Copy of field procedures and codes.

5. Field Equipment:-

Case
Booking board/folder
Pencils (HB) & sharpener
Eraser
Protractor & Scale rule
Hand Calculator
Compass
Clino
Optical square
Carry bag
Bark gauge
Pine diameter tape (3m)
30m fibreglass tape
100m survey band & repair kit
"Topofil" hip chain

Red plastic tape
Height sticks (5m x 2m Sections)
Height Stick (1.3m for P.O.M.)
Number punches (0-9)
Paint (white & paint thinners)
Paint brush & tin
Numbered metal tags(bundles of 1-99)
Blank metal tags
Plastic tie wire
Scrub slasher
Hammer & sledge hammer
Star pickets (top painted white)
Wooden Survey pegs (painted white)
Plastic Sample bags & foil tags
Dieback sampling kit
Chainsaw

3.2 Plot Establishment

(a) Check in at the main gate of the minesite and record details in the log book. Consult the daily blasting plan for blasting activity (Appendix 1.2). If blasting is to occur in an area you wish to visit, another area will have to be chosen. Alternative plots to be established/measured - should have been prepared.

(b) Turn on the vehicle "Tripmaster" when leaving the main gate. Proceed along the designated route to the Plot Reference Point (P.R.P.) as shown on the Plot Tie Sketch, taking extreme care with travelling along major haul roads.

(c) Upon reaching the designated P.R.P., ensure that its location is in an easily visible position and will not be disturbed by grading etc. It should be located at least 2m from the road verge. If it is necessary to alter the position of the P.R.P. from that designated in the Plot Tie Sketch - then the new position should be recorded. A new bearing and distance to the plot positions will have to be re-plotted (remembering the distance on the Plot Tie Sketch will have to be multiplied by 0.984 to allow for photocopy error).

3.2 Plot Establishment (Cont.)

(d) At the P.R.P., drive a wooden survey peg into the soil to a depth of 30cm, and clear the surrounding scrub and debris for a distance of 2m.

(e) Using compass and 100m survey band, proceed from the P.R.P. along the designated bearing (shown as True bearing on the Plot Tie Sketch) for the required distance until the plot position is reached. A slope correction is made if the slope measured using the clinometer is over 8 degrees.

(f) At the required plot position drive into the ground (using a sledge hammer) a steel corner post (star picket). This point forms the south-west corner of the 20m x 20m square plot. Thus the plot is oriented north-south, east-west. The plot is located in this position regardless of the surrounding topography. However, if the plot falls within a different species mixture (than is shown on the maps) or in a non planted area (as distinct from a failed area) then the plot is not established. This is noted on the Plot Tie Sketch.

(g) Proceed 20m to the south-west corner of the plot and position the corner post. This is repeated for the north-east and north-west corners of the plot using an optical square (or compass if the plot is heavily sloping). Allowance for slope must be made if the slope is greater than 8 degrees. Closing error should be within ±20cm. The side of the plot can be demarcated using cotton thread from the hip chain. If the vegetation is very dense, then clearing around the plot perimeter with the scrub slasher will be required.

(h) Tag every tree species within the plot that is over one metre in height. Numbered aluminium tags (1-99) are nailed to the base of the tree (facing the South Boundary). Tags are suspended from the stem using plastic tie wire if either the stem is less than 10cm diameter overbark or if nailing a tag to the base of the tree will damage it. If the tree is multi-stemmed, the tag is placed around the tree at ground level.

(i) The first tree to be tagged is the tree on the highest contour furrow within the pit and closest to the S.W. corner. The trees are then numbered consecutively along the row and away from the S.W. corner of the plot. Once the end of a particular row is reached, trees within the next planting row are numbered in the opposite direction. Trees are numbered consecutively from 1-99 from plot to plot to minimise tag wastage. The direction of numbering should be recorded on the Plot Diagram (on reverse of fieldsheet).

(j) All trees within the plot over one metre in height are tagged - whether the tree is alive, dying or dead.

3.3 Plot Assessment

Following establishment, the plots are assessed - the information being recorded on the Bauxite Rehabilitation Monitoring Project Field Measurement Sheet.

(a) The following plot information is recorded at the top of the Field Measurement Sheet:- (See Appendix 3.4 for codes).

Plot ID: Six figure code:-

Column 1 - Minesite No.
Column 2-4 - Strata No.
Column 5-6 - Plot No.

H.O.C.S. Ref.:

Column 1-2 - Block Code.
Column 3 - Compartment No.
Column 4-6 - Pit No. & Section ID.

Planting Year: Date planting established.

Date: Month/Year. Assessor: Initials of assessor.

Operations: Evidence of any recent silvicultural operations.

Erosion: Any obvious erosional features within the plot - could include visible gully or sheet erosion or buildup of sediment.

Salinity: Any evidence of a salinity problem (eg. white crust, appearance of salt tolerant species).

Dieback: Whether a dieback sample is taken within the plot at this assessment (refer to Appendix 3.5 for sampling procedures).

Slope & Aspect: Slope of the plot in degrees measured at the plot centre. General aspect of plot - eg. NE, S, SE.

Fire: Evidence of recent fire (eg. stems and/or understorey charred or scorched, fresh epicormic shoots visible).

Ground Cover: Percentage ground cover (including tree seedling) within a 5 x 5m square at the S.W. corner of the plot.

Seedlings: Number of tree seedlings within 5 x 5m square described above. The approximate percentage of each species is noted in the "Comments" section of the fieldsheet.

Banksias: Number of Banksia grandis seedling/trees regenerated within the plot.

(b) At the time of full assessment (at age 7-8 years or following initial thinning/culling), trees within the plot are assessed and the following information is recorded (See Appendix 3.4 for attribute codes):-

Tree No.: Tree number as shown on the aluminium tag.

Stem No.: Record the stem number where multiple stems are arising from the ground or tree is forked below 1.3m. The orientation of each stem is identified in the "Comments" section. For each stem is measured total height and stem form is assessed . Diameter and bark thickness is measured if the stem is over 10cm diameter. All other parameters are assessed for the whole tree.

Species: Record as a two letter code. If a positive identification is not made, then a full sample is taken and labelled with the plot and tree number. "?" is recorded in the species column.

D.B.H.: Diameter at breast height overbark in cm, measured at 1.3m above mineral soil on the uphill side of the stem, and at right angles to the long axis of the stem. If the measurement point is unrepresentative, the a represnetative point should be selected. The new point measurement (P.O.M.) should be recorded. The diameter of the tree is not recorded if under 10cm.

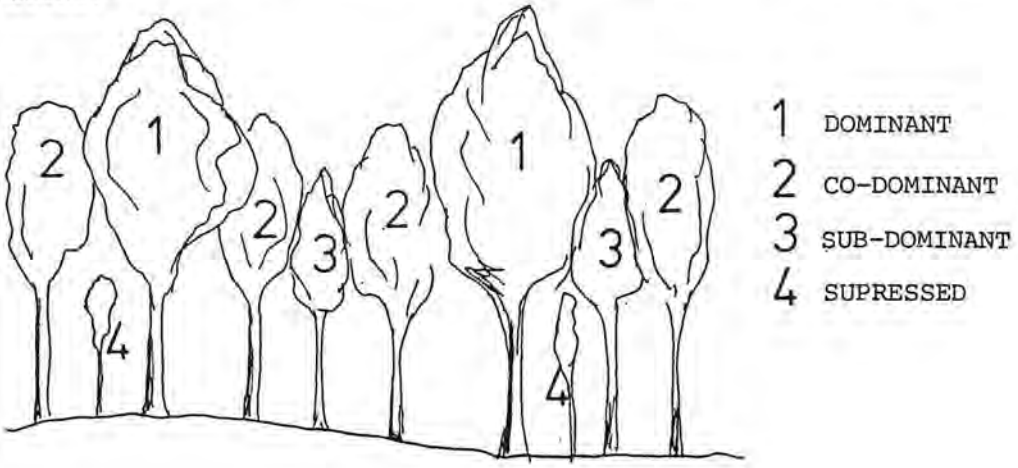
Bark Thickness: Thickness of the bark at 5cm below breast height (to nearest 0.1cm). An average of two readings using a ice pick type bark gauge is recorded.

Total Height: Total height of the tree measured to 0.1m using height sticks for trees less than 5m and to the nearest 0.2m using a clinometer for trees greater than 10m. If the understorey is too dense to use height sticks, then a clinometer is used. For leaning trees measure the perpendicular height from tip to ground. For sloping ground measure vertically from the tip to a point horizontal to the base of the stem.

Seeding: Evidence of seed production (fruit or cones). Include both buds and fruit as well as fruit remaining after seed shed.

Vines: Presence or absence of vines and/or creepers either on the stem or ground, alive or dead.

Class: Record tree dominance within the canopy. See diagram below:-



Health: A subjective classification of the health or thrift of the tree being assessed.

Decline in vigour: Obvious signs and/or cause indicating a decline in vigour or death.

Form: General form of the stem being assessed; either straight, forked or malformed. Height of forking is recorded in the comments section.

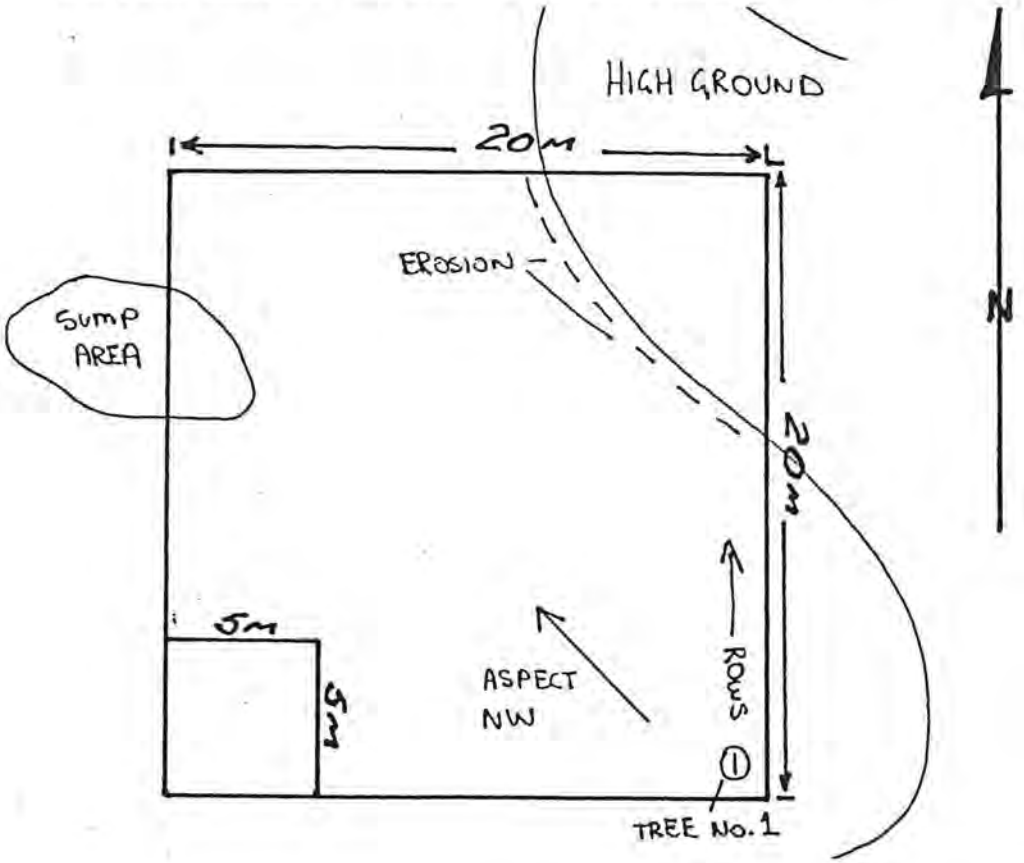
Crown Diameter: Measurement on the ground of the projected crown perimeter. The average of two readings taken at right angles is recorded. Measured to nearest 0.5m for every tree.

Comments: Brief comments on orientation of multiple stems/height of fork and any other information considered relevant.

(c) On the reverse of the fieldsheet is recorded in the "Comments" section:-

- Direction and sequence of tag numbers.
- Details of tree seedlings species regeneration.
- Species of understorey.
- Unusual features or site features either permanent or temporary.
- The general condition of the site.
- Any other relevant comments.

A sketch of the site showing any relevant features is made using the plot diagram. An example is shown below:-



3.4 Code List

(a) Codes for Plot Parameters:-

Blocks

Jarrahdale Division -	Gordon	- GD
	Chandler	- CH
	Mundlimup	- ML
Dwellingup Division -	Turner	- TN
	Marrinup	- MR
	Holyoake	- HK
	Urbrae	- UR
	Marradong	- MG
	Saddleback	- SB

Minesite

Jarrahdale No. 1 = 1	Willowdale = 5
Jarrahdale No. 2 = 2	Saddleback = 6
Del Park = 3	Marradong = 7
Huntly = 4	

Operations

(1) No evidence of recent silvicultural operation.
(2) Evidence of recent thinning.
(3) Evidence of recent thinning and culling.
(4) Evidence of recent logging.
(5) Evidence of any other operation.

Erosion

(1) No obvious erosional features.
(2) Erosional features (gully or sheet erosion, sediments) present.

Salinity

(1) No evidence of salinity.
(2) Evidence of salinity.
(3) Severe salinity problem.

Dieback

(1) No sample taken at this assessment.
(2) Sample taken at this assessment.

Fire

(1) No evidence of recent fire.
(2) Evidence of recent fire.

(b) Codes for Tree Parameters:-

CODE

AC - Eucalyptus accedens - Powder Bark Wandoo.
AG - E.agglomerata - Blue-leaved stringybark.
AS - E.astringens - Brown Mallet.
BA - E.baxteri - Baxter's stringybark.
BI - E.bicostata - Eurabbie.
BO - E.botryoides - Bangalay.
BD - E.burdettiana - Burdetts Gum.
CE - E.caesia - Gungurru.
CA - E.calophylla - Marri.
CM - E.camaldulensis - Murray River Red Gum.
CI - E.citriodora - Lemon-scented Spotted Gum.
CL - E.cladocalyx - Sugar Gum.
CR - E.crebra - Narrow-leaved Red Ironbark.
CY - E.cypellocarpa - Spotted Mountain Gum.
DE - E.decipiens - Limestone Mallet.
DI - E.diversicolor - Karri.
DU - E.dundasii - Dundas Blackbutt.
EX - E.exserta - Queensland Pepperiment.
FC - E.ficifolia - Red Flowering Gum.
GL - E.globulus - Tasmanian Blue Gum.
GO - E.gomphocephala - Tuart.
GN - E.goniocalyx - Spotted Mountain Gum.
GR - E.grandis - Flooded Gum.
GU - E.guilfoylei - Yellow Tingle.
HA - E.haematoxylon - Mountain Gum.
JA - E.jacksonii - Red Tingle.
LA - E.laeliae - Darling Range Ghost Gum.
LE - E.leucoxylon - Smooth Barked Ironbark.
LO - E.loxophleba - York Gum.
MC - E.maculata - Spotted Gum.
MA - E.marginata - Jarrah.
ME - E.megacarpa - Bullich.
MI - E.microcorys - Tallow Wood.
MU - E.muelleriana - Yellow Stringybark.
OC - E.occidentalis - Swamp or Flat-topped Yate.
PA - E.patens - Swan River Blackbutt.
PI - E.pilularis - Blackbutt.
PR - E.propinqua - Grey Gum.
RE - E.resinifera - Red Mahogany.
RO - E.robusta - Swamp Mahogany.
RU - E.rudis - Flooded Gum (W.A.).
SA - E.saligna - Sydney Blue Gum.
SG - E. sargentii - Blue Mallet.
SI - E.sideroxylon - Red Ironbark.
SP - E.spathulata - Swamp Mallet.
ST - E.stricklandii - Strictland's Gum.
WA - E.wandoo - White Gum.
PB - Pinus brutei - Aleppo Pine
PC - P.canariensis - Canary Island Pine.
PE - P.elliotii - American Pitch Pine.
PH - P.halepensis - Aleppo pine.
PN - P.pinaster - Maritime Pine.
RA - P.radiata - Monterey Pine.
TA - P.taeda - Loblolly Pine.

GR - B.grandis - Bull Banksia.
CC - Calitris calcarata - Black Cypress Pine.
CD - Casuarina decussata - Karri Oak.
CF - Casuarina frazeriana - Sheoak.
CU - Cupressus lusitanica - Mexican Cypress.
PK - Parkland style planting.
PS - Parkland style planting and subclover.

Seeding

(1) No fruit.
(2) Fruit scarce.
(3) Fruit normal.
(4) Fruit heavy.

Creepers

(1) Not present on tree.
(2) On tree alive.
(3) On tree dead.

Class

(1) Dominant.
(2) Co-dominant.
(3) Sub-dominant.
(4) Suppressed.

Health

(1) Good.
(2) Average.
(3) Poor - some healthy foliage.
(4) Poor - no healthy foliage.
(5) Dead.

Decline in Vigour

(1) Healthy.
(2) Undecided.
(3) Insect attack.
(4) Fungal attack.
(5) Leaf discoloration.
(6) Growth Cracks.
(7) Small leaf size.
(8) Drought Stress.
(9) Sivicultural operation.
(10) Windthrow.
(11) Salinity.
(12) Fire.
(13) Ground cover competition (eg. vines).

Form

(1) Single stem - straight.
(2) Single stem - malformed.
(3) Multiple stems - straight.
(4) Multiple stems - malformed.

3.5 Dieback Sampling

Your sampling equipment should include:-

(a) Back pack.
(b) First Aid Kit.
(c) Alcohol in proper approved container.
(d) Aluminium Tags.
(e) Plastic bags.
(f) Cable Ties.
(g) Artline 70 for writing on plastic bags.
(h) Field sheets.

Field Sampling Technique

Select a recently killed indicator plant for sampling, and take a sample using the following procedures:-

(a) Ensure the mattock has been sterilised using Biogram. Remove sterilising agent residue by digging the mattock into the ground away from the plant to be sampled.

(b) Clean leaves, twigs and soil from around the base of the plant to be sampled, exposing the collar region to a depth of about 15cm.

(c) Chop sections of root, bark and cambian from all around the plant. In the case of zamias, chop into the centre of the bole and take the woody, fibrous tissue from the bole. When sampling blackboys collect the small, radiating brittle roots and sections of pithy core, from six centimetres and deeper. Emu bush has a large underground stem and lower trunk section which may be sampled in the same way as banksia and snoddygobble.

(d) Collect several handfulls of soil from around the base of the tree, also collect chips of bark, wood and roots from around the colar region. Ensure that cross contamination does not occur. (eg. Infected material on hands)

(e) Place this material in a plastic bag with an aluminium tag showing:-

(i) The Date.
(ii) B.R.M.P. Plot No.

Clearly lable bag with a permanent marker pen with the above.

APPENDIX 4

SAMPLE PLOT TIE SKETCH
& FIELDSHEETS.

FORESTS DEPT. OF W.A.
INVENTORY AND PLANNING

REHABILITATION MONITORING
FIELD MEASUREMENT SHEET

SHEET ___ OF ___

F.D.799/83.

PLOT ID 2,0,0,2,0,1 HOCS REF G,D,4,1,7,B PLANTING YEAR 7,0 ASSESSOR M,C DATE 2/8/82
OPERATIONS 1 EROSION 2 SALINITY 1 DIEBACK 1 SLOPE 1,5 FIRE 1
GROUND COVER 0,5 SEEDLINGS 0,0 1 BANKSIA 0,0 ASPECT N,W

TREE NO.	STEM NO.	SPECIES	D.B.H. (CM)	BARK (CM) THICKNESS	TOTAL HEIGHT (M)	SEEDING	CREEPERS	CLASS	HEALTH	DECLINE IN VIGOUR	FORM	CROWN DIAMETER	COMMENTS:
													P.R.P. TO S.W. CORNE
													112M @ 195°T
45		MC	1 0·6	1·7	8·1	4	1	3	2	0	2	20	FORKED @ 4·0M
										1			SLIGHT INSECT ATTACK
46		RE	1 7·4	2·0	10·7	3	1	1	1	0	1	60	
										1			
47		MC	1 7·0	2·2	10·4	3	1	1	1	0	2	35	FORKED @ 6·0M
										1			
48		MC	1 5·7	2·0	8·6	1	2	1	1	0	1	40	
										1			
49	1	RE	1 5·4	1·8	9·5	2	1	2	2	0	3	70	E. STEM
										1			
	2		1 2·6	1·6	8·5						3		W. STEM
50		MC	1 5·2	1·7	10·3	3	1	2	2	0	2	30	FORKED @ 8·0M
										1			
51		MC	1 7·2	2·1	12·7	3	1	1	2	0	2	30	FORKED @ 10·0M
										1			HAS GROWTH CRACKS.
52		MC	1 3·2	1·6	11·8	3	1	2	2	0	2	30	FORKED @ 10·0M
										1			
53		MC	1 5·3	1·8	9·3	4	1	2	2	0	2	35	P.O.M. @ 1·20M
										1			FORKED @ 4·0M
54	1	RE	1 3·1	1·3	11·0	3	1	2	2	0	3	50	N. STEM
										1			
	2		0·0	0·0	11·2						3		S. STEM
55		MC	1 4·2	1·6	10·2	3	1	2	2	0	2	35	FORKED @ 6·0M
										1			
56		RE	1 7·5	1·4	11·4	3	1	1	2	0	2	55	FORKED @ 5M
										1			
57	1	MC	1 8·9	2·2	12·9	4	1	1	2	0	2	40	S. STEM. FORKED @ 10·0M
										1			
	2		0·0	0·0	3·0						2		N STEM
58		RE	0 0·0	0·0	8·3	2	1	0	2	0	1	00	
										1			
59		RE	0 0·0	0·0	7·9	2	1	0	3	0	3	200	
										1			
60		MC	1 8·1	2·0	12·4	3	1	1	2	0	1	235	FORKED @ 11·0M
										1			
61		RE	2 0·0	2·0	15·0	3	1	1	2	0	1	145	
										1			
62		MC	1 4·3	1·8	10·4	3	1	2	2	0	1	235	
										1			
63		RE	1 6·1	2·0	11·0	3	1	2	2	0	1	145	
										1			
64		MC	1 6·5	2·4	11·0	3	1	2	2	0	1	140	
										1			
65		MC	0 0·0	0·0	7·2	1	1	0	2	0	1	200	

COMMENTS:

Plot has mixture of E. resinifera + E. maculata. Health of trees fair to good - similar to surrounds. Trees subject to insect attack - especially smaller trees.

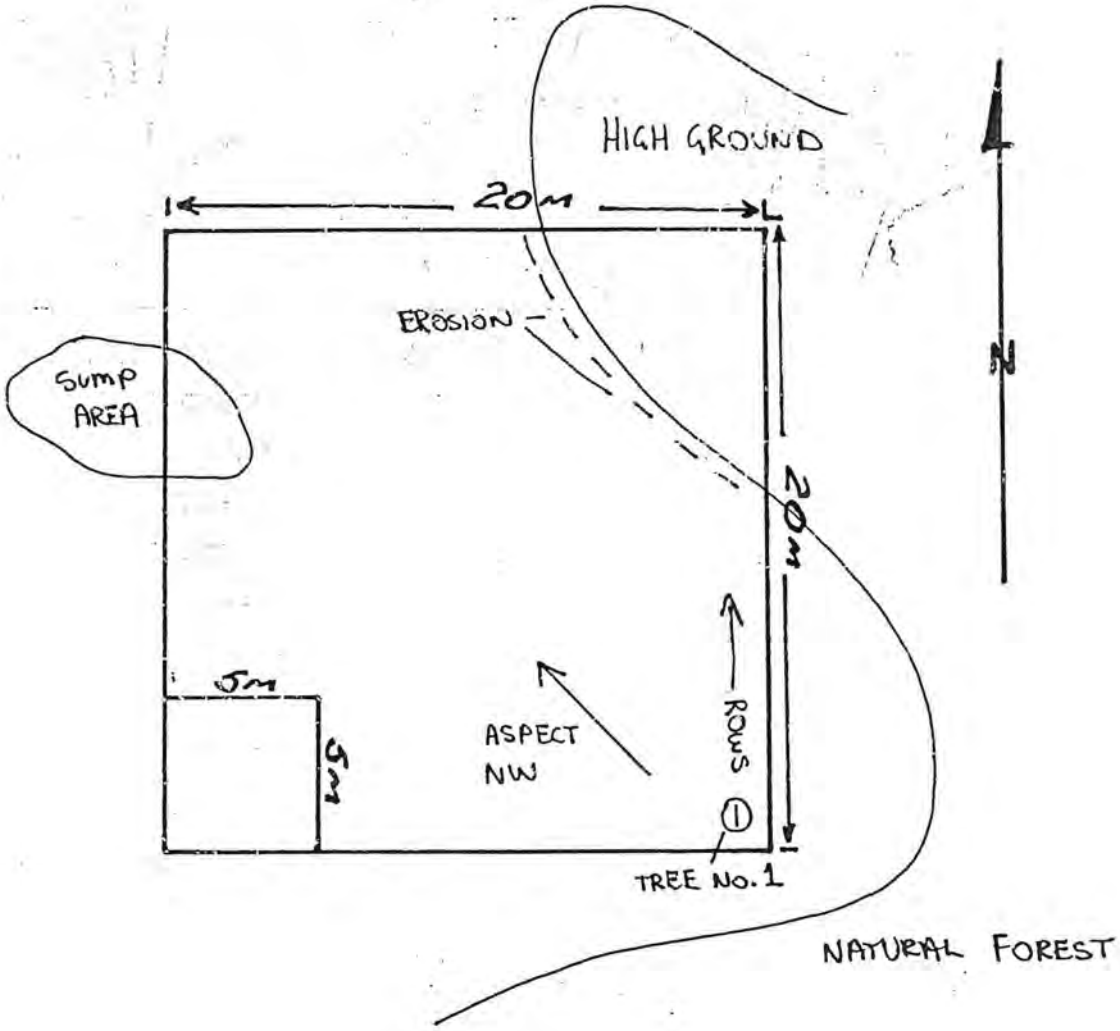
Ground cover limited to some grasses + Acacia sp.

Some natural regeneration - 2 marri seedlings.

No thinning or culling carried out

Rows run N|S (began assessment at SE corner heading N)

Gully erosion on pit sides.



FORESTS DEPARTMENT (F.D. 800/83)

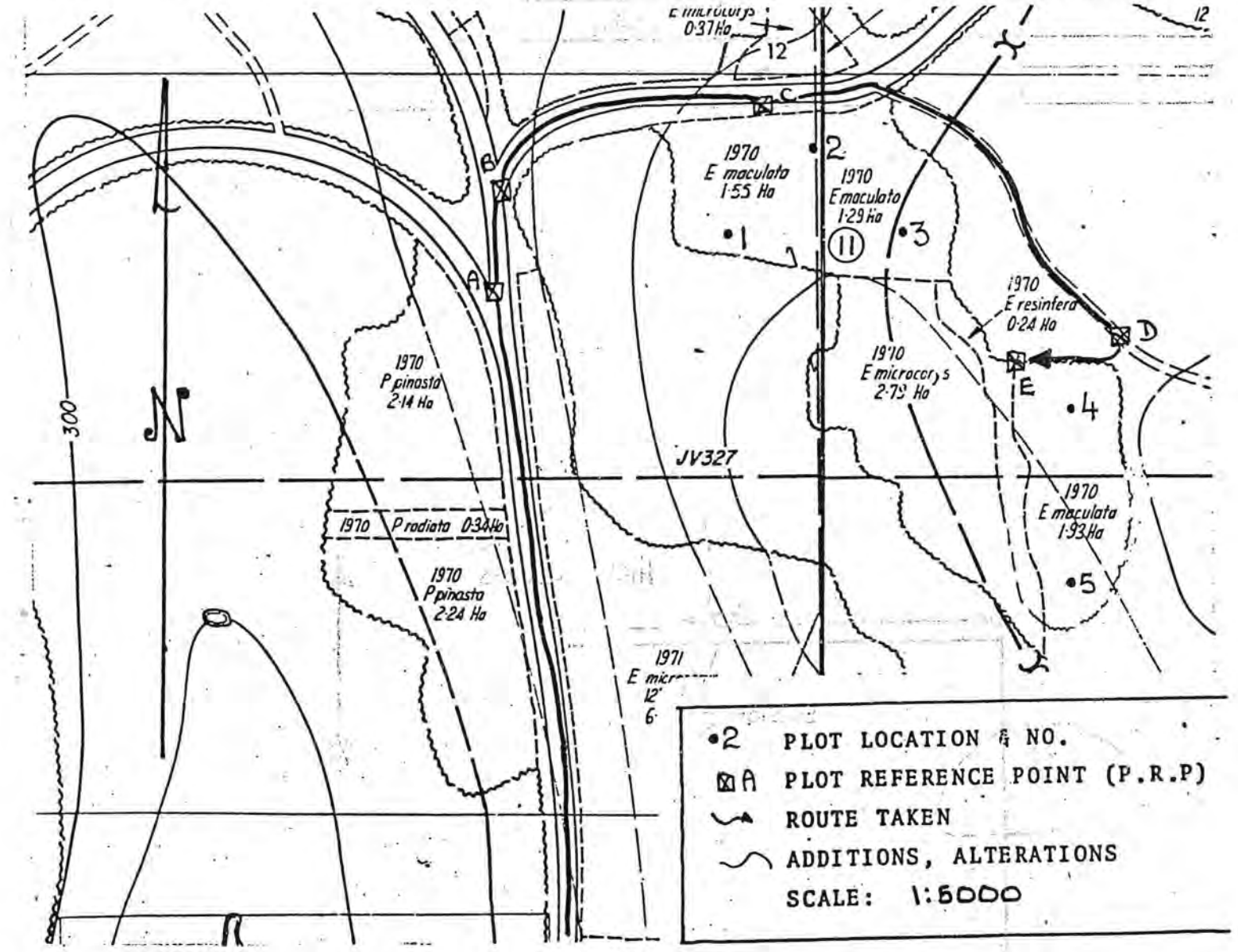
BAUXITE REHABILITATION MONITORING PROJECT - PLOT TIE INFORMATION

DIVISION: ..... REF(F.D.)..... MINESITE .....

BLOCK & CPT. ..... (ALCOA) ..... P. YEAR .....

PIT ..... SECTION ..... SPECIES .....

PLOT NO. ..... STRATA NO..... .....



•2 PLOT LOCATION & NO.

A PLOT REFERENCE POINT (P.R.P)

ROUTE TAKEN

ADDITIONS, ALTERATIONS

SCALE: 1:5000

PLOT LOCATION	STATION	F.S.B.G.	B.S.B.G.	METRES
INTERSECTION OF HAUL RD 3 + ROSELLA RD	A to B	NTH ALONG	ROSELLA	80M
	B to C	E. ALONG	TRACK	255M
	C to 1	195°T	15°T	100M
	C to 2	131°T	311°T	55M
	C to 3	134°T	314°T	158M
P.T.O FOR REFERENCE TO PLOT	to			
NOS 4+5	to			
	to			PTO

COMMENTS:

PLOT LOCATION	STATION	F.S.B.G.	B.S.B.G.	METRE
FROM PRP-C SE along track to PRP-D	C to D			
SW to junctn of Euc Maculata + Euc Resinifera	to			
and northern bdy rehab area	D to E			
	E to 4	131°T	311°T	60
	E to 5	166°T	346°T	160
	to			
	to			
	to			