BEST PRACTICE
ENVIRONMENTAL
MANAGEMENT
IN MINING

Onshore Minerals and Petroleum Exploration

Environment Australia
Department of the Environment

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Cover Photo: Ironbarks Forest, Stawell, Victoria. Percussion drilling. Low impact exploration practices were developed for exploration of this area with no clearance of vegetation. Photo: Western Mining Corporation Ltd.

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The Environment Protection Agency is an agency of the Australian Federal Environment Department.

FOREWORD

Environment protection is a significant priority for our society. For government, a major role is setting environment standards and ensuring individuals and organisations meet them. Also, government, industry and community organisations are working increasingly as partners in protecting our environment for present and future generations.

Representatives of the mining industry in Australia and the Environment Protection Agency, an agency of the Australian Department of the Environment, have worked together to collect and present information on a variety of topics that illustrate and explain best practice environmental management in Australia's mining industry. This publication is one of a series of modules aimed at assisting all sectors of the mining industry — minerals, coal, oil and gas — to protect the environment and to reduce the impacts of mining by following the principles of ecologically sustainable development.

These modules include examples of current best practice in environmental management in mining from some of the recognised leaders in the Australian industry. They are practical, cost-effective approaches to environment protection that exceed the requirements set by regulation.

Australia's better-performing mining companies have achieved environmental protection of world standard for effectiveness and efficiency — a standard we want to encourage throughout the industry in Australia and internationally.

These best practice modules integrate environmental issues and community concerns through all phases of mining from exploration through construction, operation and eventual closure. The concept of best practice is simply the best way of doing things.

The case studies included in these modules demonstrate how best practice can be applied in diverse environments across Australia, while allowing flexibility for specific sites. They achieve this through including practical techniques, recommendations, guidance and advice from Australia's leading mining practitioners.

I encourage mine managers and environmental officers to take up the challenge to lift performance in environment protection and resource management and to apply the principles in these modules to their mines.

Barry Carbon

Executive Director,
Environment Protection Agency, and Supervising Scientist

EXECUTIVE SUMMARY

Well planned and managed exploration activities should have a minimal environmental impact and restore the site, as much as possible, to its original condition.

Society now demands that our environment be protected. These demands have moved the industry to develop and apply best practice environmental management techniques.

Exploration is an ongoing activity, often occurring several times in one area over many years. No area of land can, therefore, ever be described as fully explored. Economic changes and technological advances necessitate on-going access for scientific assessment of areas for their resource potential.

Best practice environmental management begins with pre-exploration planning and continues until exploration is completed. The program should:

- ensure proper participation of all stakeholders about programs of work and outcomes;
- protect the environment outside exploration areas;
- minimise disturbance and contamination within exploration areas; and
- restore areas after exploration is completed.

These measures will instill more public confidence for exploration activities in the future.

Exploration and evaluation techniques range from the most environmentally benign, such as remote sensing from satellites, to the more invasive, such as close spaced intensive drilling.

Environmental planning and management offer their greatest benefit when preventing, or at least minimising, environmental impacts by:

- promoting environmental awareness within exploration companies;
- educating and training employees and contractors; and
- developing and applying industry codes of practice.

This module discusses potential environmental impacts that can arise during various stages of exploration activities and management of those impacts. Environmental impacts can be minimised through participation of stakeholders, personnel training, selection, use and timing of appropriate equipment.

Effective practical techniques to restore the environment at the completion of exploration activities are also discussed. Case studies are included to demonstrate how the best practice principles have been applied at a number of sites in Australia. An environmental checklist is presented as an appendix to assist people in the field.

There are many published handbooks, environmental guidelines and codes of practice on exploration by the mining and petroleum industry association and governments. These documents are often supplemented by training sessions and induction courses outlining environmental responsibilities for exploration personnel and contractors. Some of these documents are listed in Further Reading.

Best practice environmental management in mining relies on common sense, applying good planning principles, being aware of potential impacts and applying good house keeping practices. Following these practices will also make rehabilitation much easier and allow sustainable land use when exploration is completed. Adopting these practices provides greater public confidence in exploration activities in the future.

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1. INTRODUCTION

1.1 Guiding

Exploration for minerals and petroleum in Australia covers vast tracts of land where geologists search for clues that a commercial prospect might exist. Mostly, it is an information gathering activity covered by an exploration licence.

Such exploration has little or no lasting impact on the environment. However, sometimes exploration has changed the landscape unacceptably, causing problems for long term land users and to the environment.

These days such environmental impacts of all phases of mining are being avoided through best practice environmental management. Such best practice integrates community concerns through consultation. It covers all facets of a mining operation, from the first stages of exploration planning to rehabilitation and land use.

This module identifies the major impacts of mineral and petroleum exploration in Australia and describes best practice methods of avoiding or minimising them. It focuses more on minerals than petroleum exploration, although they both raise similar environmental issues.

1.2 Purpose of Exploration

Not all exploration aims to produce commercial prospects. Government and academic agencies often conduct exploration or surveys to collect information for mapping, for planning future land uses, investigating water resources, or increasing knowledge of natural processes, such as the understanding of saline groundwater systems and naturally acidic soils and rock types.

However, most activity and environmental impacts result from individual prospectors, prospecting syndicates, and small and large companies looking for commercial orebodies or petroleum reserves. Exploration is a continuous process. As existing mines and oil and gas fields become exhausted more resources must be found.

Prospecting today relies on sophisticated instruments to aid mineral exploration because visible, near-surface deposits have become rarer. New finds are now more often made at some depth below the surface using increasingly sophisticated scientific techniques.

In the 1960s Canadian researchers found that, to produce a commercial mine, around a thousand mineral prospects are investigated of which only a hundred are drilled for reconnaissance and only ten progress to intensive drilling. Modern exploration may have altered the ratios but not by much. Such figures highlight the high commercial risk and low success rate of exploration throughout the world.

Exploration is a dynamic and evolving process influenced by changing geological concepts, by new technologies (of mineral use and of exploration methods) and by economics. Changing resource prices and extraction methods mean that an uneconomic prospect today may become commercially viable in the future. Hence, over decades or even centuries in a highly mineralised provenance, exploration may be repeated many times.

The **Kanowna Belle** gold discovery within the old Kanowna Goldfield near Kalgoorlie, WA, is one of Australia's largest recent gold discoveries. It was made using modern geochemical technology to identify drilling targets in an area mined earlier this century. In the gold rush days coarse gold was visible on the surface of commercial deposits. This latest find would not have been made if the area was not re-explored using modern methods.

Similar re-exploration discoveries in Australia include the **Argyle diamond mine** (WA), the **Olympic Dam copper/gold/ uranium mine** (SA), the **Northparkes base metal mine** (NSW) and the **Century lead/zinc deposit** (Qld).

The **Girilambone copper mine** (NSW) is an example of applying new low cost extraction technology to make a known deposit economically viable.

1.3 Environmental Management Issues

The minerals and petroleum industries must show, particularly to local communities and land users, that exploration will have little or no impact on the environment. This requires environmental planning and management to produce exploration programs that:

- involve affected communities in developing work programs and determining outcomes;
- protect the environment outside exploration areas;
- avoid or minimise disturbance and contamination within exploration areas; and
- restore areas after exploration.

In the past some exploration caused long-term impacts. Aeroplane passengers crossing Australia's arid outback may see thin straight lines, running for many kilometres. This is the result of past seismic exploration when bulldozers scraped away the surface soil to prepare for lined series of explosive charges to determine the underlying rock structures. As well as their visual impact these tracks have caused erosion, allowed access by people to these previously hard to reach locations and helped the spread of feral animals, such as camels, horses and donkeys.

Exploration methods have now changed. Past practices are no longer acceptable. The module sets out best practice approaches to avoid or minimise environmental impacts at all stages of exploration.

Adverse impacts can result from both poor management practices and exploration activities as outlined below.

Poor management practices include:

- failure to fill or make safe trenches (costeans) dug to sample soil layers;

- unnecessary or excessive clearing of local vegetation prior to exploration activity;
- inadequate controls on fuel or fluids used in drilling;
- failure to cap and make safe drill holes;
- unnecessary cutting of access tracks; and
- allowing transport of weeds or other exotic species and plant diseases between regions.

Impacts from exploration activities include:

- machinery noise;
- dust;
- land and waterway disturbance from exploration camps;
- disturbance of fauna;
- disturbance of areas significant to Aboriginal and other cultures; and
- disruption to other land users, such as farmers, pastoralists or Aboriginal communities, impacting on crops, stock or other traditional landuse.

Anything less than best practice exploration activities could produce enduring reminders of disturbance, either physically etched into the landscape or in the minds of other land users. Unacceptable impacts can lead to costly litigation, unfavourable publicity and possible failure of future mining proposals.

1.4 Consultation with Stakeholders

These days the Australian minerals and petroleum industries rely increasingly on the significant environmental knowledge of local people in planning and carrying out an exploration program.

Local residents, farm or pastoral property owners and occupiers, local authorities and Aboriginal groups all have information that can help avoid or minimise local and regional environmental impacts of exploration. There may also be social and economic issues that must be addressed before a program can begin. As part of the community, exploration companies share responsibility for protecting all aspects of the local and wider environment, not just while exploration is carried out, but also for the future. Such a realisation ensures entire community involvement from the beginning and throughout any exploration program, that is, from initial planning to the eventual return of the land to its original or another agreed use.

Under Australian law, some aspects of mining exploration must be discussed with parties likely to be affected. However, current community expectations would require at least this level of consultation for all aspects.

It makes good business sense for exploration companies to become part of the local and wider community so that they can develop common goals for any proposed operation.

To produce the best results for everyone, the company must sit down with all affected parties throughout all stages of the project — ideally from initial exploration and, as the project develops, through evaluation, construction, operation and post-operation phases.

Community consultation and involvement aspects are discussed in a separate module in this series on *Community Consultation and Involvement*.

Talking by all stakeholders from the beginning allows the project to be community-centred rather than project-centred. This means that the project is developed by the whole community, with every one participating willingly.

The main components of best practice exploration are summarised in Placer Exploration Limited's Environmental Policy which states that the company "is committed to responsible environmental behaviour during mineral exploration.

The company will:

- strive to protect the natural and social environments within which exploration is to be conducted;
- respect the rights, cultural beliefs and relevant concerns of all parties having a legitimate interest in land proposed for exploration;
- comply with all legal requirements in force in all countries and states where exploration is occurring;
- minimise the impacts of exploration wherever possible, consistent with economic and other constraints;
- apply the best practical methods known and available to the company during mineral exploration;
- consult with land users, owners, lessees and with government authorities so that statutory and other requirements are known and to encourage two-way communication;
- rehabilitate land affected by mineral exploration with the goal of returning it to its pre-exploration land use;
- monitor exploration impacts so that less impacting methods can be found and will monitor rehabilitation to ensure its long -term success; and
- train and otherwise assist its employees to achieve the above environmental goals."

2. STAGES OF EXPLORATION

2.1 Exploration Methods

Commercial petroleum deposits and ore bodies can be found in various sizes, shapes or concentrations in a range of locations. Once various minerals have been targeted, exploration usually follows a pattern of staged assessment, involving both non-intrusive and intrusive methods.

A national or regional program may use a variety of techniques that focus on smaller and smaller areas. At each stage the target area decreases while exploration intensity increases, resulting in greater impact on the immediate environment.

Consequently, the techniques used follow a sequence of increasing environmental impact. Some or all of the following are used:

- remote sensing — analysis of satellite imagery;
- remote sensing — airborne geophysics and aerial photography;
- surface geological mapping;
- surface geochemical surveys — soil, rock chip or drainage system;
- surface geophysical surveys;
- reconnaissance drilling;
- target drilling;
- infill drilling;
- track and costean (trench) cutting;
- camp construction;
- construction of shafts or declines; and
- bulk sampling and trial mining.

2.2 Reconnaissance/Area Selection Stage

Before beginning physical exploration, companies often identify broad areas of interest from their knowledge of ore forming processes and geology. This is known as reconnaissance/area selection, the first stage in a process which generally has little impact, if any. This may then be followed up by:

- remote sensing, including the study of satellite imagery, high level aerial photography and airborne geophysical data — non-intrusive methods also capable of indicating the potential for sub-surface deposits;
- geochemical data-gathering through helicopter-based drainage surveys;
- ground follow-up with reconnaissance level geological mapping, surface geochemistry and surface geophysics.

2.3 Target Selection Stage

Reconnaissance exploration will usually identify specific targets areas for closer exploration. The number of target areas frequently reduces by 50 per cent or more, once specific targets are identified.

While this stage may be dominated by more detailed geological mapping and geophysical surveys, effective geochemical sampling may require a lightweight vehicle-mounted rig such as a rotary air blast drilling system (RAB). The prime purpose of RAB drilling is to recover material that is representative of the bedrock (eg. weathered, but in situ rock or representative soil). RAB drilling is particularly suitable in well developed weathered profile areas during advanced exploration programs to a depth of about 50 metres. For the target selection stage use of RAB is usually limited to a 10 metre depth.

Representative samples may be collected on site (eg 1-2 kg for many metalliferous deposits), or bulk samples (eg 10-50 kg) taken and split/processed at a later stage. Sample intervals usually range from 0.5 to 2.0 metres, or grab samples may suffice. Drill hole density will depend on the geological nature of the prospect, the surrounding drainage pattern, how advanced the target selection process is, and what other techniques have been applied. When properly managed, the overall environmental impact of this target selection stage is minimal.

Increased environmental impacts at the end of this stage result from drilling to verify earlier geophysical and geochemical clues for minerals. Much of this early testing will use existing access tracks. A small, temporary base camp may be needed.

2.4 Target Testing — Evaluation Stage

When significant minerals have been detected, more intensive study is conducted. Very few prospects, perhaps one in a hundred, reach this stage.

Target testing involves more detailed geophysics and, possibly, geochemistry for which trenches (known as costeans) may be dug to expose bedrock for detailed mapping and sampling. The trenches, depending on size, are excavated with machinery ranging from hand tools to a back-hoe or a bulldozer.

This stage includes drilling, often with multiple, heavy mobile drilling rigs, requiring a more substantial base camp and, in some cases, an airstrip.

If this evaluation stage reveals significant minerals, bulk sampling may be needed. This can be done by a trial pit, or through sinking shafts and/or driving decline tunnels deep into the target. Such sampling is expensive and usually requires additional licence approvals.

Impacts at this stage can be considerable and need careful management.

Modern practice aims to avoid or minimise local impacts during the reconnaissance/exploration stage.

- The petroleum exploration industry no longer cuts seismic lines with bulldozers, instead compacting the surface with rollers before using vibrating machinery in place of explosives.
- Where possible, explorers use helicopters to fly in lightweight drill rigs and supplies.
- Low-pressure-tyred mobile rigs reduce the impact on the surface and on vegetation in arid areas.

These practices either eliminate or reduce impacts to the point where post-exploration landscapes are soon indistinguishable from pre-exploration.

2.5 The Overall Program

Some exploration programs may not follow such set stages. Even when they do there is likely to be a gradual transition from one stage to another. Often, different stages will occur concurrently in different parts of the same exploration area.

Environmental impacts of these activities vary from nil through minimal to significant *(see Table 1)*. As most exploration does not result in mining, the effects are likely to be short term, provided that the site is rehabilitated. The important issues are the extent and intensity of the impacts and the degree to which they can be remedied.

Even if exploration does not result in the discovery of an orebody, minimising impacts will be recognised. This is important for maintaining good community relations and should reduce community opposition to future exploration.

In general, avoiding or fixing exploration impacts results in better company performance and is a minor component of exploration costs.

Table 1 The Potential Environmental Impacts of Various Exploration Activities - White (1993)

Environmental Impacts								
Exploration activity	**Disturbance**				**Pollution**			
	Soil	**Vegetation**	**Fauna**	**Heritage**	**Ground**	**Water**	**Air**	**Noise**
Airborne surveys	Z	Z	L	Z	Z	Z	L	L
Reconnaissance geophysics/Geochem	L	L	L	L	L	L	L	L
Geo-physics	L	L	L	L	L	L	L	L
Survey gridding	L	M	L	L	L	L	L	L
Scout drilling (existing tracks)	L	M	L	L	L	L	L	M
Track construction	M	M	M	L	L	L	L	M
Target drilling	M	M	M	L	L	M	L	M
Pattern drilling	H	H	M	M	M	M/H	L	M/H
Camp construction	H	H	H	L	L	M	L	M
Costeaning	H	H	H	L	M	M	L	M
Shaft/decline construction	H	H	M/H	M	M	M	M	M/H

Z = zero to negligible L = ow (minimal) potential M = medium potential H = high potential

3. MANAGEMENT OF ENVIRONMENTAL EFFECTS

3.1 Planning

Good environmental planning and management minimises or avoids environmental impacts. It reduces overall costs through avoiding costly environmental damage and resulting remedial works. It includes:

- **Cultural change within exploration companies**
- Increased environmental awareness and sensitivity is part of a culture change in exploration companies. Given the low probability that any prospect will lead to commercial mining, all exploration should minimise environmental impacts.
- **Education of employees and contractors**
- Education is a most important element in environmental management. Contractors and employees must understand and carry out corporate environmental policy, practices and objectives. They must be educated to care for the environment, both physical and social. In areas where cultural sensitivities are important this would include cross-cultural awareness programs.
- **Development of industry codes of practice**
- Exploration teams in all States and Territories throughout Australia should follow codes of practice established by government, industry associations or, increasingly, by individual companies. These address environmental management practices as well as procedures for dealing with local communities and others with interests in land targeted for exploration. Some of the examples of government, industry association and company guidelines and codes of practice for environmental management and for community consultation are listed in Further Reading.

In general, best practice environmental management during exploration relies on common sense, awareness of potential impacts and good housekeeping practices.

While operational detail will vary according to location, season and climate, the following principles should be followed:

- **movement of vehicles** in wet weather should be avoided to minimise damage to tracks and other areas, thus avoiding erosion problems later;
- **common terrain or vegetation types** should be favoured for access and physical activity because they will be generally of lower conservation value and less sensitive to disturbance;
- **natural, biological or cultural features** likely to be affected by proposed mining should be identified during exploration planning; [If they are believed to exist in a planned exploration area then appropriate impact avoidance and minimisation procedures should be incorporated into the exploration program. (An example of this is provided in Case Study 7A, KCC in the module *Planning a Workforce Environmental Awareness Training Program*.)]
- **timing of access** is also important to limit impact of exploration on migratory birds, breeding times for native fauna and farming activities like cropping, mustering, lambing and calving.

Seasonal factors may dictate when noisy activities such as drilling can take place, particularly near watercourses. Due notice of weather conditions should be paramount when considering track construction.

Cadia copper/gold project in central NSW is one of the largest gold mines in Australia. Operated by Newcrest Mining Limited it is in an area with a rich mining heritage. It includes remnants of stone buildings constructed by Cornish miners in the 19th century as part of the mine infrastructure. One such building, a stone engine house, has a Permanent Conservation Order. Newcrest has funded restoration of the derelict building and will convert it into a visitors centre.

3.2 Minimising Disturbance

Access:

The first priority in any exploration program for both environmental and cost advantage is to use existing tracks as far as practicable.

Grid lines on which to conduct geological, geochemical and geophysical surveys are now rarely bulldozed or cleared but simply marked by wooden pegs and/or biodegradable flagging tape. In heavily wooded areas, these grid lines may need to have lines of sight established by cutting vegetation, but no trees should be felled and there should be little soil disturbance.

Today, many companies no longer clear tracks or drill pads, but drive over the vegetation to visit sites thus ensuring that, even where plants are crushed, root stocks remain. Trees, particularly old growth trees, should be retained where practicable. Care is needed to ensure that middle or lower storey vegetation is not of more conservation significance than the trees.

Seismic lines for petroleum exploration in gibber (stony) country are now established using rollers to compress the gibber instead of constructing an access track. This provides reasonable pad contact with the surface, the soil structure remains intact and, over time, the original surface profile re-emerges.

Santos Ltd's Code of Environmental Practice, published in April 1991, states that "as far as practicable, seismic lines should be concealed and rendered inaccessible to the public when they cross public roads or tracks, lead to environmentally sensitive areas and/or provide access to livestock watering places, water bores or private property."

On salt lakes and pans, trikes, all terrain vehicles and vibrosis trucks now use balloon tyres, producing much less impact than conventional four wheel drive vehicles.

If tracks must be constructed, field visits and advance planning will minimise environmental disturbance by:

- positioning tracks along ridge tops or on the bottom slopes some distance from watercourses
- rolling, or clearing with a grader/dozer blade set 300 mm above ground level;

- avoiding clear visibility from existing tracks or highways (by incorporating a dog-leg soon after entry) and by construction to no greater a standard than is required by the exploration program.

Tracks should be designed and sited to minimise likely recreational vehicle use. Broadly curving tracks create less visible impact at ground level than straight tracks and travel speeds are lowered, reducing dust generation.

In some areas, using excavators rather than bulldozers may reduce construction impact.

Self-repair of arid lands is relatively rapid if damage to the vegetative cover and topsoil layer is minimised. Where vegetation and topsoil must be removed, the minimum area possible should be cleared and the materials stored for later use in track rehabilitation.

Any soil or traffic movement may spread noxious weeds, so equipment must be carefully cleaned before entering a new area. Specific areas may need special attention, for example to avoid the spread of the die back root pathogen *Phytophthora cinnamomi* which kills many native species. In such areas all equipment should be carefully high pressure spray cleaned and, possibly, disinfected with sodium hypochlorite or ABF-42 (a poly-quaternary micro-biocide). Runoff from these washings must be contained in a sump and detoxified as these disinfecting agents are toxic to fish and water organisms.

Correct treatment should be discussed with local authorities.

Drilling:

This is usually the most intrusive aspect of exploration. The three basic techniques — rotary air blast, reverse circulation and diamond drilling — have similar environmental effects, differing mainly in access requirements and extent of ground compaction.

Manoeuvrability and productivity of drilling rigs are continually improving thus reducing site impacts. Some rigs are now much lighter, reducing ground compaction and enabling transport by helicopter in difficult terrain or fragile environments.

Mounting on low ground pressure, tracked or large-tyred vehicles is a growing trend.

Increased efficiency means less time on a site. Soil compaction is reduced through drilling during dry seasons. Minimising topsoil removal from drill sites and access tracks reduces overall impact.

Where topsoil has to be removed it should be stored nearby in low mounds together with any plant litter. Topsoil should be returned as soon as possible (preferably within 6 months) to maintain seed viability and microbial activity. If drilling sumps are required then soil and sub-soil should be stockpiled separately and replaced in the reverse order to its excavation.

More details are provided in the module on *Rehabilitation and Revegetation* in this series.

Some vegetation may be cleared to reduce bushfire hazard. Also, all drill rigs should have knapsack sprays, fire extinguishers and efficient exhaust pipes fitted with spark-arresters. Catalytic converters fitted to unleaded fuel vehicles operate at high temperatures. Driving these vehicles in long dry grass should be avoided to reduce the chance of fire.

Exploration drilling can cause significant ground and water pollution. A major concern is encountering substantial quantities of water. If the water is saline, particular care is required to contain it (in tanks or a dam if necessary) to avoid contact with vegetation. Even where there is good quality water, care will be necessary in arid areas to avoid waterlogging of drought resistant vegetation. However, good quality water is a valuable resource and often arrangements are made with the landholder to case the hole and install a pump. Where water quality and the environment supports the need for off-site release, removal of suspended material using settling sumps and filters, such as straw bales, will assist in protecting natural watercourses.

Diamond drilling, in particular, requires sumps to contain drilling fluid and to act as settling chambers for the ground rock produced in the process. These sumps should always be placed downslope of the drill rig to ensure all site run-off drains into the sump. Depending on the geology and/or the need for drilling additives, it may be necessary to line sumps with plastic sheeting. In particularly sensitive areas, portable above-ground tanks may be preferred. These drilling fluids are reused and recycled. After use, they are generally left to dry out and then buried. Increasingly, biodegradable drilling additives are used.

Often the greatest environmental threat in a drilling campaign is the transport and storage of fuel and lubricants. Australian Standard 1940-1993 (the storage and handling of flammable and combustible liquids) should be applied, by isolating fuels and oils in impervious secondary containment to control any spillage. Refuelling of vehicles away from drainage lines, using automatic shut-off delivery nozzles, minimises the chance of spills. Where equipment is maintained in the field all fuel, oils and other lubricants are to be contained and correctly disposed of off-site (following consultation with the local authorities).

Larger scale oil and gas drilling requires specialised heavy duty equipment because the resource is usually significantly deeper than most mineral reserves and is often under considerable pressure. Special blow out preventers are thus an important feature of all petroleum drilling rigs. Well casings prevent petroleum hydrocarbons in the pay zone of an oil producing well from intruding into aquifers and other strata both during and after drilling.

Petroleum drilling usually requires a large sump for drill fluids, a dam for water, a camp and a burn pit for any waste oil produced. Such areas are fenced off and the contents are allowed to evaporate. The sump is then filled and rehabilitated. Unsuccessful holes are plugged with cement; successful holes are completed with a 'Christmas tree' arrangement of valves and regulators for later use as production wells.

Costeans:

Costeaning (trenching) is another intrusive exploration activity used to evaluate a deposit. Impact is minimised by costeaning across, rather than down, the slope, by having sloping ends to allow animals to escape if they fall into them and by promptly refilling and revegetating them after sampling.

Camps:

For an extended drilling program, any fuel storage at campsites should be located to minimise environmental disturbance. Natural clearings alongside existing access tracks and away from watercourses can be used to minimise impacts. All rubbish should be taken off site or effectively buried. Waste waters from kitchens and showering facilities should be directed to earth drains designed to prevent discharge.

Toilet facilities should consist of drill holes or chemical systems — the contents of which should be disposed of off site. Any necessary pits should be covered with at least a metre of fill. It should be routine practice to use gas for cooking rather than wood from around the camp, as both living and dead timber is important to a healthy ecosystem.

Natural Drainage Patterns

Unless stream sediment geochemistry or geological mapping is involved, it is standard practice not to explore close to natural drainage lines, whether ephemeral or permanent. In particular, refuelling or maintenance of equipment should be avoided in these areas. If tracks are built, disturbance to watercourses and riparian vegetation should be avoided.

In arid areas, drainage may occur by sheet flow rather than channel flow. Mulga plant communities may depend on this method of water replenishment. In these terrains it is essential to build sufficient culverts or provide channel ways across tracks to restore the sheet flow conditions as rapidly as possible. If tracks are created by clearing, care is needed to avoid windrows on the margins, as these will interrupt the overland flow of water, channelling flow along their margins to cause erosion. Similarly, built up sections of track should include culverts to lessen interference with sheet or channel flow of water.

In sloping terrain, cross drains discharging into table/spur drains may be required on tracks to avoid scouring from run-off waters. In some places the cross drains may require rip-rap and/or silt traps.

Cannington Project

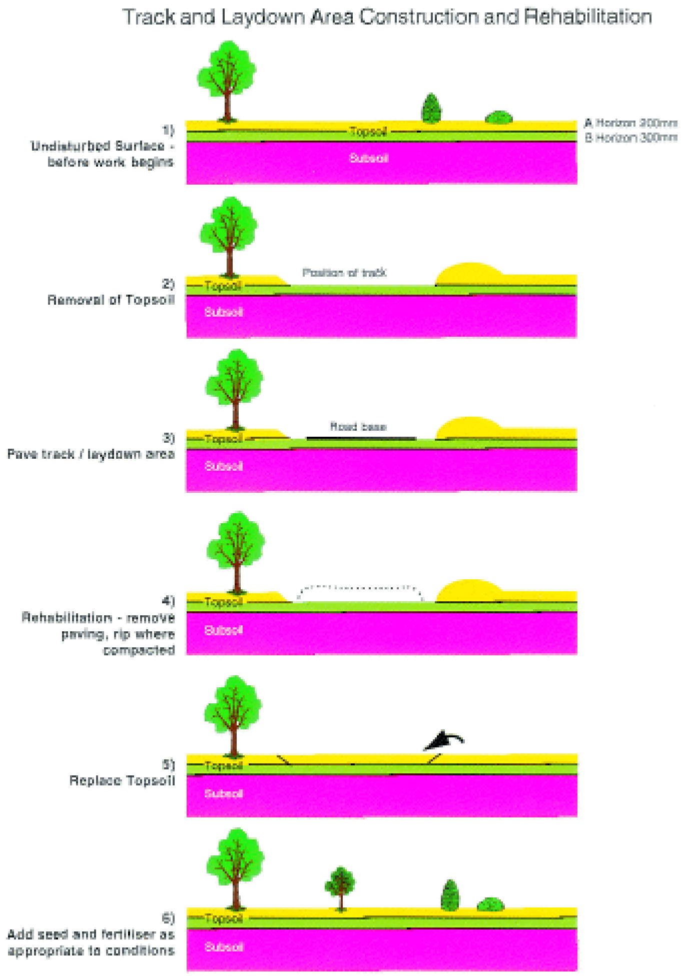

Figure 1 Used with permission: BHP World Minerals

Topsoil & excavated materials manage-ment. The regimen followed for removal, selective handling, storage and replacement of excavated materials from the surface soils down is governed by geochemical classification and management recommendations.

This calls firstly for careful removal of the "A" and "B" horizon topsoil to a depth of 500mm. The 200mm "A" horizon contains a viable seed source, organic matter and nutrients. The 300mm "B" horizon is also suitable for rehabilitation. Deeper materials are excavated, selectively stockpiled and replaced following procedures based on the management recommendations.

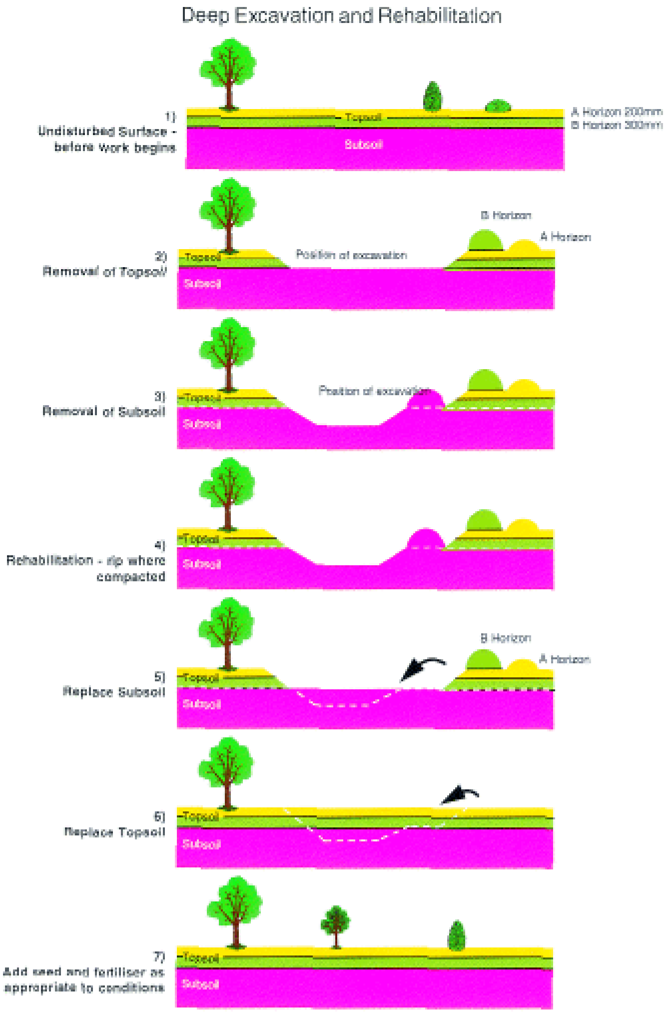

Figure 2 Used with permission: BHP World Minerals

3.3 Personnel Training

Careful planning and project design can be rapidly undone in the field if company personnel and contractors do not follow best practice environmental management.

All staff and contractors need basic environmental management training as well as specific training for particular exploration areas. Issues covered should include:

- regulations applying to the area, including specific conditions on the exploration title document;
- work practices that avoid or minimise impacts — particularly for operators of machinery such as graders and dozers;
- handling of rubbish and waste water at camp sites;
- landowner or manager sensitivities, including Aboriginal communities and their specific cultural requirements;
- minimising impacts in environmentally sensitive areas, particularly on special precautions with soil pathogens, weeds etc.;

- procedures for handling any culturally or archaeologically sensitive material that may be discovered; and
- rules about alcohol, keeping of pets, use of vehicles off-road, hunting and fishing.

These sessions should be backed up with training manuals and brochures to ensure that up-to-date information on best practice is always available to employees and contractors.

Rehabilitation must employ the most effective techniques to return the environment as soon as possible to its former condition or to a stable, sustainable and agreed land use. Limiting water and wind erosion is essential.

4. REHABILITATION

4.1 Non-Intrusive Exploration

Geological mapping, geochemical sampling, airborne geophysics and ground-based gravity and magnetic surveys leave behind little if any impact. Seismic, resistivity, induced polarisation and electromagnetic surveys all require cable arrays and pits/probes to ensure contact with the ground. Aluminium foil is often used to line the small pits. Rehabilitation after these geophysical surveys requires: retrieving cables carefully to avoid vegetation damage; collecting aluminium foil; and replacing soil in the pits, in the reverse order to which it was extracted. As pits would be dug where little vegetation exists (except perhaps low grasses) impacts of these surveys is also minimal.

Wooden pegs and biodegradable tape used to mark survey lines should be removed wherever possible. Where metal pegs have been used, they should be removed to reduce injury to animals.

4.2 Access Tracks

Tracks no longer required by the landowner, occupier or land manager should be rehabilitated to prevent entry by other people, to prevent erosion and to assist in revegetation. Revegetation is the most important factor in ensuring soil stability.

For cleared tracks, campsites or other areas where constant use has caused compaction, the ground may be deep ripped by bulldozer or excavator, or shallow-ripped using grader tines or an agricultural harrow pulled by a four wheel drive vehicle to prepare it for either natural regeneration from surrounding seedstock, or for direct seeding.

In areas where natural regeneration is already occurring, small excavators fitted with extended ripper bars are valuable in protecting regrowth. Their manoeuvrability makes them the preferred equipment for contour ripping on slopes. Whatever equipment is used, ripping should be rigidly confined to compacted areas, to maximise the protection of existing vegetation and minimise disturbed ground that is often preferentially colonised by weed species. For example, on minor tracks where vegetation still exists between wheel tracks, tines can be removed to protect this central area.

Santos Ltd's Code of Environmental Practice, Drilling and Workover, published in April 1991, states that where provision of a new access track is unavoidable it should be constructed in a manner best designed to include erosion control structures, such as spur drains and contour banks etc.

These structures are detailed in Figures 3 and 4.

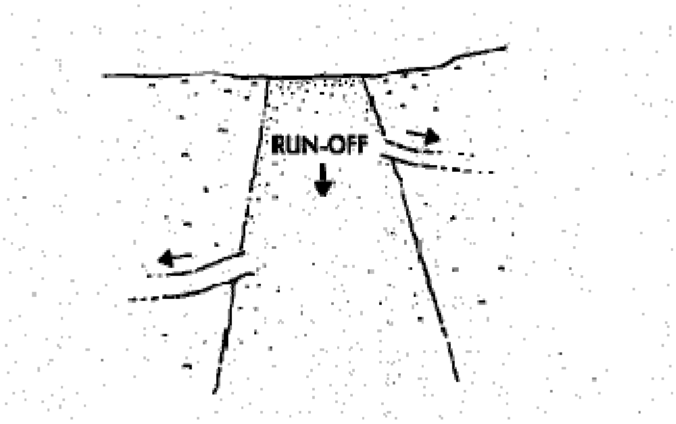

Figure 3 Example of spur drains
Figure: After Santos, 1991

New access tracks should be constructed to include erosion control devices such as spur drains and contour banks.

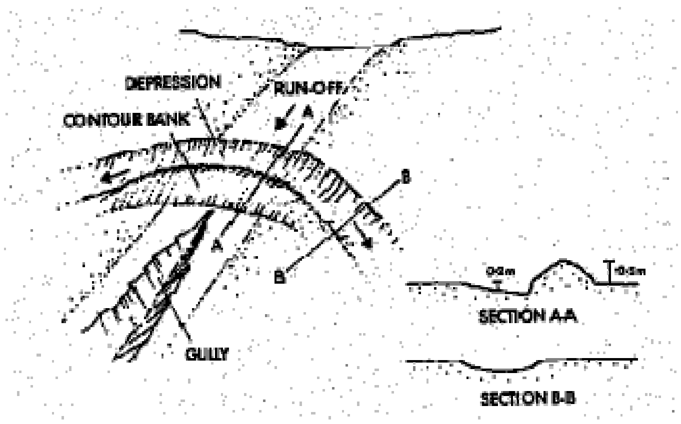

Figure 4 Example of erosion control structure on eroded track
Figure: After Santos, 1991

4.3 Drilling

Remove and dispose of offsite all soils contaminated with hydrocarbons or drill fluids after treatment. Any drill samples not removed from site or returned down holes should be blended in with topsoil at this final ripping stage. Plastic bags should not be used for samples. If plastic bags are used, they must be disposed of offsite after removal of samples.

Until recently, drillholes were left as they were completed, often with PVC casing protruding from the ground. PVC casing breaks down in sunlight, becoming very brittle, and, once broken, becomes an injury hazard for larger wildlife. The hole itself may also be a death trap for smaller animals. Erosion around old drill collars, particularly on tracks, can lead to further damage as vehicles tend to drive into the bush to avoid the developing holes.

Today, best practice means that all holes are capped below ground level. Capping can be done by using plastic, concrete or other materials to prevent erosion and animal injury or entrapment. However, buried plastic caps may crack under vehicle pressure and steel may rust rapidly in many parts of Australia so concrete capping is the preferred method.

The environmental officer at Western Mining Corporation's nickel operation at Kambalda in Western Australia solved this problem by developing a simple, low-cost concrete plug which is long lasting, inexpensive and easy to install (and remove if necessary). Moulded in a 250 mm plastic funnel, the plug incorporates a length of recycled 13 mm polypipe, which provides an above ground marker, and an aluminium tag for identification set into the top surface. This is illustrated in Figure 6.

If groundwater has been encountered, sealing of the entire hole, or sections of it, may be necessary to prevent pollution of groundwater through connection of different quality aquifers. Sealing also prevents artesian flows from being wasted and allows pre-drilling hydrostatic conditions to be maintained in confined aquifer conditions.

Detailed guidelines covering this specialist area have been produced by the Victorian Department of Energy and Minerals (see Further Reading). In areas where the groundwater supply is limited minimise its use.

In farming areas it may be a condition of exploration that any water discovered from drilling is reported to the land owner or occupier. In some cases these holes could become water bores.

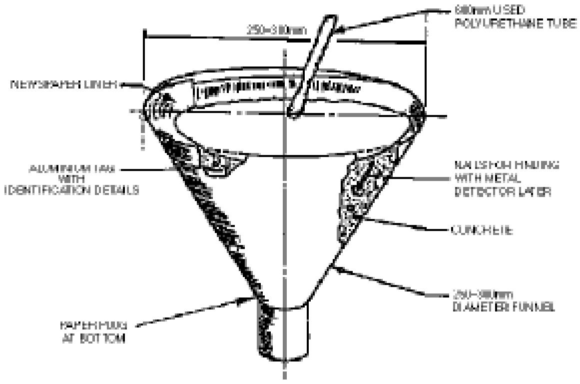

Figure 5 Right method of moulding concrete plug
Figure: After Chamber of Mines and Energy, W.A., 1995.

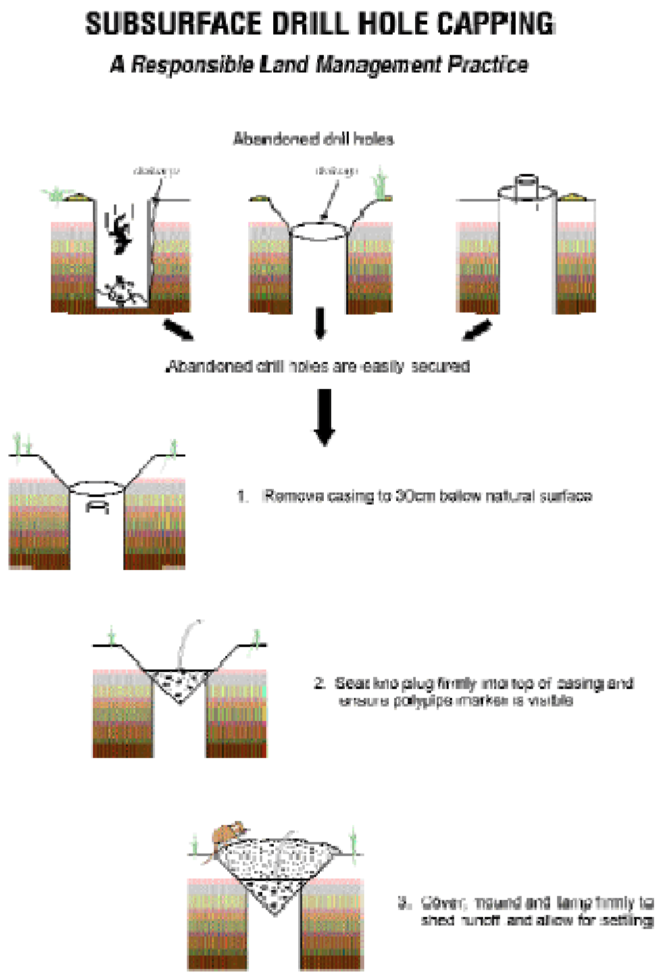

Figure 6 Western Mining Corporation capping device, Kambalda Nickel operation.
Figure: Western Mining Corporation

4.4 Revegetation

Where topsoil has been removed and stored for six months or more, seed viability and microbial activity may be diminished. Upon re-spreading it may need supplementary seeding and fertilising. However, in most cases narrow track development and small drill sites allow the surrounding vegetation to provide sufficient seed for natural regeneration, provided that the surface is rough and seeds are able to lodge and germinate.

With good housekeeping during exploration followed by simple replacement of topsoil, harrowing and ripping of any compacted areas, most disturbed areas can be restored to their natural condition within two years of the time of last disturbance — even in fragile desert environments. More details are provided in the module on *Rehabilitation and Revegetation* in this series.

Revegetation in agricultural areas rarely goes beyond restoration of land to grazing pasture, if that was its prior use. In crop areas, it is more usual to compensate the farmer for any lost crops. Preferably, operations should be conducted outside the cropping period.

When rehabilitation is complete, best practice includes a periodic inspection schedule to ensure that erosion control, weed control and revegetation work has been successful. Inspection timing and frequency will depend on the terrain and climate. If rehabilitation has not been successful it should be repeated and documented to assist field teams in the future.

CONCLUSION

If exploration is going to be a low-impact activity, responsibility rests primarily with the operators' willingness to adopt an environmental ethos from their earliest exploration planning. They need then to apply this culture to policies, procedures and, most importantly, to employee and contractor training. Best practice requires general environmental management training for company personnel and contractors and specific education on the needs of the area being explored. This encourages low-impact, temporary activity affecting small areas for short periods.

As exploration may be a recurrent activity in an area, it is essential that the industry minimises the environmental impact of every exploration program. Indeed, for exploration to be successful there must be no lasting environmental impact when locating an economic orebody or petroleum reserve. Such an environmental outcome is an essential requirement to being allowed back into an area and building public confidence to allow exploration.

With exploration technology improving, the surface disturbance will be continually minimised. Drilling will become necessary only when there are good indications of a potential orebody.

The ideal, but presently unattainable, situation is for only those areas containing an economic orebody or energy reserves to be physically disturbed by exploration. New technology is moving towards this ideal through non-intrusive sensing methods, resulting in decreased environmental impact.

Continued improvement in geophysical and geochemical techniques to see through cover material will reduce the need for drilling to determine bedrock conditions. Lighter, more compact and more efficient drills, together with a considerably increased environmental awareness, will reduce the impact of exploration activities.

Best practice environmental management during exploration requires all participants to develop and apply an environmental culture. It means a commitment by all to improve continuously the way we do things.

This module sets out a range of environmental management practices that are easily applied to avoid or minimise environmental impacts.

FURTHER READING

Allan, J. & Kristensen, S. 1991. 'Exploration in a Biologically Sensitive Area', in *Australian Mining Industry Council Environmental Workshop Proceedings* vol. II pp. 109—120.

Australian Mining Industry Council, *Mine Rehabilitation Handbook.*

Australian Standards Association, *Australian Standard 1940—1993 The Storage and Handling of Flammable and Combustible Liquids.*

Chamber of Mines and Energy, W.A., Department of Mines and Energy, W.A., Environmental Protection Authority, W.A., Department of Conservation and Land Management, W.A., Australian Mining Industry Council, *Making the Grade — A New Approach to Exploration*, video and booklet.

Department of Energy and Minerals, Victoria, 'Abandonment of Mineral Drillholes', *Guidelines for Environmental Management in Exploration and Mining*.

Department of Energy and Minerals, Victoria, 'Exploration and Rehabilitation of Exploration Sites', *Guidelines for Environmental Management in Exploration and Mining*.

Department of Minerals and Energy, Queensland, 'Environmentally sound exploration practices, exploration in environmentally sensitive areas and exploration and mining in watercourses' in *Draft Technical Guidelines for Environmental Management for Mining in Queensland.*

Herriman, N. 1991, 'Modern Mineral Exploration Practice' in *CRA Exploration Pty Ltd. and its Environmental Impact*, unpublished report.

Jones, H. 1991, 'Some Environmental Successes and Failures in Exploration' in *Mineral Exploration in an Environmentally Conscious Society*, Australian Institute of Geoscientists Bulletin No. 11. pp. 63—64.

Land Conservation Council of Victoria 1990, *Wilderness Special Investigation Description Report*.

Ringwood, K., Barr, D. & Evans, R. 1991, *Low Impact Exploration — The Deep Lead Flora and Fauna Reserve, Stawell Victoria*, unpublished report.

Santos Ltd. 1991, *Codes of Environmental Practice, Drilling & Workover*.

Tasmanian Department of Mines, *Mineral Exploration Code of Practice.*

White, G. 1993, 'Exploration and the Environment' in *Outlook 93 Conference Proceedings*, pp. 497—501.

Woolard, C. 1991, 'Environmental Management of Exploration Impacts KNO Case Histories' in *Australian Institute of Mining and Metallurgy Regional Conference on Geology, Mining and Metallurgical Practices in the Eastern Goldfields*, Kalgoorlie, Western Australia.

Examples of government, industry association and company guidelines or codes of practice for environmental management and for community consultation include:

- *Mineral Exploration Code of Practice* — published by the Tasmanian Department of Mines.
- *Exploration and Rehabilitation of Exploration Sites — Guidelines for Environmental Management in Exploration and Mining* — published by the Victorian Department of Energy and Minerals

- "Environmentally sound exploration practices, exploration in environmentally sensitive areas and exploration and mining in watercourses" in *Draft Technical Guidelines for Environmental Management for Mining in Queensland* — published by the Queensland Department of Minerals and Energy
- *Code of Conduct for Mineral Exploration in Environmentally Sensitive Areas in the Northern Territory* — a joint publication by the NT Chamber of Mines and Petroleum (Inc), the NT Department of Mines and Energy and the NT Conservation Commission.
- *Landholder-Explorer Procedures* — jointly agreed between the Queensland Mining Council, Farmers' Federation, United Graziers' Association, Canegrowers' Council and Graingrowers' Association.
- *Guidelines for Mineral Exploration in Areas of Aboriginal Interest in Western Australia* — published by the Chamber of Mines and Energy of Western Australia Inc.
- *Code of Conduct for Mineral Exploration, Mining and Processing in Victoria* — published by the Victorian Chamber of Mines.
- *Environmental Handbook for Mineral Exploration Activities in SA* — published by the SA Department of Mines and Energy.
- Santos Ltd — various publications including *Dozer Manual, Archaeology Procedures Manual and Codes of Environmental Practice for Drilling; Seismic and Production*. Field handbooks to assist personnel to understand better the environment in which they work have also been produced by Santos.

Appendix A

Placer Exploration Limited

Environmental Checklist for Exploration Areas

How to Use this Checklist

Once an area has been selected for on-the-ground mineral exploration, three phases of activity take place:-

*pre-exploration planning and preparation

* implementation of the exploration program, and

* post-exploration clean-up and assessment.

At the initial planning stage for each exploration program, go through all sections of this Checklist to make sure that you have taken everything possible into consideration.

At several stages during the exploration program, consult this checklist to ensure that bad practices have not crept in to the daily routines.

Every State of Australia and each country in South-east Asia has different requirements for environmental protection during exploration. Hold discussions with relevant authorities and obtain relevant Guidelines or Codes from mining industry associations or chambers.

At all times, the responsibility lies with **you**, as Placer's representative, to ensure that guidelines are followed and standards maintained. Placer's longer term future in the exploration area may depend on how well you satisfy its environmental responsibilities.

This checklist should be filled in for each separate exploration program in a new area or when the period of time between programs on the same area of ground exceeds 12 months.

Forward a photocopy of the completed checklist to your regional office and retain this original in the appropriate file for the project.

NAME OF PROJECT MANAGER ____________________

NAME OF FIELD COORDINATOR ____________________

EXPLORATION PROJECT NAME ____________________

PRE-EXPLORATION

Coordination Have you:	YES	NO	ACTION BY
1. selected the member of the field crew who, as Field Coordinator, will be responsible for ensuring that Placer's commitments are met?	❑	❑	______
2. discussed with the Field Coordinator any special natural and/or social aspects of this program's environmental protection program?	❑	❑	______

Comments: ____________________

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Communication Have you:	YES	NO	ACTION BY
1. determined who owns, leases or uses the land?	❑	❑	______
2. contacted the owner, lessee or land user?	❑	❑	______
3. obtained the necessary permits or approvals from local, State or National Government authorities and from the owner, lessee or land user, if required?	❑	❑	______
4. prepared a plan for the local landowner or lessee?	❑	❑	______
5. contacted the local shire, media outlets and other people or groups that can provide advice or assistance in successfully cond-ucting the exploration program?	❑	❑	______
6. provided a set of Placer's environmental guidelines to all contractors and employees?	❑	❑	______
7. advised all field staff on special requirements or restrictions that will apply for this exploration program?	❑	❑	______

	YES	NO	ACTION BY
8. taken photographs of potentially sensitive sites (tracks, bushland, water supplies, air strips etc.) to use as a record of pre-exploration conditions?	❑	❑	________

Comments: ____________________

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Contractors Have you:

	YES	NO	ACTION BY
1. received the completed contracts in which the contractors accept previously agreed responsibilities for environmental protection?	❑	❑	________
2. determined that all contractors carry workers' compensation and public liability insurance?	❑	❑	________

Comments: ____________________

____

____

Assessment Have you:

1. investigated whether the exploration area is special, unique or otherwise sensitive in the following ways:

	YES	NO	ACTION BY
a) has high agricultural or pastoral value or special concerns about lambing, crop growth or harvesting etc.?	❑	❑	________
Check with:			
land owner and/or lessee	❑	❑	________
Department of Agriculture or Primary Industries	❑	❑	________
b) at risk from plant disease, weeds or feral animals?	❑	❑	________
Check with:			
land owner and/or lessee	❑	❑	________
Department of Agriculture or Primary Industry	❑	❑	________

	YES	NO	ACTION BY
local government authority	❑	❑	________
Agriculture Protection Board or similar	❑	❑	________
Department of Conservation or similar	❑	❑	________
c) has important Aboriginal cultural or archeological values?	❑	❑	________
Check with:			
local Aboriginal people	❑	❑	________
local Land Council or similar association	❑	❑	________
Department of Aboriginal Sites or similar	❑	❑	________
Federal Department of Aboriginal Affairs	❑	❑	________
Aboriginal and Torres Strait Islanders Council	❑	❑	________
d) has high conservation values?	❑	❑	________
Check with:			
Department of Environment or similar	❑	❑	________
Department of Conservation or similar	❑	❑	________
State Museum	❑	❑	________
local conservation/community groups	❑	❑	________
e) has important water resources?	❑	❑	________
Check with:			
local or State water supply authority	❑	❑	________
Geological Survey or Mines Department or similar	❑	❑	________
f) is affected by entry or other restrictions?	❑	❑	________
Check with:			
Federal Department of Defence or State	❑	❑	________
Departments for Land Administration or similar	❑	❑	________

Have you investigated whether the exploration area is special, unique or otherwise sensitive in the following ways:-

	YES	NO	ACTION BY
g) has seasonal restrictions of various types?	❑	❑	________
Check with:			
land owner and lessee	❑	❑	________
local government authority	❑	❑	________
other State and/or Federal Government Departments and authorities	❑	❑	________

		YES	NO	ACTION BY
	local bush fire control authority	❑	❑	________
	h) has potential for community concerns about exploration?	❑	❑	________
	Check with:			
	local government authority	❑	❑	________
	local ratepayers/residents associations or similar	❑	❑	________
	State Government Departments or authorities with responsibility for social impact assessment	❑	❑	________
2.	put together a plan that will protect or minimise damage to those parts of the exploration area having high environmental, social or other values?	❑	❑	________
3.	checked the conditions attached to the exploration tenement as required by the Department of Minerals and Energy (or similar)?	❑	❑	________
4.	visited the site with the local landowner, lessee or member of an interest group to assess special site requirements?	❑	❑	________
5.	arranged for all vehicles, drill rigs and other equipment to be checked for environmental acceptability (that is, free of seeds and mud, free of fuel leaks, mufflers and safety gear well maintained etc.)?	❑	❑	________
6.	initiated and received reports from specialists (botanist, Aboriginal studies etc.) that may be a pre-requisite to ground-disturbing exploration?	❑	❑	________
7.	provided sufficient fire fighting equipment in vehicles and campsites?	❑	❑	________
8.	attached a copy of tenement/permit conditions and all required licenses to this checklist to allow easy reference to them during exploration?	❑	❑	________

Comments: ____

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DURING EXPLORATION

Some of these checklist items should be assessed at the very beginning of the exploration program:

Campsite	YES	NO	ACTION BY
1. Does it avoid high value vegetation, sites of Aboriginal significance or other special areas?	❑	❑	__________
2. Is it more than 100 metres from the nearest water body?	❑	❑	__________
3. Have adequate precautions been taken to protect the camp and fuel storage areas from wild fire and to prevent the escape of fire?	❑	❑	__________
4. Are toilet and refuse disposal facilities suitable with little potential to impact on the environment?	❑	❑	__________
5. Is the camp well sited in relation to existing access tracks, flooding, minimisation of vegetation clearing etc.?	❑	❑	__________

Comments:

Roads and Tracks			
1. Can existing roads and tracks be used in preference to making new ones?	❑	❑	__________
2. If new access is required, are places of high social and natural environmental values being avoided?	❑	❑	__________
3. Have heavy rains been adequately planned for in the siting and construction of new tracks?	❑	❑	__________

	YES	NO	ACTION BY
4. Where new tracks leave existing roads, are the entry/exit points hidden to discourage tourist and other casual use?	❑	❑	________

Comments: ________________________________

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Drilling

	YES	NO	ACTION BY
1. Can drill sites be located on land disturbed by other activities (existing tracks etc.) or where vegetation damage can be minimised?	❑	❑	________
2. Are drilling sumps sufficiently large to retain all slurry produced during drilling?	❑	❑	________

Comments: ________________________________

____

____

Protection of Vegetation

	YES	NO	ACTION BY
1. Is smoking and use of multiple camp fires banned or controlled to reduce the risk of fire?	❑	❑	________
2. Is minimal vegetation being cleared in track, grid line or drill pad construction?	❑	❑	________
3. Are excavations such as costeans being kept to the minimum size necessary to complete the required job?	❑	❑	________
4. Is spoil from excavations being carefully placed to minimise impacts on vegetation?	❑	❑	________
5. To assist in rehabilitation, is vegetation growing above excavations and cleared areas being stockpiled ?	❑	❑	________
6. Where vegetation clearing is occurring, is damage to soil and root systems being minimised?	❑	❑	________

	YES	NO	ACTION BY
7. Where line or track clearing is being undertaken, is it being kept to the minimum width necessary?	❑	❑	________

Comments: ____________________

____

____

Protection of Topsoil

	YES	NO	ACTION BY
1. Is topsoil being stored separately from sub-soil?	❑	❑	________
2. Is topsoil being stored in heaps less than two metres high?	❑	❑	________
3. Is topsoil being re-applied to disturbed areas as quickly as possible after the excavation has served its purpose?	❑	❑	________

Comments: ____________________

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____

Prevention of Liquid and Solid Spillages

	YES	NO	ACTION BY
1. Are regulations relating to the storage and use of fuel and other liquids being met?	❑	❑	________
2. Are routine maintenance programs being carried out to ensure that leakage and spillage from machines and equipment is minimised?	❑	❑	________

Comments: ____________________

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____

Litter

	YES	NO	ACTION BY
1. Is litter being discarded in any sections of the exploration area?	❑	❑	________
2. Are rubbish bins available at campsites to encourage proper disposal of refuse?	❑	❑	________

Comments: ____________________

____

General	YES	NO	ACTION BY
1. In areas of water shortage, is water being wisely used in campsites and by drilling rigs?	❑	❑	________
2. Are drill holes or shaft de-watering bringing saline water to the surface in such a way that soil or vegetation is being damaged by salt?	❑	❑	________
3 On agricultural and pastoral properties, are the wishes of the land owner/lessee being respected?	❑	❑	________
4. Are domestic pets causing problems to stock or native animals?	❑	❑	________
5. Are firearms being used responsibly by exploration personnel?	❑	❑	________
6. If exploration is taking place in areas of higher population density, are public requests for information being adequately attended to?	❑	❑	________
7. Are exploration staff respecting private land owner's property and privacy?	❑	❑	________
8. Is there on-going communication with contractors to ensure their compliance with Placer's guidelines for environmental protection?	❑	❑	________
9. Has the owner, lessee or land user been visited to advise that the exploration program has commenced?	❑	❑	________

Comments: ____

____

____

POST EXPLORATION

Once all exploration has been completed, check that the following items have been satisfactorily completed

	YES	NO	ACTION BY
1. Have disturbed areas been rehabilitated according to Placer's management guidelines (topsoil return, ripping or scarifying, creation of a rough surface, seed scattered and seedlings planted)?	❑	❑	________

		YES	NO	ACTION BY
2.	Has all rubbish, including sample bags, been removed from site, burnt or buried in pits at least one metre deep?	❑	❑	________
3.	Have all drill holes been filled or capped according to local regulations or guidelines and Placer's minimum requirements (see Code of Practice)?	❑	❑	________
4.	Have all excavations been filled, with proper rehabilitation procedures applied?	❑	❑	________
5.	Has all equipment been removed off site?	❑	❑	________
6.	Have the conditions attached to the exploration tenement/permit and all license conditions issued by other regulatory authorities been checked to ensure that all have been met?	❑	❑	________
7.	Have all grid pegs been recovered or laid flat on the ground?	❑	❑	________
8.	Have all drill sumps been filled and rehabilitated?	❑	❑	________
9.	Has the owner, lessee or land user been asked to tour the site to ensure his/her satisfaction with site clean-up and rehabilitation?	❑	❑	________
10.	Has a written report been provided to senior Placer staff in the event of difficulties or unresolved problems having arisen?	❑	❑	________
11.	On agricultural land, have compensation payments been paid for loss of earnings and damage to improvements or have restoration measures been undertaken to the satisfaction of all parties?	❑	❑	________
12.	Have all windrows associated with tracks and grid lines been rehabilitated?	❑	❑	________
13.	Have photographs been taken of disturbed sites after rehabilitation has been completed?	❑	❑	________

	YES	NO	ACTION BY
14. Have arrangements been made or initiated for annual checks of the exploration area to ensure successful rehabilitation?	❑	❑	________
15. If the land owner, lessee or other land user is satisfied with rehabilitation, has a letter been signed by the owner/lessee/user confirming his/her satisfaction?	❑	❑	________

Comments: ____

SUMMARY AND FINAL COMMENTS

____

Signed by the field coordinator as a true and correct record of Placer's Environmental Performance during the exploration program and to verify that this checklist was used to the best of the coordinator's ability.

Dated this ____________ day of ____________ 199___

Appendix B

Placer Exploration Limited — Environmental Hit List

Before Exploration

- Complete and abide by Pre-exploration section of the Environmental Checklist.
- Document and/or photograph all previous activities in the region.
- Consult EMP when constructing a campsite, that is, fuel storage, waste disposal and recycling, site selection etc.
- Communicate with all interested parties, ensuring them that Placer takes their environmental responsibilities very seriously.
- Ensure all relevant approvals are obtained.
- Prepare a plan for minimisation of environmental impacts.

During Exploration

- Complete and abide by During Exploration section of the Environmental Checklist.
- All disturbance to the environment must be kept to an absolute minimum, in particular clearing, tracks and hydrocarbon spills.
- When constructing drill pads avoid large trees & thick bushes, and keep dozer/loader blade above the surface where possible.
- Avoid placing drill pads on environmentally sensitive areas, for example, creek banks and steep slopes, as often the exact location of a drill hole can be slightly altered (check with geologist).
- Take precautions to avoid the spread of weed species.
- Ensure that mixing of chemically different aquifers is prevented.
- If surfacing groundwater is highly saline, construct sumps to prevent its spread.
- If groundwater supply is limited, minimise its usage.
- Maintain communication with all interested parties.

Environmental Cleanup

(to be completed directly after a drilling program)

- Remove all litter and machinery from the exploration site.
- Remove or treat all soil contaminated by hydrocarbon spills.
- Ensure all holes are adequately capped.
- Backfill sumps if required by land user.
- Recontour slopes if erosion is a problem.
- Maintain communication with all interested parties.

Rehabilitation

(to be completed no later than 6 months after final drilling program)

- Complete Post Exploration section of the Environmental Checklist.
- Either remove by loader or manually empty all sample bags, ensuring no plastic or calico remains on site (dependent on current land use).
- Backfill or bury all drilling sumps and holes, replacing topsoil last (allow for subsidence).
- Rip or scarify all disturbed areas.
- Spread fallen vegetation over all rehabilitated areas.
- Seed and fertilise rehabilitated area if necessary.
- Block off entrance to rehabilitated tracks.
- Invite landowner and public to view rehabilitation.

Case Study 1

Western Mining Corporation developed specialised low impact exploration practices to satisfy regulatory requirements for access to the Deep Lead Flora and Fauna Reserve near Stawell, Victoria. This reserve contains 335 native vascular plant species of which eight are endangered in Victoria, four are described as vulnerable, five rare and five seriously depleted. During botanical surveys two orchid species not known elsewhere were found. This work significantly upgraded the importance of the flora found in the reserve. In addition, the reserve is relatively weed free and a rare arboreal squirrel glider colony was also found during the zoological survey. Following detailed discussions between the company, the Department of Conservation and Environment and a Public Advisory Group a set of working conditions were prepared for the company. The primary goal was to minimise activity on the ground by personnel and mechanical equipment.

The exploration methods used were geochemical soil sampling, a transient electromagnetic technique (TEM), induced polarised technique (IP), percussion and diamond drilling. The company used existing tracks, no clearance of vegetation and innovative procedures such as: surface boarding to support equipment; surface tarpaulins to capture all material exiting drill holes; oil absorbent materials spread out on plastic sheets beneath drill rigs as a precaution against fuel spills or leaks; water stored in portable tanks rather than sumps; additional dust suppression measures; and careful storage and restoration of surface soils, sods and litter to eliminate impacts. Vehicle movements were restricted and, during diamond drilling, water and sludge were pumped to tankers located on nearby tracks. Drilling was scheduled for summer thus minimising ground compaction and impact on lilies and orchids which are summer dormant.

These measures protected the biodiversity of the area and increased the overall knowledge of the area's flora and fauna due to work conducted by the company and its flora and fauna consultants.

Case Study 2

Placer Exploration Limited Environmental Protocol and Assessment of Field Teams

Placer Exploration is committed to best practice environmental management. All of its mineral explorations are designed for minimal impact on the environment. Any disturbed land is thoroughly rehabilitated.

In June 1994, Placer Exploration Limited implemented an Environmental Protocol to ensure its field teams followed their Environmental Management Plan (EMP) and Environmental Checklist (see Appendix A). The Protocol is an assessment tool that includes educational material, suggested delegations of responsibilities and two environmental performance indicators. It is designed to achieve the company's commitment outlined above. The protocol gives responsibility and ownership of environmental outcomes to each member of the field team.

It was introduced at a seminar for field teams in January 1995, emphasising their responsibility for minimising environmental impacts and rehabilitating disturbed land. To ensure field teams meet their goals, areas affected by their exploration are assessed by the Environmental Technical Officer (ETO) who then reports back to the team on their environmental performance.

For successful environmental performance, all phases of the operation must be managed properly. For exploration this involves:

- forethought and planning before the exploration activity;
- minimising impacts during exploration;
- environmental cleanup immediately following the programmed exploration; and
- rehabilitation within six months of programmed exploration.

To assist field teams the ETO developed the Environmental Hit list (see Appendix B). It is a robust, laminated, A5-sized, dot-point summary sheet that fits in a vehicle glove box.

Two environmental performance indicators (EPIs) were developed that assign a numerical value to each project thus allowing comparison between projects. Data collected from each project is reported in a table showing each variable in the formula and the calculated EPIs.

Environmental Performance Indicator Formulas are:

- **Drilling program that has undergone an Environmental Cleanup immediately after drilling completed.**
- EPI = no. of open holes + no. of areas with excessive tracks + no. of hydrocarbon spills + no. of areas with significant litter / Total no. of holes drilled
- **Drilling program that has undergone rehabilitation no later than six months after drilling completed.**
- EPI = no. of drill sumps left open + no. of drill holes not buried + no. of areas left unscarified or unripped + no. of sample bags left / Total no. of holes drilled

Results of the assessments are circulated so that everyone in the company knows which projects teams are the best performers. This has lead to healthy competition among field teams. The assessment outlines clearly the areas needing improvement. The performance indicators also allow comparison of the field teams and indicate the company's performance over time. While visual assessment is somewhat subjective, this is minimised by using simple variables in the EPI and by using one officer to assess the projects.

As with most management systems, this process will be modified and improved over time to enable greater feedback and increase commitment to good environmental performance.

Case Study 3

BHP Minerals at its Cannington, north-west Queensland, silver and base metal deposit provides an example of comprehensive management of target drilling of more than 460 percussion and diamond drill holes. Inspection at any of the drill holes reveals minimal environmental disturbance.

The first stage in preparing the drill site is to remove and stockpile topsoil from around the sites for the drill collar and the drill sumps. 'A' horizon topsoil is carefully removed to a depth of 200 mm. This material contains viable seed, organic matter and nutrients. The next layer, the 'B' horizon, which can also be used for rehabilitation, is removed to a depth of 300 mm. Lower levels (that is, below 500 mm) of the sub-strata are also excavated and stockpiled according to their salinity or acid generating potential.

During drilling, the bentonite-based drilling mud, used to keep drill holes open, is recirculated through a series of pits rather than being allowed to run off into local drainage channels. See Photo.

There are seven distinct stages in rehabilitating a drill site.

1. Capping the drill hole to ensure that no fauna are trapped in the hole.
2. Demobilising the rig.
3. A drying out period to allow water to evaporate from the drilling muds, which will then cake and crumble to a fine, non-toxic powder. Residue settles at the bottom of each pit and is subsequently buried under backfill. If oily residues appear on the water surface in the pits, mesh shade cloth is placed over the open pits to exclude birds. The shade cloth is not removed until the water has evaporated.
4. Backfilling commences with sequential replacement of the stockpiled material so that the layers go back in reverse order to their removal, with the 'A' horizon topsoil being replaced last.
5. The surface is then scarified.
6. Seed from species natural to the area is sown immediately before the wet season.
7. Regrowth of natural vegetation is visible within a few weeks of the wet season commencing, and the drill sites are generally well covered within six months.

Case Study 4

Rehabilitation of arid lands subjected to exploration activity has been accelerated and improved by CRA Exploration (CRAE) through applying Aboriginal fire management techniques to assist seed release in regenerating spinifex grasses. This accelerates effective rehabilitation of smaller disturbed areas (usually less than 2 hectares) such as drill pads, hard standing areas and borrow pits. Such regeneration avoids the dominance by annual species previously experienced using other methods.

After discussing the issue with local Aboriginal people, CRAE started looking at the broader ecological problems in the arid zone.

They noted a striking decline in the number of native mammals in the desert and fewer species of flora appearing. Studies indicated this decline had occurred recently, in the 30 to 50 years since Aboriginal groups had abandoned their traditional life in the Western Desert and settled in missions and other European communities. The last Aborigines moved out in the early 1960s.

When Aborigines moved out, with them went the practice of frequent burning, mostly covering 10 ha or so in a mosaic pattern, with an occasional big fire. This, coupled with the invasion of the desert by foxes and cats, is believed to have led to the significant decline of arid zone fauna.

The great skills with which these fires were set by Aborigines to take advantage of wind conditions, humidity and topography, emerged in their conversations with scientists. Their pattern of burning meant that there were always many areas adjacent to each other at different stages of growth and decline, and there was rarely enough fuel over a big area to feed vast bush fires of the kind that have been common in recent years.

When the bushes are burnt, the seeds stored in the sandy soil are heated. This makes them receptive to the next rain, soon after which 20 or 30 species of plants, most of them herbs, will blossom and provide food and medicine for local people and food and shelter for native fauna. Even after the heat of a fire has split the seed coat, the seeds may have to wait several years for water, in a region that has a sparse 150 mm to 250 mm of rainfall a year. Some seeds are remarkable 'time capsules' as, protected by a hard casing, they remain dormant for 40 or 50 years — in a few instances for as much as 100 years — before bursting into life after fire and rains.

CRAE employed local Aboriginal communities to burn the desert spinifex in a traditional way which allows the revival of scores of plant species and encourages the return of animals.

The CRAE project provides guidelines for using fire to rehabilitate areas throughout the remote arid interior of Western Australia. CRAE is now conducting further trials to develop fire behaviour models that will help in planning safe burning programs to enhance and protect the remarkable desert ecosystem.