ANALYSIS OF THE 25 YEAR PLAN FOR THE PROPOSED CONSOLIDATED DELPARK/HUNTLY MINE

A REPORT TO THE
MINING AND MANAGEMENT PROGRAMME LIAISON GROUP

JULY 1986.

Del Park/Huntly 25 Year Mine Plan

Report of a Working Group convened to consider the 25 year bauxite mine plan proposed by Alcoa for a combined Del Park/Huntly operation.

Working Group consisted of

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1. Introduction

Previous 25 year bauxite mine plans to supply the Pinjarra Refinery foresaw the Del Park operation moving north, west and south of Dwellingup before crossing the Murray River. The Huntly operation was to move northwards to the vicinity of the North Dandalup River.

Since these plans were finalized in 1982 several substantial changes have occurred which require that the plans, particularly that for Del Park, now be reviewed. Firstly, an apparent long term downturn in the world alumina/aluminium market has emerged which compromises the economic viability of the Del Park plan. In particular Alcoa is anxious to avoid the large capital cost of the Murray River crossing. Ore development work in the northern part of Teesdale indicates generally poor quality and this is another unattractive feature of this route. Secondly, the declaration of the Lane Poole Reserve in 1984 and subsequent publicity focussed public attention on the Murray Valley and the potential impact mining may have in the vicinity. Though Alcoa has negotiated the right to construct a conveyor crossing (CALM, 1986), all parties now see difficulties with this strategy. Thirdly, there has been protracted debate with some sections of the Dwellingup community with respect to mining near the town. Resolution of the problem to the satisfaction of all parties is unlikely, even if Alcoa proceeds with its planned substantial investment in new noise-reduced continuous mining technology.

If the Murray River crossing is to be abandoned, the alternatives for the Del Park operation are limited. The South Dandalup Dam presents an impassable barrier in the north while Dwellingup is centrally placed in the 8km space betweeen the Dam and the Lane Poole Reserve. Only three options are available:

attempt to maximize mining in the vicinity of Dwellingup then proceed eastwards. This would exacerbate conflict with Dwellingup residents; it would open early access to the high quality bauxite reserves in Holmes block adjacent to the Lane Poole Reserve and through which pass the major access

roads to the reserve; and would in the longer term direct mining into the high-quality, older-aged regrowth jarrah forest east of Dwellingup (Holyoake and Plavins blocks). This is Alcoa's favoured economic option because it opens access to the large, high quality bauxite reserves east of Dwellingup, the existence of which played a major role in the late 1960s in determining the Pinjarra Refinery location.

- bypass Dwellingup with minimum conflict and proceed eastwards. This would require early access to the high quality forest mentioned above which is also within the proclaimed Disease Risk Area (DRA).

- terminate the present Del Park thrust and relocate north of the South Dandalup Dam in the same region as the Huntly mine. In this region minimum scope occurs for conflict with conservation and population centres and some 50 years of mining could be accommodated for both operations south of the Serpentine Dam. For Alcoa it means incurring major infrastructure and exploration data losses at Del Park and costs at the new location.

After preliminary discussion of these issues with the State, Alcoa was invited to propose new 25 year plans for the Del Park and Huntly operations. This study, conducted on behalf of the Mining and Management Programme Liaison Group (MMPLG), considers the conceptual 25 year plan submitted by Alcoa in response to this invitation (see Map 1). The plan proposes a single 25 year programme for a consolidation of the Del Park capacity with the Huntly operation. The role of the MMPLG is to recommend to the Minister for Minerals and Energy what it considers to be a balance betweeen Alcoa's need for a commercially viable mining operation and the State's interest in efficient and integrated landuse. The plan is a long-term strategy: it evaluates broad issues of boundary, direction and sequence of mining and the major potential impacts on other landuse. The focus of the study is within the proposed mine plan area and no substantial comparison of alternatives is attempted.

Since there are currently several major developments in the planning and management of mining and rehabilitation which promise considerable future progress, the opportunity is also taken to define a conceptual land use plan which anticipates the integration of these developments into practice. This Land use Plan is presented separately.

2. Background

A comprehensive description of attributes and land use of the region between the Serpentine and South Dandalup Reservoirs has been prepared to provide a full background for this report. This description includes land use priority allocations, forest attributes and management, water supply and a discussion of recreational use of catchments. No conservation reserves exist in the region. Major long term research areas exist in the west of the area but are dealt with in the report.

The bulk of information consisting of commentary, maps and plans is too great to form part of this report and has been lodged with the MMPLG separately.

3. The proposed mining operation.

Following exhaustion of the bauxite reserves in the current Del Park approved 5 year plan, operations will conclude and facilities and equipment will be relocated to Huntly about 1989. The Huntly operation will be expanded to produce 10 - 11.5 million tonnes of bauxite per year depending on market conditions. Map 1 indicates the proposed 25 year mining area.

The average thickness of bauxite in the plan area is 3.7m, with averages for particular ore areas ranging from 3.4 to 4.3m. The area mined annually will range from 100 to 160 ha with a long term average of 132 ha. Forest clearing will generally be 35% greater than this to accommodate conveyors, haul roads, pit batters and other ancillaries.

Initially the conventional mining method - drilling and blasting caprock, excavation by front-end loaders and transport to the mobile crusher terminus by rear dump trucks - is expected to be used. Later, a continuous mining system using mechanical rock breaking and mobile in-pit conveyors may be introduced. Though it is anticipated that continuous mining will eventually replace blasting and trucking, the exact nature of the final system and its schedule for introduction will be determined by the technical and economic advantages established in the development programme.

Engineering studies presently underway indicate that an upgrade of the existing Huntly overland conveyor should provide adequate capacity for the proposed consolidated operation. Maps made available to MMPLG indicate a possible sequence of overland conveyor development to access the 25 year plan area. Detailed studies will be required to clarify both the location and timing of these developments and may result in some significant variations from those shown on the maps.

The mining sequence proposed is to proceed northwards from the present Huntly area to the North Dandalup River by year 15. This encompasses most of the previous Huntly 25 year plan area. Subsequent development is eastwards into DRA and up to a convenient geographic boundary just west of the 1100 mm rainfall isohyet.

To aid in the evaluation of the plan Alcoa has prepared the maps which allocate one of five levels of 'preferability' index to each ore area. This index is an integration of the cost effects of all sources of bauxite quality and distribution variation including:-

- available alumina
- reactive silica
- iron
- organic impurities
- ore thickness
- bauxite transport cost.
- infrastructure cost (workshops, power supply etc)

Each ore area is colour coded for preferability index on the maps made available to the MMPLG.

4.0 Analysis of the plan

4.1 Western boundary

Alcoa's proposed 25 year mine plan excludes mining in most of Whittaker block north west of the main area of proposed operations. Ore in this area has been reasonably well defined by drilling and it is thought to contain some 17 million tonnes of low preferability index ore spread over an area of 3500ha. Alcoa considers that mining and processing this ore would be sub-economic for the foreseeable future.

Whittaker block is typical of terrain immediately adjacent to the Scarp: it is extensively degraded by dieback and has generally low grade, widely dispersed bauxite deposits. The area also well exposed to public view and private property. It is traversed by Del Park Road (a major local road), Scarp Road (a major forest and tourist track) and the Bibbulmun Track (a recreational walk trail). There is a developed campsite of growing popularity at Whittakers Mill (Loc 1398). Three small freehold properties (Loc 1362, 1363 and 1381) are included within the area, each of which has permanent residents. Developed farmland extends along the Scarp. Several smaller properties on the north west corner appear to be semi-residential small farms. In the south of the area the Conjurunup pipehead facility is scheduled for installation on the Conjurunup Creek in about 1992.

In the State's view the exclusion of this ore raises two major concerns:

- it is contrary to the established practice of preferentially directing mining into diseased forest areas,

- if currently sub-economic ore is bypassed while adjacent economic ore is exploited, the likelihood of the sub-economic ore ever proving viable for mining is reduced,

To provide some measure of the relative benefits and disbenefits of mining in the area the data in Table 1 was assembled.

TABLE I

Whittaker vs Regional Bauxite Parameters

	Whittaker	Regional
Reserves (10^6 tonnes)	17	562
Mining duration (yrs)	1.5	51
Ore thickness (m)	3.4	3.7
Haul distance (km)	3.1	2.0
Orebody area (ha)	215	6800
Clearing area (ha)	320	9185
Ore area (%)	6	19
Region preferability index	246	139

Note:

- Data provided by Alcoa.
- Region is between Sth Dandalup and Serpentine Dams west of 1100mm rainfall isohyet, excluding Whittaker.
- Region preferability index represents only that portion of the total mining and refining cost which varies with the choice of mining area. Index is made relative to current costs as 100 (Refer to section 3).

In the State's view there are some unattractive aspects to mining in Whittaker block:

- the ore makes up only 6% of the area with total clearing of 9% compared to the regional averages of 19% and 26%. Thus the wide ore dispersion results in a larger proportion of ancillary clearing. These figures also assume a central crusher location rather than long haul roads from adjacent mining areas, both are unattractive propositions for Alcoa economically, but the latter could require an even larger proportion of ancillary clearing.

- potential for conflict with property owners, residents and recreationists, and the problem of road crossings and deviations is high in relation to the amount of ore available, and will compromise access to some ore.

- The Conjurunup Dam is expected to be operating at about the same time that mining could be scheduled to enter the Whittaker area (i.e. after 1994). Although Alcoa has demonstrated its ability to mine close to reservoirs without affecting water quality, this dam, being a pipehead facility, is relatively vulnerable. Most other operations planned for the Conjurunup Catchment are more distant from the Dam or will be completed before its installation.

These negative aspects, and the State's obligation to recognize Alcoa's need for a commercially viable mining operation, appear to outweigh the concern at bypassing Whittaker block.

The southern section of the proposed western boundary projects westwards but does not cross Del Park Road. It will be the closest approach (about 6km) of mining to the Pinjarra water supply facility on the leg of the South Dandalup River below the dam, and will require particular attention to drainage control and turbidity prevention during mining.

The south-eastern portion of Whittaker and northern portion of Turner block (including the Warren, Bennett and Hansen experimental catchments) have been included within the 25 year mining envelope proposed by Alcoa at the request of the Working Group. This portion of the western area contains the only deposits in the area Alcoa considers to have economic potential. Alcoa proposes that its inclusion be subject to the bauxite proving economic after detailed drilling is complete.

4.2 Eastern boundary

The eastern boundary in the proposed 25 year mine plan is some 10km long: the northern half lies along the western branch of Big Brook (a major Serpentine tributary); the southern half lies along a minor tributary of the South Dandalup. The boundary averages about 1km west of the 1100mm isohyet. Alcoa does not propose to approach this eastern boundary until well into the final 10 years of the plan.

This boundary conforms with the agreement between the State and Alcoa embodied in the Wagerup Environmental Review and Management Programme (Alcoa, 1978). In this agreement Alcoa undertook not to mine in the eastern portion of its lease until it had first been shown that mining could be conducted there without significantly increasing the salinity of water resources. Though there is no formal agreement between the State and Alcoa on the precise location of the boundary, it has been commonly accepted that the 1100mm annual average rainfall isohyet provides a good regional approximation. In the proposed plan Alcoa has chosen a conservative eastern boundary to the west of the 1100mm isohyet.

While the 1100mm isohyet is an adequate regional separation of moderate and low salt risk zones it has some deficiencies on the local scale:

- soil salt content can be very variable locally,

- the impact of mining may extend beyond the pit boundaries through surface or subsurface water movement or by the spread or intensification of dieback,

- estimates of the location of the annual average rainfall isohyets vary according to the period of record and number of stations used in their preparation, and according to short-term climatic

fluctuations, factors which have no bearing on the issue of salt sensitivity,

- salt sensitivity is most appropriately dealt with in terms of soil salt storage and not rainfall.

It is therefore desirable to reconsider the method for determining the boundary on both the regional and local scale. For this purpose a background is provided in Appendix A which reviews the issue of salt sensitivity and boundary setting. On present knowledge the eastern boundary currently proposed by Alcoa is conservative in terms of salinity risk, is free from complications and can be approved as proposed. However, as hydrological knowledge improves and as mining approaches the boundary there is a need to be able to define a local boundary which more accurately reflects the salinity risks involved. Guidelines for the definition of a local boundary are proposed in Appendix A.

4.3 Proposed sequence of mining

The first 15 years of the proposed plan consists of a northward continuation of present operations into generally high preferability index ore in Urbrae and Wilson blocks as was already approved in the current Huntly 25 year plan. This will require construction of a spur conveyor reaching northwards some 6km. Mining will terminate on the North Dandalup River and then relocate for the 15-25 year period within DRA in generally high preferability index ore in White and Scott blocks. This area will be serviced by an eastern extension of the main conveyor, and a number of south-east heading spurs to provide adequate conveyor coverage.

Beyond 25 years it is envisaged that a northward spur from the main conveyor in White block will be extended into Torrens and Clinton blocks.

The move into DRA in year 15 is dependent on the inferred ore values in White and Scott blocks being confirmed by drilling, the results of which will not be available for some 5 years. However, Alcoa considers there to be a high probability that the White/Scott values will be confirmed so that only minor revision of the proposed mining sequence may be required.

Given the range of conditions existing in this particular region, Alcoa's preferred sequence of mining is more strongly influenced by investment and transport costs than by the cost effects of bauxite quality variations. A particular investment cost with a large impact on long term sequence decisions is the cost of relocation of central workshop/services facilities. These costs generate a strong preference for a generally concentric pattern of ore extraction around the established workshop/services centre until all the ore resource within economic reach of that centre is exhausted.

This factor has a major influence on Alcoa's preference for the eastward move into DRA beyond year 15, though attractive ore quality is an added consideration.

In order to understand the strong preference for operating for as long as possible from the existing centre and to explore an alternative to DRA entry, Alcoa was requested to provide another 25 year conceptual plan still involving the consolidation of mining operations between Serpentine and South Dandalup Rivers. The plan provided to MMPLG by Alcoa consists of the same Ø-15 year proposal followed by a continuation of the northern thrust through Wilson block into Myara. This northern thrust would result in a linear extension of mining the full distance from South Dandalup to Serpentine west of DRA; it would access ore of low to average preferability index in Wilson and Myara and would require relocation of the workshop/services centre to Myara soon after year 15.

There are several important factors that might be considered in a detailed evaluation of the 15-25 year portions of the plans:

the relative difference in investment costs, transport costs and ore quality and the impact of these on the economy of the mining and refining operations in relation to future alumina market expectations.

the benefit to the State of a reduced proportion of good quality, disease free forest in the mining sequence. A more westerly mine sequence will generally be more desirable due to the greater extent and impact of disease in western areas (Forests Dept. 1982).

the impact on subsequent mining in the region e.g. is the infrastructure required for this 25 year period rationally planned in relation to that required in subsequent periods.

the impact on minesite work force travelling distances and housing.

the incentive for Alcoa to develop intensive disease management systems.

the practicality of keeping options open. Long-term uncertainty in the mining sequence would inhibit investment in forest production and may require greater exploration drilling costs.

It is not within the brief of this Working Group to further evaluate the two mining sequences. However, it is clear that the second sequence is less economic for Alcoa although it does delay entry to DRA by at least 10 years

4.4 Exploration

The proposed plan includes most of the current Huntly 25 year plan area in its 0-15 year horizon. Exploration is well advanced in this area but the shortened period of mining proposed will require the exploration programme to be stepped up. Beyond year 15 the plan proposes mining in White and Scott blocks within Disease Risk Area (DRA). Limited drilling data is available in these areas. The plan is partly based on inferred ore values and exploration drilling will be necessary to confirm the suitability of these areas. Alcoa expects that exploration will confirm these values and that only minor revision of the mining sequence will be necessary.

Within DRA exploration will require standard hygiene procedures based on high quality dieback maps. This brings together two complex programmes which will require careful integration. Exploration drilling is conducted at various intensities over time to progressively define orebodies. This may involve up to four stages of drilling spread over some two decades. Mapping is based on skilled interpretation of large scale aerial photographs. The complications are:-

where exploration stages are separated by more than a few years it is necessary to update dieback maps.

photographic interpretation can be confused by the effects of fire. Consequently, fire must have been excluded from areas to be photographed for the preceding 3 years. In the context of a regular controlled burning rotation of 5-6 years this is a large constraint.

photography requires exacting light conditions which only occur on average 3 days per annum, most commonly in autumn when symptom expression is also most clear. The occurrence of suitable conditions is unpredictable but when they occur large areas can be covered (up to 20,000 ha/day).

a map planning lead time of some 1-2 years is required in the current CALM programme.

If DRA cover is to be applied to the area in the 0-15 year period of the proposed plan as suggested in section 4.5.4, planning will need to commence as soon as possible. An exploration/mapping schedule is dealt with conceptually in the Landuse Plan. However, the matter is sufficiently important and the complexities sufficiently great to warrant specific working arrangements to be instituted. The objective of such arrangements should be to ensure that dieback map availability is not an impediment to rational planning of mining and disease control. Alcoa has undertaken to contribute funds to expand CALM interpretation capacity to achieve this.

In areas near the proposed eastern boundary Alcoa has indicated its intention to conduct investigation of soil salt storages. This could appropriately be integrated with exploration drilling at least from the access point of view.

4.5 Mining in the Disease Risk Area (DRA)

The plan proposes widespread exploration and limited mining within DRA in the 0-15 year period followed by full-scale mining entry after year 15. The latter move is dependent on the inferred ore values in White and Scott blocks being confirmed by drilling, the results of which would not be complete for some 5 years. However, Alcoa considers it to be highly likely that the White/Scott values will be confirmed and that only minor revision of the mining sequence will be necessary.

The DRA, with its legal status, formal procedures and high standards for disease control in operations, has become a major feature of jarrah forest management. Its status was reinforced by an extensive information programme based on the knowledge of dieback available in the 1970s. This information programme was successful in moulding public opinion that quarantine was a necessary measure for protection of the forest. Improved knowledge of disease susceptibility and factors influencing disease impact now give a more optimistic outlook for the viability of the forest and the availability of its resources, but the prior public perception of quarantine remains. Though the minor incursions into DRA planned in the 0-15 year period of the plan might be easily dealt with in terms of the limited local impacts, the prospect of full scale entry in the year 2000 warrants a full analysis to explore whether this is compatible with present policy and public perceptions, and to identify what steps might be necessary to resolve any difficulties.

4.5.1 History of the DRA concept

In 1974 amendments to the Forest Act allowed for disease risk areas to be proclaimed as a measure to control disease, principally dieback caused by the soil-borne fungus Phytophthora cinnamomi. The accompanying Forest Diseases Regulations (1975) provided a means of doing this in the form of stringent control over access and operations, which was imposed in the forest in 1976-77. Initially this was viewed as a short term (3 years) period of quarantine to allow undisturbed expression of disease, aerial photography and the preparation of detailed dieback distribution maps. These maps were then to be used as a basis for planning hygienic forest operations. The original time period was found to be far too short to achieve full photography and mapping and to accommodate the dynamic nature of the disease. It was also found that the formal regulation of access was a valuable control measure per se.

By 1980 the pressure for access to timber resources, which had been embargoed for the quarantine period, was mounting. Advancing knowledge of disease management was also cause for confidence and a major review of dieback policy was carried out (Forest Dept., 1982 (b)). This review formalized the continuation of DRA, dropped the notion of quarantine and formulated policies to guide access to resources. Full-scale logging entered DRA, initially on a trial basis in 1980, and more recently in routine operations, all under stringent dieback hygiene conditions.

In the Northern Jarrah Forest the DRA boundary was set on the regional scale on a north-south alignment to exclude the generally heavily diseased western areas and to include the less diseased and potentially salt sensitive eastern areas. On the local scale the alignment was based on convenient geographic features (such as roads or reservoirs) and not on a detailed consideration of disease risk factors. Substantial areas of good quality lightly disease affected forest do exist west of the present alignment.

4.5.2 Current policy

The new CALM Act embodies the former Forest Act disease regulations and the Dieback Policy 1982 statement remains current. This statement was a major review and update of policies, the aim of which was to propose management policies which would:

impose hygiene on all operations in healthy forest
foster natural disease resistance
rehabilitate diseased areas where needed
manage the forest for long term productivity.

The statement also had two implied objectives:

to assert that disease management should be of the highest order in all healthy forest, not only in DRA
to reconcile the long term adoption of DRA status with access to resources.

The primary policy statement (No. 1) requires that any proposed operation should be assessed for disease risk, impact and consequences, irrespective of location whether inside or outside DRA. This has become known as the "Seven Way Test" (Forest Dept., 1983). Operations for which the risks, impacts and consequences are or could be made acceptable would be given approval to proceed. Policy 10 requires that a similar risk, impact and consequences assessment be applied to broad land units within DRA to give four management categories (A1 to A4). The categories are graded with respect to risk to land use values should the fungus be accidentally introduced, and a commensurate level of availability for resource extraction as follow :-

A1: Long-term isolation. Has high risk, impact and consequences of loss of conservation and environmental values. Nature conservation areas in State Forest, National Parks, Nature Reserves and the major new reserves of as yet undecided tenure (Land-Poole, Monadnocks and Eagle Hill Reserves) fall into this category.

A2: Short-term isolation. Awaiting evaluation of risk by dieback interpretation and potential impact assessment then to be re-allocated into A1, A3 or A4.

A3: Limited access. Low risk for approved operations. Resource utilization may proceed subject to the seven way test.

A4: Other areas not considered to be at risk e.g. Murray landform. Available for resource utilization.

The A3 category is available for mining where this complies with other policy requirements i.e. a demonstrated need (Policy 11); under conditions of permit with good maps and using up-to-date hygiene (Policy 12); results to be monitored (Policy 13).

The objective of attaining the highest order of disease management for all healthy forest has not been fully realized outside DRA. Areas within DRA had to take precedence in mapping, rigorous hygiene could not be comprehensively built into all non-DRA operations for a host of practical reasons, and access to non-DRA forest was not fully controllable. The DRA status therefore retains significant advantages for disease control both in its legal backing and in its established practices and image. Policy 14

aims to extend the benefits and sustain the advantages of DRA by having boundary flexibility, so that more good quality protectable forest could be included, and areas not requiring DRA status could be excluded. This policy is especially relevant in the envelope of the proposed expanded Huntly mine, where extensive areas of good quality forest exist west of the DRA line.

4.5.3 Recent research developments

Dieback management in the jarrah forest has in the past relied nearly exclusively on attempts to reduce artificial spread of the fungus (Shea 1979; Underwood and Murch, 1984). This is reflected in Dieback Policy 1982 where hygiene is a predominating theme, though improving natural resistance and minimizing impact of disease are mentioned. Recently, improving natural resistance in the form of removing the highly vulnerable host Banksia grandis has been introduced as part of the FIRS operation (see Landuse Plan), the first measure of this type to be adopted.

Recent research has given hope of greatly extending the use of disease reducing procedures. In 1983 Shea et al found severe disease on upland apparently well-drained laterite profiles to be associated with poor internal drainage, such poor drainage creating conditions highly favourable for subsurface fungal activity and transmission.

This work suggested that high impact disease might be exclusively associated with sites exhibiting impeded drainage (or where such a condition was artificially created) all other sites being relatively safe. Unfortunately, this has not been confirmed in subsequent research. Examination of a large number of diseased sites failed to reveal the existence of obvious impedance to drainage on all high impact sites. Other factors in addition to drainage may therefore be contributing to high impact disease. One possible factor is indicated in work by Tippett et al (1986) who found that the normal summer water deficits experienced by jarrah on Z and H site types inhibited fungal activity whereas a P site type did not experience summer water deficits and displayed sustained fungal activity through summer. The absence of summer water deficits

appears to be a feature of the P site type and may contribute to its widely observed disease vulnerability. Further site and host factors or indicators of them are being sought to enable a potential disease impact classification system to be developed.

Though these studies remain inconclusive at this stage, they support three new general disease management strategies which can reasonably be put into practice:

site classification: disease impact will vary systematically according to site. Though our capacity to classify sites into impact classes has not yet advanced very far some preliminary classification can be incorporated into current planning of operations, and further development should occur in the near future.

efficient drainage: both vertical and controlled surface drainage should be facilitated, subsurface lateral drainage, ponding and water-logging must be avoided to the greatest possible extent.

drying soil profiles: rapid restoration of dense and vigorous plant communities should follow disturbance.

The bauxite mining and rehabilitation operation has considerable scope to put these strategies into practice. Recent advances in drainage and revegetation, and the meshing of these with site classification and other disease control treatments to create a comprehensive disease management system is elaborated in the Landuse Plan. The strict application of this system will minimize the adverse impacts and consequences of disease associated with mining.

4.5.4 Factors to be considered in DRA entry or extension

The dieback management category allocated to the DRA area proposed for mining in the 25 year plan (i.e. White and Scott blocks) is A2 (short term isolation). When aerial photography and mapping are complete in the next few years, this area will need to be re-allocated to the A3 category (limited access) if resource use is to be permitted. Such a classification would be consistent with the emerging pattern of dieback management allocations since only areas with a conservation priority use are being assigned to the A1 (long term isolation) category. CALM should determine whether there is any likely complication to this re-allocation.

Under Dieback Policy 82 any major new operation should be subject to the risk/impact/consequences analysis outlined in Policy 1 (i.e. the Seven Way Test). Mining entry to DRA is such a major new operation. However the operation is not planned to commence for some 15 years and in that time considerable advance in methods and in evaluation of impacts and consequences is expected (see Landuse Plan). A rigorous analysis is therefore not attempted now, though it is necessary to indicate if the proposal is sound in concept.

Stringent hygiene is applied in the preparatory stages of mining such as exploration, and in high risk stages such as clearing and soil movement. However, it is not possible to apply the full range of hygiene measures to the bauxite extraction stage. Some major hygiene strategies are clearly impractical (e.g. dry soil only operations in disease-free areas; "split-phase" operations where a clean break is maintained between extensive field activity in non-diseased areas and access via diseased areas.) Thus, mining must be regarded as incurring a relatively high

risk of spread of the fungus. On the one hand the Dieback Policy statement is quite rigid on the application of hygiene principles (Policies 1,4,5); but on the other it also provides scope for compromise in suggesting that risks should be considered in relation to consequences, that the aim is to minimize rather than eliminate spread, and that up-to-date hygiene rather than rigid standards will be permissible (Policies 1,8,9,12). The Policy also requires the consequences to be evaluated in terms of impact on land use. In most of the 25 year plan envelope the priority land use is water production. The major impacts for water production of disease spread can be reasonably expected to be beneficial (Batini et al. 1980). However, other compatible uses which include protection of forest and catchments are vulnerable to severe impact and warrant a much more cautious approach to dieback than might be appropriate for the priority use.

The risk from limited hygiene in mining is offset by the substantial potential to minimize disease impact and ameliorate adverse consequences for forest and catchment protection. Development of intensive disease management systems commenced with the Urbrae Project in 1984. This Project aims to examine the practicability and cost of applying a range of disease management measures, (including hygiene) to a full-scale mining operation. It begins the process of developing the expertise and evaluating the benefits of comprehensive disease management. Given another 15 years of such development it is quite likely that mining could satisfy an exacting Seven Way Test in spite of the impracticality of applying a full suite of hygiene measures.

Exploration and drilling in current mining areas already operates under hygiene requirements. These requirements are detailed in an annually updated manual of agreed working arrangements prepared jointly by CALM and Alcoa. A change that would be desirable for entry into DRA would

be to base drilling hygiene on aerial photographic interpretation for dieback rather than ground survey. Long lead-times are highly desirable in planning related to mining, particularly in DRA where comprehensive disease management would be mandatory (see Landuse Plan). Exploration and drilling programmes and the dieback interpretation programmes upon which they will be based should therefore be given a high priority for clearance to facilitate early planning. Alcoa has undertaken to fund an expansion of aerial photographic interpretation capacity within CALM to this end.

The major objective of Dieback Policy 82 was to attain the highest possible standards of disease management in healthy forest. The Policy proposed regular review of DRA boundaries to consider whether additional areas should be included to achieve this objective.

These are strong grounds for inclusion of most of the 0 -15 year area of the plan within DRA. They are:-

the quality of the forest is generally good. The extent of disease is low to moderate, it has a large proportion of high quality site and forest types suitable for intensive silviculture. These characteristics are detailed for the two eastern compartments in each of Urbrae and Wilson block in Table II.

the area is crucial for the development and evaluation of intensive disease management systems essential for the projected entry into DRA and highly desirable for all operations in healthy forest outside DRA.

DRA would provide long-term, legally enforceable access control.

the DRA status brings significant advantages in disease control both because of its specific legal role and in its established practices and image.

However, the proposal may bring the political difficulty of being seen to limit public access specifically to facilitate mining, or of being interpreted as a means to compromise mining in the area. It might also be argued that presently applicable disease management policies are adequate to successfully develop the new disease management systems.

On balance it appears to be worth pursuing the benefits available in DRA proclamation but this should be subject to detailed boundary review and clear specification of the purpose of any extension.

An appropriate boundary to encompass most of the Ø-15 year area is proposed in Appendix B.

Table II

Site and Forest Quality in parts of Urbrae and Wilson Blocks.

	Urbrae		Wilson	
Compartment Number	1	2	3	4
Total area within plan (ha)	791	1071	1101	1155
% Dwellingup landform	64	31	47	51
% pole forest structure	84	47	90	95
% pre-76 dieback	15	9	13	24
% dieback in Dwellingup landform	7	3	8	12

Note
- includes only that part of each compartment west of DRA (see map 3).
- Dwellingup landform is according to System 6 classification, includes best site quality jarrah forest.
- pre-1976 dieback is latest available.
- data extracted from FMIS and maps by Kim Allen; Kelmscott Inventory Office, CALM.

Since the alignment of the DRA boundary on the local scale is quite arbitrary, local incursions into DRA, subject to real disease risk boundaries, should be entertained. Such real boundaries would be aligned with drainage features i.e. incised stream channels or catchment divides, which constrain the area of impact of disease. Any entry should also be subject to the seven way test. It is appropriate to deal with proposal for minor entry to DRA in the 5 year plan procedure.

The Forest Disease Regulations 1975 prescribe a permit system for access to DRA. These regulations were prepared with a view to controlling individual or small-scale access during the then intended short period of quarantine. They still remain appropriate for policing occasional small-scale entry but are not readily adapted to major resource extraction activities permissable under the policy changes of 1982. The permit system should be updated to provide regulated but streamlined access control for major operations. This might be done by formal change to the Regulations or by a change in administrative practice within CALM.

Some wider perceptions of the issue of mining entry to DRA may need to be addressed in the decision making process. A brief listing of factors likely to be relevant to public and timber industry interest in the issue is as follows:-

- the 1982 Dieback Policy does not see DRA as a quarantine but rather a means by which the highest possible standards for resource extraction, including bauxite mining, might be imposed. The timber industry already operates extensively within DRA under such standards.

- Alcoa has a history of responsible environmental management and has been fully co-operative in the development and implementation of dieback hygiene measures for its drilling, surveying, construction and rehabilitation activities. Alcoa has stated its commitment to extend dieback control methods by development of the widest practicable range of disease reducing measures.

- Bauxite mining is not scheduled for full scale entry to DRA for 15 years. Prior to this, intensive dieback management methods will be progressively developed, applied and evaluated in the Ø - 15 year period of the plan.

- the State has a long standing obligation to provide Alcoa with a commercially viable mining operation. The Company's present investment in mining and refining facilities is predicated on eventual access to the bulk of the bauxite reserves west of the 1100mm rainfall isohyet, including DRA. The question of access to ore reserves has become more critical to Alcoa following its agreement to forego mining in conservation reserves and other sensitive areas including some 15% of the bauxite reserves.

- Alcoa is committed to rehabilitate areas which may become diseased as a consequence of their operations, and to rehabilitate areas in the envelope of their operations which were diseased prior to the advent of mining.

- the bauxite/alumina industry provides substantial socio-economic benefits to the State and Nation.

4.5.5 Resume

Major conclusions of this section are as follows:

there is sufficient promise in new disease management strategies to entertain future bauxite mining in DRA. There is adequate time to evaluate these strategies before entry is planned in about 2000.

the area proposed for mining within DRA in the 15-25 year period of the plan will need re-allocation to the A3 dieback management category if mining is to proceed,

exploration and drilling, especially in DRA, should be expedited. This will require an increase in dieback mapping capacity and Alcoa has undertaken to contribute funds for this purpose.

There are significant benefits to be gained by proclaiming DRA status over much of the forest in the 0 - 15 year span of the plan. This should be done subject to detailed review of the boundary and clear specification of the purpose of the extension.

limited incursion into present DRA within rational local disease risk boundaries presents no technical problems, and can be dealt with at the 5 year plan stage,

the permit system for access to DRA should be modified to provide efficient control over major operations,

public and timber industry perceptions of mining entry into DRA will need to be addressed.

4.6 Research Aspects

4.6.1 Dandalup Experimental Catchments

The Dandalup experimental catchments were established in 1977 by the then Forests and Public Works Departments. The main study area involves six catchments averaging 98ha in area and all encompassed in the 0-15 year time span of Alcoa's proposed plan. Name, area and proposed years of mining in the vicinity for each catchment is given in Table III.

TABLE III

Little Dandalup experimental catchments

Catchment Name	Area (ha)	Mining in vicinity (yr)
Warren	88	1988-92
Bennett	88	1988-92
Hansen	73	1995-98
Higgins	60	1994 to 2003
Lewis	210	1995 to 2001
Jones	69	1998 to 2001

The catchments have a scientific study management priority in the current Working Plan (Forests Dept. 1982). The purpose of the catchments is to test the effects of forest landuse (including disease, silviculture and mining) on streamflow volume and quality in the high rainfall zone. Each catchment is equipped with a stream gauging station, some have borefields to monitor groundwater and all are located in areas kept relatively free of disturbance for some years before and since setting up the study. The experimental method involves monitoring the catchments

over several years to obtain data on the undisturbed hydrologic characteristics, to establish relationships between the catchments, to select one (or more) as controls and to treat the rest. The period of observation of the response to treatment will need to be of long duration (at least 1 to 2 decades) because jarrah forest catchments usually have highly buffered responses and because some of the treatments envisaged will be on-going.

The study has advanced to the stage where selection of controls has been narrowed down to Lewis and Bennett, and treatment has been initiated on Warren and Hansen. The new amalgamated 25 mine year plan presents an opportunity to review the study and to ensure that any scope for conflict with mining is resolved.

The study is under the direction of the bauxite and forest management subcommittees of the Research Steering Committee. Discussions were held with relevant members of these subcommittees and with Alcoa. These discussions indicated that the Dandalup catchments study has matured into a major research exercise which is expected to provide timely information on a range of important forest management issues:

- forest thinning as an option to increase water supply. Basic data on forest density versus water yield is required for evaluation and possible incorporation into water resources planning within the next 15 years. Present indications suggest that significant increases in water yield (from 20-100mm depending on rainfall) are possible from forest thinning over small catchments.

- forest thinning as a silvicultural treatment. Basic data is required on forest density (timber yield, disease susceptibility, on-going management regimes) versus water yield to guide forest management operations.

- water yield effects of rehabilitation in dieback affected areas.

- water yield effects of mining and rehabilitation and the interaction of these effects with forest thinning and disease.

Not all of these issues can be properly addressed in the study and the Water Authority and CALM sought priority to be given to forest thinning treatments independent of bauxite mining on the grounds that thinning has already commenced on an operational scale; it is applicable to a potentially larger area than bauxite mining; it is a very important variable in water resources planning in the high rainfall zone and results are required within 15 years. On the other hand bauxite mining is also a major factor in jarrah forest hydrology and its impacts should be quantified. In addition, both Alcoa and the State have an interest in minimizing the amount of ore rendered unavailable to mining.

Several other factors have bearing on the allocation of treatments and the scope for mining:

- It is not possible to make a totally binding commitment to a particular long term course for treatment since the final decision must be made with the best available knowledge of the day. Proposed treatments and on-going management of the catchments will be regularly reviewed.

- The study has always been seen to have potential conflict with mining. In 1977 Alcoa was requested to defer any plans for mining for 12 years. Subsequently, in preparation of the first Huntly 25 year plan in 1982 Alcoa were informally assured that the study would not be an impediment to mining. In fact Alcoa was encouraged to entertain mining in some catchments. Recently Alcoa has provided funds for the treatments undertaken on Warren and Hansen catchments in the belief that this would not further compromise access to ore.

- Conveyor alignment: the three catchments Higgins, Lewis and Jones lie along the proposed northern conveyor corridor. Though it is considered undesirable to have the conveyor traverse a catchment, missing all three would unduly constrain route selection. In terms of compatibility with the proposed treatment and gain in flexibility of alignment Lewis was chosen for possible conveyor placement.

- Accessibility of ore adjacent to catchments to be excluded from mining: the exclusion of whole catchments may reduce the viability of extraction of adjacent ore by imposing more costly haul road alignments and reducing tonnages to be carried on a given haul road section. The Hansen catchment is the most extreme case of this type but preliminary analysis by Alcoa indicates the extra costs of its exclusion from mining could be tolerable.

- Definition of the boundary around catchments to be excluded from mining: another aspect of reduced accessibility to ore is the need to provide an unmined buffer beyond the perimeter of catchments to be excluded from mining. Tentative guidelines for the size of the buffer were decided. The buffer should be up to 100m wide where the divide is flat and ill-defined and has well developed bauxite; down to 25m where it is steep and well defined, conditions which reduce the likelihood of bauxite development across the crest. In mining and rehabilitation water should be efficiently drained away from the divide. These guidelines should be reviewed as appropriate for a particular situation or in the light of further development in knowledge of the relevant processes.

Taking all these factors into account a compromise programme which satisfies divergent objectives and retains sufficient flexibility was established as follows:-

- Warren: mining and intensive rehabilitation to restore maximum possible vegetation density and vigour. The objective being to probe the largest likely reduction in streamflow. Some 50% of its area is severely degraded by dieback. This area was intensively rehabilitated in 1984/85. Mining should occur in 1988-92 and be followed by intensive rehabilitation. In the longer term if the restored forest density exceeds expectation thinning treatments may be imposed.

- Bennett: mining and standard rehabilitation of pits and diseased areas to be undertaken in the period 1988 - 1992. Mining in Bennett would enable full exploitation of the ore on the common divide with Warren thus enhancing the Warren treatment and improving the attractiveness of mining in the locality.

- Hansens: an extreme forest thinning treatment (down to $7m^2/ha$ basal area) was imposed in summer 85/86. This treatment goes beyond what would currently be entertained in regular operations but is designed to probe the limits of response, particularly with respect to disease. Recent research (Tippett et al, 1986) suggests that the water deficits which develop over summer on most jarrah forest sites inhibit disease activity. Thinning and generally improved water availability may remove this inhibition and allow greater expression of disease in areas already infected but currently displaying only minor impact. Mining, due in the vicinity in 1995-98, should be excluded, though an extreme disease reaction to the treatment would be grounds for review.

- Higgins and Jones: both to have forest thinning treatments in 87/89. With Hansen catchment, these two will enable a range of thinning treatments to be tested. One of the two, probably Jones, will be required to also test on-going management aspects and must be considered at this stage to be permanently set aside from mining. The other, Higgins, may have substantially demonstrated its response to its once-off treatment by the year 2000 and should be reconsidered for mining after that time (i.e. as part of the eastern extension into DRA in about 2003).

- Lewis: to have the standard mining and forest management treatment of the day when mining is due in 1996. In the meantime it will serve as an a control. By the time of its treatment it will have some 20 years of record, enough to enable development of models to predict its untreated streamflow into the future, and against which to compare the treated result. However, it would be desirable to have a long-term untreated control and studies are underway to see if a suitable catchment is available outside the 25 year plan area. This test of mining and forest treatment in a typical lightly disease affected forest is scheduled some years later than is really desirable. It would be valuable to augment this with some earlier mined catchment work.

4.6.2 Salinity Research

The approach of mining close to the 1100mm annual isohyet in the years 2005 to 2010 raises the issue of when the company is likely to want to cross into the more salt sensitive areas, and hence the timetable of the joint Alcoa-State research programme aimed at addressing the salinity risks involved.

While the need to enter the more salt sensitive areas is beyond the scope of the current 25 year mine plan, the research programme is significantly affected by the plan as the lead times involved are particularly long (eight to 10 years pretreatment, 10 - 20 years post treatment).

Long term future market conditions, changes in production and refining procedures and constraints on access to ore all influence the life of the bauxite resource in the western forest. This is presently considered to range from 40 - 60 years for individual minesites. Numberous other factors could also make major changes to this time scale. For example both the State and the company may see benefit in mining some ore to the east of the salt boundary before all ore in the western forest is mined. From the point of view of long term planning for water resources, land use and the mining industry itself, it would be desirable to have resolution of the salinity issue as soon as possible. On the other hand the cost of the research programme, particularly if it involves mining several million tonnes and stockpiling the ore as is currently planned, will be expensive, and Alcoa is reluctant to incur such a cost before it is really necessary.

Resolution of the time frame required for this research is important but peripheral to the evaluation of the current 25 year mining plan. The new plan emphasises the importance of studying the hydrologic effects of the interactions between bauxite mining and the spread and intensification of dieback disease, and has implications for the location of research catchments. Consequently the Bauxite sub-committee of the State Research Steering Committee should review its research programme paying particular attention to the timing and location of the research. This review should be carried out in conjunction with the MMPLG.

5. Major Conclusions

1. Bypassing marginal bauxite in Whittaker block is on balance an acceptable proposal (Section 4.1).

2. The proposed eastern boundary is acceptable. Guidelines should be adopted which adequately define the salt-sensitive boundary on the local and regional scale. Suggested guidelines in Appendix A provide scope for adjustment of the proposed boundary but this is appropriately done on the 5 year plan time scale (Section 4.2).

3. Specific working arrangements should be adopted which ensure that disease interpretation capacity is not an impediment to rational planning of mining and disease control. Multiple entry to DRA for exploration will require on-going disease interpretation over 15-20 years. This will require an increase in interpretation capacity and Alcoa has undertaken to contribute funds for this purpose (Section 4.4, 4.5.4 and Landuse Plan).

4. There is sufficient promise in new disease management strategies to approve in principle future mining within DRA, subject to the development and evaluation of new disease management systems proving satisfactory (Section 4.5, Land Use Plan).

5. There are significant benefits to be gained by proclaiming DRA status over much of the forest in the 0 - 15 year span of the proposed plan. However, this should be subject to detailed consideration of the boundary and clear specification of the purpose of the extension.

6. The Dandalup experimental catchments programme proposed can be endorsed (Section 4.6.1).

Appendix A. The Boundary Between Low and Moderate Salinity Risk Areas of The Darling Range: Discussion of an Improved Definition

The risk of increasing stream salinity through a modification to forest cover, be it bauxite mining and rehabilitation or other land use change, is strongly dependent on the soil solute levels accumulated in the deeply weathered landscape of the Darling Range. Extensive drilling programmes by numerous groups since the mid-1970s have consistently identified a trend of increasing salt storage from the Darling Scarp in the west to the western edge of the wheatbelt in the east. The level of salt storage has been correlated with both annual rainfall and distance from the scarp, factors which themselves are strongly correlated. The method of determination of salt storage is given in Tsykin and Slessar (1985).

In the management of forest logging operations, administration of clearing control legislation and the environmental review of bauxite mining operations, the generally accepted zone of low salinity risk is the region to the west of the 1100mm annual average isohyet. While the 1100mm isohyet forms a useful regional planning boundary between low and moderate salt risk zones it has limitations at the local scale. Definition of the boundary in terms of actual salt storage is clearly preferable.

Early definition of the zone of low salinity risk was based on stream base flow salinity sampling. Areas were considered a low salinity risk if there base flow salinities were less than 500mg/l. It was recognised, however, that base flows prior to the land use disturbance did not necessarily reflect the possible salinity of the discharging groundwater following disturbance. It was also recognised that considerable additional streamflow can be generated from shallow soils following

vegetation disturbance. This additional streamflow component is low in salinity and dilutes the saline additional groundwater discharge. The additional salts and water from both sources should be considered when determining the impact on overall stream salinity.

Agricultural development in areas where annual rainfall exceeds 1100mm has generally resulted in only a minor effect on average stream salinity. Average stream salinities rarely exceed 300mg/L in these areas even if significant proportions of their catchment have been cleared (Department of Conservation and Environment, 1980; Collins and Barrett, 1981, Loh et al, 1983). Computations of the worst case of 100 % agricultural development suggest that average salinities would not exceed about 450mg/L TSS. Salt storage levels which would ensure that these salinity changes are not exceeded range between 0.35 kg/m^3 and 0.4 kg/m^3 depending on the assumptions made. Further evaluation will be required before the adoption of a single value on which to define the salt risk boundary.

A substantial drilling programme by Alcoa has enabled the establishment of regional prediction equations for salt content throughout the main areas of mining interest within their lease (Tsykin and Slessar, 1985). Better definition of these levels will be possible in the future as more soil salt storage data becomes available.

Such equations should be used to define the regional boundary rather than the current 1100mm annual average isohyet. No major change in the boundary is expected if this proposal is adopted as the 1100mm ishoyet generally falls between the current estimates of the 0.35kg/m^3 and 0.4 kg/m^3 isopleths of salt content. Pockets of relatively high salt storage for areas west of the 1100mm ishoyet have been recorded and undoubtedly pockets of lower salt storage occur east of the 1100mm isohyet. In reality no sharp divide exists and large variability occurs at the local scale.

Towards the end of the twenty five year period when mining approaches the regional boundary, a local mining boundary should be established as part of the 5 year mine planning process. This boundary should take into account the local salt storage, drainage characteristics and disease status.

The following guidelines for local boundary setting are proposed:

i) Where mining is proposed west of the adopted regional isopleth and drainage is westward, the State should accept any salinity risk that may be involved,

ii) Where mining is proposed west of the adopted regional isopleth but drainage extends eastwards crossing the isopleth, two conditions must be met. Firstly, the salt storage of the hillslope section down slope of the pit must be demonstrated to be less than the adopted value. Secondly, the potential for new or additional disease impact on the valley floor below and downstream of the pits must be assessed as low,

iii) Where the adopted value regional isopleth traverses an ore body or an ore area the whole body or area may be mined if, firstly, drainage is westerly and salt storage is demonstrated to be less than the adopted value or, secondly, drainage is easterly and the conditions of (ii) are met,

iv) The onus of proof of salt storage rests with Alcoa. Drilling must be permitted to gather salt storage data at appropriate locations. Drilling should be sufficient to establish the mean salt storage of the area downslope from the proposed mine pits to a relatively high level of confidence. This level of confidence will need to be decided in relation to the degree of local salt storage variability which becomes apparent in future work. The development of local scale salt storage prediction capability as an alternative to drilling would be acceptable. However, a prediction accuracy similar to the drilling would have to be established.

v) Interpretation and further refinement of these guidelines is the responsibility of the State. Disease assessment is also the States responsibility.

vi) Disease status may change with time and so local boundary fixing should be conducted on a short term planning horizon. The 5 year plan scale would be appropriate.

Appendix B: Boundary selection for the proposed DRA extension.

In addition to enclosing the target area, the chosen boundary alignment should facilitate access control and be secure from risk of natural disease spread from outside. The alignment should also suit mining patterns such that whole operating areas (crusher locations) are not divided and hence uniform practices can be adopted within any area.

In the 0-15 year area of the proposed plan, stream-lines offer the best scope to meet these criteria. Road and track crossings of streams are infrequent and can readily be equipped for controlled entry. Valley bottoms are generally already infected but form a boundary secure from further disease intrusion. Valley bottoms are also a natural boundary for mining since bauxite is confined to ridges. Mine operating areas in the proposed plan are generally bounded by streams.

The proposed boundary for the DRA extension based on these factors is as follows:

The northern limit to the 15 year horizon in the proposed 25 year plan is the North Dandalup River which is also a suitable northern DRA boundary.

From the North Road bridge on the North Dandalup River the boundary should follow North Road southwards to the crossing of Wilson Brook. This section closely follows the proposed mining boundary and Wilson Brook, except for excluding a small area in the triangle between the North Dandalup River and Wilson Brook.

From the North Road/Wilson Brook crossing follow Wilson Brook to its source just south of Torrens Road.

Then cross over the divide of the North Dandalup/Conjurunup Creek catchments in a southerly direction to meet a minor Conjurunup Creek tributary, then proceed to the main channel of Conjurunup Creek, proceed eastwards then take the south east branch to include the Urbrae project area. Along this section the proposed boundary follows internal mining area boundaries and conveniently separates current mining areas from the area to be included in DRA.

The final leg of the boundary crosses the Conjurunup Creek/South Dandalup catchment boundary in a south easterly direction to meet a minor South Dandalup tributary and proceed to where it intersects the existing DRA boundary.

This boundary alignment is shown on the attached map 4.

The proposal excludes the Hansens catchment area from DRA mainly because it would otherwise include substantial lengths of Torrens and North Roads, both major forest tracks better left open if possible. If this compromises sound disease management in the Hansens region this decision could be reviewed.

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BOUNDARY

D.R.A.

1993 - 2001 MINING AREA

1986 - 1993 MINING AREA

1986 - 1993 MINING AREA

2001-2006 MINING AREA

2006-2010 MINING AREA

Disease Risk Area

Disease Risk Area

Disease Risk Area

WARREN BENNETT

URBRAE

HIGGINS

LEWIS

HOLDEN

MAP 1

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ALCOA OF AUSTRALIA LI

25 YEAR MINING PROGRESSION CLARK MINE 1986-201

SCALE 1:5000 | DATE APR 1986

Serpentine Catchment Area.

North Dandalup Dam Site

North Dandalup Catchment Area.

BOUNDARY

D.R.A.

2006-2010 MINING AREA

Disease Risk Area

1993 - 2001 MINING AREA

Conjurunup Dam Site

Conjurunup Catchment Area.

2001-2006 MINING AREA

1956 - 1993 MINING AREA

1100mm Position

South Dandalup Dam

South Dandalup Catchment Area.

1986 - 1996 MINING AREA

Approximate

SWAMP OR MARSH
GRAVEL PIT
DAM
BUILDING
PRIVATE PROPERTY
ALCOA PROPERTY

MAP 2. Catchments

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ALCOA OF AUSTRALIA LIMITE

25 YEAR MINING PROGRESSION
CLARK MINE 1986-2010

SCALE 1 75 000 | DATE APR 1986 | DRG NO

MYARA

TORRENS

WILSON

BOUNDARY

WHITTAKER

D.R.A.

WHITE

URBRAE

TURNER

SCOTT

1993 - 2001 MINING AREA

2001-2006 MINING AREA

2006-2010 MINING AREA

1986 - 1993 MINING AREA

1986 - 1993 MINING AREA

Disease Risk Area

Approximate 1100mm Position

MAP 3. Forest Blocks

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25 YEAR MINING PROGRESSION
CLARK MINE 1986-2010

SCALE 1:75 000 | DATE APR 1986 | DRG No

BOUNDARY

DRA

1993 - 2001 MINING AREA

1986 - 1993 MINING AREA

2006-2010 MINING AREA

2001-2006 MINING AREA

Disease Risk Area

Disease Risk Area

Disease Risk Area

WARREN

BENNETT

HIGGINS

HIGGINS

LEWIS

URBRAE

1986 - 1993 MINING AREA

1100mm

Position

Approximate

MAP 4 PROPOSED DRA EXTENSION

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25 YEAR MINING PROGRESSION

CLARK MINE 1986-2010