STATEMENT OF ENVIRONMENTAL OBJECTIVES FOR SEISMIC OPERATIONS IN THE COOPER AND EROMANGA BASINS SOUTH AUSTRALIA

May 1998

PRIMARY INDUSTRIES AND RESOURCES SA

STATEMENT OF ENVIRONMENTAL OBJECTIVES FOR SEISMIC OPERATIONS IN THE COOPER AND EROMANGA BASINS, SOUTH AUSTRALIA

Compiled by C.D. Cockshell

1st edition
May 1998

Report Book 98/16

PRIMARY INDUSTRIES AND RESOURCES SA

Petroleum Group
Primary Industries and Resources South Australia
191 Greenhill Road, Parkside **(before August 1998)**
101 Grenfell Street, Adelaide **(from August 1998)**
GPO Box 2355, Adelaide SA 5001

Bibliographic reference
Cockshell, C.D. (Compiler), 1998. Statement of environmental objectives for seismic operations in the Cooper and Eromanga Basins, South Australia. *South Australia. Department of Primary Industries and Resources. Report Book*, 98/16.

CONTENTS

Figures

Tables

ACKNOWLEDGMENTS

This document has been developed through consultation between PIRSA, the petroleum exploration industry, environmental interest groups and other Government agencies. It was initiated following discussions on Santos' revision of their codes of environmental practice.

Intensive and extensive discussions were held during numerous workshop sessions with the following bodies:

- PIRSA Petroleum Group
- PIRSA Environment Branch
- Santos
- Conservation Council of South Australia
- Nature Conservation Society of South Australia
- The Wilderness Society (SA Branch)
- Australian Conservation Foundation (SA)
- Friends of the Earth

A draft of the document was the subject of a targeted consultation process. Responses were received from the South Australian Chamber of Mines and Energy, Boral Energy Resources, Flinders Institute of Public Policy and Management, Department of Environment and Natural Resources, Primary Industries South Australia and Department of State Aboriginal Affairs.

ABBREVIATIONS

CEP	code of environmental practice
EMS	environmental management system
GAS	goal attainment scaling
PIRSA	Primary Industries and Resources South Australia

EXECUTIVE SUMMARY

This document contains the environmental objectives relating to seismic exploration activities required to be achieved by any licensee operating in the South Australian part of the Cooper and Eromanga Basins (i.e. any operator). Objectives have been identified for the following specific land systems: dunefield, floodplain, wetlands, gibber plain, tableland and salt lake. These objectives conform to the national strategy for ecologically sustainable development (Ecologically Sustainable Development Steering Committee, 1992) and aim to protect biodiversity.

This statement of environmental objectives has been developed through consultation between Primary Industries and Resources South Australia (PIRSA), the petroleum exploration industry and environmental interest groups. It expresses the expectations of the environmental performance of explorers using seismic exploration techniques. Each operator undertaking seismic operations shall achieve the three objectives set out below. Any code of environmental practice (CEP) submitted under Regulation 16 of the *Petroleum Act 1940* must include a commitment to achieve these objectives before approval will be considered. It is proposed that a legislative requirement to achieve the objectives will be introduced during 1998 with a Bill for a new Petroleum Act. This is in line with PIRSA's objective-based and co-regulatory approach to environmental management.

The three objectives (which are supported by a number of goals) are:

- **Objective 1: ensure that the potential impacts of the proposed seismic operation on biological diversity and cultural components of the environment are assessed within a planning process and incorporated into field management procedures.**
- **Objective 2: monitor and manage those activities that have, or are likely to have, temporary impacts on biological diversity, cultural components of the environment, groundwater or other land users and facilitate rehabilitation so as to minimise such impacts if they occur.**
- **Objective 3: avoid undertaking any activities which have, or are likely to have, long-term significant adverse impact(s) on biological diversity, cultural components of the environment, groundwater or other land uses.**

As a general guideline, the community should expect recovery of seismic impact to within natural variability in about eight years. However, climatic events in this arid environment may markedly affect recovery periods. Impacts that are irreversible or are likely to take 16 years or longer in this environment to recover are taken to be long-term.

Achievement of these objectives will be assessed by using one or more of the following methods:

- goal attainment scaling (GAS)
- defined conditions
- scientific surveys
- photo-monitoring
- other techniques as appropriate

Two sets of criteria for GAS are included. One is an 'enabling' set, for measurement on completion of a work program, where achievement of acceptable levels is likely to lead to acceptable long-term outcomes. The second set is focused on the longer term rehabilitation of affected areas. Use of this second set of criteria incorporates the changing expectations of seismic line conditions over time and defines the criteria for ultimate 'recovery' of the seismic line.

Audits of seismic lines to ascertain the achievement, or otherwise, of the objectives will be undertaken by operators and the results provided to PIRSA. Random audits will be undertaken by PIRSA. Audits by third parties may also be made.

If an operator proposes to undertake a seismic survey in a land system not covered by approved assessment criteria (e.g. those contained in this document), then the operator will need to develop appropriate criteria in consultation with Government, industry and, if required, community interest groups. Such criteria would need to be approved by PIRSA.

This document will be reviewed at least once every three years. It is expected that the objectives would be unlikely to change, but changes to assessment methods, criteria etc. may reflect changing technology, research and community expectations.

INTRODUCTION

This document contains the environmental objectives relating to seismic exploration activities required to be achieved by any licensee operating in the South Australian part of the Cooper and Eromanga Basins (i.e. any operator). It outlines the means by which the achievement of these objectives will be measured by both the licensee and the Petroleum Group of PIRSA and describes how PIRSA will provide assurance to the community that the operator has complied with these requirements. It applies to all seismic operations undertaken pursuant to licences granted under the *Petroleum Act 1940* within the Cooper and Eromanga Basins of South Australia.

This statement of environmental objectives has been developed through consultation between PIRSA, the petroleum exploration industry and a number of environmental interest groups, and is based on the current state of knowledge. It is approved by PIRSA. Any CEP for seismic operations submitted under Petroleum Regulation 16 will need to include a commitment to achieve the objectives set out below, in order for approval to be considered. The document also serves as a public declaration of what is required of an operator and how environmental performance will be assessed and enforced by PIRSA.

Regulatory regimes

The *Petroleum Act 1940* (including the Petroleum Regulations 1989) is the prime legislation relating to petroleum exploration within South Australia. Although it has been revised many times since 1940, it remains largely prescriptive. Under Regulation 16(4) of this Act, a CEP is required to be submitted for approval for all operations. CEPs submitted for approval have, to date, basically been sets of prescriptive procedures that implicitly aim to avoid or minimise environmental impact.

PIRSA has initiated replacement of the existing, largely prescriptive regulatory regime to one based on the achievement of objectives within an environmental management system (EMS) framework. Accordingly, a new objective-based approach to the environmental management of an operator's activities in the Cooper and Eromanga Basins in South Australia has been developed in consultation with targeted stakeholders. The process of stakeholder consultation which includes project assessment and approval will be incorporated in the new regulatory regime.

This statement of environmental objectives is based on a series of environmental objectives (or outcomes) which are defined for the operator's seismic operations. It is part of this move toward objective regulation. Required outcomes are explicitly stated and have been developed through targeted stakeholder consultation. The method by which each objective is achieved is flexible and is the prerogative of the operator.

These objectives are complemented by each operator's CEP and detailed environmental procedures which describe procedures for achieving environmental objectives for seismic exploration in the Cooper and Eromanga Basins in South Australia. The environmental procedures are designed for use by operator personnel and contractors when undertaking operations in the field or planning operations in the office. The procedures should form a component of the contractual arrangements between the operator and relevant contractors, but are not legally binding between the operator and the State Government. However, under the current Act and Regulations, the CEP is legally binding between the operator and the Government.

Where a program or operation is determined to be 'significant', additional processes may be required, depending on the level of significance and the nature of the objectives to be achieved. This level will be initially highlighted by the EMS and subsequently will be determined by PIRSA on the basis of environmental, social and economic issues. The aim of these processes is to determine whether or not specific activity approval is required and, if so, under what specific conditions. A report, *Guidelines for determining project environmental significance*, has been drafted by PIRSA Petroleum Group (1997) and forms the basis for determination of 'significant' as used in this statement.

It is intended that the objectives and goals set out below will be incorporated in the regulatory regime when a new Petroleum Act, anticipated for late 1998, is enacted. The current Act and Regulations do not specifically recognise this document. However, until new legislation is implemented, it will be recognised by expressing CEP approval in terms of ensuring that objectives contained in it will be satisfied. That is, PIRSA will not approve any CEP that does not incorporate the objectives established herein.

Company EMSs

It is intended, under the new Act, that achievement of the environmental objectives set out in this document will be a legal requirement of an operator's EMS. Operators who have implemented an EMS will not be required to seek approval for activities that are not deemed to be significant. Definition of significant is discussed below. The EMS provides the framework within which all aspects of the operator's environmental responsibilities in the Cooper and Eromanga Basins in South Australia are managed. The management system will ensure, as far as reasonably possible, that the environmental objectives established herein will be achieved for all seismic operations. Key elements of an EMS are:

- the environmental policy, which is a public declaration of the operator's environmental goals and its commitment to responsible environmental management
- documentation of procedures, which provides detailed information on how to undertake various activities required by the EMS and assigns personnel responsibilities
- the environmental procedures and CEPs for the various operations, which outline the management techniques and practices and document the requirements to be followed
- various educational handbooks, posters etc. used to raise the environmental awareness of operator and contractor personnel

The EMS will conform with national and international EMS standards, in particular the International Standards Organisation standard ISO 14001, which can be used as a guide in the on-going development of the EMS. Formal accreditation of an EMS will not be required for PIRSA to accept an EMS as satisfying the requirements. The EMS will continue to evolve in response to management reviews, changing technology, new industry practices, regulatory requirements, research, monitoring and community expectations.

This statement of environmental objectives is a high-level document that is positioned within each operator's EMS as shown in Figure 1. The content for each key component of the licensee's EMS and the statement of environmental objectives are outlined in Figure 2.

Where operators do not have an EMS that conforms to relevant standards, the necessity to achieve the objectives will still apply, but closer monitoring of operations by PIRSA will be required. In addition, more prescriptive conditions will be placed on operations and processes to ensure compliance with the objectives herein. Such operators will be encouraged to develop an appropriate EMS.

Impact of seismic activities on the environment

One of the core objectives of Australia's national strategy for ecologically sustainable development (Ecologically Sustainable Development Steering Committee, 1992) is to protect biological diversity (biodiversity). The impact of seismic operations on the environment should be viewed in the context of this objective. Significant impacts on biodiversity are recognised as those with far reaching cumulative effects.

The direct impacts of seismic activities are not extensive because they are generally confined to the width of the seismic lines (usually 4–5 m) and should not extend into the surrounding landscape. As the seismic activities are not laterally extensive, they have very minor potential for significant cumulative and hence ecological effects. However, some issues such as 3D seismic surveys, which may directly impact up to 2% of the survey area, are being studied for significance in terms of ecological impact. In addition, all seismic lines have the potential to facilitate access to areas by third parties and exotic species.

A study of the criteria for assessing the impacts of abandoned seismic lines and wellsites in the Cooper Basin by Fatchen and Woodburn (1997) has identified that the impacts of seismic lines are, in the main, visual rather than ecological. The study, however, observed that even where the return of soil, microtopography and original levels of plant species richness and diversity occurred, the linearity of the seismic lines continued to make them visible in certain instances.

General comments on the impacts of petroleum and mining activities on biodiversity are included in Appendix 1.

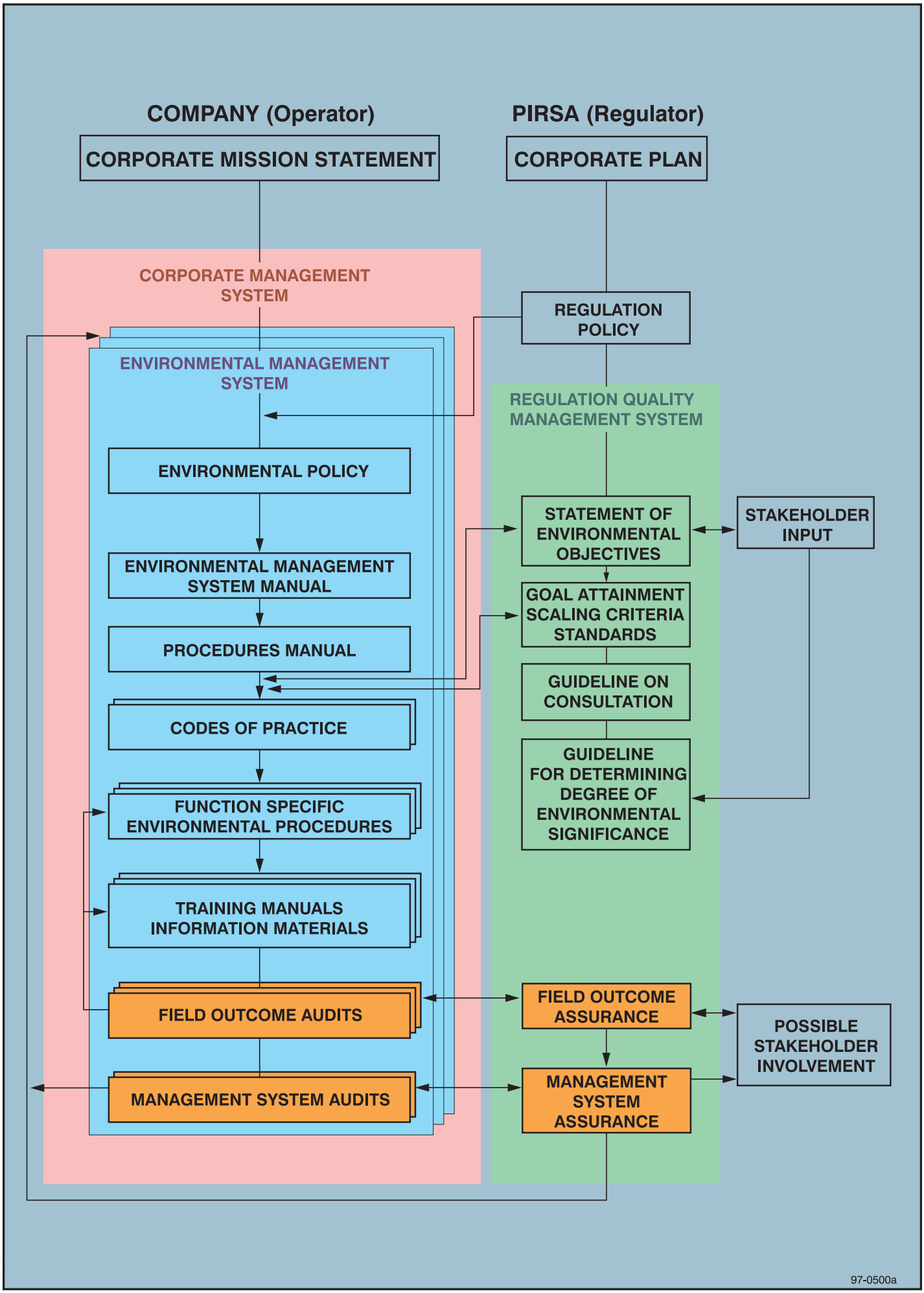

Fig 1 *Relationship of company and PIRSA EMS components*

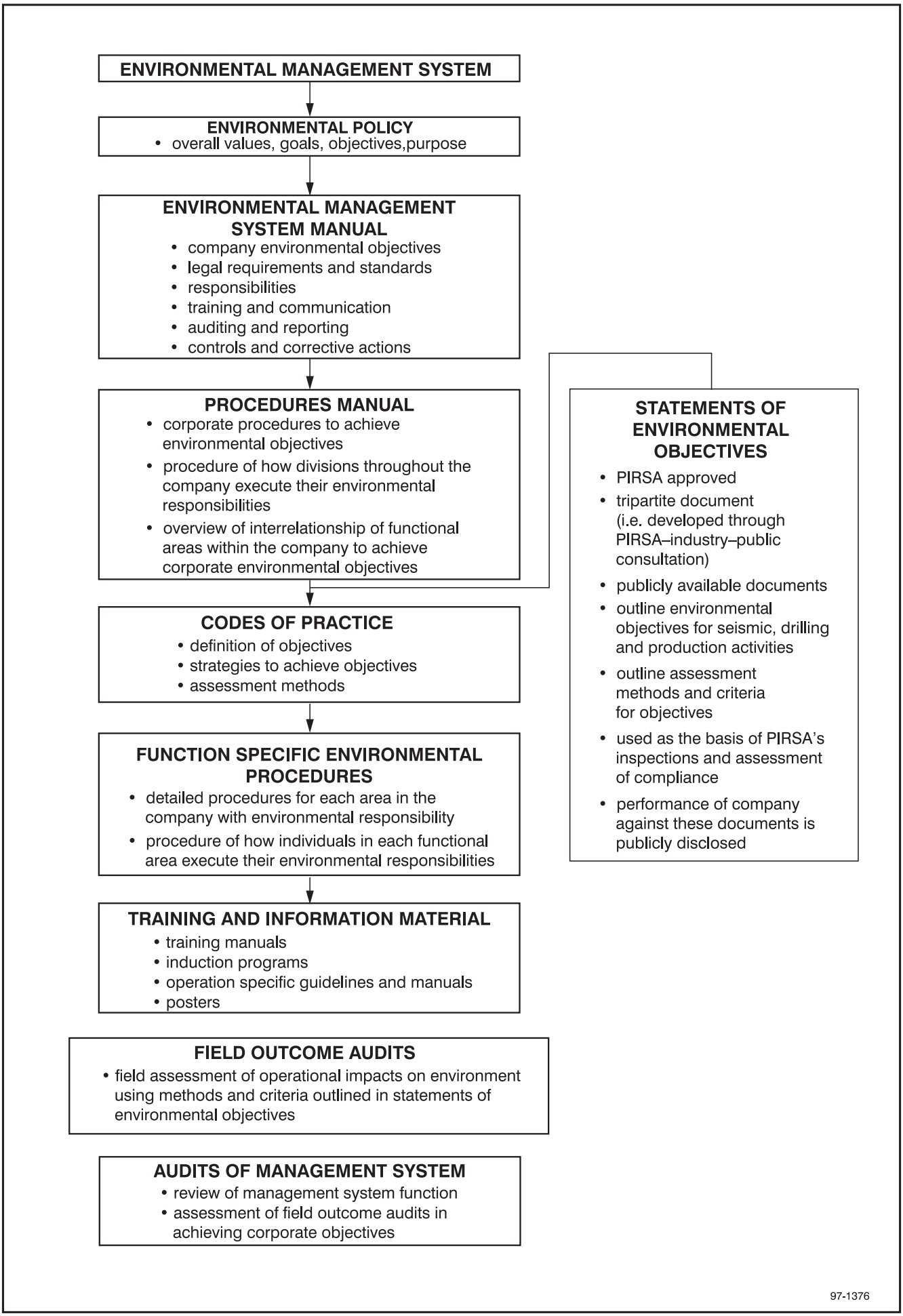

Fig 2 *Generalised contents of key components of company EMS*

ENVIRONMENTAL OBJECTIVES

The overall environmental aim relating to seismic exploration is to ensure operations are undertaken in an ecologically sustainable and socially acceptable manner. This is conformable with the national strategy for ecologically sustainable development (Ecologically Sustainable Development Steering Committee, 1992). The key pertinent objectives of this strategy are:

- to enhance individual and community wellbeing and welfare by following a path of economic development that safeguards the welfare of future generations
- to protect biodiversity, which is defined as the variety of all life forms, and comprises the different plants, animals and micro-organisms, their genes and the ecosystems of which they are a part

The key to achieving these objectives in seismic exploration is to conform to the national strategy for the conservation of Australia's biological diversity (Australian and New Zealand Environment and Conservation Council, 1996). The goal of this strategy is to protect biodiversity and maintain ecological processes and systems.

In most cases, it is the visibility of seismic lines in the landscape that is more significant than ecological impact. The primary aim of the following objectives is to minimise such visual impact to a level that is acceptable to the community. This involves a level of value judgement, balancing economic benefit, environmental impact and social values. Based on these concepts, the following objectives are applicable for seismic exploration operations.

Figure 3 outlines the area for which the objectives and assessment criteria contained herein is applicable.

Objective 1

Ensure that the potential impacts of the proposed seismic operation on biological diversity and cultural components of the environment are assessed within a planning process and incorporated into field management procedures

The assessment of achievement of Objective 1 will include assessment of achievement of the following goals.

Goal 1.1 identification of important or sensitive environmental and cultural components such as ecosystems and habitats that contain high biological diversity or high wilderness values, or that are of social, cultural or scientific importance

Goal 1.2 identification of any threatening processes and activities that have, or are likely to have, significant impacts including cumulative effects on the environmental and cultural components

Goal 1.3 assess any adverse impact on biological diversity likely to arise from the proposed operation on a regional basis, including ecological parameters such as vegetation and terrain types

Goal 1.4 ensure that issues raised in the planning process are incorporated into clearly defined field management procedures

Objective 2

Monitor and manage those activities that have, or are likely to have, temporary impacts on biological diversity, cultural components of the environment, groundwater or other land users, and facilitate rehabilitation so as to minimise such impacts if they occur

The assessment of achievement of Objective 2 will include assessment of the extent to which the following goals are achieved. GAS criteria (App. 2) will be used in the determination of minimal impact, in the context of this objective.

Goal 2.1 clearing or other impacts on native vegetation are minimised

Goal 2.2 disturbance or other impacts on native fauna and their habitats are minimised

Goal 2.3 impact on soil is minimised

Goal 2.4 impact on surface drainage is minimised

Goal 2.5 visual impact of operations (including litter) is minimised

Goal 2.6 impact on other land users is minimised

Goal 2.7 third party use of sites, following the completion of operations, is discouraged

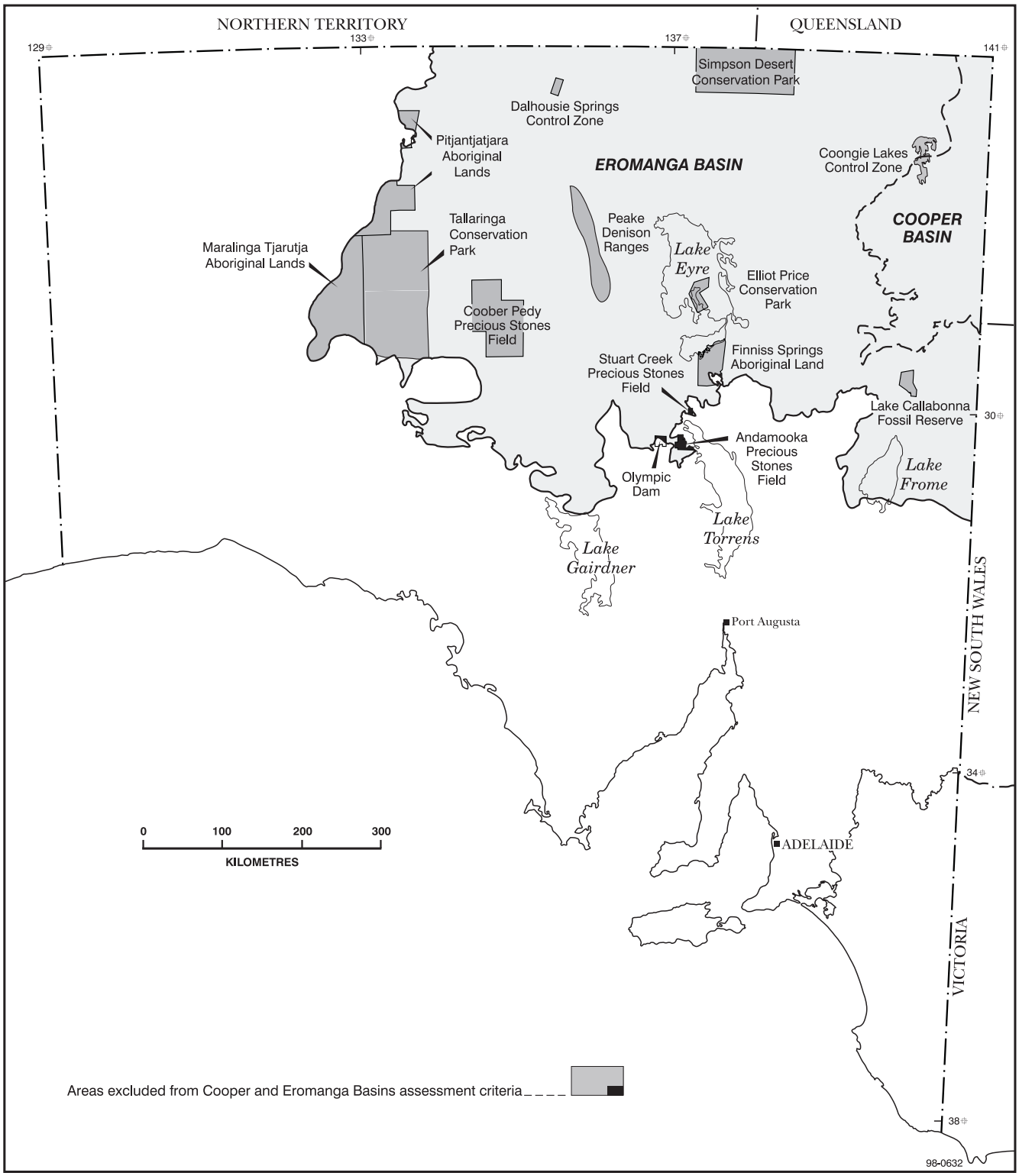

Fig. 3 *Area covered by assessment criteria*

Objective 3

Avoid undertaking any activities which have, or are likely to have, long-term significant adverse impact(s) on biological diversity, cultural components of the environment, groundwater or other land uses

Significant impacts on biodiversity are recognised as those with far reaching cumulative effects. The assessment of achievement of Objective 3 will include assessment of the extent to which there is no significant long-term adverse impact on the features described in Goals 2.1–2.6 and also to the following components of the environment.

Goal 3.1 cultural sites

Goal 3.2 areas of high biological diversity or wilderness value

Goal 3.3 areas which are of social or scientific importance

Goal 3.4 rare and endangered fauna and flora

Goal 3.5 introduction and spread of exotic species

The distinction between temporary and long-term impact depends on many factors, but is ultimately a value judgement based on the level of community acceptance. These factors are generally related to the high variability in climatic events in the arid environment (such as significant rainfall, flooding or drought events, and seasonality of these events), but differing terrain units, vegetation units and timing of operations, all have an effect. Dependent on these factors, a general guideline is that the community should expect recovery from seismic impact after about eight years with current techniques. Impacts which are irreversible or are likely to take 16 years or longer to recover are defined as long-term.

ASSESSMENT METHODS

One of the implications of objective-based regulation is the need for a means of identifying and assessing achievement of environmental objectives. Stakeholders were consulted in the development of Objectives 1–3 and application of the following assessment methods.

Assessment of the achievement of Objectives 1–3 will be undertaken by one or more of the following techniques. Table 1 indicates where use of each of these methods is most pertinent.

- *GAS* — this method (outlined in App. 2) covers objectives that can be assessed against a series of outcomes to enable an assessment of the level of environmental performance of approved activities.
- *Defined conditions* — this covers all objectives that can have relatively long-term consequences and can only be adequately managed through the avoidance of defined unacceptable activities. This can also include demonstration that specific tasks or processes have been adequately undertaken.
- *Scientific surveys* — this covers objectives where the assessment of their achievement needs to be validated by more detailed monitoring. Such surveys may include ecological, social or cultural studies, or other scientific investigations on specific aspects.
- *Photomonitoring* — photographic evidence provided by operator(s) can provide visual documentation on the state of impact. Reoccupation of photopoints in time can provide visual evidence of the level of recovery of seismic impact.
- *Other techniques as appropriate* — other techniques may exist, or may be developed in the future, which could be beneficial. Use of other techniques can be included where they are appropriate and effective.

GAS

The GAS technique will be applied to assess the achievement of the following objectives and goals:

Goal 1.3

For the Cooper and Eromanga Basins in South Australia, assessment criteria have been developed for dunefield, floodplain, wetlands, gibber plain, tableland and salt lake land systems (Tables A2.2, A2.3). If an operator proposes to undertake seismic activities in land systems for which assessment criteria have not been developed and approved, new criteria will need to be developed. This will require consideration of the impact of the proposed activities on vegetation, the land surface, visibility, other land users etc. Significant environmental elements will also need to be identified and measures developed for their protection.

Table 1 *Techniques for assessing the environmental objectives for seismic operations in the Cooper and Eromanga Basins, South Australia*

	GOAL[(a)]	ASSESSMENT METHOD			
		GAS	Defined conditions	Scientific surveys	Photo-monitoring
1.1	'identify important environmental and cultural components'		X	X	
1.2	'identify threatening processes and activities'		X	X	
1.3	'assess adverse impact on biodiversity on a regional basis'	X	X	X	
1.4	'define field management procedures'		X		
2.1	'minimise the impact on vegetation'	X	X	X	X
2.2	'minimise the impact on fauna'	X	X	X	?
2.3	'minimise the impact on soil'	X	X	X	X
2.4	'minimise the impact on surface drainage'	X	X	X	X
2.5	'minimise the visual impact'	X	X	X	X
2.6	'minimise impact on other land users'	X	X		X
2.7	'discourage third party use'	X	X		X
3.1	'protect cultural sites'		X		?
3.2	'protect areas of high biodiversity or wilderness value'		X	X	?
3.3	'protect areas of social or scientific importance'		X	X	?
3.4	'protect rare and endangered flora and fauna'		X	X	?
3.5	'avoid introducing exotic species'		X	X	?

(a) Goals are abbreviated; refer to pp. 6 and 8 for full descriptions.

Objective 2

Assessment of achievement of this objective can be undertaken using the criteria for minimal impact during seismic line preparation and during seismic line rehabilitation (Tables A2.2, A2.3). Monitoring the impact on native vegetation is also a reasonable surrogate for assessing the impact on fauna and their habitat. The impact of seismic lines is confined to a small portion of the total area through which they pass. Therefore, natural revegetation should lead to the restoration of fauna habitats and population patterns with very minor or no residual impact in a more regional context.

Where GAS is used as the audit tool on completion of a seismic survey (Table A2.2), a score of 0 to +2 will be considered to be in compliance with the legal requirements. GAS scores of -2 will indicate areas needing immediate remedial action. This may include physical remediation as well as system review to ensure non-recurrence. A recurrent score of -1 in a particular facet of operations or outcome will indicate the need for system review to raise the standards. It is expected that achievement of these criteria will lead to acceptable medium-term recovery. In this context, Table A2.2 is an 'enabling' set of criteria.

Table A2.3 denotes the expectations of outcomes for seismic lines, a short time after completion, for example, one to two years old. A GAS score of 0, +1 or +2 denotes acceptable levels of performance at this time. The actual time period will vary depending on climatic events, land systems and individual land units within these systems.

In the medium term, for example, where lines are two to eight years old, a GAS score of +1 or +2 denotes acceptable outcomes. In this case, aspects that are scored at -1 or -2 will require remedial action.

Where lines are older, e.g. more than eight years old, and have had at least three significant rainfall, flooding or drought events, a GAS score of +2 (Table A2.3) will denote an acceptable outcome. That is, full environmental recovery will be expected for the long term. In this case, a score of 0, -1 or -2 will indicate the need for remedial action.

Defined conditions

A number of objectives are in terms of more definitive outcomes, more attuned to yes/no assessment. The following objectives are appropriate for assessment against defined conditions.

Objective 1

The licensee is required to identify all sensitive environmental components and threatening processes in the light of each of these objectives. This will be assessed on the basis that a licensee can demonstrate it has identified these components and processes to the satisfaction of PIRSA. It is expected that these will be included as part of the operator's EMS process.

Critical and significant impacts that need to be avoided for particular land systems or units are set as a condition of approval. For example, no gibber mantle removal is set as a condition of approval, as gibber plains are particularly susceptible to water erosion damage.

Objective 2

Defined conditions may be specified, in conjunction with GAS criteria, to manage particular short-term impacts.

Objective 3

Assessment of this objective will entail the identification of the extent of avoidance of activities that have, or are likely to have, significant long-term adverse impact(s). Defined conditions may include general conditions, as included in Appendix 3, which are applicable to all surveys, as well as survey specific conditions.

Scientific surveys

The assessment of some objectives is suited to longer term monitoring and/or periodic surveys. Surveys may also be used, where necessary, to validate criteria used in the GAS technique and to validate defined conditions, particularly relating to ecological aspects. These surveys would need to be undertaken by appropriately qualified personnel and may include monitoring of fauna and flora growth and distribution patterns for pre- and post-disturbance.

All objectives may require assessment by scientific surveying. Assessment by environmental surveys and monitoring has been undertaken in the past (Stone, 1984; Buckley, 1985; Graetz and Pech, 1987; Social and Ecological Assessment Pty Ltd, 1989; Stoll, 1989; Graetz, 1990) and more recently by Fatchen and Woodburn (1997) and will continue in the future as required. The licensee or PIRSA may initiate such studies.

Photomonitoring

Photographs of seismic impact and revisiting of photographic monitoring points has long been used to provide visual evidence of impact and recovery rates. A recent study by Fatchen and Woodburn (1998) indicates that photographic evidence still provides valuable evidence of achievement of Objectives 2 and 3. However, it is likely that such evidence will need to be complemented by other measurements.

Other techniques as appropriate

The above assessment techniques have been extensively trialed for practicality and appropriateness in measuring achievement of the stated objectives. They have been found to be the most appropriate to date. However, this does not mean that other techniques are excluded. It is expected that where other techniques are found to benefit the assessment process, they will be included as appropriate.

AUDITING AND REPORTING

Operator internal audits

Prior to commencement of, or during a seismic survey, the operator will nominate a representative sample of lines to be audited in environmentally sensitive areas (e.g. the Cooper or Strzelecki floodplains, wetlands, tablelands and gibber plains). Representative sample sites, ideally, should be easily accessible from existing roads or tracks. Other sites may be selected away from existing tracks or in less sensitive areas on a random basis to provide a check of standards throughout the licence area, and provide representative sampling of all land units. The seismic survey crew is to be made aware that a sample of lines will be audited but the precise lines will not be made known. The operator's field representative shall undertake and audit the nominated lines within five weeks of the survey being completed and prepare an audit report.

PIRSA audits

PIRSA will undertake random audits of seismic surveys both in the field and in the office, using the assessment techniques defined above. The aim of these audits is to ascertain achievement or otherwise of Objectives 1–3. The audits will also check the accuracy of the operator's audit reports, the effectiveness of the operator's EMS and provide feedback to company personnel.

The selection of sites to be audited will be random, to ensure vigilance on behalf of the operator and contractors. Even so, the more environmentally sensitive land units, particularly those covered by company audits would be amongst the most likely sites for PIRSA audits. PIRSA will advise of any specific photomonitoring that is deemed to be required, in addition to any which has been initiated through the operator's EMS.

A summary of the results of PIRSA's audits will be included as part of PIRSA's reporting on environmental management of petroleum operations and will be made public.

Third party audits

Audits of the field outcomes of company seismic operations may be made by third parties. These may be commissioned by PIRSA, or the licensee, or may be by independent parties. If these audit findings are to be compared to those of the licensee and/or PIRSA, the same assessment criteria must be used. Items of note from these reports can be included in PIRSA's reporting on environmental management.

COMPLIANCE

It is the duty of every person, licensee, operator and contractor to ensure achievement of Objectives 1–3. In the event of failure to achieve any of these objectives the operator, contractor and individual responsible may each be guilty of an offence.

PIRSA will provide feedback to licensees following completion of audits. High levels of achievement will be acknowledged, for example in PIRSA's annual report.

PIRSA's response to non-compliance will depend on the extent, severity and recurrence of non-compliance. PIRSA will follow the enforcement pyramid (Fig. 4), which has the ability to escalate punitive measures to ensure compliance. The aim of this philosophy is to have non-compliance remedied at the lowest possible levels of the enforcement pyramid. Where significant under achievement of these objectives occurs (e.g. GAS scores of -2), immediate remedial action will be required. This can take the form of active physical remediation and/or system review.

Maximum fines which may be imposed under the *Petroleum Act* are a Division 1 fine (currently $60 000) for a licensee or body corporate or, in any other case, a Division 5 fine (currently $8000). The maximum penalty under the *Petroleum Act* is licence cancellation.

This section on non-compliance is provided for convenience of reference only. It cannot limit the operation of the *Petroleum Act*, or any discretion to prosecute, suspend or cancel licences, or impose penalties under this Act. Each situation will be dealt with on its own particular circumstances.

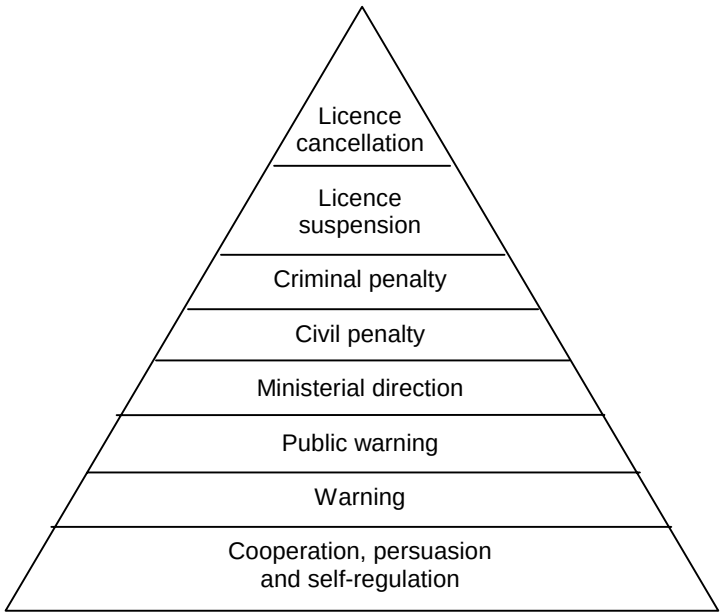

Fig. 4 *Enforcement pyramid (after Laws and Aust, 1994)*

DOCUMENT REVISION

This document will be reviewed on a regular basis. It will evolve in response to changing regulatory requirements, research, technology, industry practices and community expectations. New knowledge gained from scientific surveys will validate the criteria used in the GAS technique of assessment. Current research already indicates areas that would benefit from further investigation. Such work will take time to undertake and incorporate in a consultation process. Examples of this may include assessment criteria for seismic line visibility and detailed evidence of recovery from impact in various land units.

It is appropriate to finalise the current snapshot in the evolution of this statement and issue it as a working document. It is expected that further areas of investigation will be identified in the process of using this document. Such studies can be incorporated in subsequent reviews. It is expected that such reviews will be undertaken at least every three years. Additional reviews may be undertaken where new information or expectations are likely to lead to a major revision.

Once the new Petroleum Act is enacted this statement of environmental objectives will require review to reflect the new Act and associated Regulations.

APPENDIX 1

Impact of activities on the environment

Examples of significant cumulative effects on the environment, determined by the State of the Environment Advisory Council (1996) are:

- extensive removal of vegetation (mainly evident in agriculture)
- extensive deforestation
- urban development

The significance of the cumulative effects for these examples is attributed to the fact that the clearing of vegetation is often so rapid and extensive that the natural systems cannot recover by adequately responding to the impact.

The ability of a particular ecosystem to recover adequately, and the significance of any cumulative effects due to seismic activity, depends on the extent of the disturbance. The impact of petroleum operations on plant biodiversity and native birds and reptiles in Australia figures low on the scale of impacts imposed by human activities as highlighted by a number of studies and reports (Leigh and Briggs, 1994; Garnett, 1992 a, b; Cogger *et al.*, 1993; Wager and Jackson, 1993; Lee, 1995; Kennedy, 1992; State of the Environment Advisory Council, 1996).

Specific studies on impacts and their recovery from seismic operations have been undertaken in the Cooper Basin (e.g. Buckley, 1985; Social and Ecological Assessment Pty Ltd, 1987, 1989; Graetz, 1990).

The State of the Environment Advisory Council (1996, p.6-6) stated:

> Numerous mining sites and petroleum fields occur across Australia but the land area they actually occupy is very small (less than 0.01%). ...the most widespread effects are associated with roads and infrastructure that provide access to remote areas surrounding prospecting leases and mining towns. The major controversies over land use for mining occur where mining priorities coincide with sites of high biodiversity or cultural significance.

This has been reinforced by an independent study commissioned by PIRSA into the criteria for assessing the impacts of abandoned wellsites and seismic lines in the Cooper Basin (Fatchen and Woodburn, 1997, 1998).

APPENDIX 2

GAS

Introduction

In early 1994 PIRSA Petroleum Group began a study with the Flinders Institute of Public Policy and Management in which the concept of goal attainment scaling (GAS) was introduced as a means of measuring environmental performance against particular objectives. In late 1994 PIRSA Petroleum Group and Santos (operator, Petroleum Exploration Licences 5 and 6, Cooper Basin) commenced using GAS as an evaluation tool for environmental objectives of restoration activities on abandoned wellsites and seismic lines (Sharp, 1994). This concept has subsequently been introduced to the mining industry (Sharp, 1996; Malavazos, 1996) and to environmental interest groups (Sharp, 1997).

GAS is to be used in assessing the achievement of environmental goals that can be appropriately measured by defined criteria, either in qualitative or quantitative terms. Each outcome level is rated according to its likelihood of occurring. A feature of GAS is that for any goal (environmental or otherwise) stakeholders are involved in evaluating and seeking consensus on the most important aspects of the goals to be achieved within a particular time frame, and the range of expected outcomes of the activities undertaken within such a time frame. The technique forces participants to document the expected outcomes as indicated in Table A2.1.

Table A2.1 *Outcomes for assessing GAS criteria*

Scale	Probability of occurring	Outcomes achieved	Acceptability
+2	low	much more than expected	excellent
+1	medium	more than expected	good
0	high	expected	satisfactory
-1	medium	less than expected	unsatisfactory
-2	low	much less than expected	very unsatisfactory

The outcomes can be defined in various ways, including descriptive statements, photographs and quantitative measurements. It is a pragmatic method of evaluation that does not require intensive, long-term scientific sampling or training.

PIRSA Petroleum Group (1998) has developed a guideline for the assessment of abandoned wellsites in the Cooper Basin using descriptive GAS outcome criteria illustrated by photographs. The GAS outcome criteria for seismic lines (Tables A2.2, A2.3) use descriptive statements. It is expected that a future development will be the use of supportive photographs.

Time dependency

The achievement of environmental objectives is very dependent on time, particularly in an arid environment such as the Cooper and Eromanga Basins, as well as on climatic conditions, soil and vegetation characteristics within the various land systems and units. Consequently, it is important to recognise that objectives and assessment criteria need to be set for a series of time steps. For instance, at a time immediately after completion of a seismic line, the objectives and criteria focus on expected outcomes which are predominantly physical (such as soil profile and texture), which should enable the achievement of longer term objectives, such as regrowth of particular plant species and communities. These early time frame objectives can be termed 'enabling objectives'. The later objectives are the real aim of the process and focus on recovery of biodiversity and ecosystems.

A great deal of correlation between plant species, communities and their physical environment exists, as demonstrated by a number of studies (Gillen and Reid, 1988). Therefore, the re-establishment of these physical characteristics can be used as short-term indicators for the longer term objectives.

In addition, achievement levels will change in time after completion of a seismic program. For example, a sand dune cut 1.5 m deep may be expected on completion of a survey and be rated at a GAS level of 0. However, the occurrence of a 1.5 m deep cut 10 years after the survey would have low probability of occurring, be a very unsatisfactory level of achievement and be rated -2. This is indicated in Figure A2.1.

There are two approaches to incorporate this time dependency of environmental outcomes. The first is to use many sets of GAS criteria, each representing the expectation of the nominated period after completion (as indicated in the Figure A2.1). The advantage of this option is that the relative level of achievement remains the same over time (i.e. an expected (0) level of performance at time = x will correspond to an 0 level at time x + n if appropriate recovery is occurring. The disadvantage is that several (or many) sets of criteria may be required, and different sets may need to be selected depending on year of survey, climatic conditions etc.

The second method is to use one set of criteria for all lines, climatic conditions and extent of time since survey completion. The anticipated result of this approach is that the distribution curve of GAS scores of lines of increasing vintage should show a skewness to the positive side (i.e. there should be increasing occurrences of +1 and +2 scores and reducing occurrences of -1 and -2 scores). The advantage of this option is that criteria remain constant and the system is simpler to use. These options are graphically represented in Figure A2.2.

By judicious choice of criteria for defining each level in option 2, the level of expected outcomes, and thus acceptability, can be measured by the skewness of the distribution curves. That is, if the expected and therefore acceptable level at a short time (e.g. one to two years) after completion is 0 then, at some time later (e.g. three to eight years), the expected/acceptable level should be +1. If the community expects impacts to recover in a medium time frame (e.g. after eight years) then, at this time, the expected/accepted value should be +2. At such time, scores less than +2 would be deemed to be less than fully recovered to community standards, and hence reflect an under achievement of the overall objectives. At this point in time, scores of -2, -1 or 0 would be classed as very unsatisfactory and indicate the need for remedial action.

Use of GAS

GAS will be used by the operator and PIRSA to monitor the effectiveness of the company's management practices in delivering the expected outcomes over time. The results of the GAS assessment will be gathered on a site-by-site basis, and where less than expected performance is detected, corrective action will be sought and enforced by PIRSA. The corrective action taken by the company will be used to assess the responsiveness and effectiveness of the company's EMS.

The objective of the management system will be to deliver environmental outcomes (within given respective time frames) which are either in the expected or much more than expected categories for the time frame used in the criteria.

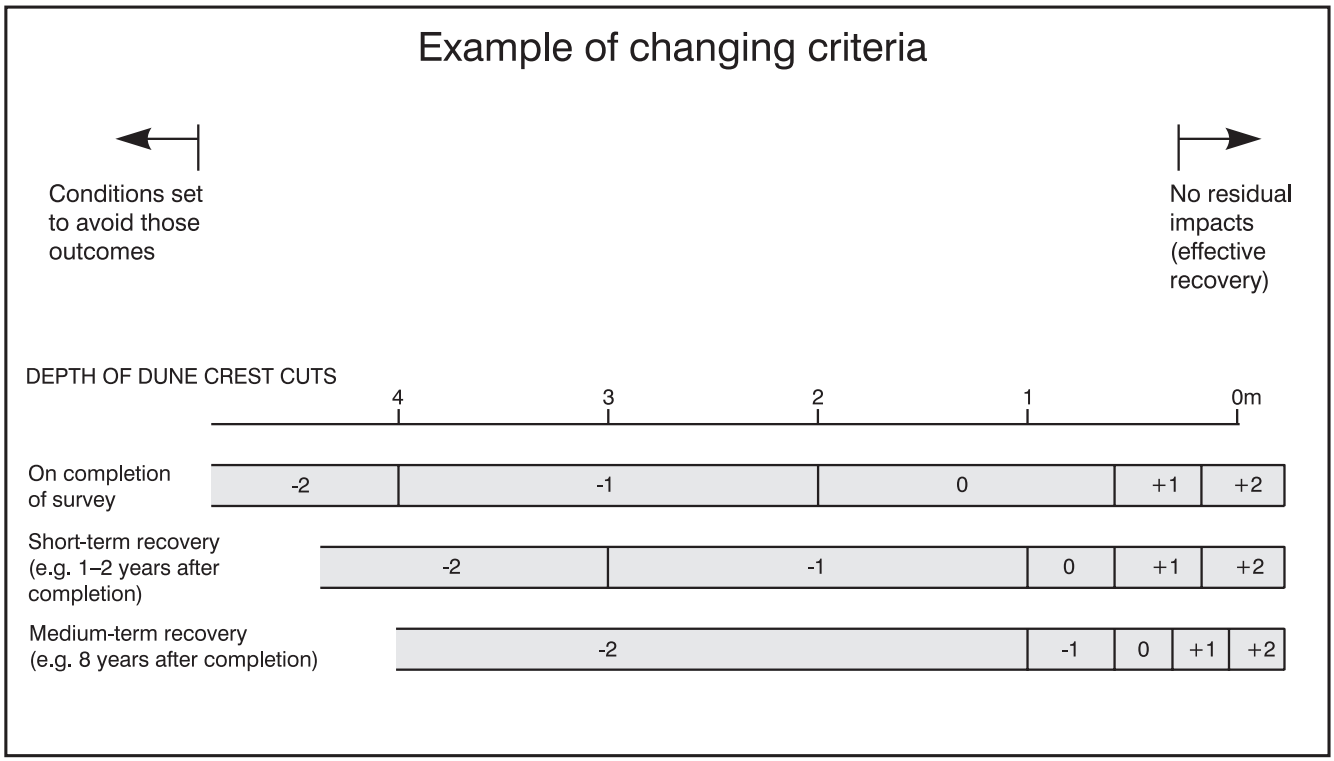

Fig A2.1 *Range of measurable outcomes (e.g. depth of dune crest cut)*

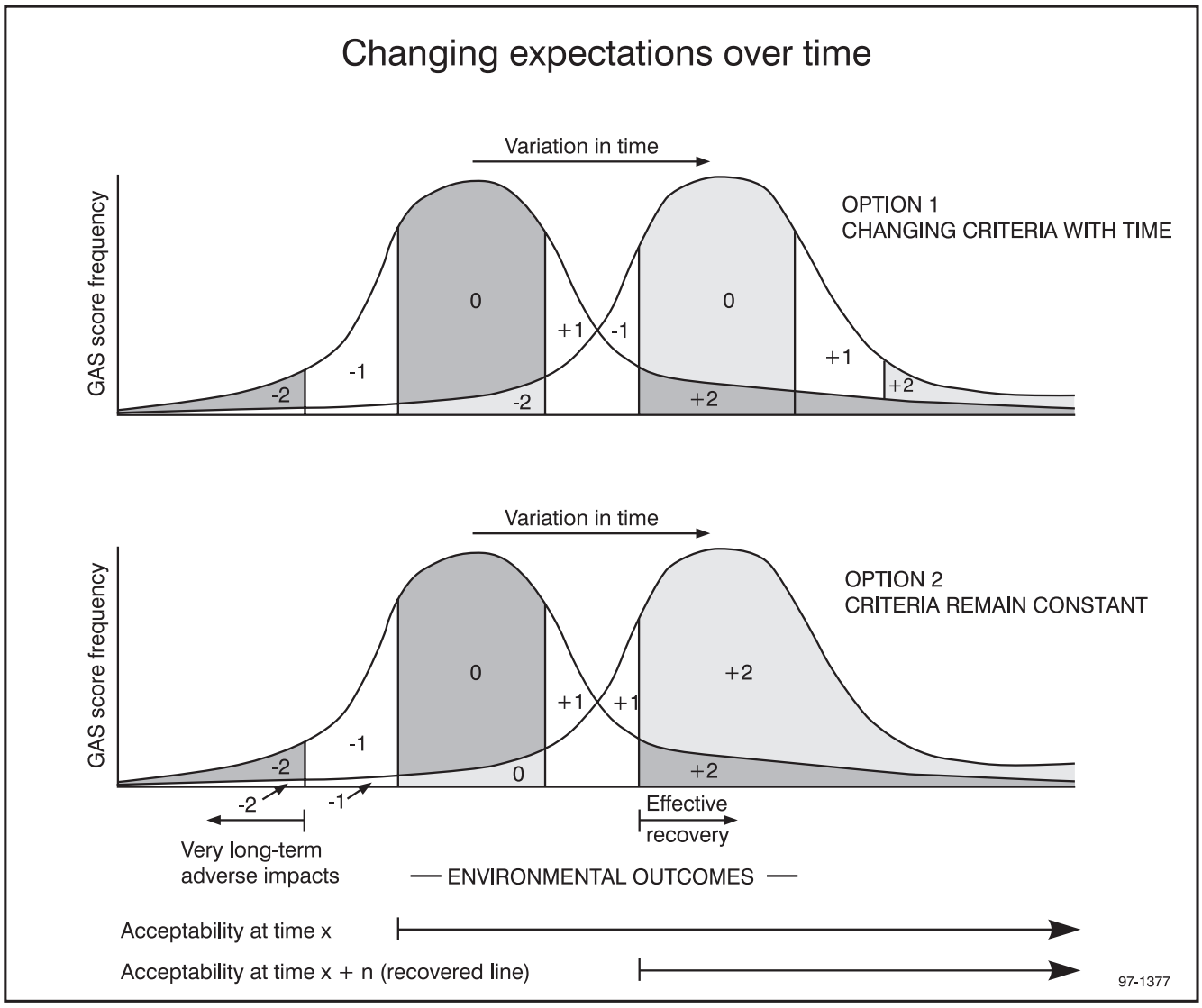

Fig A2.2 *Distribution curves of GAS scores*

TABLE A2.2
GAS criteria for assessing seismic lines on completion of survey in the Cooper and Eromanga Basins, South Australia

LAND SYSTEM	MEASURE (Associated goals) [a]	SCORE				
		+2 [b, c]	+1 [b, c]	0 [b, c]	-1	-2 [d]
Non land system specific	*Impact on infrastructure* 2.6	• No impact to any pastoral, tourist or production infrastructure.	• No observable repair or damage to infrastructure.	• Any impact to infrastructure has been reported and reinstated or repaired.	• Repair to damaged infrastructure is incomplete or inappropriate. • Damage has not been reported.	• Damage to any infrastructure has been left unrepaired and not reported.
	Visual impact 2.5, 2.7	• No evidence of seismic operations.	• Only wheel tracks are evident. • Line weaves. • Line of sight is impaired.	• Established roads and tracks have been reshouldered. • Doglegs have been placed at established roads and tracks in vegetated areas. • Dozer or grader has been walked 40 m either side of established road or track. • Line weaves through vegetated areas. • Line of sight is impaired.	• No doglegs at established roads or tracks in vegetated areas. • No weaving through vegetated areas. • Line of sight is unimpaired.	• Line is clearly evident and dominates the landscape.
	Uphole site restoration 2.3, 2.5 [e]	• No evidence of upholes.	• No evidence of cuttings. • Some evidence of operations.	• Cuttings are evident but dispersed around hole. • No subsidence.	• Hole is plugged. • Cuttings form mound <0.5 m high. • Subsidence is evident.	• Hole is open. • Cuttings form mound >0.5 m high.
	Pollution or litter 2.1, 2.2, 2.3, 2.5	• No pollution or litter.	• No evidence of water or oil pollution. • Maximum of 1 pin flag/km. • No other litter.	• Waste water and vehicle oil spills have been managed appropriately. • Maximum of 2 pin flags/km. • Maximum of 1 item of other litter/km.	• Waste water forms ponds or extensive boggy ground. • Vehicle oil spills have not been remedied. • Maximum of 3–4 pin flags/km. • Maximum of 1–4 items of other litter/km.	• Extensive waste water ponding. • Oil spills of more than 20 L have not been remedied. • Five or more pin flags/km. • Five or more items of other litter/km.
Dunefield	*Impact on vegetation* 2.1, 2.2 [f]	• No removal of vegetation.	• No removal of Priority 3 shrubs <1 m high.	• No removal of Priority 1 and 2 vegetation. • No removal of Priority 3 shrubs >2 m high. • Less than 30% of tree branches have been removed.	• Priority 1 or 2 vegetation <2 m high have been removed, including rootstock. • Priority 3 shrubs >2 m high have been removed, including rootstock.	• Priority 1 or 2 vegetation >2 m high have been removed, including rootstock.
	Disturbance to land surface 2.2, 2.3 [e]	• No dune cuts. • No windrows.	• Dune cuts are <0.5 m deep. • Windrows in swale are <100 mm high.	• Dune crest cuts are 0.5–2 m deep. • Side cuts are <1.5 m deep. • Sand is stacked along side of cut. • Windrows in swale are <0.3 m high. • Clay-rich dune cuts are <1 m deep.	• Dune crest cuts are 2–4 m deep. • Side cuts are 1.5–3 m deep. • Minor ramping of sand onto swale. • Windrows in swale are 0.3–0.5 m high. • Clay-rich dune cuts are >1 m deep but rehabilitated. • Off line trafficking is evident.	• Dune crest cuts are >4 m deep. • Extensive ramping of sand onto swale. • Side cuts are >3 m deep. • Claypans have been cut. • Windrows in swales are >0.5 m high.

(…/cont.)

(Table A2.2 cont.)

LAND SYSTEM	MEASURE (Associated goals) [a]	SCORE				
		+2 [b, c]	+1 [b, c]	0 [b, c]	-1	-2 [d]
Floodplain and wetlands	*Impact on vegetation* 2.1, 2.2 [f]	• No removal of vegetation.	• No removal of Priority 3 shrubs 1–2 m high.	• No removal of Priority 1 and 2 vegetation. • No removal of Priority 3 shrubs >2 m high. • Less than 30% of tree branches have been removed. • Rootstock is intact.	• Priority 1 and 2 vegetation <2 m high have been removed. • Priority 3 shrubs >2 m high have been removed. • Rootstock is intact.	• Trees and/or shrubs >2 m high have been removed. • Rootstock has been removed.
	Disturbance to land surface 2.2, 2.3, 2.4, 2.5 [e]	• No windrows. • No interference with drainage channels.	• Windrows are <100 mm high for >50% of line. • Only creek banks <0.5 m high have been cut.	• Windrows are <100 mm high. • Creek banks 0.5–1 m high have been cut. • Creeks are not blocked. • Wheel tracks are <100 mm deep.	• Windrows are <0.3 m high. • Creek banks 1–2 m high have been cut and not restored. • Creeks are blocked by material <1 m deep.	• Windrows are >0.3 m high. • Creek banks >2 m high have been cut. • Creeks are blocked by material >1 m deep. • Wheel tracks are >0.2 m deep. • Soil compaction is evident.
Gibber plain and tableland	*Impact on vegetation* 2.1, 2.2	• No disturbance to vegetation.	• No removal of vegetation.	• Maximum of two trees 1–3 m high have been unavoidably removed at creek crossings. • Less than 30% of tree branches have been removed. • Creek crossings are doglegged.	• Vegetation has been removed unnecessarily. • Three or more trees 1–3 m high have been removed at creek crossings.	• Trees have been removed unnecessarily. • Two or more trees >3 m high have been removed at creek crossings.
	Disturbance to land surface 2.2, 2.3, 2.5 [e]	• No evidence of seismic line.	• Only wheel tracks are evident.	• Line has been rolled or walked. • No blade work. • Creek banks have been cut only where necessary. • Creeks are not blocked.	• Creek banks 1–2 m high have been cut and not restored. • Creeks are blocked by material <1 m deep. • 'Windrows' [d] exist but are <50 mm high. • Off line trafficking is evident.	• Gibber mantle has been removed. • Creek banks >2 m high have been cut and not restored. • Creeks are blocked by material >1 m deep. • 'Windrows' [g] are >50 mm high.
Salt lake	*Disturbance to land surface* 2.3, 2.5 [e]	• No evidence of seismic line.	• No evidence of shotholes. • Little evidence of foot trafficking.	• Only footprints are evident. • No significant evidence of shotholes.	• Wheel tracks are <0.2 m deep. • Minor evidence of shotholes.	• Wheel tracks are >0.2 m deep. • Bog holes are evident. • Dominant evidence of shotholes (e.g. cratering, blow out, discolouration).

(a) Goals under Objective 2:

- 2.1 Clearing or other impacts on native vegetation are minimised.
- 2.2 Disturbance or other impacts on native fauna and their habitats are minimised.
- 2.3 Impact on soil is minimised.
- 2.4 Impact on surface drainage is minimised
- 2.5 Visual impact of operations (including litter) is minimised.
- 2.6 Impact on other land users is minimised.
- 2.7 Third party use of sites, following the completion of operations, is discouraged.

(b) If any criterion (dot point) within a -1 or -2 cell occurs, then a score of -1 or -2 will be allocated.

(c) For 0,+1 and +2 cells, all relevant criteria (dot point) within the cell must be satisfied to score at that level.

(d) Some criteria at -2 level may also be subject to defined conditions, but are included in this table to ensure that they are clearly identified.

(e) All vertical measurements to be measured from normal ground surface.

(f) Priority classification refers to Wiltshire and Schmidt (1977).

(g) 'Windrows' in this context means mounding of gibbers through the action of wheel trafficking and associated dispersal of gibbers away from wheel tracks.

TABLE A2.3

GAS criteria for assessing the level of rehabilitation of seismic lines in the Cooper and Eromanga Basins, South Australia

LAND SYSTEM	MEASURE (Associated goals) [a]	SCORE				
		+2[b,c]	+1[b,c]	0[b,c]	-1	-2[d]
Non land system specific	*Vegetation regrowth* 2.1, 2.2	• Line is virtually indistinguishable from the surrounding flora. • All vegetation has approximately the same natural variability on or off line.	• Vegetation on line is well established, but is only ~50% of the height and distribution of the surrounding flora.	• Regrowth is evident; new shoots are appearing (grasses, shrubs, annuals). • Density of new vegetation is ~50% of that of the surrounding vegetation. • No weed infestation.	• Some regrowth is evident, but at a density well below 50% of the surrounding vegetation. • Some weed infestation.	• Line is clearly distinguishable from surrounding flora. • Extensive weed infestation.
	Visual impact 2.5	• No evidence of seismic operations.	• Line is only evident when occupying a known reference point.	• Line weaves through vegetated areas. • Line of sight is impaired.	• No doglegs in vegetated areas. • No weaving. • Line of sight is unimpaired.	• Line is clearly evident and dominates the landscape.
	Third party use 2.7	• No third party use.	• Very little evidence of third party use.	• Little evidence of third party use.	• Significant third party use.	• Line has become a major track.
	Uphole site restoration 2.3, 2.5[e]	• No evidence of upholes.	• Evidence of upholes is difficult to discern.	• Cuttings are evident but dispersed around hole. • No subsidence.	• Hole is plugged. • Cuttings form mound <0.3 m high. • Subsidence is evident.	• Hole is open. • Cuttings form mound >0.3 m high.
	Pollution or litter 2.1, 2.2, 2.3, 2.5	• No pollution or litter.	• No water or oil pollution. • Maximum of 1 pin flag/2 km. • No other litter.	• No evidence of water or oil pollution. • Maximum of 1 pin flag/km. • No other litter.	• Minor evidence of vehicle oil spills. • Maximum of 2 pin flags/km. • Maximum of 1 item of other litter/km.	• Waste water has changed the microenvironment. • Oil spillage is clearly evident. • Three or more pin flags/km. • Two or more items of other litter/km.
	Erosion 2.3[e]	• No evidence of erosion.	• Minor localised erosion.	• Minor erosion. • No gullies.	• Significant erosion. • Gullies <0.3 m deep have formed. • Floodwaters have been diverted along seismic lines.	• Severe erosion. • Gullies >0.3 m deep have formed. • Watercourses have been altered by seismic line; line has become a creek.
Dunefield	*Disturbance to land surface* 2.3, 2.5[e]	• No evidence of seismic operations.	• Dune cuts <0.5 m deep are still evident. • Windrows in swales are <100 mm high and occur for <50% of line. • Disturbance to dune flanks is barely visible.	• Dune cuts <1 m deep are still evident, providing cut is not vertical. • Side cuts are <0.5 m deep. • Windrows in swales are <100 mm high.	• Dune cuts are 1–3 m deep. • Side cuts are <2 m deep. • Windrows are <0.3 m high.	• Dune cuts are >3 m deep. • Side cuts are >2 m deep. • Dune cuts are vertical. • Sand is ramped into corridor. • Windrows are >0.3 m high.

(…/cont.)

(Table A2.3 cont.)

LAND SYSTEM	MEASURE (Associated goals) [a]	SCORE				
		+2[b,c]	+1[b,c]	0[b,c]	-1	-2[d]
Floodplain and wetlands	*Disturbance to land surface* 2.2, 2.3, 2.4, 2.5[e]	• No evidence of seismic operations.	• Windrows are <50 mm high and occur for <50% of line. • Only wheel tracks are evident.	• Windrows are <50 mm high. • Creek bank cuts <1 m deep have reformed. • Creeks are not blocked.	• Windrows are consistently <100 mm high. • Creek bank cuts < 2 m deep have not reformed. • Creeks are blocked by material <1 m deep. • Wheel tracks are <100 mm deep.	• Windrows are consistently >100 mm high. • Creek bank cuts >2 m deep have not reformed. • Creeks are blocked by material >1 m deep. • Wheel tracks are >100 mm deep. • Soil compaction is evident.
Gibber plain and tableland	*Disturbance to land surface* 2.2, 2.3, 2.5[e,f]	• No evidence of seismic operations.	• Slight evidence of wheel tracks.	• Wheel tracks are evident but <50 mm deep. • Creeks are not blocked. • No 'windrows'[f].	• Wheel tracks are >50 mm deep. • Creek banks have not reformed. • 'Windrows'[f] exist but are <50 mm high.	• Creeks are blocked. • 'Windrows'[f] are >50 mm high. • Significant evidence of erosion.
Salt lake	*Disturbance to land surface* 2.3, 2.4 [e]	• No evidence of seismic operations.	• Little evidence of seismic operations. • No evidence of shotholes.	• No wheel tracks are evident. • Little evidence of foot trafficking. • No significant evidence of shotholes.	• Wheel tracks are <0.2 m deep. • Minor evidence of shotholes.	• Wheel tracks are >0.2 m deep. • Bog holes are evident. • Dominant evidence of shotholes (e.g. cratering, blow out, discolouration)

(a) Goals under Objective 2:

- 2.1 Clearing or other impacts on native vegetation are minimised.
- 2.2 Disturbance or other impacts on native fauna and their habitats are minimised.
- 2.3 Impact on soil is minimised.
- 2.4 Impact on surface drainage is minimised.
- 2.5 Visual impact of operations (including litter) is minimised.
- 2.6 Impact on other land users is minimised.
- 2.7 Third party use of sites, following the completion of operations, is discouraged.

(b) If any criterion (dot point) within a -1 or -2 cell occurs, then a score of -1 or -2 will be allocated.

(c) For 0,+1 and +2 cells, all relevant criteria (dot point) within the cell must be satisfied to score at that level.

(d) Some criteria at -2 level may also be subject to defined conditions, but are included in this table to ensure that they are clearly identified.

(e) All vertical measurements to be measured from normal ground surface.

(f) 'Windrows' in this context means mounding of gibbers through the action of wheel trafficking and associated dispersal of gibbers away from wheel tracks.

APPENDIX 3

Defined conditions

The following defined conditions are applicable to all seismic surveys in the Cooper and Eromanga Basins.

Non-land system specific

1. Vehicle access to seismic lines is to be via existing access tracks or pre-existing seismic lines, except where they have rehabilitated. Other temporary access tracks may be utilised where such use is likely to result in less environmental impact than other options.
2. All seismic crew personnel are to be given adequate environmental briefing and to be provided with appropriate documentation.
3. No cultural sites are to be disturbed by seismic operations.
4. All rare and endangered fauna and flora species and communities are to be avoided.
5. Any artesian water flow resulting from uphole or shothole drilling must be plugged immediately.
6. No unnecessary interference is to occur with natural drainage or topographic features.
7. All seismic lines are to be disguised from existing access tracks to minimise third party access.
8. Seismic sources are not to operate within 20 m of any pipeline, utility, installation or building. This distance may need to be larger for explosive-sources pending size of explosive used.
9. No mature trees are to be removed.

Land system specific

1. There is to be no blading or removal of gibber mantle on gibber plains or tablelands.
2. Cuts into clay-rich sand dunes are to be <1 m deep, prepared to minimise erosion and visual impact, and rehabilitated where necessary.
3. Line preparation along tablelands and escarpments must avoid erosion and visual impact.
4. There is to be no blading with earth moving equipment in terrains which are naturally conducive to vehicular access, such as clay pans, dry lake beds etc.
5. Sand dune crest cuts are to be offset along the length of the seismic line to minimise visibility.
6. Salt lakes and areas subject to inundation must be carefully assessed for their conduciveness to support seismic vehicles prior to any such access.
7. Dune crest cuts are to be <4 m deep.
8. Side cuts on sand dunes are to be <3 m deep.
9. Extensive side cuts on dune flanks are to be avoided.

REFERENCES

Australian and New Zealand Environment and Conservation Council, 1996. *National strategy for the conservation of Australia's biological diversity*. Department of the Environment, Sport and Territories, Canberra.

Buckley, R., 1985. *Preventative and restorative techniques for reducing environmental impact of arid-zone geophysical exploration tracks*. Prepared for Comalco Aluminium Ltd. Amdel Report, 1987. *South Australia. Department of Primary Industries and Resources. Open file Envelope,* 8014 (unpublished).

Cogger, H.G., Cameron, E.E., Sadlier, R.A. and Egglar, P., 1993. The action plan for Australian reptiles. *Australian Nature Conservation Agency. Endangered Species Program, Project 124.*

Ecologically Sustainable Development Steering Committee, 1992. *National strategy for ecologically sustainable development.* Australian Government Publishing Service, Canberra.

Fatchen, T.J. and Woodburn, J.A., 1997. Criteria for the abandonment of seismic lines and well sites in the South Australian portion of the Cooper Basin: Stage 2 — identification and evaluation of assessment criteria. *South Australia. Department of Primary Industries and Resources. Open File,* DME 1994/389 (unpublished).

Fatchen, T.J. and Woodburn, J.A., 1998. Consultancy report for criteria for the abandonment of seismic lines and wellsites in the Cooper Basin. Stage 3 — validation of assessment criteria and methodologies. Interim Report. *South Australia. Department of Primary Industries and Resources. Open File,* DME 1994/389 (unpublished).

Garnett, S., 1992a. The action plan for Australian birds. *Australian National Parks and Wildlife Service. Endangered Species Program, Project 121*.

Garnett, S. (Ed.), 1992b. Threatened and extinct birds of Australia. *Royal Australian Ornithologists Union. Report,* 82.

Gillen, J. and Reid, J., 1988. *The Coongie Lakes study.* Department of Environment and Planning, Adelaide.

Graetz, R.D., 1990. Auditing the codes of environmental practice. *South Australia. Department of Primary Industries and Resources. Confidential File,* DME SR 27/2/86 (unpublished).

Graetz, R.D. and Pech, R.P., 1987. Detecting and monitoring impacts of ecological importance in remote arid lands: a case study in the southern Simpson Desert of South Australia. *Journal of Arid Environments,* 12:269-284.

Kennedy, M., 1992. *Australian endangered marsupials and monotremes: an action plan for their conservation.* IVCN, Gland, Switzerland.

Laws, R.A. and Aust T., 1994. The changing face of government regulation. *APEA Journal,* 34: 845-852.

Lee, A.K., 1995. The action plan for Australian rodents. *Australian Nature Conservation Agency. Endangered Species Program, Project 130.*

Leigh, J.H. and Briggs, J.D. (Eds), 1994. *Threatened Australian plants: overview and case studies.* Australian National Parks and Wildlife Service, Canberra.

Malavazos, M., 1996. Goal attainment scaling: a tool for assessing environmental performance. Paper presented at a workshop on goal attainment scaling, MESA and the Chamber of Mines and Energy, 16 August 1996, Adelaide. *South Australia. Department of Primary Industries and Resources. Open File,* DME 1996/310 (unpublished).

PIRSA Petroleum Group, 1997. Guidelines for determining project environmental significance. Draft. *South Australia. Department of Primary Industries and Resources. Open File,* DME 1996/1 (unpublished).

PIRSA Petroleum Group, 1998. Field guide for the environmental assessment of abandoned petroleum wellsites in the Cooper Basin, South Australia. *South Australia. Department of Primary Industries and Resources. Brochure.*

Sharp, C.A., 1994. Introduction to goal setting and goal attainment scaling: for measuring the achievement of environmental objectives in the petroleum industry. Paper presented at a seminar, MESA and Flinders Institute of Public Policy and

Management, 20 December 1994, Adelaide. *South Australia. Department of Primary Industries and Resources. Confidential File,* DME SR 27/2/150 (unpublished).

Sharp, C.A., 1996. Introduction to goal attainment scaling: assessing environmental performance. Paper presented at a workshop on goal attainment scaling, MESA and the Chamber of Mines and Energy, 16 August 1996, Adelaide. *South Australia. Department of Primary Industries and Resources. Open File,* DME 1996/310 (unpublished).

Sharp, C.A., 1997. A model for environmental performance evaluation. Paper presented at a workshop on goal attainment scaling as a tool for the evaluation of environmental performance, MESA, 5 February, Adelaide. *South Australia. Department of Primary Industries and Resources. Confidential File,* DME SR 27/2/150 (unpublished).

Social and Ecological Assessment Pty Ltd, 1987. *Revegetation of seismic lines in PELs 5 and 6.* Report prepared for Santos Ltd and Delhi Petroleum Pty Ltd. *South Australia. Department of Primary Industries and Resources. Open file Envelope,* 9334 (unpublished).

Social and Ecological Assessment Pty Ltd, 1989. *The impact of seismic lines in gibber land units*. Report prepared for Santos Ltd. *South Australia. Department of Primary Industries and Resources. Open file Envelope,* 9334 (unpublished).

State of the Environment Advisory Council, 1996. *Australia, state of the environment 1996:* a*n independent report presented to the Commonwealth Minister for the Environment.* CSIRO Publishing, Collingwood, Victoria.

Stoll, J.A.E., 1989. *Environmental management of mining in South Australia*. Nature Conservation Society of South Australia, Adelaide.

Stone, M., 1984. A study of the effect of seismic surveys on the environment with special reference to the Amadeus Basin, Central Australia. *University of Tasmania. MSc thesis* (unpublished).

Wager, R. and Jackson, P., 1993. The action plan for Australian freshwater fishes. *Australian Nature Conservation Agency. Endangered Species Program, Project 147.*

Wiltshire, D. and Schmidt, M., 1997. *Field guide to the common plants of the Cooper Basin, South Australia and Queensland.* 3rd edition. Prepared for Santos Ltd.