ENVIRONMENTAL MANUAL
FOR
WORLDWIDE GEOPHYSICAL OPERATIONS

2001 Edition

INTERNATIONAL ASSOCIATION
OF GEOPHYSICAL CONTRACTORS

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The International Association of Geophysical Contractors (IAGC) is an international trade association, headquartered in Houston, Texas USA with offices in Sevenoaks (London), England, representing the independent service companies and geoscience departments of operating companies that perform most of the geophysical exploration worldwide in search of new oil and gas supplies. Geophysical equipment manufacturers, geophysical data processing centers and data handling firms, geoscience, environmental and safety consultancies, and other suppliers of products and services to the industry also are members of the association. Since its founding, IAGC has been the standards setter in the geophysical industry. We are a results-oriented organization comprised of leaders from all segments of the geophysical community.

For more information about the association, its products, services and the benefits of membership, visit our web site at www.iagc.org.

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IMPORTANT NOTICE

This Environmental Manual has been prepared by volunteers drawn from IAGC member companies who have used their best efforts to provide the industry with useful information for conducting geophysical field operations in an environmentally sensitive manner. However, IAGC does not represent that these standards address every environmental topic nor risk that may be encountered. Users of these standards are especially cautioned that adherence to the standards will not ensure that any particular operation will be in compliance with prevailing law in the jurisdiction where the operation is performed. Environmental laws and regulations vary from country to country, state to state and locality to locality. All geophysical operators and others using these guidelines are advised to seek appropriate counsel concerning the environmental requirements in their particular areas of operation.

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IAGC ENVIRONMENTAL COMMITTEE
MISSION STATEMENT

Mission:

To provide a forum in which to facilitate the open and full exchange of environmental views and issues facing the geophysical industry.

Goals:

- To serve as a catalyst for achieving the highest level of environmental stewardship throughout the geophysical industry.
- To provide a focal point for communications, both within and outside the industry, on relevant environmental issues.

January 15, 2001

To our geophysical industry colleagues and friends:

It is our pleasure to provide the IAGC Environmental Manual for Worldwide Geophysical Operations (2001 edition), which revises and upgrades the 1994 version of the IAGC Environmental Guidelines for Worldwide Geophysical Operations. This industry standard is intended for use by IAGC member companies and others to assist in meeting your environmental obligations, commitments, and expectations around the world.

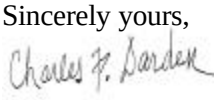
The manual has been developed with a focus on the personnel performing geophysical field activities. Consequently, general operating procedures and practices are described at the job-site level. Additionally, specific recommended practices have been tailored to the variety of operating environments – desert areas, tundra, rainforest, wetlands, marine, etc. – encountered during these operations. Responsibilities of crew members, party chiefs, and company/client management also are suggested.

The format of this field-level manual has been aligned with accepted industry health, safety, and environmental (HSE) management systems. References are provided to complimentary guidelines and standards.

The information and recommendations in the manual build on understanding and experience within the geophysical industry regarding operational best practices. However, we also recognize that, as organizations inside and outside the industry read and use the manual, they will see ways to improve it. IAGC is committed to an ongoing effort to enhance the effectiveness of the manual and welcomes all comments and feedback on it.

We believe that IAGC member companies (and, indeed, the entire geophysical industry) must demonstrate environmental leadership. Oftentimes, we are the first footprints of the energy industry into an area at a time when expectations of the public, government, and our own companies about HSE performance are increasing. We urge your use of this manual, and its companion IAGC Land and Marine Geophysical Safety Manuals, in the design and implementation of all of your operations.

Sincerely yours,



Charles F. Darden
President

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1.0 GENERAL OPERATING PROCEDURES

1.1 INTRODUCTION

1.1.1 Purpose of the Manual

This manual is the first update of the Environmental Guidelines which IAGC issued in 1994. It reflects the significant changes that have taken place in the second half of the 1990's in both geophysical industry data acquisition technology and in public perceptions about environmental protection. The industry has seen a dramatic shift in operations from traditional 2-D data acquisition to 3-D and now to 4-D data acquisition. Likewise, awareness and expectations by the public and government regarding sound environmental practices, together with regulations, have increased.

The original guidelines largely focused on raising management awareness of the best practices available to contractors in performing field acquisition activities in an environmentally responsible manner. This updated version focuses more on the personnel actually performing the work in the field. It also continues to serve as a basis for clients and contractors to assure the public and regulators that their geophysical activities will comply with best practices and regulations.

Geophysical surveys are typically used to create images of the subsurface geology to plan for drilling and mining operations. They serve to focus those efforts on the most productive areas. This reduces environmental impact by minimizing surface locations subsequently needed for mineral resource development. They may also be used to avoid placing structures on geologically hazardous zones.

Geophysical field operations are typically localized and of limited duration, so their environmental impact can be minimal and temporary. In planning and carrying out geophysical operations, consideration needs to be given, among many other things, to:

- Specific host physical environments, such as arctic, rainforests, deserts, oceans, mountains, marshes, and wetlands, as well as developed areas of agriculture, mineral extraction, and urbanization.
- Potentially affected local communities and their social, cultural, and economic characteristics and sensitivities.
- Work functions, including planning, accessing, clearing, acoustic source operations, logistical support, camps, and reclamation/clean-up activities.
- Environmental regulations and public interests across varying governmental systems and cultural situations.
- Education and awareness of all stakeholders about the process and its associated factors.
- Monitoring of performance as the work progresses.
- Balancing protection of personnel safety and health with environmental protection.

The **General Operating Procedures** in this section of the Manual apply to both **Land and Marine Geophysical** operations. The specific sections that follow apply to particular operating conditions. In all cases, it is assumed that the client's company or their contractor has obtained the necessary environmental permits to commence work, citing this manual as the practices to be followed. The successful implementation of the practices in this manual is highly dependent on the commitment of adequate resources by both the contractors and the client companies.

1.1.2 General Description of Geophysical Acquisition Activities

Geophysical acquisition is performed on land, at sea and in the shallow water transition zones (TZ). The method most often employed is the seismic method, which is described below for the benefit of those who are not familiar with seismic survey operations.

The basic principles of seismic data acquisition are similar to echo sounding. A seismic energy source on the surface of the earth is used to transmit short bursts of sound energy into the earth. Rock layers within the earth reflect “echoes” of sound back to the surface of the earth, where receivers arranged in lines or arrays covering several kilometers collect them. Cables or telemetry links transmit the received signals to a data recorder. The recorded data are later processed and analyzed to produce images of the subsurface geology.

On land, the energy sources are typically vibrators mounted on trucks, or explosives placed in shot-holes which have been drilled by truck-mounted or portable drills. The receivers are typically geophones, which are like small microphones pushed into the soil to measure the ground motion.

In water, the energy source is typically arrays of air-guns which are towed from a seismic survey ship and release bursts of high pressure air into the water. The receivers are typically hydrophones which measure the pressure waves in the water.

Seismic operations can generate both visual impact and noise and disturbance, such as through the use of vehicles involving large truck mounted machinery or survey ships towing large arrays of equipment. These impacts are typically minimal, localized, temporary and of short duration. Physical impacts of seismic operations can sometimes be longer-lasting if not properly addressed.

Other geophysical data acquisition methods such as gravity and magnetic data acquisition are sometimes carried out in conjunction with seismic survey operations.

On Land

Land seismic and other geophysical acquisition activities span various types of natural environments. Deserts, tundra, mountains, forests, grasslands, agricultural fields, coasts, swamps and marshes have all been sites of geophysical acquisition programs. Geophysical surveys have been conducted in rural areas, small towns, villages, industrial areas, and large urban areas. Although this manual does not specifically address operations in urban or developed agricultural

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areas, it is recognized that they require care in planning and implementation, such as to protect sensitive buildings or underground pipes or to avoid disrupting drainage areas.

The equipment and mode of operations varies with terrain. Where there is road or off-road access for vehicles, the recording equipment and source equipment (vibrators or shot-hole drills) may be truck-mounted and the geophones and cables transported by and deployed from similar vehicles. In difficult terrain or environmentally sensitive areas, the equipment used may be portable and carried by hand or helicopter.

Energy sources may vary due to environmental sensitivity, terrain, and data objectives. Explosives and vibrators are the most common. Technological and safety-related advances in these two types of sources have had great impact on the industry and research continues in this important area. Airgun (compressed air) sources can be used in lakes and rivers within land projects.

Recording systems have also developed over time in response to technological advancement and logistical concerns. The systems in use today can be divided into four main types: one-way radio telemetry, two-way radio telemetry, cable telemetry, and analog cable systems. Each of these has specific advantages and disadvantages related to terrain, climate and client preference. Radio telemetry can sometimes improve the level of access and disturbance for deployment.

Land geophysical acquisition can best be seen as large scale land use projects. Planning is essential for deployment, maintenance, security, and usage of sensitive electronic equipment, as well as trucks, off-road vehicles, boats, aircraft, and base camp/support facilities. Due to the large extent of many modern 3-D geophysical programs, the planning stage is more critical to accommodate increasing numbers of people and equipment to accomplish these surveys. 2-D programs, although less common, are still performed. They require the same types of planning and attention, but for smaller numbers of people and equipment. An exciting new technology has been seen in recent years in the form of 4-D geophysical programs. Essentially, these are (usually) 3-D programs designed to be repeated at regular intervals of time to measure changes related to natural or man-made processes, such as fluid movement, or tertiary recovery operations. Semi-permanent deployment of receivers downhole is a prime method of reducing variables to isolate time-related changes.

At Sea

Deepwater seismic or towed streamer, as it is commonly called, is defined as ending as close inshore as it is possible to come with a deepwater vessel. Deepwater geophysical acquisition is performed by towing from one to as many as ten or more streamers. These receive the earth's response to a sound signal which an energy source, such as an airgun array, initiates at timed intervals.

Ocean Bottom Cable (OBC) seismic acquisition is defined as having the detectors deployed on the seabed. The OBC detectors may be the usual type of deepwater marine streamer or be specially constructed for different environmental conditions. The seismic cables may be positioned directly

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on the bottom, dragged or hung vertically for geophysical acquisition purposes. The energy source most commonly used is the airgun array operating from a separate vessel. One ocean bottom geophysical crew may consist of as many as five ships, each handling a different aspect of the operation, such as deployment and retrieval of the detectors, energy source and recording. Ocean Bottom geophysical vessels may operate in waters as shallow as two fathoms (4 meters) and as deep as 1000 fathoms (2000 meters).

Deepwater seismic is performed utilizing towed streamers to receive the earth's response to a sound signal initiated from an energy source such as an airgun.

Shallow Water and Transition Zone (TZ)

Other possible survey areas involve Shallow Water or Transition Zone (TZ). This kind of survey is sometimes performed by a marine crew, but for the most part is associated with land operations. TZ covers areas of shallow shelving coastal shorelines which are typically characterized by tides, currents, breaking waves and difficult access. The detectors (seismic cable) used in Ocean Bottom geophysical acquisition will be the most common type used in TZ geophysical acquisition due to the harsh environmental conditions. Numerous types of energy sources will be used in TZ operations, from airguns and vibrators to explosive charges. TZ operations are performed using small craft to carry and deploy the equipment with much shoreside equipment and support.

1.2 ENVIRONMENTAL MANAGEMENT

Environmental management systems allow companies to adopt a systematic approach to managing environmental issues and continuous environmental improvement as well as ensuring compliance with relevant legislation. These systems assure responsible operating practices through the identification and assessment of a project's effects on the natural and social environment and subsequent development of control and recovery measures to manage these

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effects. Environmental management should be an integral system within the management systems of both contractor and client companies.

Environmental management is essential and needs to be strongly emphasized. It is a responsibility of line management. It should include:

- Communication of management policies and commitment of those involved.
- Provision of financial and personnel resources.
- Assignment of environmental accountability to all parties and personnel for -
    - Operating procedures.
    - Standards and targets to be achieved.
    - Training of affected personnel.
    - Monitoring, reporting and auditing systems.
    - Emergency response planning.
- Engagement of internal and external stakeholders.

Subject headings below provide guidance and advisory information on how to implement an environmental management system. They follow the standard structure of a HSE management system. It should be noted that environmental management systems may be certified to independent, international standards such as ISO 14001.

Note: The information provided below focuses mainly on land seismic operations. However, the general principles and guidance apply equally to marine operations.

1.2.1 Leadership and Commitment

Top-down environmental commitment and company culture is essential to the success of the system. Senior management of both the contractor and client companies need to provide strong, visible leadership, commitment, and the necessary resources, and ensure informed involvement and commitment at all staff levels. Senior management should also be involved in setting and reviewing strategic environmental objectives.

1.2.2 Policy

An organization's Environmental Policy is a statement of the standards by which the organization will operate. It reflects the organization’s intentions and principles of action regarding its environmental performance. It is a key component of an organization's Environmental Management System. As such, it needs to be written, communicated, understood, consistently implemented and maintained at all levels of the organization.

Typically the policy addresses the company's position on compliance with environmental legislation, regulations and operating standards, as well as environmental effects and concerns. It

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thus provides essential messages to be given to management and employees of the organization, its business partners, regulators and the general public.

1.2.3 Organization, Resources and Documentation

Management Responsibilities

Successful handling of environmental matters is a line responsibility. However, senior management must also ensure that the necessary organization, resources, and environmental management system documentation are in place, and responsibilities and authorities defined and communicated to all levels of staff.

Stakeholder Identification and Communication – managing perceptions

Functional two-way communication and dialogue is a critical component of an effective management program. To facilitate open and meaningful dialogue between the organization, its employees, contractors, and interested parties, programs and operational controls should be in place which enable all interested parties to be aware of:

- The importance of compliance with applicable environmental regulations and company policies.
- The importance of achieving the organization's goals and objectives.
- The potential environmental and other effects of relevant work activities and the benefits of improved performance.
- The importance of engaging stakeholders early on in a project, listening and responding to their issues and concerns.

The organization should be responsive to public attitudes and concerns. It should implement and maintain procedures to receive, document and respond to internal and external communications from relevant interested parties concerning the environmental and other effects of its activities, products, processes, management, and performance.

An external environmental education and training program should be handled through established public relations efforts and community advisory groups (such as Citizens' Environmental Advisory Councils where established and applicable). It is, however, important that the organization not limit itself solely to these approaches. It may sometimes be necessary to develop new mechanisms to communicate and consult with relevant stakeholders.

Environmental Training

People inside the organization must understand operating procedures and policies to effectively implement them. Training efforts need to emphasize the importance of each individual's environmental performance responsibilities and accountability.

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Training must be conducted on appropriate environmental issues according to job responsibility. Managers must be trained on environmental regulations, how they affect the company, and the company's responsibilities in complying with all applicable requirements. Personnel, including contractors and subcontractors, must be trained in procedures for specific tasks.

Operations training needs to include site-specific information on:

- Wildlife, plant life, and aquatic life which might be encountered.
- Current land and water use.
- Local cultures and archaeological sites.
- Clearing, access and transportation.
- Waste minimization, handling, and disposal methods.
- Fire prevention and control.
- Handling and storage of hazardous materials, fuels, and oils.
- Shot-hole plugging.
- Reclamation measures.
- Regulations, conventions and other legal requirements which apply.
- Client environmental policy and expectations.

The IAGC Safety Manual is to be used in conjunction with this Environmental Manual to identify significant applicable environmental procedures.

Environmental training must be addressed during planning and be continued as part of the routine health, safety and environment and crew level meetings.

1.2.4 Evaluation and Risk Management

Environmental Screening Study

Client companies frequently commission environmental and social experts to carry out an Environmental Screening Study to identify the environmental sensitivities and human uses of the proposed area of operations. This typically requires a literature search for all available data on the geography, climate, flora, fauna, water resources, and human industrial, commercial, cultural and recreational activity in the area. It may also require additional field work or baseline studies if data are incomplete. As this document should highlight key issues for possible management during the activity, some preliminary engagement with key stakeholders may take place at this stage. This description of the existing environment can provide valuable initial input to an Environmental Assessment.

Environmental Assessments

The operating company often conducts Environmental Assessments (EAs) during the planning stage, to identify and assess the environmental and social issues of an area where operations are

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planned, and identify measures to reduce or avoid impacts. Depending on the potential risk and numbers of issues, different levels of EA may be conducted. This could include a full environmental impact statement conducted by an independent team or, depending on the project, a risk assessment focusing on specific environmental issues.

Best practice and regulations are increasingly requiring that assessments of environmental and social/cultural impacts be integrated. Special considerations relating to social impact assessments are discussed in a separate section below.

The EA should be conducted well in advance of any operations, to allow all parties sufficient time to incorporate requirements and measures into their individual contract plans. EAs are an ongoing dynamic process requiring further assessment and re-evaluation at each new phase of a project.

For information, Appendix A contains a chart illustrating the basic principles of the environmental assessment process. This is taken from World Bank Guidelines and shows environmental assessment in the context of the whole project.

The environmental assessment should:

- Clearly describe the existing environment and proposed activities (including the environmental screening study, if available).
- Define direct and indirect environmental and social impacts.
- Explain methods for reducing or avoiding impacts, mitigation and proposed remediation.
- Identify and respond to concerns of the interested public and the community through stakeholder engagement.

The initial description should include current land use, any existing environmental problems, accessibility, environmental sensitivities, issues of public concern, and a review of any local or national regulatory requirements. Although dependent on the working environment, the impact of the geophysical operations is generally limited in comparison to drilling and production activities although spread over a wider area. However, some impacts can be locally significant and long-lasting in some cases if not appropriately addressed.

Environmental (Natural and Physical) Issues to Consider

A well conducted Environmental Assessment will consider each type of operation and identify the environmental features it may affect. Issues that should be addressed in the environmental assessment or certainly early in the environmental planning stage are:

- Soils, slopes and drainage - Determine locations of land type, farmland, prairies, mountains, saltwater, brackish and freshwater marsh. Identify particular features, such as substrate types, prairie, pasture land, marsh stability (including areas of floton marsh), water levels, and pond depths. Federal, state, and local restrictions may protect areas of particular environmental

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significance. Examples of where restrictions may apply include the beach front of barrier islands, unusual marsh features, such as marsh ridges, and eroding and other vulnerable marsh areas.

- Erosion - Erosion control measures can reduce the effect of operations, particularly in areas with steep slopes, high winds, rapid water flow or freezing and thawing weather conditions. Altering surface conditions can change the rate and pattern of the erosion process.

- Water Management - Drinking water supplies, biological habitats and recreational usage depend on water quality. Safeguard surface and groundwater by careful practices in the field. Determine locations of wells, creeks, rivers, lakes, irrigation canals and ponds, levees, dams and other water control structures. Maintain integrity of water control systems to prevent saltwater intrusion. Understand tidal effects and potential effects of extreme tidal conditions.

- Hydrology Impact - Identify idle zones where marsh and riverbank areas may be particularly vulnerable to erosion from the wash created by vessel traffic.

- Sensitive Environments - Accessing and operating within an area may cause some temporary alteration to vegetation. Cutting down or driving over vegetation can cause erosion and habitat disruption. Determine specific vegetation types and locations. Consider effects on vegetation in determining suitable equipment types, as well as potential restrictions such as line clearance restrictions in forested areas. Identify potential fire hazards, especially in dry summer conditions.

- Zoological Impact - Operators should be alert to the presence of animal wildlife during geophysical activities. Identify significant wildlife activity. Determine precautions required to limit the disturbance of wildlife, particularly during nesting, breeding, and migrating seasons. Operations may be restricted during certain seasons. International treaties, federal, or state restrictions may apply to certain protected species and nesting colonies, such as cetaceans and other marine mammals, manatees, turtles, bald eagle nests, bird rookeries, alligator nesting sites, etc. These restrictions will be defined within the relevant federal and/or state agency permits. Do not transport wildlife from one area to another. Estimate potential equipment damage resulting from wildlife activities.

- Aquatic Impact – Contact local authorities, experts, and/or agencies for information early in the planning process. At times it may be necessary to adjust geophysical operations due to effects on aquatic life, particularly with respect to energy sources, recording cables and anchoring.

Communication with area users can improve coordination among parties. An open line of communications with the public during the planning stage will minimize misperceptions of those unfamiliar with geophysical operations. This should include the distribution of information describing the seismic method, equipment to be used, and details of the planned operations, together with discussion, identification, and development of plans to address local issues.

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Stakeholder issues and concerns should be understood by the company and incorporated as best as possible into a project's plans. Communication and consultation can generate information useful to improve planning and implementation of the operations, such as by identifying particularly vulnerable resources or sensitive activities in the area of the survey.

Social/Cultural Impact Assessments

It is important to manage impacts of geophysical operations on the social, cultural and economic structure within communities affected by these activities. Failure to seek out, understand and be responsive to the expectations of local communities, and to communicate the plans and procedures of the project to them in ways they can understand, may significantly increase risks to successful completion of the project.

It's important to manage impacts on social, cultural, and economic structure with communities affected by these environments.

Any environmental assessment should address social, cultural and economic issues through studies and consultation. Cursory treatment of these issues in the EA must not be allowed. Companies should seek qualified consultants to advise them on managing these issues, whether they be with an indigenous tribe in a tropical rainforest or a fishing village along a seacoast. This may require specialized experts, such as sociologists or anthropologists, who are familiar with relevant local communities and able to design effective consultation and mitigation programs to address characteristics and issues particular to those communities.

For example, it may be necessary to:

- Identify key local leaders who truly represent the general sentiments of the local people. This is both difficult and critical to success. The earlier in project planning this can be accomplished, the higher the probability of success.

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- Establish a consultation process to identify and stay abreast of community issues and concerns.
- Develop an understanding of the history associated with previous (e.g. "outside") activities in an area before engaging the local public. Whether or not another company or industry has built or destroyed trust in the area will help in designing the communication strategy.
- Ensure that *potential* health issues for the crews are reviewed in a systematic manner.
- Ensure that the presence of crews will not jeopardize the health of the local population or disrupt the local economy.
- Anticipate that the local public will be seeking ways to economically benefit from the project. Communicate very clearly the temporary nature of geophysical operations. Do not promise things that will be difficult or impossible to deliver.
- Train all crew members on local customs, traditions, and religious beliefs to avoid conflicts. Apply and enforce rules and procedures that protect the resources and cultural beliefs of the local communities from intended and unintended actions of the crews.
- If necessary, restrict operations during certain seasons or during certain periods of the day so as not to interfere with local community hunting and fishing activities.
- Where practicable, identify potential archeological sites before operations and make appropriate plans to deal with them. If a site is encountered, instruct crew personnel not to alter it.
- Recognize all situations where the operations may lead to colonization (e.g. road construction into previously isolated regions) and manage them with consultation from local leadership.
- Identify ways to provide appropriate benefits to the local community. Evaluate all philanthropic efforts in light of the community's capacity to sustain such efforts after the work is completed and the project demobilized.

Risk Managment

Once all risks are identified, a management plan should be put in place to establish measures, such as best practices and specific work procedures, to avoid, minimize, or offset the predicted adverse impacts. This may include mitigation measures, along with monitoring, remediation, and follow-up evaluation to assure the management plan is working. (See discussion of Environmental Management Plan below.)

Contracts with geophysical contractors should also address risk management through adequate definition of the desired operating practices to minimize environmental impacts. Contracts should address:

- Types of equipment to be used.
- Types of energy sources to be used.
- Methods for preparing survey lines.
- Crew logistics.
- Line and camp restoration plans.

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- Waste handling and disposal.
- Pollution prevention measures.
- Emergency response plans.

1.2.5 Planning

Environmental issues must be part of both pre-survey and daily planning. The contractor and client must mutually ensure that relevant environmental issues identified during the evaluation and risk management stages described above are addressed during the planning stage.

An understanding of environmental stipulations imposed by the client's and contractor's policies and procedures, the landowner, other relevant land users, the local community, and government agencies is also essential to successfully complete the pre-survey plan. Thus stakeholder engagement activities are essential to a project's success.

The end result of the pre-survey planning should be a project- and area-specific Environmental Management Plan which can be integrated into the overall Project HSE Plan for use by the crew in the field. (See discussion of Environmental Management Plan below.)

Pre-Survey Planning

Site-specific pre-survey planning should be carried out by appropriate personnel. These operations and crew personnel can use the list below to check the environmental sensitivities identified and proposals already made and to identify additional items to be addressed. The list may also be useful in scoping the Environmental Screening Study and EA, as many of the issues should be reviewed in those documents and through stakeholder consultation.

TIME OF YEAR –

- How will conditions change?
  - Freezing and thawing.
  - Rainy season – flooding.
  - Wildlife breeding and migration areas.
  - Hunting seasons and other traditional land use activities.

REGULATIONS –

- What regulatory agencies will be involved in the survey?
  - Which is the lead agency?
  - When should the project be discussed with regulatory agencies?
  - What regulatory permits to work are required for the project?

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- Have the environmental regulations been reviewed concerning:

  - pollution?
  - hunting?
  - fishing?
  - timber cutting?
  - endangered species?
  - permitting?
  - sensitive habitats?
  - noise?
  - Harvesting?
  - Access?
  - Employment of labor?
  - land use?
  - Reporting?
  - claims settlement?

- Do all parties understand their reporting responsibilities?
- How is this information to be documented during operations?
- How far in advance do the notices or permit applications need to be submitted?

SCOUTING –

- What information is available that may assist the planning of the operation? Maps? Aerial photos?
- What operators have worked in the survey area?
- Are previous environmental profiles of the survey area available?
- Who needs to be contacted to establish mutual understanding?

  - Government representatives?
  - General area landowners?
  - Special interest groups?

- Are there seasonal access restrictions?
- What are the environmental implications and alternatives of the equipment selected?
- Can the survey or equipment be adjusted to access the terrain?
- Springs, wells, dams and other water resource areas?

  - What are water supply aquifer depths?
  - Should a pre-survey water sample be obtained from existing wells?
  - Should the flow rate be measured and recorded?
  - Is water removal from streams, lakes, rivers and/or stock tanks allowed?
  - Water currently polluted? Pollution sources identified?

- What information can be obtained and plotted on area maps or air photos to aid in operational planning?
- Area of responsibilities of the different regulatory agencies?
- Existing access, line, camp and other clearings that could be used for this survey?

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- Infrastructure and human activity?

    - High population areas?
    - Commercial forests and cultivated farmland?
    - Permanent structures such as pipelines, oil and gas wells, and buildings and their set-back zones?
    - Sensitive and unique areas (e.g., coral reefs, waste disposal sites and ordinance areas)?
    - Significant known archaeological, historical or cultural places?
    - Local hunting and fishing areas and trap lines?
    - Native allotments or reservations?
    - Special permit areas?
    - Diving or underwater operations?
    - Shipping, fishing and other marine activity

- Natural habitats, etc.?
- Flood plains and wetland areas?
- Steep slopes that require special access or erosion protection?
- Significant wildlife breeding, nesting, spawning or migration areas?
- Dangerous wildlife, i.e., bears, snakes, crocodiles, lions, etc.
- Are there a sufficient number of maps for distribution?

CULTURAL / ARCHEOLOGICAL –

- What cultural issues need to be addressed?
- What sites are of particular cultural importance?
- Who are the appropriate regulators?

WILDLIFE –

- What species of plants, animals and aquatic life are present?
- What procedures should crew members follow when they are encountered?
- Will any migration paths be occupied for significant periods?
- If the survey area contains endangered species, where can identification photographs be obtained?
- What identification training is needed?
- What special reporting procedures are needed?
- What quarantine procedures should be used to prevent the introduction of exotic species?

EMERGENCY RESPONSE –

- What emergency response plans are needed?
- What hazardous materials storage and use plans are needed?

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- What are the appropriate area regulations?
- Can non-hazardous substitutes be used in place of hazardous substances?

OPERATIONS –

- What reporting is required for contractor, subcontractors, regulatory agencies, and client?
- What are the regulatory restrictions or limitations on equipment?
- How will compliance with regulations and guidelines be monitored?
- What are the specifics on all permits?
- What field crew environmental and safety training is needed?
- What are the disposal requirements in the project areas?
  - What disposal facilities are available?
  - What are the approved disposal methods?
- What procedures should be followed, and who should be contacted in case of flowing shot-holes?
- What are the energy source adjustments when approaching set-back zones for structures, water wells and water bodies?
- What reclamation measures are appropriate and what will be needed?
- What maintenance requirements are needed to reduce or eliminate spills, exhaust gases or machinery noise?
- Will there be congestion of land crews or vessels in the survey area?
- Will current maps be issued or updated daily?

OPERATIONS SPECIFIC TO MARINE SURVEYS -

- How will soft starts (ramp-ups) be handled?
- What (if any) requirements will there be for dedicated environmental observers or monitors?
- How will visits by regulators be handled?

Information gathered during the pre-survey planning should feed back into the Environmental Assessment where necessary and identify requirements for the project-specific Environmental Management Plan.

Environmental Management Plan (EMP)

The purpose of the Environmental Management Plan is to describe measures and actions that will be implemented to eliminate or reduce key identified biophysical, social, cultural, and economic impacts to acceptable levels. These procedures and control measures should be established prior to mobilization of field operations.

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The environmental management plan should be initiated by the EA process. It wraps up mitigation measures, monitoring requirements, etc., from the EA and ensures that actions from the EA (i.e., procedure and plan development/implementation) are given to specific action parties.

The EMP also gathers or makes links to other relevant documentation/procedures/plans. All documentation developed during the planning, i.e. procedures, mitigation measures, emergency response plan, reclamation plan, guidelines, specific requirements of contractor, client and government, etc., should be gathered together in the Environmental Management Plan. These elements are discussed further below.

Example Mitigation Strategies

- Exclusion zones - Areas where operations are completely, seasonally or partially excluded may be listed within various agency and landowner permits or the EA may identify where exclusion zones should be voluntarily implemented during the operations. Exclusions may apply to various land/marsh types, levees and other water control structures, restoration projects, areas of protected wildlife and vegetation, and archaeological sites. In the marine environment, this may include timing of surveys to avoid fish spawning, whale migration, recreational activities, etc.

- Restrictions - Equipment types, number of passes for each equipment type, marsh water levels, crops and irrigation, dates and times of operations, minimum holes depths, and permissible line clearance are all possible restrictions that may be defined within various permits and/or addressed in the company's plans and procedures. In the marine environment, this may include airgun soft start (ramp-up) procedures to minimize disturbance to marine mammals. Appendix B contains an example procedure for minimizing acoustic disturbance to marine mammals from seismic surveys.

- Additional requirements, including onsite environmental monitors, periodic environmental inspections, daily/weekly progress reports, meetings with agency representatives and mitigation requirements are crucial to ensuring an environmentally successful project, as well as being a frequent condition of landowner and agency permits.

Guidance on Field Operations and Equipment Types

- Equipment types deployed will depend on terrain conditions and suitability. This equipment, in turn, may determine the operational techniques required.

- Airboats can be operated over the majority of marshland. Carefully planned airboat operations have minimal impact on the environment and provide efficient transportation for personnel, equipment, mini-rams, and lightweight drills.

- Marsh buggies are suitable for solid marsh areas. Lightweight buggies can be used on less stable marsh provided the surface does not break. Carefully planned buggy operations in

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suitable marsh conditions have a low impact on the environment. Marsh buggies are suitable for carrying vibra-rams and drill units. The weight of the vibra-ram may also be a significant factor. Lightweight MarshMaster buggies are suitable for transportation for personnel, equipment, mini-rams and lightweight drills. MarshMasters offer an alternative to airboats when the terrain is unsuitable.

- Skiffs and ski barges are used for transporting equipment and personnel along access canals and other waterways. Areas of no wake may be designated to protect riverbanks and levees. Man-made canals may be privately owned and no access permitted.

- Helicopters may be used to transport equipment to field locations, thus avoiding the transport of heavy equipment across the land/marsh.

Highland buggies are utilized in farmland or prairie conditions to reduce surface disturbance.

- Off road trucks/All Terrain Vehicles, (ATVs) tractors, and highland buggies may be used on farmland and prairies, along tracks and paths around areas of land/marsh for the transportation of personnel and equipment. These vehicles should be used when track conditions are favorable.

Guidance on Damage Control

- Field operations must take into account the potential effect that continuous use of equipment in an area will cause. A restriction on the number of passes along each line for each type of equipment should be defined and may already be included in permits. The following provisions should be carefully monitored by the crew and any onsite environmental consultant in environmentally sensitive areas such as marshes and wetlands.

- Airboat tracks must be kept to specific paths along the line and traverses across open marsh kept to a minimum. Maximum use of available waterways and ponds should be used to

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reduce running across the marsh. In some areas, access to the marsh may be restricted to periods when local water levels are high. Regular inspections should be conducted to check the condition of the marsh. If mud becomes visible along airboat tracks, the operators must widen the path. If damage continues, areas should be flagged to indicate no access permitted. Noise restrictions may apply around inhabited areas and in vicinity of protected wildlife.

- Buggy ground pressure and the long-term effects on the marsh must be carefully considered before using a buggy. Marsh buggies may depress the marsh and tracks may be permanently visible. Marsh stability must be sufficient to hold the weight of the buggy and any equipment mounted upon it. Various options for buggies exist and should be considered when selecting buggies. Some permits may refuse permission to use buggies altogether while others may only approve particular types of buggies.

- Additional measures to protect the environment may be required in some areas. When possible, levees should not be crossed. When this is not feasible, jumps must be constructed from plywood to prevent the levee from breaking down. Alternatively, plastic mats may be suitable in areas where only light traffic is expected. Equipment staging areas and airboat parking lots must be similarly protected.

- Line clearance should be kept to a minimum and only sufficient to allow access for the equipment intended to follow. Line clearance standards/procedures should be clearly defined. All line clearance should be approved by the relevant authorities before commencement and carefully monitored for compliance with any restrictions in place. Remediation/restoration measures should be implemented as appropriate.

Guidance on Waste Management

Companies should develop and implement procedures to ensure appropriate disposal and handling of the many waste products that will be generated by geophysical operations. A waste management program should be developed, including provisions to maximize the use of recyclable and biodegradable items and to minimize waste.

Starting points may include:

- A site map of the camp.
- A list including quantities and types of potential pollutants.
- A list of best management practices.
- An Emergency Response Plan.
- Preventive maintenance programs.
- Substitution of less toxic chemical and materials.
- Improvement of materials management, segregating, separating, covering, berming, and diverting flow.

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- Training of personnel in proper handling and disposal techniques.
- A waste tracking system which ensures that company waste reaches its approved final destination.
- Contracting a hazardous waste/recycling handler (i.e., local operator verification) should address the following issues:
  - Is the hazardous waste handler licensed?
  - Does the transporter have industry experience in handling those wastes generated by your operations?
  - Where will the transporter ultimately dispose of the waste?
  - What precautions has the transporter taken to minimize spills or leaks?
  - Does the transporter have a written contingency plan for handling spills and leaks?
  - Have the transport drivers been adequately trained in emergency response involving spills or leaks?
  - What spill control equipment is available on their vehicles?
  - Will the transporter adhere to a set schedule in order to prevent the possibility of overloading available storage systems?
  - Have these systems been audited?
  - Are there records of past performance and, if so, performance improvement?

Guidance on Noise Effects

Companies should identify the types of noise and noise levels the geophysical operations will generate and what, if any, restrictions are or should be placed on noise levels. Ambient noise may be present in the survey areas and may be a contributing factor when two types of noise are combined. Operational noise may come from vehicles, helicopters, fixed-wing aircraft, vessels, drilling equipment, seismic sources, and personnel necessary for the operations. Ambient noise present may include prevalent winds, rain, waves at sea, local population, local commerce, and transportation systems such as highways, railways, or airports.

During the planning stage, directions the noise will be dispersed and the distance these noises will be audible to the human ear should be identified. It is necessary to consider both short- and long-term effects, if any, on local populations and wildlife.

Guidance on Spills

Companies should have in place and be prepared to implement a procedural guideline that identifies responsibilities and gives general advice on actions to take in case of accidental spills of waste, fuel or any hazardous materials. Marine vessels should carry a suitable spill kit in addition to equipment required in the Shipboard Oil Pollution Emergency Plan (SOPEP).

- If a spill occurs:
  - Enforce no-smoking or open lights near the spill.

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- Notify authorities immediately.
- Request professional assistance if required.
- Identify and record the navigation survey location, prevailing winds, currents, and sea state.

- Take remedial action to stem leakage.

  - Plug the hole.
  - Transfer spilling fluids to reduce head of pressure on the breached tank.
  - At sea, list or trim the vessel if possible to bring the hole above the water line.

Although rapid containment can help reduce the severity of the spill, caution must be used at all times. The safety of personnel must be the main concern. Personnel involved in clean-up or containment should have an adequate level of training and wear the appropriate Personal Protective Equipment (PPE) for the quantity and nature of the material spilled.

- Contain the spill.

  - Assemble a containment boom.
  - Prepare pumps if necessary.
  - Apply sorbent pads or mopping.
  - At sea, concentrate on the downwind, leading edge of the spill where the material may be the thickest.
  - Do not use any kind of dispersants unless directed to do so by appropriate authorities. At sea, it is not recommended to use dispersants in depths less than 20 meters (10 fathoms).

Identify all spills, regardless of quantity, and take action to prevent recurrence.

Historical, Archeological and Cultural Sites

Evidence of past cultures may be encountered during geophysical operations. Archeological sites should not be disrupted and the taking of artifacts is not allowed under any circumstances. Newly discovered sites should be recorded and reported to the appropriate authorities at the completion of the survey. Crews generally can lay cables and geophones across archeological sites without disruption. Geophysical operations can sometimes be conducted on or over archaeological sites without adverse impact on sites, especially in the absence of dozing or any activity known to cause significant surface disturbance. However, the survey may need to be adjusted to avoid a known site.

Work Force Code of Conduct

Companies should have in place a policy regarding employee, subcontractor, and third-party Code of Conduct. This should describe the expected behavior of all personnel associated with the

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project while engaged in the operations. This Code of Conduct should further describe the procedures for travel in and out of country, dealing with the local population and workforce, actual working hours, and after hour activity. These practices should be followed so as not to disrupt the community and local environments.

Emergency Response Plan

Operators should prepare an Emergency Response Plan during pre-survey planning. Planning reduces the potential for emergencies and their severity. The IAGC Safety Manuals for Land and Marine Geophysical Operations are recommended for assistance in developing safe operating procedures. Consider the following in developing the Emergency Response Plan:

- What events could require emergency response during this project?
    - Significant spills?
    - Other waste spills?
    - Damage to wells, pipelines and other surface or subsurface structures?
    - Fires and explosions in the survey area?
    - Medical evacuation?
    - Other emergencies (e.g., floods, storms, civil/political unrest, wars, terrorism)?
- What key steps are needed to recover from these incidents?
- Who is the Emergency Response Coordinator?
- How will the Emergency Response Plan be documented and posted?
- Who will act as public spokesperson?
- What are the responsibilities of individual crew members?
- What emergency response drills are needed?
- What reporting procedures are needed for government agencies by both the contractor and client?

Reclamation Plan

To ‘minimize the footprint’ at a survey site, efforts are needed to assess the impact of operations in the local, regional and global environments, with the intent to return the area to its original condition. By educating all involved parties, physical disturbances can be minimized and restoration of the site to its original condition can be achieved.

Environmental monitoring may be necessary to gauge the impact of operations on the site. By implementing appropriate plans with sufficient detail, it is possible to minimize and control waste generation, limit physical disturbances, and operate in a responsible manner. Geophysical contractors, in concert with client companies, should aspire to restore the area to its original state.

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A reclamation plan should be prepared before the survey and be agreed to by the operator, local authorities and landowners. It may include promoting re-growth through seeding, fertilization and replacement of vegetation with an approved species. In some cases, it may be appropriate to drag or plow the lines to recondition and loosen the surface prior to re-vegetation. Before and after photographs can assist documentation of the reclamation. A closure inspection by management should ensure adherence to the planned environmental stipulations.

For the most part, reclamation should be performed during the survey operations. Each part of the crew is responsible for ensuring that no refuse is left in their area of operations and that all the equipment they use is collected. Additionally, the back line crew must double check that the line is clear of refuse and equipment. In some circumstances, it may be necessary to employ an additional reclamation crew responsible for restoring the area according to the reclamation plan. It is the responsibility of line management to ensure the reclamation program is being followed.

Activities which should be taken are to:

- Pick up all pin flags, signs, flagging, mud products, and refuse.
- Ensure that the natural drainage of the area is restored where possible.
- Install cross drainage ditches on steep slopes to divert run-off into the adjacent vegetation.
- Remove all temporary stream crossings. Stabilize the stream banks at the crossings.
- Undertake active re-vegetation measures if natural re-growth is not considered sufficient.
- Implement additional erosion control measures if needed in some areas.
- Take appropriate measures to discourage access to the area after completion of the operation.
- Ensure that campsites are clean and that no refuse has been left behind.
- Ensure that the sump has been filled in. Put an extra cap of soil on top to compensate for compaction.
- Ensure that fences and gates are restored.
- Audit to ensure compliance with permit requirements and reclamation plans.

1.2.6 Implementation and Monitoring

Execution

It is essential to establish and clearly communicate responsibilities for the completion and execution of the environmental management plan to all parties concerned, e.g., Party Manager, Quality/HSE Advisor, etc. Sample duties should include:

- Providing permit and agency information to enable the crew to define an operational plan which minimizes the operation's environmental impact.

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- Supervising the operation and ensuring compliance with the HSE Management System and all environmental, safety and health regulations affecting the crew operation.
- Being the custodian of the plan and revising and updating as required, including advising and providing feedback to the senior line manager on the implementation of this work procedure.
- Supervising the field operation, ensuring that all field staff and subcontractors are familiar with the procedures established to minimize environmental damage and that all damage is promptly reported to, and appropriate remedial action taken by, line managers.

Implementation

In the implementation step, those who are responsible for the expectations will develop the tactics to address priorities. Clearly defined roles and responsibilities are critical, along with training to support implementation.

Mobilization Meeting

A meeting of all crew personnel should be scheduled to familiarize them with the project's environmental management plan before the start of operations. Each person needs to understand what can and cannot be done. Everyone should become familiar with reporting procedures. Early clean-up of all environmental problems, regardless of cause or responsibility, should be emphasized. An Emergency Response Coordinator should be designated. Each operation should have adequate supplies of containment and clean-up equipment and crew members should be delegated to become proficient in its use.

Environmental Monitoring

An environmental monitoring program should be implemented by the field crew consistent with the requirements of the Environmental Management Plan. Monitoring before, during and after a geophysical operation measures the effectiveness of an environmental program. The monitoring will be site-specific. In some cases, there may be specific monitoring requirements. Operators should consider an evaluation of environmental performance at the conclusion of an operation to facilitate improvement.

Communications / Reporting

Communications should be considered a vital aspect for successful environmental management. HSE issues and information may be communicated within the organization, to the client, and any subcontractors or interested third parties through:

- Daily, weekly, monthly reports, safety logs, near-miss reports, incident reports, and production logs.

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- On-site meetings such as:

  - Mobilization meetings.
  - Crew HSE meetings.
  - HSE committee meetings.
  - Toolbox meetings.

To emphasize the importance of keeping an open line of communications between upper management, line management support and crew personnel, reporting of other meetings will be beneficial, such as:

  - Pre-survey HSE meetings.
  - Weekly operations meetings.
  - HSE Review Committee meetings.
  - Management status meetings.

Procedures also need to be established for communication with stakeholders and the results of those communications incorporated into the HSE management activities.

Follow-up/Actions

Each operational site should display a “Critical Actions List" which encompasses all items brought forward by the environmental plan which require action. This list should clearly display the required actions, the names of the persons responsible for the action, and the target date for completion. Finally, it should show the date that the action item was completed for closure purposes.

Site management and any visiting line management should periodically review and sign off on this “Action List” to ensure that all actions are being followed and completed in the manner necessary.

Daily Planning

Daily planning should address the following questions where relevant (and again, consistent with the requirements established in the Environmental Management Plan):

- What steps will be taken to minimize -

  - Vegetation clearing?
  - Vehicle, boat, aircraft, and foot traffic?
  - Travel in sensitive wildlife areas?
  - Stream crossings?
  - Fire hazards?
  - In-field equipment maintenance?
  - Risk of spills?

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- What daily routine will ensure -

    - Proper waste disposal?
    - Progressive line and camp clean-up?
    - Vehicle leak or spill detection?
    - Spotting and reporting of endangered species?
    - Reporting of environmental incidents, loss of containment, disturbance to wildlife, etc.?
    - Non-compliance within stipulated parameters?
    - Avoidance and protection of historical, archeological and cultural sites?

1.2.7 Auditing and Review

Environmental Audits

Environmental audits provide an internal and external control to ensure the environmental management system functions as planned. Audits should be done on a timely basis in order to:

- Verify that operations follow regulations, policy and site-specific procedures. (i.e. the contractor's Environmental Management System and the Project HSE Plan).
- Verify that monitoring practices are effective.
- Identify procedures that can improve effectiveness.

Ideally, audits should be conducted by the environmental staff and line management. The audit results should be documented and a report prepared to address:

- Conformity or non-conformity.
- The effectiveness of the implemented Environmental Management System.
- Implementation of any corrective actions recommended in previous audits.
- Follow-up to assure effective implementation.
- Conclusions and recommendations incorporated into future programs.

The findings, conclusions and recommendations should be reviewed by line management who should then:

- Ensure the continuing suitability and effectiveness of the Environmental Management System.
- Address the possible need for changes to policy and objectives.
- Address the possible need for improvements and changes to procedures in the field.

Project Review and Final Report

Upon survey completion, a review should be done to determine:

- Was waste properly disposed of?
- Was any fuel/oil spilled?
- Was any equipment lost?
- Were all applicable reports filed?
- Have all regulations been satisfied?
- Status of rehabilitation efforts (if required)?
- Were EA recommendations useful and appropriate?
- What improvements can be made next time?

A final report may be required by the client.

2.0 LAND OPERATIONS

(To be used in conjunction with the General Operating Procedures and procedures for specific environments addressed in relevant sections below)

2.1 START-UP

It is essential to conduct health safety and an environmental (HSE) meeting at start-up. All relevant crewmembers, supervisors, and a client representative should attend. Field workers and their supervisors need to understand what is required of them. Less experienced personnel may need more background. Attendance and topics covered at all environmental and safety meetings should be documented.

Prior to start-up, it will also be necessary to:

- Reconcile any conflicting environmental and safety concerns.
- Explain the environmental planning to pertinent agencies.
- Discuss environmental issues and reporting procedures with crew supervisors and managers, senior crew personnel, and subcontractors.
- Define minimum approach distances and protocols for environmentally sensitive areas (such as water bodies, drainage canals, breeding or nesting grounds, etc.) before clearing begins, mark them clearly, and respect them as the survey continues.
- Describe the emergency response plan, including functional responsibilities, to all personnel.

2.2 CLEARING/SURVEYING

When clearing areas for geophysical operations, whether preparing lines, access routes, campsites, or helipads, the objective is to provide sufficient and safe access for personnel and equipment while minimizing environmental effects. Excessive clearing of trees can increase erosion. Clearing near water bodies can increase sedimentation and affect fish populations. Clearing activity may also disrupt wildlife. Fallen vegetation can block natural drainage routes. A straight, uninterrupted field of view down a survey line in a forest can be aesthetically disturbing. Lines may also be used by people to obtain access to new areas, possibly increasing poaching and colonization and other activities with adverse environmental and/or social impacts.

Reducing the effect of clearing can be achieved by minimizing the amount of vegetation that is cut. Leaving root stock in place or reseeding or replacing with appropriate plants can assist regeneration.

Hand Cut Lines

Lines should generally be hand cut for heliportable operations, on steep slopes, at water crossings, and in rainforests.

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Hand cut lines in rainforests can be kept to a minimum width thus reducing the effects of clearing.

It is essential to minimize the amount of vegetation disturbed. Use of Global Positioning System (GPS), acceptance of shorter line of sight, and other practices which reduce the need for tree clearing should be promoted. Specific activities which should be done are to:

- Minimize the width of the line consistent with safety (e.g., no wider than six feet or two meters).
    - ♦ Do not cut trees of a diameter greater than the local regulations permit (or, in the absence of regulations, greater than 8 inches or 20 centimeters).
    - ♦ Leave the topsoil, root-stock, and seeds on the line to encourage better regeneration
    - ♦ Leave in place smaller vegetation with a safe walking surface.
- Remove leaners (cut trees that have not completely fallen) to prevent them from pulling down other trees, to enhance decay, and to prevent injury when leaners fall.
- Implement fire prevention measures if fire hazards exist.
    - ♦ Do not build fires when the vegetation is dry.
    - ♦ Explain smoking hazards and controls to be implemented relative to fire prevention.
- Do not fell trees across pipeline rights-of-way, trails or watercourses.
- Try to cut and scatter limbs to ensure that tree trunks fall flat to the ground. Contact with the ground speeds up decay.

Access Roads and Vehicular Survey Lines

Clearing vehicular access to or along the line may be with a bulldozer, shredder or similar equipment. When a line is cleared by this method, close supervision of equipment operators is needed to ensure adherence to procedures and regulations to avoid making such access deeper and wider than required. Specific best practices are to:

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- Use existing routes as much as practical.

    - ♦ Leave isolated trees and significant stands of vegetation undisturbed if practical.
    - ♦ Weave around trees using the path of least resistance to minimize timber loss.
    - ♦ Minimize the width of the route, particularly at water crossings.
    - ♦ Clear minimal passing areas as needed and approved.

Weaving around trees using the path of least resistance minimizes timber loss. This tracked shot-hole drilling rig is being used for exactly that purpose.

- Keep routes away from water bodies, if practical, except at crossings.
- Hand cut lines at water crossings to prevent putting sediment and brush into the water.
- Do not block or fill any natural drainage paths, where possible. Return drainages to their natural state when finished.
- Allow cross route drainage.
- Build periodic diversions to prevent the route from becoming a new drainage path.
- On side slopes, tilt route slightly downhill to allow better drainage and reduce erosion.
- Avoid bulldozing or grading steep slopes. If the route is on a steep slope, hand cut the line when practical.
- Build gates at fence crossings to reduce drive-arounds if allowed by the fence owner.
- Interrupt the line of sight to make the route less obtrusive.

    - ♦ Put a dogleg in the route where it intersects a road or water body.
    - ♦ Alternatively, do not clear a short portion along the line when practical.

- Abandon routes in a manner to discourage the use of routes after operations (such as by blocking them).

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- If a landowner requests a route for his own use after operations, make the landowner aware of any adverse environmental and other effects that may result.
- Check with local authorities before providing a route.

- Choose a direction in which to fell trees to reduce collateral effects and promote regeneration.
- Cut tree limbs so that tree trunks fall flat to the ground to speed up decay.
- Remove leaners when it can be done safely.
- Where needed back-sighting is blocked by a branch, remove it rather than the entire tree.
- Control visitors and noise.
- When bulldozers are necessary to access an area:

  - Keep blade about four inches or ten centimeters above the ground to leave the root stock in place.
  - Use a cutter blade behind the main blade to cut off small shrubs above the ground.
  - Lower the blade only to remove objects that could create a safety hazard.

Camp Clearings

The main goal is to minimize environmental impacts by minimizing the number of camps, as well as the size of the area that must be cleared.

Using existing clearings, and restricting the use of locally cut lumber minimizes the environmental impacts that could be caused by camp location and construction.

- Ensure that camps are located in permitted areas.
- Plan camps to minimize the number of sites needed.
- Use natural or existing clearings to the maximum extent possible.

  - Use the same fly camps for all crews.
  - Use camp sites from previous operations when possible.

- Minimize the size of the cleared area consistent with safety and health considerations.
- When clearing a camp site, minimize disturbance of topsoil and vegetation root stock as much as possible.
- Minimize the area used by vehicles in the camp.
- Locate camps above the highest annual flood level if practical.

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- Do not permanently disrupt the natural drainage of the area.
- In areas of heavy rainfall, disperse runoff from the camp in order to minimize erosion.
- Install drainage patterns away from streams, rivers, etc., where possible.

Helipads and Airstrips

Clearing areas for helipads and airstrips is very similar to clearing for camps, except that more attention must be paid to any tall, surrounding trees that could interfere with the flight path on approach or take-off of an aircraft.

- Use existing or natural clearings rather than clearing new areas.
    - ♦ Use hilltops for helipads if lightly vegetated or build them next to water bodies to reduce the need for clearing.
    - ♦ Plan helipads and airstrips in areas of sparse vegetation.
    - ♦ Make multiple use of camps and helipads (i.e., use the survey fly camp as a helipad later).
    - ♦ Use line intersections as helipads where appropriate.
- Keep the clearing to a minimum size consistent with safety. Consult the aviation subcontractor for guidance and specifications.
- Do not disrupt the natural drainage of the area.

Placing helipads close to water bodies reduces the need for clearing.

Brush Disposal

Reducing the amount of vegetation cut reduces the amount of disposal necessary.

- In commercial logging areas, coordinate with forestry officials and permit holders.
- Dispose of brush progressively with clearing.

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- Dispose of brush out of the way of access roads.
- Do not dispose of brush in water bodies.

- Remove obstructions and restore natural drainages.
- If needed, windrows should be on the downhill side of the right-of-way to act as a sediment trap and to reduce erosion.

  - On level terrain, design windrows so they do not leave visible signs or have the potential to block or channel water flows.
  - To reduce the fire hazard, do not push windrows against standing timber.
  - Compact the windrow to speed up decay, or preferably, roll it back over the line to prevent access.
  - Alternate windrows to opposite sides of the line to allow fire breaks and access.

2.3 RECORDING OPERATION

Recording crews must pay attention to fire prevention. Allow supervised smoking only at designated times and locations. Restore the line according to the reclamation plan, unless otherwise specified.

- Drive only on designated roads and trails.
- Prohibit unsupervised smoking, especially when working in dry, vegetated areas.
- Pick-up debris, garbage, pin-flags, survey stakes, flagging, etc.
- Restore according to the reclamation plan.

Report any remaining clean-up or restoration needed for attention by a special reclamation crew.

2.4 TRAVEL

Land Travel

Terrain and other environmental conditions vary to such an extent that rules for land travel can only be stated in general terms. Where regulations do not exist, common sense should prevail.

The following recommendations apply to some or all conditions existent in land travel. In general, they are intended to be useful in formulating a common sense approach to addressing environmental concerns for any given area of operations.

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Slow vehicle speeds and careful driving are helpful in limiting dust and avoiding wildlife or domestic animals.

- Travel on existing roads, trails, or fence lines wherever practical.
  - ♦ Use a “no shortcuts” policy.
  - ♦ Minimize travel along the line by good daily planning.
  - ♦ Use passing areas rather than overtake in the vegetation or clearing of a double width.
  - ♦ Minimize activity off the line.
- Limit vehicle speed to avoid damage to topsoil and raising dust.
- Avoid driving on lines after heavy rains as vehicles can leave ruts. Rehabilitate all ruts.
- In the absence of specific guidance, use vehicles that do not create ruts.
  - ♦ Try to prevent creation of ruts in order to minimize line width.
- Plan efficient refueling of vehicles daily to minimize travel and the chances of spills.
  - ♦ Periodically check for leaks under all operating vehicles. Remove contaminated soil for proper disposal.
  - ♦ Keep a leak/spill report for each vehicle as part of a daily inspection plan. Make repairs at the earliest available opportunity.
- To prevent fires when driving over dry grasslands, clear the undercarriage of brush.
  - ♦ Be especially careful of catalytic converters, as they operate at high temperatures.
  - ♦ Use spark-arresting mufflers in dry areas.
- Have firefighting equipment available while operating in dry areas.
  - ♦ Make sure all vehicles carry a suitable fire extinguisher.

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- Do not throw litter or cigarettes out of vehicles.
- Take special care while driving where there is wildlife or domestic livestock to avoid accidents.
- Do not sound the vehicle's horn near colonies of birds or other wildlife.
- Control site access by visitors and unauthorized personnel.

Water Travel

Caution and common sense can help minimize environmental effects of travel on water. Water travel is preferred to off-road land travel. When traveling over water, care should be exercised to reduce the risk to aquatic life. Speeds should be adjusted to minimize wake to protect shorelines. Fuel transfer and handling should be done in such a way to prevent spills.

- Use slow speeds to minimize bank erosion.
- Be cautious of aquatic life.
- Plan operations to minimize disturbances in nesting areas and areas where aquatic life exist.
- Make sure fuel tanks have caps and are not filled over the water.
- Keep absorbent materials on board in case of fuel spills.
- Plan docking areas such that safe and environmentally-sound supply, maintenance and refueling activities can take place.

Air Travel

Flight paths and approaches should be planned to minimize disruptions to animals due to noise and downdrafts, which may also create a nuisance in populated areas.

- Maintain aircraft in flight at a suitable altitude, consistent with local regulations and safe operating practices, to avoid unnecessarily disturbing wildlife and people.
    - ♦ Keep aircraft at an appropriate distance from sensitive wildlife areas.
    - ♦ Check regulatory requirements regarding minimum altitudes.
    - ♦ Maintain aircraft at a suitable distance from cliff faces where there are nesting birds.
- Locate landing areas and flyways to minimize disturbance to wildlife and the public.

2.5 STREAM CROSSINGS

Types of stream crossings include fording, log fill bridges, timber bridges, culverts, snow and ice bridges, and boats. Stream crossings will depend on the terrain and the equipment being used.

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When making stream crossings, care must be taken not to permanently disrupt the natural habitat. Disruptions include increased sediment in the stream, blockage of fish migration and removal of stream bank vegetation, as well as permanent alterations to the watercourse or its flow rate.
If temporary structures are required, construction materials should be removed once the crossing is no longer required. If a more permanent crossing is required, careful consideration must be given to the construction of the crossing so as to minimize the effect to the nearby land and water.

Fish migrate for reproduction, growth, and, for smaller fish, to escape predators by moving to smaller channels. Migrations can occur over long distances and durations. In cold climates, fish move downstream to deep pools for over-wintering before the winter freeze sets in. Therefore, project activities should be scheduled to minimize effects.

Stream bank vegetation shades the stream, keeping temperatures down. If the temperature rises, the fish population will move to more favorable habitats, if available, or may be replaced by a warmer water fish species. Stream bank vegetation should not be disturbed by survey line crossings. Camp construction near streams should be planned with environmental effects in mind.

Fords

Shallow fording is simply finding a good, safe spot in a stream and driving or walking across. Ideally the crossing will be in an area with a firm or gravel bottom. Existing stream crossings should be used whenever practical. The key objectives are to reduce sediment disturbance in the stream and potential erosion of the banks.

- Scout for places to ford a stream where:
    - There is a shallow, stable approach.
    - The water is not too deep and has a firm or gravel stream bed.
    - Minimal clearing of stream bank vegetation is necessary.
    - The approach is not on the outside of a bend in the stream.
    - Sediment disturbances will not affect fisheries or fish pools immediately downstream.
- Minimize the number of fords created by using nearby existing crossings.
- Hand cut vegetation at the approach and move it away from the stream. Do not allow debris to fall into the stream. If necessary, stabilize the approach with a clean, coarse granular material or by using wooden planks or metal runners.
- Ensure that approaches do not permanently alter the natural drainage into the stream. Temporary run-off diversion may be appropriate to minimize erosion and vegetation loss.
- Cross at right angles to the stream. Drive slowly and do not spin the vehicle's wheels.
- Minimize the number of fordings by good daily planning.

Log Fill Bridges

Log fill bridges may be used in operations requiring unusually heavy equipment to cross a stream. These bridges are structurally superior to piling brush and debris over a stream in order to cross. Log fill bridges are best used when there are no fish present in a stream, when fish passage is not required or when the stream channel is dry. The logs can be reused for other bridges. In any case, it must be removed from the stream bed on completion of the survey.

Snow and Ice Bridges

Snow and ice bridges facilitate safe crossings of frozen streams where they are not already frozen down to the stream bed and which otherwise would not bear the weight of vehicles crossing. They may also be used to reduce bank erosion. These bridges thaw at the end of the winter season. They should not alter the water flow or quality of the stream in the process. The ice bridge should be slotted if the bridge could form a temporary dam while thawing.

- Scout for the best areas to build bridges where:
    - Approaches are of low slope.
    - Minimal hand clearing of stream bank vegetation is necessary.
    - There are no pools for overwintering fish.
    - Fish migration channels will not be closed.
- Ensure that the bridge is thick enough to support passage and check it frequently. Check the weights and ground pressure of all vehicles which may use the bridge.
- Do not build an ice bridge that will stop the flow of the stream under the ice. Full depth freezing will cause icings further upstream and could reduce the pool size for overwintering fish.
- Culverts can be used to handle overflow but must be removed before the thaw.
- Use only snow and ice to construct the bridge or its approaches. Do not use soil or debris in construction.
- Construct approaches with snow or ice of sufficient thickness to protect the stream bank.
- Remove equipment which falls through the ice as quickly as possible.
- Cross ice bridges quickly to avoid crushing.
- Minimize the number of crossings by efficient planning.

Timber Bridges

Timber bridges may be used for crossing small creeks, streams and swamps to ensure employee safety. The use of bridging over the stream minimizes the effects on fish. However, unauthorized use potentially promotes adverse secondary environmental effects. Therefore, bridges should be removed according to the reclamation plan. Local timber may be used to build bridging, but tree cutting and clearing should be kept to a minimum.

Culverts

Culverts are sometimes used as temporary crossings of streams. They must be properly designed, installed, and maintained to protect the stream and its environment. Culverts should be removed at the end of the job. Other methods of stream crossing should be considered first.

Boats

Boat crossings do not normally present significant environmental problems but do present significant safety issues. Adequate water depth is required to minimize effects on aquatic life. Docking facilities should be built to avoid erosion of banks. Measures must be taken to prevent discharge of fuels, oils and lubricants.

2.6 BASE CAMPS

Managing a base camp must assure health and hygiene while minimizing pollution due to camp wastes. Disposal of water usually can be through a properly functioning sump. Disposal of raw sewage can be through an approved septic system. Food wastes and packaging must not be left lying around, as they attract wildlife and are unsightly. Further, some packaging does not decay. Fuel and oils must be handled and disposed of properly.

Treating drinking water to meet health standards can be accomplished in many ways. Here a two-bladder system is used: while treating one bladder from the chemical treatment shed, water from the other bladder can be used.

Land Camps

- Locate sewage sumps in a position where they are:
  - In absorbent soil.
  - Downslope and away from the camp (and downwind if practical).
  - Downstream from the camp water source and above the high water mark of any nearby water body.
- Construct a sump:
  - Deep enough to contain the volume of waters from the camp plus enough volume for rainwater, or cover the sump.
  - So that surface water cannot run into it.
- Cover the sump to reduce access to insects and animals.
- When abandoning sumps, place an extra cap of soil to allow for compaction.
- Locate latrines a suitable distance from any water body.
- Handle sewage so that surface and groundwater are not contaminated.
- If sumps are inappropriate, sewage treatment plants may be necessary.
- Store and handle fuels in accordance with the procedures in the "Hazardous Material, Fuels and Oils" section.
- Separate waste materials and ensure appropriate disposal.

Non-combustible garbage should be collected, segregated, and sent to a local, authorized disposal facility, if available.

- Level trailers by jacks rather than by leveling the ground.
- Abandon campsites according to the reclamation plan.
- Ensure that drinking water meets health standards.
- Ensure that any fires are controlled and that fire fighting equipment is available.
- Locate generators close to the camp and require a noise barrier. Take into consideration the effects of prevailing winds.
- Clear any grass, brush, and other flammable material away from the generator and fuel supply. (A distance of 15 m (50 ft) is recommended.)
- Equip the generators with spark arrestors. Inspect the spark arrestors frequently and repair or replace them if they become defective.

Floating Camps-Quarter Boats

In some operating environments, camps and other facilities may be on boats or barges. This allows the camp to be moved intact, eliminating the need for land camps. These vessels should be self-contained with water and sewage treatment facilities.

- Choose mooring sites to minimize environmental disturbances.
- Remove waste and garbage to an approved facility for proper disposal.
- Do not discharge waste overboard.
- Store explosives, fuels and oils in accordance with the section "Hazardous Materials, Fuels, and Oils".
- Have in place emergency procedures for containing inadvertent spills.
- Minimize blockage of water ways used by other vessels.

2.7 SHOT-HOLES

Environmental concerns include minimizing surface damage during shot-hole drilling operations, shallow aquifer protection, and proper plugging. If the hole is wet, it may have penetrated an aquifer and care may be needed to preserve its integrity. Special procedures will be required if aquifer contamination and flowing holes are perceived to be a problem.

General Practices

- Consider using biodegradable charges where appropriate.
- Adapt the charge to the immediate environment. Where the charge must be reduced for environmental reasons, consider the use of vertical stacks (several small charge shots at the same shot point instead of one large charge shot) to maintain signal quality and penetration.
- Ensure that appropriate offsets are used at structures and water bodies.
- Do not leave any refuse around the drill location. Do not burn trash at the location; remove it for proper disposal.
- Take measures to ensure all charges are fired. Disable misfired charges by breaking the capwire as deep as practical. Consider double capping of charges as a viable method to reduce the possibility of a misfire.
- After drilling and loading the shot-hole, backfill it with cuttings or another authorized material.
  - Avoid adding backfill material too quickly because it can cause bridging.
  - Consider placing a shot-hole plug near the surface to avoid wash-in.
  - If a hole is to be left open for loading later, place a temporary plug at the surface to remove the risk to animals of being accidentally trapped or injuring themselves in the open holes.
- Level out excess drill cuttings around the shot-hole if regulations permit.
- Remove all trash from around the shot-hole as part of standard operating procedure.

Wet Holes

- Backfill wet holes to just above the standing water level to protect aquifers.

  - ♦ When necessary, use loading poles to ensure the material is properly backfilled.
  - ♦ After covering the standing water level, use cuttings and/or other authorized material to fill the remainder of the hole.
  - ♦ Avoid adding backfill too quickly because it can cause bridging.

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Properly conducted shot-hole drilling operations can minimize surface damage in a variety of environments.

Flowing Holes

- If a flowing shot-hole occurs:

  - ♦ Notify the Party Manager, who will coordinate plugging efforts and, if necessary, notify the authorities.
  - ♦ Attempt to plug it immediately.

- Do not load explosives into flowing holes.
- If the flow is too great for backfilling, consider placing an inflatable plug or other suitable method at the top of the aquifer to stop the flow.

2.8 POULTER METHOD

The Poulter method uses explosive-filled pouches held on stakes commonly detonated above ground. Several pouches, each on an individual stake, are detonated simultaneously in a source array. The Poulter method has very little effect on the environment because the explosives are detonated above ground. The main concerns are safety, noise, fire prevention and effects on animals and people.

- Maintain an adequate distance between the explosive and vegetation to prevent fires (usually greater than 1 meter/3 feet) and minimize vegetation disturbance.

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- ♦ Use low flash explosives to minimize risk of fire.
- ♦ Have proper firefighting equipment readily available to the shooting crew.
- ♦ Train personnel in proper fire-fighting methods.

- Ensure that the shooting crew checks behind them frequently for possible fires.
- Use procedures to keep personnel, livestock and wildlife safely away from the shot area.
- Make sure the clean-up crew picks up all trash (with a search width adequate to retrieve all debris), and that they carry firefighting equipment.

2.9 VIBRATORS

Vibroseis operations may consist of 4 to 12 vibrators, each weighing 60,000 lbs. Vibrators may be used in areas where data objectives warrant their use, explosives are difficult to use, environmental or safety concerns discourage the use of explosives or shot-hole drills, or when vibrators are more economical. Some simple planning and adjustments can significantly reduce the impact of vibrators on the environment and project area.

- Spread arrays or laterally space vibrators so as not to occupy the same tracks or base plate locations in order to significantly reduce environmental impact. While more area is initially impacted or occupied, recovery is considerably faster. This applies to all areas such as sand dunes, sagebrush, grasslands and agricultural areas.
- Where possible, start and end a day's work at road or trail crossings so as to minimize transit down lines to get in and out of the area.
- Plan refueling, maintenance, parking and staging areas at road or tail crossings to minimize traffic up and down the line.

These truck mounted vibrators benefit from low ground pressure tires which can significantly increase recovery time from any impact.

- For appropriate areas, consider the use of wide, low ground pressure tires. While this will initially affect a larger area, recovery will be considerably faster or the area will show no impact at all. At the same time, recognize that wide tires may present their own problems relative to gates, bridges, line changes, transit, transport, etc.
- Avoid back tracking and sharp turns with vibrators wherever possible.

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- Use parameter testing to help minimize the size of the vibrator operation. The selection of larger vibrators over smaller ones may reduce the number of vibrators required, power levels or number of sweeps required for good data and minimal impact.
- In certain urban and wildlife areas, consider the use of noise suppressant mufflers or skirts to reduce impacts.
- Do additional planning for vibrator operations which may involve archeological concerns, as the operations may occupy considerably more area than would otherwise be needed.
- Do conscientious and consistent preventive maintenance on vibrators to minimize oil leaks and ruptured hoses from their high-pressure systems. Have oil spill clean-up material readily available. Clean up oil or hydraulic leaks as soon as practical in the manner prescribed in this manual.

2.10 HAZARDOUS MATERIALS

Fuel and Oils

GENERAL

Geophysical operations require that some vehicles and generators be refueled and maintained in the field, while others are serviced in local towns. Small fuel and oil spills that might occur may result in contaminated soil, surface and groundwater. Clean-up procedures and equipment should be available. Operating procedures should minimize the chance and size of a spill during maintenance, refueling or storage.

STORAGE

All fuel storage tanks must comply with applicable local and national regulations. This includes properly documented and approved Spill Prevention, Contingency and Countermeasure Plans or similar documents.

- Install fuel storage facilities to contain spills and protect soil and groundwater.

    - Do not place stationary fuel storage facilities within the annual flood plain of a water course or closer than the locally recommended distance to a water body.
    - Locate fuel storage above the high water mark of any lake or stream.
    - Assure that fuel storage facilities have a secondary containment system, such as a berm, capable of holding the capacity of the largest container plus an appropriate volume to accommodate rainfall.
    - Put fuel storage on flat, stable terrain or in natural depressions separated from water bodies.
    - Cover fuel storage facilities to prevent rainwater incursion into the containment area.
    - Locate fuel storage a safe distance downslope from camps.
    - Store fuels in a manner which minimizes the potential for spills.

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- Inspect fuel tanks routinely for leaks and assure the person responsible for the vehicle or tank reports any leaks.
- Maintain stationary fuel storage areas free of other combustible material to isolate potential fires.
- Normally keep valves closed between fuel tanks which are manifolded together.
- Make sure fuel trucks have a valve between the output of the tank and the refueling hose.
- Keep emergency repair equipment for the refueling hose and connections at the tank site and on the fuel truck.
- Store drums above ground to prevent corrosion and facilitate leak detection.
- Although fuel drums may be off-loaded from aircraft on frozen lakes or rivers, do not store them on the ice unless required.

- Mark all fuel tanks or drums with their contents and the name of the company which owns or operates them.
- Where fuel trucks are used as stationary fuel storage facilities, assure that they comply with the same standards as a fixed installation.

LUBRICATING OIL

- Recycle, burn or dispose of lubricating oil in an acceptable manner. In some cases, it may be possible to mix used lube oil with diesel for use as fuel.
- Do not pour used lube oil onto the ground or into the sump.
- Recycle oil filters or dispose of them at an approved landfill.

REFUELING

- Perform fuel transfer operations so that there are no spills.

  - If practical, refuel vehicles directly from the fuel truck to reduce the number of fuel transfers.
  - Avoid fuel transfer operations in the flood plain of a river if possible.
  - Catch drips and spills during the refueling operations.
  - Place drip pans, absorbent material or drip basins under unsealed connections during refueling.
  - Carry out fueling on a concrete pad or an area that has been compacted and covered with an impermeable material whenever possible.
  - Do not fill fuel trucks or tanks to maximum capacity; leave room for expansion and vehicle movement.
  - As a recommended practice, use automatic shut-off nozzles for the dispensing hose (similar to those used in petrol stations).

- Make sure the fuel handler knows the location of all fuel shut-off controls and shut-off procedures and never leaves the refueling operation while it is in progress.

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- Make sure the fuel handler is trained to respond to and contain a fuel spill.
- While refueling boats, if automatic shut-off nozzles are not available, transfer the fuel to a portable tank on dry land and then transfer the tank to the boat. Where this is not practical, be prepared to deploy a containment boom quickly.
- If a fuel barge is used, have appropriate spill response equipment available.
- Use additional refueling procedures in the IAGC Safety Manual as appropriate.

LEAKS/SPILLS

- Have tools and materials available to clean up any spills or drips.
    - ♦ Make sure equipment includes absorbent material, shovels and plastic bags.
    - ♦ Use absorbent material of a color which contrasts with the background to avoid it being left on the ground after the clean-up (e.g., not white in snow-covered areas).
- While performing maintenance on a vehicle, ensure there are sufficient drip trays in position to catch any spills or leaks. A large, impermeable plastic sheet placed under the entire vehicle could act as a secondary catchment system.
- Clean up spills or leaks of oil or fuel immediately and dispose of all material properly.
- After cleaning up a spill, mark the site on the map for follow-up inspection.
- Report all spills or leaks in accordance with both the operator's procedures and local regulations.
- Store waste fuels, oils, lubricants, hydraulic fluids, solvents and certain paints appropriately and label them with the contents and operator's name. Use the same storage procedures as for unused fuel and oil.
- Have an emergency response plan available for spills. Communicate it to responsible crew members and review it regularly at training or safety meetings.

Engine Exhaust

- Service the exhaust systems of all vehicles and equipment on a regular basis to ensure that noise and emissions are kept to appropriate levels.
- Do not allow unburned fuels and exhaust gases to create localized pollution.
- Use spark arrestors to prevent fires in dry areas.

Other Hazardous Materials

Hazardous materials apart from fuels and oils are sometimes used by geophysical crews. These include solvents used for cleaning equipment, batteries, paints and cable repair materials. The preferred practice is to find substitutes that are not hazardous.

Explosives are considered a "hazardous material" in all countries. Regulations for their storage, use and transportation are well established and procedures are strictly enforced. Explosive safety is covered in detail in the IAGC Land Geophysical Operations Safety Manual.

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- Identify all hazardous materials used on the crew and attempt to find less hazardous substitutes.
- Ensure that any hazardous materials used by the crew are handled correctly and that the safety information provided by the manufacturer is available to the crew.

    - ♦ Dispose of waste materials in the manner approved by regulations.
    - ♦ Keep complete records of hazardous material purchases, usage, storage, disposal and spills according to local or company requirements.
    - ♦ Store hazardous materials correctly according to regulations and manufacturer's directions.

- Do not use CFC (chlorofluorocarbon) products and aerosol propellants, except with refrigeration equipment where closed recovery recharge systems are employed.

    - ♦ Use alternates to CFC systems for new installations.

- Transport, store, use and dispose of all batteries, especially lithium and nickel cadmium, in an approved manner. (See the IAGC safety manual for additional information.)
- Consider the use of recyclable or reusable materials whenever prudent.

2.11 WILDLIFE AND LIVESTOCK

Animals

The interaction between geophysical operations and animals can vary greatly, depending on the type and area of operation and the kind of animals. Consideration should be given to potential loss of grazing range, foraging area, modification of migration routes, and disruption of animals or nesting areas vulnerable to predators. There are times of the year when wildlife is more sensitive to external influences. Such times include mating, birthing, denning and spawning.

Surveys need to be planned to avoid animals and their living areas whenever practical. Where interaction is unavoidable, steps need to be taken to minimize disruption to animals and habitat. Protect of personnel in life-threatening situations is a priority.

- Stay clear of wildlife areas marked on the planning map to avoid active denning, nesting, spawning, migration and feeding areas.
- Where practical, conduct operations in a manner that will not restrict animal movement. Simultaneous operations on closely-spaced survey lines, such as during a 3-D survey, may have an increased effect on wildlife.
- Make a spotting report for endangered species if required by authorities.

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- Strictly forbid hunting and trapping of animals, including fishing, by crew workers.
- Do not allow purchase of wildlife killed for consumption, furs, or artifacts from local hunters, as this may encourage further killing. Purchase food only from recognized vendors.
- Do not allow crewmembers to purchase or accept gifts that would encourage locals to exploit wildlife.
- Kill wildlife only when it threatens human life, and then only when all deterrents have been exhausted.
- Report incidents and any significant problems with wildlife to appropriate authorities.
- Do not permit intentional harassment of animals.
- Minimize disturbance to traditional native hunting and fishing areas.
- Do not allow crewmembers to take part in locally authorized culls without management approval.
- Where practical, have livestock moved away from the operation.
- Do not allow pets on the crew.
- Ensure crewmembers have a basic understanding and can recognize the signs of animal-borne disease, such as rabies and/or distemper.
- Ensure that all closed gates are re-closed after passing through them and maintain the integrity of fences so that livestock cannot pass.
- Prohibit firearms on the crew unless specific exceptions are provided by senior management.

Plants

Plant growth and vegetation balance can be affected by vehicle passage and by the transfer of vegetation and seeds from one area to another. People and vehicles should be directed around endangered species. If such plants are known to exist in an area, attempt to operate during dormant seasons.

- Train personnel to recognize and avoid endangered species known to be present in the work area.
- Attempt to avoid known areas of endangered plants or operate during dormant seasons.
- Check with local residents on the location of endangered plant species.
- Report to authorities as required.
- Wash down equipment to avoid transporting seeds or plant diseases to non-native areas. Follow containment and proper disposal procedures for this wash water.

2.12 RECLAMATION ACTIVITIES

When there is a chance to perform reclamation activities during the survey, it makes for less of a task at the end of the job. Each part of the crew must be responsible for ensuring that no refuse is left in their area of operations and that all equipment they use is accounted for and removed. The approved Reclamation Plan must be followed for the reclamation process at the end of the survey.

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Example activities are to:

- Retrieve all pin flags, signs, flagging, mud products, and refuse.
- Ensure that the natural drainage of the area is restored.
- Remove all temporary stream crossings.
- Reseed or revegetate if natural re-growth will not be sufficient.
- Ensure that campsites are clean and that no refuse has been left behind.
- Ensure that the sump has been filled in. Put an extra cap of soil on top to compensate for compaction.
- Ensure that fences and gates are restored.
- Restore windrows back to the line.

3.0 DESERT AND SEMI-ARID CLIMATE OPERATIONS

(To Be Used In Conjunction With The General Operating Procedures and appropriate measures from Section 2.0 Land Operations)

3.1 INTRODUCTION

The desert and semi-arid regions addressed in this section typically have low annual rainfall, high rates of evaporation and may have high mean annual temperatures. Surface terrain may be mountainous or plains, exposed bedrock, gravel, boulders or shifting sand.

Because of the low rainfall, vegetation is sparse. Plants are slow growing, thorny, with small or no leaves and have an extensive root system. Damaged vegetation may take several seasons to recover, if ever. Vegetation loss compounds the erosion effects due to wind, heavy rainfall and flash flooding. Dune movement may also be reinitiated by loss of vegetation.

Vegetation is an important component of the food chain in the desert. Animals, such as insects, reptiles, rodents and a few larger mammals, rely on succulent plants for their water supply or, alternatively, on their prey.

These conditions require that great care be taken in conserving both vegetation and water sources.

3.2 PLANNING

- Use water wells as a source of camp water only if the water table will not be affected.
- Obtain any required local government approval for the use of water before establishing of a base camp.
- Test water potability before use.
- Plan the survey to bypass oases, springs or water holes.

Use of previously made tracks reduces impacts in desert or arid environments.

3.3 OPERATING PRACTICES

- Leave isolated trees and stands of vegetation undisturbed.
- Avoid driving over vegetation whenever possible.
- Use previously-made tracks for travel in deserts or savannas.
- Dispose of sewage in such a way that fresh water supplies will not be affected as a result of the high permeability of the soils.
- In planning waste disposal practices, remember that some wastes will be preserved for a much longer period in a dry climate than a moist one.

3.4 RECLAMATION ACTIVITIES

Performing reclamation activities during the survey operations reduces the work to be done at the end of the job. Each part of the crew must be responsible for ensuring that no refuse is left in their area of operations and that all equipment they use is accounted for and removed.

Example activities are to:

- Pick up all pin flags, signs, flagging, mud products and refuse.
- Ensure that the natural drainage of the area is restored.
- Actively reseed or revegetate if natural re-growth is not considered sufficient. Ensure that campsites are clean and that no refuse has been left behind.
- Ensure that the sump has been filled in. Put an extra cap of soil on top to account for compaction.

4.0 ARCTIC AND SUB-ARCTIC OPERATIONS;

(To be used in conjunction with the General Operating Procedures and appropriate measures from Section 2.0 Land Operations)

4.1 INTRODUCTION

For the purpose of this document, arctic and sub-arctic areas are generally defined as those having a mean annual temperature less than 10^{o} F and which show evidence of permafrost, either continuous or discontinuous. Generally, these areas lie at latitudes greater than 60 degrees north or south, although they do extend to lower latitudes in some parts of Asia. These conditions can also be found at very high elevations.

In the arctic, the permafrost is generally continuous and the surface thaws only to a shallow depth during the short summer months. This surface melt cannot soak into the topsoil due to the permafrost below and, thus, it either remains in place or drains to a natural water body. Vegetation consists mainly of grasses, mosses and lichens which make up the tundra. Occasional stands of willow can be found along riverbanks and elsewhere.

Maintaining this active layer is extremely important as it is this layer which supports the wildlife of the area. Minimizing disturbance to the tundra is one of the main objectives of these arctic environmental procedures. For this reason (and because of the ease of access over frozen rivers), geophysical operations in the arctic generally are conducted in the winter when sufficient snow cover exists. Summer operations can be conducted, provided vehicles of low ground pressure or helicopters are used.

Farther south in the sub-arctic, the permafrost is generally discontinuous and water drainage is less of a problem. Vegetation consists of grasses and coniferous trees for the most part. Geophysical operations are conducted mainly in the winter, but summer operations are not uncommon.

During the winter, when the majority of geophysical operations take place, wildlife activity tends to be at its least active period. Nevertheless, there is the possibility of interaction and conflict with wildlife, and precautions need to be taken. Concerns include wildlife being attracted to camp food waste (particularly foxes and polar bears), and disturbance of denning areas where females may be caused to abandon their young. Vehicular travel may also result in greater freeze-down of, or blockage of, upstream flows into pools used by over-wintering fish, thereby restricting the volume of water available to the fish.

Other issues specific to the arctic include the need to bypass pingos (gravel mounds caused by frost upwelling), protecting the underlying tundra by use of low ground pressure vehicles, and waste management due to the preserving effect of the cold.

4.2 PLANNING

- Mark the location of pingos on the survey map and plan an adequate exclusion zone around them according to their size.
- Check the permit to determine whether it contains any stipulations on the ground pressure of vehicles and plan to use the correct ones.
- Provide the crew with environmental training pertinent to the area.
- Consider use of biodegradable products including lubricants.

4.3 OPERATING PRACTICES

Clearing

- Do not lower the blade of a bulldozer to the level of the tundra while in motion. Keep the blade at least 10 centimeters/4 inches above the tundra. Use a shoe below the dozer blade only if it does not cause damage; otherwise, suspend the blade hydraulically.
- Never drop the blades of a bulldozer to the tundra; gently lower them.
- Never remove the tundra, as this provides insulation for the underlying permafrost. Take special care not to damage the organic mat in areas of patterned ground.
- Use only ice or snow when filling low spots on the tundra.
- If damage does occur to the tundra, put down locally recommended seed and fertilizer that complies with regulatory requirements on the exposed spot. Mark the spot on the map. (Keep a log and map for each vehicle and camp train, as well as a supply of seed and fertilizer.)

Helicopters may be used to transport equipment to field locations thus limiting the transport of heavy equipment across the permafrost.

Winter Travel

- Operate only when the surface of the ground is firm enough to avoid breaking through and when it has sufficient snow cover to avoid tundra damage, or is allowed by the authorities.
- Use vehicles with low ground pressure to minimize surface disturbance.
- Do not make hard, tight turns that break through the snow cover and damage the tundra.

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- Ensure that vehicle drivers are adequately trained in how to start their vehicles to avoid "jackrabbit starts" or spinning the drive wheels.
- When moving the camp, use enough tractors for each train to reduce the chance of surface disturbance.
- When vehicular travel is necessary near frozen rivers and streams, consider travelling on the ice rather than on the land to reduce erosion of the banks.
- Do not travel closer to a pingo than allowed by local regulations. This distance should be marked on the survey map.

Summer Travel

- Try not to make more than three passes on the same off-road track except at stream crossings. Offset each pass and distribute vehicle travel as much as practical to each side of the survey line. Check local regulations, however, as they may specify a different procedure.
- Avoid rutting the surface and damming drainage routes, because the resulting concentration of water can warm the permafrost.
- Ensure that all travel is only for the purpose of the survey. Do not permit side trips for sightseeing.

Wildlife

- Bypass sensitive areas identified by the local authorities, such as denning areas and pools for over-wintering fish.

Camps

- Store grey water (shower and basin drainage) separate from black water (toilet drainage).

Skid mounted waste burner for use in arctic camps help ensure correct disposal methods.

- Dispose of grey water by appropriate methods such as:
  - ♦ Discharging it to the surface, if permitted by authorities.
  - ♦ Boiling it off to the atmosphere.
  - ♦ Returning it to a central disposal facility.
- Incinerate solid sewage and sludge or send it to a disposal facility.

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- Consider using special incinerating (non-flushing) toilets to avoid black water production.
- Use melted snow only for washing. Do not use it for drinking water unless passed through a suitable purification system.
- Incinerate kitchen wastes daily. Recycle metal and plastic cans or dispose of them in accordance with local regulations.
- Contain garbage in animal-proof containers until incinerated.
- Bag any residue from incinerating combustible solid waste (ashes) and return them for proper disposal.
- Each time the camp is moved, check around the area and pick up any debris found.

4.4 RECLAMATION ACTIVITIES

Performing reclamation activities during the survey operations reduces the work to be done at the end of the job. Each part of the crew should be responsible for ensuring that no refuse is left in their area of operations and that all equipment they use is accounted for and removed.

Example activities are to:

- Visit each area that has been reseeded during the survey (by helicopter when appropriate to minimize ground damage) to check that the seed germinated and the vegetation is growing. Reseed again as necessary.
- Visit each camp location and survey line to ensure that the area is clear of pins, flags and debris.
- Over the summer period when the crew is inactive, store camp trailers on logs or gravel pads to prevent extensive depression of the ground surface and freezing the runners into the ground.

5.0 RAINFOREST OPERATIONS

(To be used in conjunction with the General Operating Procedures and appropriate measures from Section 2.0 Land Operations)

5.1 INTRODUCTION

Rainforests contain a large variety of plant and animal species, many of which are yet to be identified. Such areas of high biodiversity are increasingly rare. They are often the subject of local, regional and/or international efforts to protect them from damage by human activities.

Rainforests are a delicate balance between the forces of nature. They typically receive between 1.5-10.2 meters/60-400 inches of rainfall per year. The forest regulates this large amount of rainfall, controlling flooding and erosion in the process. The thin, topsoil found in the rain forest is protected by the multi-layered canopy of the forest trees. Disruption of the canopy can expose the ground level ecosystem to the harsh effects of the tropical rains. Erosion is the major concern. The shallow root system and heavy canopy of the rainforest is susceptible to the high wind loads from helicopters when the supporting trees have been cleared.

A geophysical operation in a rainforest can involve several hundred people in the field at any one time. The consequences of several hundred people on the environment must be controlled and monitored in accordance with specific measures.

The following are specific issues significant to rainforests:

- Interaction with local cultures.
- Effects of erosion and increased turbidity.
- Interruption of migration and mating patterns of forest animals.
- Fragile forest structure due to shallow root systems.
- Contamination of groundwater.
- Reduction of the canopy habitat of animals.
- Endangered or unknown plant and animal species.
- Reduction of the rainforest as a source of oxygen.

5.2 PLANNING

Limiting the size and number of camps and helipads is essential to minimize the amount of forest cleared. Erosion control and reseeding or planting should be planned where natural re-growth is not considered adequate.

5.3 OPERATING PRACTICES

- Do not allow camps to be provided with meat or food obtained from the forest.

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- Minimize removal of roots and topsoil for all installations to reduce erosion and enhance vegetation re-growth.
- Restrict the creation of new access roads or tracks to prevent migration of people into less developed areas.

Use of river banks or other naturally cleared areas for helipads or drop zones reduces vegetation required to be cleared.

Helipads and Helicopter Operations

- Space helipads at intervals as far apart as is practical. Plan for multiple use, such as at intersections.
- Locate helipads in existing clearings, secondary growth areas or areas where there is no significant hardwood growth. River banks and hilltops minimize the amount of flyway to be cut.
- Attempt to locate helipads away from habitats or breeding areas of protected, sensitive or endangered animal species.
- Minimize the size of flyways, provided appropriate safety considerations are taken into account.

- In flyways, cut trees to a minimum height of 1 meter/3 feet above ground to allow re-growth from their existing root systems.
- When using large helicopters, use long sling lines, consistent with safety, to minimize the effects of downdraft from the rotor.

In flyways, trees are cut to a minimum height of 1 meter above ground to allow re-growth from their existing root systems.

Line Preparation

- Use Inertial GPS surveying where it can significantly reduce the amount of line clearing necessary.
- Attempt to clear lines using only machetes or brush hooks, supplemented as necessary with chain saws.
- Avoid cutting trees greater than 20 centimeters/8 inches in diameter or trees identified as hardwoods or of value to the local population.
- Move lines around large trees and areas with significant hardwood growth.
- Minimize the width of survey lines.
- When tree cutting is done, ensure that trees have fallen to the ground. Leaners (cut trees that have partially fallen) are a safety hazard and can pull down other trees, further damaging the root system of the forest. Contact with the ground also accelerates decomposition of fallen trees.
- Remove and scatter branches from felled trees. Carry out branch and brush dispersal as clearing progresses.
- Cut timber for bridging only as necessary. Use soft-wood trees from secondary growth where practical.
- Use bridging on steep slopes to prevent erosion and to provide safe footing for crews. If bridging is not used in steep terrain, avoid creating well defined paths that will contribute to erosion. Where this is unavoidable, use a biodegradable erosion control material (e.g., woven jute, straw mats, etc.).

To avoid erosion when operating near water bodies, cut only the amount of vegetation necessary along the banks. River and lake levels can vary significantly in rain forests. Consider the high water mark in planning river and lake approaches.

Additional Pollution Prevention

Heavy rainfall and resulting swift currents along some watercourses should be taken into account in designing all facilities. Special care should be given to fuel storage, explosive storage, water and sewage disposal facilities in these conditions.

5.4 RECLAMATION ACTIVITIES

Natural re-vegetation is typically the most effective method for reclaiming survey lines in rainforests. Sensitive areas, access roads, helipads and campsites may require special treatment. Methods will depend on local conditions and regulatory requirements.

Performing reclamation activities during the survey operations reduces the work to be done at the end of the job. Each part of the crew should be responsible for ensuring that no refuse is left in their area of operations and that all equipment they use is accounted for and removed.

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Example activities are to:

- Pick up all pin flags, signs, flagging, mud products, and refuse.
- Ensure that the natural drainage of the area is restored.
- Remove all temporary stream crossings.
- Ensure that campsites are clean and that no refuse has been left behind.

Helipads may require special treatment for reclamation and if necessary, can be reforested based upon local conditions and regulatory requirements.

6.0 WETLAND OPERATIONS

(To be used in conjunction with the General Operating Procedures and appropriate measures from Section 2.0 Land Operations)

6.1 INTRODUCTION

Wetlands are both coastal (tidal) and inland (non-tidal), may be seasonal and may be categorized into the following groups:

- Coastal wetlands consist mainly of tidal marshes, mud flats and mangroves, which are periodically flooded by salt or brackish water.
- Inland wetlands consist of swamps and marshes located mostly in river flood plains, isolated depressions and along the margins of lakes and ponds.
- Swamps are characterized by trees, shrubs, and mosses as the principal vegetation, and are generally inundated.
- Marshes are areas of low vegetation and cyclic inundation.
- Mangroves are areas subject to constantly changing flows of fresh and salt water with specifically adapted vegetation. (Note that some mangrove species, such as found in Nigeria, do not grow back when cut down, so re-vegetation has to be assisted.)

Wetlands vegetation is generally resilient to mechanical stress, but soils recover slowly from compaction and displacement. Channeling may affect the water flow, which can cause erosion and changes to the water chemistry.

Wetlands can provide wildlife habitat, groundwater recharge, flood control, improved water quality, and subsistence, commercial and sport usage. The size of a wetland does not affect its sensitivity. Wetlands of less than .4 hectares/one acre can support an abundance of wildlife. These environments are frequently breeding and nesting grounds for many types of animals, including protected species.

Special care must be taken to maintain the equilibrium of the wetland environment and the surrounding transition areas. The binding of soils in the roots of marsh grasses controls water flow. Disruption of water flow by dredging existing channels, creating new channels (or deep vehicle tracks), or construction of roads may cause changes in salinity, vegetation, and erosion. Clearing of trees can result in increased underbrush and subsequent accumulation of organic material, thereby altering water quality.

6.2 PLANNING

6.3 OPERATING PRACTICES

Operations in wetlands must address the following issues:

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- Where practical, the lines should follow waterways or bypass stands of vegetation to minimize disturbance to vegetation and soils.
- Consideration should be given to the direction of tidal flow when planning line paths to avoid inducing erosion.

Camps and Quarter Boats

Barge mounted operations bases and crew quarters are preferred over land camps because there is less disruption to the soil and vegetation. Mooring locations should be selected to minimize the effects on banks and vegetation. The general procedures address other issues to be considered.

6.4 TRAVEL

Vehicles to transport personnel and equipment in wetlands include airboats, helicopters, small boats, low ground pressure (Terra-tired) vehicles, tracked buggies, pontoon equipment and other specialized equipment.

The following procedures apply to travel in wetlands operations:

- Minimize the number of vehicles on crews.
- Limit travel to essential operations and prohibit joyriding.
- Use airborne or water transport wherever feasible.
- Try to avoid practices that can cause channeling.
- Avoid floating marsh and unvegetated spots in marshes.
- Use open waterways where practical.
- Reduce turning maneuvers. Use waterways for turns.
- Do not traverse on previously-made tracks to avoid creating ruts or channels, unless required by permits.
- Minimize the use of tracked or wheeled vehicles in the field.
- Minimize maintenance performed in the field.

Airboats and Hovercraft

Airboats leave a temporary footprint on the vegetation and soil but operate at a noise level which may temporarily displace animals.

- Cover airboat hulls with a solid lubricant wear pad, such as Teflon.
- Use biodegradable materials when liquid hull lubrication is required.
- Use airboats and hovercraft where their noise effects on animals are minimal.

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Carefully planned airboat operations have minimal impact on the environment.

Small Boats

Small boats are generally quieter than airboats, hovercraft and helicopters but are limited to open waterways. They can effectively be used for individual and crew transport. Care should be taken to control speed and to avoid contact with aquatic animals. Maintenance should ensure that fuels, lubricants or other foreign materials do not enter the water. Engine tuning should ensure that pollutants in engine exhausts are minimized.

Helicopters

Helicopters have little environmental effect. Noise concerns are similar to those for airboats.

- Locate landing zones away from high populations of wildlife.
- Plan flight paths to minimize effects of noise.
- Maintain sufficient altitude to reduce downdraft effects.
- Locate helipads in natural clearings as much as practical.
- Consider using helicopters equipped with pontoons to reduce the need to build helipads in wet areas.

Wheeled and Tracked Vehicles

- Keep loading at efficient levels to reduce ground pressure while minimizing the number of trips.
- Approach levees at an appropriate angle to avoid cutting through them.
- Immediately report, flag and repair any inadvertent levee or dike damage.
- Avoid creating unnatural levees, dikes, channels, and drainage routes.

Pontoons

Lightweight pontoon equipment with special underside coatings can be effective in minimizing tracks and compression of grasses and vegetation. Heavy loading of pontoons should be avoided.

6.5 RECLAMATION ACTIVITIES

Performing reclamation activities during the survey operations reduces the work to be done at the end of the job. Each part of the crew should be responsible for ensuring that no refuse is left in their area of operations and that all equipment they use is accounted for and removed.

Example activities are to:

- Pick up all pin flags, signs, flagging, mud products, and refuse.
- Ensure that the natural drainage of the area is restored.
- Remove all temporary stream crossings.
- Actively reseed or revegetate when natural re-growth is not considered sufficient.
- Ensure that campsites are clean and that no refuse has been left behind.

7.0 MOUNTAINOUS OPERATIONS

(To be used in conjunction with the General Operating Procedures and appropriate measures from Section 2.0 Land Operations)

7.1 INTRODUCTION

Generally, mountainous areas are defined as those that lie at least 500 meters/1,640 feet above their surroundings. Their land surfaces consist of long slopes, deep canyons or valleys, and high, narrow ridges. Mountain areas cover about one-fifth of the world's land surface. In addition to reviewing the general procedures, operations at high altitude may encounter alpine conditions similar to the arctic, in which case the arctic section should be consulted.

Planned use of helicopter support minimizes potential disturbance of wildlife.

7.2 PLANNING

Scouting the terrain plays a major part in the planning aspect of geophysical operations in the mountains. The time of year the survey is expected to take place must also be considered. To prepare for these operations, the following factors need to be evaluated:

- Roadways and access to the jobsite
- Steepness of slope.
- Thickness of trees and vegetation.
- Spring thaw, mudslides and rockslides.
- Winter season avalanches and drifting snow.
- Watercourses.
- Disruption of wildlife due to machinery and aircraft noise.
- Risks from wildlife, insects, snakes, to crew operations.

7.3 OPERATING PRACTICES

Mountainous terrain and valleys may enable sound to travel a greater distance than in flat terrain. Sound may temporarily displace wildlife and cause annoyance to inhabitants. Snow cover and corresponding reduction in food supply may place additional stress on animals in winter. Daily monitoring may be required to assure that wildlife is not unduly disturbed.

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Noise levels and their effects can be reduced by:

- Selection of helicopter type.
- Planning of flight paths or routes.
- Selection of shot-hole drilling equipment including noise suppression accessories.
- Considering the topography in the placement of the program.
- Choice of energy source.

Fire can spread rapidly in dry conditions. Fire prevention is critical because steep terrain, strong winds and heavy vegetation impede access for fire control.
Fire prevention measures include:

- Awareness of seasonal conditions.
- Use of fire-retardant detonating cord.
- Use of spark suppression accessories on equipment.
- A documented fire prevention plan.
- Limited and supervised smoking.
- Training in fire prevention and firefighting.

Fire reporting procedures are important because quick response is critical due to the speed at which fires can spread. This extends to sightings of fires not associated with the operation.

7.4 RECLAMATION ACTIVITIES

Performing reclamation activities during the survey operations reduces the work to be done at the end of the job. Each part of the crew should be responsible for ensuring that no refuse is left in their area of operations and that all equipment they use is accounted for and removed.

Example activities are to:

- Pick up all pin flags, signs, flagging, mud products, and refuse.
- Ensure that the natural drainage of the area is restored.
- Remove all temporary stream crossings.
- Actively reseed or revegetate where natural re-growth is not considered sufficient.
- Ensure that campsites are clean and that no refuse has been left behind.
- Ensure that fences and gates are restored.

8.0 MARINE OPERATIONS

(To be used in conjunction with the General Operating Procedures)

8.1 INTRODUCTION

Marine geophysical surveys are used to plan offshore drilling and subsea mining operations and reduce the number of surface locations needed for mineral resource development. Such information can also help evaluate sites to avoid placement on fault, earthquake, shallow gas or other hazardous zones.

Marine geophysical surveys may create a localized, temporary disturbance but generally incur no lasting effects on the environment. Pre-survey planning should consider any possible effects to the environment in areas the survey will encompass.

Any base camps or shore-based navigation installations need to be established and operated according to the environmental procedures established for land operations.

8.2 PLANNING

The location and time of the year of the marine geophysical survey will be the key factors that determine the planning stage. The project planning process identifies hazards associated with the work area, mitigation measures and procedures to minimize the impact on the environment.

Issues to be considered may include:

- Environmental considerations -
    - Marine mammal migratory routes, calving, nursing, and breeding periods.
    - Sea turtles' migratory routes, breeding and hatching periods.
    - Fish spawning, nursery or feeding grounds and periods.
    - Living coral reefs and coral spawning periods.
- Health considerations -
    - Vaccinations (if any) required.
    - Logistics and support of medevac.
    - Possible strain on local infrastructure.
- Time of the year -
    - Weather, prevailing winds, waves, ice flow and fog.
    - Tidal and ocean currents.

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- Commercial activity -

  - Commercial fisheries.
  - Oilfield activities.
  - Shipping lanes.
  - Kelp harvesting.
  - Military areas.

- Recreational Water Activities.
- Transportation:

  - Crew changes by boat and helicopter.
  - Bunkering at sea.

- Security, including lobbyist activity, military activity and local infrastructure.

8.3 OPERATIONS START-UP

It is essential to conduct an environmental and safety review meeting prior to start-up. All relevant crewmembers, onshore supervisors and a client representative should attend. This may be the first time that on-board personnel will be exposed to the environmental concerns relevant to the survey. All onboard personnel and their supervisors need to understand what is required of them. Persons with less experience in the area may need more local knowledge. Attendance and the topics covered at all environmental and safety meetings should be documented.

Prior to start-up it will also be necessary to:

- Reconcile any conflicting environmental and safety concerns.
- Discuss any regulations and requirements specific to the area of operations
- Discuss standards and targets to be achieved.
- Discuss environmental issues and implement reporting procedures with crew supervisors and managers, senior crew personnel and subcontractors.
- Establish authority of any person(s) designated as cetacean observer to enforce airgun soft start (ramp-up) procedure.
- Describe the emergency response plan, including functional responsibilities, to all personnel.

8.4 TRAVEL

Water Travel

Caution and common sense can help minimize environmental effects of travel on water. Care should be exercised to reduce the risk to aquatic life. Fuel transfer and handling should be done in such a way to prevent spills.

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- Keep absorbent materials on board in case of small fuel spills.
- Use slow speeds to minimize bank erosion when near protected shores.
- Be cautious of aquatic life.
- Make sure fuel tanks have caps and are not filled over the water.
- Plan operations to minimize disturbances in nesting or molting areas and areas where aquatic life exists.
- Plan docking areas such that safe and environmentally-sound supply, maintenance, and refueling exercises can take place.

Air Travel

The physical effects of air travel are generally limited to the shore-based landing areas. Flight paths and approaches should be planned to minimize disruptions to animals due to noise and downdrafts, which may also create a nuisance in populated areas.

- Maintain aircraft in flight at a suitable altitude, consistent with local regulations and safe operating practices, to avoid unnecessarily disturbing wildlife, marine life and people.

    - ♦ Keep aircraft at an appropriate distance from sensitive wildlife or marine life areas.
    - ♦ Maintain aircraft at a suitable distance from cliff faces where there are nesting birds.

- Locate landing areas and flyways to minimize disturbance to wildlife, marine life and the public.

8.5 HAZARDOUS MATERIALS

Fuel and Oils

STORAGE

All petroleum products and hazardous substances loaded on vessels should be stored in approved containers labeled for that specific product (e.g., fuel oil, lube oil, streamer oil, degreasers, etc.).

Should it become necessary to load barrels of product that cannot be put into tanks, these barrels must be clearly labeled as to their content. A barrel rack permanently mounted on the vessel should be used so that the barrels can be stored on their sides and secured to prevent shifting at sea. A spill containment pan shall be mounted under the rack(s) to catch any accidental spillage. Sufficient absorbent material should be stored nearby to ensure that no products can enter the waterway or become a safety hazard.

- Normally, keep the valves closed between fuel tanks which are manifolded together.
- Mark all fuel tanks or drums with their contents.

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- Mark portable tanks and drums with the name of the owner or operator's company.
- Store petroleum products in bounded areas where spills can be contained and collected.

REFUELING

The vessel Master has overall responsibility for carrying out a safe and orderly transfer of petroleum products onboard his vessel.

- Post appropriate warning signals before transfer operations commence.
    - Hoist the "bravo" flag for daylight transfers.
    - Use one all-around red light for nighttime and periods of reduced visibility.
- Establish a working frequency for radios, test radios and assign personnel to their duty stations.
- Stop all hot work and strictly enforce a "no smoking" policy.
- Assign one person to stand by the receiving station. This person shall be in direct communication with the pumping facility.
- Assure that the Chief Engineer continuously monitors tank levels during transfer operations.
- Assure both the Master and Chief Engineer log the times and quantities of product transferred.
- Provide adequate supplies of absorbent material at both the pumping and receiving stations to prevent product from entering the water if a spill occurs.
- The vessel Master will determine when conditions are suitable for transferring products at sea.
- Equip refueling vessel with fenders adequate for the purpose of vessels mooring at sea.
- Assure transfer hoses are of sufficient length and strength to allow maneuvering of the vessels, should sea conditions dictate.
- To avoid spills, drain all product transfer hoses into a suitable container and cap them before moving them.

LEAKS/SPILLS

- Report all spills or leaks in accordance with both operator's procedures and local regulations.
- Assure that all vessels carry a suitable oil spill kit in addition to equipment required in the Shipboard Oil Pollution Emergency Plan (SOPEP).
- Clean up spills or leaks of oil or fuel and dispose of them properly.
- Store waste fuels, oils, lubricants, hydraulic fluids, solvents and certain paints appropriately and label them as to content. Use the same storage procedures as for unused fuel and oil.
- Have an Emergency Response Plan readily available for spills. Communicate it to responsible crewmembers and review it regularly at training exercises. SOPEP requires that the vessel carry out an oil spill clean-up drill at regular intervals. The interval is to be decided by the vessel owners but should be at least once every three months.

Engine Exhaust

The exhaust systems of all equipment should be serviced on a regular basis to ensure that noise and emissions are kept to appropriate levels. Newly constructed marine geophysical vessels should be outfitted with exhaust gas monitoring systems as per flag and class requirements.

Other Hazardous Materials

Hazardous materials, apart from fuels and oils, are sometimes used by geophysical crews. These include solvents used for cleaning equipment, batteries, paints and cable repair materials. The preferred practice is to find substitutes that are not hazardous.

Explosives are considered a "hazardous material" in all countries. Regulations for their storage, use and transportation are well established and procedures are strictly enforced. Explosive safety is covered in detail in the IAGC Land Geophysical Operations Safety Manual.

- Identify all hazardous materials used on the crew and attempt to find less hazardous substitutes.
- Ensure that any hazardous materials used by the crew are handled correctly, and that the safety information provided by the manufacturer is available to the crew.

    - ♦ Dispose of waste materials in the manner specified by regulations.
    - ♦ Keep complete records of hazardous material purchases, use, storage, disposal, and spills according to local or company requirements.
    - ♦ Ensure that hazardous materials are stored correctly according to regulations and manufacturer's directions.

- Do not use CFC (chlorofluorocarbon) products and aerosol propellants, except with refrigeration equipment where closed recovery recharge systems are employed.

    - ♦ Use alternatives to CFC systems for new installations.

- Transport, store, use and dispose of all batteries, especially lithium and nickel cadmium, in an approved manner. (See the IAGC safety manual for additional information.)
- Consider use of recyclable or reusable materials whenever possible.

8.6 AQUATIC LIFE

The interaction between geophysical operations and aquatic life can vary greatly, depending on the type and area of operation and the kind of aquatic life. Consideration should be given to potentially interfering with migration routes and disruption of reef ecosystems or displacing aquatic life vulnerable to predators.

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There are certain times of the year when aquatic life is more sensitive to external influences. Such times include migration, mating, birthing and spawning. In some areas of the world, it will be mandatory to plan the location and timing of seismic surveys to avoid disturbance to aquatic life. Surveys should be planned to avoid interfering with known migrations and spawning periods whenever practical. Where interaction is unavoidable, steps should be taken to minimize the disruption.

- Stay clear of aquatic life areas marked on the survey area charts to avoid active spawning, migration and feeding areas.
- Implement airgun soft start (ramp-up) procedure to minimize disturbance to marine mammals is recommended.
- Keep a log of all observations of endangered species if required by authorities.
- Strictly forbid fishing and trapping of aquatic life by crewmembers.
- Purchase food only from recognized vendors.
- Do not allow crewmembers to purchase or accept gifts that would encourage locals to exploit wildlife.
- Report incidents involving aquatic life to the appropriate authorities.
- Do not permit intentional harassment of aquatic life.
- Minimize disturbance to traditional native fishing areas.

Logs of marine mammals or endangered species sighted are sometimes required by authorities.

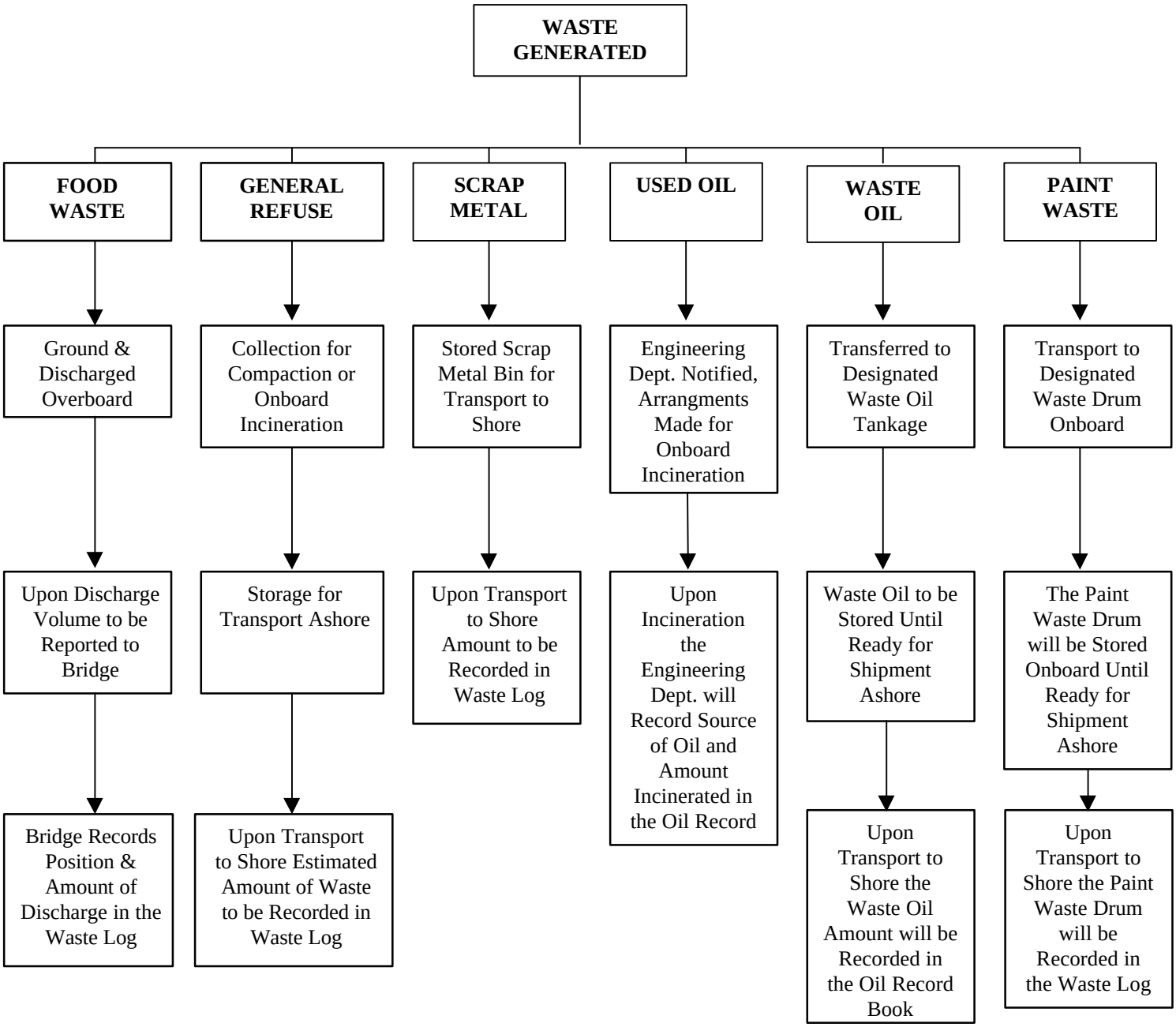
8.7 WASTE MANAGEMENT

A waste management program must be developed to maximize the use of recyclable and biodegradable items and to minimize waste. It is the responsibility of the vessel Master to develop a Waste Management Plan for the vessel. Only certain waste is suitable for overboard disposal, as indicated in the following procedures.

- Dispose of plastic or plastic products of any kind properly. This includes such items as styrofoam cups, write rings, plastic bags, tape, line, etc. Bag waste of this type and place it in the proper containers for onboard incineration or disposal ashore. Store plastics suitable for recycling separately and recycle them if facilities exist.
- Dispose of domestic waste (i.e., cans, glass, paper, or other garbage/waste from living spaces aboard) properly. Separate all burnable items and burn them if an incinerator is available. Separate all other items (i.e., glass, cans, metal, etc.), compact and store them in a designated area for proper recycling or disposal ashore. Store materials suitable for recycling separately and recycle them if facilities exist.
- Dispose of maintenance waste (i.e., paint sweeping, rags, deck sweeping, oil soaks, machinery deposits, etc.) properly. Incinerate all burnable items. Compact all other items, if possible, then properly bag and place them in a designated area for disposal ashore.
- Dispose of operational waste (i.e., cargo residues, work space trash and waste, incinerator ashes including plastic, clinkers, and metals, etc.) properly. Keep cargo residues aboard for proper disposal ashore. Separate workspace trash and waste into burnable and non-burnable categories and dispose of them according to the previously mentioned procedures.
- When incinerator ashes are cold, compact, bag and store them in the designated area for disposal ashore.
- Store all batteries onboard and dispose of them onshore according to the manufacturer's specifications and local regulations.
- Treat all sewage wastes in the ship's sewage treatment facility, according to all applicable international and/or local government standards, before overboard discharge.
- Follow the Convention for the Prevention of Pollution from Ships (MARPOL 73/78) specifications for the distance offshore for discharge of food and cooking wastes.
- Pump bilge only if oil/water separators are used and are functioning effectively.
- Prior to entry into port, notify local authorities of the types and quantities of waste and/or garbage being sent ashore for disposal.

Refer to MARPOL 73/78 for international minimum standards for waste disposal.

Segregation Of Common Marine Waste By Type



- **FOOD WASTE –** all food or organic refuse from galley, kitchen or dining areas.
- **SCRAP METAL –** all metal waste.
- **GENERAL REFUSE –** plastic, rags, glass, cardboard, dunnage, lining, packing material, cable skin, etc.
- **USED OIL –** all used refined oil products containing no suspended solids, including used paint thinners amenable to incineration.

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- **WASTE OIL –** any used oils containing suspended solids not amenable to onboard incineration.
- **PAINT WASTE –** any collected paint waste material that cannot be incinerated.

8.8 VESSEL OPERATIONS

To reduce onboard environmental effects:

- Make sure the cable deck, cable storage and under streamer reel areas are constructed to act as drip trays to capture all spilled oil.
- Drain drip trays into a holding tank where the cable oil can be stored for a period of time.
- Recycle used or spilled cable oil on board using separators or send it ashore via the correct containers for disposal or recycling.
- Keep all hoses and associated tools for pumping and filling cable sections in good operational condition and regularly check them for leaks.
- Have an operator present while cable oil is being pumped into a section.
- Assure that cable sections being drained, filled or flushed with cable oil are contained within the drip tray area.
- Check that cable sections being transferred off a vessel (either at sea or at the dock) are void of leaks, or are drained and dry, to avoid a spill during transfer and transportation.
- Dispose of cable skin material, 0-rings, etc., in the correct manner.
- When reporting oil spills to the local authorities, follow appropriate reporting procedures.
- Do not use CFC (chlorofluorocarbon) products and aerosol propellants, except with refrigeration equipment where closed recovery recharge systems are employed.
- Maintain refrigeration systems and check them for CFC leaks on a regular basis.
- Do not use spray cleaners containing CFCs (such as some aerosols) on connectors during connection or disconnection of sections.
- Prohibit the use of freon as a cleaning agent.
- Assure that oil absorbent pads/material is available for spills. Use correct procedures for disposal of such pads/materials after use.

Auxiliary Boat Operations

- Operate boats used to assist in streamer deployment, retrieval and maintenance in compliance with all applicable laws and regulations.
- If a waste storage area is not available onboard the auxiliary vessel, collect all trash and take it back to the main vessel or ashore.
- Secure all portable fuel tanks to the boat for safety and to prevent loss.
- Adjust engine fuel mixtures to maximize clean burning and reduce emissions.

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- Assure that boats carry oil-absorbing packs for use in cleaning up small spills that may occur during streamer handling operations.
- Consider use of propeller guards, jet drives, and tunnel hull designs to reduce the potential hazard to hoses, recording cables, and aquatic life.

Deployed Equipment

- Assure that all towed surface equipment is highly visible and labeled with the vessel's name, company name, company address, and company telephone number.
- Use and dispose of all batteries in the correct manner according to manufacturer's specifications and local regulations.
- Use biodegradable lubricants and rust preventatives on towed equipment.
- Securely attach all equipment and fairing to avoid loss.
- Check all bridles and tow harnesses for wear and replace them as necessary. A regularly scheduled inspection and maintenance program is the best deterrent for loss. Dispose of all old hardware removed according to the procedures outlined for the disposal of solid waste.
- Use a secondary retaining device to prevent loss of attachable units, should they become disengaged from the primary mounting.
- If fluid filled recording cables are used, inspect them for leaks and reseal them before deployment if damaged.
- Follow safe handling procedures for lithium batteries exposed to seawater.
- Minimize use of tape to patch holes and fasten weights on streamer cables.
- Replace loose tape before deploying equipment. When tape is used for fastening, use appropriate methods to ensure the tape remains attached.
- Avoid use of petroleum-based adhesives in conjunction with tape.
- Prefer weights that can be attached to the streamer without the use of tape.
- Dispose of used firing line hoses and hardware according to the procedures for the disposal of solid wastes.
- Properly maintain all air system components to prevent oil from being discharged into the water.

Retrieval of Lost Equipment

- Document and communicate contingency plans for retrieval of lost equipment.
- Make a reasonable effort to retrieve lost equipment.
- Attach active acoustic location devices to auxiliary equipment to aid in location and retrieval.
- Use strobe lights and radar reflectors mounted on floating, towed equipment to aid in determining its location.
- Notify all local traffic and the appropriate regulatory agencies when equipment is lost.
- Retrieve lost equipment as soon as possible after a location is reported.

8.9 RECLAMATION ACTIVITIES

Reclamation activities for marine geophysical operations will be less extensive than those used for land-based operations.

Example activities are to:

- When anchored marker buoys are used during the marine survey, fully recover them as soon as they are no longer needed or the survey is completed.
- If anchored stand-by buoys have to be moved within an oilfield to allow the survey to proceed, place them back in the original location so as not to disturb any pipelines or virgin seafloor.
- Account for all in-sea equipment utilized during the survey.

9.0 REFERENCES

9.1 ENVIRONMENTAL LAWS AND REGULATIONS

Environmental legislation that applies to geophysical operations varies greatly between countries. As a result, a copy of the country's environmental regulations must be obtained before starting the planning for any geophysical survey. National ministries are usually the best starting point in determining what environmental regulations apply to the geophysical survey to be conducted. Regulations also may be obtained from:

IUCN, Environmental Assessment Services
International Union for the Conservation of Nature
Avenue du Mont Blanc,
CH- 1 196 Gland,
Switzerland

Annex V of the 1973 Convention for the Prevention of Pollution by Ships (MARPOL) contains regulations regarding disposal of garbage from ships.

9.2 GUIDELINES

Relevant guidance documents have been prepared by other international and national/regional petroleum industry organizations.

International Association of Oil and Gas Producers (OGP) (formerly E&P Forum)

- *E&P Forum Oil Industry Operating Guideline for Tropical Rainforests,* 1991, Report No. 2.49/170
- *Oil and Gas Exploration and Production Operations in Mangrove Areas: Guidelines for Environmental Protection*, 1993 (with IUCN), Report No. 2.54/184
- *Oil and Gas Exploration and Production in Arctic and Subarctic Onshore Regions – Guidelines for Environmental Protection,* 1993 (with IUCN), Report No. 2.55/185
- *Exploration and Production (E&P) Waste Management Guidelines*, 1993, Report No. 2.58/196
- *Guidelines for the Development and Application of Health, Safety and Environmental Management Systems*, 1994, Report No. 6.36/210
- *Environmental Management in Oil and Gas Exploration and Production*, 1997 (with UNEP), Report No. 2.72/254

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These and other guidelines are available from:

International Association of Oil and Gas Producers (OGP)
25/28 Old Burlington St.
London W1X 1LB, England
Telephone: 44-20-292-0600
Website: http://www.ogp.org.uk

National/Regional Petroleum Industry Organizations

These should be consulted for available guidelines relevant to specific geographical areas.

IUCN

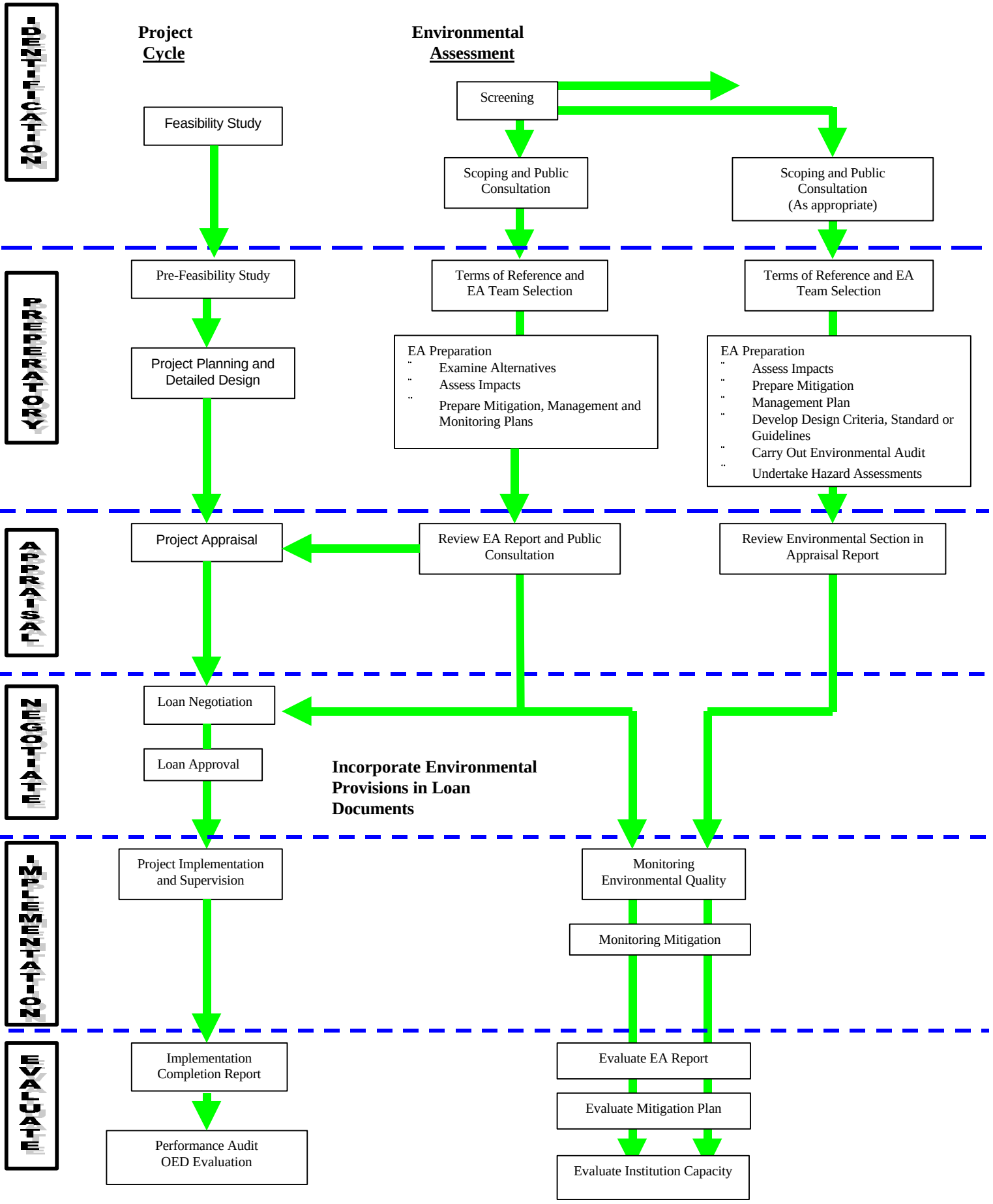
The World Conservation Union (IUCN) has prepared a guideline entitled *Oil Exploration in the Tropics – Guidelines for Environmental Protection* (1991), which is available from IUCN at the address listed above. IUCN has also co-authored several of the OGP Guidelines listed above.

APPENDICES

A. Basic Principles of the Environmental Assessment Process as taken from the World Bank Guidelines

B. Guidelines for Minimizing Acoustic Disturbance to Marine Mammals from Seismic Surveys

Appendix A. Basic Principles of the Environmental Assessment Process as taken from the World Bank Guidelines



Appendix B.

Following is an example of a procedure which could be used to minimize the effect of marine airguns on marine mammals.

GUIDELINES FOR MINIMISING ACOUSTIC DISTURBANCE TO MARINE MAMMALS FROM SEISMIC SURVEYS

April 1998 Version

These guidelines are aimed at minimising acoustic disturbance to marine mammals from seismic surveys and other operations where acoustic energy is released. Application of the guidelines is required under licence conditions in blocks licensed under the 16th and 17th rounds of offshore licensing. However, member companies of the UK Offshore Operators Association (UKOOA) and the International Association of Geophysical Contractors (IAGC) have indicated that they will comply with these guidelines in all areas of the UK Continental Shelf (UKCS) and in some cases elsewhere. The guidelines apply to all marine mammals, including seals, whales, dolphins and porpoises. All surveys using higher energy seismic sources (including site surveys as well as large scale seismic surveys) should comply with these guidelines.

Precautions to reduce the disturbance caused by seismic surveys

Seismic surveys at sea do not necessarily constitute a threat to marine mammals, if care is taken to avoid situations which could potentially harm the animals.

A. The Planning Stage

When a seismic survey is being planned, operators should:

- Contact the Joint Nature Conservation Committee (JNCC - see Further Information for address) to determine the likelihood that marine mammals will be encountered. In sensitive areas, the JNCC may request precautions in addition to those outlined below (for example, the special conditions attached to some oil and gas licenses).

- In areas which are important for marine mammals (as indicated in consultation with the JNCC) operators should seek to provide the most appropriately qualified and experienced personnel to act as marine mammal observers on board the seismic survey vessel. If possible, such observers should be experienced cetacean biologists. As a minimum, it is recommended that observers should have attended an appropriate training course.

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- If advised to do so by the JNCC, discuss the precautions which can be taken to reduce disturbance, and the design of any scientific studies with the Sea Mammal Research Unit (see Annex for address). In areas where marine mammals are abundant, properly conducted observation and recordings using qualified observers (see above) carried out before, during and after the seismic survey, can provide valuable information on its effect.

- Operators should plan surveys so that their timing will reduce the likelihood of encounters with marine mammals, although at present there is limited information on their distribution in some areas.

- Operators should seek to reduce and/or baffle unnecessary high frequency noise produced by air-guns or other acoustic energy sources.

B. DURING THE SEISMIC SURVEY

When conducting a seismic survey, the following procedures should be followed:

- LOOK AND LISTEN

  Beginning at least 30 minutes before commencement of any use of the seismic sources, the operator and observers should carefully make a visual check from a suitable high observation platform to see if there are any marine mammals within 500 meters, using the cues mentioned later in these procedures to detect the presence of cetaceans. Hydrophones and other listening equipment may provide additional information on the presence of inconspicuous species, such as harbor porpoises, or submerged animals, and should be used whenever possible. This will be particularly appropriate in poor weather, when visual evidence of marine mammal presence cannot be obtained.

- DELAY

  If marine mammals are present, the start of the seismic sources should be delayed until they have moved away, allowing adequate time after the last sighting (at least 20 minutes) for the animals to move well out of range. Hydrophones may also be useful in determining when cetaceans have moved. In situations where seal(s) are congregating immediately around a platform, it is recommended that commencement of the seismic sources begins at least 500 m from the platform.

- THE SLOW BUILD UP

  Where equipment allows, power should be built up slowly from a low energy start-up (e.g. starting with the smallest air-gun in the array and gradually adding in others) over at least 20 minutes to give adequate time for marine mammals to leave the vicinity. There should be a soft start every time the air-guns are used, even if no marine mammals have been seen. The

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soft start may only be waived for surveys where the seismic sources always remain at low power levels e.g. some site surveys.

- KEEP IT LOW

  Throughout the survey, the lowest practicable power levels should be used.

C. REPORT AFTER THE SURVEY

A report detailing marine mammals sighted (standard forms are available from JNCC), the methods used to detect them, problems encountered, and any other comments will help increase our knowledge and allow us to improve these procedures. Reports should be sent to the JNCC (see Further Information for address). Reports should include the following information:

- Date and location of survey
- Number and volume of airguns used
- Nature of air-gun discharge frequency (in Hz), intensity (in dB re. 1µPa or bar metros) and firing interval (seconds), or details of other acoustic energy used
- Number and types of vessels involved in the survey
- A record of all occasions when the air-guns were used, including the watch beforehand and the duration of the soft-start (using standard forms)
- Details of any problems encountered during marine mammal detection guidelines, or during the survey
- Marine mammal sightings (using standard forms)
- Details of watches made for marine mammals and the seismic activity during watches (using standard forms)
- Reports from any observers on board

Background to the guidelines

These guidelines reflect principles which could be used by anyone planning marine operations that could cause acoustic or physical disturbance to marine mammals. The recommendations contained in the guidelines should assist in ensuring that all marine mammals in areas of proposed seismic survey activity are protected against possible injury, and disturbance is minimized.

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The guidelines were originally prepared by a Working Group convened at the request of the Department of the Environment, developed from a draft prepared by the Sea Mammal Research Unit. The guidelines have been reviewed twice by the Joint Nature Conservation Committee following consultation with interested parties and in the light of experience after their use since 1995.

Please note: As these guidelines are concerned with reducing risks to marine mammals, all other notifications should be given as normal.

Existing protection

Section 9 of the Wildlife and Countryside Act 1981 prohibits deliberate killing, injuring or disturbance of any cetacean (equivalent in Northern Ireland is Article 10 of the Wildlife (Northern Ireland) Order 1985). This reflects the requirements of the Convention on the Conservation of European Wildlife and Habitats (the Bern Convention) and Article 12 of the EC Habitats and Species Directive (92/43/EEC), implemented by The Conservation (Natural Habitats, etc.) Regulations 1994 and The Conservation (Natural Habitats, etc.) Regulations Northern Ireland 1995.

In addition, the UK is a signatory to the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas and has applied its provisions in all UK waters. Amongst other actions required to conserve and manage populations of small cetaceans, the Agreement requires range states to "work towards....the prevention of ...disturbance, especially of an acoustic nature".

Marine mammal presence in UK waters

Records indicate there may be 22 species of cetacean either resident in, or passing through, UK waters. There are 9 regular visitors seen in coastal waters, the most common species of which are harbor porpoise, white-beaked dolphin, bottlenose dolphin and common dolphin; the most common seen in deeper offshore seas are the long-finned pilot whale, common dolphin, harbor porpoise and killer whale. Northern right whales are very rare - they are an endangered species, having been hunted very close to extinction.

There are two species of seal which are resident in UK waters, the common or harbor seal and the grey seal. Both species breed in the UK, with common seals pupping in June/ July, and grey seals pupping from September to December, the exact timing depending on their location. Seals may be particularly vulnerable to disturbance during the pupping season. Other species, such as the hooded seal, may occasionally be seen in waters to the north of the UK.

Cues for detecting the presence of cetaceans

Even when quite close to vessels, cetaceans are often difficult to detect. The following points should help in ensuring that an adequate search has been made.

- Seismic operators should allow adequate time (at least 30 minutes) for sightings to be made prior to commencement of any use of the seismic sources

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- The ease of detecting cetaceans declines with increasing sea state, so care should be taken to ensure an adequate search has been made in the prevailing conditions.

- Searches should be made from a high vantage point with a clear all-round view, e.g. the bridge roof or crow's nest. If necessary use two or more vantage points to give an all-round view.

- The sea should first be scanned slowly with the naked eye and then scanned slowly with binoculars.

- Hydrophones are a useful aid to detecting cetaceans. Cetaceans communicate with each other using whistles, creaks, chirps and moans which may be heard over considerable distances. Trains of clicks are used for echolocation and while foraging. They may be heard with a hydrophone at distances of several kilometers. In areas which are known to be frequented by small cetaceans, any hydrophones used should be capable of receiving the high frequency sounds used by these animals.

- Submerged cetaceans are much more at risk than those on the surface. This makes it particularly important to use a hydrophone whenever possible to detect vocally active animals that may be invisible from the surface.

- Dolphins and porpoises generally surface 2-3 times per minute in order to breathe. Dive times and surfacing behavior are more erratic when they are feeding, but most dives are unlikely to exceed 5 minutes. Large whales surface less often and may remain submerged for some time.

- Splashes may be a cue to the presence of cetaceans, although in seas rougher than sea state 2 cetacean splashes may be difficult to detect and distinguish from wave splashes.

- Blows of large whales may be more obvious, but still may be difficult to detect in strong winds.

- Some species may be attracted to boats from some distance away, probably by engine noise. They may accompany a vessel for a considerable period and even bowride if it is fast-moving. If possible, look over the bow of the ship to check for cetaceans close in to the ship which may be hidden from view from the normal vantage points. The arrays of hydrophones which are towed by survey vessels may also be attractive to dolphins.

- Feeding seabirds can sometimes be evidence of the presence of cetaceans. Species which are likely to associate with cetaceans include gannets, kittiwakes and Manx shearwaters, although any flock of birds should be checked for the possible presence of cetaceans.

- An oily slick at the sea surface may signify the presence of cetaceans. These slicks may also be attractive to birds such as fulmars and storm petrels.

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Cetaceans are capable of brief swimming speeds of 30 knots (34 mph), and sustained movement at 8 knots (10 mph), although some may swim at much slower speeds. If disturbed, they may alter their heading rapidly.

Seismic surveys

Modern large-scale surveys are conducted using towed arrays of "air-guns" - cylinders of compressed air. Each cylinder contains a small volume (typically between 10 and 100 cubic inches) at a pressure of about 2000 psi. The array, typically containing some tens of such cylinders, is discharged simultaneously, to generate a pressure pulse which travels downwards into the sea bed. Some of this acoustic energy is emitted into the wider marine environment; however, the designers of air-gun arrays seek to maximize the transmission of energy into the sea bed, with the result that the energy dissipated into the wider environment is reduced. As a survey proceeds, the air-gun array is recharged with air from a compressor on board the towing vessel. The process is repeated at intervals of approximately ten seconds - the timing dependent on the objectives of the survey.

Potential effects of acoustic disturbance on cetaceans

The most prevalent form of acoustic disturbance in UK waters is probably the noise generated by boats; however, the noise caused by boat traffic is so widespread that many cetacean populations may have become used to it, although this does not necessarily mean that the animals are unaffected. The limited research on the effects of disturbance due to the passage of vessels shows there is some evidence that cetaceans will avoid approaching ships and alter migration routes in response to marine traffic.

Effects of seismic surveys

The extent to which seismic disturbance from airguns affects cetaceans is not well known for all species, since only a limited amount of research has been done (see Annex for further details). Most published research relates to the effect on large whales (particularly bowhead whales) of older air-gun arrays, which were different from those currently in use.

Seismic air-guns are designed to produce low frequency noise, generally below 200 Hz, used to build up a picture of the seabed and the underlying strata. However, recent research has shown that high frequency noise is also produced (Goold 1996a). Low frequency noise is more likely to disturb baleen whales than toothed dolphins; baleen whales communicate at frequencies mostly below 3 kHz, which are likely to overlap with the dominant frequencies used by seismic air-guns. The sensitivity of toothed dolphins to sound falls sharply below 1 kHz, and sounds below 0.2 kHz are probably inaudible to them. The sounds used by dolphins for communication are often above 4.8 kHz, and echolocation sounds can occur up to 200 kHz. Goold (1996a) found significant levels of energy across the recorded bandwidth up to 22 kHz. This high frequency noise, incidental to seismic operations, will overlap with the frequencies used by toothed dolphins, and

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could potentially cause disturbance. There is some evidence of disturbance of dolphins by seismic activity (Goold 1996b, Stone 1997, 1998).

Seismic activity could have a number of different effects on small cetaceans: it may interfere with communication or alter behavior. In the worst case, there is some risk of physical damage in the immediate vicinity of air-guns. There is no evidence to suggest that injury has occurred to any cetacean in UK waters as a result of seismic activity, although such injuries may be difficult to detect. Seismic surveys may have indirect effects on local cetacean populations because of changes they may cause in the distribution of prey species.

The risk to cetaceans is increased by their natural inquisitiveness, and the fact that they may be attracted to areas of human activity where seismic surveying is about to take place.

Further information and comments on these guidelines

If you have any comments or questions on these guidelines, or suggestions on how they may be improved, please contact:

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ANNEX

CONTACT NAMES AND ADDRESSES

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FURTHER INFORMATION

Davis *et al.* 1990. *State of the Arctic Environment, Report on Underwater Noise.* Prepared by LGL Ltd, PO Box 280, King City, Ontario, Canada L0G 1K0. Prepared for the Finnish Initiative on Underwater Noise. Provides a useful summary of the available scientific information of the possible effects of acoustic disturbance on cetaceans.

Environmental Guidelines for Exploration Operations in Nearshore and Sensitive Areas, published by the UK Offshore Operators Association, 3 Hans Crescent, London SW1X 0LN.

Evans, P.G.H. & Nice, H. 1996. *Review of the effects of underwater sound generated by seismic surveys on cetaceans.* Report to UKOOA, Sea Watch Foundation, Oxford.

Goold, J.C. 1996a. Broadband characteristics and propagation of air gun acoustic emissions in the southern Irish Sea. *(in press).*

Goold, J.C. 1996b. Acoustic assessment of populations of common dolphin *Delphinus delphis* in conjunction with seismic surveying *Journal of the Marine Biological Association 76:* 811-820.

Moscrop, A. & Simmonds, M. 1994. *The threats posed by noise pollution and other disturbances to the health and integrity of cetacean populations around the UK.* A report for the Whale and Dolphin Conservation Society, pp. 1-8. (Includes a review of work on acoustic disturbance of cetaceans). Available from the Whale and Dolphin Conservation Society, Alexander House, James Street West, Bath, Avon, BA1 2BT.

Richardson, W.J., Fraker, M.A., Würsig, B. & Wells, R. 1985. Behavior of bowhead whales *Balaena mysticetus* summering in the Beaufort Sea: reactions to industrial activities. *Biological Conservation 32:* 195-230.

Richardson, W.J., Greene, C.R. Jr., Malme, C.I. & Thomson, D.H. 1995. *Marine mammals and noise.* Academic Press, San Diego.

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Stone, C.J. 1997. Cetacean observations during seismic surveys in 1996. *JNCC Reports, No. 228.*

Stone, C.J. 1998. Cetacean observations during seismic surveys in 1997. *JNCC Reports, No. 278.*

Turnpenny, A.W.H. & Nedwell, J.R. 1994. *The Effects on Marine Fish, Diving Mammals and Birds of Underwater Sound Generated by Seismic Surveys.* Fawley Aquatic Research Laboratories Ltd, Fawley, Southampton SO45 1TW. (This includes an extensive further bibliography). Available from United Kingdom Offshore Operators Association, 3 Hans Crescent, London, SW1X 0LN.

USEFUL CETACEAN IDENTIFICATION GUIDES:

Cawardine, M. 1995. *Eyewitness handbooks - Whales, dolphins and porpoises.* Dorling Kindersley. ISBN 0-7513-1030-1. Price £14.99. Available from bookshops.

Evans, P.G.H. 1995. *Guide to the identification of whales, dolphins and porpoises in European seas.* Sea Watch Foundation Publication, Oxford. Available from Sea Watch Foundation, Unit 29, Southwater Industrial Estate, Station Road, Southwater, West Sussex RH13 7UD. Price £5.00 + 50p p&p.

Leatherwood, S. & Reeves, R.R. 1983. *The Sierra Club handbook of whales and dolphins.* Sierra Club Books, San Francisco. ISBN 0-87156-341-X (hardback) ISBN 0-87156-340-1 (paperback). Available from some bookshops.

Sea Watch Foundation / BBC Wildlife 1994. *Identification guide to whales and dolphins of the British Isles.* Laminated wall chart available from Sea Watch Foundation Publication, Oxford. Available from Sea Watch Foundation, Unit 29, Southwater Industrial Estate, Station Road, Southwater, West Sussex RH13 7UD. Price £2.95 + £1.00 p&p.

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www.iagc.org

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