COMPLETION CRITERIA

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The views expressed in this paper are the personal opinions of the authors and are not intended to convey or imply the policy of their Departments or the Government.

1. COMPLETION CRITERIA - CURRENT STATUS

The recognition of the need for rehabilitation of minesites has grown from the adaption of some basic soil conservation techniques to shallow excavations in the seventies in Australia to the widespread acceptance that all minesites need to be returned to some useful purpose after mining. The current trend is exemplified by the sophisticated rehabilitation Alcoa and Worsley bauxite mining operations in the Darling Ranges and the mineral sands operations around Eneabba and Capel.

The term "rehabilitation" can comprise a range of outcomes. Allen (1988) identified several levels (interpreted by Hopkins and Caporn).

> "Reconstruction" (includes "Restoration") which creates ecosystems identical to those present prior to disturbance.
>
> "Reclamation" establishes ecosystems that are similar but not necessarily identical in terms of the species composition to pre-disturbance ecosystems.
>
> "Rehabilitation" produces land that is useful but usually has a purpose that differs from the pre-disturbance situation and is invariably composed of different species.

In Australia the term "rehabilitation" is used to mean any or all of Allen's levels, e.g.

> "Rehabilitation" is usually defined as the process necessary to return disturbed land back to a predetermined stable surface form and productivity. (Dames and Moore, 1982).

The term "completion criteria" can also mean many things to different people. Some would see them focused on the end of the rehabilitation process and others might regard them as a starting condition. The authors believe completion criteria are relevant to all the major rehabilitation stages from inception to conclusion.

Completion criteria are rehabilitation performance objectives set as conditions of approval for each stage of rehabilitation and for the project as a whole. The purpose of completion criteria is to guide rehabilitation towards the preferred land use objective.

The definition of post mining land use objectives should therefore preceed the setting of rehabilitation completion criteria whenever possible. (This should occur at the earliest opportunity in the mine planning process).

Where the rehabilitation outcome is not reliably predictable the completion criteria and land use objectives will be mutually conditional.

However the aim is to devise completion criteria which give a reasonably assured prospect of attaining the desired land use in terms of its function, productivity, stability and sustainability.

In Western Australia completion criteria are not nominated as such but appear in the guise of the various conditions of project approval under the three classes of controlling acts:

- Environmental Protection Act (EPA) 1986 (and its predecessor EPA 1972).
- Mining Act 1978 as amended.
- Various Agreement Acts.

These conditions have evolved into a three pronged approach expressed as conditions on the mining lease, as programmes under two types of clause in the Agreements or occasionally as a condition of implementation of a proposal under the EPA:

- Mining to be conducted to an approved development programme with specific environmental protection and management measures.
- Annual environmental reports (for projects extending beyond two years).
- A bond to ensure adherance to the conditions and to provide sufficient funds to undertake rehabilitation on default.

Under Agreement Acts bonds have not been seen to be necessary until recently.

Interstate, completion criteria seem to have a similar status, being incorporated within the traditional processes of mining approval and control without being explicitly acknowledged. It is not clear yet whether there will be any federal move to encourage more prominent or uniform completion criteria.

Overseas, the United States "Surface Mining Control and Reclamation Act" (S.M.C.R.A.) of 1977 has spawned very extensive and detailed regulations to enforce post mining land use performance. Demanding environmental auditing procedures are employed to gauge compliance with completion criteria. The system is two tiered with the federal act providing broad guidelines and each State fleshing out the individual detailed criteria.

The authors do not believe it is necessary or desirable to follow the path of greatly enhanced statutory control to enforce rehabilitation completion criteria. The existing system in W.A. should be adequate provided the climate of formal and informal co-operation between regulators and developers persists.

2. THE NEED FOR COMPLETION CRITERIA

There are three main groups with a stake in producing effective completion criteria.

- The mining industry and its shareholders.
- The Government and regulatory authorities.
- The public in general and interest groups in particular.

Whilst each group approaches the issue of completing mining rehabilitation from different perspectives, and with different responsibilities and constraints, there is a surprising degree of commonality in the desired outcome.

- There is a need for an agreed end to Company responsibility for the site.
- There is a need for an agreed acceptable result.
- There is a need for all parties to be seen to be responsible and successful.

Industry Perspective:

- Planning for new projects should include interim and final rehabilitation objectives to assess project viability and mine development.
- Current operations need attainable, measurable rehabilitation goals to set standards, guide programme and facilitate budgeting.

- Criteria will be matched to currently achievable technology and be sufficiently flexible to avoid impossible targets.

- Companies will have an agreed mechanism to acquit their responsibility within reasonable timeframes and cost limitations. It is a trigger for release of the bond.

- Successfully achieved completion criteria are necessary to support the industries future mining ambitions.

- Government and society will accept the specified result ie. no shifting the goal posts.

- Old or failed sites may be gauged against current industry standards only where appropriate.

Government Perspective:

- The State wants mining companies to use the best available rehabilitation practices.

- Project costing must include rehabilitation to the specified standard.
- Designated land uses must be effected in reasonable time frames with a continuity of rehabilitation effort.

- Rehabilitation must return land to a stable and sustainable specified land use with predictable and appropriate maintenance inputs.

Public Perspective:

- The public needs a viable mining industry to produce wealth.

- The public wants the environment protected from unacceptable impacts.

- The public wants both the industry and the regulatory authorities to be accountable for the compromises necessary to produce a viable industry and acceptable environmental impacts.

Western Australia's long history of mining has produced a diversity of rehabilitation needs and results. They vary according to the era, the type of mine, the company and the location. They are as dissimilar as the deep burial of acid spoil from a 50 million cubic metre open cut pit and minor reshaping, ripping and seeding of a 1 hectare shallow excavation.

Most W.A. minesites prior to modern standards of rehabilitation were intended to be made tidy, stable and safe but were not often deliberately reconverted to a specific predetermined land use. Where these old sites have not naturally rehabilitated they provide an example of the legacy both the Government and the industry have no intention of repeating.

In more recent times a number of mine sites have been reclaimed, rehabilitated or reconstructed to preordained land uses. The bulk of these were on private freehold land, usually returned to some agricultural purpose, and sometimes even improved for that function. Currently there are a number of mine sites in native vegetation ecosystems with the general ambition of reclaiming the original land use. Only one of these mine sites has specific quantifiable completion criteria for vegetation rehabilitation. Some of these extensive mines are in sensitive locations amidst complex native plant communities. These projects are flagships for the industry and represent the apogee of the restoration ecologists art. Company management and environmental scientists are now asking the inevitable question, when will we reach a satisfactory end point?

The authors suggest that some very significant end points have already been reached and others require further development. The recognition of existing achievements as completion criteria and the setting of future criteria will help to resolve this critical question.

3. A PHILOSOPHY FOR COMPLETION CRITERIA

The authors are aware of the varying views on the practicality and desirability of completion criteria. It is one of the most challenging issues technically and equally difficult from a regulatory viewpoint. The first step towards a concensus is to agree on a philosophy for completion criteria. We suggest the following are key elements.

- It is in everyone's interest to have effective completion criteria.
- Some degree of formally binding completion criteria is necessary combined with a substantial element of self management and professionalism.
- The concept of completion criteria may invite ready acceptance but in practice it is difficult. Its development in W.A. should be conducted in an atmosphere of negotiation and consultation.
- In keeping with current management theory, goals should be specific, attainable and measurable.
- Quantitative measures must be tempered by realistic tolerance limits.

- Even with the most rigorous development of completion criteria, assessment will involve both quantitative measures and qualitative judgement.

- Interim goals may be necessary for longer timeframes and to confirm successful progress.

- Completion criteria must be project and site specific.

- Everyone must accept that capabilities and standards are ever changing. Completion criteria should be sufficiently flexible to encourage "over achievement" without being a "moving target".

- The whole of industry has a responsibility to continuously research and improve techniques and share the information.

- Within the constraints imposed by individual sites, completion criteria obligations should be equitably applied across the industry where or when ever feasible.

- Completion criteria may be set for a particular successional stage of development where climax communities are reasonably predictable.

- It must be recognized that completion criteria must contend with an element of risk and uncertainty that all human endeavour contracts.

- In the end, the Government of the day is the final arbiter of "completion criteria" on crown lands. The Government determines what balance will be struck between productivity and environmental change on behalf of the community at large.

- Completion criteria on older minesites will be conditioned by the economic capacity of the mine to pay. Rehabilitation costing should be part of new project assessment and approval. Realistically, economic commitment by a company to completion criteria cannot be open ended.

4. WHAT AIMS, WHAT BENEFITS?

There are three principal aims in adopting completion criteria.

- Return of the minesite to a designated, stable and sustainable land use.

- Approval of the public.

- Benefits to the company.

Repairing the Land

The mining industry routinely makes the claim to being a temporary user of land, returning the land to its previous use or a new productive function. Successfully achieved completion criteria will incontrovertably affirm the contention. The best evidence is the improved pasture, the farm dam or the new recreation site resulting from mining. However, rehabilitation of natural values such as native vegetation complexes are not so readily evinced. Whilst completion criteria for natural systems are difficult to quantify they are also commensurately more valuable and necessary to preserve the industries place as a legitimate temporary user of land.

Some mining practices have unavoidably left undesirable and non endemic landforms and vegetation. Most of these are legacies from the past but with others such as huge open cut pits there is limited opportunity to modify the landform and they will persist.

"It is recognised that there may be some damage from surface mining even with the best planning and reclamation methods" G.V. Holmberg.

It is critical for the industry that the economic and practical limitations constraining these rehabilitation tasks are recognised. Completion criteria are a formal and unambiguous tool for just this purpose.

The land ~~use~~ care ethic is here to stay. Virtually everyone recognises that we must minimise land degradation. Successful completion criteria will demonstrate that the mining industry can sustain land use values.

Approval of the Public

The Government and their regulators are as dependent on public approval as the mining industry. In some quarters of public opinion, the Government, the regulators and the industry suffer a credibility gap.

What other explanation can there be for a major newspaper article titled:

(Miners) "Heroes or villains" The West Australian - 24th August 1991.

At present in Western Australia there is little focus on the issue of completion criteria per se. News media and their audience have tended to focus on the more general environmental and politically confrontational mining issues particularly concerning the establishment of projects. The concentrated WA urban population is not exposed to

neighbouring minesites which draw attention to the progressive nature of rehabilitation and its ultimate endpoint. Even where a company such as Alcoa invites open inspection the public debate tends to be reduced to stereotyped images:

"Anyone seen a minesite around here?"
RETORT
"Anyone seen a Jarrah forest around here?"

The implicit completion criteria barb in the retort would be lost on most of the newspaper readership. So the public constituency can probably be divided into five attitudinal groups:-

- Mining equals an ugly hole in the ground and is a necessary evil to preserve our standard of living.

- Mining equals an ugly hole in the ground which cannot be repaired and is therefore not acceptable in many places.

- Mine sites can be made green again so mining is acceptable in most places.

- Mine rehabilitation can replace vegetation but not whole ecosystems.

- Mining changes ecosystems but modern techniques can restore or rehabilitate effective land uses.

In our opinion the first three cover the most commonly held public perceptions and the last two represent the range of views amongst environmental activists, the industry and the regulators. It is difficult to say when and to what degree the political process will be influenced by a more penetrating public expectation of modern rehabilitation techniques. However, despite the current economic recession, the trend towards increasing environmental awareness and concern is certain to escalate.

Consequently the regulators and the industry can expect some very exacting questions about their rehabilitation achievements and the end points of mining.

An answer couched in terms of premeditated and successfully achieved completion criteria may well be the most persuasive response.

Benefits to the Company

Effective rehabilitation and public approval are perhaps the most important outcomes fostered by successful completion criteria, but other side benefits can also accrue.

- Early specification of completion criteria can reduce rehabilitation costs especially in relation to expensive items like earthmoving.

- Successfully achieved completion criteria can improve the value and marketability of the rehabilitated estate. This will, in turn encourage landowners to accept mining overtures.

- Completion criteria can provide performance incentives to companies which are recognised by progressive bond release or other official acknowledgement.

- Staff will be better motivated where their efforts are targeted to specific goals and will gain satisfaction from their achievements.

- Companies and individuals can gain prestige in their professional peer groups on attaining completion criteria. It could be adopted as a corporate performance indicator.

5. THE REHABILITATION CYCLE

Site

The first reality to recognise in the rehabilitation cycle is the lack of choice concerning the site. Rehabilitation tasks occur wherever a mine is developed and therefore potentially includes every environment in Australia. Types of rehabilitation and completion criteria are very varied and site specific.

Types of Mining

The nature of the mining operation will predetermine the basic rehabilitation options. There are three basic types of mining in relation to rehabilitation:

- Quarrying where there is little overburden and generally no toxic materials.

- Strip mining where moderate to large quantities of overburden are backfilled behind the mining face. There may be toxic materials to deal with.

- Open cut mining with deep pits and associated out of pit waste dumps. Toxic wastes may be present.

Underground mining has little surface impact. Frequently only small waste dumps are involve which, like tailings disposal areas can be treated like the waste dumps of the open cut mine.

Shallow strip mining with no toxic materials to dispose of is an entirely different rehabilitation prospect to a deep pit with acid generating minerals in out of pit overburden dumps. Whilst each mine is unique, the industry has developed some general criteria and a common wisdom for tackling the various types of mines. However the expected pattern of rehabilitation can suffer major upsets when economics or technology cause radical operational changes. For example tailings may be reprocessed or an underground mine may convert to an open cut pit.

The mining rehabilitation planning cycle starts with a generally recognised formula which must be adapted to the peculiarities of the site. The basic rehabilitation plan and draft completion criteria can be set at this early stage as part of the mine planning, e.g. the basic landform types and general location of dumps and final void water bodies should be determined.

Land Use Objectives

Post mining land use objectives are the next consideration in the cycle. Usually the owner of the land determines post mining land uses by negotiation with the company. Expectations must be conditioned by the prevailing rehabilitation capabilities of the industry. This capability can be determined by the example of similar successful rehabilitation or by analysing the characteristics of the site, the proposed mining operation and applicable rehabilitation technology. A significant proportion of the proposed land use objectives can now be predicted with some confidence. (See Roe, 1990). Private land holders are usually rather particular about completion criteria and companies accept that they are necessary for both parties.

Land use objectives requiring the restoration of complex natural ecosystems are somewhat more speculative and are at the forefront of the industries capability. Such objectives are characteristic of public lands with tenure ranging from pastoral leases to national parks or nature reserves and other specific purpose leases. Often this type of land attracts the deceptively simple ambition of a return to the premining or "natural" condition. The natural condition may be defined with great exactitude by an inventory of the flora and fauna or by the nomination of control or reference areas. A return to a natural complement of flora and fauna is thought to be the best bet for recovering all the natural ecological processes, without necessarily knowing what they are. Within the framework of a natural environmental land use special features may receive purposeful attention such as water quality or timber production.

The obvious problem with a return to natural land use objective is that most mining creates a new environment which may not reproduce the same features or functions as the premining conditions. It is a matter for both rehabilitation science and for judgement whether a particular mining operation realistically allows a return to natural land use objective. When setting completion criteria for such objectives one needs to be aware of the uncertainties see the rehabilitation process as a staged series of land uses as site capacity builds up.

The final land use objective represents the ultimate completion criteria.

The Rehabilitation Phase

Rehabilitation planners would no doubt like to have all of their completion criteria at the outset so they know exactly what goals they have to achieve. As we have seen, the site, the type of mine and the land use objectives all give planned or "top down" criteria but they may tend to be a little tentative and imprecise. The reality is that much of the "hard" quantative criteria only become available empirically. That is, you don't know exactly what you can achieve until you try it. The key ingredient in this iterative process is time. It therefore makes sense to structure the completion criteria as a chronological sequence matching the major phases of rehabilitation. A simple example:

- landforming
- water management
- vegetation establishment and development
- fauna occupation
- monitoring and remediation

Criteria can be set for each stage and achievements acknowledged as they occur. There will be marked variance in the scale of these stages depending on the longevity of the mining operation and differences in many other factors. Completion criteria development during the rehabilitation phase will be strongly influenced by research programmes.

The rehabilitation cycle is iterative as a natural consequence of it being an empirical process but also because things do not always go to plan. Erosion, weeds, fire, feral animals, dieback, seed stealing ants etc can pop up unexpectedly. Even the most refined rehabilitation process is still essentially an experiment in nature's laboratory. Completion criteria need to be sufficiently flexible to take on the solutions thrown up by the problem solving nature of rehabilitation science.

Monitoring is the essential corollary to the process and is the principal means of cycling information gained from experience into the planning phase. It is essential that this monitoring be undertaken and be appropriately structured to facilitate understanding of the system and be related to the end land use condition. Remember that these data are the basis for the completion criteria.

Cost is a conditioning factor if not a limiting consideration in forming completion criteria. There is no point in setting criteria that are so expensive to implement that the company goes bankrupt and is therefore unable to fulfill any part of its rehabilitation obligations. Also there is the law of diminishing returns. The cost of propogating an intractible species may well out weigh the value of doing it.

THE REHABILITATION CYCLE

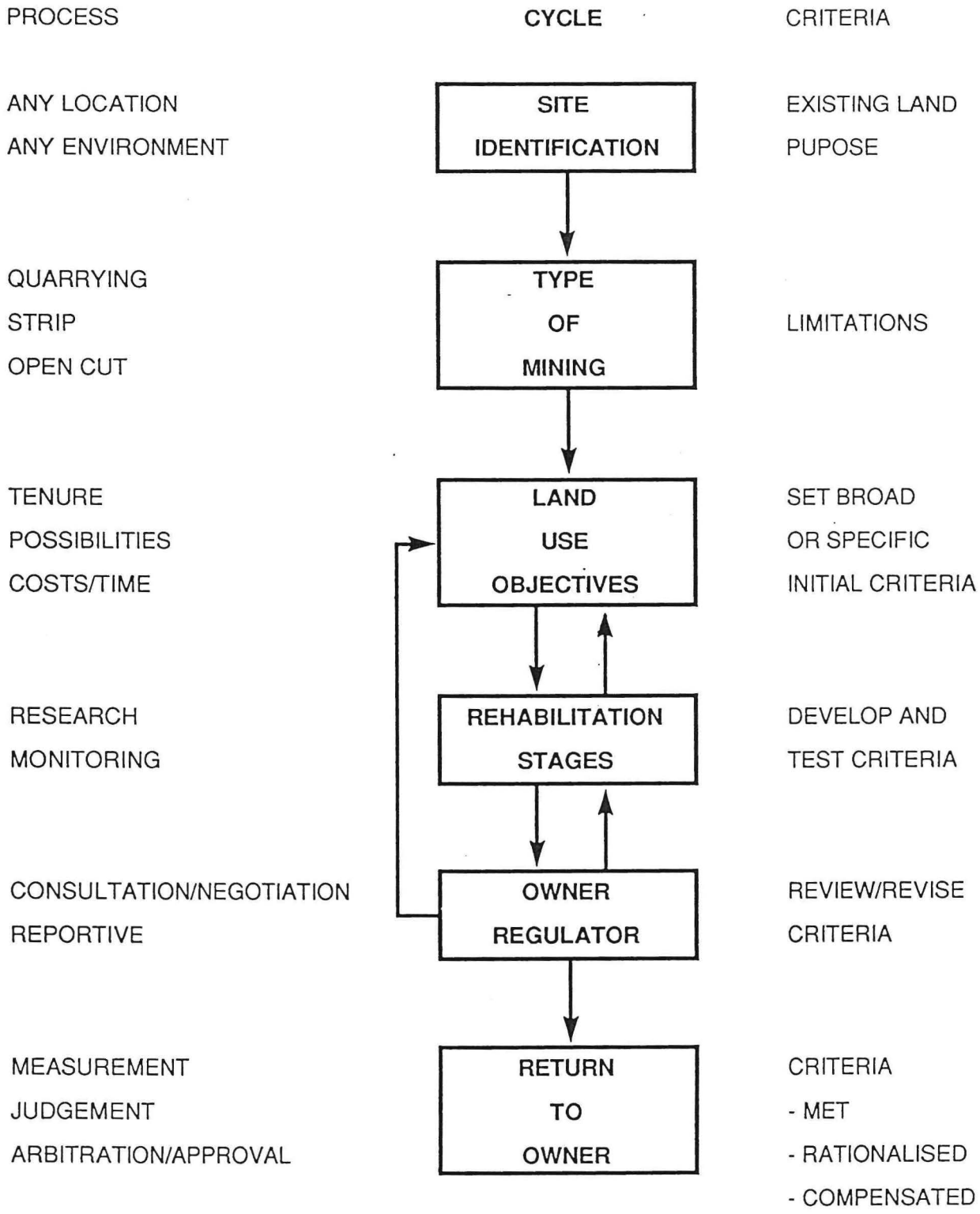

Figure 1

ERRATUM

LAST SENTENCE SECTION 5 SHOULD READ:

When setting completion criteria for such objectives one needs to be aware of the uncertainties and potentially long time frames. Some practioners see the rehabilitation process as a staged series of land uses as site capacity builds up.

Handing the Land Back to the Owner

This is the final stage of the rehabilitation cycle. Occupancy or partial use may well occur earlier to the benefit of all but sooner or later an official termination of company responsibility must occur. On Mining Act tenements where there is a bond, the retirement of the bond by government is a definitive point in the process. While the avenue of neglect in common law will still be open, the official termination of responsibility must be seen as a signal that the company has met community and government obligations and no further demands can be made. If future communities want further action then they must recognise that it will be at the communities cost.

It is also important to recognise that there must be a final arbiter. All through the rehabilitation cycle it is the view of the authors that there be cooperation and concensus as much as possible. However final acceptance of the land to the agreed land use must be undertaken by experts within government who have been involved in the setting of the criteria. In the case of private land the land owner takes on the arbiting role although he may well need to rely on technical expertise from elsewhere to provide adequate knowledge and there are some avenues for government to assist in this process.

6. REHABILITATION PARAMETERS

The principal objective of rehabilitation is to obtain stable landforms and vegetation communities. It is recognised that natural physical and biological systems are dynamic and are in balance with operating processes. Logically, rehabilitation systems could be considered satisfactorily completed when they too are in dynamic equilibrium and the relevant processes act in similar ways to those in the reference areas.

Thus completion criteria and monitoring ideally should be based on processes. Unfortunately our knowledge of processes is generally inadequate to use in this way and we are usually forced to operate with empirical measures. The following parameters or characteristics of the desired use are based on empirical knowledge built up through solving practical problems encountered in the rehabilitation of many mine sites and degraded land units/vegetation associations. There is considerable overlap in using an empirical classification because processes operate across the artificial boundaries created.

Landforms

There is logic in requiring landforms to be visually compatible with the general landscape; if the physical characteristics are similar the processes should operate at similar rates.

Breaking this down into more fundamental parameters, slope is basic and is often specified as a criterium. Slope angle should be low and slope length short to minimise potential for erosion. Form also will have a bearing on erosional processes and may be detailed in the criteria.

The surface material is another important aspect both as a growing medium and to reduce erosion potential. As a growing medium, it is often required to replace soil in the original layers. This tends to maintain nutrient levels and provides an appropriate physical structure for the vegetation to grow in. Further, its use as a seed source may be specified.

The soil/surface layer is also important for its hydrological properties. Grain size and fabric at the surface affect erosion potential from both wind and water. Compaction affects water infiltration and run off as well as the penetration of plant roots. This characteristic is often specified as a criterium either directly or more commonly as a requirement to rip along the contour. This has the additional benefit of ensuring slope lengths on the micro scale are very short. Mulches may be crucial to ameliorate some poor physical characteristics in difficult sites and may be specified.

Toxic materials have the potential to affect both vegetation and water quality. Appropriate placement of potentially polluting material is often specified. The depth of burial may not be as critical as how the material is placed to minimise activation of its polluting properties.

Water Management

Runoff water quality is specified frequently as a criterium. It is a useful output indicator of processes that may be extant and is vitally important from a users viewpoint. Site specific criteria may be used but the two Australian Water Resources Council Technical Papers 7 and 77 by Hart on water quality criteria are good starting points.

Engineering design of water control structures and stream channels may be specified. These will be necessary to avoid active stream bed or broad scale surface erosion.

Water bodies tend to be forgotten leftovers but they also should have criteria developed. The most important aspects are the depth of water and the shoreline characteristics. The former has a significant bearing on the ecology of the water body while the latter is critical to the interaction with the terrestial ecosystem around the water. Criteria must depend on use; wetlands for water fowl should have shallow verges and dense shoreline vegetation while recreation areas a beach with either no vegetation or a lawn is more appropriate. Aquaculture ponds would have very specific requirements of depth and shoreline characteristics.

Another aspect that may have to be considered is the water chemistry. Acidity must be considered if acid forming minerals are present. Alkalinity or acidity may be a problem if water bodies are on or near tailings. Salinity may be relevant, especially in the arid areas. The evaporative area may need to be restricted to limit the concentration of dissolved salts.

Vegetation

Many of the physical aspects of the growing medium for plants have already been covered in the preceding sections. The basic botanical measures of plant cover, total number of species present and species richness are all primary criteria likely to be used for native vegetation and some other end land uses. Increasing emphasis may be placed on the structure of the vegetation association. This could be expressed in the form of percentages of vegetation types or the distribution of key species. Productivity measures may be used for specific end land uses.

There may be a need to specify seeds or seed sources to be used. This will depend on the availability and cost of seed, the importance of obtaining locally collected seed and seasonal factors. In some instances, the sowing of seeds, seed treatment and other propogation techniques may need to be specified either directly or through the basic botanical measures. For example if you are required to have Banksia spp. present in the vegetation association their seed must be conditioned using some form of heat treatment like the hay burner developed at Eneabba. Xanthorrhea spp. may be best introduced to the rehabilitation plots as seedlings, whereas several species of Hakea and Grevellia or even some uncommon species like Regalia megacephalia are best established from cut brush mulches. This technique may also assist in protecting the soil and seedlings from water and wind erosion.

Ability to withstand a use or management practice is another factor that may be used as criteria. It has already been applied to pasture as an ability to cope with grazing and it is being considered for management practices like control burning and other silvicultural methods.

A major problem with assessing the revegetation of a disturbed area is determining it stage of seral succession in comparison with the desired end vegetation association. The vegetation of a control or reference plot is frequently at the climax stage of succession with most if not all the species present having been there for several generations. In a rehabilitation plot few species will have been through a complete life cycle and as a result structural elements like mature or senescent eucalypts with their own micro habitat will not be present.

The question is often asked "At what stage in the succession can it be determined that the desired vegetation association has been successfully established?" There is no simple answer. Without waiting for the passage of time for at least two generations of the most long lived species all we can do is guess. However time series monitoring of progressive rehabilitation during a long project can greatly increase confidence in those estimates.

Looking at one characteristic in graphical form, it would be expected that the values would rise rapidly at first with the rate of rise slowing until eventually a horizontal assymptote is reached, representing the characteristic prior to disturbance. A family of succession curves will be generated if the characteristic in each year's rehabilitation is monitored over time. At a given time, say year 17 in the theoretical example, there is a curve following the seral succession of each of 16 rehabilitation plots. This will give a very good indication of what is happening. In the theoretical example it took six years to reach a criterium of 50% of the value prior to disturbance. The first three years of rehabilitation have well exceeded the target and eleven of plots have achieved the 50% target. Moreover the five that have not met criterium can be shown by comparison with the data from earlier years to be within expectations.

Real data do not show such smooth and predictable curves. Seasonal variations and improvements in rehabilitation techniques will give a much more confused picture but the basic principals remain the same. The problem becomes one of where and how is all this data to be stored and manipulated!

Theoretical arguments would suggest that given enough data from the site or adjacent areas the actual criteria could be set to the values achieved after just two or three years. However the natural and man made variations would dictate that longer time periods of ten years or more for at least a significant proportion of the rehabilitation would be necessary for sound scientific judgement.

Fauna

There is an implicit assumption in most rehabilitation that fauna will return to a mine site when the vegetation has reached the appropriate stage in the seral succession.

Accordingly, the regulatory authorities have made few specific demands concerning fauna.

However it is noted that a few companies are making an effort to provide more resources for food and have incorporated roosting and nesting sites and shelter from predators in their rehabilitation.

Criteria for particular fauna can be set where there is sufficient information on habitat requirements.

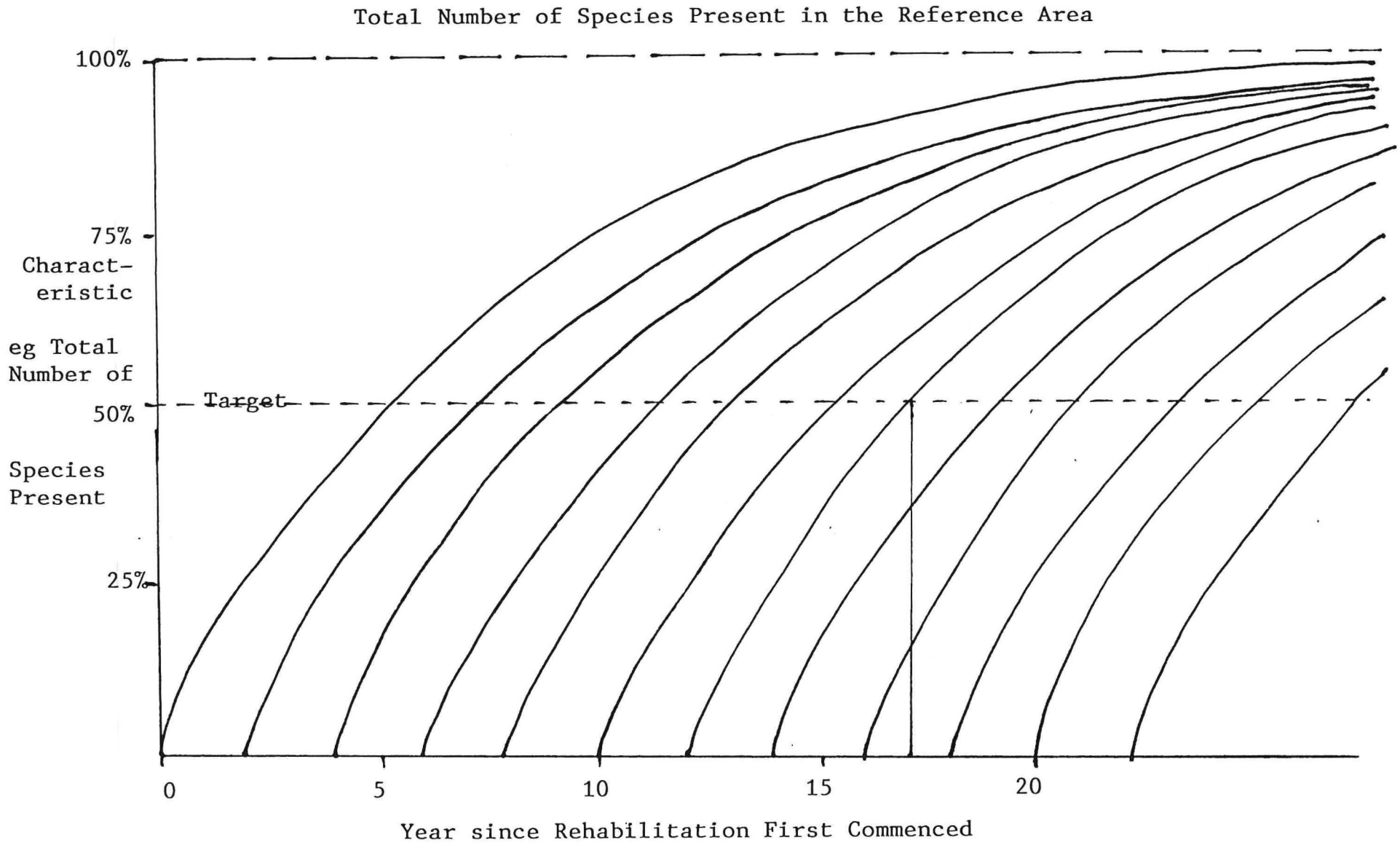
Total Number of Species Present in the Reference Area
100%
75%
Charact-
eristic
eg Total
Number of
Species
Present
Target
50%
25%
0
5
10
15
20
Year since Rehabilitation First Commenced

Figure 2

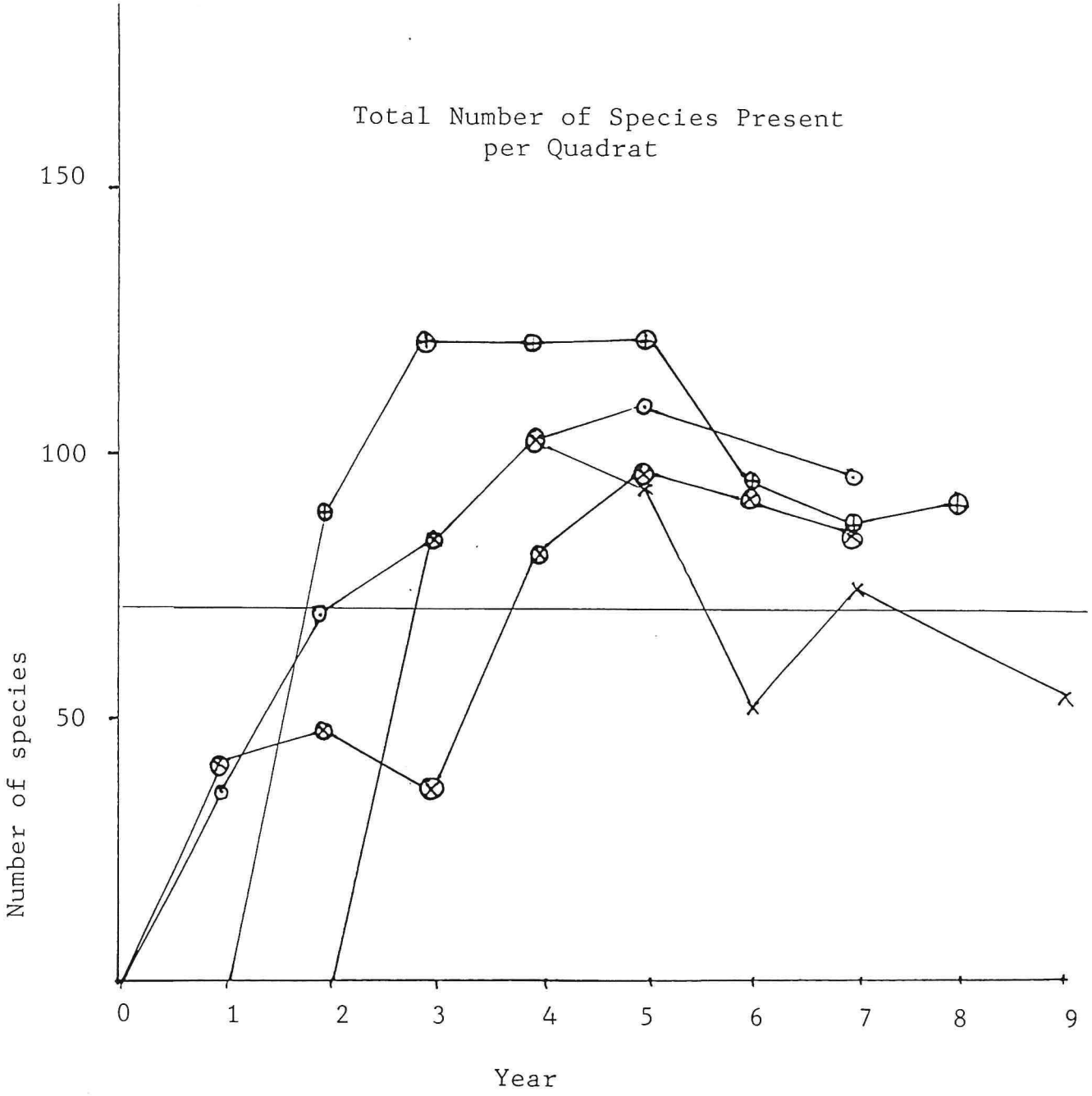
Total Number of Species Present
per Quadrat
150
100
50
Number of species
0
1
2
3
4
5
6
7
8
9
Year

Figure 3

7. PROCEDURE FOR DETERMINING COMPLETION CRITERIA

Why Completion Criteria?

Why use the term and the concept of completion criteria? The authors suggest that completion criteria will give a sharp focus to rehabilitation efforts and achievements at an important time in the mining industries development. Completion criteria will give recognition to the considerable rehabilitation achievements of mining companies and set the agenda for meeting the future environmental challenge. Quantitative and objective completion criteria not only define the possibilities and goals but also the limitation.

> e.g. "Somewhere between extreme concern for the environment and the need for surface mining, there is a middle ground where both sides can meet." (G.V. Holmberg 1983)

Having established many fundamental rehabilitation criteria such as landforming, water management and soil stabilisation the industry is reaching for new plateaus in the hierarchy towards ecological reclamation. Completion criteria will be essential to the definition, measurement and acknowledgement of these ambitions.

Are Completion Criteria a New Thing?

No. Completion criteria, by other guises, are an existing part of the rehabilitation cycle. The term and the concept of "completion criteria" simply recognises and defines the significance of the major end points for each stage of the cycle.

All Part of the Cycle.

Post mining land use objectives interact with rehabilitation completion criteria throughout the rehabilitation cycle. It usually proceeds through a three step process:

- Preplanning

  Setting of initial land use objectives and attendant rehabilitation completion criteria. Preferably as early as possible.

- Rehabilitation phase

  Implementation using industry standard techniques with improvements and site specific problem solving by research and monitoring. Initial completion criteria are tested and developed.

- Assessment and review

  Appropriate processes of consultation and negotiation with formal reporting procedures provide for the measurement and judgement of completion criteria.

The cycle is iterative for each stage of rehabilitation or repeated to effect improvements.

This model of the process could be described as "top down" to the extent that land use objectives and rehabilitation completion criteria can be preordained. In practise it becomes more "bottom up" as rehabilitation practise reveals what can be achieved. The balance between the two approaches is unique for each project and depends on all of the influential factors previously described in this paper.

The benefits of the cycle are a pragmatic recognition of capabilities and limitations, a flexibility to incorporate improvements and an adaptability to different types and scales of project.

Management of the Process

Mining rehabilitation in W.A. is managed by a common acceptance of the need for a blend of legally enforceable sanction and voluntary performance. The authors believe the existing system is adequate for the current situation and do not recommend a pursuit of greatly increased statutory powers. The industry in general and a number of projects in particular have reached a stage where the question of completion criteria naturally arises.

It is hoped that the personal opinions expressed in this paper will contribute to the debate on completion criteria and support an wholistic and timely consideration of the subject.

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