3 PROJECT DESCRIPTION

3.1 INTRODUCTION

This chapter provides background information on oil and gas developments in the Sakhalin Island region and a description of the proposed Lunskoye seismic survey. Details of the proposed operations are presented including:

- existing oil and gas developments;
- evaluation of the need for the survey;
- survey location;
- seismic survey methodology;
- details of the seismic survey vessels;
- description of the principal activities and implementation schedule;
- preliminary identification of the main sources of potential impacts.

3.2 SAKHALIN ISLAND OIL AND GAS RESOURCES

3.2.1 Introduction

The Russian Federation is currently the world's largest natural gas exporter, with 6.7 trillion cubic feet (Tcf) in net natural gas exports in 2001 and 7.1 Tcf(1) forecast for 2002 (Energy Information Administration, 2002). For crude oil, and petroleum products, Russia is the second largest oil exporter behind Saudi Arabia. In 2001 the country's net oil exports rose for the seventh consecutive year, reaching 4.91 million barrels (bbl) (2) per day in net crude oil and oil products, and these figures are predicted to have risen again in 2002. Crude oil and gas exports therefore represent an important financial resource, with export revenues providing approximately 25% of the Russian Federation Government's income (Energy Information Administration, 2002).

Sakhalin Island and its surrounding waters have been identified as a high priority source for the oil and gas sector due to the large oil and gas reserves, high levels of current and anticipated investment, and the island's strategic position on the Pacific Rim (Trade Partners UK, 2002).

Onshore oil, gas and condensate (3) fields have been in production on Sakhalin Island since 1928. To date, some 4,000 onshore wells have been drilled with approximately 40 fields producing 10.5 million barrels per year (bbl/yr) (4) (Petromin, 2001 and Friends of the Earth Japan, 1995). In 1975, the former

(1) 1Tcf is equal to 2.9×10^{10} m^3, therefore 6.7 Tcf is equivalent to 1.94×10^{11} m^3 and 7.1 Tcf is equivalent to 2.06×10^{11} m^3 .
(2) One barrel (bbl) is equivalent to 35 gallons (UK) / 159 litre, therefore 4.91 million bbl is equivalent to 780 million litres per year (l/yr).
(3) Gaseous hydrocarbons which are a mixture of pentanes and higher hydrocarbons. This resource changes state to become a liquid when temperature is reduced or pressure is increased.
(4) 1.7×10^9 l per year.

Soviet Union signed a general agreement with Japan on oil and gas in the Sakhalin continental shelf region. The agreement led to the discovery of two offshore oil and gas fields, and subsequent exploration revealed a further four fields, reaffirming views that the region's main petroleum potential lay offshore (1). The Sakhalin region requires the application of advanced technologies for successful development due to severe meteorological climatic constraints. These technological difficulties, a decline in global oil prices and other financial barriers led to the suspension of field developments in the 1980s (Trade Partners UK, 2002).

In the early 1990s, the Russian Federation Government and the Sakhalin Oblast Administration tendered Sakhalin leases to foreign consortia, to enable experience to be gained and used as a base for further developments over the coming decades (Petromin, 2001). Six licence blocks were defined and named Sakhalin I-VI (see *Figure 2*). The Sakhalin I (2) and Sakhalin II projects are currently under development and are described below (Trade Partners UK, 2002).

3.2.2 *Sakhalin I Project*

The Sakhalin I project began in 1975 with the discovery of the Chaivo and Odoptu fields. Further exploration led to the discovery of the Arkuntun-Daginskoye Field, which was later added to the Sakhalin I development site (see *Figure 2*). In 1995, the Sakhalin I consortium was formed which joined Russian (Rosneft and Sakhalinmorneftegas), Japanese (Sodeco) and American (Exxon Mobil) companies (Slavic Research Centre, 1999).

Crude oil production is planned to commence in 2005, and the project area is expected to produce between 59 and 88 million bbl crude oil (3) and 2.8×10^{-3} – 8.4×10^{-3} Tcf (4) of gas per year. The eventual capital investment for this project is estimated at US$15 billion (Trade Partners UK, 2002).

3.2.3 *Sakhalin II Project*

In 1991, the Russian Federation Government and the Sakhalin Oblast Administration invited international companies to tender proposals for the right to conduct a feasibility study for the future development of the Piltun-Astokhskoye and Lunskoye Fields. The tender was won by a consortium consisting of Marathon Oil Company, McDermott and Mitsui, later to be joined by Royal Dutch Shell and Mitsubishi. The consortium established SEIC in 1994, and signed a PSA (see *Chapter 2*) with the Russian Federation government for the Sakhalin II licence block in the same year, making the Sakhalin II project the first oil and gas scheme to be developed under a PSA in Russia (Trade Partners UK, 2002).

(1) Initial surveys showed that offshore reserves were 25 to 50 times the production capacity of onshore reserves (Petromin, 2001).
(2) Named in the order licence blocks were offered to foreign investors by the Russian Federation government.
(3) 9381 to 13992 l per year.
(4) 20 to 30 million m^3 per year.

In 1997, McDermott sold their share in SEIC to the remaining shareholders, and in 2000, Marathon's interest was traded to Shell, resulting in a present day consortium of Shell (55%), Mitsui (25%) and Mitsubishi (20%).

The eventual capital investment for Sakhalin II is estimated at US$10 billion, which represents the largest single foreign investment project underway in Russia at this time.

The Sakhalin II project has estimated reserves of approximately 1 billion bbls of oil (1) and 16 Tcf (2) of natural gas (Sakhalin Energy website, 2002). The project comprises the phased development of two fields:

- the Piltun-Astokhskoye oil and gas condensate bearing formation to the north of the Island in the Sea of Okhotsk;
- the Lunskoye field predominantly gas bearing formation to the east of the island in the Sea of Okhotsk.

Sakhalin II was the first offshore field development project in the region to produce oil with production from the Piltun-Astokhskoye field beginning in July 1999. This development is named Phase 1 and incorporates the Piltun-Astokh-A (PA-A or Molikpaq) platform and tanking facilities.

Phase 2 of the Sakhalin II project aims to achieve full-time production from the Piltun-Astokhskoye and Lunskoye fields (see *Figure 3*). The key facilities to be installed for Phase 2 development are as follows:

- the PA-B platform will be a drilling / processing platform in the Piltun-Astokhskoye Field;
- the Lun-A platform will be a drilling and minimal processing platform in the Lunskoye Field;
- the Onshore Processing Facility (OPF) which will receive gas, condensate and oil from the Lun-A and PA-A and PA-B platforms;
- an oil pipeline system including booster stations which will receive oil from the Molikpaq and PA-B platforms and gas condensate and oil from the Lun-A platform for transportation to an Oil Export Terminal (OET) at Prigorodnoye in the south of the island;
- a gas pipeline system (including compressor stations) which will gather gas from PA-A, PA-B and Lun-A platforms for transportation to the LNG terminal at Prigorodnoye;

(1) 140 million tonnes.
(2) 4.6×10^{11} m^3.

- a phased two-train Liquefied Natural Gas (LNG) plant at Prigorodnoye with LNG export facilities;

- an offshore Tanker Loading Unit (TLU) to transport oil from the OET to tankers in Aniva Bay;

- an Infrastructure Upgrade Project (IUP) involving road, bridge and airport upgrading works to enable the Sakhalin II Project to proceed.

The developments introduced above are the subject of a separate ES, which has been submitted to the Russia Federation for approval. An additional ES is being prepared for submission to potential international lenders and stakeholders in Q1 of 2003.

3.3 NEED FOR THE SURVEY

3.3.1 *Sakhalin II Project*

The successful development of the Lunskoye Field within the wider Sakhalin II Project will provide a supply of hydrocarbons to downstream energy and petrochemical industries and provide a revenue stream to the PSA partners, including the Russian Federation Government. Secondary and indirect effects of the development of the Sakhalin II Project include the creation of local employment opportunities and local economic stimulation for suppliers of raw materials, equipment and services.

3.3.2 *Seismic Surveys*

The identification of new prospects and the development of identified oil and gas reserves requires ongoing investment in exploration and field appraisal activities. The collection of geological information using seismic survey techniques is an established and important part of the exploration and appraisal process. Analysis of seismic data allows a more accurate assessment of limits and boundaries for known oil and gas reserves to be carried out. The re-estimation of the Lunskoye Field gas reserves from previous seismic surveys in the area led to an increase of 40% in predicted reserves, making the field the largest proven shelf gas field in the Sakhalin region (American Business Centre – Yuzhno-Sakhalinsk, 2001).

3.3.3 *Previous Seismic Surveys*

Five seismic surveys have been previously conducted in the Lunskoye Field since 1972 (1). The most recent survey was carried out in 1997. Seven exploration wells have also been drilled to date. Detailed delineation (2) of the majority of the field has been achieved from these investigative works;

(1) The full details of these surveys are not available.
(2) Information on oil and gas reserve boundaries and structures.

however, shallow gas sand obscures [1] the seismic image over the central portion of the field where the majority of the drilling will occur.

3.3.4 *Proposed Seismic Survey*

The proposed 3D seismic survey [2] will undershoot [3] the gas sands by acquiring data along lines at a different orientation to the previous 3D survey. The 1997 3D survey collected data in a north-south direction along the longitudinal axis of the shallow gas sand, but was unsuccessful in undershooting the feature. The proposed 2003 survey will collect data in an east-west direction along the feature's narrower lateral axis, to achieve successful undershooting of the gas sands and provide the required data for this important section of the field.

The primary reasons for conducting the proposed seismic survey are:

- avoidance of shallow gas pockets during drilling;
- avoidance of shallow faulting during drilling;
- avoidance of reservoirs isolated by secondary faulting (which restricts the amount of resource that can be extracted);
- identification of optimal locations of production wells within the field to reduce the number of wells required, minimising associated drilling impacts (*eg* the footprint), risks and costs;
- accurate appraisal of the extent, volume and nature of the available reserves, and the possible identification of previously undiscovered reservoirs;
- targeting suitable areas, away from faults and fault zones within the field for the re-injection of drill cuttings and produced water [4].'

(1) The presence of gas can fully obscure areas of the subsurface.
(2) See *Chapter 6* for definition.
(3) A technique for the acquisition of seismic data avoiding areas that are blocking seismic energy *eg* the shallow gas sands in the Lunskoye Field.
(4) Oil and gas reservoirs have a natural water layer (called formation water) that due to its greater density lies underneath the hydrocarbons. Oil reservoirs frequently contain large volumes of water, while gas reservoirs tend to produce only small quantities. To achieve maximum oil recovery, additional water is usually injected into the reservoirs to help force the oil to the surface. Both formation and injected water are eventually produced along with the hydrocarbons, and, as an oil field becomes depleted, the amount of produced water increases as the reservoir fills with injected seawater. At the surface, produced water is separated from the hydrocarbons, treated to remove as much oil as possible, and then either discharged into the sea or injected back into the wells. In addition, some installations are able to inject produced water into other suitable geological formations (UK Offshore Operators' Association, 2002). Care needs to be taken when identifying suitable areas for the re-injection of produced waters as the disposal of pressurised waters can induce the activation of faults and fractures.

3.4 SURVEY LOCATION

The Lunskoye Field is situated 12 km offshore to the northeast of Sakhalin Island (see *Figure 2*) in water depths of 35 to 55 m. The field is 25 km long and 8 km wide with an area of approximately 200 km^2. The proposed seismic survey area covers an area of 327 km^2 with a water depth range of 25 to 60 m. The site is defined by the (UTM [1]) coordinates:

Easting	Northing
679245	5689009
692286.5	5690720
689060.5	5715358
676019	5713647

(spheroid: WGS84 [2] , datum: WGS84)

This area incorporates the Lunskoye Field and turning circle requirements for the vessel and survey equipment.

3.5 PROPOSED SEISMIC SURVEY METHODS

3.5.1 Seismic Survey Technique

Seismic survey techniques allow detailed information to be obtained about geological structures and rock layers beneath the earth's surface. This is achieved by directing sound waves from a sound source (*eg* an airgun) to the layers of rock beneath the surface. The sound waves travel at different speeds according to the different types of rock, fluid or gas encountered. Reflected waves are recorded by detectors and then processed electronically to produce graphical images. Geologists then interpret these images, identifying and characterising oil and gas reservoirs.

3.5.2 Equipment Specification

The proposed survey will use airguns as the sound wave source. The airguns will be arranged in two arrays each with two or three sub-arrays of ten airguns, giving 40 to 60 airguns in total. These arrays, known as source arrays, will be towed approximately six metres below the sea surface by a dedicated seismic survey vessel (see *Figure 4*). The airguns on each array will fire approximately once every 20 seconds. Each array will be triggered alternately in a process known as 'flip-flop' mode, therefore an energy pulse will be emitted from the survey vessel once every 10 seconds during surveying operations.

(1) Universal Transverse Mercator.
(2) World Geodesic System, 1984.

In accordance with *'Guidelines for Issuing Permits for Drilling, Blasting, Seismic Survey, and Other Activities that will Adversely Affect marine Biological Resources in the Littoral Waters of the USSR, and on the Continental Shelf of the USSR, Except for the Caspian Sea'*, individual airgun barrel volumes will not exceed 3.5 litres.

Reflected waves will be recorded by hydrophones (1), which will be towed at a nominal depth of seven metres beneath the sea surface by the same vessel. These groups of hydrophones are called 'streamers' and for the proposed survey there will be 4 to 8 streamers each with a length of 3,600 metres. The specific seismic vessel to be used for the survey has not yet been identified, so specifications of the typical airguns and streamers likely to be used for this type of survey are provided in *Table 3.1*.

3.5.3 *Pre-seismic Site Survey*

In addition to the seismic survey, SEIC is proposing to conduct a side scan sonar survey to yield information on the location, size and height of features on the sea floor within the Lunskoye Field (2). This will allow the identification and mapping of any features that may represent potential obstructions to the collection of seismic information during the main survey.

The planned side scan sonar is the EG&G Model 272-TD Towfish. It is a towed model, where the sonar transducer and receiver are mounted in a single housing, which is streamed behind a vessel. Side scan sonar transmits pulses in a narrow beam to the side of the towed housing and produces three-dimensional images of the sea floor. The operating frequency of the side scan sonar is planned at 105 kHz ± 10 kHz with a pulse length of 0.1 ms and a pulse rate of up to 7 pulses per second. The nominal source level is 228 dB re 1 μPa-m_{rms} (3). The horizontal beam width of the side scan sonar is 1.2° and the vertical beam width is 50° tilted down 10° or 20°.

The survey will be conducted immediately prior to the seismic survey using the same vessels. Details of the side-scan sonar survey are reported in *Table 3.2*.

(1) Electrical instruments for detecting and monitoring sound in the marine environment through changes in pressure.
(2) For example, bathymetric features or ship wrecks.
(3) A full explanation of the units of measurement used within this ES is provided within *Section 5.3.5*.

Table 3.1 *Typical Survey Equipment Specifications*

Airgun Detail & Specification		Streamer Detail & Specification	
Number of airgun arrays	2	Number of streamers	4 – 8 (1)
Number of guns per array	20 – 30	Operational length (m)	3,600 each
Individual gun chamber volumes (litres)	0.8 - 3.5 (50 – 214 in^3)	Streamer materials	Kerosene filled or solid (1)
Approximate volume (litres) (based 47.5l per array)	95 (47.5 per array) (5800 in^3)	Nominal towing depth (m)	7
Separation (m)	50	Separation distance (m)	100
Operating pressure (kg/cm^2)	140	Average line length (km)	13.5
Peak value (bar m) (out- 128 Hz filter)	40	Approximate turning circle radius (km)	1.5
Peak-to-peak (bar m) (out- 128 Hz filter)	90	Tail buoy warning devices	radar reflector, lights and bright colour
Firing interval (m)	25 (50 per gun array)	Identification aids	Global Positioning System (GPS)
Operational depth (m)	6		
Cycle time (seconds, s)	10		

Table 3.2 *Typical Technical Specifications for the Side-Scan Sonar*

Technical Specifications	
Type	272 – TD Side Scan Sonar Towfish
Operating frequency (kHz)	105 +/- 10
Pulse length (ms)	0.1
Peak output (dB)	228 reference 1 micropascal at 1m
Horizontal beam width	1.2 (3 dB points)
Vertical beam width	50 with 10 – 20 tilted down

(1) To be determined during the seismic contractor tender process.

3.6 SURVEY VESSELS

3.6.1 *Typical Seismic Survey Vessel and Support Vessel Specifications*

The seismic survey vessel and support vessels to be used for the seismic survey and seismic site survey will be determined on completion of the tendering process for the seismic survey contractor.

Table 3.3 reports the specifications that are likely to be used for the Lunskoye seismic survey based on the experience of seismic survey experts within SEIC and the specifications for previous seismic survey programmes of a similar type.

Table 3.3 Typical Seismic Survey Vessel Specifications

Specifications	Seismic Survey Vessel	Support Vessel
Length (m)	90	50
Width (m)	20	12
Fuel consumption (cubic metres per day)	34 (bunker fuel)	5
Gross tonnage (tonnes)	5,800	1,200
Propulsion system	3 ducted propellers (aft) and an electric bowthruster	2 ducted propellers and 2 thrusters
Navigation systems	GPS on bridge, gyro compass, autopilot, radars, robtrack system and echo sounder	Radar, global positioning systems (GPS), radio/satellite communication equipment, autopilot, echosounder and gyrocompass
Steering systems	2 independent GPS systems, corrections, real-time navigational system (to allow steering on subsurface coverage), acoustic network (1) on streamers (front, mid, tail) and GPS on tailbuoy	Rudder
Positioning Accuracy	Vessel 5 m, tailbuoy 10 m	N/A

3.6.2 *Vessel Safety Systems & Operational Controls*

All survey operations will be conducted in accordance with the vessel's standard operating procedures, which detail the manner in which all operations are to be conducted. These procedures also detail the responses and actions to be taken in the event of an accident or disruption in conditions (see *Chapter 7*).

(1) The acoustic network allows an accurate picture of the streamer to be determined whenever required.

In addition to the vessel standard operating procedures and relevant SEIC HSE procedures, SEIC require that operations conform with a number of international guidelines including:

- International Association for Geophysical Contractors *Environmental Manual for Worldwide Geophysical Operations* (Marine Operations Provisions) (IAGC, 2001);
- *Convention for the Prevention of Pollution from Ships* (MARPOL, 1973 / 1978);
- JNCC *Guidelines for Minimising Acoustic Disturbance to Marine Mammals from Seismic Surveys* (JNCC, 1998).

During survey operations, the seismic survey vessel will not be able to operate in water depths of less than 25 m, with an absolute minimum operating depth of 20 m. This equates to a limit to how far inshore the vessel can travel of 4 to 5 km from Sakhalin Island's northeastern coast.

3.7 PRINCIPAL ACTIVITIES & SURVEY SCHEDULE

3.7.1 Principal Activities

The seismic survey vessel will arrive on site fully fuelled and equipped to carry out the complete survey without the requirement to visit port. Once on-site, the vessel will deploy the source arrays and streamers and sail at a speed of approximately 4.5 knots (2.3 metres per second, ms^{-1}) along a series of predetermined courses (lines) within the survey area (see *Figure 5*). The average line length will be 13.5 km, and lines spaced 200 to 400 metres apart will follow an east-west direction approximately perpendicular to the shoreline. The time taken for the vessel to complete each survey line will be approximately two hours. On completion of a line, the vessel and streamer equipment will turn and manoeuvre into position to begin the next line. The turning circle will have a radius of some 1.5 km and the time taken to complete this process will be approximately three hours. Within each 24-hour survey period, there will be approximately 10 hours of seismic data acquisition and 14 hours turning (*pers comm* SEIC, 2002).

The support vessel will be used to guide other shipping and fishing vessels away from the seismic vessel and the streamers. It will also be used for clearing any debris or fishing equipment ahead of the survey vessel, providing safety cover in the event of accidents or crew evacuation, and towing the survey vessel away from dangerous waters / installations in the event of a loss of power. In addition, bunker fuel will be stored onboard to enable refuelling of the seismic survey vessel if required. The support vessel may also be used for marine mammal monitoring purposes (see *Chapter 7*).

3.7.2 *Survey Schedule*

The Lunskoye seismic survey is currently scheduled for July / August 2003, however, the timing of the survey will depend on vessel availability and weather constraints. The duration of the survey will be approximately four weeks based on 24-hour operations and incorporating provisions of 10% and 20% respectively for 'down time' (*eg* time taken to correct equipment failure) and 'standby' (*eg* the ceasing of survey activities due to meteorological conditions) (*pers comm* SEIC, 2002).

3.8 *SOURCES OF IMPACTS*

Sources of impacts from noise, effluent discharges, solid and scheduled wastes, air emissions and spills, leaks and dropped objects associated with the survey programme are discussed below.

3.8.1 *Noise*

The main noise sources will be from the side-scan sonar and seismic survey equipment, and the vessel propeller systems. The largest sound pressure level will be generated by the seismic survey airguns and the frequency content of the emitted pulse will be a function of the airgun volume. A range of airgun volumes is used to increase the signal level, increase the bandwidth and to focus the signal in a downward direction to limit the spread of sound away from the target area (see *Figures 6, 7* and *8*).

Propeller noise varies strongly according to vessel type. For seismic vessels, every effort is made to reduce propeller noise because it interferes with the seismic measurements. Ambient spectral noise levels due to shipping are approximately 95 dB re 1 micropascal /Hz at 1m at 70 Hz (maximum) down to 65 dB re 1 micropascal/Hz at 1m at 300 Hz (1).

For distances over several kilometres, airgun noise is considered the dominant source of potential impacts (*pers comm* SEIC, 2002).

3.8.2 *Effluent Discharges*

The principal effluents discharged to the marine environment are predicted to comprise of:

- greywater (2) from sanitary effluent *eg* wash water and laundry discharges;
- drainage water *eg* bilge water (3) and machinery spaces drainage;

(1) An explanation of the units of measurement used can be referred to in *Section 5.3.5*.
(2) Greywater is water from culinary activities, bathing and laundry facilities, deck drains and other non- oily waste water drains (excluding sewage).
(3) Bilge water is water generated in the bilge of the ship's machinery spaces and therefore maybe contaminated with oil and other substances, some of which may be harmful if discharged directly to the marine environment. Direct discharges of untreated bilge water will not occur during the Lunskoye seismic survey.

- service water/cooling water;
- treated blackwater *eg* sewage effluents and runoff from medical facilities.

SEIC report that the seismic survey vessel will comply with the requirements of MARPOL (*ie* the installation of oil/water separators for bilge and machinery spaces, an oil record book and an International Pollution Prevention (IOPP) Certificate [(1)]). Discharges of bilge water or drainage from machinery spaces will therefore have to be treated to the specification of 15 parts per million (ppm) oil content or lower prior to overboard discharge. The seismic vessel will also be equipped with adequate grey and blackwater treatment facilities. *Table 3.4* provides information regarding the typical bilge, oil recovery and oil/water separators utilised by SEIC in seismic survey programmes (*pers comm* SEIC, 2002).

Table 3.4 Typical Effluent Equipment Specifications

Item	Specification	
Oil/water separator	Capacity (m^3 per hour (h))	3
	Maximum Water Pressure (bar)	3.95
Recovery oil tank	Capacity (m^3h^{-1})	4.7
Sludge Tank (receptacle for contaminated oil)	Capacity (m^3h^{-1})	3.98
Bilge water tank	Capacity (m^3h^{-1})	6.5

Cooling water and surplus service water *eg* from drinking water generation systems may contain residual chlorine (typically less than 1 part per million for potable water generation systems).

It is predicted that other effluents discharged during survey operations *eg* deck drainage due to rainfall or spray run-off, and effluents from deck cleaning operations may contain oil.

3.8.3 Solid & Scheduled Waste Generation

Three different waste groups are predicted to be produced from the seismic survey operations:

- scheduled wastes [(2)] *eg* lubrication oil, hydraulic fluids, cable oils, lithium batteries, and containers used to store lubricating fluids;
- solid wastes *eg* paper and plastic;
- food wastes and solid sewage wastes.

(1) References 36 and 37 of *MARPOL 73/78 Annex 1*, 1973 as amended by the 1978 Protocol.
(2) Waste containing a chemical, or mixture of chemicals exceeding threshold concentrations and/or organic in nature, resistant to degradation by chemical, physical or biological means, toxic to humans, animals, vegetation or aquatic life and bioaccumulative in nature.

The seismic survey vessel will be fitted with an incinerator, which will dispose of the majority of the solid and food/sewage waste produced onboard. Typical incinerator specifications are reported in *Table 3.5.*

Table 3.5 Typical Incinerator Specification

Incinerator Detail and Specification	
Type	OG 400C
Capacity (Kcal/h, 580kw)	500,000
Maximum solid waste per charge (litres (l))	400
Maximum sewage sludge (l h^{-1})	30
Combustion chamber temperature (°C)	1,200
Operational combustion chamber temperature (°C)	850 - 1,150
Manufacturer	Fremo
Burner capacity (l h^{-1})	18 - 28

Remaining wastes will be stored on board the vessels and disposed of in port following completion of the survey. Wastes will be separated into types where possible and solid wastes (glass, plastics) will be compacted for storage purposes. Non-hazardous types will be disposed of to landfill or similar disposal facility. Scheduled wastes will be retained on board and returned to the manufacturer on completion of the survey. Oily rags will be incinerated.

Contractors will be required to treat and dispose of wastes in full accordance with MARPOL regulations (see *Chapter 7*) and appropriate local legislation and best practice guidance.

3.8.4 Atmospheric Emissions

The principal atmospheric emissions during survey operations are predicted to comprise of combustion products from propulsion systems and power generation equipment onboard the vessels. An indication of these exhaust emissions is presented in *Table 3.6*. Emissions have been estimated using US Environmental Protection Agency (US EPA) data, and are based on assessments for a 24-hour operation schedule (US EPA, 1985 and Mineral Management Services, 1989).

Additional combustion products are predicted to be released from the operation of the onboard incinerator.

Table 3.6 Estimated Vessel Emissions to Atmosphere

Parameter	Seismic Survey Vessel (kg/day)
Carbon dioxide (CO_2)	5,920
Nitrogen oxides (NO_x)	256
Sulphur dioxide (SO_2)	26
Carbon monoxide (CO)	104
Hydrocarbons	48

3.8.5 *Spills, Leaks and Dropped Objects*

The streamer equipment for the Lunskoye survey may be solid-filled or kerosene filled depending on the contractor that is assigned to the project (see *Chapter 6*).

Collision or snagging of the streamer equipment may result in releases of kerosene from the streamer segments, if liquid filled streamers are used. Rupturing of one cable section could be expected to result in the loss of up to 100 to 200 litres of kerosene. If the streamers used are solid-filled, a proportion of the lead weights used to hold the equipment at the correct depth would be predicted to be lost during the course of an average survey. SEIC estimate that less than one weight strip would be lost per streamer per month leading to an estimation of less than 8 strips for the Lunskoye seismic survey (*pers comm* SEIC, 2002). SEIC also estimate that four plastic streamer depth control units ('birds') may be lost during the four week survey period. No streamers losses are estimated, due to inflatable devices that are activated if the equipment sinks to an unacceptable depth. Tailbuoy losses are rare, but cannot be discounted when estimating equipment loss and the dropping of objects during the Lunskoye seismic survey (*pers comm* SEIC, 2002).

An assessment of the impacts resulting from these losses and releases are reported together with preventative monitoring and management measures in *Chapters 5, 7* and *8*.