Environmental impact report for seismic operations in the Otway Basin, South Australia

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ENVIRONMENTAL IMPACT REPORT FOR SEISMIC OPERATIONS IN THE OTWAY BASIN, SOUTH AUSTRALIA

Doug Roberts, DCR Geoconsulting

EXECUTIVE SUMMARY

An environmental impact report (EIR) for seismic operations in the Otway Basin in the South East of South Australia has been prepared in accordance with the *Petroleum Act 2000*. The EIR provides information on the South East regional physical and social-economic environment and a basic description of land seismic operations in the region. This document should be regarded as providing an overall perspective of environmental impact in the region.

A description of the environmental risks and effects of seismic operations is provided to assist in the evaluation of the level of impact of seismic assessment and details of processes creating environmental risks are tabulated. The risk management techniques and strategies to be applied to individual seismic projects are described and checklists and data sources are provided. These are to be used for the effective planning of individual seismic operations.

An environmental risk assessment is conducted to establish the levels of risk and consequences of any events, which may result from those risks arising from seismic operations. Based on this assessment, a set of environmental objectives is proposed to form the basis of a revision of the preliminary statement of environmental objectives for seismic operations in the Otway Basin following consultation on the EIR.

The information provided is compiled from extensive datasets, experience available for seismic operations in the South East and the ongoing monitoring of previous seismic surveys. Also included, are references to scientific studies undertaken on the specific aspects of the effects of seismic activities on flora and fauna.

INTRODUCTION

The Otway Basin is a proven petroleum province covering onshore and offshore parts of South Australia, Victoria and Tasmania. Seismic exploration has occurred in the basin since the early 1960s and remains as a prime exploratory tool for petroleum. Over the past 15 years there have been major advances in environmental awareness and management in the petroleum exploration industry, including technological improvements.

The Otway Basin in South Australia is located in the South East region of the State, generally south of an east–west line through Kingston (Fig. 1). By the end of 2000, over 8900 line kilometres of 2D seismic and 415 km^2 of 3D seismic had been acquired since exploration commenced in the region in 1961. Since the early days, standardised practices for seismic operations in the region have been prepared and improved through introduction of codes of environmental practice (Stone,1990 and, Langley, 1996). These have aided the minimisation of environmental impacts and improved industry awareness. Other industry bodies such as the Australian Petroleum Production and Exploration Association and the International Association of Geophysical Contractors have also developed codes of environmental practice, which have been adopted by the exploration industry generally (APPEA, 1996 and IAGC, 1999).

In September 2000 the South Australian *Petroleum Act 2000* was enacted, replacing the *Petroleum Act 1940*. The new Act includes extensive provisions for environmental management and clearly identifies a series of documents and processes used for the assessment of exploration and development operations.

The new Act requires all operations to be covered by a statement of environmental objectives (SEO) specific to the type of operation. Prior to promulgation of the new Act, a preliminary SEO for seismic operations in the Otway Basin was prepared (Cockshell, 2000). The SEO was intended as a transitional document from the earlier prescriptive codes to the objective based regulation contained in the new Act.

Based upon the objectives identified in this environmental impact report, a revised SEO will be prepared, which is intended to be generic in nature and thus cover all seismic exploration activities in the Otway Basin.

Primary Industry and Resources South Australia's (PIRSA) knowledge of seismic activities gives rise to the expectation that under current classification criteria, most specific seismic exploration projects will be classified at the 'low' level of environmental significance.

DESCRIPTION OF SOUTH EAST REGIONAL ENVIRONMENT

The following information is primarily extracted from the publication *Biodiversity Plan for the South East of South Australia* (Croft et al., 1999).

For the purposes of preparing the Biodiversity Plan, the South East of South Australia is defined as the land area of South Australia south of the 36-degree line of latitude (Fig. 1: this area extends up to 90 km north of the Otway Basin). The region represents the limit of grassy woodland, forest and wetland plant communities more typical of southeastern Australia, and the southern limit of the mallee plant communities found to the north. Its estimated area is about 2 100 000 ha (Table 1) with 78% of the region comprising privately owned agriculture land and native vegetation covering approximately 13% (Fig. 2). Williams et al. (1993) claims that there is less than 6% non-degraded native vegetation in the Otway Basin in South Australia.

Table 1 Landcover area estimates

Type	Approx. area *(ha)*	Total area *(%)*
Urban	2 680	<1.0
Perennial lake–swamp	76 200	3.6
Native vegetation	270 000	13.0
Agro-forestry	98 000	4.6
Agricultural land	1 641 000	78.0
Other (inc. sand, rock)	12 120	<1.0
Total	**2 100 000**	

Source: GIS mapping (1987, aerial photography landcover mapping; 1997 Forestry area mapping)

PHYSICAL DESCRIPTION

Climate

The South East has a cool, moist climate with cool, wet winters and long, mild, dry summers. The general trend is for rainfall to decrease northwards and away from the coast from a maximum of 850 mm annual rainfall near Mount Burr, to 450 mm near Keith and Bordertown. Most rain falls in the winter months.

Topography

The South East has a low relief with unique landforms originating from a long, complex geological history. The region is still gradually rising, preserving the record of fluctuating sea-levels over the last 700 000 years in a series of 13 calcarenite ranges or stranded dunes, 2–10 km apart and 20–50 m above the plains parallel to the current coast southwest of Naracoorte (i.e., Ardune, Baker, Dairy, East Avenue, Harper, Naracoorte, Reedy Creek, Robe, Stewarts, West Avenue, Woakwine and Woolumbool Ranges and Hynam Dune). These ridges are composed of sand with marine shell fragments. In places the sand has been hardened to rock by percolating groundwater.

The general gradient of the land towards the coast is 1:1600, and to the north less than 1:5000 (SEWC, 1983). Thus surface water moves slowly towards the coast until a range directs it northwards along the eastern side of the range, resulting in extensive swamps and lakes, prevalent at the time of European settlement. Generally there is a lack of surface streams and rivers, but where they exist, (such as Mosquito, Naracoorte and Morambro Creeks), their catchments originate in western Victoria. Near the coast several streams originate from springs, including Stoney, Benara and Eight Mile Creeks and Piccaninnie Ponds outlet. The first system of private drains enhanced natural flows, but later drains were excavated to bisect ranges and thus effectively draining the interdunal swamps.

Prior to the construction of this extensive network of over 1450 km of drains, the vast quantity of water that accumulated on the interdunal flats limited the potential of the area for agriculture. Now that the water discharges directly to the sea, what was once swamp is now productive farm land. However, as an unfortunate consequence, less than 8% of the of the former wetland habitat survives. These wetlands provide a refuge for many flora and fauna communities with high conservation values (SEWC, 1984).

Inland of the calcarenite ranges, northeast of a line between Frances and Keith, extends an area of 20 000 year old, mostly east-west trending, terrestrial windblown, siliceous sand dunes. These dunes are an extension of the Little Desert of western Victoria.

Part of the region is underlain by Gambier limestone of Miocene age (Twidale et al., 1983). This Gambier limestone is exposed to varying degrees in the Naracoorte and Mount Gambier areas, where lack of surface drainage and lime dissolution has formed sinkholes and caves (karst), which are distinctive features of the region.

Native vegetation

The South East contains a variety of habitats, including wetlands, mallee, stringy bark forest, and grassy woodlands. Since European settlement, about 87% of the original native vegetation has been cleared primarily for agriculture, with native vegetation now covering approximately 13% (270 000 ha) of the region (Table 1). Much of this native vegetation cover is, in fact, open parkland of remnant mature river red gum trees with a pasture understorey (Laut, 1977). Intact, relatively undisturbed native vegetation covers less than 6% of the area (Williams et al., 1993). Native vegetation is not evenly distributed, but is concentrated in areas less suited to agriculture, either on deep sands, saline soils or sheet limestone. For a number of vegetation types, most of the remaining areas are along roadsides or scattered woodland and forest trees in farmland.

Of the 13% remaining native vegetation, 25% is conserved within Government reserves, with a further 15% of private land under Heritage Agreement (Fig. 2).

Means of conserving native vegetation include:
National Park and Wildlife Reserves
    (National Parks and Wildlife Act 1972)
National Parks
  Conservation Parks
  Game Reserves
  Sanctuaries
    (National Parks and Wildlife Act, 1972)
Land for wildlife
Conservation Reserves
    (Crown Lands Act 1929)
Native Forest Reserves
    (Forestry Act 1950)
Heritage Agreements
    (Native Vegetation Act 1991)

Including Heritage Agreements, an estimated 108 725 ha (40%) of the native vegetation in the South East has the conservation of its flora and fauna as the primary management objective. Heritage Agreements comprise privately owned native vegetation forming an important network of ‘off park’ areas of native vegetation. However, 60% of the remaining native vegetation is not included in reserves or Heritage Agreements.

The Biodiversity Plan for the South East provides lists of the native floral species found in the South East. Many are rated as rare, endangered or vulnerable under State and Commonwealth legislation. Wetlands are considered to be particularly significant because of the high conservation status of almost all wetland vegetation associations and their high biological value.

Fauna

The region contains a vast array of native wildlife. The South East is considered to be a highly significant region for birds, with 275 bird species regularly visiting the region. This represents 77% of the total State species. The South East is also home to many bat species but contains a low number of reptile fauna compared to other regions, with only 21% of the State's reptile species represented. The Biodiversity Plan for the South East describes the variety of fauna in the South East with many rated as rare, endangered or vulnerable under State and Commonwealth legislation.

SOCIAL, CULTURAL AND ECONOMIC ENVIRONMENT

The following sections are extracted, with some additions, from information contained in *The South East — a South Australian regional profile*; sourced from Planning SA (2001).

History of settlement

Aboriginal people were the first inhabitants, arriving at least 20 000 years ago, and evidence of prehistoric indigenous life still remains. Clearly visible are the shell heaps (middens), stone fish-traps and ceremonial sites of the Coorong. Many words also survive from the Aboriginal tribes of the coast and the inland. These include *Coonawarra* (honeysuckle rise), *Kalangadoo* (swamp with many gums), *Nangwarry* (a path to the cave), *Bool Lagoon* (a sweet drink) and *Tarpeena* (redgum tree).

Although the South East coast was charted at the turn of the nineteenth century, European settlement of the region did not begin until 1844. The first settlers were pastoralists who took advantage of the fertile country, temperate climate and plentiful water to establish vast sheep flocks and, later, other agricultural pursuits. Communities and townships followed, including the opening of southern ports and the coastal shipping trade thrived.

Robe (established in 1846) became the colony’s third busiest port, exporting wool and horses, and receiving goods and passengers — including large numbers of Chinese settlers who trekked to the Victorian gold fields. Beachport (established in 1878) was an important whaling station. The forestry industry developed from a government nursery at Leg of Mutton Lake in 1875, followed by the first large-scale forest reserve at Mount Burr in 1880. The first pulp and paper mill opened at Snuggery in 1941.

Agriculture

With reliable rainfall and abundant underground water, the South East has a strong history as a highly productive agricultural area. Agriculture is predominantly large-scale production of sheep, cereal crops, beef cattle, dairy, wine grapes and vegetables, particularly potatoes, for fresh market and processing. Crop and pasture seed production is also significant and contributes a major portion of the State's production. Fishing is an important and established component of the regional economy. Rock lobster harvesting is the largest of the fishing sectors. Aquaculture is a small, but growing, industry and now there are over 25 licensed aquaculturalists in the region. Forestry is predominantly large-scale plantations of softwoods (mostly *pinus radiata*).

In recent years, farm forestry has shown significant growth along with large increases in the planted areas of hardwoods (mostly Tasmanian blue gums). A large proportion of agricultural product is processed within the region prior to export. These activities, together with timber milling and processing, dominate manufacturing in the region and contribute most to manufactured exports. The region also has a large service sector, particularly in transport, trade and finance. There are also substantial community and personal services providing for the people in the region.

Infrastructure

The region is connected to Adelaide and the eastern states via two major highways and a network of minor roads link the major centres and smaller towns. Since 1995, the average daily vehicle count along the Dukes Highway has grown by about 5% per year in the Adelaide direction and by about 3% per year in the Victorian direction. Similarly, the average daily vehicle count along the Keith to Mount Gambier road has steadily grown at a rate of about 4% per year since 1993 in both directions.

Most products destined for overseas markets are transported to Portland, a major port 100 km to the southeast of Mount Gambier. There is a passenger and commercial airport at Mount Gambier and many smaller airstrips throughout the region. Electricity for the regional power grid is generated at Ladbroke Grove south of Penola using local natural gas as fuel.

Tourism

As a tourism destination, the South East provides a diverse range of travel and holiday opportunities, and benefits from its position between Adelaide and Melbourne. Food, wine and natural features attract visitors, and the region also hosts a number of festivals and events. Visitor statistics from the Bureau of Tourism Research (BTR) indicate that in the calendar year 1999 there were 282 000 overnight visits to the South East region by South Australian residents, 201 000 visits by interstate residents and 45 000 international visitors who stayed overnight in the region. South Australian visitors stayed for 730 000 nights, interstate visitors stayed 453 000 nights and overseas visitors spent 72 000 nights in the region. Expenditure by domestic visitors in the South East (both overnight and daytrip) in 1998 has been estimated by the BTR to be $157 million.

Wine grapes

A rapid expansion in viticulture activity has occurred in the South East in recent years. The area of vines planted (bearing plus non-bearing) was over 10 000 ha in 1998–99 and produced 15.8% of the State's grapes for winemaking.

Forestry

The majority of the State's forestry activity is based in the South East. In June 1999, Forestry SA had 79 282.4 ha of standing plantations in South Australia, of which 64 969.5 ha (81.9%) are in the South East. Conifer plantations accounted for 99.2% of the plantations in the South East in 1999, with the remainder being Tasmanian blue gums and other hardwoods. Tasmanian blue gum plantations in the South East are rapidly replacing large areas of pastoral land and are becoming a significant factor in planning and approvals for seismic projects.

Manufacturing

Manufacturing in the South East has primarily developed to process local commodities. Although dominated by primary product processing, the region has a wide variety of manufacturing operations such as wineries, oilseed processors, wood products and paper manufacturing, and a range of engineering and metal fabrication works.

Rock lobster and seafood processing, abattoirs, flour milling, and concrete products and concrete production are other significant manufacturing activities.

Water resources

Good quality groundwater from aquifers is plentiful in the majority of the South East and is the primary source for reticulated water supplies and rural supplies for industry, irrigation, stock, and domestic use. Irrigation for horticulture, viticulture and agriculture accounts for more than 90% of water extractions. Groundwater reserves in the South East are prescribed areas as defined by the *Water Resources Act 1997*, with use and management of the resource regulated by licensing agreements. The South East contains very few surface streams and rivers and little reliance is placed on these resources. However, the complexity and significance of the region's surface water system and its interdependency with the groundwater system, warrants due consideration when planning seismic surveys in the region.

Gas resources

The Katnook Gas plant, 10 km south of Penola, has been in operation since 1988 and processes gas from several gasfields in the surrounding area. The gas is produced from Cretaceous age reservoirs from depths of 1800–2500 m. Pipelines deliver the processed gas to several industrial users, electricity generation plants and to domestic consumers in Mount Gambier. The current reserves are expected to supply the existing market for the next ten years, but if further discoveries are made, potential exists to supply major metropolitan areas such as Adelaide.

Minor oil recoveries have been made within the basin and there is potential for the discovery of commercial quantities of liquid hydrocarbons in the South Australian portion of the Otway Basin.

There is a significant resource of natural gas in the offshore portion of the Otway Basin and further exploration may be followed by commercial development. This could lead to the development of offshore and onshore facilities as well as pipelines within the region. A facility operates at Caroline, 20 km to the southeast of Mount Gambier, which produces carbon dioxide gas from within the Otway Basin.

DESCRIPTION OF SEISMIC OPERATIONS

The seismic method

Seismic allows the explorer to ‘see’ below the surface and identify areas where oil and gas may have accumulated. The seismic method uses energy sources such as vibrator trucks or buried explosive charges. The energy source causes sound waves, which travel into the earth and are then reflected from subsurface geological structures (Fig. 3). The returning reflections are recorded in a digital format and sent to a seismic data processing centre to produce a ‘cross-section’ of the layers of the earth’s crust. The following sections explain the field procedures for recording seismic data.

Planning

Once the geologists and geophysicists of an exploration company have proposed a seismic program, the seismic program is plotted onto detailed topographic and cadastral maps (Fig. 4). There are two basic types of seismic survey:

- A 2D survey records data along a single line of traverse, giving a cross-sectional ‘picture’ of the subsurface. 2D seismic lines are normally 10–50 km long and spaced 500–5000 m apart.
- A 3D survey records data over a ‘grid’ of lines simultaneously, giving a three dimensional view of the subsurface, beneath an area covering 20–200 km^2.

These surveys may have energy source lines at right angles to the geophone lines and have a closer line spacing of 200–400 m. Seismic lines are usually 4–5 m wide. The seismic lines are carefully laid out to avoid sensitive environmental sites as well as cultural features such as buildings, dams and water wells.

Permitting

Landowners and land managers whose property may be traversed by a seismic line are contacted and visited to explain the program and to discuss access and identify any issue requiring special attention. This process is called ‘permitting’.

Surveying and line preparation

After the location of seismic lines have been agreed, the surveyors peg out the location of each line by placing markers at an interval of 10–20 m along the lines. Fencing crews construct temporary gates and fence crossings along the lines. Pre-existing gates are used if possible.

On cleared land, little or no preparation is required to accommodate the line for the seismic crew. An agricultural slasher may be used to cut the pasture grasses so that the only signs left of the operation are the wheel tracks along the line. On uncleared land, a single track may need to be cleared to allow access for the seismic trucks. The line weaves around trees and weaves through significant stands of vegetation to minimise both vegetation removal and the resultant visual impact.Prior to 1991, a bulldozer was normally used to ‘prepare’ lines for seismic vehicle access in the South East. This method was replaced with the use of a heavy-duty slasher (manufactured under the model name ‘Hydro-ax®’) to minimise environmental impacts (Plate 1). With this technique, the topsoil is not removed, plant and rootstock is left in the ground and no windrows are created. Experience has shown that the use of a Hydro-ax® when clearing facilitates rapid and natural regeneration (Williams et al., 1993).

Plate 1 Hydro-ax®. (photo 047942)

Recording

After line preparation, the main seismic crew will move onto the line. The crew consists of up to four vibrator trucks (Plate 2), a recording truck and the line crew.

Each vibrator truck has a 'vibrator pad' (Plate 3), which is lowered on to the ground at each energy source position and vibrated with a range of low to medium frequencies in the range 5–100 Hz. In rare cases explosives are used in a drilled 'shothole' to provide the energy source. This occurs for technical, environmental or logistical reasons where data from using vibrator trucks is poor or vehicle access is restricted or inappropriate. If the energy source is dynamite, a number of drilling rigs are used instead of the vibrator trucks.

Plate 2 Vibrator trucks at work. (photo 047923)

Plate 3 Vibrator pad. (photo 047924)

The line crew is responsible for laying out a long line of geophones (Plate 4). The geophones are small devices, which detect the seismic signal and are placed at intervals of 2–3 m along the line. The electrical signals generated by the geophones are converted to digital signals and transmitted along a cable to the recording truck. The energy source is systematically applied along the line every 10–20 m. After a section of line has been completed, the geophones and cables are picked up and moved to the next portion of line. Seismic crews are made fully aware of environmental requirements and the need to respect the rights and interests of landowners and land users.

Plate 4 Geophone lines. (photo 047925)

Weathering layer

Information about the weathered, near-surface characteristics of the earth is required to ensure accurate processing of the seismic data. A weathering crew (Plate 5), consisting of a truck-mounted drilling rig, associated water truck and support vehicle, drills shallow holes to a depth of less than 30 m. Information on the weathering layers is then measured by lowering a special geophone into the hole which records seismic waves created with a weight drop impact at the surface. The weathering holes are drilled every 2–4 km along each line and are backfilled with the original drill cuttings tamped to the surface to reduce subsidence and reinstated to enhance natural recovery.

Plate 5 Weathering layer crew. (photo 047926)

Campsites

Generally, a campsite for a seismic operation consists of several mobile trailer-mounted units, including kitchen, bathrooms, offices and bedrooms. Alternatively, a camp may be constructed from transportable units (Plate 6). The camp may need to cater for between 30–80 persons, depending on the size of the seismic project. The use of a self-contained campsite can be beneficial to the project but does require attention to the consequent risks to the land. Camps are set up on cleared pastoral land and can pose a risk to the local environment if incorrectly managed. Some seismic crews do use the local townships to provide accommodation for their crew but this may lead to longer travel times and greater exposure to and impacts on other road users.

Plate 6 Seismic campsite. (photo 047927)

Line checking

At the end of seismic operations, the survey pegs and all equipment are removed from the line. A small number of permanent markers may be left along some fence lines by seismic operators, while fencing crews remove temporary gates and any required restoration is carried out. Once the seismic crew have left the area, landowners are again contacted to ensure operational objectives have been met. Once any additional requirements are satisfied, many operators require that a release form be signed by the landowner to demonstrate satisfaction with the outcome of the survey.

Following recording of lines within high value native vegetation, monitoring programs may be conducted to assess the regeneration of native flora as well as to check that there has been no introduction of weed species (Plates 7and 8).

Plate 7 Seismic line following recording (March 1995). (photo 047473)

Plate 8 Seismic line following partial regeneration (March 2001). (photo 047479)

DESCRIPTION OF ENVIRONMENTAL RISKS AND EFFECTS

Actual and foreseeable events, including operational events and atypical events, are discussed in this section. Processes that may create risks to the natural environment are considered first and are analysed in terms of key potential environmental impacts. Many of the same processes create risks to the social and economic environment and these are covered in the following section, together with key potential impacts on the social and economic environment. Information is also given on existing management techniques, which have proved effective in minimising the impact of seismic operations.

PROCESSES CREATING RISKS TO NATURAL ENVIRONMENT

The components of the seismic survey that could result in environmental impacts include:

Operation of line preparation equipment

Due to the nature of the seismic operation, it is a fundamental requirement that good access is provided to the ground along lines, so that the vehicles can pass along and the geophones can be planted firmly in the ground to provide satisfactory results. The line preparation equipment such as heavy-duty slashers (e.g., Hydro-ax®), rollers and stick rakes, are used to prepare the access in naturally vegetated areas (6% of the land in the Otway Basin (Williams et al., 1993)) by removing dense vegetation where required.

It is possible in short strips to use hand cut lines, which will grant access to personnel in order for them to place geophones without the necessity for vehicle access. This distance would normally be less than 250 m, before severe detriment to the quality of the seismic data occurs. The vibrator trucks used are large vehicles and normally require a line 4–5 m wide to avoid damage to the vehicle by overhanging vegetation. In 3D surveys it may be possible to use narrower receiver lines (3 m wide) for access. However, equipment may damage the terrain; for example, the wheel tracks of the various vehicles used can form ruts and cause soil compaction.

Operation of drilling equipment

Drilling rigs and water trucks are large vehicles that work along the seismic lines, drilling holes to depths of up to 30 m in the Otway Basin. In some areas of the basin, the depth to the confined Dilwyn Formation aquifer is less than the depth programmed and there is potential for the aquifer to be breached. Planning shallower holes in risky areas can minimise the risk of a breach. If an aquifer is breached, the drill crew can cement the hole to prevent leakage.

If holes are not carefully plugged and backfilled there is a risk that subsidence could lead to a trap being formed, from which small animals may not escape, or larger animals (including agricultural stock) may injure a limb if they stumble into an open hole.

Operation of energy sources

The operation of the vibrator trucks commonly results in the formation of 'pad marks' where the vibrator pad is pressed into the soil. The resulting compaction varies with soil types and can be deeper in sandy soils and wetter areas. There is also the potential for high levels of dust and noise, which could have a localised effect on the native fauna and other land users. Wheel tracks and rutting can also occur during the movement of the various seismic survey vehicles along the line. In native vegetated areas it is usually not desirable to rehabilitate the pad marks or rutting by ripping the area, since the rootstock left in the track by the line preparation methods may be further damaged.

Accidental fuel and oil spills

The seismic crew uses hydraulic oil, fuels and lubricating oils extensively as part of routine operations. There is potential for accidental spills while refuelling or servicing vehicles and through the breakage of oil lines due to wear and tear. Procedures for maintenance of equipment must ensure that this risk is minimised and cleanup response must be rapid if a spill occurs. Quantities are likely to be small.

Crew vehicles and footwear

The presence of the seismic crew could possibly result in the introduction of weeds and other exotic threats to areas of the natural environment. Thus, during the planning stage of the survey, local weed and agricultural disease management issues should be identified. Planning should consider the season and climate, as some pathogen born diseases (e.g., dieback) are transported during these conditions. Careful hygiene procedures on entering native vegetated areas are needed to minimise the risk of introducing weeds and follow-up monitoring programs are required.

Accidental initiation of wildfire

Working in the South East in the summer and early autumn months can bring a serious fire risk to the area. Crew policies to prohibit smoking outside of vehicles and care in the use of machinery — such as slashers, welders and grinders — are necessary to minimise this risk. Compliance with fire regulations, extra care during fire bans and correct and working fire prevention and fighting equipment on each vehicle is essential.

Each of these activities has the potential to result in detrimental impacts on the physical, biological and socio-economic environment of the South East region and each can be managed in a way to minimise the risks.

IMPACTS ON NATURAL ENVIRONMENT

The key potential environmental events (hazards) associated with seismic surveys in the area are identified as:

Disturbance to native vegetation and habitat

- Creation of access for third parties and feral animals
- Introduction of weeds, agricultural diseases and other pests
- Vegetation clearance and visual impact
- Disturbance to wildlife and loss of habitat
- Fire.

Disturbance to soils

- Compaction (wheel ruts) and pad marks
- Bogging of vehicles.

Disturbance to general area

- Litter and pollution.

Disturbance to groundwater

- Aquifer pollution
- Breaching of confined aquifer.

Disturbance to surface water

- Damage to significant wetland habitat
- Damage to watercourse morphology and habitat.

There have been several scientific studies undertaken on the environmental impacts of seismic activities, to validate levels of disturbance and recovery. These include Williams et al. (1993), on vegetation structure; Williams (1997), on vegetation floristics; and Carthew (1999), on faunal impacts. The studies provide a baseline for estimating the level of impact and recovery, and identify areas where more detailed management of environmental impacts may be warranted.

PROCESSES CREATING RISKS TO SOCIAL AND ECONOMIC ENVIRONMENT

The components of the seismic survey that could result in effects on the social and economic environment include:

Property management during surveys

The majority of the land in the South East is cultivated, cleared or improved for pastoral, horticultural or agricultural purposes. Detailed interaction with land users is essential to the successful conduct of a seismic survey. Good communication can minimise the many risks associated with a large number of seismic crew members and vehicles crossing pastoral and cropping land. The longer-term impact of the seismic survey is usually negligible but there are many short-term risks such as damage to crops, movement of stock and damage to property.

Operation of energy sources

The operation of energy sources such as vibrator trucks can result in short term nuisance factors such as vibration, noise and dust. These can be minimised with planning to keep to specified distances from buildings and residences. There is also the possibility of creating wheel ruts and pad marks along the seismic lines. Soil compaction can be a problem in soft ground and may require some gaps in coverage, reduced power levels and restoration by ripping and reseeding.

Setting up and using campsites

The operation of campsites has risks to the land in the form of pollution from oil spills, waste disposal storage tanks and rubbish as well as compaction to the soil. These effects are minor, since the site can be readily rehabilitated.

Operations on public roads

There are many vehicles used by the seismic crew, which will add to the local traffic in the area. Where seismic lines cross roads there is a requirement for warning signs and cable mats to minimise damage to the cable and to third-party vehicles. In addition, there are risks to public and crew safety, which need to be managed.

Drilling operations

Drilling operations (weathering layer or shothole) can lead to similar impacts to recording operations, due to vehicle and crew movement. There is also the potential for disturbance to soil and for stock and faunal impact, due to holes becoming exposed as a result of subsidence of tamping materials. This is normally managed with the placement of plastic inserts into the hole, which minimises the potential for subsidence.

IMPACTS TO THE SOCIAL AND ECONOMIC ENVIRONMENT

Many impacts on the natural environment also can have an impact on the social and economic environment. Key additional potential social and economic environmental impacts from seismic surveys in the area are:

Disturbance to community resources and safety

Buildings and other infrastructure

Buildings could be affected by proximity to the seismic energy source. Safe working distances for the type of source being used are required.

Road crossings and traffic

There are safety risks related to seismic lines crossing public roads and there may be a requirement to slow passing traffic during a survey. Close consultation with local Police prior to placing any signage intended

Noise, air quality, groundwater, disease

These factors can affect local residents' amenity both during and following the operation.

Wildfire

Uncontrolled fire can have a huge impact on all aspects of both the natural and socio-economic environment and fire prevention is a major focus of all field operations.

Disturbance to Aboriginal heritage

- Archaeological
- Ethnographic.

Disturbance to cultural heritage

- Geological Monuments
- Buildings and community facilities
- Register of the National Estate.

Disturbance to existing land uses

Surveys have their largest short-term impact on a wide variety of land users during the operation. There is generally very minimal longer-term impact, which may require rehabilitation. In the short term, the impact is managed and minimised by close consultation and cooperation with the land user. The impact varies with the season and the cycle of agriculture — for example, during cropping there is very high potential for impact especially during the harvesting operations, which should be avoided. Adequate compensation for loss of production is required when a seismic line passes through a growing crop.

Each type of horticulture has its own set of requirements to minimise the disruption. The following list disruptions shows what must be managed to maintain good relationships with land users.

Impact on pastoral operations

The following issues must be managed as part of the land user liaison process; disruption, stock, fences, soil compaction, loss of pasture, disease prevention, weed prevention, quarantine properties, organic stock.

Impact on forestry plantations

It is usually a commercial decision negotiated with the plantation owner on how much of a plantation forest (softwood and hardwood) is cleared for a seismic line. The rapid increase in areas planted with Tasmanian blue gum by many non-local resident owners has led to increasing difficulties in some cases, due to the management arrangements and the needs of operators and requirements of the *Petroleum Act 2000*.

Impact on vineyard operations

Detailed access arrangements are needed to avoid impact to the fixed vine plants and associated harvesting operations.

Impact on horticulture

Consideration should be given to seismic operations during cropping, irrigation, harvest and between crops. Sometimes special crops — such as hybrid seed crops, organic food and genetically modified organism trials — may result in specific and complex special requirements for access.

Impact on other industries

Impact on other industries (i.e., commercial and manufacturing) may be limited to requesting access to industrial properties for geophone lines, while avoiding the area with the energy sources. There is a need to ensure compliance with all industrial work rules which apply under various Acts and Regulations as appropriate.

Guidelines for petroleum operators

To assist petroleum operators in fulfilling the relevant sections of the Petroleum Act and its regulations, liaison guidelines for landholders and petroleum explorers has been prepared by PIRSA in conjunction with the South Australian Chamber of Mines and Energy and the South Australian Farmers Federation. This guideline is particularly pertinent to operations in the South East due to the intensity of farming and the variety of rural pursuits undertaken. The guideline aims to facilitate good working relations between the landholder and the petroleum operator/seismic contractor and hence minimise the social impact on existing land users.

Landholders have raised operational and philosophical issues during the course of seismic operations, particularly during the past 15 years, when petroleum exploration activities have been both intensive and expansive. The experience gained during the course of discussion and resolution of these issues by company operators and PIRSA enables clear identification of key issues of interest to existing land users and relative levels of impacts.

RISK MANAGEMENT TECHNIQUES

Techniques for managing the identified environmental risks have been developed over many years of seismic surveying activities in the South East. This has been, and remains, a demonstration of the precept of continuous improvement through the efforts of company operators, seismic contractors and Government regulators. Techniques will continue to improve through the advent of new environmental knowledge, changing technologies and community involvement. The following section outlines the key management techniques and methodologies in use for avoiding or minimising environmental impacts while acquiring seismic data of a standard suitable for the exploration for, and development of petroleum.

The implementation of procedures to minimise risks from seismic operations in the Otway Basin will be specific to each operating company and project. Each company needs to adopt and adapt a code of practice applicable to the working area of the project, as outlined in Langley (1996), *Environmental Management of seismic operations in the South East of South Australia*. The operating company may also prepare specific procedures in a similar format to Langley (2000), which is an example from the Cooper and Eromanga Basins. The practices contained in these codes have been very successful in minimising the impact of seismic operations on both the natural environment and the social and economic environment.

Planning Process

The following checklist provides guidance on the sequence of events to be followed in planning seismic line locations for specific projects. In each case the terrain crossed by a proposed seismic line is assessed and described so that any potential risks can be identified.

- ☐ Preliminary line locations are established based on the exploration (geological and geophysical) objectives of the project. Information on degree of flexibility in location should be established for each seismic line.

- ☐ Preliminary lines are plotted on cadastral/topographic maps, recent aerial photography and georeferenced satellite imagery. Line positions are adjusted within limits of flexibility to minimise impacts with sensitive areas and obstacles such as buildings.

- ☐ The revised locations are then compared with key environmental database maps (Table 2) to ensure that less apparent sensitive locations are identified and avoided if possible. It is convenient to carry out this process using a Geographic Information System (GIS) integrated with the seismic mapping system to enable cross-checking of the various datasets and the original exploration objectives.

- ☐ Field scouting visits may then be desirable to check locations and confirm completeness of the mapping datasets. At this time, arrangements may also be made for an inspection of the proposed seismic lines by representatives of the appropriate Aboriginal Heritage association.

- ☐ Line locations can be finalised, subject to further adjustment at the time of field surveying. A detailed description of each line should be prepared, noting sensitive terrain or sites to be crossed together with any specific requirement, such as hand carrying of cables, Hydro-ax® line preparation and energy source gaps, or the noting of reduced energy intervals. This description then becomes the basis of the field operations as a guide to reducing the impact.

For 3D surveys, the above descriptions will be detailed over an areal extent, rather than along every line, with flexibility given to the surveyors to adjust line positions to further minimise impact. Similarly, when 2D lines are being surveyed in the field, the surveyors may make any required adjustments, within limits, to further minimise the impact of the lines.

Common techniques

The procedures (or code of practice) for seismic operations established by the operating company will provide details on how the impact can be minimised and how risks can be avoided. The following are some of the techniques of risk management which have been successfully used in the Otway Basin:

- planned larger gaps between source positions in sensitive areas
- hand carrying of recording cables and geophones
- hand clearing of native vegetation to allow foot traffic but not vehicles
- narrow lines through higher environmental value vegetation
- line clearance by Hydro-ax® to retain rootstock
- weaving lines between trees
- line clearance by bobcat slasher for narrow receiver line access
- doglegs in line at intersections
- rehabilitation–reseeding with appropriate native vegetation species
- restoration of wheel tracks
- monitoring regeneration and weed infestation
- carry out weed eradication program.

Previous techniques

For previous seismic surveys, the following aspects have been identified and information used in consultation with the relevant parties (e.g., District and City councils, Aboriginal Heritage Committees, and State government agencies) for logistical and planning purposes — the cadastral information for the final line locations will provide ownership details from the council.

- list of all properties and landowners required for submission with survey application
- Aboriginal and European heritage sites
- railways
- pipelines
- main roads
- industries (e.g., timber, woodchip, potato chip, paper, gas production, tourism, wineries)
- aquifers
- drainage systems
- native forests
- crops (e.g., seed crops, grapes, potatoes, feed, canola)

- pastoral (e.g., cattle, dairy and sheep, organic beef)
- heritage agreements
- national parks and wildlife reserves
- Ramsar[1] sites.

(Note: not all items in this list are necessarily covered by every project.)

GIS data sets

The following GIS datasets relevant to seismic planning (table 2) are maintained by various government agencies, including the Department for Environment and Heritage (DEH), Primary Industries and Resources South Australia (PIRSA), Forestry SA and the Department for Water Resources (DWR). The data is routinely updated and the latest versions should be consulted for individual seismic projects. Care is required to ensure that the correct geodetic datum is used.

Table 2 GIS datasets relevant to seismic planning in the South East

Title	Comment
Biodiversity plan for South East	Remnant vegetation, rare and endangered flora and fauna
Register of National Estate	Codes only and location
Native vegetation heritage agreements	Location
National Parks and reserves	Location and class
No exploration access	Preliminary SEO map
Conservation Reserves	Location and class
Forest Reserves	Native and pine plantation; does not show blue gums fire breaks included
Soils	Laut et al. (1977); land unit classification. New detailed mapping available.
Environmental sensitivity maps*	to be compiled
Groundwater	Top Dilwyn Formation mapping
Wetlands of South East	detailed mapping 1997
Geological monuments	locations, name, type
Cadastral map	large file, titles and Landowners
Threatened flora	Locations
Culture (roads, railways, towns)	topographical map detail
Pipelines	actual and proposed
Aboriginal heritage	Native title, shown only over Victorian border
Petroleum permits	(P)EL, (P)PL, applications, new
Drainage	map locations

*Under construction — use hardcopy maps prepared by MESA in 1990.

Table 3 summarises the possible impacts (consequences) from the identified main sources of risk (hazards) and lists the ways that the risk associated with the various components of the seismic survey can be avoided and managed and mitigating steps taken should specific events occur.

ENVIRONMENTAL RISK ASSESSMENT

It is a requirement of the *Petroleum Act 2000* that an assessment is made of the potential consequences of events, which could pose a threat to the environment. In order to carry out an environmental risk assessment for seismic operations in the

[1] Australia is a signatory to the Ramsar Convention, which was established in 1971 to conserve significant wetlands habitats.

South East of South Australia, a methodology has been employed which firstly identifies the activities that may be a source of risk (hazards) and the possible associated environmental impacts (consequences). This is summarised in Table 3.

Table 3 Risks, impacts and management of seismic operations

Main source of risk *(hazard)*	**Possible impact** *(consequence)*	**Risk avoidance planning objectives**	**Operational techniques**	**Recovery–mitigation techniques**
• Operation of line preparation equipment	• Disturbance to native vegetation and habitats • Disturbance to existing land users	• If possible, avoid native vegetation when planning lines • Plan for minimum line widths	• Hand carry through narrow strips of vegetation • Prepare lines with Hydro-ax® leaving rootstock intact • Weaving between trees	• Block off access after use • Monitor regeneration progress • Carry out active rehabilitation if required
	• Creating visual impact in vegetated areas	• Avoid long straight lines	• Use weaving and doglegs	• Block off line segments with vegetation or earth mounds
	• Creating access points for grazing animals, feral pests and third parties	• If possible, avoid native vegetated areas	• Minimise line widths	• Block off access after use with vegetation or fencing
• Operation of drilling equipment	• Disturbance to groundwater by intersection of shallow Dilwyn Formation aquifer • Creating a hazard to stock and other fauna if holes subside or are not filled	• Ensure depth estimate to Dilwyn Formation is known and program depth accordingly	• If Dilwyn Formation marker is intersected, hole must be cemented • Holes blocked with plug(s) to prevent subsidence	• Backfill, plug holes and clean up cuttings (natural regeneration occurs usually over 2–3 years)
• Setting up and using campsites	• Disturbance to soils, rubbish and pollution	• Place campsites on cleared site in agreement with landowner	• Install appropriate storage tanks for waste storage and removal	• Remove all rubbish and waste • Restore site to pre-existing condition after use
• Operation of energy sources	• Disturbance to soils by compaction or bogging or erosion • Disturbance to buildings	• Avoid surveys in early Summer and during wet seasons • Avoid soft ground after rain	• Skip source points where appropriate • Use lower energy levels on sources	• Pad marks may need to be rehabilitated by filling, ripping and reseeding

Main source of risk *(hazard)*	**Possible impact** *(consequence)*	**Risk avoidance planning objectives**	**Operational techniques**	**Recovery–mitigation techniques**
• Operation of vehicles on roads	• Disturbance to community and safety • Noise and dust nuisance	• Minimise use of roads by planning vehicle movements	• Advise Council and police of activities • Road crossings well marked • Cable mats used and fastened down	• Spray down dirt roads if too dusty • Holes left in bitumen are filled with mastic© or a similar product
• Accidental fuel and oil spills	• Disturbance to soils and groundwater pollution	• Preventative maintenance on vehicles and equipment	• Careful procedures for servicing of vehicles and equipment	• Remove contaminated soil from spills to acceptable waste repository
• Operation of line preparation vehicles	• Disturbance to Aboriginal cultural heritage	• Ensure consultation with heritage custodians prior to line preparation	• If site discovered by survey, flag, avoid and advise custodians and Division of State Aboriginal Affairs	
• Operation of line preparation vehicles and seismic sources	• Disturbance to heritage sites other than Aboriginal heritage	• Ensure lines are planned to avoid heritage areas • Plan suitable minimum distances from buildings	• Plan skips in source coverage and hand carry geophones and cables through the area	
• Crew vehicles and footwear	• Introduction of exotic weed species or agricultural diseases	• Thorough cleaning of vehicles and footwear before conducting a survey in each different area	• Additional wash downs when crossing quarantined properties or entering high value vegetation	• Weed propagation to be monitored and eradicated
• Operations within national parks and wildlife reserves, geological monuments, other sensitive areas.	• Loss of natural and social value	• Avoid these sites for survey as part of planning process	• In some situations, access may be sought with special conditions (e.g., for hand carry of cables and geophones.	
• Accidental initiation of wildfire	• Disturbance to both natural and socio-economic environment	• Training and enforcement of 'no-smoking along lines' policy • Ensure fire equipment and training of all crew is satisfactory	• Follow all fire ban requirements both generally and within forest plantations • Fire tender used with agricultural slasher in summer	• Use line radios to report incidents and assist local authorities in fire fighting at discretion of operator were appropriate

The next step in the risk analysis process is to identify the likelihood of occurrence for the key potential environmental impacts from the survey. Qualitative likelihoods are described in Table 4.

Table 4 Assessment of likelihood of occurrence

Likelihood of occurrence	Description
Almost certain	happening continuously
Likely	likely to occur during project lifetime
Possible	might occur at some time
Unlikely	has occurred a few times
Rare	may occur only in exceptional circumstances

The methodology used is adapted from Knight (1999)

Environmental consequences arising from potential initiating events have been categorised from 'Negligible' to 'Disastrous'; the categories are described in Table 5.

Table 5 Consequences of environmental effects*

Category of effect	Qualitative description of environmental effects	
	natural environment	*socio-economic environment*
Negligible	Possible incidental impacts to flora and fauna in a locally affected environmental setting; no ecological consequence.	Community is aware of operations and concerns have been addressed.
Minor	Temporary reduction of the abundance of flora and fauna in the affected environmental setting; no changes to biodiversity or ecological system.	Temporary disturbance to community.
Major	Reduction of abundance in the affected environmental setting; limited impact to local biodiversity without loss of pre-incident conditions.	Longer term disturbance able to be managed with communication to affected community.
Severe	Substantial reduction of abundance in the affected environmental setting; significant impact to biodiversity and ecological functioning; eventual recovery of ecological systems possible but not necessarily to the same pre-incident conditions.	Significant effect which can be mitigated by extensive rehabilitation and negotiation with community.
Disastrous	Irreversible and irrecoverable changes to abundance in the affected environmental setting; loss of biodiversity on a regional scale; loss of ecological functioning with little prospect of recovery to pre-incident conditions.	Significant and long-lasting negative economic and social effects.

*Methodology used is adapted from: Knight (1999).

The level of risk is determined from a proposed 'environmental event potential matrix', which is represented in Table 6. The table uses a proposed level of environmental effect ranging from 'negligible' through to 'tolerable' to 'intolerable'. The levels are subjective but are estimated to reflect the acceptance levels of the community in general.

Table 6 Proposed environmental events potential matrix

Environmental consequences	Event likelihood*				
	rare	*unlikely*	*possible*	*likely*	*almost certain*
Negligible effect	negligible	negligible	negligible	negligible	negligible
Minor effect	negligible	negligible	tolerable	tolerable	tolerable
Major effect	tolerable	tolerable	tolerable	tolerable	intolerable
Severe effect	tolerable	tolerable	intolerable	intolerable	intolerable
Disastrous effect	intolerable	intolerable	intolerable	intolerable	intolerable

*Negligible: of little or no concern.

Tolerable: degree of risk which is acceptable to the community, provided it is managed through appropriate operational procedures and techniques.

Intolerable: high degree of risk, which the community finds unacceptable.

An overall environmental risk assessment matrix is provided in Table 7, which compares the likelihood and consequence of key environmental aspects arising from seismic operations and assigns a level of risk. The table uses the same possible impacts (consequences) and sources of risk (hazards) as in Table 3.

The risk assessment process demonstrates that a tolerable level of risk is presented to all ranked values (or attributes) related to seismic operations. Risk reduction and management actions for these tolerable-level risks have been identified in the risk management techniques section above.

PROPOSED PRIMARY ENVIRONMENTAL OBJECTIVES

Continuous improvement in environmental performance of seismic operations in the Otway Basin over the past 15 years has lead to use of techniques for line preparation and community interactions, which have been demonstrated to have minimal local temporary impact and negligible long-term effect. This outcome leads to two primary (or overarching) objectives by which the performance of specific seismic operations should be measured. The first objective promotes the management and minimisation of short-term temporary effects of seismic operations and the second to the avoidance of activities, which have a risk of longer-term damage to the environment.

The proposed objectives are outlined below.

Objective 1

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

Objective 2

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, surface water or other land uses.

Table 7 Overall environmental risk assessment for Otway Basin seismic operations

Main source of risk *(Hazard)*	Frequency	Possible impact *(Consequence)*	Environmental aspects affected	Likelihood	Severity of Consequence	Duration of Consequence	Risk level *(Table 6)*
• operation of line preparation equipment	• maximum of two passes confined width of recording vehicles	• disturbance to native vegetation and habitats	native vegetation native fauna	likely	*minor* effect due to small area and to techniques retaining rootstock for regeneration	3 to 5 years	Tolerable
		• disturbance to existing land users	agriculture forestry	likely	*minor* effect due to low impact of methods and to communication and cooperation with other land users		tolerable
• operation of line preparation equipment		• creating visual impact on vegetated areas	native vegetation tourism	unlikely	*negligible* effect due to techniques used to disguise lines	3 to 5 years	negligible
• operation of line preparation equipment		• creating access points for grazing animals, feral pests and third parties	native vegetation	likely	*minor* effect on most lines but needs special attention in higher value vegetation.	possibly permanent (if not remedied)	Tolerable
• operation of drilling equipment	• maximum of two passes along line by water truck • one pass by drill rig and recording vehicle	• disturbance to groundwater by intersection of shallow Dilwyn Formation aquifer	groundwater	possible	*minor* effect due to remedial practices	possibly permanent	Tolerable
		• creating a hazard to stock and other fauna if holes subside	native fauna agriculture	possible	*minor* effect due to management procedures		tolerable
• setting up and using campsites	• one site per ten surveys	• disturbance to soils, rubbish and pollution	soil visual	likely	*minor* effect able to be rehabilitated	1 year	Tolerable
• operation of energy sources	• one pass per line with maximum of four vibrator trucks	• disturbance to soils by compaction or bogging or erosion • disturbance to buildings, etc	soil	likely	*minor* effect with some natural rehabilitation and some requiring remediation	1 year	Tolerable

Main source of risk *(Hazard)*	**Frequency**	**Possible impact** *(Consequence)*	**Environmental aspects affected**	**Likelihood**	**Severity of Consequence**	**Duration of Consequence**	**Risk level** *(Table 6)*
• operation of vehicles on line or roads	• minimum amount to ensure efficient vehicle usage	• disturbance to community and safety • noise and dust nuisance	community	likely	*minor* effect especially when large survey is conducted but minimised by adherence to procedures and warning signs	duration of survey (maximum six weeks)	Tolerable
• operation of line preparation vehicles		• disturbance to Aboriginal cultural heritage	heritage sites	unlikely	*minor* effect due to prior heritage clearance, training and reporting of sites	permanent	negligible
• operation of line preparation vehicles and seismic sources		• disturbance to heritage sites other than Aboriginal heritage	heritage sites	unlikely	*minor* effect due to survey planning procedures and crew training	permanent	negligible
• accidental fuel and oil spills	• not applicable	• disturbance to soils, surface water and groundwater pollution	soil surface water	unlikely	*minor* effect due to relatively small potential spill volumes and good access for cleanup	1 year	negligible
• crew vehicles and footwear	• not applicable	• introduction of exotic weed species or agricultural diseases	native vegetation agriculture–horticulture	unlikely	*minor* effect requiring remediation in both native vegetation and agricultural areas and follow-up weed eradication programs where necessary	permanent	negligible
• operations within national park and wildlife reserves, geological monuments and other sensitive areas.	• very rare occurrence; activities confined to roads and existing access tracks only	• loss of natural and social values	heritage sites native vegetation significant wetlands	possible	*minor* effect as planning is undertaken to avoid these areas or else to operate under special conditions.	permanent	Tolerable
• accidental initiation of wildfire	• no wildfires have been initiated yet by seismic operations in South East	• disturbance to both natural and socio-economic environment	native vegetation	rare	*major* effect causing damage to natural environment and to rural community but with repair occurring over time.(minor if contained)	possibly long term (>5 years)	Intolerable

SPECIFIC ENVIRONMENTAL OBJECTIVES

More specific environmental objectives for seismic operations in the South East are suggested in Table 8. These Objectives are sourced from the risks and possible impacts in Table 7 and each could be assigned as a subset to either Objective 1 or 2 above as noted.

Table 8 Environmental objectives specific to seismic operations in the South East

Specific environmental objectives *(1 and 2 indicate which of the objectives each point relates to)*	**Main source of risk** *(hazard)*	**Possible impact** *(consequence)*
Avoid disturbance to rare, vulnerable or endangered fauna and flora (2)	operation of line preparation equipment	disturbance to native vegetation and habitats
Minimise clearing and other impacts on native vegetation and wildlife habitats (1)		disturbance to agriculture and forestry industries
Minimise visual impact of operations (1)	operation of line preparation equipment	creating visual impact on vegetated areas
Discourage third party use of sites, following the completion of operations (1)		
Avoid disturbance to rare, vulnerable or endangered fauna and flora (2)	operation of line preparation equipment	creating access points for grazing animals and feral pests and third parties
Avoid the introduction and spread of exotic species (2)		
Minimise adverse impact on underground water resources (1)	operation of drilling equipment	disturbance to groundwater by intersection of shallow Dilwyn Formation aquifer
Minimise pollution, litter or remnant equipment at survey sites (1)	setting up and using campsites	disturbance to soils, rubbish and pollution
Minimise adverse impact on soil (1)	operation of energy sources	disturbance to soils by compaction
Minimise adverse impacts on other land users (1)	operation of vehicles on line or roads	disturbance to local community and safety
		noise and dust nuisance
Minimise pollution, litter or remnant equipment at survey sites (1)	accidental fuel and oil spills	disturbance to soils and groundwater pollution
Minimise adverse impact on surface drainage (1)		
Avoid disturbance to cultural heritage sites (2)	operation of line preparation vehicles	disturbance to Aboriginal cultural heritage
Avoid disturbance to cultural heritage sites (2)	operation of line preparation vehicles and seismic sources	disturbance to heritage sites other than Aboriginal heritage
Avoid the introduction and spread of exotic species or diseases (2)	crew vehicles and footwear	introduction of exotic weed species or diseases
Avoid activities which may have long term impacts on areas of high biological diversity or wilderness value, or have social or scientific importance (2)	operations within national park and wildlife reserves, geological monuments and other sensitive areas	loss of natural and social values
Minimise the risk of initiation and propagation of wildfire (2)	accidental initiation of wildfire	disturbance to both natural and socio-economic environment

CONSULTATION CHECKLIST

The following checklist is a guide to the various parties who must be consulted for their consent to conduct the operations for any given survey. The cadastral information for the final line locations will provide ownership details from the council.

- ☐ List of all properties and landowners required for submission with survey application
- ☐ District and City councils
- ☐ State Government Departments (Including PIRSA, the Department for Water Resources and Department for Environment and Heritage)
- ☐ Industries (e.g., timber, woodchip, potato chip, paper, gas production, tourism, wineries)
- ☐ Non-government organisations (for example Aboriginal heritage committees, farmers groups, local conservation groups, native title claimants)

(Note: Not all items in this list are necessarily covered by every project.)

To ensure that both this generic EIR and the resultant generic SEO was subjected to a public consultation process, the Minister of PIRSA classified the overall activity of seismic operations in the Otway Basin at the 'medium' level of environmental significance.

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