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OILSPILL SCAT MANUAL
for the
COASTLINES OF BRITISH COLUMBIA

Procedures for the Assessment
of Oiled Shorelines and Cleanup Options.

Prepared by

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for

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ABSTRACT

The Shoreline Cleanup Assessment Team (SCAT) program is a systematic and comprehensive process that can be used in the event of an oil spill to provide a real time evaluation of shoreline oil conditions and to provide data and/or advice to the spill response organization and cleanup operations personnel in developing and planning response actions.

The SCAT program is based on detailed assessments of stranded oil conditions, geomorphologic features, and environmental resource, human use, and cultural sensitivities along affected shorelines using standardized procedures, terminology, and definitions. These assessments, if applied in full on a large coastal spill, can involve three levels of detail (three types of shoreline surveys):

- an initial aerial reconnaissance to define the extent of the affected area,
- a systematic, low altitude aerial videotape survey to document and then map the shoreline oiling conditions, and
- a systematic and detailed ground survey to collect data on oiling conditions, coastal geology, coastal ecology, and human use/cultural resources in the affected area.

A fourth component can be to establish monitoring sites to document changes in oil conditions and ecological recovery at representative locations.

This manual presents and explains for potential users, the shoreline survey procedures which are the primary data collection component of the SCAT program. It provides details on personnel, logistics, survey methods, documentation and mapping, with particular emphasis on the the ground assessment survey component. Guidance is provided on shoreline segmentation, characterization of stranded oil, coastal environments and shoreline geomorphology, ecology and archaeology.

Résumé

Le programme de L'Equipe d'Evaluation de Nettoyage du Littoral (SCAT) fournit une méthodologie compréhensive et systématique qui peut être utilisée en cas d'un déversement de pétrole pour fournir une évaluation de temps valable des conditions d'huile sur les littoraux et pour fournir de l'information et/ou des conseils à l'organisation qui répond aux déversements et au personnel en charge des opérations de nettoyage dans le développement et la planification de leurs réactions.

Le programme SCAT est basé sur des évaluations détaillées des conditions d'huile isolées, des traits géomorphologiques, et de la sensibilité envers les ressources environnementales, l'usage humain, et la culture au long des littoraux affectés tout en utilisant des procédures, terminologie, et définitions standardisées. Si ces évaluations sont appliqués entièrement sur un grand déversement de littoral, elles peuvent impliquer trois niveaux de détails (trois genres d'études du littoral):

- une *patrouille* aérienne préliminaire pour déterminer la superficie affectée,
- un relevé systématique aérien à basse altitude sur bande magnétoscopique pour documenter et ensuite tracer les conditions de l'huile sur le littoral, et
- une étude systématique et détaillée, faite au sol, qui sert à accumuler de l'information sur les conditions du déversement, la géologie côtière, l'écologie côtière, et l'usage humain/ressources culturelles dans la région affectée.

Une quatrième étude peut être d'établir un site pour un système de contrôle qui documente les changements dans les conditions du déversement et le rétablissement écologique à des locations représentatives.

Ce manuel présente et explique aux usagers potentiels les procédures d'études de littoraux qui sont les collections d'information primaire du programme SCAT. Il fournit des détails sur le personnel, la logistique, les méthodes d'étude, la documentation et la cartographie, tout en plaçant une emphase sur l'étude de l'évaluation au sol. Des conseils sont fournis sur la segmentation du littoral, la caractérisation de l'huile isolée, les environnements côtiers et la géomorphologie, écologie et archéologie du littoral.

PREFACE

This is one of a series of manuals being developed for the various coastal provinces of Canada which will provide a common methodology and terminology for the Shoreline Cleanup Assessment Team (SCAT) program. At the time of writing, compatible manuals are being developed by Environment Canada for the coasts of Atlantic Canada and the Great Lakes.

The SCAT procedures described in this manual are derived from field experience gained in British Columbia during the *Nestucca* incident in 1989 and from procedures developed by Exxon USA and Woodward-Clyde Consultants following the *Exxon Valdez* oil spill. The Exxon SCAT program was applied extensively in Alaska, where it proved to be a highly successful and valuable approach in collecting information for the spill response program (Owens & Teal, 1990; Owens 1991 a,b). The basic concept, uniform terminology, and the name 'SCAT' have been retained in this manual; however much of the procedural detail, terminology, and application have been expanded or adapted to reflect the character of the coastal environments of British Columbia. The scope of the procedures has been broadened to cover a wide range of possible spill conditions. Although designed for British Columbia, the SCAT program described herein can be applied in a generic manner to other coastal environments.

Questions or comments on this manual can be directed to the following;

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The use of trade names in this document does not constitute endorsement by Environment Canada, and other products of similar value are available.

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1.0 ORIENTATION TO THE SCAT PROGRAM

1.1 INTRODUCTION

The Shoreline Cleanup Assessment Team (SCAT) program is a systematic, orderly and comprehensive approach that can be used following an oil spill to provide real-time information on shoreline oil conditions. This assessment can be used by operations personnel to scope and plan the resources and equipment required for response activities. The data gathering procedures provide detailed assessments of stranded oil, geomorphologic features, environmental resources, human uses, and cultural sensitivities along affected shorelines using standard procedures, terminology, and definitions. The approach is applicable to large spills from tankers, coastal freighters, offshore wells, or marine terminals, where many kilometres of shoreline have been oiled or are threatened by an oil spill, as well as to small spills where assessment or documentation are required.

The **purpose of this manual is to present and explain SCAT procedures** to field personnel and managers who would potentially utilize the SCAT approach. The SCAT procedures described in this manual are ready for use as presented; nevertheless, this document is not intended to be used as a definitive protocol for shoreline assessment, but rather as the foundation from which to build or fine tune the actual procedures that would be followed in the event of a spill. In practice, the SCAT procedures can be reconfigured, expanded or selectively applied to accommodate the idiosyncrasies of a given spill or its organizational structure. The modified SCAT procedures described in this manual reflect the opinion of Woodward-Clyde and Environment Canada with respect to a typical, well-rounded, practical version that is likely to be suitable for most spill situations, not only in BC, but in many coastal environments worldwide.

1.2 FRAMEWORK AND SCOPE

It is not intended that this manual fix the mechanism or process by which a SCAT program is implemented or administered within the overall spill response framework. The SCAT program could be established by the spiller, or the lead government agency taking responsibility for the spill response, or a body such as REET (Regional Environmental Emergency Team) which provides scientific, technical and environmental advice. Typically, the SCAT reports through a technical manager to a spill response organization (government or industry) or the On-Scene Coordinator (OSC).

Internally, SCAT procedures are implemented through the Shoreline Cleanup Assessment Team (SCAT), a management structure which is supported by one or more shoreline assessment surveys, and typically by several scientific/technical coordinators or advisors. The shoreline assessment personnel may be specialized according to the type of survey they conduct (reconnaissance, video, ground assessment, or monitoring). Likewise the coordinators/advisors may be specialized according to discipline (e.g., archaeology, ecology, logistical support).

It is effective for the SCAT team to be responsible for:

- shoreline assessment surveys,
- shoreline sensitivity identification/verification,
- technical advice for shoreline treatment activities, and
- shoreline monitoring programs.

The shoreline assessment surveys, including the monitoring program, are one of the most important functions of the SCAT and, subsequently, are the focus of this manual. Existing shoreline sensitivity information on ecological, human use and cultural concerns is available in databases, atlases, and compilations. The completeness of these resources varies for different coastal areas. These are commonly supplemented with current or new data collected by the SCAT at the time of a spill.

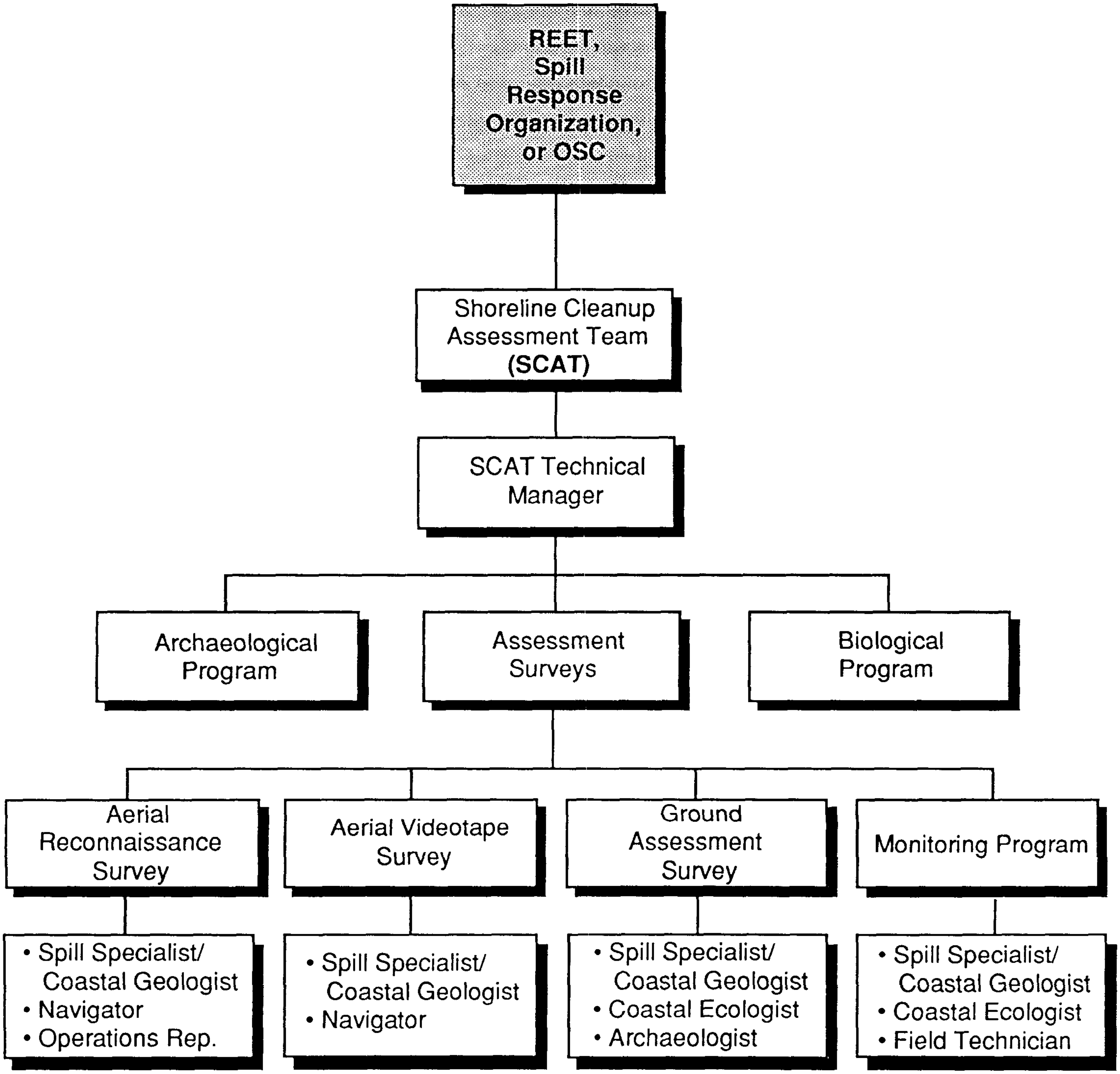


Figure 1. Typical Shoreline Cleanup Assessment Team (SCAT) Organization

Technical advice for shoreline treatment is provided by the SCAT mainly through recommendations from the field assessment surveys. The field assessment surveys ideally would be staffed by impartial experts from consulting firms, academia, or industry, but also may be staffed by government agency personnel with expertise in spill response, coastal geology, ecology or archaeology. In general, the recommended cleanup constraints and response options for a given segment or area of shoreline are submitted by the survey personnel to the SCAT Technical Manager for review. The SCAT Technical Manager should be a senior professional with extensive experience in shoreline assessment, oil spill response, and shoreline cleanup. The Technical Manager may take into account environmental, human use, and cultural sensitivities and other shoreline characterization data, as well as available response resources and technique effectiveness. The SCAT Manager then would present the most effective and environmentally sound response option(s) to the Spill Response Organization Manager and/or OSC. The options also would be presented to the appropriate regulatory agencies for review and approval. Once a mutually acceptable response option is identified and approved, the plan or recommendations would typically be forwarded to the Cleanup Operations Manager for implementation.

In some situations, however, the ground assessment personnel may have the authority to determine the most appropriate response option(s), including natural recovery, in the field, particularly if the field crew includes agency and native council representatives. Thus, the process of making decisions and obtaining approvals for the response option(s) may range from a mechanism with many levels of management and committees to one which is integrated into the ground assessment survey. In all cases, decisions and approvals would include the same basic procedures, and would draw directly on the same shoreline survey information.

1.3 OVERVIEW OF THE SHORELINE ASSESSMENT SURVEYS

The shoreline surveys are the primary data collection component of the SCAT procedure; they are described in detail in the remaining chapters of this manual. Generally, the shoreline surveys are conducted in four successive steps:

- Aerial reconnaissance survey (Section 2.0)
- Aerial videotape survey (Section 3.0)
- Ground assessment survey (Section 4.0)
- Monitoring program (Section 5.0)

The first step of the SCAT procedure is to conduct an **aerial reconnaissance survey** to describe the general oil conditions and to define the limits of the region to be studied in subsequent, and more detailed, aerial and ground surveys. The aerial reconnaissance surveys provide an overall perspective of the magnitude of the spill as well as identifying shorelines that are threatened or currently impacted by oil. This stage is an adjunct to any surveillance and tracking flights and is not intended to replace those key activities. The reconnaissance surveys are typically conducted by an oil spill specialist, navigator, and Cleanup Operations representative. The information from reconnaissance surveys is used to establish shoreline protection locations and their priorities and to direct the initial shoreline assessment aerial videotape surveys to the most heavily impacted or highest priority shorelines.

The next step in the SCAT procedure is the **aerial videotape survey**, which is conducted by a coastal geologist or oil spill specialist/videotape camera-operator and a navigator. The aerial videotape survey provides low-altitude documentation of the shoreline from which preliminary shoreline character and initial oil distribution maps are produced. Documentation provided by the aerial videotape surveys is then utilized by Operations for planning and scoping purposes and for establishing priorities for the ground assessment surveys.

The **ground assessment surveys** are the most detailed and comprehensive of the three assessment phases, and provide the SCAT with the necessary data to formulate appropriate response recommendations. In addition, ground surveys furnish Operations with the required information for implementing the response program and minimizing impacts to the environmental and cultural resources of the area. The ground survey is carried out by a crew that consists primarily of a coastal geologist with oil spill experience and a coastal ecologist. An archaeologist is required for areas that are known or suspected to contain cultural resources. Other crew members, such as an Operations representative, representatives of government agencies, and native and land owner/manager personnel, can provide valuable input and assistance in the field and facilitate the decision process, but are not essential to the completion of the surveys.

Initially, the shoreline is divided into predetermined segments within which the shoreline character is relatively homogeneous in terms of physical features and sediment type. Longer segments may be divided into subsegments if oil conditions vary significantly from one portion of the segment to the other. The field crew, using appropriate vehicle, boat, or aircraft support, then conducts systematic surveys of the individual segments to define shore-zone features, describe the ecological community, identify human uses and cultural resources, and document the character and distribution of any stranded oil. In addition, the crew evaluates apparent or potential effects of the oil, or proposed treatment activities, on the human uses and on the ecological and cultural resources.

Each segment is photographed and/or videotaped and is described using predefined methods and terminology to ensure uniformity of information between sections of shoreline and between survey crews, if more than one crew is deployed. The data sheets and forms used for documentation are included in this manual and are designed so that the most pertinent information can be input, using templates, to a database for storage, analysis and retrieval.

Information generated by aerial and ground assessment surveys is used on a site-specific basis to help evaluate:

- whether or not a section of shoreline warrants treatment,
- the priority for treatment response, and
- the most appropriate response option(s) to control or remove the oil.

The field survey data are combined with other existing information on human use, ecological resources, or cultural features to evaluate any timing or operational constraints that may modify the recommended response activities. This evaluation is subsequently used by planners and Operations personnel to develop a response program.

Once the more heavily impacted or highest priority shorelines have been surveyed, a **monitoring program** can be implemented to assess the fate and persistence of stranded oil and the recovery of affected shorelines. This monitoring program provides a feedback mechanism to evaluate the effectiveness and effects of earlier treatment decisions and response options.

The monitoring program usually consists of establishing several sites in areas with different degrees of oil conditions, exposures, treatment techniques (including no treatment), substrates, and degree of biological and other impacts to monitor the changes in oil conditions and recovery over time. Transects are set up across the beach at representative locations, and then periodic surveys are conducted to monitor oil cover, beach topography, sediment distribution, types and densities of biota, oil penetration, and other parameters along each transect. Observations of oil character and classification are also made. The program is very useful in documenting the effectiveness and effects of various treatment techniques and natural cleansing processes, in addition to evaluating local coastal processes. This program proved essential in the documentation of both treated and untreated shorelines following the *Exxon Valdez* incident. The monitoring surveys are conducted by crews consisting of an oil-spill specialist/coastal geologist, coastal ecologist and a field technician.

1.4 OBJECTIVES OF THE SHORELINE ASSESSMENT SURVEYS

The objectives of the **Aerial Reconnaissance Surveys** are:

- to gain an overall perspective on the magnitude of the spill,
- to locate oiled and threatened shorelines, and
- to provide input to Operations and to the Shoreline Cleanup Assessment Team for determining locations and priorities for protection actions and aerial videotape surveys.

Aerial Videotape Surveys aim:

- to document, in a detailed and consistent manner, the shoreline oil conditions throughout the spill area in video and graphic (map) formats, so that treatment planning and prioritization can be initiated,
- to provide information to the Shoreline Cleanup Assessment Team for establishing locations and priorities for ground surveys, and
- to enable mapping of other spill-related data such as the location of sensitive habitats, human uses, potential logistical staging areas, shoreline accessibility, and potential cultural resource site locations.

Ground Assessment Surveys are conducted:

- to collect detailed information on shoreline oil conditions, and on the physical and ecological character of the oiled shorelines so that appropriate treatment response operations can be developed,
- to identify and describe any environmental, human use, or cultural features that might affect, or be affected by, the timing and implementation of response activities, and
- to confirm and clarify observations from the aerial videotape surveys.

Monitoring Programs are designed:

- to document changes over time in shoreline oil conditions (fate, character, distribution) and shoreline morphology and sediments, which have been caused by the efforts of the treatment operation and/or natural processes,
- to document changes in, or the recovery of, biota over time in areas which have been cleaned and/or left to natural recovery, and
- to evaluate the effectiveness and effect of the treatment decisions and options which were applied to various shoreline segments.

1.5 APPLICATION OF SCAT PROGRAM

The SCAT program is designed to provide several essential functions that include:

- serving in a **technical support** capacity to the spill response organization, OSC or Operations to assist them in spill response decision-making, planning and implementation,
- providing **information and documentation** to regulatory agencies and land owners/managers as a mechanism for their input, and
- generating a **database** to assist treatment operation planning, implementation and progress tracking.

The technical support is provided primarily in the form of data on shoreline oil conditions, geomorphology, accessibility, and ecological, cultural, and human use constraints. These data are obtained from the aerial reconnaissance, low-altitude videotape, and/or ground surveys and summarized for use by Operations in response planning and implementation. The aerial videotapes, documentation forms, sketch maps, and response option recommendations, generated by the field crews and synthesized by the SCAT managers and staff, are particularly useful in identifying the appropriate treatment technique(s) and the operational and logistical requirements for implementing the response program. For example, the videotapes can be reviewed to determine the specific nature of the shoreline, vessel and helicopter accessibility, exposure, and general oil condition. The forms and sketch maps further define the location, degree, and character of the oil and identify constraints that must be taken into account. The response recommendations are reviewed by SCAT personnel in terms of available logistics, implementation time, effectiveness on similar shorelines, and other factors to determine the most appropriate and effective response option, which is then submitted to Operations. This information increases the overall efficiency of the operation, and greatly reduces the potential for unanticipated problems once the treatment crews reach the shoreline. The SCAT allows Operations to focus on shoreline protection and treatment rather than on collecting and reviewing data.

Regulatory and agency input, for incidents where the spiller takes responsibility for the response, is facilitated by the SCAT in two ways. The first is through possible participation on the ground survey crews, where the regulatory agencies can provide input into the documentation of the oil conditions and the response option recommendations. The second is through the review process, where copies of the SCAT ground assessment survey reports, along with the final response recommendations from the SCAT and Operations, are submitted to the regulatory agencies for their review and comment. SCAT, however, is not intended to be an advisory or decision-making body with regard to regulatory or agency issues. Once agreement is reached on the appropriate course of action, the response plan, including treatment techniques and constraints, is submitted to Operations for implementation.

The SCAT procedure thus assists in building consensus which facilitates the necessary approvals for treatment. The field data can be entered into a database and geographical information system (GIS) to allow the generation of statistics and maps displaying a variety of information such as oil distribution, segment locations and boundaries, shoreline sensitivities, number of kilometres surveyed, number of kilometres treated, treatment activities by segment, sediment distribution, and exposure to waves. This type of information has proven vital in planning, implementing and tracking a large spill response operation.

1.6 HOW TO USE THIS MANUAL

This manual can be used as either a quick reference guide or as a source of detailed information on the recommended stages, procedures, and implementation of a SCAT program. A flow diagram showing the interrelations and implementation sequence of the primary SCAT stages is provided in Figure 2.

The following presentation sequence is used in this manual:

- **Introduction (Section 1.0):** a general overview and a summary of the SCAT process;

- **Detailed Description of the SCAT Procedures (Sections 2.0 through 5.0):** descriptions of each stage of the SCAT program from aerial reconnaissance (2.0) and aerial videotaping (3.0) to ground assessment surveys (4.0) and monitoring programs (5.0);

- **Supporting Information (Appendices A-H):** background information and explanations which support the earlier chapters; including material which provides an understanding of the relevant environmental processes. Also included are a **Glossary of terms (Appendix G)** and a **Bibliography** of relevant documents and publications **(Appendix H)**; and

- **Blank Forms Package (Appendix I):** a complete set of the SCAT field forms referred to in this document which are ready to copy for actual field use. A set of instructions for completing each of these forms is also included in this appendix.

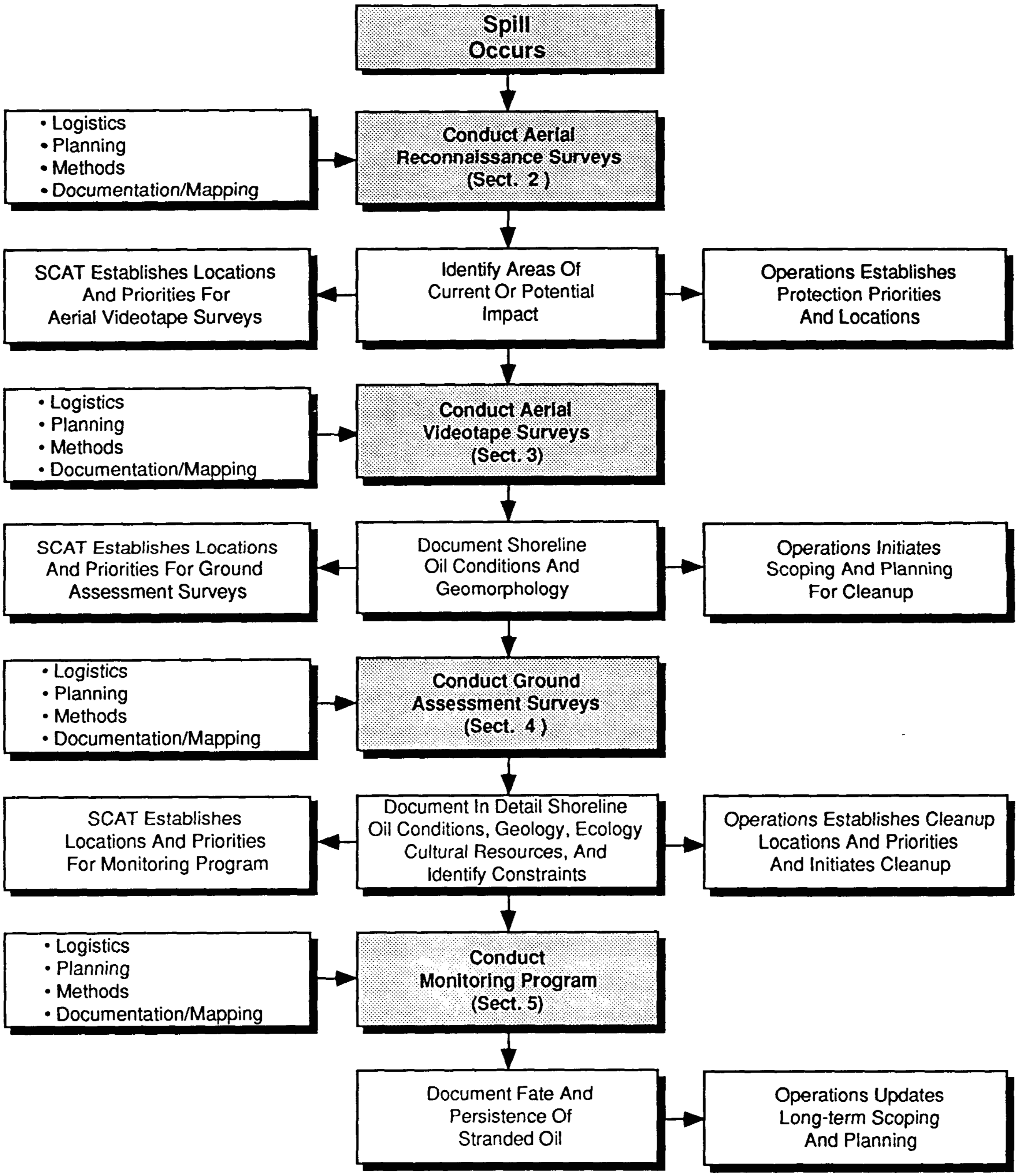


Figure 2. SCAT Procedure Implementation Sequence

2.0 AERIAL RECONNAISSANCE SURVEYS

2.1 INTRODUCTION

The aerial reconnaissance survey is conducted following procedures recommended in this section. Details on the survey objectives, logistics, methods, mapping and documentation, and priorities are provided in the following discussion.

2.2 OBJECTIVE

The objective of this initial aerial reconnaissance survey is to determine which shorelines, if any, have been oiled and which are threatened by oil. This information provides an overall perspective which can then be used in conjunction with existing environmental, resource and cultural sensitivity data to determine which areas need to be or can be protected and the appropriate implementation priorities. The information also can be used to establish locations and priorities for the aerial videotape surveys. **This activity is separate from, but partially dependant on, a surveillance and tracking program which focuses upon the movement of oil on the water.**

2.3 PERSONNEL

The reconnaissance survey personnel consists of an **oil-spill specialist/coastal geologist (OG), navigator/mapper, and Operations representative.**

The **OG** provides the expertise to identify the oil on open water, as it is often difficult to spot thin silvery sheens from the air, and to differentiate between oil, particularly emulsified oil, and organic debris. The debris typically consists of spruce needles, *Fucus* or kelp. The OG also identifies shorelines affected by oil and is usually able to differentiate between the black lichen or mussels and oil on rock shorelines.

The **navigator/mapper** would be familiar with aerial navigation procedures to ensure that locations of oil slicks, sheens, and oiled shorelines are mapped accurately, along with the date and time of each observation. If ground stops are required or found to be necessary, all ground truth locations are included on the maps. The primary role of the **Operations representative** is to gain perspective of the degree of shoreline oiling and the magnitude of the spill.

2.4 LOGISTICS

2.4.1 Aircraft

The optimum aircraft for these surveys is a single-pilot, three- to four-passenger twin-engine helicopter with inflatable floats and sufficient range to cover the spill area without refueling. Experience has found that the Aerospatiale Twin-Star or A-Star, Bell 206 Long Ranger, or Messerschmitt BO-105 are well suited to these surveys due to their excellent field of vision, range, speed, and manoeuvrability. Other aircraft with similar characteristics also would be acceptable. Bell 205, 212, 412 and 214 helicopters could be used, if necessary, but they have a limited field of vision from the passenger area which can create navigational difficulties.

Fixed-wing aircraft with wings over the fuselage are acceptable; however, they fly at higher speeds, are less maneuverable, have less visibility, and typically cannot land, unless on floats, to provide spot checks on the ground of aerial observations. Fixed-wing aircraft with wings under the fuselage are not acceptable for this purpose and are not considered.

2.4.2 Videotape Recording and Camera Equipment

The type or make of video equipment used in these surveys is not critical, although a small and lightweight videotape camera is easy to operate within the aircraft. A time/date imprint function is an advantage. A zoom capability is preferable, particularly if a fixed-wing aircraft is used. Water-resistant cameras are recommended for ground stops or if filming is to be done with the aircraft doors removed.

For still photography, a 35-mm camera with a zoom lens is preferred. Kodachrome 36 exposure slide film is recommended to accentuate the oil (Kodachrome is biased toward reds and browns). Fast film, such as ASA/ISO 400, enables faster shutter speeds for photos from moving aircraft, and during overcast days. A power winder or motor drive allows rapid and convenient film advancement. Slide film provides the option of producing slides for presentations or prints for reports and other documentation. Water-resistant cameras or camera enclosures are advisable if ground stops or if shots out of open windows or doors are planned. Two operable camera bodies should be taken on the survey, in the event that one breaks down. The two cameras could also be fitted with different lenses and film speeds.

2.5 RECOMMENDED SURVEY METHODS

Aerial reconnaissance is best conducted from a helicopter or small fixed-wing plane to allow for slow speeds and greater manoeuvrability. A helicopter is preferable because it allows periodic ground stops to verify observations, if necessary. Surveys usually combine high-altitude (up to 500 m) observations to gain an overall view of the spill and low-altitude surveys (less than 100 m) to provide greater detail and resolution. Surveys are almost always conducted during the lower half of the tidal cycle to ensure that the majority of stranded oil is visible. Both videotape and still photography are used during the reconnaissance to document observations, aid in planning operations, and resolve any questions that may arise later concerning the degree and location of the oil.

The following **Reconnaissance Survey Procedures** are recommended:

- determine the areas to be surveyed, associated logistics, tidal stages, and the supplies necessary to complete the survey prior to departure each day;
- identify alternate survey areas in case the primary locations are inaccessible due to weather;
- file a flight plan and determine the fuel supply locations and requirements, including refueling points, in advance to ensure safety and efficiency;
- review prevailing surface current circulation patterns and recent local wind data before each survey to evaluate the probable direction of spill movement;
- conduct high-altitude reconnaissance first to locate the oil and potentially oiled shorelines; and
- conduct low-altitude surveys to better assess the degree and extent of the stranded oil (some areas may require a resurvey if tidal currents and/or wind direction change).

Equipment is checked daily for normal operation before departure. This check includes the videotape camera for both picture quality and recording, the SLR camera and batteries, communication system, power supply, battery levels (if applicable), wiring and connections, etc.. An inventory is taken of supplies, such as blank videotapes, film, batteries, the appropriate maps for both the primary and alternate areas, writing instruments, etc., to ensure that these are available in sufficient quantities for the planned and/or alternate activities.

2.6 MAPPING AND DOCUMENTATION

Topographic maps or nautical charts can be used for navigation and oil documentation. Small-scale topographic maps are preferred. For reconnaissance surveys, the recommended scale is 1:50,000. Documentation on the maps should include information regarding:

- flight lines, including date and time;
- locations of both floating slicks and oiled shorelines, including the date and times of the observations; and
- reference to data on the location of any still photographs or video tapes, including the roll and frame or tape number and the photographer's initials.

A commentary on the videotape identifying the location, time and description of the subject being taped should be recorded.

2.7 PRIORITIES FOR SHORELINE PROTECTION AND TREATMENT

The initial priorities for the protection of highly vulnerable or sensitive areas must be determined very shortly after the spill occurs and before the slick impacts the areas to be protected. The need for timeliness requires that shoreline protection decisions be made largely on the basis of existing sensitivity atlases, databases, and the direction of slick movement. If the slick remains coherent, and off the coast, for a period of days it is possible that shore protection decisions for areas could be refined with data collected from the SCAT reconnaissance surveys or even from detailed SCAT ground based surveys.

SCAT procedures generally are implemented following the initial passage of the oil slick through an area and commonly focus on shoreline cleanup, rather than on shoreline protection. This is because vulnerable/sensitive areas not protected during the initial stages of the spill are likely to be oiled before SCAT procedures can be implemented, and also because the oil which remains behind following the initial passage of the slick is less mobile than the oil in the body of the slick. Pooled oil can be remobilized from the shoreline, however, and the SCAT information can be of some use in adding key protection points in the oiled region.

The initial reconnaissance surveys should identify existing and potential areas of shoreline oiling; this information can be used to establish tentative cleanup priorities. Several factors must be considered when establishing priorities for shoreline treatment:

- **Environmental sensitivity** - mariculture sites, sites in and around fish spawning habitats, pinniped haulouts, bird rookeries, salt marshes and other sites with high sensitivities to stranded oil or to cleanup efforts should receive a high priority.
- **Cultural/Human use sensitivities** - areas used for subsistence, commercial fishing grounds, recreation areas and parks, resort beaches, jetties, marinas, commercial water-front, and inhabited areas should be evaluated, and usually are assigned a high priority.
- **Seasonal variability** - pinniped haulouts, bird rookeries, or fly-ways may not be in use at the time of the spill, and this factor could change the relative priorities for protection and cleanup.
- **Access** - sensitive areas with poor access may receive a lower ranking than areas with good access as priorities are set. This action would maximize the effectiveness of protection or cleanup, if resources are scarce relative to need.

The establishment of these priorities is important for planning aerial videotape and ground surveys, as areas of high priority would be surveyed and treated first.

3.0 AERIAL VIDEOTAPE SURVEYS

3.1 INTRODUCTION

The aerial videotape surveys are conducted in areas identified from the aerial reconnaissance as having been oiled. The aerial videotape surveys provide a systematic and consistent visual documentation of oil distribution along the affected shorelines. The maps and videotapes generated from these surveys are useful both for Operations personnel to scope and plan treatment activities and for SCAT coordinators to plan ground assessment surveys. Treatment supervisors can view videotapes to assess the amounts and distribution of oil and potential access problems prior to mobilization for cleanup or treatment. Combining aerial-based tasks of reconnaissance and aerial videotape surveys should be considered when aircraft availability and manpower may be limited, or unjustifiable during smaller spills.

Videotapes can be used for a number of purposes, including the mapping of:

- Shoreline oil conditions (Appendix B),
- Access points,
- Logistical staging areas,
- Shoreline geomorphology/sediments (Appendix C),
- Ecological habitats (Appendix D),
- Anadromous stream locations, and
- Cultural resource sites (Appendix E).

3.2 OBJECTIVE

The objective of the low altitude aerial videotape survey is **to provide detailed and systematic documentation on the extent of shoreline oil conditions**. The surveys and subsequent documentation identify locations and distribution of the lightly to heavily oiled areas, the oil cover, shoreline configuration, substrate types, and potential access restrictions. Experience has shown that some lightly to very lightly oiled areas can be identified only with difficulty by the videotape surveys, usually where the amount of oil is small or where the distribution is sporadic.

3.3 PRIORITIES FOR AERIAL VIDEOTAPE SURVEYS

The criteria for aerial videotape survey priorities are similar to protection and treatment priorities, and are based on **environmental and cultural sensitivities, logistical feasibility and the degree of shoreline oil conditions** (protection priorities are based on the potential for becoming oiled). Those areas with the greatest sensitivity and heaviest oiling typically are candidates for the initial treatment effort and likely would be surveyed first, subject to available logistics.

3.4 PERSONNEL

The aerial videotape survey crew consists of an **oil spill specialist/coastal geologist (OG)** with oil spill and videotape recording experience and a **navigator**. Navigation is conducted from the front seat because of the superior visibility. The navigator is responsible for logging the flight-line, general shoreline oil information and time intervals on the maps while the OG operates the video camera and provides the commentary. To maximize flight time and range, it is preferable that no other passengers accompany the videotape surveys.

3.5 LOGISTICS

The logistical requirements for the aerial videotape survey (summarized in Table 1) consist primarily of aircraft, supplies, videotape and communication equipment, maps and permits.

TABLE 1. AERIAL VIDEOTAPE SURVEY LOGISTICS

Equipment	Type	Considerations
AIRCRAFT		
Preferred		
Aerospatiale Twin- or A-Star Bell 206 Long Ranger or Standard Messerschmitt BO-105 Bell 212, 412, 214 or 205 Other helicopters Fixed-wing planes (wing over)		• Visibility • Camera movement • Fuel requirements • Speed • Range • Manoeuvrability and landing ease
Other aircraft with similar characteristics would also be acceptable.		
CAMERAS (for use with Camera/Recorder/Monitor System)		
Required		• On Screen Date/Time • Durable • Audio recording capabilities • Low light capabilities (CCD circuitry)
Preferred	HI-8mm, Super VHS 3/4-inch UMATIC	• CCD Type • Quality Telephoto Lens • Auto/Manual Iris • Auto/Manual color balance • Auto/Manual focus • Docking with recorder, and/or single cable connection • High resolution (300 to 500 lines)

TABLE 1. AERIAL VIDEOTAPE SURVEY LOGISTICS

Equipment	Type	Considerations
CAMERAS (continued)		
Acceptable	Regular 8mm	• Low cost, good quality
	Regular VHS	• Readily available, acceptable quality
	Regular Beta	• Acceptable quality
CAMCORDERS (for use instead of Camera/Recorder/Monitor system)		
Required		• On Screen Date/Time • Durable • Audio recording capabilities • Low light capabilities (CCD circuitry) • Built-in monitor
Preferred	HI-8mm	• High resolution (500+ lines)
Acceptable	Regular 8mm, Regular VHS, Regular Beta	• Low cost • Durable • Compact • Resolution of 230 to 250 lines
RECORDERS (for use with Camera/Recorder/Monitor System)		
Required		• Compatible with cameras and monitors

TABLE 1. AERIAL VIDEOTAPE SURVEY LOGISTICS

Equipment	Type	Considerations
RECORDERS (continued)		
Preferred	HI-8mm, Super VHS, 3/4-inch UMATIC	• Controlled from camera • Video in/out • Two-channel audio recording • Audio-level indicators • Audio in/out (mike and line) • Docking with camera, and/or single cable connection
Acceptable	Regular 8mm	• Low cost, good quality,readily available
	Regular VHS, Regular Beta	• Durable • Compact • Resolution of 230 to 250 lines
MONITORS (for use with Camera/Recorder/Monitor System)		
Preferred	5 to 9 inch screen	• Colour • RF inputs • Video and audio line inputs • Controls and inputs accessible in aircraft configuration • Power supply available on aircraft • Sun shade • External DC power input
Acceptable	no other units	

TABLE 1. AERIAL VIDEOTAPE SURVEY LOGISTICS

Equipment	Type	Considerations
COMMUNICATIONS		
Preferred	2-Channel	• Voice activated • Noise canceling mikes • Minimum of 4 crew system, plus pilot • 2-channel, selectable inputs • 2-channel out recording • External DC power inputs plus battery
Acceptable	no other units	
SUPPLIES		
Aircraft Power Converter		• 12-30 volts (dc) in to 12 volts (dc) out • Connections for camera, recorder, monitor and communications systems
Battery Backups (2)		• Camera, recorder, monitor and communications systems for at least 1 hour

TABLE 1. AERIAL VIDEOTAPE RECORDING LOGISTICS (concluded)

Equipment	Type	Considerations
SUPPLIES (continued)		
Videotapes		• Highest quality available • Sufficient tapes for day's planned survey and alternate sites, plus extras for damage - good rule to carry several extra tapes
Camera (for still photography)		
35 mm SLR		• Water-resistant or enclosed is advisable, zoom lens for close-ups, Kodachrome 36 slide film is recommended - data backs to record date and time, if possible, are preferred
Maps		• Strip maps preferable, carry maps for survey plus alternate sites
Drinks/Food		• Constant talking can be aided by cold drinks and hard candies
Clothing		• Dress according to conditions - surveys with doors and window removed are often windy - rain, sleet or insects striking the body at high speeds are uncomfortable

3.5.1 Aircraft

The aircraft requirements for an aerial videotape survey are similar to those described previously for the reconnaissance survey. In summary, the preferred aircraft is a small- to medium-size, single-pilot, twin-engine helicopter with room forward for the navigator and removable rear doors or windows to maximize visibility and camera movement. Larger helicopters, and even fixed-wing aircraft, may be used if necessary, but can significantly lower the quality of the product and efficiency of the operation. Fixed-wing planes with wings below the fuselage are inadequate for this purpose and are not used except in unusual circumstances.

3.5.2 Video Equipment

The preferred videotape recording systems are outlined in Table 1. It is important that the system have a date and time imprint feature to reference locations. A preferred camera option is a zoom feature to provide closeups of oiled areas and of small coves where access for the aircraft may be difficult. Zoom closeups generally provide a lower quality image and are used for only short periods of time. Cameras can be water-resistant or equipped with water-resistant coverings; they also can be fitted with remote microphone and headset jacks to facilitate connection to the communication system. Ideally, a separate camera and recorder system, including a two-channel communications system and remote colour monitor, would be used to allow greater versatility, better quality control and fewer wire connections to the camera. The system could be supplemented by a small camcorder for ground stops that involve taping outside the aircraft.

3.5.3 Communications System

The communications system usually consists of aviator-style headsets with voice-activated (VOX) mouth microphones for all crew members. The system is wired so that all parties can converse and record onto the audio track(s) of the camcorder or video recorder. Generally, some form of central connection box is required, although wireless systems can be used. In either case, there usually are a number of wires running between the front and back of the aircraft that should be taped together. This minimizes the possibility of wires catching on various parts of the aircraft and being inadvertently disconnected. All connections can be of the lock or twist quick-disconnect variety to allow easy passenger entrance and exit from the aircraft. The communication system and camera are connected to the aircraft power supply whenever possible to avoid delays that may be caused by discharged batteries. A battery backup system is necessary to permit videotape work during ground stops.

3.5.4 Maps

Topographic maps are used for the aerial videotape survey to permit accurate navigation and oil mapping. The preferred scale for aerial videotape surveys is typically 1:10,000 to 1:20,000. Larger scale maps are acceptable; but provide lower resolution and can create difficulties in navigation along relatively straight shorelines.

3.5.5 Permits

Prior to aerial videotape or other surveys where shoreline landings are anticipated, special-use permits or written permission may be required. The authorization generally is provided by the individual land owners or managers, which might include native village councils or private individuals. In some cases, permission may also be required by various provincial and federal resource agencies. Agencies owning or managing land along the BC coast include Parks Canada, the Department of National Defense, and BC Provincial Government. This process can be started immediately following a spill, as it may take several days or longer to complete. Some permits may require that copies of raw or processed data obtained from these surveys be provided to the land owner or manager within a reasonable time frame.

3.6 RECOMMENDED SURVEY METHODS

Aerial videotape surveys should be conducted systematically following a predetermined set of priorities. The procedures to be conducted each day are discussed in the following sections and include pre-flight planning, OG/navigator/pilot interface, videotape surveying, field documentation, and post-flight equipment and supply checks.

3.6.1 Pre-Flight Planning

Pre-survey planning is conducted daily to ensure safe and efficient operations, including:

- determination of the areas to be videotaped, associated logistics, and the supplies necessary to complete the survey prior to departure;
- identification of alternate survey areas in case the primary locations are inaccessible due to weather;
- filing of a flight plan, including fuel requirements and refuelling points, in advance to ensure safety and efficiency, and
- checking of equipment for normal operation before departure.

Tidal stage, sun angle, transit times, and fuel locations must be considered in planning the daily activities. The equipment check includes the video camera, for both picture quality and recording, the communication system, power supply, battery levels (if applicable), and wiring and connections. Supplies, such as blank videotapes, batteries, the appropriate maps for both the primary and alternate areas, and writing instruments are inventoried. If possible, maps of the areas to be surveyed are cut into page-size sections or "strip maps" and placed in a binder in sequential order to facilitate navigation and documentation.

3.6.2 Personnel Interface

Both crew members, and often the pilot, are wired into the audio track on the videotape; therefore, it is necessary to work out, in advance, a method by which crew members can interface and avoid talking over each other. The OG operates the camera and provides the majority of the narration. The navigator interrupts only briefly to provide additional pertinent observations, identify prominent landmarks and to mark the time (e.g.in one-minute intervals). The pilot should limit his conversation to responding to questions and notifying the OG and navigator of upcoming course changes. Course change information can include an explanation to minimize possible interpretation difficulties when others view the tapes. Typically, the pilot's external and internal communications are separate and only the internal communications are keyed to the audio track. Ideally, a two-channel, real-time interface communications system is used with the OG narration provided on one track and the navigator and pilot comments on the other.

3.6.3 Video Surveying Procedures

Whenever possible, the aerial videotape survey is conducted under the following conditions and taping parameters:

- from an altitude of 30 to 60 m, at a speed of 35 to 55 km/hr (20 to 30 kts) and at a distance offshore of approximately 50 m, depending on shoreline type or coastal relief;
- at low slack tide with a water elevation less than 25% of the tidal range, so that the majority of the intertidal zone is visible;
- from the rear passenger area by filming out of the side of the aircraft with the navigator in the front;
- with the rear door removed from the helicopter to allow for an unrestricted view and adequate movement of the camera;
- with the camera angled down (30 to 45°) and slightly ahead (15 to 30°) so that shoreline areas come into focus during the commentary; and
- with the sun behind the helicopter whenever possible, to ensure high quality resolution. (This factor can be incorporated into the daily planning so that the east-facing shorelines of an island or coast are filmed in the morning and the west-facing shorelines are filmed in the afternoon, when logistics, priorities and timing allow).

Although personal preference usually prevails, experience has shown that the camera can be placed on the person's leg or knee with the eyepiece pointed up. This allows the OG to have an unobstructed view of the shoreline for accurate characterization while periodically looking into the eyepiece to ensure proper camera position. Another technique is to place the camera on the shoulder with one eye looking through the eyepiece and the other looking at the shoreline. The optimum situation involves the use of a colour monitor so that the camera operator can easily view the image that is being recorded on the screen at a size that is considerably larger than the eyepiece image (often the eyepiece image is in black and white rather than colour).

The OG provides a continuous narrative description of the location and degree of shoreline oil distribution and character, the shoreline geomorphology, exposure, and other pertinent observations. If oil is not present, the OG states this periodically. It is important to maintain a continuous narrative, even if the information is repetitive, because only short portions of the tape may be viewed at any given time. The camera is best oriented so that the water line is in centre frame and the entire intertidal zone, the backshore, and a portion of the nearshore zones are included. This framing provides information on the shoreline geomorphology, oil distribution, access, ecology, and potential cultural resource site locations. Additional information is provided by Owens and Reimer (1991).

A separate tape is used to start the survey each day. This provides insurance, in case a tape is damaged or lost, and removes the possible need to re-survey areas covered in previous surveys. An overlap of the areas where one tape or survey ends and another begins ensures that there are no gaps. A sufficient overlap is usually 500 m, but a kilometre or more is recommended for long, straight, uniform sections of coast.

Ground stops are made periodically to confirm visual observations and to better assess the presence or extent of questionable oil distribution. These ground truth stops are particularly important in lightly oiled areas where lichen, mussel beds, dark or wet substrates, organic stains and red algae can be mistaken for oil from the air. If all questionable features are investigated by ground stops early in the survey, the observers can clarify what they see and develop a high degree of accuracy in distinguishing between natural features and oiled shorelines. During a ground stop the OG can inspect the shoreline from the helicopter, if the oil is in clear view, or can deplane to obtain the necessary clarification. In both cases, the OG can videotape the area to provide additional documentation.

3.6.4 Field Mapping and Documentation

The navigator is responsible for the written documentation and navigation during videotaping. Prior to taping, the navigator synchronizes his watch with the video camera clock. The tape start point and time are noted on the map with subsequent times and locations marked on the map at fixed intervals, for example, every minute. Other navigator responsibilities include:

- calling out prominent landmarks, such as headlands, bays, coves, villages, navigational markers, etc.,
- marking flight-lines to indicate the path, direction of travel, and which areas, if any, were not taped, and
- recording shoreline oil observations.

The use of a dual-channel audio system greatly enhances accuracy for location referencing and simplifies this procedure.

3.6.5 Post-flight Check

All videotapes taken each day are reviewed, in part or in full, to ensure the camera and OG functioned properly and that no areas need to be resurveyed. Batteries and other equipment are checked and recharged or replaced as necessary. Further logistic and videotape supply requirements are reviewed to ensure that the survey is not delayed by lack of tape, maps, or other supplies. A critique of the day's activities is conducted between crew members and the pilot to ascertain if procedural changes might improve or streamline the operation.

3.7 POST-SURVEY MAPPING AND DOCUMENTATION

The aerial videotape recording of the shoreline is only one step in the process. Documentation and processing of the information after the survey should include:

- mapping the oil conditions and shoreline geomorphology,
- preparing flight-line maps and indexes, and
- copying and cataloguing the videotapes.

These tasks are completed after each field survey or at the end of each day when the information is fresh in the crew members' minds. This timing also provides a rapid turnaround of information for treatment operations and planning.

As soon as practical after each survey, the shoreline oil information is transferred from the tapes to a corresponding set of similar scale maps. This is achieved by a review of the tapes and flight-line maps simultaneously, and by plotting the degree and locations of stranded oil on a separate set of maps. Colour coding or symbols may be used to record the degree of oil. Information from the video and audio portions of the tapes and notations from the navigational maps are included in the preparation of the oil distribution maps. This ensures that no significant information is omitted. It also may be desirable to produce geomorphological maps from the tapes for planning purposes and potential fate and persistence studies; the prominent geomorphological characteristics are mapped following the same procedures as the oil conditions. Maps of ecological habitats, shoreline accessibility, potential logistical constraints, and logistical staging areas may also be prepared from the tapes.

Upon completion of the oil distribution and geomorphological maps, the original videotapes are copied, indexed, and catalogued so that copies can be made available to operations, planning and other groups for review. Surveys are not always in a sequential geographic order and the tapes can be re-organized to facilitate easy retrieval of a particular shoreline section. Specifically, the tapes can be copied in a sequential manner beginning at one end of the affected area and working toward the other. After all of the tapes have been copied, they can be assigned specific numbers and indexed in tables by tape and the segment numbers covered by each tape. The corresponding flight-line maps with time (minute-by-minute) callouts also are indexed. These maps are at a larger scale than the originals and are cut up into page size sheets for insertion in binders and maintained with the videotapes and index.

By following this process, a particular segment can be easily located and viewed by first looking in the index table to obtain the videotape number that corresponds to the desired segment(s). The flight-line maps for that tape are then examined to determine the dates and times when the specific area was videotaped. The specific locations can be identified by matching the dates and times on the flight-line maps with those imprinted on the videotapes.

The original tapes should be stored at central files or another secure place. These should be clearly labelled "Original" and be used only to create copies for subsequent viewing or editing. **In NO instance should an original tape be edited.**

4.0 GROUND ASSESSMENT SURVEYS

4.1 INTRODUCTION

Shoreline ground assessment surveys are conducted on segments of shoreline where oil is known or suspected to be present. The surveys follow a priority sequence established on the basis of the reconnaissance and aerial videotape surveys, and on pre-existing shoreline sensitivity atlases and databases. The ground assessment personnel provide detailed, systematic and comprehensive real-time observations, which are used to guide and select treatment techniques and procedures. This section details crew members and their responsibilities, logistics, methods and documentation procedures.

4.2 OBJECTIVES

The objectives of the ground assessment surveys include:

- confirmation of observations made during aerial videotape surveys;
- documentation of shoreline oil conditions in greater detail than the videotape surveys;
- cross-checking information on environmental sensitivities compiled in atlases and databases;
- identification of general environmental effects;
- identification of potentially affected human uses and cultural resources;
- recommendations for appropriate response options; and
- identification of human use, ecological and cultural resource constraints on treatment operations.

Ground assessment surveys provide a means by which the responsible or interested government agencies and land owners can be involved in the documentation process and in the development of recommended response options by having representatives participate on the crews.

4.3 PRIORITIES FOR GROUND ASSESSMENT SURVEYS

After completion of the aerial videotape surveys and associated mapping, priorities can be established for the ground assessment surveys. Generally, the priorities for ground surveys are similar to those for treatment activities.

Those areas which receive the highest priority include areas with:

- moderate to heavy oil conditions;
- the greatest environmental and/or cultural sensitivities and human use; and
- an upcoming spring tide or seasonal winds.

Logistics also are a consideration when establishing priorities, depending on the available modes of transportation. Specifically, if only helicopters are available, shoreline areas with no helicopter access may receive a lower priority, regardless of their sensitivities, until vessels or other more appropriate modes of transportation are available.

4.4 PERSONNEL

Each ground assessment survey crew consists of an **oil-spill specialist/coastal geologist (OG), ecologist (ECO)**, and **archaeologist (ARCH)** who provide key technical knowledge and expertise. The archaeologist position is required only in areas where cultural resources are known or suspected to exist. In most cases, the survey crew positions are staffed by experienced professionals from consulting firms or academia, but may also be staffed by agency representatives with appropriate qualifications. This section outlines the general qualifications, responsibilities, and duties of each crew member. Representatives from Operations, the provincial and/or federal government and land owners/managers may also participate, but are not essential to the completion of the assessment and documentation mission of the ground assessment survey. The representatives can, however, contribute to the documentation and response option recommendation. This participation may minimize subsequent discussion on the degree and extent of oil conditions and recommended response options.

4.4.1 Oil Spill Specialist/Coastal Geologist (OG)

The **OG** has at least B.Sc. level training in geology or physical geography with oil spill experience and familiarity with shorelines in the spill area. The OG is responsible for the following areas:

- the logistical direction of the crew;
- documentation of oil conditions including completion of the Shoreline Oiling Summary (SOS) or Marsh Oiling Summary (MOS) forms, surface oil distribution and sketch maps;
- photographic documentation;
- collection of any samples that may be required; and
- consultation with the Operations representative, if present, concerning appropriate response options for a given site.

4.4.2 Ecologist (ECO)

The **ECO** has a B.Sc. degree or the equivalent in biology or ecology with oil spill and intertidal experience and is familiar with the intertidal biological communities and ecological processes common to the spill area.

The ECO is responsible for the following tasks:

- the cross checking of ecological sensitivities catalogued in atlases and databases;
- the characterization of intertidal communities and the assessment of their overall health and effects of oil or cleanup efforts;
- recommending precautions or constraints that could be followed during cleanup or treatment to minimize effects on the biota; this could include a "no treatment recommended" (NTR) option for a given shoreline section;
- completing the Shoreline Ecological Summary (SES) and Marsh Ecological Summary (MES) forms as appropriate; and
- photographic documentation, as required.

4.4.3 Archaeologist (ARCH)

The **ARCH** has a graduate degree (M.A. or Ph.D.) in archaeology or anthropology, or a B.A. with an equivalent combination of training and experience, plus regional or coastal experience.

The ARCH's responsibilities are to perform the following tasks:

- identify and update data on known archaeological or historical sites;
- identify and document previously undiscovered sites;
- determine potential impacts to historical sites that might result from shoreline treatment activities;
- recommend constraints on treatment operations to protect the sites;
- complete the Human Use (HUS), Cultural Resource Evaluation (CRE), and Provincial Site Inventory* forms;
- collect artifacts, if authorized; and
- document the survey as necessary with notes, photographs, and sketches.

* (The Provincial Site Inventory form is only required if deemed essential by the ARCH due to the specifics of the site.)

4.4.4 Operations Representative

The Operations representative is typically a senior employee of the party or organization that takes responsibility for, or control of, the spill cleanup. The individual should be familiar with hands-on aspects of oil-spill shoreline response operations and the available spill response resources. The responsibilities of the Operations representative are to:

- assist in data collection where feasible,
- evaluate, in consultation with other crew members, whether treatment is recommended for a particular area and which technique(s) are appropriate, and
- estimate the level of effort required to treat the area.

4.4.5 Agency Representative(s)

This position would likely be filled by a representative from Environment Canada, Environmental Protection, Coast Guard, and/or the BC Ministry of the Environment and would represent the interests of the federal and provincial government in the documentation of the stranded oil, determination of the need for treatment and the development of recommended options. Whether in the field or in subsequent meetings, one or more of these agencies normally would have a responsibility to decide on the need, type and extent of treatment. When in the field, the representative could assist other members of the crew in the documentation process, as necessary, by helping with the forms or taking photographs. He or she would be familiar with the regional environment and have some experience in oil spill response.

4.4.6 Land Owner or Manager Representative

This position is filled by the individual land owner or his representative, or representative of the agency or corporation responsible for managing the lands. This representative has responsibilities and duties similar to those of the provincial and federal agency representatives.

4.5 LOGISTICS

The logistical requirements for a ground assessment survey crew consist primarily of transportation, food, housing, communications, equipment and supplies and are a function of the size of the crew and the length of time scheduled for the survey. The logistical requirements and considerations for ground surveys are summarized in Table 2 and are discussed in the following sections.

TABLE 2. GROUND ASSESSMENT SURVEY LOGISTICS

Equipment	Preferred Types	Considerations
Vessel		
Skiff with Outboard	Inflatable/hard bottom	Safety; beach access
Back-up Skiff	Inflatable/hard bottom	Safety
Dry Workspace	-	Meetings: report completion
Photocopier	Compact, easy maintenance	Report production, related supplies (toner, paper)
Communications:		
-vessel/Com. Ctr.	MARSAT, radio telephone, FAX, VHF	Coordination w/vessel and Command centre: safety
-field/vessel	marine radio VHF marine radio	Coordination w/ vessel and SCAT team: safety
Crane	-	Skiff deployment/retrieval: safety
Stern of Vessel	Low freeboard	Safety
Field Crew		
Hand-held 2 way radio(s)	VHF Marine (5 watt)	Safety, coordination
35mm Camera with Dateback	Point & shoot (e.g. Olympus Infinity)	Waterproof, simplicity, durability
Film	Kodachrome (slide) Kodacolor (print)	Do not use: 1) Ektachrome near water, or 2) ASA 200 or above film speed (lighting)
Photo Scale	1 cm increments 10 cm in length	For close-up photos, should be easy to read
Waterproof Paper (8 1/2" x 11")	Rite 'n the Rain or equivalent	Durability, copy forms for field work

TABLE 2. GROUND ASSESSMENT SURVEY LOGISTICS

Equipment	Preferred Types	Considerations
Field Crew (cont.)		
Field Notebooks	Rite 'n the Rain Survey or equivalent	Durability: waterproof
Maps & Charts	Topographic, Nautical	Location: scale
* EPIRB	-	Safety: waterproof: compact
First Aid Kit	-	Safety: waterproof
Ice Chests	Large	Dry storage on skiffs
Shotgun & Shells	12 gauge pump, slugs & buckshot	Dangerous wildlife (bear) Protection
Survival Equipment	Hunter's survival kit or better	Safety: waterproof: light weight
Shovels	Folding or clam	Heavy duty: compact
Range Finder	Hand held, 0-50m range	Estimating size of oiled areas
Compass	Liquid filled, 1-degree graduations	Mapping
Flagging Tape	Fluorescent	Mapping
Global Positioning System (GPS) Receiver	Hand held, portable	Location fixes for remote areas/sites
Plastic Bags - Garbage	Heavy duty	Equipment/sample protection
Leak-proof Plastic Bags	1-gal freezer	Equipment protection photo documentation package
Tape -Duct	2" wide	General purpose

TABLE 2. GROUND ASSESSMENT SURVEY LOGISTICS (concluded)

Equipment	Preferred Types	Considerations
Office Supplies	Paperclips, pencils, paper, waterproof markers, rulers, protractors,scissors	-
Personal		
Raingear	Heavy duty	Protection: safety
Rubber Boots	Heavy duty, non-skid soles	Protection: safety
Gloves		
-Liners	Polypropylene, cotton	Warmth
-Waterproof	Rubber	Protection: warmth
-Work	Leather, high quality	Protection
* PFD/Exposure Suit	Mustang suits/float coat	Safety
Day Pack	Heavy duty	Carry supplies
Clipboards	Notebook type plastic Heavy duty	Water resistant Cold temperatures: form and paper storage
Related Supplies	Pencils, waterproof markers, etc.	-

* EPIRB - Emergency Position Indicating Radio Beacon
* PFD - Personal Floatation Device

4.5.1 Transportation

The three preferred modes of transportation for the crews are: vehicles, vessels and helicopters. Float planes are an option, but they have numerous limitations in terms of landings and weather and, therefore, are not considered in this document. For most of the BC coast, the most efficient and cost-effective transportation mode would be by vessel, unless the affected area is easily accessible by road, in which case vehicles would be the preferred mode. Outside of the populated southern parts of the province and adjacent to settlements elsewhere, vessels often provide the best means of access to almost all shoreline areas. In addition, they operate in all but the most adverse weather conditions and provide meals, housing and work space for crew members while minimizing transit time to and from the survey areas.

Suitable vessels are large enough to provide adequate berthing and work space for the size of the crew, while not being so large that they cannot access areas with limited water depths and turning space. The vessel would have at least one, preferably two, skiffs with sufficient capacity for all crew members, a skiff driver, and adequate survival, safety and communications gear. Appropriate Coast Guard certification and applicable permits for food service and passengers would be required before a vessel was used. The vessel would have adequate stores of food, fuel and fresh water for periods of one week or longer without resupply.

If land access is available, the preferred vehicles are four-wheel-drive station wagons and four-wheel-drive pickup trucks with an extended cab and/or camper shell and adequate storage space for equipment. Vehicles would be equipped with a CB radio or mobile phone for communications with the command centre and for safety. Unlike vessels, advance arrangements are necessary for work space, meals, and lodging each day when crew members return from the field. Transit time to and from the survey areas is a factor that must be taken into account during the daily and long-range planning for the field operations and schedule.

Helicopters can be used for transportation of crews, but are less efficient than vessels due to potential limited landing areas along many shorelines, weather and visibility restrictions, and range and transit time to the spill area; fuel availability may be a limiting factor in remote locations. Also, as with vehicles and land-based operations, arrangements are necessary for meals, work space and lodging each day when personnel return from the field. Helicopters have some advantages as they can provide access to many exposed or high-energy and/or rock shorelines that cannot be safely approached by vessels or accessed by land. In addition, they can move quickly from one remote area to another so that a large area can be covered in a relatively short time period. If the crew consists only of the three scientific members, smaller helicopters such a Twin-Star, A-Star, 206 and B-105 are preferable, whereas, a 212, 214, 412 or 205 would be required to include a full crew. The larger helicopters are less flexible due to their decreased manoeuvrability and requirements for larger landing areas.

4.5.2 Communications

Each crew is equipped with at least one hand-held, two-way radio to provide communications between the crew and vessel or helicopter and, in the event of an emergency, the command centre. Multi-channel VHF marine radios with at least 5 watts are recommended. An Emergency Position Indicating Radio Beacon (EPIRB) is a standard item for crews that work in remote areas for use in the unlikely event the crew becomes separated from the vessel or aircraft and other means of communication fail. If vehicles are used, they should be equipped with a CB radio or mobile phone.

4.5.3 Equipment and Supplies

Equipment and supplies for ground assessment survey crew members, summarized in Table 2, generally are limited to safety gear, survival kits, cameras, shovels, field notebooks and forms, compasses, waterproof boots and rain gear. The appropriate maps and aerial photos are also required. Water-proof or water-resistant cameras with data backs to record the date and, if possible, the time each photograph was taken are preferred. Automatic cameras are relatively rugged and generally provide adequate pictures but often lack the clarity required for accurate documentation. Single Lens Reflex (SLR) cameras provide better pictures but are less rugged and can be affected by damp or cold. Kodachrome 35 mm, 36-exposure slide film is preferred.

The easiest shovels for field digging are the collapsible camp or military variety preferably with the pick on the backside. Clam shovels are also well-suited for assessing the presence of subsurface oil while still providing a good degree of portability. Waterproof field notebooks are recommended and field forms can be copied onto this type of paper in case of inclement weather. Compasses are convenient for determining orientation on complex shorelines and, although most good compasses are adequate, the Brunton types are preferable, particularly if bearings are to be recorded. Combination compass/clinometers are also useful in recording slope/ beach face angles.

4.6 RECOMMENDED SURVEY METHODS

Field procedures for ground assessment surveys are often based on personal preference. Therefore, the survey activities discussed below are intended to be suggested guidelines rather than specific instructions. This discussion includes pre-survey planning, general survey strategy, post-survey activities, and specific responsibilities and procedures for the OG, ECO and ARCH.

4.6.1 Pre-Survey Planning - General

A **training program** is an integral part of all field activities, whether large or small, to focus on procedures for safety and survival before conducting a ground survey program. Training is particularly important for a survey involving multiple crews, to ensure that the crews are coordinated and calibrated.

Ideally, all participants together review:

- hazard and safety issues,
- survey objectives, procedures and logistics,
- methods for completing data forms, and
- calibration of oil condition and shoreline characterization terms.

In the event that an extensive region is affected by a large to moderate oil spill, it may not be feasible to quantitatively survey the entire area. Therefore, much of the survey may focus on observations and qualitative descriptions of both oil characteristics and abundance of various intertidal species. Collective calibration of the participants is a key element to ensure that the observations and measurements form a meaningful information base.

Calibration refers to the process of developing consistency between OG's, ECO's, and ARCH's when making observations and measurements. This process is particularly important for oil cover, as an estimate of 50 percent by one OG may be estimated as 60 or 70 percent by another without prior calibration. Similarly, the OG's would develop practical guidelines for their own use. As an example, if maps derived from the field data use category limits of 25, 50 and 75% oil cover to reduce the data, then it is important that (1) either the category limits be defined specifically as "less than or equal to 50%" or "greater than or equal to 50%", or that (2) the exact break point number be avoided and the OG record only to the nearest 5% (e.g. 45 or 55%). If these types of decisions are not made prior to the field survey, then the onus is on the data reduction team to decide how to use the data that has been collected. This type of planning and standardization is crucial to the collection of an integrated and standardized data base. The same process applies to ECO's who would discuss the appropriate identification and field techniques to estimate the abundance of key species.

A training program is conducted with, at a minimum, examples of the various shoreline oil condition categories, descriptors and species abundances. ARCH's would also receive instructions on how to rapidly and accurately "read" the intertidal and tree fringe areas, as this level of survey does not permit a systematic examination of all areas. The training can be conducted in a classroom with slides and other visual aids, but is more effective in the field, or as a combination of the two locales. This training is best carried out as a single group, if feasible, or in smaller groups by the senior crew members for each discipline. Overlap of individual crew members with their replacements provides some calibration as new personnel become involved in the program.

Planning also involves the **procurement of equipment and supplies**. Packets of information on the areas to be surveyed are distributed to each crew, including:

- full sets of topographic maps and nautical charts, large and small scales;
- low-altitude aerial photos, large and small scales;
- copies of existing sensitivity atlases, maps, and databases.

Maps and photos can save a considerable amount of time, which may otherwise be spent on the ground attempting to locate specific features without aerial photos and appropriately scaled maps. In general, the large-scale maps are used to navigate and locate general areas, whereas the smaller-scale maps and aerial photos can be used for documentation and location of specific sites. Many of the navigation problems can be alleviated by the use of commercially-available hand-held GPS (Global Positioning System) receivers, which provide rapid and accurate location data. A fix to +/- 25 m can be obtained within 2.5 minutes and would provide coordinates suitable for a GIS-type data base.

A **logistical support team** would be responsible for obtaining existing data on the area to be surveyed and for supplying data packages to the field crew(s). Each ground assessment survey member would be responsible for the review of existing data for the area(s) to be surveyed before the survey occurs. This might include geological maps, sensitivity atlases, locations of seabird colonies, pinniped haulout or breeding areas, and other maps of environmentally or culturally sensitive features. Acquisition of archaeological site data requires close cooperation and coordination with the appropriate provincial and federal agencies and Native organizations. Active participation by key provincial agencies (e.g. *Archaeology Branch; Ministry of Municipal Affairs, Recreation and Culture*; and the *Environmental Emergency Services Branch, Ministry of Environment*) is critical to the success of the undertaking. The Archaeology Branch is responsible for the administration of the provincial site file. The Environmental Emergency Services Branch has compiled archaeological and other environmental data in high-risk areas for immediate use in an oil spill emergency. It is crucial that this information is accessed efficiently so that pertinent site data can be forwarded to the response organization and integrated into the SCAT field program.

4.6.2 Pre-Survey Planning - Daily

Prior to departure each day, all crew members participate in preparation for the day's planned activities. Preparation would include the following tasks:

- define the low-tide window;
- determine the area to be surveyed and the survey direction;
- identify preliminary segment boundaries based on the shoreline classification system as outlined in Appendix A;
- determine alternate areas and segment boundaries in case weather or sea conditions prevent access to primary location(s);
- acquire all maps and background ecological, human use and cultural data required for the day. This would include locations of anadromous streams, eagle nests, pinniped haulouts, fishing grounds, and known cultural resource sites and land use maps that may be required to survey planned and alternate sites;
- confirm duties and responsibilities of each team member;
- ensure that adequate supplies of film, notebooks, pencils, forms, sample containers (if required), batteries, and other field equipment items are on hand and check for proper operation; and
- conduct a radio check before departing the vessel, skiff or aircraft and agree on calls, channels, and estimated times of arrival (ETA's), with the captain or pilot.

4.6.3 General Survey Strategy

The first part of a survey includes a pass of the entire segment in the skiff or helicopter in order to:

- verify if the predetermined segment boundaries are correct,
- acquire a good perspective of the extent of stranded oil, and
- estimate the level of effort required to complete the assessment.

If operating out of a vehicle, viewing the segment from an elevated vantage point in the backshore can usually serve the same purpose. Once on shore, the crew spreads out and begins walking from one end of the shoreline to the other while observing and documenting important oil features. If little or no oil is observed and treatment is not recommended, only a cursory assessment is required by the ARCH and ECO.

Each crew member will focus on their primary responsibility: the ECO typically stays toward the lower intertidal zone, as this is usually the most ecologically sensitive area; the ARCH focuses on the supratidal and backshore regions of the shoreline, as this is where most archaeological features would be found; and the OG focuses on the mid- and upper-intertidal zone, as this is typically where most oil becomes stranded. If agency personnel are present, they assist in the documentation. Appropriate activities could include digging pits to assess oil penetration and burial, and taking measurements and photos. An artistically inclined member of the crew could begin to make a sketch map of the beach or segment while the OG, ECO and ARCH complete their forms and notes. If the segment is short, it may be preferable to walk the entire segment while making general observations and then return to areas that require more detailed documentation. Conversely, on long segments, it is more efficient to make extensive notes as crew members progress along the shore, to avoid backtracking.

After completion of the observation and measurements, crew members typically discuss individual assessments to ensure that they are in agreement and that nothing has been overlooked. This is particularly applicable when agency and land owner/manager representatives are present. Treatment options are discussed by all crew members to ensure that factors such as ecology, cultural resources, potential fate and persistence of the oil, and the existing or potential human uses of the area are considered. If agreement on all major points is not unanimous, an attempt is made to ensure that there is at least a consensus on oil character and distribution prior to departing the segment.

4.6.4 OG Survey Procedures

Performance of the following procedures and tasks is the responsibility of the OG, although portions can be delegated to other members of the crew, if necessary:

- evaluate predetermined segment boundaries on-site and modify, as required (Appendic A), based on shoreline geomorphology (Appendix C) and oil conditions (Appendix B);
- draw a sketch map of the segment or beach, preferably from an elevated reference point, or from the skiff, slightly offshore, to obtain the best perspective;
- record oiled areas and their dimensions on the sketch map along with locations of pits, photos, VTR's, samples, prominent geological features, etc. (note: it is sometimes preferable to draw a rough sketch in the field and refine the sketch back on board the vessel or in the office using small scale maps or aerial photos; small-scale (i.e., 1:1000 or less) topographic maps can be used as sketch base maps);
- complete the **Shoreline Oiling Summary (SOS)** or **Marsh/Wetlands Oiling Summary (MOS)** form, either from information on the sketch map or from direct measurements (see Section 4.7.1);
- record subsurface oil feature information as the pit is dug, to avoid mixing of strata from the pit walls and ground water filling the pit prior to documentation;
- take photographs as a panorama or from either end of the beach or segment to obtain a perspective of the oil conditions and geomorphology;
- take other photographs to document the most representative oil features and any unique or unusual types of oil present; and
- record all photograph locations and the direction in which they were taken, including roll and frame number, on the sketch map and in a photo log or notebook, along with a brief description noting prominent features or subjects.

Additional photo documentation procedures are given in Section 4.7.1. Prior to leaving the segment, the OG checks that the Shoreline Oiling Summary (SOS), or Marsh/Wetlands Oiling Summary (MOS) form and sketch map (oil distribution map may be completed later) are complete and consistent, or ensures that adequate notes have been taken to fill in the forms later.

4.6.5 ECO Survey Procedures

The responsibilities of the ECO include the following survey activities:

- cross-check the data from ecologic sensitivity atlases and databases with observed conditions;
- collect all information on the segment, including the general impressions of the area, distribution of oil versus biota, observations of abundance, recruitment, or mortality of indicator organisms, and birds and wildlife sighted during the survey;
- sketch the surveyed area, or draw pertinent features (i.e., boundaries of dominant biota, oiled areas, physical features, locations of eagle nests, etc.) on topographic sketch maps (optional), ideally these maps should be on the same base and at the same scale used for the OG sketch maps;
- photograph the shoreline, dominant biota, oil conditions, and other pertinent features; include people or objects (ruler, notebook, pencil, etc.) for scale and maintain a log of the film-roll number, frame number, date, time, location, orientation, and subject of each photograph, and note location on sketch map; and
- complete **Shoreline Ecological Summary (SES)** or **Marsh Ecological Summary (MES)** forms from notes and maps (see Section 4.7.2).

The main task of the ecologist is to collect the information necessary for completion of the survey forms, including a general characterization of the intertidal community fish spawning habitats and a specific evaluation of the area affected by the oil. The entire segment usually cannot be assessed from a single vantage point; thus, the evaluation form is not to be completed by reference to the first part of the beach observed. Notes taken while surveying the whole segment provide the information base for the SES or the MES forms, which are completed at the end of the survey. These forms are a synthesis of the information and the completed entries apply to the whole segment, unless there is sufficient inhomogeneity in the segment, in which case a separate form for each subdivision is completed. Working with the OG and other crew members on the sketch maps helps to insure consistency on the location of major site features.

The assessment of an oiled area focuses not only on the affected species and the degree of impact, but also on the recovery potential of the area. Items to consider for recovery potential include:

- general condition and health of the biota in adjacent, unoiled intertidal zones;
- density of the indicator species and their locations with respect to the oil;
- productivity of the area or across-shore zone; and
- potential for recruitment or recolonization from adjacent or nearby areas.

4.6.6 ARCH Survey Procedures

The ARCH determines the existence of known sites from previously compiled data prior to the field assessment of a segment. Once on shore, the ARCH surveys both the intertidal zone and tree fringe, updating known sites and discovering and documenting any discovered sites. The **Cultural Resource Evaluation (CRE) and Human Use Summary (HUS)** form is completed in the field based on observations, interviews and previously acquired background data. Specifically, the activities of the ARCH include:

- "read" the intertidal and tree fringe areas to identify likely site locations (can be done, in part, from videotapes);
- survey high-probability areas first;
- update known sites by recording additional information on site location, size, depth, presence of surface features and condition;
- draw a sketch accurately locating site and human use areas in the segment
- document new sites in the same manner as the known sites;
- record detailed notes on specific areas examined, intensity of survey, flora and fauna observations, and paleontological deposits, if present;
- provide photo documentation of observations when possible; and
- complete CRE and HUS forms, and Site Inventory form, as necessary (see Section 4.7.3).

4.6.7 Post-Survey Activities

As soon as practical after completion of the day's surveys, crew members review all forms, maps, sketches, photo logs, and field notes for completeness, accuracy, and legibility. In many cases, forms or sketch maps filled out in the field may not be fully legible, particularly if filled out during wet weather. In some cases, crew members may choose to recopy or complete the forms at the end of the day from detailed notes. Sketch maps are often redrawn at the end of the day using aerial photos to trace a base map and then adding the required information. All members could then use the same base map to insure consistency and avoid confusion about relative locations of oil and major features.

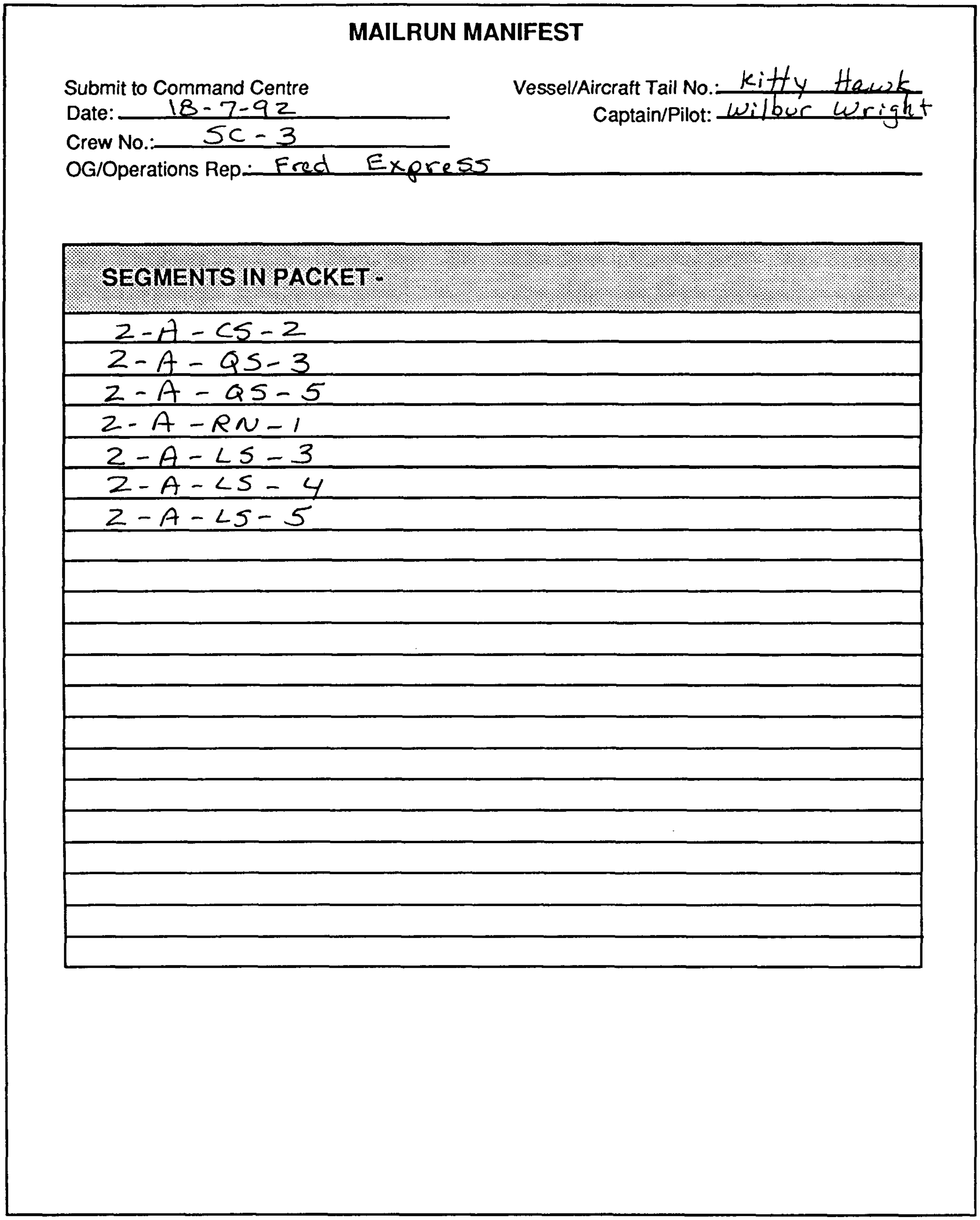
After completion of all forms, maps and notes, everything is copied, including field notes. One copy is kept on file with the crew in the event that questions arise following review at the command centre. The originals, with the exception of the field notes, are submitted daily in a package to the command centre. The package includes in separate envelopes:

- all original forms and maps,
- copies of the field notes for each segment surveyed that day, and
- any exposed film rolls with copies of the appropriate photo logs.

A daily or regular mail run picks up the packages, which are accompanied by a manifest to facilitate tracking in the event items or packages are lost or misplaced. A copy of the manifest is kept on file with the crew. An example of a mail run manifest is shown in Figure 3.

A daily progress report (Figure 4) may be submitted to the command centre, verbally and/or in writing (via FAX or mail run for remote crews). The report could include:

- the number, locations and designations of the segments surveyed that day;
- an indication of whether or not the survey and paperwork for each survey is complete;
- requests for supplies, permits or personnel; and
- the plans for the following day.



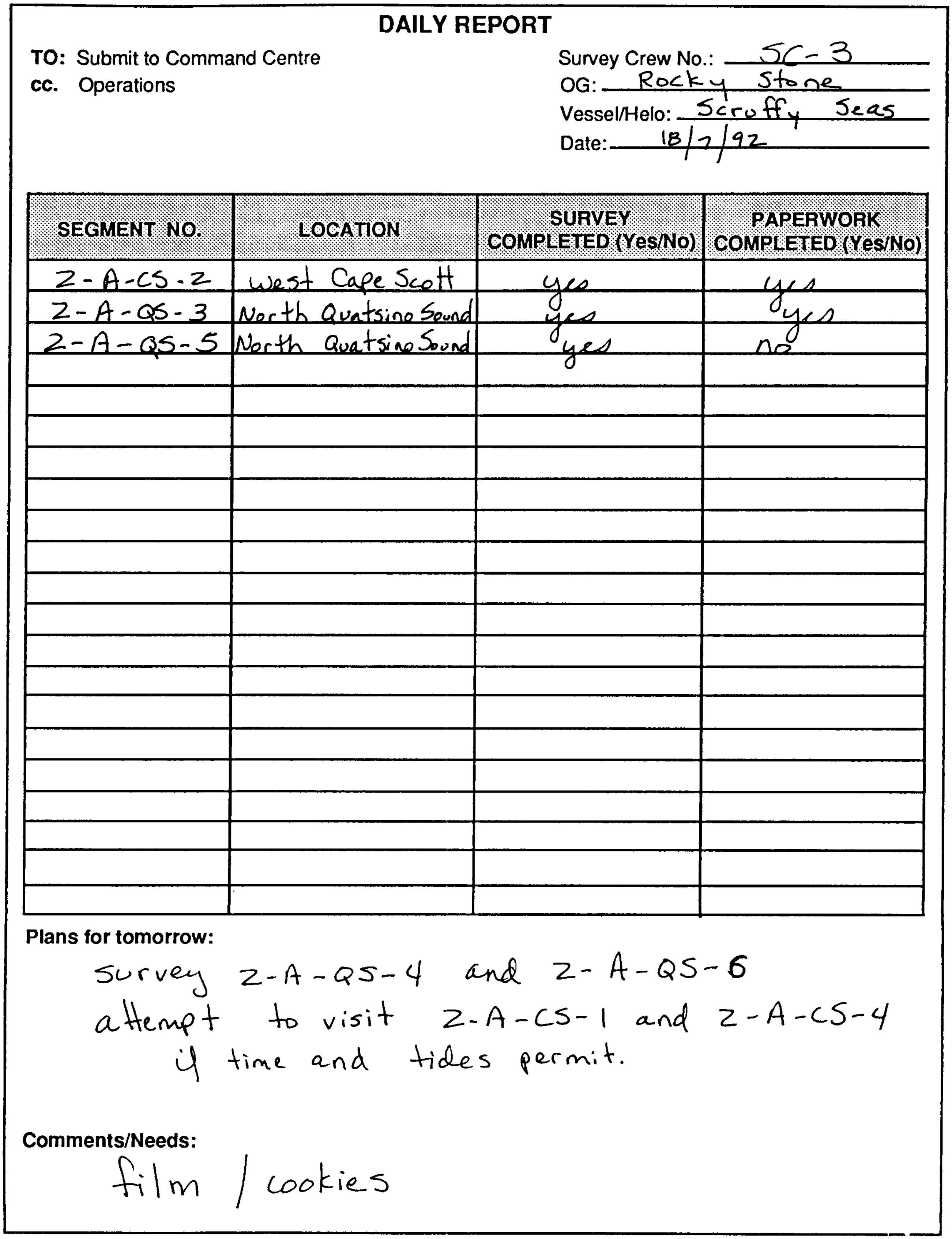
MAILRUN MANIFEST

Submit to Command Centre
Date: 18-7-92
Crew No.: SC-3
OG/Operations Rep.: Fred Express

Vessel/Aircraft Tail No.: Kitty Hawk
Captain/Pilot: Wilbur Wright

SEGMENTS IN PACKET -
2-A-CS-2
2-A-QS-3
2-A-QS-5
2-A-RN-1
2-A-LS-3
2-A-LS-4
2-A-LS-5

Figure 3. Example of Mail Run Manifest



DAILY REPORT

TO: Submit to Command Centre
cc. Operations

Survey Crew No.: SC-3
OG: Rocky Stone
Vessel/Helo: Scruffy Seas
Date: 18/7/92

SEGMENT NO.	LOCATION	SURVEY COMPLETED (Yes/No)	PAPERWORK COMPLETED (Yes/No)
Z-A-CS-2	West Cape Scott	yes	yes
Z-A-QS-3	North Quatsino Sound	yes	yes
Z-A-QS-5	North Quatsino Sound	yes	no

Plans for tomorrow:

survey Z-A-QS-4 and Z-A-QS-6
attempt to visit Z-A-CS-1 and Z-A-CS-4
if time and tides permit.

Comments/Needs:

film / cookies

Figure 4. Example of Daily Report Form

Equipment is checked and supplies replenished for the next day. A critique of the day's activities and procedures helps to identify any problems and to suggest alternatives that could make the surveys safer, more efficient, and/or more enjoyable. The proposed plans for the following day can be discussed to allow crew members to review and obtain the necessary maps, data, equipment, and supplies.

4.7 DOCUMENTATION AND MAPPING

This section provides examples and descriptions of the various forms, maps and other methods of documentation used by the ground surveys, along with definitions of standard terms. The segment number is included on EACH form, map and note due to the volume of paperwork generated by the shoreline surveys. A full set of blank forms and instructions for completing them, from which photocopies can be made, is included in Appendix I.

4.7.1 Oiling/Geology

Shoreline Oiling Summary (SOS) Form. An example of a completed SOS form is shown in Figure 5. The form provides information and guidance to Operations personnel, and documents, in detail, the location, degree, type and extent of oil conditions for informative, comparative, legal, and potential long-term monitoring purposes.

Marsh/Wetlands Oiling Summary (MOS) Form. Salt-marshes have unique geological and ecological characteristics, compared to other shore types in BC, and a separate form characterizes the geomorphology and oil conditions in salt-marshes. This form (Figure 6) is also applicable to extensive mudflats which have many similar characteristics to salt-marshes. Documentation of the oil conditions is the same as that described for the SOS form. An explanation of each data entry on the SOS and MOS forms is provided in Appendix I.

Explanations of the SOS/MOS form codes and resultant data are provided in Table 3. Special attention has been given to the subject of differentiation between surface and subsurface oil in Table 3 and on the form.

Oil Categorization. It is important to consistently describe and categorize the oil conditions to establish cleanup priorities and develop a response plan. Therefore, descriptions of oil conditions, either surface or subsurface, have been standardized to avoid potential problems that might evolve by the use of different survey methods. A tiered approach (Table 4) is used to allow for different levels of survey detail, so that one can document simply the **surface oil cover** (width of oiled area and distribution (%) - Table 5) or, in more detail, the **surface oil category,** (surface oil cover and average thickness - Table 6), or **subsurface oil category** (penetration depth or thickness of oil lens and relative oil concentration - Table 7). All of the necessary parameters for the different levels of documentation are included on the SOS form, and can be combined to achieve the desired degree of detail. The standardized terms for width, distribution, thickness, relative oil concentration, are defined in Table 3. Using this approach enables data from different surveys with different levels of detail to be compatible with each other. This might apply, for example, to data from a ground or aerial reconnaissance survey (surface oil cover), or from a more detailed ground survey (surface or subsurface oil category).

Sketch Maps. A sketch map is drawn for each segment to identify the physical layout of the shoreline, the location of the oil, pits and photographs. Oil conditions can be shown as shaded areas with the substrate type(s) added wherever possible. A letter designation is given to each area that corresponds to a letter designation on the SOS/MOS form. The dimensions for each oiled area are indicated, as well as the percent oil cover estimates. Pits are indicated by a symbol, such as a triangle and given a numerical designation that corresponds to one on the SOS/MOS form. Similarly, photographs have a numerical frame number designation and a dot and connecting arrow showing the location and direction in which the photo was taken. Aerial photos or small-scale maps can be used to trace the base map for the sketches to enhance their accuracy and scale. If only a portion of the segment is sketched or several sketch maps are drawn, a sketch location map indicates how the sketches match or overlap. Examples of a sketch location map and completed sketch are shown in Figures 8 and 9, respectively. These sketches are based on the data presented in the SOS form (Figure 5).

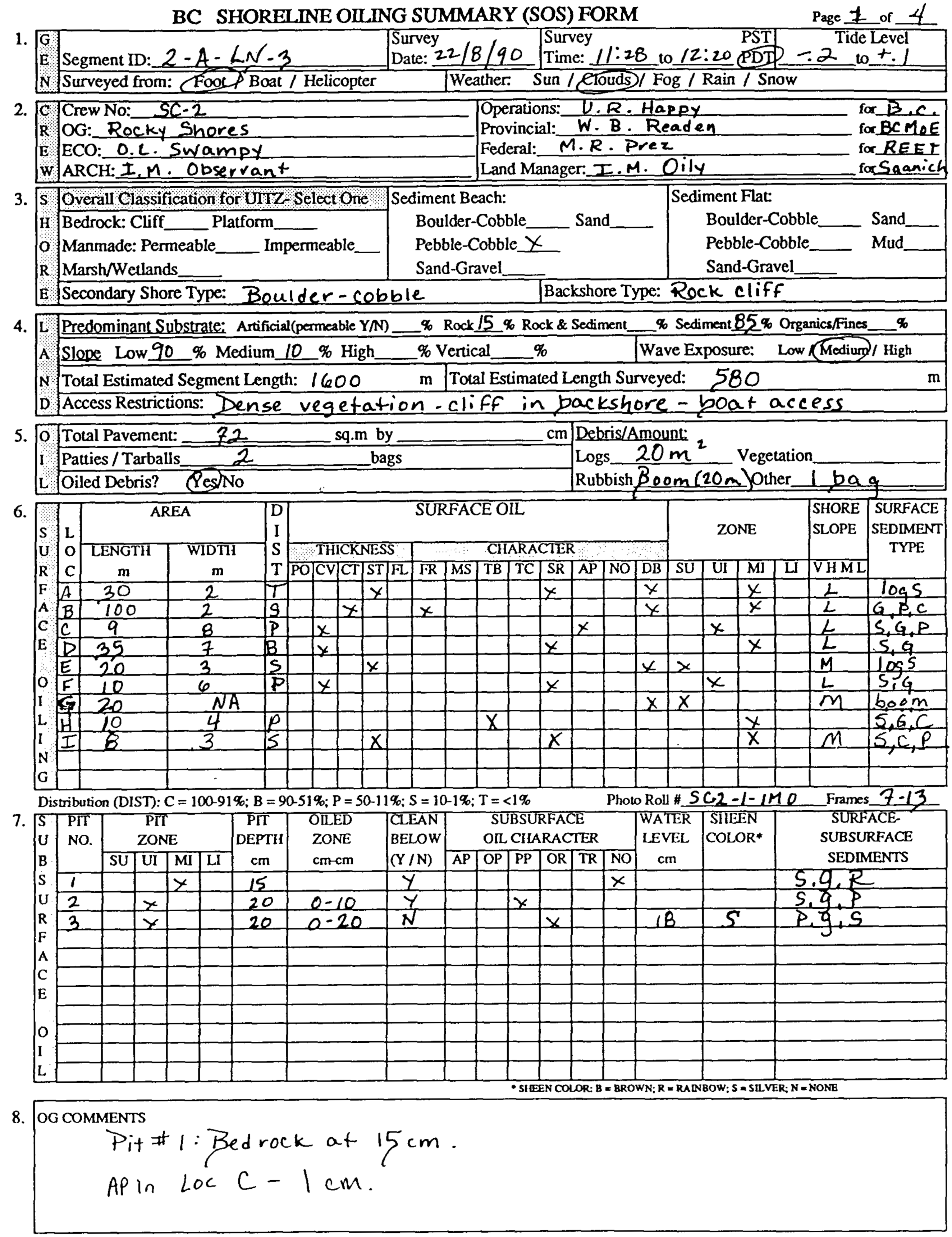
Surface Oil Cover Maps. A surface oil cover map is prepared for each segment to indicate the locations and boundaries of each oil category; heavy, moderate, light and very light. These categories are determined by combining the oil distribution (%) with the combined width of the oiled area across the shoreline (Table 5). The base maps are generated by the Geographical Information System (GIS) for each segment. The BC Ministry of the Environment has the BC coastline digitized into a GIS. Symbols are used to designate oil categories in such a way that they cannot be misinterpreted during entry into the GIS. The boundary of each oil category is clearly marked. An example of a completed oil distribution map, based on the data presented in the SOS form and sketch maps, is given in Figure 10, along with the recommended symbols and legend.

Photo Documentation Procedures. Certain procedures are followed to ensure consistency and clarity of photographs and to document overall or specific oil conditions or the general configuration of a shoreline. The recommended procedures are as follows:

- maintain an accurate log of photographs in the field (at a minimum include the location and a description of the object of the photo);
- include location and direction of photos on the sketch map (usually by writing the frame number next to a dot indicating the location with an arrow pointing in the direction of the shot);
- transcribe the photo log to labels (see Figure 11) to be submitted with the film for processing;
- identify rolls (numbering can follow this form: Survey Crew No.-Roll No./Photographer's Initials. Roll numbering is sequential by crew, for example, **SC3 - 1 - ART** and **SC3 - 2 - ART);**
- write roll numbers on both the film canister and the cap of the plastic film container using a black permanent marker;
- place each completed roll in a water-tight bag along with the field photo log and labels; and
- complete photograph labels; include roll number, frame number and comments or a description of the subject that was photographed. Complete all information on the first label on each sheet. Subsequent labels on a sheet need only contain frame number, comments and any changes from the previous labels, such as date, segment number, site number, etc.

Some factors that should be taken into account when taking the photographs include:

- take at least one photograph at each segment even in inclement weather;
- panoramas are helpful, even if they require several frames;
- take at least one photo from each end of the beach or segment;
- try to take the panorama or general photos from an elevated vantage point where possible;
- take photos so that the oil conditions are clearly shown, and if possible, include some prominent and preferably permanent feature (i.e., bedrock outcrop, large boulders, trees, stream, neighbouring island, etc.) for scale and geographic reference. Scale bars, rulers, notebooks, lens caps, etc., are also extremely important in providing scale references for closeups, particularly of pits;
- begin the sequence of photographs for each segment with a photograph of a page in the notebook with the segment number, date, time and team number written in dark, bold letters, to identify the photograph location later if the photo log is lost; and
- include photographs that represent each major type of surface and subsurface oil and any unusual oil conditions found at the site.



BC SHORELINE OILING SUMMARY (SOS) FORM

Page 1 of 4

1\. GEN

Segment ID: 2-A-LN-3

Survey Date: 22/8/90

Survey Time: 11:28 to 12:20 PST / [✓ PDT]

Tide Level -.2 to +.1

Surveyed from: [✓ Foot] / Boat / Helicopter

Weather: Sun / [✓ Clouds] / Fog / Rain / Snow

2\. CREW

Crew No: SC-2

OG: Rocky Shores

ECO: O. L. Swampy

ARCH: I. M. Observant

Operations: V. R. Happy for B.C.

Provincial: W. B. Readen for BC MoE

Federal: M. R. Prez for REET

Land Manager: I. M. Oily for Saanich

3\. SHORE

Overall Classification for UITZ- Select One

Bedrock: Cliff____ Platform____

Manmade: Permeable____ Impermeable____

Marsh/Wetlands____

Sediment Beach:

Boulder-Cobble____ Sand____

Pebble-Cobble X

Sand-Gravel____

Sediment Flat:

Boulder-Cobble____ Sand____

Pebble-Cobble____ Mud____

Sand-Gravel____

Secondary Shore Type: Boulder-cobble

Backshore Type: Rock cliff

4\. LAND

Predominant Substrate: Artificial(permeable Y/N) ___% Rock 15 % Rock & Sediment ___% Sediment 85 % Organics/Fines ___%

Slope Low 90 % Medium 10 % High ___% Vertical ___%

Wave Exposure: Low / [✓ Medium] / High

Total Estimated Segment Length: 1600 m

Total Estimated Length Surveyed: 580 m

Access Restrictions: Dense vegetation - cliff in backshore - boat access

5\. OIL

Total Pavement: 72 sq.m by ____ cm

Patties / Tarballs 2 bags

Oiled Debris? [✓ Yes] / No

Debris/Amount:

Logs 20 m² Vegetation____

Rubbish Boom (20m) Other 1 bag

6\.

SURFACE OILING	LOC	AREA LENGTH m	AREA WIDTH m	DIST	SURFACE OIL THICKNESS PO	CV	CT	ST	FL	CHARACTER FR	MS	TB	TC	SR	AP	NO	DB	ZONE SU	UI	MI	LI	SHORE SLOPE V H M L	SURFACE SEDIMENT TYPE
F	A	30	2	T				X						X			X			X		L	logs
A	B	100	2	S			X			X							X			X		L	G,P,C
C	C	9	8	P		X									X				X			L	S,G,P
E	D	35	7	B		X								X						X		L	S,G
	E	20	3	S				X									X	X				M	logs
O	F	10	6	P		X								X					X			L	S,G
I	G	20	NA														X	X				M	boom
L	H	10	4	P								X								X			S,G,C
I	I	8	3	S				X						X						X		M	S,C,P
N																							
G																							

Distribution (DIST): C = 100-91%; B = 90-51%; P = 50-11%; S = 10-1%; T = <1%

Photo Roll # SC2-1-IMO Frames 7-13

7\.

SUBSURFACE OIL	PIT NO.	PIT ZONE SU	UI	MI	LI	PIT DEPTH cm	OILED ZONE cm-cm	CLEAN BELOW (Y / N)	SUBSURFACE OIL CHARACTER AP	OP	PP	OR	TR	NO	WATER LEVEL cm	SHEEN COLOR*	SURFACE-SUBSURFACE SEDIMENTS
S	1			X		15		Y						X			S,G,R
U	2		X			20	0-10	Y			X						S,G,P
R	3		X			20	0-20	N				X			18	S	P,G,S
F																	
A																	
C																	
E																	
O																	
I																	
L																	

* SHEEN COLOR: B = BROWN; R = RAINBOW; S = SILVER; N = NONE

8\. OG COMMENTS

Pit #1: Bedrock at 15 cm.

AP in Loc C - 1 cm.

Figure 5. Example of Completed Shoreline Oiling Summary (SOS) Form Prepared From Sketches in Figures 8 & 9 (See also Figure 10)

BC MARSH/WETLANDS OILING SUMMARY (MOS) FORM

Page 1 of 2

1. GEN
Segment ID: 2-A-CS-4
Survey Date: 8/22/90
Survey Time: 10:30 to 12:45 PST [✓ PDT]
Tide Level -.5 to +.1
Surveyed from: [✓ Foot] / Boat / Helicopter / [✓ Hovercraft]
Weather: Sun / Clouds / [✓ Fog] / Rain / Snow

2. CREW
Crew No: SC-2
OG: Rocky Shores
ECO: Jim Fowler
ARCH: Indiana Jones
Operations: B.C. Cleanup for E.C.
Provincial: I.M. Aware for MOE
Federal: M.R. Prez for DOE
Land Manager: I.M. Owner for Saanich

3. SHORE
Overall Classification for UITZ - Select One
Bedrock: Cliff____ Platform____
Manmade: Permeable____ Impermeable____
Marsh/Wetland____
Sediment Beach:
Boulder-Cobble____ Sand____
Pebble-Cobble____
Sand-Gravel____
Sediment Flat:
Boulder-Cobble____ Sand X
Pebble-Cobble____ Mud____
Sand-Gravel____
Secondary Shore Type: Sand / gravel
Backshore Type: open

4. MARSH
Intertidal Zone: Sand Tidal Flat 80 % Mud Tidal Flat ____ % Gravel Beach 20 % Rock Platform ____ %
Marsh Edge (seaward): Artificial ____ % Vegetation 90 %
Manmade Levee ____ % Creek Bank 10 % Other ____ %
Est. Total Marsh Edge Length (inc. creeks): 800 m
Est. Marsh Edge Length Surveyed (inc. creeks): 600 m
Supratidal Zone: Est. Area of Marsh Vegetation ____ hect. Est. Length of Marsh Fringe ____ m
Access Restrictions: Shallow draft vessels required

5. OIL
Oiled Debris? [✓ Yes] No
Total Pavement: ____ sq.m by ____ cm
Patties/Tarballs 2 bags
Debris Amount:
Logs ____ Vegetation 2 bags
Rubbish ____ Other 2 bags

6. SURFACE OILING

LOC	AREA		DIST	SURFACE OIL													ZONE				* PART OF PLANT			SURFACE SEDIMENT TYPE
	LENGTH	WIDTH		THICKNESS					CHARACTER															
	m	m		PO	CV	CT	ST	FL	FR	MS	TB	TC	SR	AP	NO	DB	SU	UI	MI	LI	H	S	L	
A	10	2	P				x						x					x						S
B	15	2	C			x							x				x						x	S, g
C	20	4	S		x								x							x				g, Veg.
D	5	3	B			x						x							x				x	S, Veg.

Distribution (DIST): C = 100-91%; B = 90-51%; P = 50-11%; S = 10-1%; T = <1%

* H = Head; S = Stem; L = Litter

Photo Roll # SC-2.1.1MO Frames 1-7

7. SUBSURFACE OIL

PIT NO.	PIT ZONE				PIT DEPTH (cm)	OILED ZONE (cm-cm)	CLEAN BELOW (Y/N)	SUBSURFACE OIL CHARACTER						WATER LEVEL (cm)	SHEEN COLOR*	SURFACE-SUBSURFACE SEDIMENTS
	SU	UI	MI	LI				AP	OP	PP	OR	TR	NO			
1				X	20	0-20	Y					x		15	S	S
2			x		15	0-15	Y						x	15		S, G
3		x			30	0-5	N				x			25	R	S, G
						5-30	Y					x				

* SHEEN COLOR: B = BROWN; R = RAINBOW; S = SILVER; N = NONE

8. OG COMMENTS

Figure 6. Example of Completed Marsh Oiling Summary (MOS) Form

TABLE 3. SHORELINE/MARSH OILING SUMMARY (SOS/MOS) FORM CODES

SHORE (Box 3)

Primary Shoreline Classifications:

- Bedrock:
  - Cliff
  - Platform
- Sedimented:
  - Beach:
    - Boulder-cobble
    - Pebble-cobble
    - Sand-gravel
    - Sand
- Vegetated:
  - Marsh
  - Wetland
- Man-made:
  - Permeable
  - Impermeable
- Tidal Flat:
  - Boulder-cobble
  - Pebble-cobble
  - Sand-gravel
  - Sand
  - Mud

Secondary Shore Types: Any of the above, plus;

- Pocket beaches
- Delta
- Barrier island

Back Shore Modifiers:

- Cliff:
  - Rock
  - Unconsolidated
- Man-made
- Low relief:
  - Open
  - Wooded
- Water bound:
  - Bay
  - Marsh
  - Inlet
  - Lagoon
- Dunes

LAND (Box 4)

Shore Slope

Low	A shore with a slope of 30 degrees or less
Medium	A shore with a slope between 31 and 60 degrees
High	A shore with a slope between 61 and 90 degrees
Vertical	A vertical or near vertical shoreline (>90 degrees)

LAND (continued)

Wave Exposure

Fetch Distance	Fetch Window - Degrees			
	<45	45 - 120	121-180	>180
< 5 km	Low	Low	Low	Low
5 - 10 km	Low	Medium	Medium	Medium
10 - 50 km	Medium	Medium	High	High
> 50 km	High	High	High	High

SURFACE OILING (Box 6)

A four-fold rating has been developed for describing surface oil conditions on the shoreline. These conditions are :

- Heavy,
- Moderate,
- Light, and
- Very Light.

Two steps are involved in the ground survey assessment of surface oiling.

STEP ONE:
Determine Width of Oil Band and Distribution of Oil According to the Following Criteria:

Oil Width

Represents the average width of the oiled area or band in the shoreline segment measured across shore. If multiple bands or areas occur across-shore, width represents the sum of their widths.

Wide	> 6 m
Medium	> 3 m and ≤ 6 m
Narrow	> 0.5 m and ≤ 3 m
Very Narrow	≤ 0.5 m

SURFACE OILING (continued)

Oil Distribution (DIST)

Represents the % of the surface within a band or area covered by oil. In the event of multiple bands, distribution refers to the term that best represents the oil conditions for the segment. A visual illustration to assist in estimating oil distribution is included in Appendix I.

Trace (T)	<1%
Sporadic (S)	1 - 10%
Patchy (P)	11 - 50%
Broken (B)	51 - 90%
Continuous (C)	91 - 100%

The above two parameters combine in Table 5 (Initial Surface Oil Cover Matrix) to determine the initial surface oil cover category (degree of oiling).

STEP TWO:
Determine Oil Thickness According to the Following Criteria:

Oil Thickness
Refers to the average or dominant oil thickness within a band or area.

PO	Pooled or Thick Oil - Generally consists of fresh oil or mousse accumulations >1.0 cm thick (indicate the maximum and/or average thickness on the SOS form in the comments section).
CV	Cover - ≤1.0 cm and >0.1 cm thick coating on coarse sediments and in interstices.
CT	Coat - ≤0.1 cm and >0.01 cm thick coating on coarse sediments. Can be scratched off with fingernail.
ST	Stain - ≤0.01 cm thick coating on coarse sediments. Cannot be scratched off easily.
FL	Film - transparent or translucent film or sheen.

The thickness is then combined with the result of step one from Table 5 (Initial Surface Oil Cover Matrix) in Table 6 (Surface Oil Categorization Matrix) to determine the surface oil category.

SURFACE OILING (continued)

Oil Character/Debris Type

FR	Fresh - unweathered, low viscosity oil.
MS	Mousse - emulsified oil (oil and water mixture) existing as patches or accumulations, or within interstitial spaces.
TB	Tar Balls or Mousse Patties - discrete balls or patties on a beach or adhered to rock or coarse-sediment shoreline. Diameters of tar balls and mousse patties are generally <0.1 m and ≤ 1.0 m to ≥ 0.1 m, respectively.
TC	Tar - weathered coat or cover (see Oil Thickness) of tarry, almost solid consistency.
SR	Surface Oil Residue - Consists of non-cohesive, oiled, surface sediments, either as continuous patches or in coarse-sediment interstices.
AP	Asphalt Pavement - cohesive mixture of oil and sediments (the OG must indicate the maximum and/or average thickness on the form in the comments section).
NO	No Oil Observed .
DB	Debris - can consist of logs, vegetation, rubbish or general debris. Includes spill response items (sorbents, boom, snares, etc.) LG = logs VG = vegetation RB = rubbish, garbage (man-made materials)

SURFACE AND SUBSURFACE OILING (Boxes 6 & 7)

Intertidal Zone

SU	Supratidal Zone - the area above the mean high tide that occasionally experiences wave activity. Also known as the splash zone.
UI	Upper Intertidal Zone - the upper approximate one third of the intertidal zone.
MI	Mid Intertidal Zone - the middle approximate one third of the intertidal zone.
LI	Lower Intertidal Zone - the lower approximate one third of the intertidal zone.

TABLE 3. SOS/MOS FORM CODES (continued)

SURFACE AND SUBSURFACE OILING (Continued)

Surface/Subsurface Sediment Type

R	Bedrock outcrops
B	Boulder (> 256 mm dia.)
C	Cobble (64 - 256 mm dia.)
P	Pebble (4 - 64 mm dia.)
G	Granule (2 - 4 mm dia.)
S	Sand (0.06 - 2 mm dia.)
M	Mud (< 0.06 mm dia.)
AW	Manmade - Seawall (impermeable)
AR	Manmade - Rubble or open concrete (permeable)
AP	Manmade - Pilings

SUBSURFACE OIL (Box 7)

Sheen Color

B	Brown
R	Rainbow
S	Silver
N	None

TABLE 3. SOS/MOS FORM CODES (concluded)

SUBSURFACE OIL (continued)

Subsurface Oil Character/Relative Oil Concentration*
Refers to a qualitative description of the degree of oil filled pore spaces.

AP	Asphalt Pavement - cohesive mixture of weathered oil and sediment situated completely below a surface sediment layer(s) (note thickness on SOS form in comments box).
OP	Oil-Filled Pores - pore spaces in the sediment matrix are completely filled with oil. Often characterized by oil flowing out of the sediments when disturbed.
PP	Partially Filled Pores - pore spaces filled with oil, but generally does not flow out when exposed or disturbed.
OR/C	Cover (0.1 - 1.0 cm) or Coat (0.01 - 0.1 cm) of oil residue on sediments and/or some pore spaces partially filled with oil .
OR/S	Stain (0.01 cm) or film oil residue on the sediment surfaces. Non-cohesive.
TR	Trace - discontinuous film or spots of oil on sediments, or an odor or tackiness with no visible evidence of oil.
NO	No Oil - no visual or apparent evidence of oil.

A four-term rating system has been developed for describing subsurface oil conditions. The terms are Heavy, Moderate, Light, and Very Light. The above parameter is combined with the depth of penetration, or thickness of the buried oil lens, in Table 7 (Subsurface Oil Categorization Matrix) to determine the subsurface oil category.

---

*Due to the problems associated with differentiating between what is considered surface and subsurface oil for oil character categories such as interstitial MS, surface SR, AP, subsurface OP and OR that begins at the surface, etc. the following definitions have been developed:

- Fine Sediments (P,G,S,M); Subsurface begins at 5 cm below the surface. If a pit were to reveal oiling in sand from the surface down to 20 cm, the upper 5 cm would be classified as surface oil and the remainder as subsurface. However, the oiled interval still would be shown as 0 to 20 cm.
- Coarse Sediments (C,B); Subsurface begins at the bottom of the surface material (i.e. where the top layer of cobbles or boulders contact the underlying layer of sediments.
- Asphalt Pavement; Where AP exists on the surface, the subsurface begins at the bottom of the pavement.

A visual explanation of these definitions is shown in the "Subsurface Oil Definitions" sketch (Figure 7).

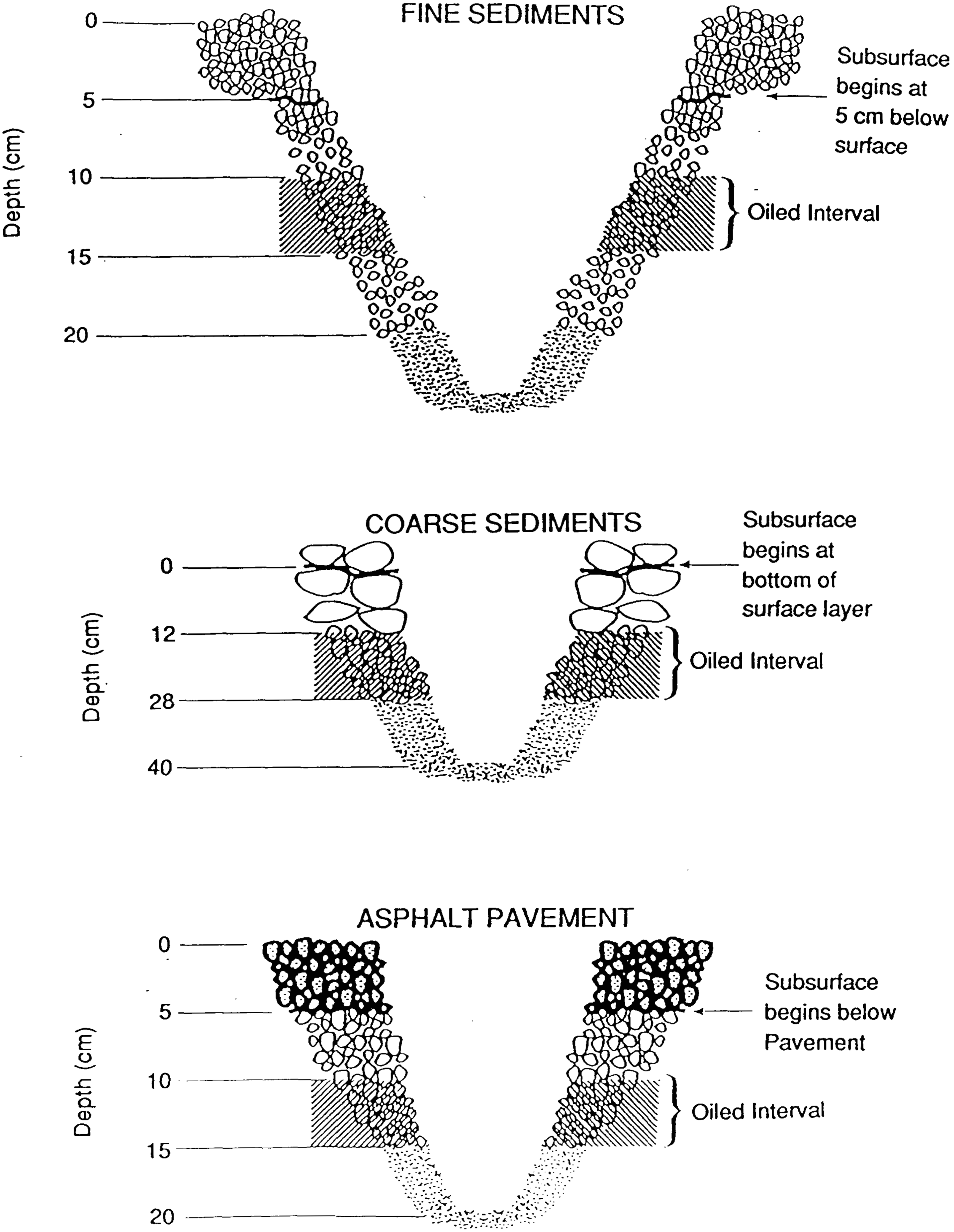


Figure 7. Subsurface Oiling Definitions

TABLE 4. METHODS USED TO DESCRIBE SURFACE OIL CONDITIONS

Length	Presence or absence only
Length - Width	A measure of total oiled area
Length - Width - Distribution	Indicates oil cover (equal to the Equivalent Area - Owens et al., 1987) *
Length - Width - Distribution - Thickness	Estimates the amount of oil **

* see Initial Surface Oil Cover Matrix (Figure 5)

** see Surface Oil Categorization Matrix (Figure 6)

TABLE 5. INITIAL SURFACE OIL COVER MATRIX

		Width of Oiled Areas			
		Wide >6 m	Medium 3 - 6 m	Narrow 0.5 - 3 m	Very Narrow <0.5 m
Oil Distribution	Continuous 91 - 100%	*Heavy*	*Heavy*	*Moderate*	*Light*
	Broken 51 - 90%	*Heavy*	*Heavy*	*Moderate*	*Light*
	Patchy 11 - 50%	*Moderate*	*Moderate*	*Light*	*Very Light*
	Sporadic 1 - 10%	*Light*	*Light*	*Very Light*	*Very Light*
	Trace < 1 %	*Very Light*	*Very Light*	*Very Light*	*Very Light*

TABLE 6. SURFACE OIL CATEGORIZATION MATRIX

		Initial Categorization of Surface Oil *			
		Heavy	**Moderate**	**Light**	**Very Light**
Average Thickness	**Thick or Pooled > 1 cm**	*Heavy*	*Heavy*	*Moderate*	*Light*
	Cover 0.1 - 1.0 cm	*Heavy*	*Heavy*	*Moderate*	*Light*
	Coat 0.01 - 0.1cm	*Moderate*	*Moderate*	*Light*	*Very Light*
	Stain/Film <0.01 cm	*Light*	*Light*	*Very Light*	*Very Light*

* from Initial Surface Oil Cover Matrix (Table 5)

TABLE 7. SUBSURFACE OIL CATEGORIZATION MATRIX

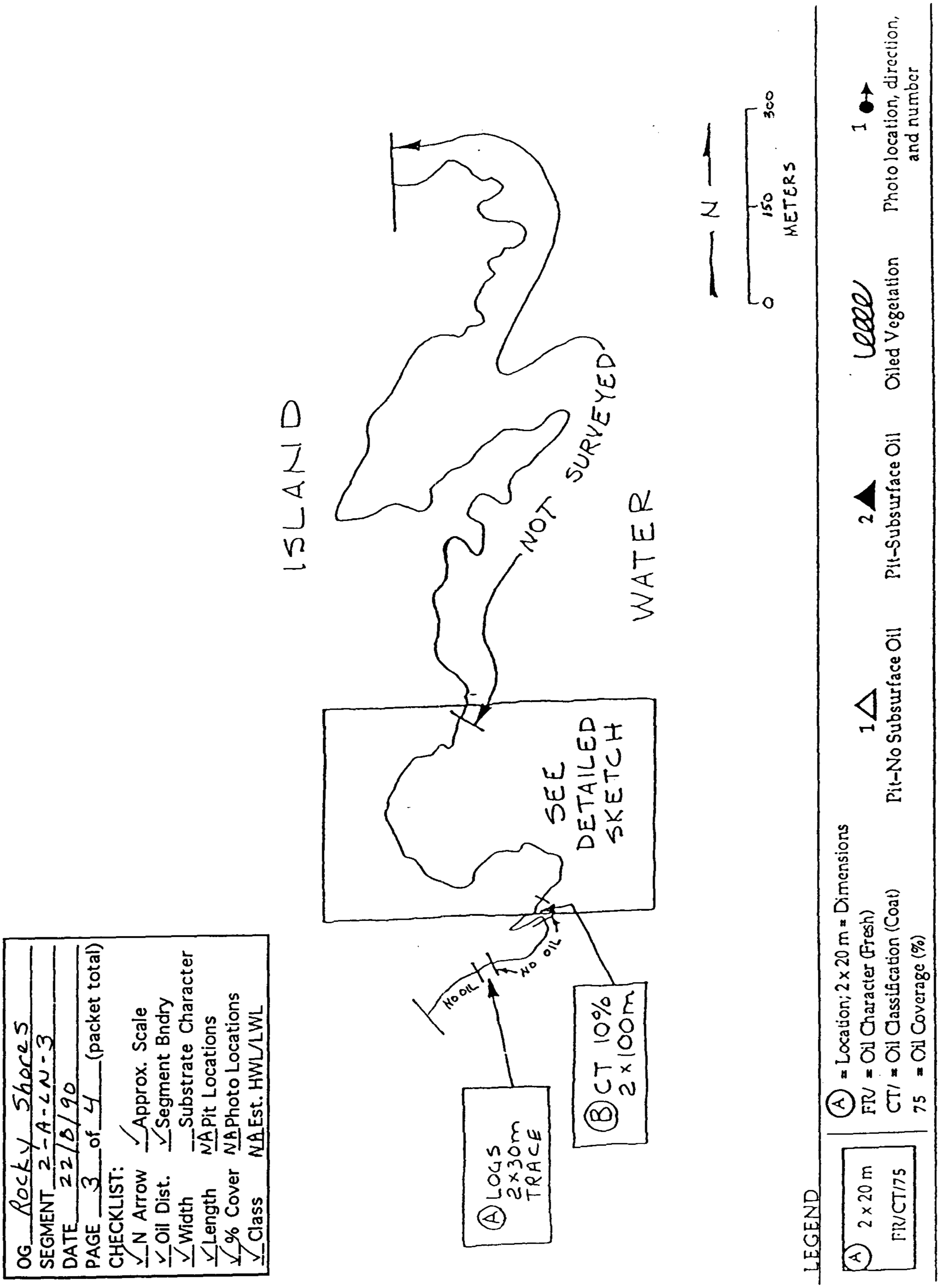
		Depth of Penetration or Thickness of Oil Lens			
		> 30 cm	21 - 30 cm	11 -20 cm	0 - 10 cm
Relative Oil Concentration	OP	Heavy	Heavy	Heavy	Moderate
	PP	Heavy	Moderate	Moderate	Light
	OR	Moderate	Moderate	Light	Light
	TR	Light	Very Light	Very Light	Very Light

OP = Oil-filled pore spaces

PP = Partially filled pore spaces

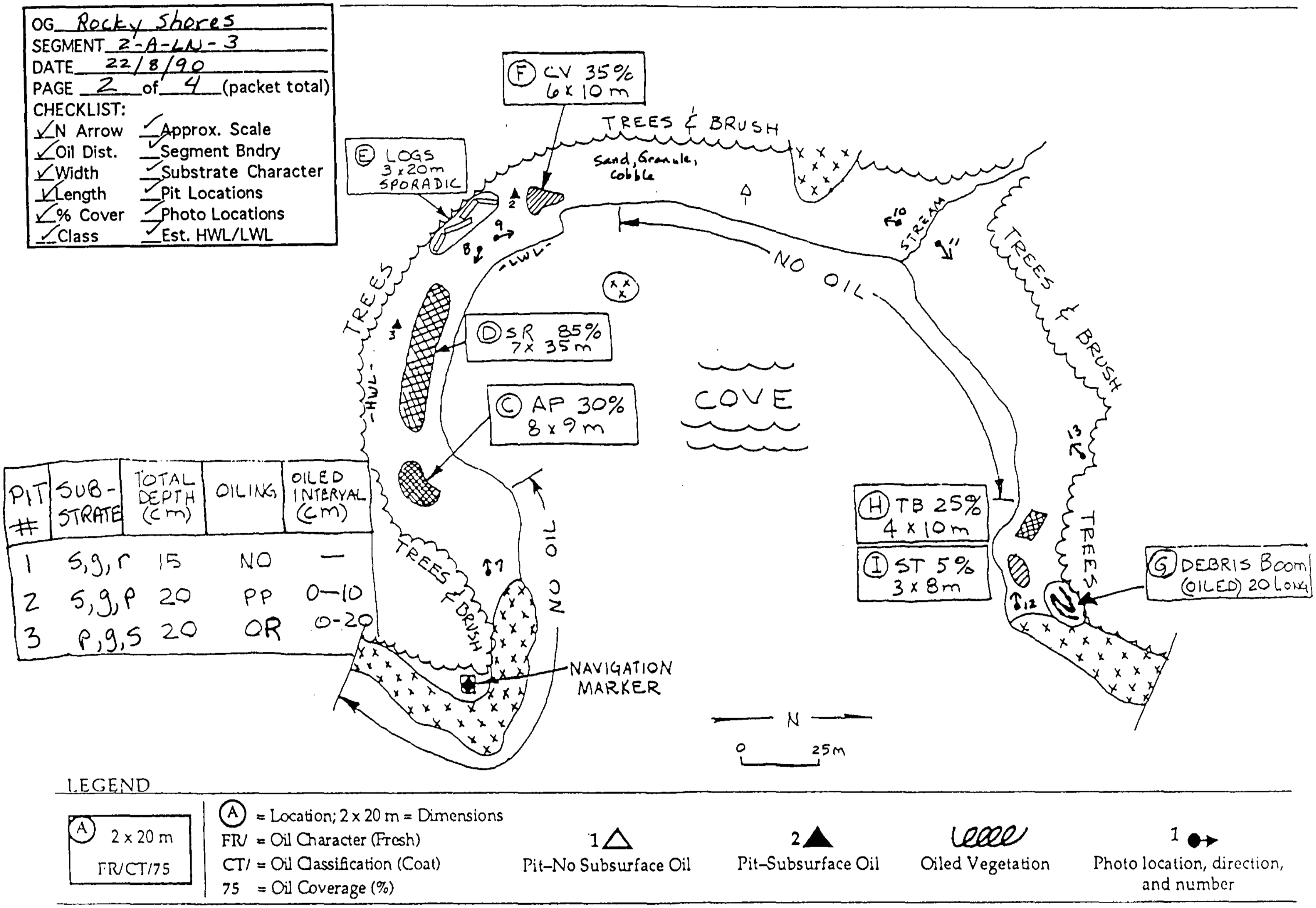
OR = Oil residue

TR = Trace



OG *Rocky Shores*
SEGMENT *2-A-LN-3*
DATE *22/8/90*
PAGE *3* of *4* (packet total)
CHECKLIST:
✓ N Arrow ✓ Approx. Scale
✓ Oil Dist. ✓ Segment Bndry
✓ Width __ Substrate Character
✓ Length *NA* Pit Locations
✓ % Cover *NA* Photo Locations
✓ Class *NA* Est. HWL/LWL

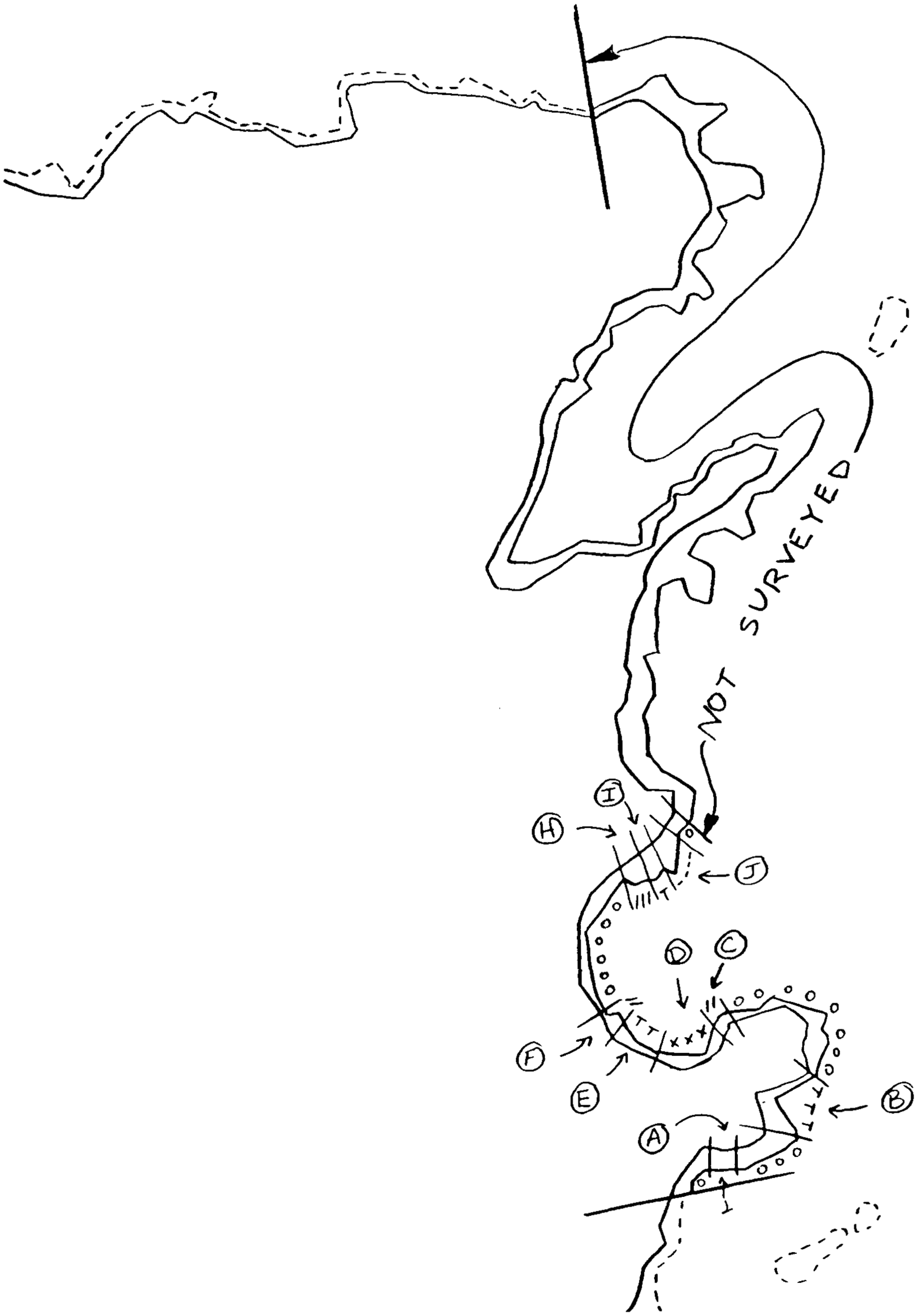
Figure 8. Example of Sketch Location Map



OG Rocky Shores
SEGMENT 2-A-LN-3
DATE 22/8/90
PAGE 2 of 4 (packet total)
CHECKLIST:
✓N Arrow
✓Oil Dist.
✓Width
✓Length
✓% Cover
✓Class
✓Approx. Scale
✓Segment Bndry
✓Substrate Character
✓Pit Locations
✓Photo Locations
✓Est. HWL/LWL

PIT #	SUB-STRATE	TOTAL DEPTH (cm)	OILING	OILED INTERVAL (cm)
1	s,g,r	15	NO	—
2	s,g,p	20	PP	0–10
3	p,g,s	20	OR	0-20

Figure 9. Example of Completed Sketch Map



XXXX - Heavy
////// - Moderate
- - - - - - Light
TTTT - Very Light
OOOO - No Oil

Segment Length: 1,240 m

METERS

0 100 200

Segment Surface Oil Cover Map
Geologist Rocky Shores
Segment 2-A-LN-3
Date 22 / 8 / 90
Page 4 of 4

Figure 10. Example of Completed Surface Oiling Distribution Map

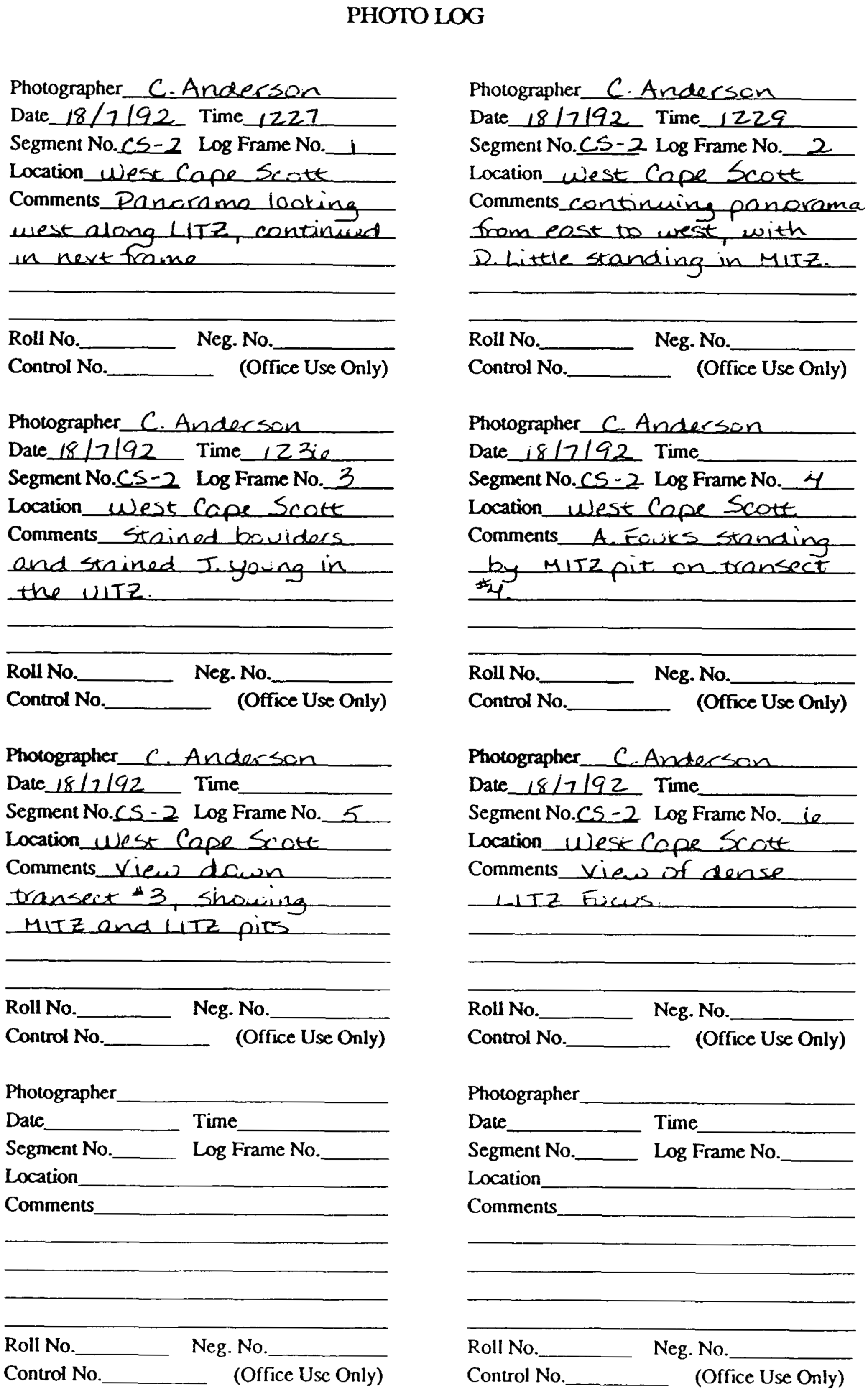


PHOTO LOG

Photographer C. Anderson
Date 18/7/92 Time 1227
Segment No. CS-2 Log Frame No. 1
Location West Cape Scott
Comments Panorama looking west along LITZ, continued in next frame
Roll No.________ Neg. No.__________
Control No.__________ (Office Use Only)

Photographer C. Anderson
Date 18/7/92 Time 1229
Segment No. CS-2 Log Frame No. 2
Location West Cape Scott
Comments continuing panorama from east to west, with D. Little standing in MITZ.
Roll No.________ Neg. No.__________
Control No.__________ (Office Use Only)

Photographer C. Anderson
Date 18/7/92 Time 1236
Segment No. CS-2 Log Frame No. 3
Location West Cape Scott
Comments Stained boulders and stained J. young in the LITZ.
Roll No.________ Neg. No.__________
Control No.__________ (Office Use Only)

Photographer C. Anderson
Date 18/7/92 Time__________
Segment No. CS-2 Log Frame No. 4
Location West Cape Scott
Comments A. Fouks standing by MITZ pit on transect #4.
Roll No.________ Neg. No.__________
Control No.__________ (Office Use Only)

Photographer C. Anderson
Date 18/7/92 Time__________
Segment No. CS-2 Log Frame No. 5
Location West Cape Scott
Comments View down transect #3, showing MITZ and LITZ pits
Roll No.________ Neg. No.__________
Control No.__________ (Office Use Only)

Photographer C. Anderson
Date 18/7/92 Time__________
Segment No. CS-2 Log Frame No. 6
Location West Cape Scott
Comments View of dense LITZ Fucus.
Roll No.________ Neg. No.__________
Control No.__________ (Office Use Only)

Photographer__________
Date__________ Time__________
Segment No.______ Log Frame No.______
Location__________
Comments__________
Roll No.________ Neg. No.__________
Control No.__________ (Office Use Only)

Photographer__________
Date__________ Time__________
Segment No.______ Log Frame No.______
Location__________
Comments__________
Roll No.________ Neg. No.__________
Control No.__________ (Office Use Only)

Figure 11. Example of Completed Photo Log Labels

4.7.2 Ecology

The SCAT procedure for systematically recording ecology information parallels that used for recording oiling observations. Forms are provided for assessing the general ecological character and state of shoreline environments (the **Shoreline Ecological Summary (SES) form**) and for assessing the ecological character and state of saline and brackish water salt-marshes (the **Marsh Ecological Summary (MES) form**). These forms present a quantitative approach to documentation of the shore-zone ecology and incorporate many features of the on-site marine/estuarine fish habitat forms used by the Department of Fisheries and Oceans (DFO).

The SCAT forms are intended to provide a general overview of the:

- ecological character and state of the intertidal and shallow subtidal zones;
- visual effects of stranded oil on indicator macro-organisms; and
- ecological considerations that relate to cleanup options and activities.

The DFO forms focus on fish habitats, and in some cases it may be desirable to use the DFO forms in conjunction with the SCAT forms. Information on the use and guidance on completion of the forms is provided by Williams (1990). The DFO forms should be of most use in describing fish habitats with high sensitivities to spilled oil; such sensitive habitat areas are included in shoreline sensitivity atlases, and the survey ecologist should identify areas within a segment needing detailed documentation prior to the survey.

Shoreline Ecological Summary (SES) Form.

The SES form (Figure 12) consists of a top section of general information which includes the segment number, date, time, crew number, name of the ecologist, and photographs collected. This is followed by a section for cross checking information from existing sensitivity atlases and databases with actual condition. This section should be used for comments on the existing information. The third section of the form describes the abundance of different coastal ecosystems in the segment. The classifications follow those of Ricketts et al. (1985) for western North America, and the abundances should total to 100%.

The fourth section (**SPECIES**) tabulates information on the general character and state of indicator species along the shore. The form concentrates on sessile algae and animal species which are common in the tidal zones and which can be readily surveyed in the course of the SCAT survey. If necessary, the list of indicator species can be modified during the early stages of survey.

The form requests three numbers for each indicator species within the intertidal zones:

- **C** is an indication of abundance and can be recorded as either percent **cover,** or individuals per square metre, at the option of the SCAT technical coordinator;
- **M** is a measure of percent dead individuals, **mortality**; and
- **R** is percentage of individuals in the most recent **recruiting** class.

A section for specific comments is also included under each shore zone. Comments should include any conclusions about the causes of mortality and the observations which support this conclusion.

A section is also supplied for information on nearshore shallow subtidal areas. Since this area is permanently under water it cannot be observed at the same level of detail possible for intertidal areas. The chief indicators chosen for shallow subtidal areas are macroalgae which can be observed during the survey. Observations on the macroalgae are limited to presence or absence, width of the algal zone, and distance of the zone offshore.

The **WILDLIFE OBSERVATIONS** section is configured so that the ecologist can fill in taxonomic information on:

- species observed, together with information on their abundance;
- if the taxa is resident or not;
- if the species is nesting or denning; and
- if any individuals are oiled.

This section can be made quantitative with timed counts at the start, middle, and end of the segment at the discretion of the SCAT technical coordinator.

Five classes of **ECOLOGICAL CONSTRAINTS** on cleanup activities are included on the form. The categories used (Standard, Deferred, Holding, Consultation Required, or On-site Monitor) are also the constraint choices used on the Cultural Resource Evaluation (CRE) Form. The constraints include two routine categories (Standard and Deferred) and three special categories (Holding, Consultation Required, and On-site Monitor):

- **STANDARD CONSTRAINTS** are applied if they are sufficient to safeguard the ecological community for the work that is planned;
- **DEFERRED CONSTRAINTS** are applied to segments where no oil is present and/or no treatment is planned;
- **HOLDING CONSTRAINTS** are applied as a temporary measure for sites where treatment is planned, but where the ecological survey is incomplete and/or further survey work is considered necessary;
- **CONSULTATION CONSTRAINTS** are applied where standard treatment could adversely affect the biological community; and
- **ON-SITE MONITORING CONSTRAINTS** are applied where high sensitivity or highly vulnerable areas require the presence of an on-site ecological monitor during cleanup.

Under actual spill conditions, most segments should receive Standard or Deferred constraints.

Marsh Ecological Summary (MES) Form

The MES form (Figure 13) begins with a top section which is identical to that used for the SES form. As with the SES form, this is followed by a section for cross-checking information from existing sensitivity atlases and databases with actual conditions. This section should be used for comments on the existing information and can be used in conjunction with maps from the atlases/databases. The third section of the form characterizes the substrate of the salt-marsh. The choices are sand, mud, and organic/peat; under most cases these should total 100%, but in some cases coarser sediment may be present.

The following section **DOMINANT VEGETATION** tabulates information on primary producers in the salt-marsh. The table requests information on the:

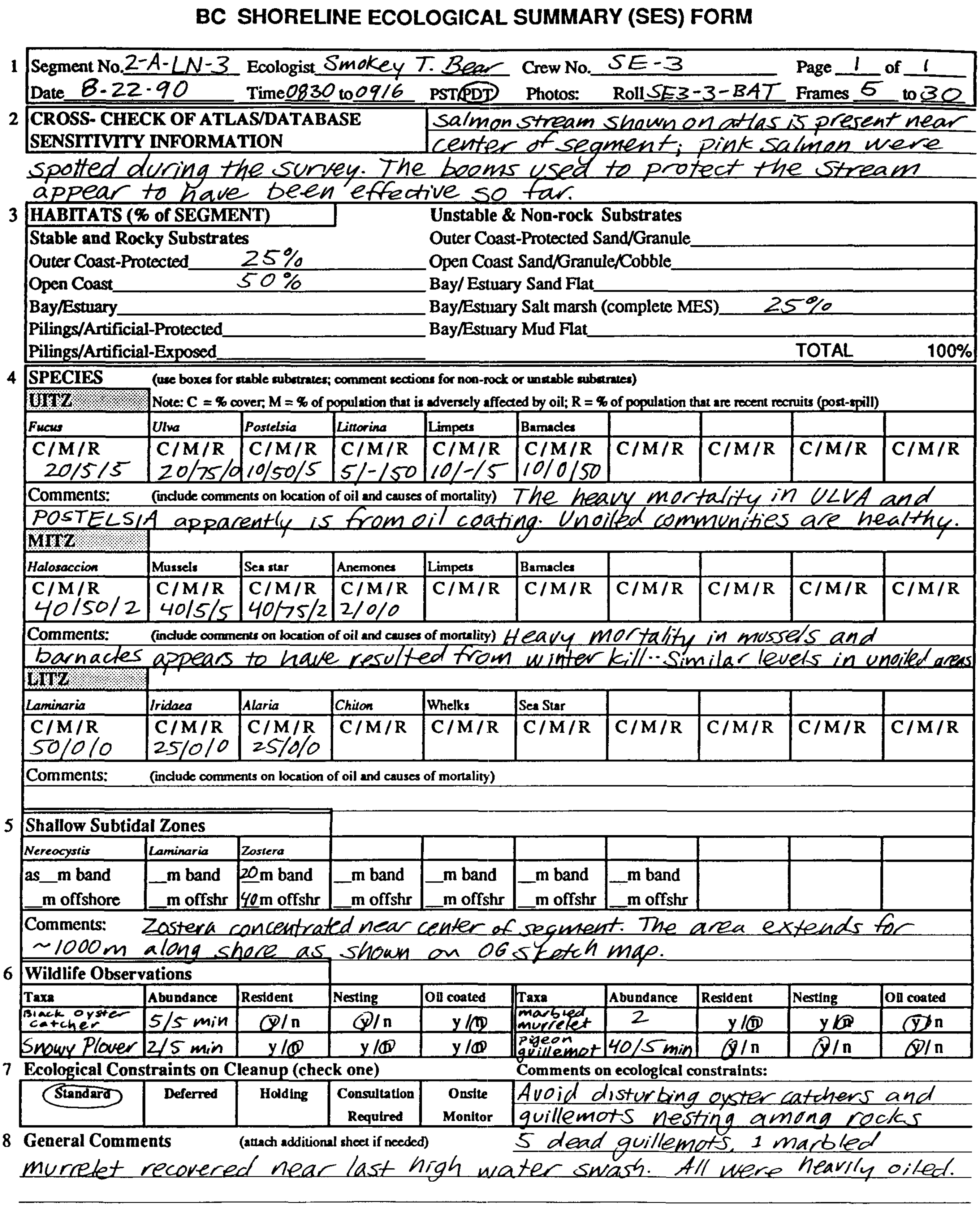
- abundance of species in the stand;
- whether the plants are flowering, seeding or dormant; and
- whether oil has affected the stems, leaves or roots.

If necessary, this list of indicator species can be modified during the early stages of survey.

The section on **ASSOCIATED ANIMAL SPECIES** includes information of invertebrates, birds, and mammals present in the marsh. The **ECOLOGICAL CONSTRAINTS** section exactly parallels the ecological constraints portion of the SES form.

Sketch Maps. The ECO can prepare field maps of the shoreline to identify the locations of various indicator species, and their abundance and state relative to oil location(s). If there is no ARCH on the crew, an attempt also can be made to locate human use areas or man-made structures. This map can be one of the important and useful shoreline assessment documents and could follow the form of the OG sketch map discussed previously (Section 4.7.1).

Photo Documentation Process. Ecological photo documentation is essentially the same as described for the OG.



BC SHORELINE ECOLOGICAL SUMMARY (SES) FORM

1 Segment No. 2-A-LN-3 Ecologist Smokey T. Bear Crew No. SE-3 Page 1 of 1

Date 8-22-90 Time 0830 to 0916 PST/[✓ PDT] Photos: Roll SE3-3-BAT Frames 5 to 30

2 **CROSS- CHECK OF ATLAS/DATABASE SENSITIVITY INFORMATION** salmon stream shown on atlas is present near center of segment; pink salmon were spotted during the survey. The booms used to protect the stream appear to have been effective so far.

3 **HABITATS (% of SEGMENT)**

Stable and Rocky Substrates		**Unstable & Non-rock Substrates**	
Outer Coast-Protected	25%	Outer Coast-Protected Sand/Granule	
Open Coast	50%	Open Coast Sand/Granule/Cobble	
Bay/Estuary		Bay/ Estuary Sand Flat	
Pilings/Artificial-Protected		Bay/Estuary Salt marsh (complete MES)	25%
Pilings/Artificial-Exposed		Bay/Estuary Mud Flat	
		TOTAL	100%

4 **SPECIES** (use boxes for stable substrates; comment sections for non-rock or unstable substrates)

UITZ Note: C = % cover; M = % of population that is adversely affected by oil; R = % of population that are recent recruits (post-spill)

Fucus	*Ulva*	*Postelsia*	*Littorina*	Limpets	Barnacles				
C/M/R 20/5/5	C/M/R 20/75/0	C/M/R 10/50/5	C/M/R 5/-/50	C/M/R 10/-/5	C/M/R 10/0/50	C/M/R	C/M/R	C/M/R	C/M/R

Comments: (include comments on location of oil and causes of mortality) The heavy mortality in ULVA and POSTELSIA apparently is from oil coating. Unoiled communities are healthy.

MITZ

Halosaccion	Mussels	Sea star	Anemones	Limpets	Barnacles				
C/M/R 40/50/2	C/M/R 40/5/5	C/M/R 40/75/2	C/M/R 2/0/0	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R

Comments: (include comments on location of oil and causes of mortality) Heavy mortality in mussels and barnacles appears to have resulted from winter kill.. Similar levels in unoiled areas

LITZ

Laminaria	*Iridaea*	*Alaria*	*Chiton*	Whelks	Sea Star				
C/M/R 50/0/0	C/M/R 25/0/0	C/M/R 25/0/0	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R

Comments: (include comments on location of oil and causes of mortality)

5 **Shallow Subtidal Zones**

Nereocystis	*Laminaria*	*Zostera*							
as__m band __m offshore	__m band __m offshr	20m band 40m offshr	__m band __m offshr	__m band __m offshr	__m band __m offshr	__m band __m offshr			

Comments: Zostera concentrated near center of segment. The area extends for ~1000m along shore as shown on OG sketch map.

6 **Wildlife Observations**

Taxa	Abundance	Resident	Nesting	Oil coated	Taxa	Abundance	Resident	Nesting	Oil coated
Black oyster catcher	5/5 min	[✓ y]/n	[✓ y]/n	y/[✓ n]	marbled murrelet	2	y/[✓ n]	y/[✓ n]	[✓ y]/n
Snowy Plover	2/5 min	y/[✓ n]	y/[✓ n]	y/[✓ n]	pigeon guillemot	40/5 min	[✓ y]/n	[✓ y]/n	[✓ y]/n

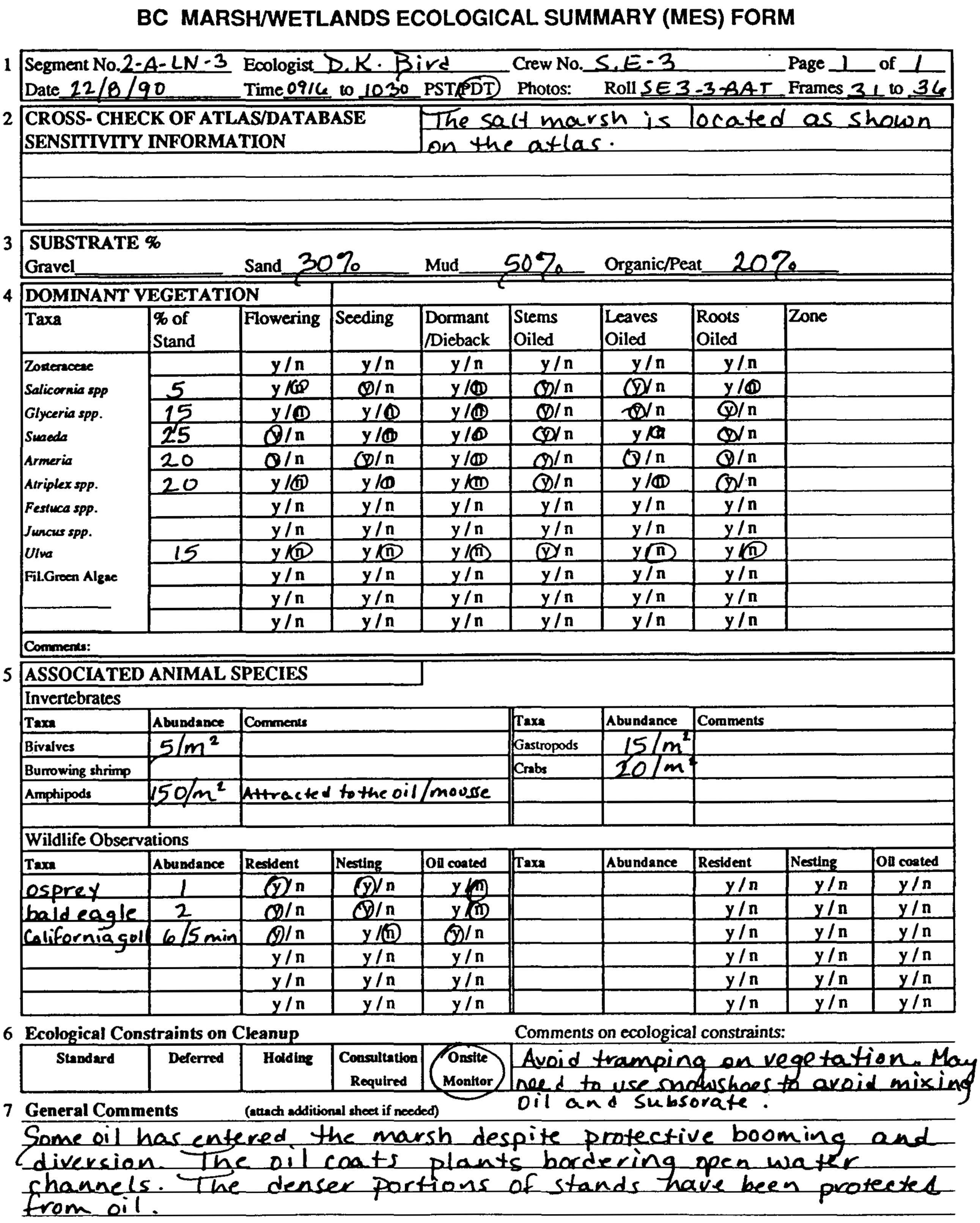
7 **Ecological Constraints on Cleanup (check one)**

[✓ Standard]	Deferred	Holding	Consultation Required	Onsite Monitor

Comments on ecological constraints: Avoid disturbing oyster catchers and guillemots nesting among rocks

8 **General Comments** (attach additional sheet if needed) 5 dead guillemots, 1 marbled murrelet recovered near last high water swash. All were heavily oiled.

Figure 12 . Example of Completed Shoreline Ecological Summary (SES) Form



BC MARSH/WETLANDS ECOLOGICAL SUMMARY (MES) FORM

1 Segment No. 2-A-LN-3 Ecologist D.K. Bird Crew No. S.E-3 Page 1 of 1
Date 12/8/90 Time 0916 to 1030 PST/[✓ PDT] Photos: Roll SE3-3-AAT Frames 31 to 36

2 **CROSS- CHECK OF ATLAS/DATABASE SENSITIVITY INFORMATION** The salt marsh is located as shown on the atlas.

3 **SUBSTRATE %**
Gravel ______ Sand 30% Mud 50% Organic/Peat 20%

4 **DOMINANT VEGETATION**

Taxa	% of Stand	Flowering	Seeding	Dormant /Dieback	Stems Oiled	Leaves Oiled	Roots Oiled	Zone
Zosteraceae		y/n	y/n	y/n	y/n	y/n	y/n	
Salicornia spp	5	y/[✓ n]	[✓ y]/n	y/[✓ n]	[✓ y]/n	[✓ y]/n	y/[✓ n]	
Glyceria spp.	15	y/[✓ n]	y/[✓ n]	y/[✓ n]	[✓ y]/n	[✓ y]/n	[✓ y]/n	
Suaeda	25	[✓ y]/n	y/[✓ n]	y/[✓ n]	[✓ y]/n	y/[✓ n]	[✓ y]/n	
Armeria	20	[✓ y]/n	[✓ y]/n	y/[✓ n]	[✓ y]/n	[✓ y]/n	[✓ y]/n	
Atriplex spp.	20	y/[✓ n]	y/[✓ n]	y/[✓ n]	[✓ y]/n	y/[✓ n]	[✓ y]/n	
Festuca spp.		y/n	y/n	y/n	y/n	y/n	y/n	
Juncus spp.		y/n	y/n	y/n	y/n	y/n	y/n	
Ulva	15	y/[✓ n]	y/[✓ n]	y/[✓ n]	[✓ y]/n	y/[✓ n]	y/[✓ n]	
Fil.Green Algae		y/n	y/n	y/n	y/n	y/n	y/n	
______		y/n	y/n	y/n	y/n	y/n	y/n	
		y/n	y/n	y/n	y/n	y/n	y/n	

Comments:

5 **ASSOCIATED ANIMAL SPECIES**

Invertebrates

Taxa	Abundance	Comments	Taxa	Abundance	Comments
Bivalves	5/m²		Gastropods	15/m²	
Burrowing shrimp			Crabs	10/m²	
Amphipods	150/m²	Attracted to the oil/mousse			

Wildlife Observations

Taxa	Abundance	Resident	Nesting	Oil coated	Taxa	Abundance	Resident	Nesting	Oil coated
osprey	1	[✓ y]/n	[✓ y]/n	y/[✓ n]			y/n	y/n	y/n
bald eagle	2	[✓ y]/n	[✓ y]/n	y/[✓ n]			y/n	y/n	y/n
California gull	6/5 min	[✓ y]/n	y/[✓ n]	[✓ y]/n			y/n	y/n	y/n
		y/n	y/n	y/n			y/n	y/n	y/n
		y/n	y/n	y/n			y/n	y/n	y/n
		y/n	y/n	y/n			y/n	y/n	y/n

6 **Ecological Constraints on Cleanup**

Standard	Deferred	Holding	Consultation Required	Onsite Monitor
				✓

Comments on ecological constraints: Avoid tramping on vegetation. May need to use snowshoes to avoid mixing oil and subsorate.

7 **General Comments** (attach additional sheet if needed)

Some oil has entered the marsh despite protective booming and diversion. The oil coats plants bordering open water channels. The denser portions of stands have been protected from oil.

Figure 13. Example of Completed Marsh Ecological Summary (MES) Form

4.7.3 Cultural Resources

Cultural Resource Forms. The three forms used by the ARCH consist of:

- Human Use Summart (HUS) form Figure 14),
- Cultural Resource Evaluation (CRE) form (Figure 15), and
- Site Inventory form (Figure 16) (used when necessary due to site specifics).

Other cultural resource forms have been developed for use during treatment and post-treatment activities, but these are not discussed here as they are not considered part of the initial SCAT program. A general explanation of the use of these forms is provided in the following discussion, whereas specific completion guidelines are given in Appendix I.

Human Use Summary (HUS) Form. One form to be completed by the ARCH is the HUS (Figure 14) which identifies significant ongoing human uses of the shoreline within the segment. These uses include **subsistence, agricultural, residential, recreational** (such as parks, tourist or resort beaches, boat ramps, marinas, public fishing areas, public clam digs or piers, hunting, scuba diving, windsurfing, and others), **commercial** (such as piers, restaurants, shops, industrial facilities, fishing areas, oyster leases, and others), **man-made structures** (including bulk heads, rip-rap, piers, bridges, seawalls, etc.) and any other **activities, uses or structures** located along the shoreline. The explanations for each entry are provided in Appendix I. A comment section is included on the form to describe the overall nature of the human uses and the density of man-made structures.

Cultural Resource Evaluation Form. The CRE form (Figure 15) is used to identify and document known and unknown cultural resources at a site and to evaluate the potential oiling and treatment impacts. This form is also used to place the appropriate level of constraint on work orders for individual shoreline segments. The five constraints were developed originally for the "Exxon Valdez" project (Mobley and Haggarty, 1989) and follow those outlined for the ecological (SES and MES) forms.

The **DEFERRED CONSTRAINT** is applied to work orders where no treatment is planned. This constraint intentionally makes no reference to the presence or absence of cultural resources, noting only that an archaeological assessment is necessary should any treatment activity be planned.

The **HOLDING CONSTRAINT** is applied to work orders where an archaeological survey is required before an evaluation can be made and before a formal archaeological constraint is applied to the work order. The constraint is used only as a temporary or holding measure pending completion of the archaeological survey.

The **STANDARD CONSTRAINT** is applied to work orders where planned treatment would not adversely affect known cultural resources present in the segment. This constraint is applied to segments which have been thoroughly surveyed. Standard constraints are applied with the understanding that if any undiscovered cultural resources are detected during treatment, they would be reported to the Archaeological Program Director by the Operations Supervisor or other individual responsible for shoreline cleaning.

The **CONSULTATION and INSPECTION CONSTRAINT** is applied to work orders where planned treatment may adversely impact known cultural resources present in the segment. The "consultation" aspect of the constraint enables the field archaeologist to exercise professional judgment regarding future treatment events in the segment after an initial on-site consultation and inspection has been conducted with the Operations Supervisor and agency monitors. This constraint requires that the field archaeologist communicate with the Operations Supervisor, either by phone or in person, to make sure that the Supervisor is aware of the reason for the constraint and to ensure that the planned treatment would not impact the cultural resources present in the segment. The field archaeologist does not have to be present during treatment if cultural resources are not likely to be impacted by the treatment activity.

An integral part of the consultation and inspection constraint is the scope of work, written by the Archaeological Program Director. The scope of work outlines the specific activity the field archaeologist follows in implementing the constraint specific to that segment.

The **ON-SITE MONITORING CONSTRAINT** is applied to all work orders in segments containing highly visible and/or very sensitive cultural resources, such as rockshelter burials. The On-Site Monitoring Constraint states that no treatment activity can take place in a segment without an accredited archaeologist present during treatment. This constraint provides the highest degree of protection for cultural resources during shoreline treatment. The scope of work for segments requiring on-site monitoring often is very specific and allows little room for modification in the field.

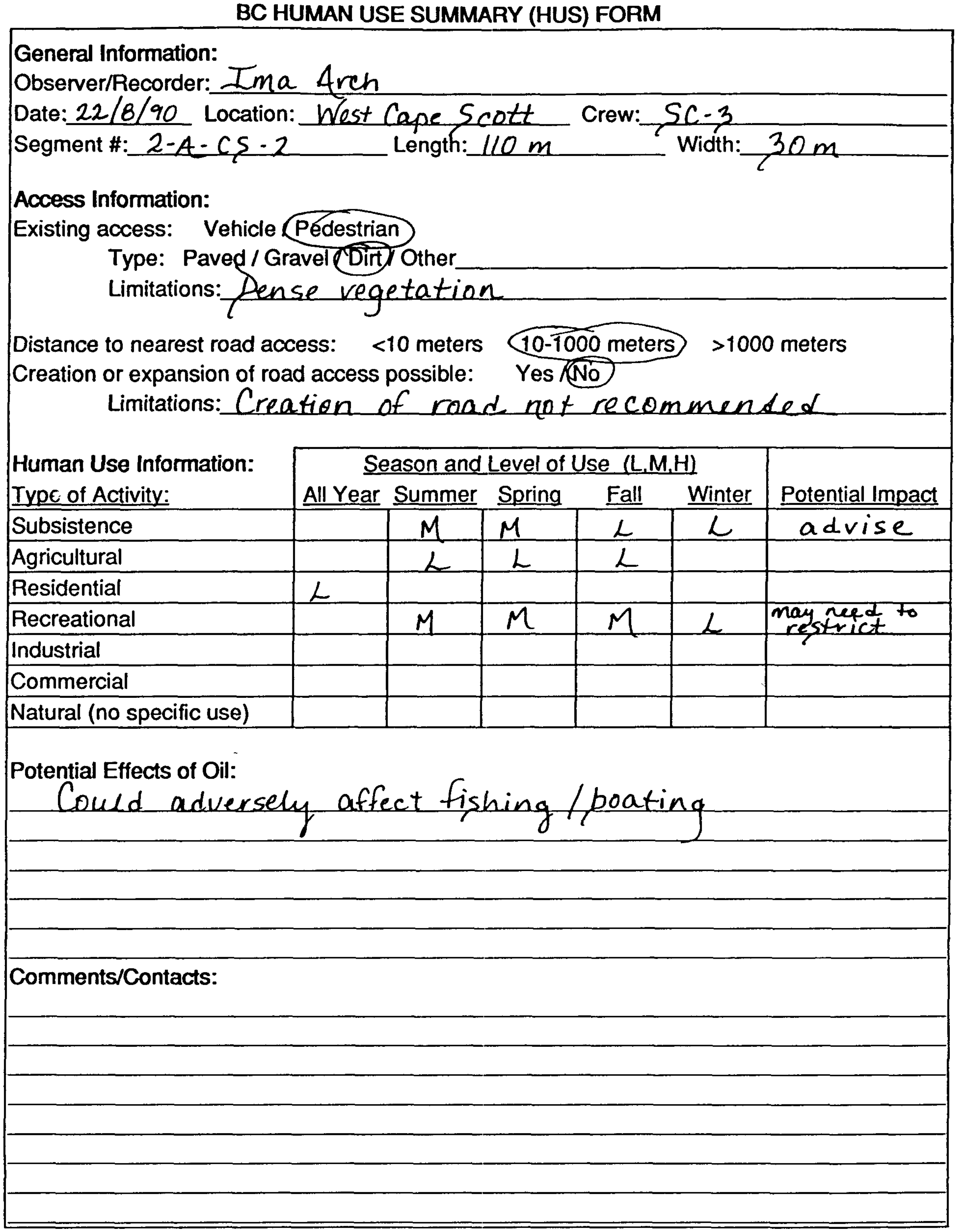
The application of these five constraints, over a wide range of treatment situations, worked effectively in Alaska following the *Exxon Valdez* spill to allow the required treatment to proceed without adversely affecting the cultural resources present (Mobley *et al.*, 1990; Haggarty *et al.*, 1991).

The Cultural resources include the physical remains of all Native and Euro-Canadian archaeological and architectural sites, but can also include the known locations of ceremonial or religious sites that may no longer contain any physical evidence of past human activity. Historic and prehistoric archaeological resources typically include surface and subsurface cultural deposits or sites, including settlements and camps, fish traps, rock art sites, standing or collapsed structures or ruins, marked or unmarked grave sites, culturally-modified tree sites, artifacts, or other objects of antiquity which provide information pertinent to the cultural history of the local area, province, or country. The site or object must exceed 50 years in age to be considered historically significant, unless it is exceptionally significant at the local, provincial, or national level.

Site Inventory Form. This form (Figure 16) is required only if deemed necessary by the archaeologist depending on the specifics of the site. Special circumstances could arise during the survey, such as the discovery of an artifact, which would require more detailed information and provincial documentation.

Comments. The system of survey and site forms, field notes, and maps used for recovery of archaeological data during a SCAT program is effective under the emergency conditions prevalent during the initial stages of an oil spill. Some information categories on the field forms would likely be revised prior to or during their use in the field depending on the exact nature of the response. Emphasis is placed on drawing detailed sketch maps of the site and the surrounding environment, particularly the relationship of the site to the intertidal zone. Extensive use can be made of video cameras/recorders during the ground assessment of the SCAT program. Video units can be used successfully during all phases of survey and are an extremely useful data recovery tool.

Maps. In BC, archaeolological sites are plotted on standard 1:50,000 scale NTS maps. These maps, along with the site records, are essential for locating sites previously recorded in a particular region of the province. Site sketch maps constructed in the field, either for previously known sites or for new sites found during a SCAT survey, are essential components of the review process and prove invaluable if it is necessary to inspect or monitor a site during shoreline treatment. Sites also have been plotted on hydrographic charts for some areas of the coast and charts are used during a SCAT shoreline survey due to the greater precision of shoreline detail compared with the 1:50,000 scale NTS maps.



BC HUMAN USE SUMMARY (HUS) FORM

General Information:

Observer/Recorder: Ima Arch

Date: 22/8/90 Location: West Cape Scott Crew: SC-3

Segment #: 2-A-CS-2 Length: 110 m Width: 30 m

Access Information:

Existing access: Vehicle [✓ Pedestrian]

Type: Paved / Gravel [✓ Dirt] / Other

Limitations: Dense vegetation

Distance to nearest road access: <10 meters [✓ 10-1000 meters] >1000 meters

Creation or expansion of road access possible: Yes [✓ No]

Limitations: Creation of road not recommended

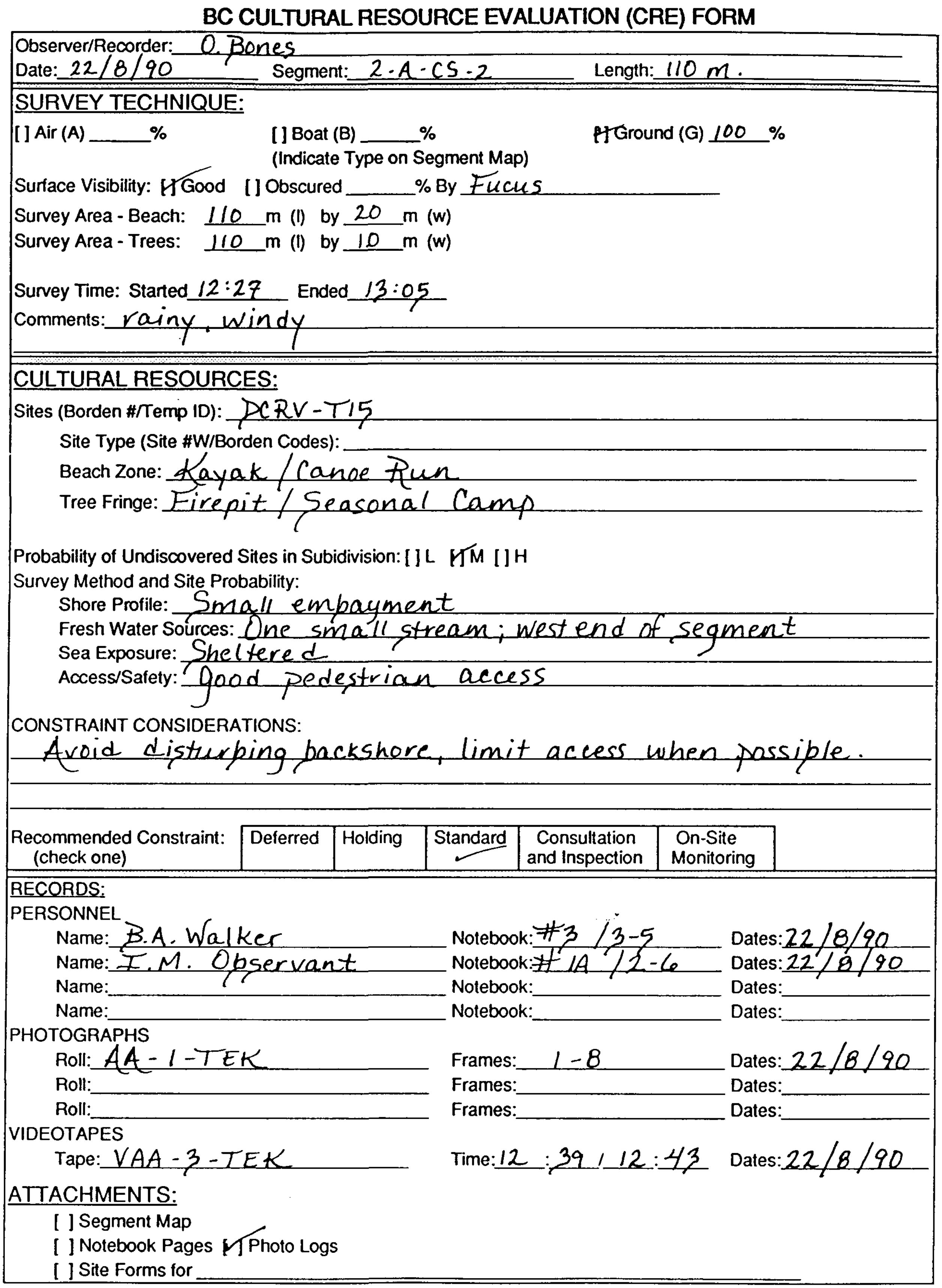
Human Use Information:	Season and Level of Use (L,M,H)					
Type of Activity:	All Year	Summer	Spring	Fall	Winter	Potential Impact
Subsistence		M	M	L	L	advise
Agricultural		L	L	L		
Residential	L					
Recreational		M	M	M	L	may need to restrict
Industrial						
Commercial						
Natural (no specific use)						

Potential Effects of Oil:

Could adversely affect fishing / boating

Comments/Contacts:

Figure 14 . Example of Completed Human Use Summary (HUS) Form



BC CULTURAL RESOURCE EVALUATION (CRE) FORM

Observer/Recorder: O. Bones

Date: 22/8/90 Segment: 2-A-CS-2 Length: 110 m.

SURVEY TECHNIQUE:

[ ] Air (A) ____% [ ] Boat (B) ____% [✓] Ground (G) 100 %

(Indicate Type on Segment Map)

Surface Visibility: [✓] Good [ ] Obscured ____% By Fucus

Survey Area - Beach: 110 m (l) by 20 m (w)

Survey Area - Trees: 110 m (l) by 10 m (w)

Survey Time: Started 12:27 Ended 13:05

Comments: rainy, windy

CULTURAL RESOURCES:

Sites (Borden #/Temp ID): DCRV-T15

Site Type (Site #W/Borden Codes):

Beach Zone: Kayak / Canoe Run

Tree Fringe: Firepit / Seasonal Camp

Probability of Undiscovered Sites in Subidivision: [ ] L [✓] M [ ] H

Survey Method and Site Probability:

Shore Profile: Small embayment

Fresh Water Sources: One small stream; west end of segment

Sea Exposure: Sheltered

Access/Safety: Good pedestrian access

CONSTRAINT CONSIDERATIONS:

Avoid disturbing backshore, limit access when possible.

Recommended Constraint: (check one)	Deferred	Holding	Standard	Consultation and Inspection	On-Site Monitoring
			✓		

RECORDS:

PERSONNEL

Name: B.A. Walker Notebook: #3 /3-5 Dates: 22/8/90

Name: I.M. Observant Notebook: #1A /2-6 Dates: 22/8/90

Name: Notebook: Dates:

Name: Notebook: Dates:

PHOTOGRAPHS

Roll: AA-1-TEK Frames: 1-8 Dates: 22/8/90

Roll: Frames: Dates:

Roll: Frames: Dates:

VIDEOTAPES

Tape: VAA-3-TEK Time: 12:39 / 12:43 Dates: 22/8/90

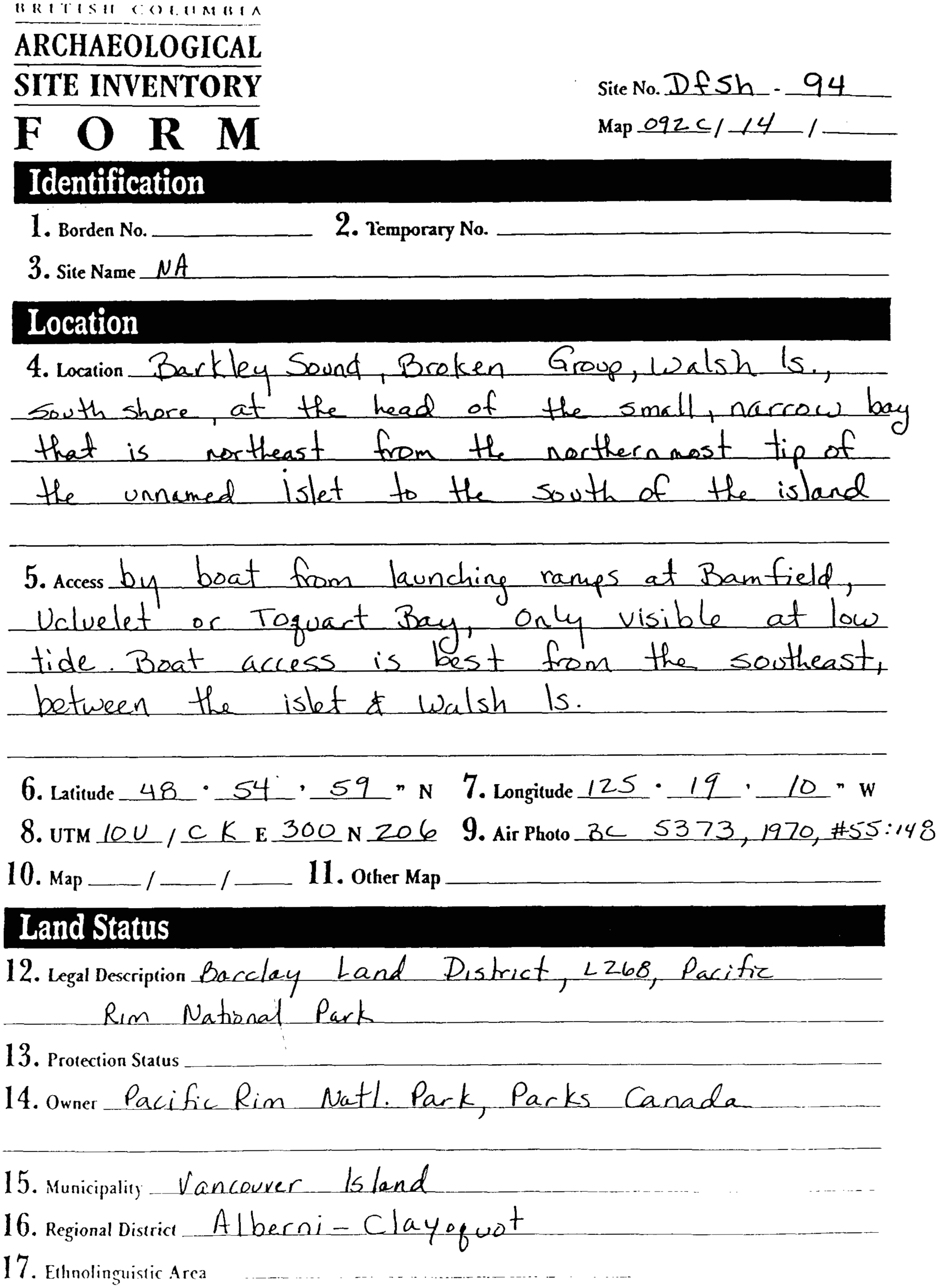
ATTACHMENTS:

[ ] Segment Map

[ ] Notebook Pages [✓] Photo Logs

[ ] Site Forms for

Figure 15 . Example of Completed Cultural Resource Evaluation (CRE) Form



BRITISH COLUMBIA

ARCHAEOLOGICAL SITE INVENTORY FORM

Site No. DfSh - 94

Map 092C / 14 /

Identification

1. Borden No.

2. Temporary No.

3. Site Name NA

Location

4. Location Barkley Sound, Broken Group, Walsh Is., south shore, at the head of the small, narrow bay that is northeast from the northernmost tip of the unnamed islet to the south of the island

5. Access by boat from launching ramps at Bamfield, Ucluelet or Toquart Bay, Only visible at low tide. Boat access is best from the southeast, between the islet & Walsh Is.

6. Latitude 48 ° 54 ' 59 " N

7. Longitude 125 ° 19 ' 10 " W

8. UTM 10U / CK E 300 N 206

9. Air Photo BC 5373, 1970, #55:148

10. Map / /

11. Other Map

Land Status

12. Legal Description Barclay Land District, L268, Pacific Rim National Park

13. Protection Status

14. Owner Pacific Rim Natl. Park, Parks Canada

15. Municipality Vancouver Island

16. Regional District Alberni - Clayoquot

17. Ethnolinguistic Area

Figure 16 . Example of Completed Site Inventory Form

Site No. DfSh - 94

Site Description

18. Site Type Resource Utilization, fish, trap.

19. Site Dimensions: L 16 (N-S) m W 2.5 (E-W) m

20. Cultural Strata NA

21. Depth of Cultural Strata: Max NA Min Med

22. Non-Cultural Strata NA

23. Archaeological Culture Northern Nootka, Nuu-Chah-Nulth, Sheshalt

24. Dates unknown

25. Features single stone wall, v-shaped or curved fish trap.

26. Present Condition 100% intact

27. Future Condition slight sedimentation, within Pacific Rim Park

Figure 16. Site Inventory Form (continued)

Site No. DfSh - 94

Environment

28. Vegetation Zone NA

29. Site Vegetation none

30. Drainage 15, S. Vancouver Is.

31. Landforms

32. Elevation (a) -0.45-0.95 m ASL (b) NA

Investigations and Collections

33. Collector NA Permit

Permit

34. Excavator NA Permit

Permit

35. Significant Artifacts NA

36. Collections NA

37. Photo Record 1982, Pacific Rim Archaeological Project, at B.C.P.M; 82: 459,461-46

38. Published References 1982, non-permit, Haggarty, J. Inglis, R., Pacific Rim Archaeology Project.

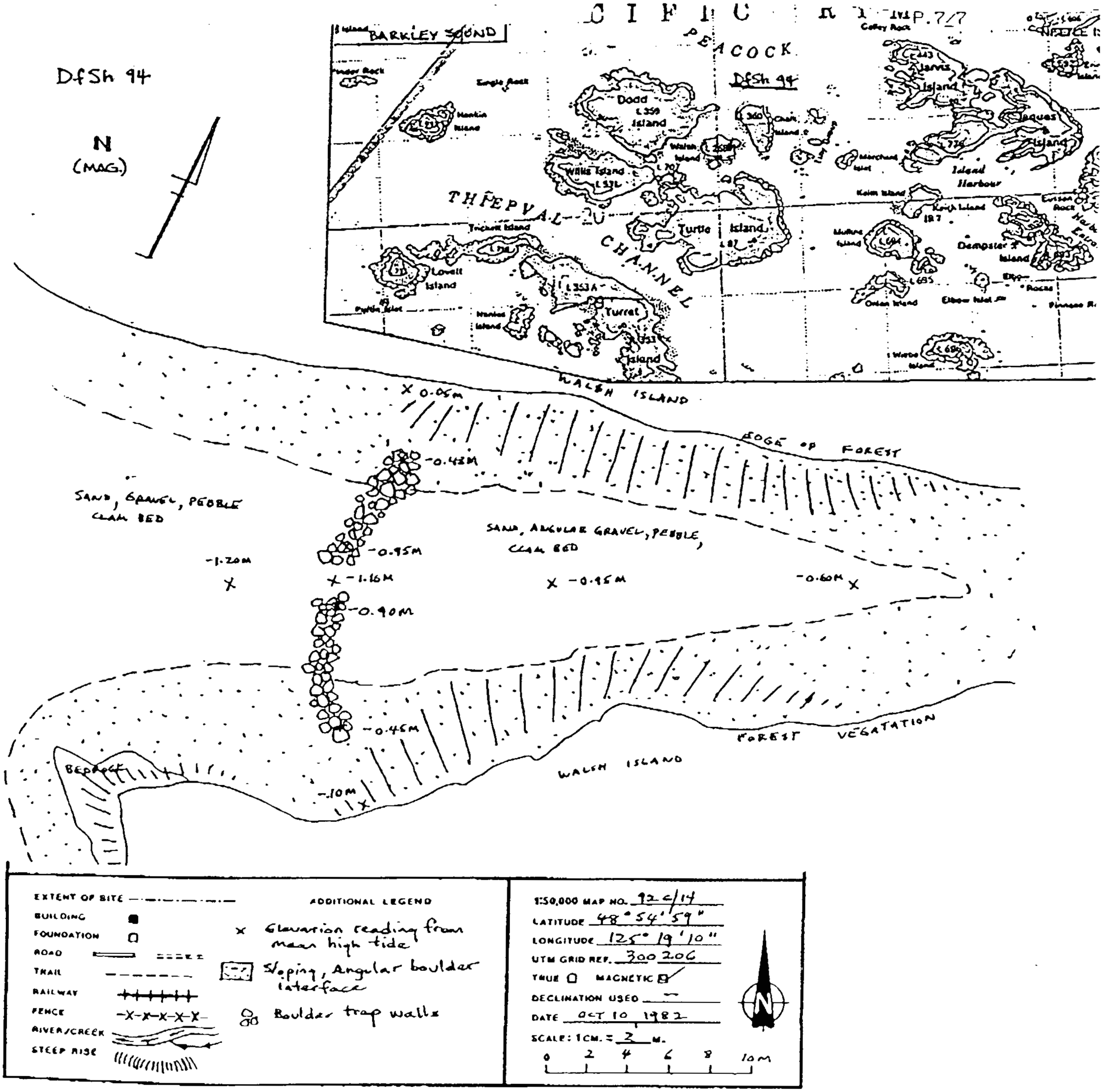
39. Unpublished References

40. Informant NA

41. Recorder L. Williamson, C Crockford (PRAP) Date: 10 / 10 / 82

Date: / /

Figure 16. Site Inventory Form (continued)



1:50,000 MAP NO. 92 c/14

LATITUDE 48° 54' 59"

LONGITUDE 125° 19' 10"

UTM GRID REF. 300 206

TRUE ☐ MAGNETIC ☑

DECLINATION USED ~

DATE OCT 10 1982

SCALE: 1CM. = 2 M.

Figure 16. (concluded) Site Inventory Form Sketch Map

PROGRAM

5.0 MONITORING PROGRAM

5.1 INTRODUCTION

Shoreline ground assessment surveys provide an assessment of the oiled shoreline at one point in time and can be applied in the planning of cleanup response and treatment activities. To assess changes in oiled shoreline conditions over time and to evaluate response activities requires a longer-term monitoring program. This type of program consists of more detailed observations and measurements that are conducted repetitively and systematically at selected sites within the affected area. The exact design, size, duration and scope of the monitoring program will vary with each spill situation, the environmental conditions and the operational response. A description of the methods used in a monitoring program following the *Exxon Valdez* spill and a discussion of results are given by Owens (1991a; Appendix H, Section H.5).

5.2 OBJECTIVES

The objectives of the monitoring program are to :

- document, over time, **changes in shoreline oiling conditions** which result from the treatment activities and/or natural processes;
- document, over time, **changes or recovery of biota** in areas which have been either oiled and treated, oiled and untreated, or unoiled; and
- evaluate the **effectiveness and effects of the treatment** decisions and options which were applied to oiled shorelines.

5.3 PERSONNEL

The monitoring crews usually consist of at least three members including an **oil-spill specialist/coastal geologist (OG)**, a **coastal ecologist (ECO)** and a **field technician (TECH)**. The OG provides the overall direction of the crew and conducts the monitoring activities related to oil cover, penetration, beach elevation, photo/video documentation, and sampling. The ECO conducts documentation of the intertidal community, marsh community, bird populations, or mammalian populations; the ecological study may include quantitative counts of quadrats which are reoccupied through time to assess recovery. The TECH provides assistance primarily to the OG, but assists the ECO as time permits.

5.4 LOGISTICS

The logistic requirements for the monitoring surveys are essentially the same as for the shoreline assessment ground surveys when using a three member crew, as discussed in Section 4.4. The transportation mode is ground based if the sites are accessible by road. Otherwise, vessels are preferred, followed by helicopters. Crews are equipped with hand-held, two-way radios and, if operating in remote areas, an EPIRB. The equipment for monitoring is much the same as for ground surveys.

5.5 MONITORING SURVEY METHODS

Methods for conducting long-term monitoring surveys covered by this section include site selection, site preparation, site monitoring and data reduction. Details on the methods for each of these components are given in the following discussion.

5.5.1 Site Selection

Long-term monitoring sites are selected based on a number of variables, including:

- oil distribution,
- character of the oil,
- wave exposure,
- substrate type,
- treatment techniques employed,
- character of the biotic community, and
- ecological impact of oil.

Sites are selected to represent the predominant shoreline or marsh types and the oil conditions found within the spill area. The number of sites depends, in part, on the size of the affected area and the number of variables which are to be studied.

5.5.2 Site Preparation

Site preparation depends on the type of environment to be studied. In the discussion which follows the procedures used for clastic beaches are described. These procedures can be modified for salt-marshes and other environments with quadrats substituting for transects.

Site preparation consists of establishing transects across the beach and surveying these relative to each other and to a common datum. The transects are a necessary framework within which accretion/erosion of the beach surface and oil conditions can be documented in a systematic manner. The number of transects may range from one or two up to as many as 20, based on the length and size of the shoreline section to be studied, the distribution of the oil and the homogeneity of the shoreline. In general, a relatively straight shoreline with similar alongshore substrate and oil characteristics would require fewer transects, whereas a section with variable oil conditions, substrates, and configurations may require additional transects to document accurately changes through time. **Single transects rarely represent the inherent heterogeneity of a beach** (Owens and Teal, 1990).

Several key factors relating to transect construction are represented by the following actions:

- transects are established with a minimum of two stakes set in the backshore, approximately aligned at a right angle to the shoreline trend.
- the two stakes are set at least 2 m apart and are sufficiently far in the backshore to minimize the chance of storm damage or erosion.
- the bearing of the transect is taken using a compass and sighting from the back to the front stake (seaward). Magnetic or true north can be used as a reference point, provided that the readings are consistent between transects and sites.

The alongshore spacing of transects varies depending on the length and homogeneity of the site, although 10 to 20 m spacing commonly is adequate to document a site. Close spacing (5 to 10 m) is more important where heterogeneous conditions exist. Distances and bearings between stakes are recorded to enable relocation of a staked point should one or more be removed by storm activity or vandalism. Stake heights are measured in the event deposition or erosion processes change the ground elevation at the base of the stakes. All stakes are levelled into a common datum. It is recommended that the first set of beach elevation profiles are surveyed with a level, taking elevation readings at a two-metre interval along the transect down to the water line. The time at which the water line is reached is recorded to calculate elevations above mean sea level by reference to local tide curves for that date and time. A layout of a typical monitoring site is shown in Figure 17.

5.5.3 Site Monitoring

Monitoring activities that may be conducted at each site and along each transect include:

- documenting the beach elevation changes along each transect;
- documenting surface oil cover estimates along each transect at 2 m intervals and to a distance of 2.5 m to either side (i.e. a 10 square metre area);
- documenting depth of oil penetration observations obtained from pits dug at designated locations along the transect, based on surface oil cover and across-shore location (SUTZ, UITZ, MITZ and LITZ);
- documenting sediment distribution estimates at 2 m intervals along one or more transects, to evaluate changes in substrate composition over time;
- collecting surface and subsurface (5 to 10 cm depth) sediment sample collection along one or more transects at designated locations in the UITZ, MITZ and LITZ (unless it is obvious that the oil is restricted to only a small portion of the intertidal zone). Samples are collected at the same distances along the transects but at locations adjacent to the previous sample to ensure that the sediments which are sampled have not been disturbed;

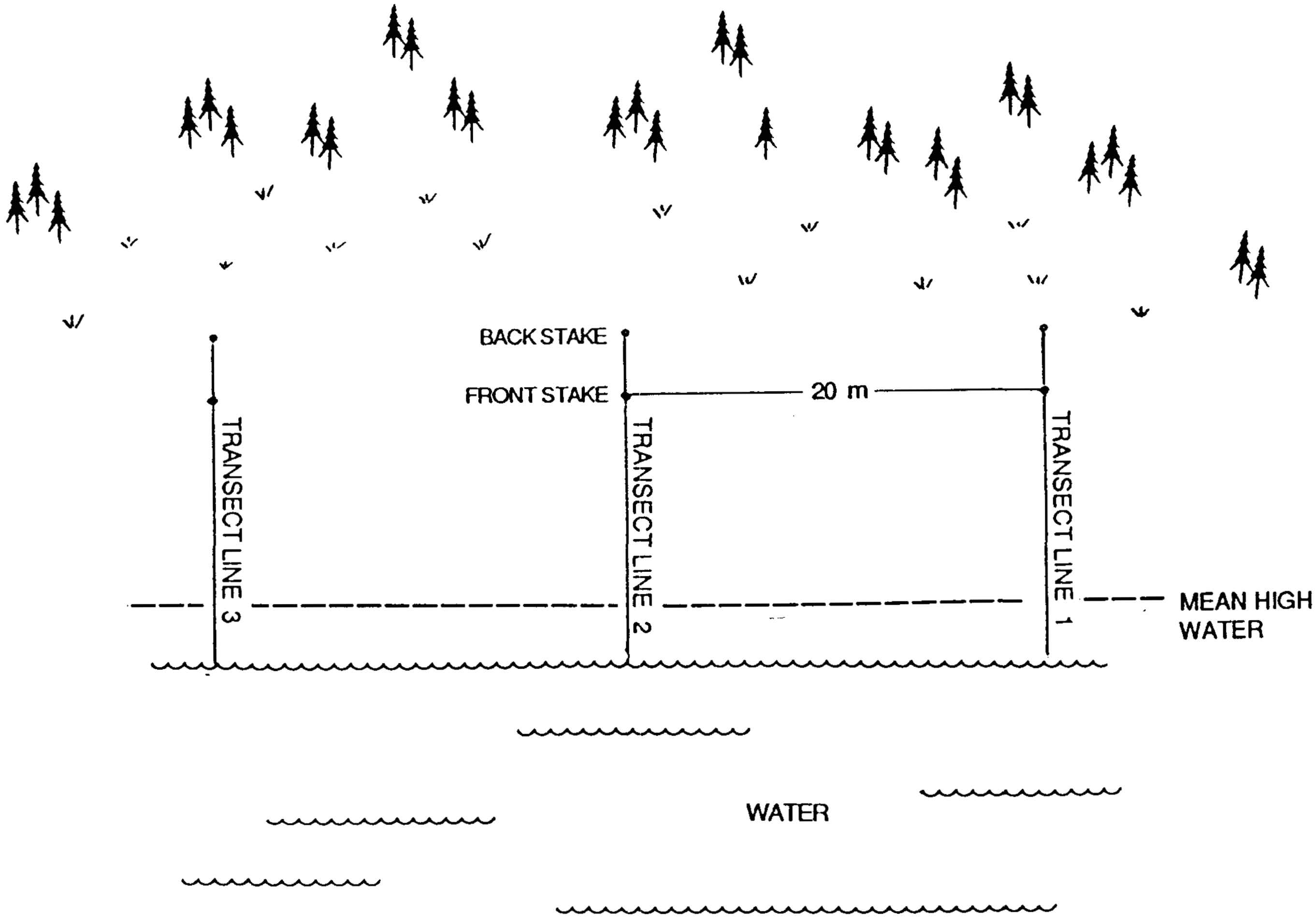


Figure 17. Typical Layout for Site Monitoring

- collecting subsurface samples to monitor changes in total petroleum hydrocarbons in the adjacent nearshore sediments;
- photographing the substrate at 1 m intervals along one or more designated transects (using a 1-m square quadrat to document the presence, abundance and appearance of the flora and fauna along that transect), or photography of particular substrate types on a stratified sample basis;
- establishing quadrats within which plant measurements or species counts can be conducted on a repetitive basis;
- photographing the site in a panoramic format from a central point to characterize the site and the oil conditions; and
- photographing and video-taping surface and subsurface oil conditions at various locations within the site. Incorporate landmarks such as trees, rock outcrops, large boulders, or other immovable objects to enable duplication of the photographs and tapes during subsequent visits.

Beach Elevation Changes. All measurements along the transect are surveyed from the back stake to ensure consistency, and because this stake has the least chance of being damaged or removed by storm activities. After the initial survey, an option is to use the pole and horizon method to obtain profile elevations (Emery, 1961). A rope or tape can be stretched out along the transect and lined up with the two backshore stakes to delineate the transect location. Beach elevations are recorded, using the procedure shown in Figure 18, on the Elevation and Oil Cover Monitoring field form (Figure 19). If the horizon is obscured, a hand level can be used to line up the top of the forward rod with the corresponding point on the back rod. Care should be taken not to move the front rod to the next 2 m interval until the back rod is ready for positioning in that same location, to avoid mislocating the back rod and skewing the subsequent interval locations. Transect, or beach profile, lines should be closed (that is, the line is surveyed from the back stake to the waterline and then back to the back stake).

Oil Cover Estimates. Oil cover estimates are made at the same time as the elevation measurements. Estimates are obtained by observing the 2 m area between the Emery rods and the 2.5 m swath to either side of the transect line (Owens et al., 1987). The estimates consider surface oil only and not oil that may exist under

EMERY METHOD

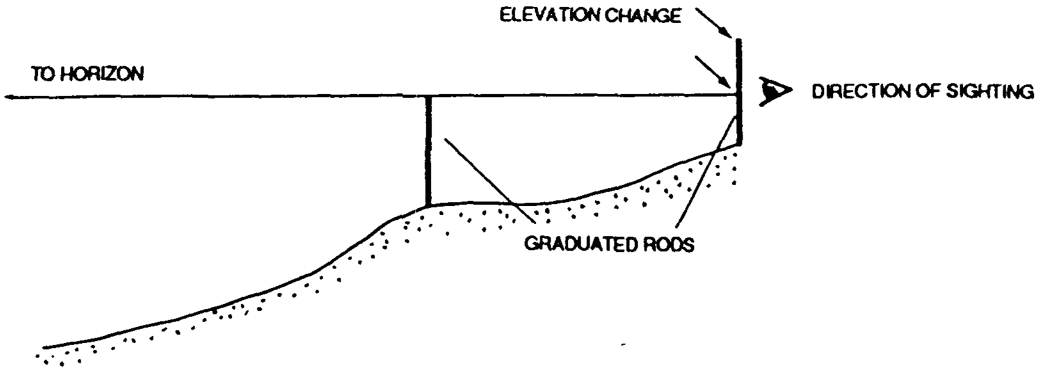
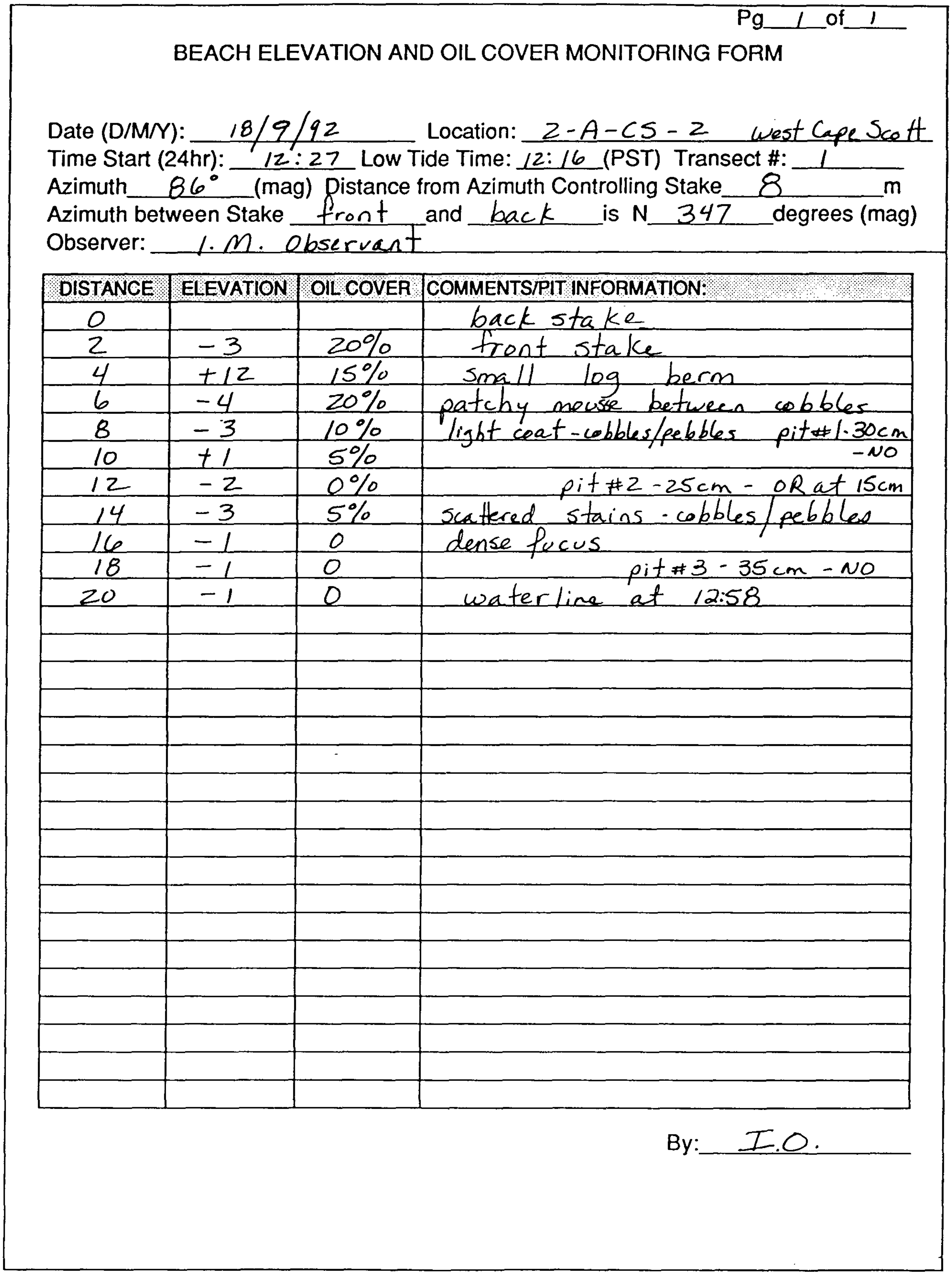


Figure 18. Use of Emery Rod Method for Measuring Elevation Change



Pg 1 of 1

BEACH ELEVATION AND OIL COVER MONITORING FORM

Date (D/M/Y): 18/9/92 Location: 2-A-CS-2 West Cape Scott
Time Start (24hr): 12:27 Low Tide Time: 12:16 (PST) Transect #: 1
Azimuth 86° (mag) Distance from Azimuth Controlling Stake 8 m
Azimuth between Stake front and back is N 347 degrees (mag)
Observer: I. M. Observant

DISTANCE	ELEVATION	OIL COVER	COMMENTS/PIT INFORMATION:
0			back stake
2	-3	20%	front stake
4	+12	15%	small log berm
6	-4	20%	patchy mousse between cobbles
8	-3	10%	light coat - cobbles/pebbles pit#1-30cm
10	+1	5%	-NO
12	-2	0%	pit#2 -25cm - OR at 15cm
14	-3	5%	scattered stains - cobbles/pebbles
16	-1	0	dense fucus
18	-1	0	pit#3 - 35cm - NO
20	-1	0	waterline at 12:58

By: I.O.

Figure 19. Field Form for Transect Data

cobbles, boulders or other sediments. Oil cover refers to the percent of the substrate surface within the 10-m square area that is covered by oil. Estimates require some care, particularly in lightly oiled areas where there is a natural tendency to overestimate. One approach is to envision herding all of the surface oil into one corner of the square and then to estimate the percent cover. If maps derived from the field data use category limits of 25, 50 and 75% oil cover, for example, to reduce the data, then it is important that either (1) the category limits be defined specifically as "less than or equal to 50%" or "greater than or equal to 50%", or (2) the exact break point number be avoided and the OG records only to the nearest 5% (e.g. 45 or 55%).

Oil Penetration Measurement. Oil penetration measurements and sediment sampling both are facilitated by the digging of pits or trenches. Penetration is measured at several locations along two or more transects and in areas of known surface and/or subsurface oil. If no surface oil is present, the pits are dug at two locations each in the SUTZ, UITZ, MITZ, and LITZ. Pits are dug as deep as practical, or to the lower extent of oil penetration, or the lower boundary of a buried oil lens. If it is not feasible to dig below the lower extent of oil, this is noted on the field form. Pits are dug at approximately the same location during each survey, with the transect number, pit number, and distance from the back stake noted on the field form (Figure 19), and data on pit depth, substrate type, oiled interval and depth to groundwater logged in a field notebook.

Oil/ Sediment Sampling. Sediment samples can be collected at the surface and at 5 to 10 cm below the surface from at least three locations: UITZ, MITZ and LITZ. The locations correspond to the presence of oil, although this is not a strict guideline as oil in low concentrations is not always visible. The repetitive sample locations are at the same distances along the transect, but not the same location to avoid sampling material that might have been used to fill in the pit from previous sampling events. Therefore, the first sample is collected at a designated distance from the back stake, but 2.5 m to the left of the transect centre line and the next sample collected at 0.5 m to the right of the previous one and so on. Samples are collected using a clean, stainless steel trowel. Nearshore samples can be collected by diver or with coring devices.

Ecological Survey. The ecologist selects and conducts a survey on one or more transects which traverse the most representative intertidal community components and/or ecological impacts for the site. The photo survey consists of observing and documenting one square metre quadrats. The results are compared to those from the same location during previous monitoring events to evaluate changes in species abundance and composition, as well as the rate of species recovery, if affected by the oil. A quadrat is a one-metre square template typically constructed of small-diameter PVC pipe with a grid constructed inside by stretching string between the sides at 10 cm intervals. An example of quadrat use is shown in Figure 20.

The survey is conducted by stretching a tape measure along the transect and observing each square metre through the quadrat. Photographing each quadrat is an extremely helpful method of documentation. A tripod would allow each photograph to be taken at the same angle and height, thereby reducing possible error in interpretation due to variations. The transect number and distance along the transect are recorded on a plastic or metal 20-cm square card placed in one corner of the quadrat. An erasable marking pen is used to change the distance and/or transect numbers between photographs. If the substrate is composed of sand or granules, epibiota is generally sparse and other techniques may be needed to survey the health of the biota.

5.6 MAPPING AND DOCUMENTATION

The data collected during the monitoring surveys are stored electronically and reduced to produce a variety of spreadsheets and graphics. The graphics are produced primarily in the form of transect profiles for beach elevation, oil cover, oil penetration, and species abundance. Oil cover maps of the entire site can be generated from the database. Examples of beach elevation profiles and oil cover maps are shown in Figures 21 and 22, respectively. As shown, the profiles can be overlaid onto those from previous monitoring events to define changes that occur over time. The maps can be compared side-by-side or can be superimposed to evaluate changes in oil cover distribution. More information on data reduction is provided in Appendix F.

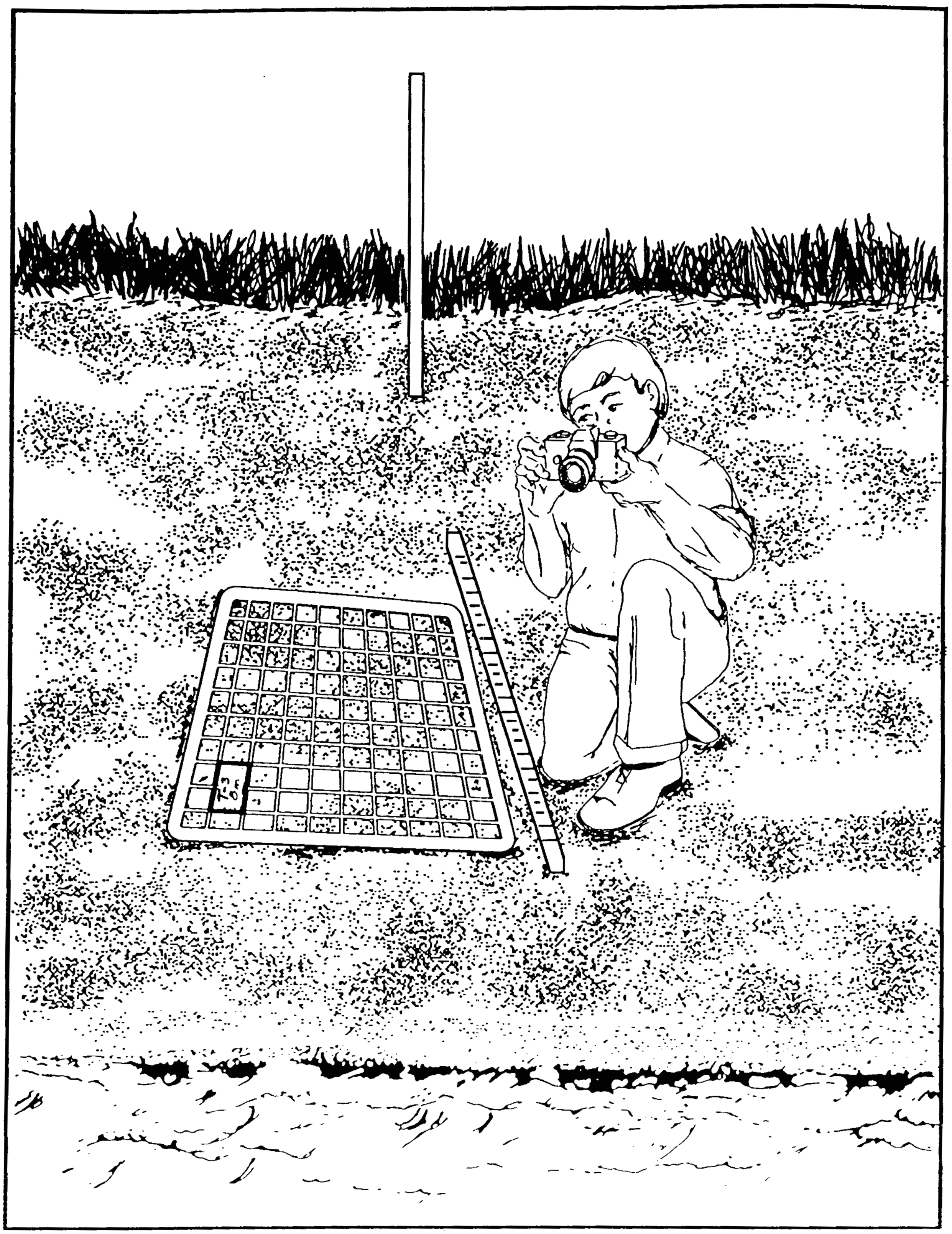


Figure 20. Example of a Quadrat Use

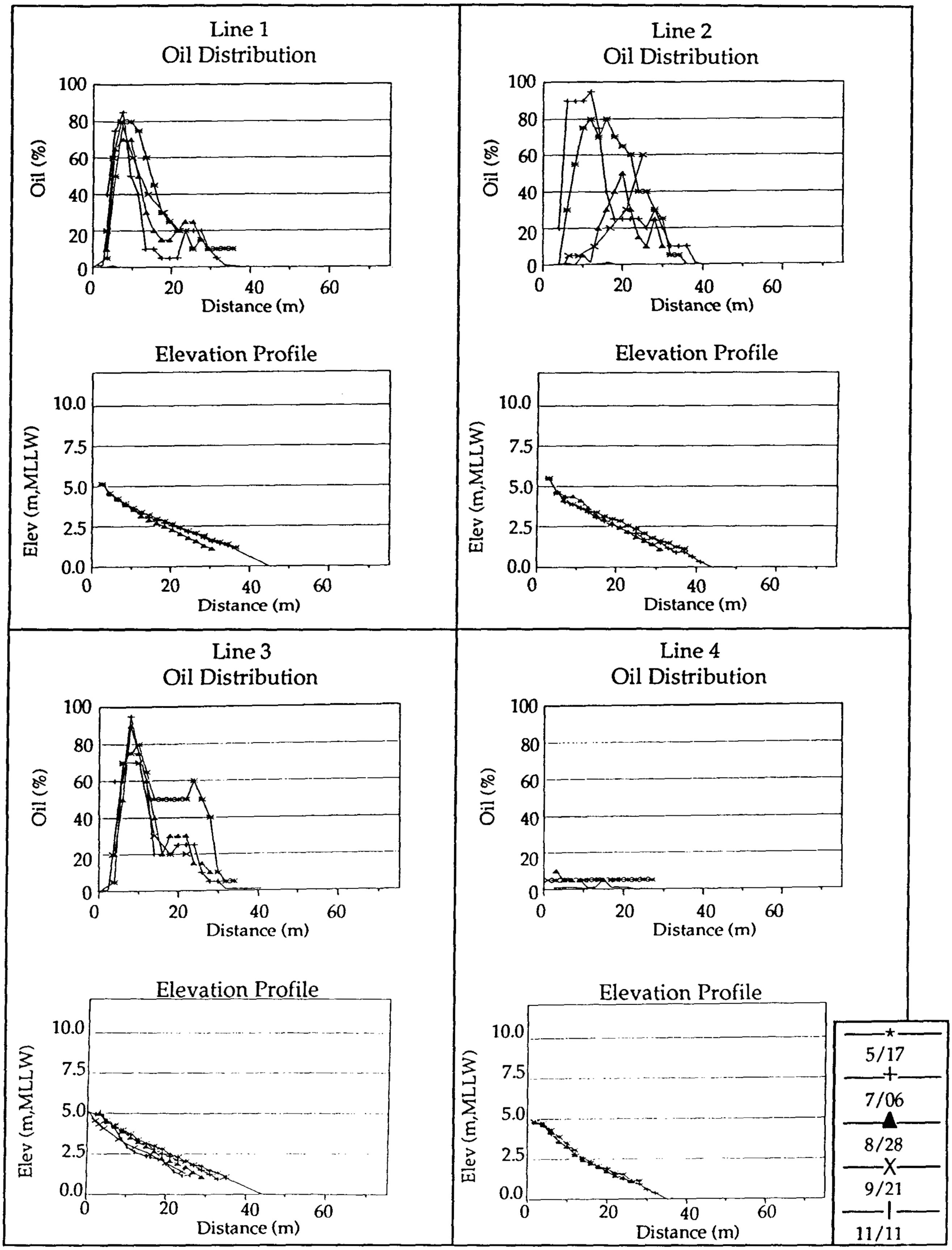


Figure 21. Examples of Surface Oil Distribution and Elevation Profiles for Each Transect at a Site

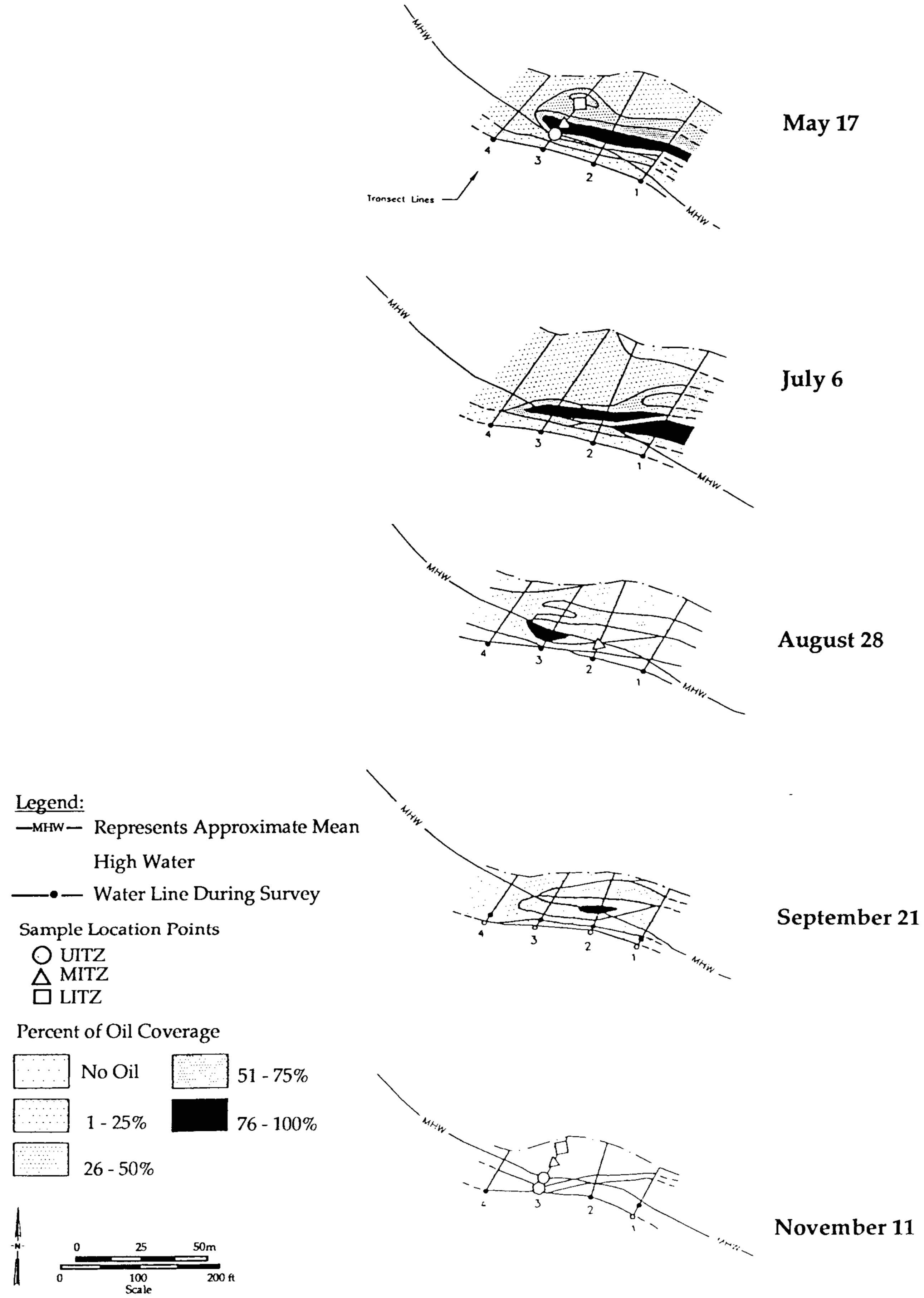


Figure 22. Example of Oil Cover Maps for Each Survey at a Site

SEGMENTATION

APPENDIX A: SHORELINE SEGMENTATION

A.1 INTRODUCTION

Shoreline segmentation is the process by which the shoreline is divided into appropriately sized units to provide:

- a detailed documentation or description of the shore zone, and
- reference points for the location of oiled areas.

Segment boundaries typically are determined by the location of prominent geological features, changes in shore or substrate types, and/or changes in oil conditions.

For the province of BC, pre-spill segmentation of an area or region is based on changes in shore type as determined by an existing classification of the shorelines of BC. The classification system uses four components including shoreline substrate, sediment, width and slope to derive the appropriate coastal class. Using this system, there are a total of 32 possible coastal classifications of which only a portion are commonly used (Table 8). Portions of the BC shoreline already have been mapped using this system, but shorelines which have not been classified and segmented by the time of a SCAT survey would have to be segmented in the field. This segmentation process can be built into a GIS database that is intended for use in spill response planning or operations.

A.2 OBJECTIVES

The primary objective of shoreline segmentation is to divide the shoreline into segments that are small enough to obtain adequate resolution and detail on the distribution of the oil, while involving an appropriate and achievable level of survey effort. Segments should not be so small that overwhelming quantities of forms and data are generated.

TABLE 8 BC (MoE) SHORELINE CLASSIFICATION SYSTEM (Harper, 1991)

SUBSTRATE	SEDIMENT	WIDTH	SLOPE	COASTAL CLASS
ROCK	n/a	WIDE (>30m)	STEEP(>20°)	n/a
			INCLINED	(5-20°'Rock Ramp, wide (1)
			FLAT(<5°)	Rock Platform, wide (2)
		NARROW (<30m)	STEEP(>20°)	Rock Cliff (3)
			INCLINED(5-20°)	Rock Ramp, narrow (4)
			FLAT(<5°)	Rock Platform, narrow (5)
ROCK + SEDIMENT	GRAVEL	WIDE (>30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	Ramp w gravel beach, wide (6)
			FLAT(<5°)	Platform w gravel beach, wide (7)
		NARROW (<30m)	STEEP(>20°)	Cliff w gravel beach (8)
			INCLINED(5-20°)	Ramp w gravel beach (9)
			FLAT(<5°)	Platform with gravel beach (10)
	SAND & GRAVEL	WIDE (>30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	Ramp w gravel & sand beach, wide (11)
			FLAT(<5°)	Platform w G&S beach, wide (12)
		NARROW (<30m)	STEEP(>20°)	Cliff w gravel/sand beach (13)
			INCLINED(5-20°)	Ramp w gravel/sand beach (14)
			FLAT(<5°)	Platform with gravel/sand beach (15)
	SAND	WIDE (>30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	Ramp w sand beach, wide (16)
			FLAT(<5°)	Platform w sand beach, wide (17)
		NARROW (<30m)	STEEP(>20°)	Cliff w sand beach (18)
			INCLINED(5-20°)	Ramp w sand beach, narrow (19)
			FLAT(<5°)	Platform w sand beach, narrow (20)
SEDIMENT	GRAVEL		WIDE (>30m)	n/a
		NARROW (<30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	Gravel beach, narrow (21)
			FLAT(<5°)	Gravel flat or fan (22)
	SAND & GRAVEL	WIDE (>30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	n/a
			FLAT(<5°'	Sand & gravel flat or fan (23)
		NARROW (<30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	Sand & gravel beach, narrow (24)
			FLAT(<5°)	Sand & gravel flat or fan (25)
	SAND/MUD	WIDE (>30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	Sand beach (26)
			FLAT(<5°)	Sand flat (27)
				Mudflat (28)
		NARROW (<30m)	STEEP(>20°)	n/a
			INCLINED(5-20°)	Sand beach (29)
			n/a	
	ORGANICS/FINES	n/a	n/a	Estuaries (30)
ANTHROPOGENIC		n/a	n/a	Man-made, permeable (31)
	MAN-MADE			
				Man-made, impermeable (32)

Segmentation should be based on an established set of criteria to ensure consistency between different shoreline areas and different survey crews. The BC shoreline classification system that is being developed and implemented by the Provincial government (MoE) is appropriate to meet these objectives.

A.3 SEGMENTATION GUIDELINES

Shoreline segmentation, or the determination of segment boundaries, is based on the coastal classification system which considers four shoreline components. Portions of the BC coast have been mapped and segment boundaries identified. If a spill occurs in one of these areas, the existing segmentation by coastal class can be used by the SCAT for documentation. For areas that have not been mapped at the time of a survey the segment boundaries can be determined using the same coastal classification system.

In general, a new segment is established when one of the four shoreline components (Table 8) changes significantly. Segment boundaries can be determined from aerial videotape surveys and it is often more efficient to establish segment boundaries prior to the ground survey.

As an example of one segmentation exercise, Saltspring Island has a total shoreline length of 134.1 km and has been segmented into 100 shore units (Owens, 1980; Appendix H, H.1b). This detailed mapping study was carried out using a scale of 1:20,000 and the lengths of the shore units that were produced can be summarized as follows:

> 5.0 km	0
4.0 - 5.0	5
2.0 - 3.9	17
1.0 - 1.9	28
0.5 - 0.9	27
0.2 - 0.49	19
< 0.2 km	4

On a more regional scale, following the spill from the *Exxon Valdez*, the initial spring 1989 SCAT survey in Prince William Sound covered approximately 1500 km of coast which was segmented into 549 shore units (Owens and Teal, 1990; Appendix H, H.5). The survey outside of Prince William Sound, where the oil was more scattered and widespread, covered over 4000 km of coastline in the Gulf of Alaska and a total of 600 segments. The difference in average segment length (2.7 km versus 6.5 km) reflects the different oiling conditions and the subsequent change in scale between the two regions, with a more detailed oil/geomorphology breakdown of shore units in Prince William Sound as compared to one characterized by short oiled segments and longer unoiled segments in the Gulf of Alaska region.

Segments or shore units that are homogeneous and have been defined initially as part of pre-spill planning, but that are found to be too long to adequately document variable oil conditions, can be divided further into subsegments as required (Section A.3.2).

A.3.1 Numbering Scheme

A consistent numbering scheme with some geographical reference is used to provide a general idea of segment location. An alpha-numeric scheme is used to designate each segment, in some areas using the segment boundaries already identified.

The BC provincial government (Ministry of Environment; MoE) is in the process of developing a hierarchical scheme for coastal subdivision. It is anticipated that, when completed, this scheme will follow a format that involves a progressive subdivision by zones, regions, areas and shore units. At present the BC coast has been divided, by MoE, into three oil spill response **zones**: North Coast, Vancouver Island and South Coast. These zones will be further divided into response **regions**. The zones are the first layer and the regions the second layer. The third layer consists of geographical **areas** which contain a number of individual shore units or **segments** (the fourth layer) based on the shoreline classification system (Table 8).

The numbering scheme uses a single-digit numerical designation for the zones, an alphabetical system for the regions and an alphanumeric system for the areas and segments respectively. A segment is identified by a two-letter area prefix that is associated with the name of an island, strait, bay, headland, or other geographical feature, and a numerical suffix. The numbers generally represent the sequence in which the segments are surveyed within the area associated with the particular prefix. For example, a segment of shoreline near Cape Scott on Vancouver Island located in Zone 2, Region A may be assigned the alphabetical prefix of CS for Cape Scott and if it were the second segment in the prefix area to be surveyed, it could be given the designation of 2-A-CS-2. The alphabetical prefix is best kept unique to avoid confusion as segments often are referenced only by their prefix and suffix (e.g. CS-2) rather than by the entire designation.

Although the numerical designation suffix for a series of segments is generally based on the order in which they are surveyed, it is practical to assign a group of numbers if more than one crew is surveying the same area. For example, one crew may be assigned numbers SC-1 through SC-50 and another crew SC-51 through SC-100.

A.3.2 Subsegment Boundary Determinations

In some areas with relatively homogeneous shorelines and substrates, the segments may be found to be too long when defined solely by the coastal classification system. In these cases, segments can be subdivided based on the distribution or character of the oil, if this varies significantly within the original segment boundaries. It is appropriate to assign separate subsegment designations to clean and oiled sections. There is no reason to subdivide the segment if the oil conditions are not variable. To avoid complicating the numbering system, subdivisions can be considered as individual subsegments and given separate designations following the standard numbering scheme with an alphabetical subsegment suffix (ie. SC-1a).

APPENDIX B: STRANDED OIL CHARACTERISTICS

B.1 GENERAL OVERVIEW

This section provides a general background on the distribution of oil on shorelines and the processes that affect deposition, erosion, penetration, burial, and remobilization. A description of oil classifications is also included. An understanding of these processes is helpful to an assessment of oil conditions and to establishing cleanup priorities. Although this section focuses primarily on crude oil, information is also provided for bunker C and diesel which are the two primary oil products transported along the BC coast.

In general, the prevailing tidal stage and wave conditions control the levels or zones within the intertidal area that are oiled. Oil tends to form windrows at sea, and thus washes ashore in patches and streaks. Only in cases of very large slicks does oil completely cover the shoreline. Typically, oil is deposited as a narrow band at the high-tide level, with occasional streaks or blotches occurring in the mid-tide zone. The prevalent wave energy and, subsequently, the sediment transport cycle (erosional or depositional) determine if the oil is buried or removed from the beach by natural processes. The sediment type(s), degree of sorting, groundwater level, and consistency or viscosity of the oil control the rate and depth of oil penetration. In addition, the substrate and consistency of the oil often influence the potential for remobilization.

Classification or characterization of the stranded oil can be based on a variety of factors. For surface oil, these include the width of the oiled zone, the percent of surface oil cover within the oiled zone (oil distribution), and the type and/or thickness of the oil (Tables 4, 5, and 6 in Section 4). Subsurface oil typically is characterized by the depth of penetration or the thickness of the buried oiled interval, and by an estimate of the quantity or concentration (Table 7 in Section 4). A series of pits or cores may be examined to determine the lateral and vertical extent of the subsurface oil.

B.2 PROCESSES THAT AFFECT OIL DEPOSITION

The deposition of oil on a shoreline depends on the type of shoreline, tidal stage and wave energy at the time of contact. On exposed shorelines, waves may be reflected from rock outcrops or beaches, thus minimizing oil deposition. If oil strands, typically it is deposited in the upper intertidal zone (UITZ) and frequently is splashed above the high-tide line by breaking waves. On sheltered shorelines, oil is deposited generally as a band in the mid- to upper ITZ with a sharply defined upper limit at the high-tide line. If oil contacts the shoreline during neap tides, often it is stranded as a relatively narrow band in the mid- to upper ITZ and may be remobilized as subsequent high-tide levels increase. Spring-tide deposition typically occurs in the upper sections of the intertidal zone and in the supratidal zone, particularly if contact coincides with storm-wave or storm-surge activity. The width of the oiled area generally is greater on low-angle beaches than on high-angle or vertical shorelines.

Surface penetration is largely dependent on oil viscosity and sediment grain size. At one end of the scale, fresh light crude oils or product stranded on coarse (boulder/cobble) and some finer-grained (pebble/granule) beaches can penetrate several tens of centimetres at the time of contact, depending on the size of the spaces between the sediments (pore space) and the depth to the groundwater table. Conversely, weathered or emulsified oils, due to their high viscosity, tend to remain on the surface of fine-grained beaches and poorly sorted substrates where the fine 'tail' of the size distribution blocks the larger pore spaces. Weathered crude oil or bunker C also have a greater potential for rapid remobilization on finer-grained substrates as they remain on the surface of this type of beach. The potential for burial or erosion is greater on fine-grained beaches, as less energy is required for sediment transport. In the case of well-sorted, coarse sediment beaches, even the more viscous oils can penetrate to some degree into the substrate. Coarser sediments, such as cobbles and boulders, also tend to trap the oil where it can accumulate to substantial thicknesses.

B.3 NATURAL CLEANING AND PROCESSES THAT AFFECT WEATHERING, BURIAL, AND REMOBILIZATION

Natural cleaning of oiled shorelines involves both the physical removal of oil from the shore, by abrasion and/or flushing, and *in situ* weathering processes. Oil that is washed from the shore into the adjacent waters is dispersed and weathers more quickly than concentrated oil stranded on land or in the intertidal zone. In all cases, the degradation, or weathering, of the spilled oil involves a progressive breakdown of the original material into its constituent components. Some oil components, particularly the low molecular weight compounds, evaporate. Oil may be washed in the adjacent waters where it is broken down and metabolized by a variety of processes. These processes break down the oil to carbon dioxide and water. Oil, or any other organic material added to a water body, tends to add to the biological oxygen demands (BOD) and to lower dissolved oxygen levels. Ocean waters typically have high dissolved oxygen levels, and dispersed oil has little effect. The most persistent fractions of the stranded oil, which are protected from wave abrasion or other physical processes, may persist in the form of tar balls, tar coats or asphalt pavements. The latter is a conglomerate of weathered or emulsified oil and sediment that can form on the surface of coarse/mixed-sediment beaches (Owens, 1973; Appendix H, H.5).

Several processes affect the fate and persistence of stranded oil. These include weathering, burial, erosion, and exposure. **Weathering** is a term that encompasses a wide range of biological, chemical and physical processes such as evaporation, dissolution, biodegradation, photo-chemical oxidation, and emulsification (NRC, 1985). Evaporation and dissolution rapidly remove lighter components of crude and, to some extent, bunker C oil, thereby increasing viscosity. Most components of diesel fuel and other light products may be removed completely by evaporation. Emulsification creates a water-in-oil emulsion, commonly referred to as "**mousse**", which has increased viscosity and volume. Oils with asphaltene contents greater than 0.5% tend to form stable emulsions, whereas those emulsions containing less are likely to 'break' and disperse. Typical emulsions for many crude and low viscosity oils can contain 30 to 80 percent water, whereas the water content for bunker C and other high-viscosity oil emulsions ranges from 10 to 40 percent.

Emulsification is an important process for a number of reasons, as it:

- increases the volume of an oil spill;
- increases the viscosity of the oil thus reducing penetration;
- facilitates the formation of pavement; and
- decreases the rate of chemical/biological weathering by several orders of magnitude.

Biodegradation and photochemical oxidation work to break down oil, usually beginning with the lighter components, into its constituent components (primarily carbon dioxide and water).

Stranded crude and bunker C oils typically weather to a tar-like substance, whereas stranded non-emulsified diesel likely evaporates and dissolves leaving little residue. This process also occurs at sea and, in the case of crude and bunker C, eventually leads to the formation of tar balls or mousse patties. On mixed sediment (cobbles, pebbles and sand), low-angle beaches the heavier oils and mousse often mix with sediments forming a conglomerate, asphalt-like material commonly referred to as asphalt pavement or tarmats (Owens, 1973). This asphalt can range from soft, or friable, to hard, with varying degrees of cohesiveness. Diesel or weathered light products mixed with sediments can form pavement in some cases but this is typically less cohesive.

Burial of oil occurs when the beach undergoes a depositional cycle and sediment is transported onto the beach from the subtidal or alongshore areas. The onshore or alongshore migration of sediments in post-*Exxon Valdez* studies was shown to cause burial by as much as a metre of clean material in some areas. Under some conditions, oiling may reduce the weathering rate. Oil typically remains buried until storm and/or increased wave activity expose, and often erode, the oil and oiled sediments from the beach. Oil deposited during, or shortly before, an erosional period would not be expected to persist. During **erosion**, oil is broken up, abraded, and/or mixed with sediment, which exposes a larger surface area to weathering and biodegradation processes. In the case of light oils and products, re-exposure may result in the oil being washed from the sediments thus creating sheens on the water.

Re-exposure or erosion of the oil may be rapid, depending on the depth of burial and the severity and frequency of storms, or burial may be permanent or semi-permanent in depositional environments, such as deltas.

In some areas, heavier oils and mousse can be trapped in interstitial spaces between boulders and large cobbles and can remain there sheltered from many of the weathering processes. This entrapment, in turn, increases the persistence of the oil unless intense wave action can rework the larger sediments and expose the oil. Diesel trapped in similar substrates likely would penetrate further into the beach, but at the same time would be more susceptible to removal by natural tidal flushing. When trapped in the subsurface of a sheltered beach environment, diesel may leach from the sediments for some time (McLaren, 1985).

B.4 THE DESCRIPTION OF SHORELINE OIL CONDITIONS

B.4.1 Surface Oil

Surface oil can be categorized by several different methods including oil character, oil type, length of oiled shoreline, width of oiled area, surface cover or distribution, oil thickness, or by a combination of these parameters (Table 4 in Section 4). Field measurements or observations often are estimates and, when a large area or a long coastline line is oiled, accurate reporting requires consistent methodology and terminology. As estimates of thickness are often associated with a degree of subjectivity, and typically the amount of stranded oil has little bearing on oil character, the *recommended method that has been developed for the categorization of stranded* oil considers surface oil cover as a function of length, width, and distribution. **Length** of oiled shoreline is an estimate or measurement of the alongshore section of coastline which has stranded oil present. **Width** is an across-shore measurement or estimate, in metres, of the oil band (if more than one band, the combined measurement) or oiled area. **Distribution** is the percent of surface area within an oiled band or area that is covered by oil. **Oil Cover** refers to either (1) the combined length, width and distribution as used in the Equivalent Area method by Owens et al.(1987, Appendix H; H.5), or (2) a visual estimate that uses the terms "continuous", "broken", "patchy", "sporadic", "trace", and "no oil" to describe the percent cover within a given area. The length, width and distribution data are recorded and used to develop the four oil cover categories "heavy", "moderate", "light" and "very light" as indicated in Table 5. These oil cover categories are a useful simplification for mapping or tabulation purposes. The **Amount** of surface oil is an estimate that involves the thickness of the oil cover. This estimate is combined in a matrix with the four oil cover categories from Table 5 (Section 4) to provide four surface oil categories (Table 6 in Section 4).

The **width** categories used in the SCAT method are:

• Wide	>6 m wide
• Medium	>3 m and ≤ 6 m
• Narrow	>0.5 m and ≤ 3 m
• Very Narrow	≤ 0.5 m wide or non-continuous oil band or area

The terms that are used to describe the **oil cover** are:

• Trace (T)	<1%
• Sporadic (S)	1 - 10%
• Patchy (P)	11 - 50%
• Broken (B)	51 - 90%
• Continuous (C)	91 - 100%

The **oil thickness** definitions are:

• Pooled or Thick	(PO)>1 cm thick
• Cover (CO)	≤1 cm and >0.1 cm thick
• Coat (CT)	≤0.1 cm and >0.01 cm thick; can be scratched off with a fingernail
• Stain (ST)	≤0.01 cm thick; cannot be scratched off easily
• Film (FL)	transparent or translucent film or sheen

The **character** of oil describes the degree of weathering, for example, fresh, mousse, tar balls or patties, tar coat, and asphalt. Definitions of each are:

- Fresh: unweathered
- Mousse: emulsified oil (water-in-oil emulsion)
- Mousse pattie: discrete patties ≤1.0 m - >0.1 m in diameter
- Tar ball: <0.1 m in diameter (usually)
- Tar coat: very weathered coating of tarry oil, with an almost solid consistency
- Surface oil residue: non-cohesive mixture of oil and surface sediments
- Asphalt pavement: cohesive mixture of weathered oil and sediment

B.4.2 Subsurface Oil

Subsurface oil is generally differentiated from surface oil as it requires a different approach during cleanup and because the two do not always occur together. Subsurface oil results from penetration through the beach surface or burial by natural processes. If the subsurface oil results from penetration, then removal of surface oil during cleanup or by natural cleansing can make detection or mapping of the associated subsurface component difficult. The character of the oil ranges from a translucent sheen to oil-filled pore spaces to an actual lens of asphalt, mousse or other viscous oil. On beaches which are characterized by sediments with large, open, pore spaces, such as well sorted cobble/boulder beaches, oil can penetrate relatively deeply into the beach, but to some extent can be remobilized by tidal flushing action. This is particularly true when large quantities of oil or low-viscosity fuels are involved. Characterization or classification of the oil is generally limited to the depth of penetration or location of the oiled interval and an indication of quantity or concentration.

The depth of penetration is expressed in centimetres measuring from the ground surface to the bottom of the oiled zone. If oil extends below the lower extent of the pit or excavation, a notation should be made to that effect. If a discrete lens of oil exists beneath the surface, then it should be quantified in terms of an interval by indicating depth to the top and the bottom of the lens as measured from the surface. The sketches in Figure 6 (Section 4) define where the measurements begin with respect to the subsurface oil. This is necessary to avoid discrepancies that may arise when the beach surface is very uneven, as commonly occurs when large clasts (cobble and boulders) are present.

The **character of subsurface oil** can be described by use of the following definitions:

• Asphalt (AP)	cohesive mixture of weathered oil and sediment, situated completely below the surface.
• OP	pore spaces are completely filled with oil, often resulting in oil flowing out of the sediments when disturbed.
• PP	partially-filled pores - pore spaces filled with oil but generally does not flow out when exposed or disturbed.
• OR/C:	cover (0.1 - 1.0 cm) or coat (0.01 - 0.1 cm) of oil residue on sediments and/or some pore spaces partially filled with oil making the matrix semi-cohesive.
• OR/S:	stain (<0.01 cm) or film oil residue on the sediment surfaces, non-cohesive.
• Trace (TR)	discontinuous film or spots of oil on sediments, or an odor or tackiness with no visible evidence of oil.

GEOMORPHOLOGY

APPENDIX C: COASTAL ENVIRONMENTS AND SHORELINE GEOMORPHOLOGY

C.1 GENERAL OVERVIEW

The Pacific coast accounts for 10.5 percent (25,717 km) of the total ocean coastline of Canada. The dominant characteristic of this region is a structurally-controlled coastline of mountains and fjords. Maximum elevations up to 4000 m in the coastal ranges and a complex shoreline of islands, inlets and fjords give this coast an irregular, rugged character. This is a west-facing coast, in a mid-latitude location and is exposed to waves generated in the North Pacific Ocean by the prevailing westerly winds. The exposed coast is a storm-wave environment, with a strong secondary swell component with high wave-energy levels throughout the year. In contrast to the exposed shorelines, wave-energy levels are very low in sheltered coastal areas.

Major reviews of physical shoreline characteristics (Clague and Bornhold, 1980) and of the physical oceanography (Thomson, 1981) provide an overall picture of the coastal zone. Detailed site-specific studies, especially in southern areas and in southern Vancouver Island, provide local detail and an understanding of processes and coastal dynamics in this region (Canada, 1974, 1975a, 1975b, 1976a, 1976b, 1976c, 1977, 1979; Eis and Craigdallie, 1980; Environment Canada, 1981; Hale and McCann, 1982; Harper, 1980a, 1980b, 1981; Holden, 1980; Howes and Harper, 1984; Krauel, 1980; McCann and Hale, 1980; Owens, 1979, 1980, 1981; Woodward-Clyde Consultants, 1982). Much of the remainder of this province, however, remains undocumented or unmapped in terms of the coastal character and of coastal processes. Specific studies have looked at deltaic processes in the fjords (e.g., Syvitski and MacDonald, 1982; Kostaschuk, and McCann, 1983; Kostaschuk, 1985; Prior and Bornhold, 1986) or at regional sea-level changes (Clague *et al.*, 1982) and regional information on intertidal ecology is provided by Carefoot (1977) and Snively (1978). Material for this section is taken, in part, from Owens (1977) and Harper and Owens (1983).

A regional inventory of shoreline types (Table 9) indicates that bedrock coasts are most common and comprise nearly 83 percent of the total shoreline length. Coastal sections with a combination of beaches and bedrock comprise an additional 8 percent,whereas only 6.5 percent is comprised exclusively of beaches. Other coastal landforms make up 1 percent or less of the total coast. The regional distribution of the landforms and coastal features is shown in Figures 23 and 24.

C.2 COASTAL ENVIRONMENT

C.2.1 Winds

The primary wind directions of this region are from the northwest in summer and from the southwest in winter. In addition to this distinct seasonal variation in direction, wind velocities are greater during winter months due to the regular passage of low-pressure systems through the region. There is considerable variability in local wind directions due to topographic effects in most fjords and valleys.

C.2.2 Waves

On the exposed coasts, the offshore annual significant wave height is 2.2 m and wave heights are greater than 3 m for 30 percent of the time in winter months, but for only 5 percent of the time in the summer months. Most of the wave-energy on the outer coast is in the form of long-period (up to 15 seconds) swell waves out of the west and the offshore annual significant wave period is 10.9 s. The seasonal variation in wave height and wave-energy levels is due to the greater intensity of the westerlies over the North Pacific Ocean during winter months. These higher wind velocities are caused by the increased pressure gradients between the low-pressure air mass over the Aleutians and the high-pressure system that is centered in the North Pacific. A secondary effect of this pressure difference in winter months is the generation of storm waves by winds associated with the cyclonic depressions that travel from west to east across the region.

TABLE 9. BRITISH COLUMBIA SHORELINE TYPES

	(a)	(b)	(c)	(d)	(e)	(f)
	British Columbia	**Strait of Juan de Fuca**	**Sooke Harbour**	**Saanich Peninsula**	**Saltspring Island**	**Queen Charlotte Islands**
BEDROCK						
rock cliffs	83	31	25	3	38	29
rock platforms		36	0	40	21.5	38
SEDIMENTS						
sand	14.5	11	4	30	0	4
mixed/gravel		19	44	14	33.5	21.5
tidal flats (sand-mud)	0.5	4	25	5	6	7.5
deltas	2	0	0	4	0	
ANTHROPOGENIC	4	4	2	4	1	0

Sources:
(a) Clague and Bornhold, 1980
(b) Owens, 1981
(c) Owens, 1981
(d) Howes and Harper, 1984
(e) Owens, 1980
(f) Groves et al., 1988

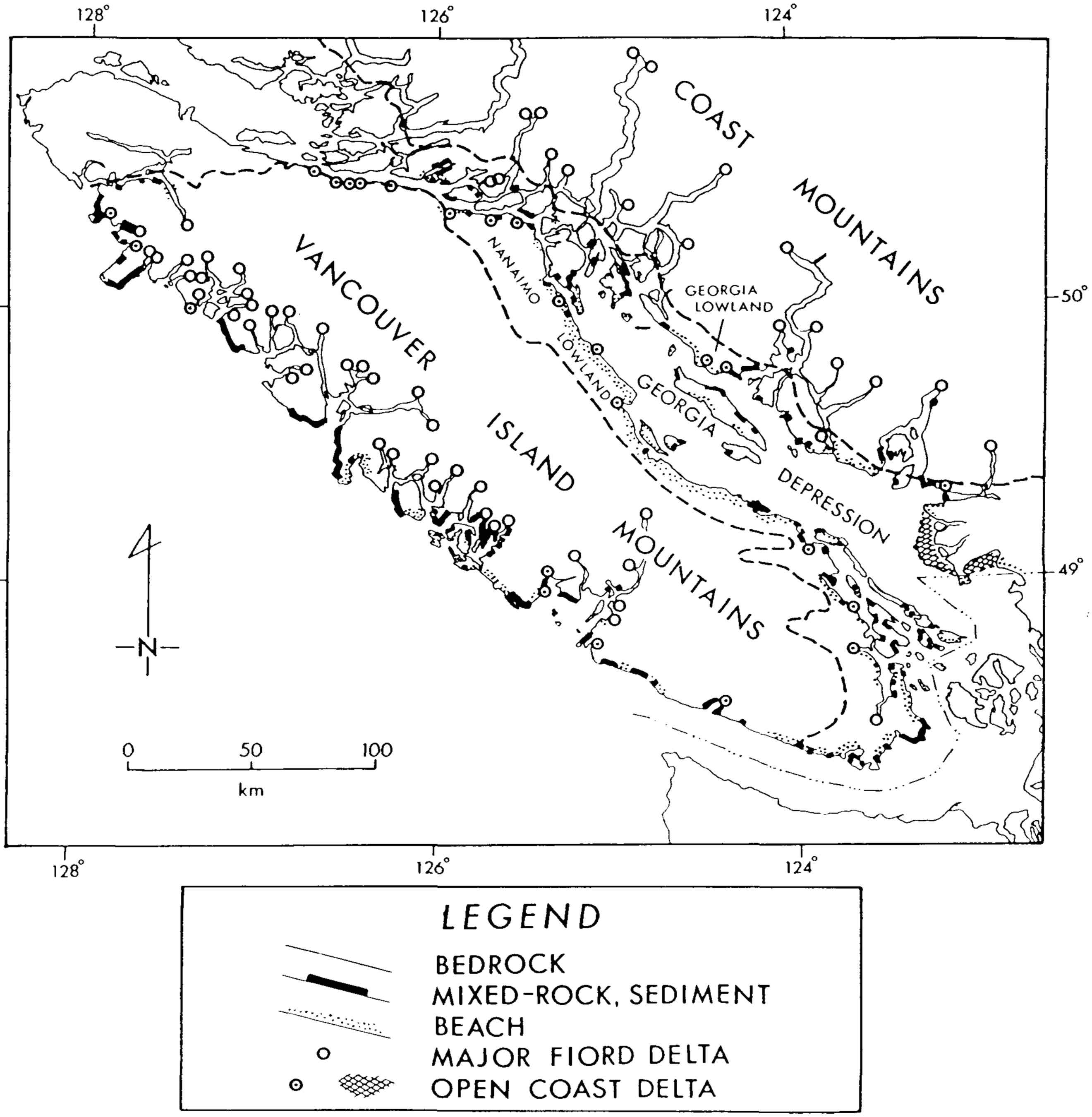


Figure 23. Shoreline Types of Vancouver Island and the Strait of Georgia (Clague and Bornhold, 1980)

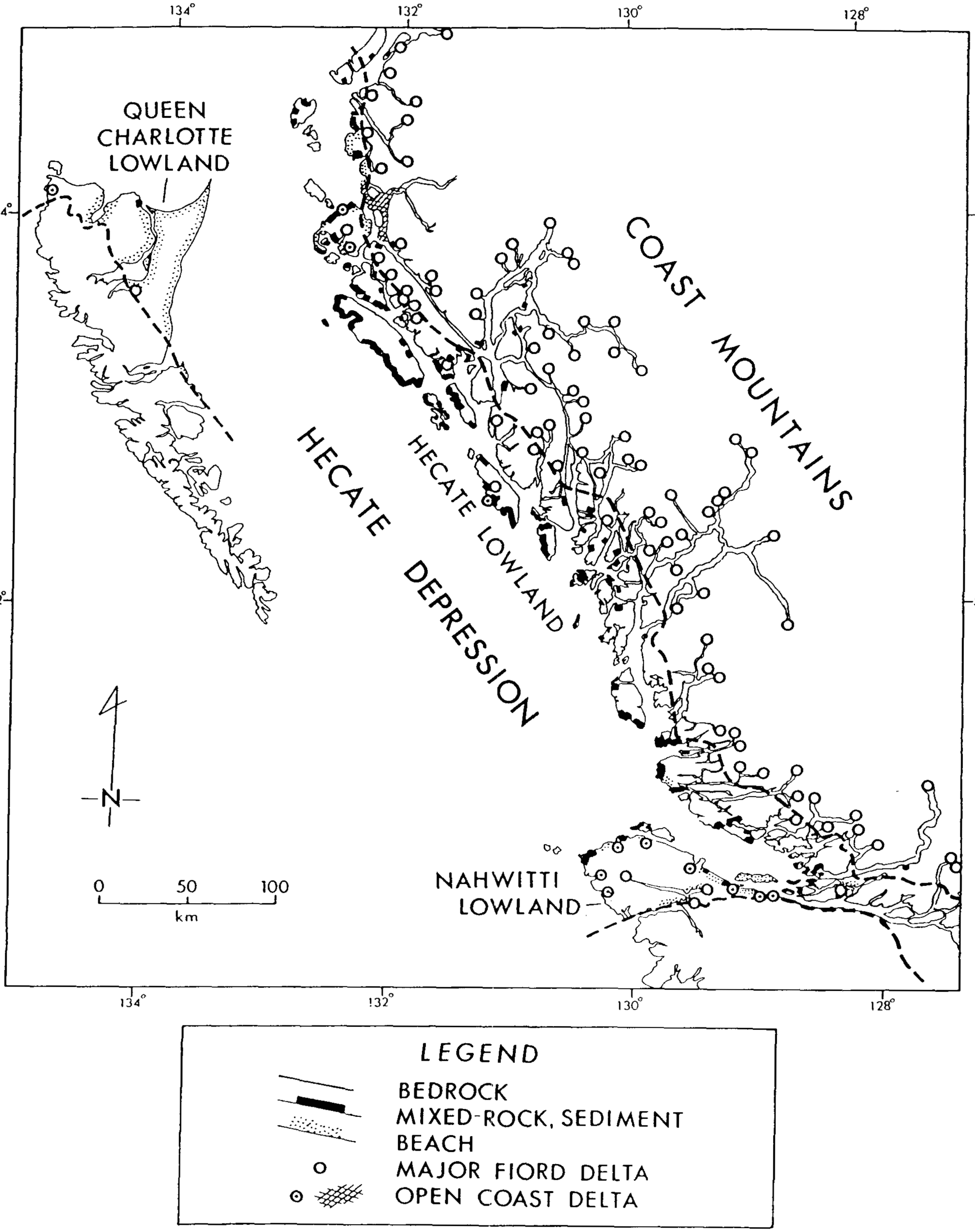


Figure 24. Shoreline Types of Queen Charlotte Sound (Clague and Bornhold, 1980)

In the sheltered coastal waters of Hecate Strait and the Strait of Georgia, waves are generated by local winds that approximately parallel these bodies of water. Annual significant wave height and wave period in this area are respectively 0.3 m (almost an order of magnitude lower than on the outer coast) and 3.5 s (MEDS, unpub. data). A seasonal difference is once again evident, associated with the increased frequency of storms in winter months. Wave heights greater than 3 m generally occur for 10 percent of the time in winter months, but for less than 5 percent of the time in summer months. Local wave-energy conditions are very variable, depending on fetch distances over which waves approaching a given section of shoreline can be generated.

C.2.3 Ice

Ice plays a very minor, virtually negligible, role in coastal processes in this region. Sea-water temperatures are always above freezing and ice forms only in inlets where inflowing fresh river water freezes.

C.2.4 Tides

The mean range of the semi-diurnal tides on this coast decreases from 5 m in northern areas to a minimum of 2 m near Victoria. A maximum range of 8.4 m has been recorded at Prince Rupert. An important effect of the tides is the generation of strong tidal currents in areas where the passage of water is constricted through narrow channels, for example, in Discovery Passage and the Seymour Narrows, at the northwest end of the Strait of Georgia. An additional characteristic of tidal currents in inlets is that the ebb frequently runs for longer, and is stronger than the flood current, due to the effects of freshwater discharge and this is particularly noticeable during the spring run-off period.

C.3 COASTAL GEOLOGY AND GEOMORPHOLOGY

C.3.1 Geology

In this Pacific coast region, resistant mountains up to 4000 m in height occur adjacent to the ocean. This mountain belt (the Cordillera) is part of a system that fringes the entire length of the eastern Pacific Ocean from Chile to Alaska. The Coast Range on the mainland is separated by the Hecate-Georgia Strait Depression from an insular range that rises to 1200 m on the Queen Charlotte Islands and to 2200 m on Vancouver Island. Seaward of the outer range, the sea floor drops off rapidly and the continental shelf is less than 50 km wide in most areas.

The structure of the Cordillera system runs northwest-southeast and this controls the primary trend of the coast. The rocks are predominantly resistant volcanics or intrusives with relatively few exposures of less resistant sedimentary rocks. The rock outcrops are only occasionally covered by glacial deposits and these are often thin and restricted in area, except on the coastal plains.

The mountainous coastal zone was considerably modified by the effects of ice during the Pleistocene. Glaciers developed on the Queen Charlotte Islands and on Vancouver Island as well as on the Coast Mountains. The rugged relief of the mountains and the formation of a fjord coastline result directly from erosion by these glaciers. Dixon Entrance, Hecate Strait, Queen Charlotte Sound, the Strait of Georgia and the Strait of Juan de Fuca have been modified by the scouring effects of the ice.

C.3.2 Coastal Geomorphology

The Pacific coast of Canada is divided into 6 environments on the basis of exposure to waves and on the geological character of the coastal zone (Figure 25 and Table 10). There exist many local variations in shoreline type due to the complex nature of this coast, but at this regional scale of discussion these are less significant than the general coastal characteristics.

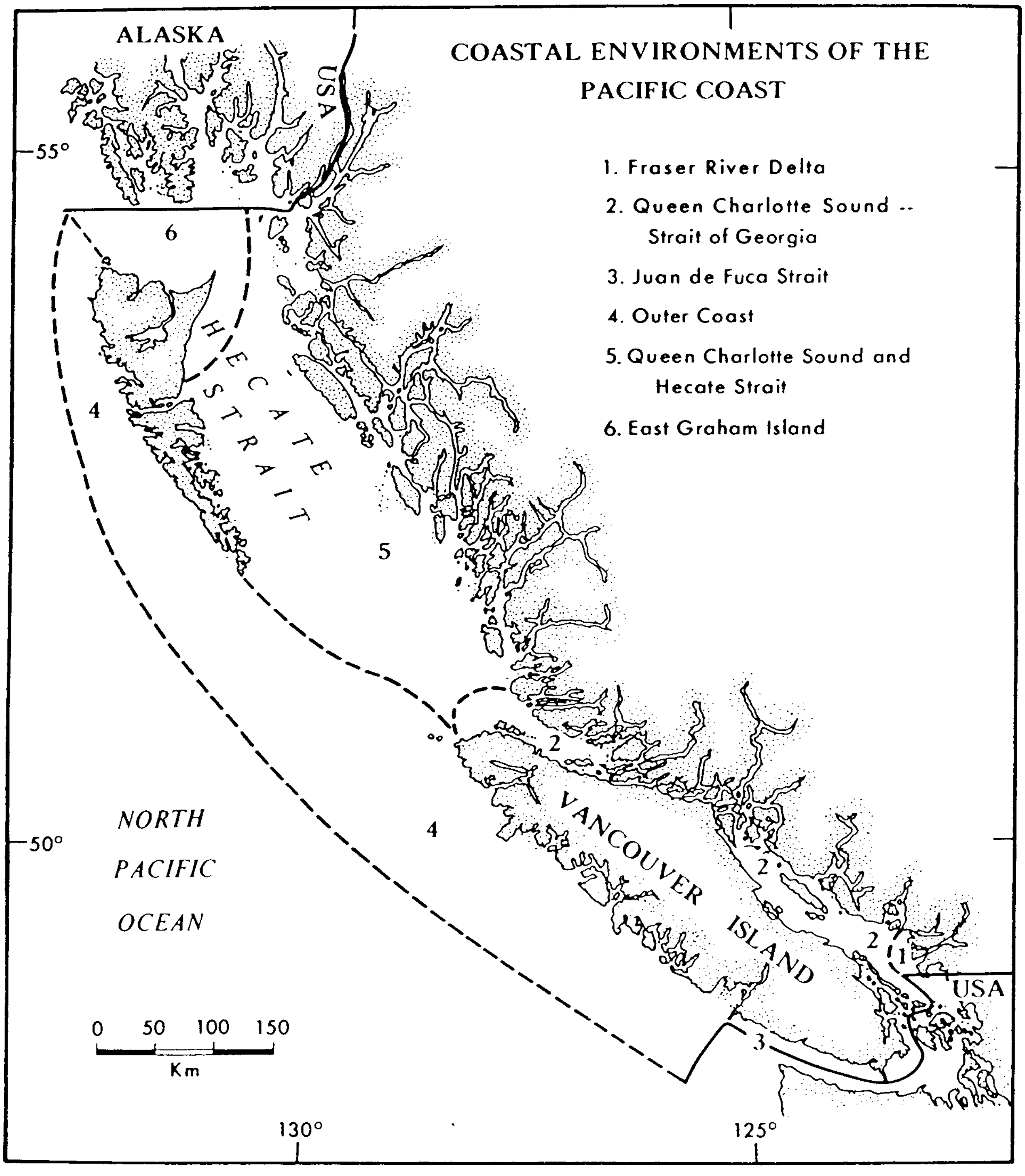


Figure 25. Coastal Environments of British Columbia (Owens, 1977)

TABLE 10. CHARACTER OF BRITISH COLUMBIA COASTAL ENVIRONMENTS

(Owens, 1977)

	GEOLOGICAL CHARACTER	COASTAL ZONE		FETCH AND WAVE EXPOSURE	MEAN TIDAL RANGE	SEDIMENT AVAILABILITY
		BACKSHORE RELIEF	BEACH CHARACTER			
1. Fraser River Delta	Unconsolidated fine-grained sediments; accumulation of river-borne material.	Low: marshes, usually dyked.	Flat intertidal zone of sand and mud up to 6 km wide at low tide: no beaches.	<50 km, very sheltered.	3 m	Very abundant.
2. Strait of Georgia	Resistant igneous rocks on mainland: volcanics and sedimentary rocks on Vancouver Is.	Low coastal plain backed by fjords cut into mountains: cliffs in less resistant rocks or glacial deposits	Absent or narrow, with pebble-cobble sediments: occur near glacial deposits on low-lying coasts.	Up to 200 km, outer coasts exposed, elsewhere very sheltered.	3 m	Scarce: some local concentrations.
3. Juan de Fuca Strait	Resistant lavas.	Low coastal plain: cliffs up to 10 m.	Pebble-cobble and narrow in east: absent or narrow in west: rock intertidal platforms.	Progressively more sheltered to the east: west shore very exposed.	2.5 m	Scarce: some local concentrations.
4. Outer Pacific Shore	Resistant volcanics or lavas.	Mountains or uplands incised by steep-sided fjords: narrow coastal plain on Vancouver Is.	Absent or narrow with pebble-cobble sediments: isolated wide sand beaches near eroding glacial deposits.	>1000 km, exposed very high energy; sheltered inner coastal zone.	3 m	Very scarce: a few local concentrations.
5. Queen Charlotte Sound and Hecate Strait	Resistant igneous rocks on mainland lavas or volcanics on Q. Charlotte Islands.	Coastal lowlands give way to mountains or uplands cut by fjords.	Absent or narrow with pebble-cobble sediments: deltas at heads of fjords.	300 km to >1000 km, exposed outer shore, sheltered inner coastal zone.	3 to 5 m	Very scarce: some local concentrations.
6. East Graham Island	Unconsolidated glacial drift or outwash sands and gravels.	Cliffs up to 100 m high: relief < 200 m.	Wide sand or sand/gravel beaches.	Up to 300 km, exposed.	3 to 5 m	Abundant.

The form of the Pacific region coastline is attributed primarily to the structural control exerted by the Cordilleran Mountain system and secondly to topographic modifications by erosion of an extensive system of fjords by the Pleistocene glaciers. The coastal zone is characterized by high relief, resistant rock outcrops and a general scarcity of sediments. Although the coasts are generally steep, wave-eroded sea cliffs are not common, the notable exceptions occurring on the west coast of Moresby Island (in the Queen Charlotte group) and on the east coast of Vancouver Island. The numerous fjords extend inland up to 110 km and give a very indented coastline. These fjords are typically U-shaped and result from the sea flooding into deep, narrow valleys that were eroded or deepened by the glaciers.

As the rock outcrops on the coast are predominantly resistant, little sediment is available for reworking by shoreline processes. Small deltas occur in sheltered areas at the heads of fjords (e.g., at Kitimat and Bella Coola) and two large prograding deltas have formed at the mouths of the Fraser and Skeena Rivers. A few extensive beach systems have developed at several locations, notably at Long Beach on the west coast of Vancouver Island and on the Argonaut Plain in northeast Graham Island, where local erosion of unresistant rocks or of glacial deposits has supplied sediment to the littoral zone. Other smaller beach systems have developed where sufficient amounts of sediment are provided by wave erosion and where there is a relatively shallow nearshore zone. A important feature along many sections of shoreline is the presence of logs at or near the high-tide level. In some sections these log accumulations are a major element of the shore-zone character.

C.4 INFLUENCE OF SHORELINE GEOLOGY AND PROCESSES ON CLEANUP

Cleanup operations can be influenced by the geology and physical processes of a shoreline in a variety of ways. Large boulders or rock outcrops in the lower intertidal or nearshore zones can restrict or prevent access of cleanup crews and/or equipment. This is also the case on wide intertidal or shallow subtidal areas which can limit access to all but very shallow draft boats. Large boulder/rubble beaches are sometimes difficult and often hazardous to traverse, particularly when wet or oily.

Oil can be trapped on bedrock and on coarse sediment beaches in cracks, crevices, and interstices, making removal and cleanup difficult. Oil can penetrate well-sorted cobble-boulder beaches, which also makes removal and cleanup a difficult task. Diesel and other fuel oils can become incorporated into fine-grained sediments on low-exposure beaches and persist for significant periods of time. Conversely, fine-grained beaches typically limit penetration of the heavier oils and permit easy access for crews but can present trafficability problems for heavy equipment. In summary, shoreline geology can influence cleanup operations in a number of ways and, as such, substrate type and geomorphology should be documented during the assessment program to assist planning and operations.

Shoreline or coastal processes can influence cleanup operations primarily by the burial or erosion of stranded oil. Oil that reaches the shorelines at the beginning of depositional cycles likely will be buried. This burial can result in a considerable increase in the level of effort required to recover the oil. Coastal processes clean a beach by exposing and eroding buried oil during subsequent erosional cycles. Increased wave activity over the winter also can remove substantial quantities of oil through abrasion during sediment reworking. Many shorelines along the BC coast have an armour layer of cobbles and/or boulders that often overlay fine-grained sediments. Stranded oil can be trapped between particles and protected from weathering processes by coarser surface sediments, leading to deeper than normal penetration. The armouring can continue to protect the oil even through winter storms when the surface armour may be reworked but the underlying oiled substrate is left relatively unaffected.

C.5 INFLUENCE OF CLEANUP ON SHORELINE GEOLOGY

Cleanup operations can influence shoreline geology through the potential long-term effects of sediment removal. Removal of large amounts of sediment can cause significant erosion of the backshore, especially on coarse-grained beaches, where there is little present-day supply of beach material to the coastal zone. In some of the more protected areas of the BC coast, large storm berms protect vegetation and, in a few locations, freshwater lagoons in low lying backshore areas. Sediment removal could destabilize the protective berms. Relocation of oiled storm-berm sediments to lower portions of the beach for natural reworking and cleansing does not result in a net loss of sediment and the consequent concern over destabilization.

Beach sediments absorb incoming wave energy and generally prevent waves from reaching the storm berms and backshore areas. Removal of large quantities of sediment can expose underlying bedrock which, in turn, does not absorb energy, allowing waves to run up farther on the beach. Previously protected storm berm backshore areas are then subject to direct wave action and erosional processes. Without the protective storm berms, many backshore vegetated areas could be exposed to salt water during high tides and storm activity. Log accumulations on the berm(s) often provide similar protection.

C.6 SHORELINE EXPOSURE CATEGORIES

The method used to estimate shoreline exposure to wave action or energy involves estimation of the fetch distance and fetch window. The fetch window is estimated using a compass to calculate the exposure, in degrees, of the shoreline to direct wave action from a point near the center of the segment. For example, if the segment is at the head of a bay facing the mouth, the fetch window would be the number of degrees, out of 360, of the arc between the two sides of the bay entrance. The fetch distance is simply the linear distance from the shoreline to the nearest landfall occupying a substantial portion of the fetch window. A relatively straight shoreline facing the open ocean would have a fetch window of 180° and fetch distance of > 50 km. The exposure is then categorized as low, medium or high based on the scheme provided in Table 11.

TABLE 11. WAVE EXPOSURE MATRIX

Fetch Distance	Fetch Window - Degrees			
	<45	45 - 120	121-180	>180
< 5 km	Low	Low	Low	Low
5 - 10 km	Low	Medium	Medium	Medium
10 - 50 km	Medium	Medium	High	High
> 50 km	High	High	High	High

SHORELINE ECOLOGY

APPENDIX D: SHORELINE ECOLOGY

D.1 GENERAL OVERVIEW

Several types of shorelines are found along the coast of British Columbia (Appendix C). The intertidal substrates range from vertical rock faces to horizontal bedrock reefs, boulder fields, cobble beaches, sand and gravel beaches, and mudflats. The major physical factors which determine the type of biotic community that develops on a given shoreline along the BC coast are the stability of the substrate and the degree of exposure to wave energy. In high wave-energy (exposed), stable substrate environments (i.e., bedrock, or large boulders), the main elements of the community are hardy plants and animals with the ability to cling to the substrate and withstand wave shock. Barnacles, mussels, one or two species of sea stars, fucoid algae (rockweed), a few other algae such as *Postelsia* (sea palm), *Endocladia*, and encrusting coralline algae, encrusting sponges, and a few species of limpets and chitons typically occur in these areas. Other, more delicate species (other sea stars, snails, anemones, crustaceans, and others) survive in this environment by sheltering among or beneath some of the dominant species, or within crevices or tide pools. Others live entirely in the supratidal or splash/spray zone, above the water line almost all of the time.

On high wave-energy (exposed) shorelines with unstable substrates (i.e., small boulders, cobbles, pebbles or sand), the epibiotic community is poorly developed, practically non-existent (except for micro-organisms), and the primary biota are burrowing animals (clams, sand crabs, worms) that can burrow deeply and rapidly.

The remaining shorelines found along the BC coast are either semi-exposed (moderate wave energy) or sheltered (low wave energy). The reduced wave action and scouring allows development of a more diverse community. Some of the same species that are dominant on exposed shores are also dominant in these environments, or are replaced by similar species, but there are generally more species of animals and plants found here. Some of the more obvious animals on rock substrates are acorn barnacles, mussels, periwinkles, turban snails, limpets, chitons, shore crabs, anemones, sea stars, and whelks. There are many species of smaller animals that nestle within mussel beds, among algae, beneath rocks, in crevices, and other sheltered places. Some animals (including fish, crabs, some sea stars, and sea otters) feed in the intertidal zone at high tide but are seldom seen there because they move down into the subtidal zone as the tide recedes.

The more obvious algae, besides rockweed, found in these lower energy environments are several species of kelp; leafy, filamentous, and encrusting red algae; and leafy or filamentous green algae.

On soft sediments (sand or mud flats) within sheltered areas, a thriving, mostly subterranean, community may be found. Burrowing animals include shrimp, crabs, clams, snails and many kinds of creatures loosely described as worms (e.g., polychaetes, oligochaetes, sipunculids, and echiuroids). On the surface in the low intertidal zone, beds of eelgrass, *Zostera marina*, a flowering plant, may be found, representing only the upper fringe of the more extensive subtidal beds. Other organisms in the zone may include leafy green or red algae, sea urchins, sand dollars, dungeness crabs, and snails. In the mid-intertidal zone, mussels, barnacles, rockweed and sea lettuce (*Ulva)* may be found attached to small isolated cobbles or pebbles, and mats of green or blue-green algae lie on the surface of soft sediments. In the uppermost intertidal or supratidal zones flowering marsh plants such as pickleweed occur, or (in brackish marshes) sedges, bullrushes, cattails, and other plants.

In addition to wave energy, other physical factors that influence intertidal organisms include air temperature, water temperature (in pools), desiccation, light, tidal exposure (amount of time covered or uncovered by water), salinity and battering by logs and other floating objects. Often it is the occasional extremes of some of these factors, rather than average daily fluctuations, that have the greatest effects on the distribution and abundance of intertidal organisms. For example, salinity may be most important with extremes resulting from heavy rainfall or snow melt runoff, or as a result of evaporation in small pools on a hot day. Likewise, air temperature extremes on hot days or in sub-freezing periods may kill large numbers of organisms.

Intertidal populations typically display "dominant year classes," (i.e., even-aged cohorts representing recruitment occurring in certain years), where such cohorts contain far more individuals than cohorts representing other years. For example, a mussel population may contain large numbers of 2, 5, and 10 year old individuals, with other age groups represented by few individuals, or none at all. These dominant year classes may result from different events occurring in different years, e.g., a mild winter coupled with high spring productivity in nearshore waters may lead to heavy reproduction in summer or fall, followed by massive settlement of new recruits, "swamping" the predators that feed on them, such that a high proportion of the recruits survive their first year, when predation is greatest. In another year, a severe winter may cause massive mortality in sessile organisms such as mussels and barnacles while sparing the mobile predators (starfish and whelks) that migrate down into the subtidal zone in winter to avoid harsh weather. With fewer prey to feed on in the following spring and summer, these predators may then exert a proportionately greater effect on the remaining prey or on new recruits of prey species.

Sometimes an entire year class or population of mussels or barnacles may be eliminated by their predators in one summer, or sometimes by desiccation in a few hot days occurring during spring tides. Without an adequate historical record or a good understanding of intertidal ecology, casual observers often assume various unfounded explanations for missing year classes. If missing year classes or reduced populations of some species are observed following an oil spill, the oil is typically presumed to be the cause, justifiably or not, in the absence of other information.

In general, intertidal organisms have evolved adaptations enabling them to tolerate a variety of physical stresses to which they are exposed in the constantly changing environment that characterizes the intertidal zone. Since most intertidal organisms evolved from marine ancestors, the main adaptations involve exposure to air and to wave shock. Organisms that live higher on the shore can generally better withstand desiccation, high temperature, and ultraviolet light than those species typically found lower on the shore.

Adaptations may be either morphological or behavioural. For example, barnacles and mussels close their valves tightly to hold in water at low tide, whereas littorinid snails secrete a water-tight layer of cement around themselves as the rock dries out to hold in their water until the tide rises. Some limpets and chitons raise their shells above the substrate in a way that expands their mantle cavity, allowing them to hold a quantity of water around their bodies. Other animals such as sea stars and crabs simply move down the shore with the falling tide, or hide in damp crevices. Some algae (e.g., *Fucus* and *Endocladia*) may lose a large proportion of their water through evaporation during a low tide on a warm or windy day, becoming brittle and seemingly lifeless, yet rapidly absorb water and resume photosynthesis as soon as the rising tide covers them. Other algae (e.g. *Ulva*) die after such treatment.

It is now a generally accepted principle among marine ecologists that the upper limits of the distributions of intertidal organisms are usually determined by their abilities to tolerate stressful physical conditions (mainly desiccation, high temperature, and ultraviolet light), whereas the lower limits are usually set by biotic interactions, i.e., competition for space, food, or other resources, or by predation. The physical conditions are generally more benign and stable lower on the shore, and for most species the supply of food or essential nutrients is also better lower on the shore. Many researchers have transplanted upper intertidal species to the lower intertidal or subtidal zones, with the nearly invariable result that, as long as the transplanted organisms are protected from grazing, predation, or competition (by cages, barriers, or removal of grazers, predators or competitors), their growth rates and reproductive outputs are greater than for control groups left at their original location higher on the shore.

It follows from the discussion above that many of the organisms observed in the intertidal zone live in less than ideal circumstances in terms of food or physical conditions, but would be subject to greater mortality through predation or competition if they chose to live lower on the shore. In fact, often what one observes on the shore is that which is left after heavy mortality (from other organisms low on the shore) and from harsh weather. The survivors are vertically stratified ("zonation") by a combination of their differing abilities to tolerate physical stresses from above and biotic stresses from below.

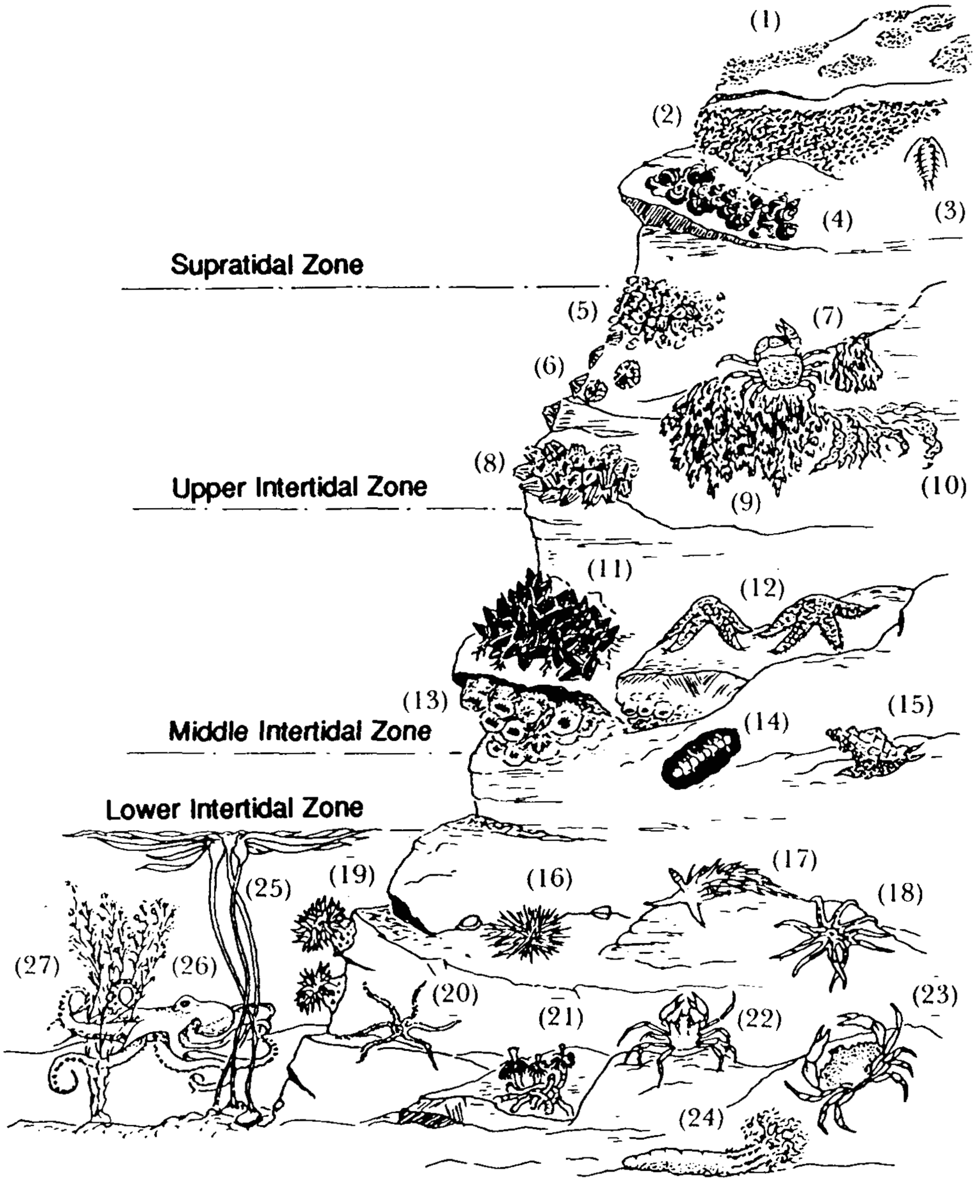
Many mobile animals, both predators and herbivores, move lower on the shore in winter in response to freezing air temperatures and increased intensity and frequency of storms, with attendant scouring and wave shock. With reduced water temperatures in winter, predators such as sea stars are less active and eat less often, so the lower shore becomes a safer haven for some of their prey. Even so, the winter is generally a period of relatively high mortality for intertidal plants and animals, and one typically observes reduced numbers of adults of most species in spring.

The intertidal community consists of many species with complex and often indirect interactions among them and with different requirements, life histories and reproductive strategies, all being affected in various ways by random climatic and oceanic events. The result is that, at any one time, shorelines in a region may show a mosaic of communities in different stages of development. A one-time snapshot view of a particular site may give a very misleading idea of the mixture of species and abundances that more accurately represent the intertidal community for that region. It is only by studying many sites over long periods of time that ecologists have been able to achieve understanding of the major forces and interactions that determine the structure of intertidal communities.

In view of the above discussion, the most successful approach to an assessment of the impacts of an event, such as an oil spill, is to focus attention on a few of the more important members of the intertidal community. One species may be considered more important than others by virtue of its greater numbers or area occupied, its predictable recruitment of large numbers of offspring, its provision of essential shelter or food for other species, or by being a "keystone" species (one whose activities have a disproportionately large effect, relative to its abundance, on the rest of the community). It is also generally preferable to focus on species representing different trophic levels within the community; these species may include primary producers (algae), herbivores (limpets, chitons, littorines), sessile filter feeders (barnacles, mussels) and carnivores (starfish, whelks, sea otters).

D.2 PREDOMINANT ECOLOGICAL CHARACTERISTICS OF THE BC COAST

Some of the predominant intertidal species of plants and animals found along the BC coast have been mentioned above but are discussed in more detail in this section based on their locations relative to the intertidal zone. A diagram summarizing the location of predominant species within the intertidal zone on a rock shoreline is provided in Figure 26. The diagram is intended as an idealized representation of a vertical shoreline and does not account for seasonal changes; for instance, the littorinid snails and many of the limpets, chitons, and sea stars depicted would be



Cross-section showing vertical zonation on a rocky shore. (1) Lichens; (2) Blue-green Algae; (3) Rock Louse; (4) Periwinkles; (5) Small Acorn Barnacles; (6) Finger Limpets; (7) Rock Crab; (8) Common Acorn Barnacles; (9) Rockweed; (10) Sea Lettuce; (11) Blue Mussels; (12) Purple or Ochre Sea Stars; (13) Aggregate Anemones; (14) Black Chiton; (15) Wrinkled Whelk; (16) Red Sea Urchin; (17) Opalescent Nudibranch; (18) Sun Star; (19) Giant Green Sea Anemone; (20) Brittle Star; (21) Calcareous Tube Worm; (22) Kelp Crab; (23) Red Rock Crab; (24) Orange Sea Cucumber; (25) Bull Kelp; (26) Octopus; (27) Sargassum.

Figure 26. Intertidal Zonation - Rock Shore (Snively 1978)

found in lower zones during winter months than those shown in the diagram. No attempt is made to assign elevation limits to the tidal zones, because the elevations corresponding to the biotic zones change from site to site within small areas, depending on shoreline morphology, aspect, season, and many other factors (see Carefoot, 1977 for a review of the many attempts to define intertidal zonation by tidal elevation). Instead, the region between the mean high tide level and the lowest low tides of the year will simply be divided roughly into thirds, which are referred to as the upper, middle, and lower intertidal zones. A transitional zone between the terrestrial environment and the upper intertidal zone is called the supratidal zone, and all of the permanently submerged area below the low intertidal zone is called the subtidal zone.

D.2.1 Supratidal Zone

The supratidal zone (also called "spray" or "splash" zone) is the area above the mean high tides that is frequently wetted by wave spray or mist. This zone is not inundated except during high spring tides or storm surges. Terrestrial plants often invade this zone during summer, but are killed by winter storm waves. The most obvious feature of the supratidal zone on rock shorelines in British Columbia often is a band of black lichen (*Verrucaria* sp.), which is easily confused with stranded oil by casual observers. The morphology of the band can often be used in differentiating between *Verrucaria* and oil. Bands of oil tend to have sharp straight upper boundaries whereas *Verrucaria* bands have sharp, straight lower boundaries. Where there is freshwater seepage from above, a filamentous green alga (*Enteromorpha intestinalis*) may extend from the intertidal zone to many metres above. Few marine animals occupy the supratidal zone; prominent among those that do are the acorn barnacles (*Balanus glandula* and *Chthamalus dalli*), herbivorous snails including periwinkles (*Littorina sitkana* and *L. scutulata*) and two species of limpets (*Collisella digitalis* and, under overhangs or boulders, *Notoacmea persona*), and a large isopod or rocklouse (*Ligia Pallasii*) which resembles a cockroach.

D.2.2 Upper Intertidal Zone

This zone is characterized by relatively long periods of exposure to air and shorter periods of inundation. Most of the species mentioned above that are found in the supratidal zone on rock shorelines also occur in the upper intertidal zone. On exposed coasts (e.g., the west coast of Vancouver Island) additional species of algae that are typical of the upper intertidal zone include the red algae *Endocladia muricata, Gigartina papillata* (and its encrusting phase, formerly known as *Petrocellis*, which resembles a spot of tar), *Iridaea cornucopiae*, and the encrusting *Hildenbrandia* sp. Rockweed (*Fucus distichus*) and a smaller form of rockweed (*Pelvetiopsis limitata*) are representatives of the brown algae in this zone. Common green algae are *Cladophora* sp. and *Urospora* sp., both of which resemble green hair. Most of the species that are common on exposed coasts also occur on more sheltered coasts, e.g., within the Strait of Georgia (*Pelvetiopsis* is an exception), and additional algal species include *Porphyra* sp. (the edible leafy red alga used in wrapping sushi), *Ralfsia*, *Scytosiphon* sp., and sea lettuce (*Ulva* sp.).

Animals of the upper intertidal zone on exposed rock shores, in addition to the acorn barnacles, periwinkles, and limpets found in the supratidal zone, include the black turban snail (*Tegula funebralis*), three more forms of limpets (*Collisella paradigitalis*, *C. pelta*, and *Notoacmea scutum*), predatory whelks (*Nucella emarginata* and *M. canaliculata*), and the lined shore crab (*Pachygrapsus crassipes*). With the exception of *Tegula*, the same species are also common on more sheltered shores.

D.2.3 Middle Intertidal Zone

Algae typical of this zone in both exposed and semi-exposed areas include several species of sea lettuce (*Ulva* spp.), red algae such as *Gigartina* spp., *Microcladia* sp., *Halosaccion glankiforme*, and brown algae including *Fucus distichus*, *Hedophyllum sessile*, *Scytosiphon* sp., and *Leathesia difformis*. The sea palm (*Postelsia palmaeformis*) occurs only on exposed shores.

Dense beds of the California mussel (*Mytilus californianus*) and associated clumps of gooseneck barnacles (*Pollicipes polymerus*) are typical of the middle intertidal zone on the open coast, although both of these species may also occur in semi-exposed areas that have moderate wave action. In quieter areas and in estuaries with occasionally reduced salinity, the California mussel is displaced by the "blue" or bay mussel (*Mytilus edulis*). Careful dissection of mussel beds reveals numerous species of small crustaceans, sea cucumbers, molluscs, worms, and other animals nestled among the mussels, along with juveniles of some of the larger species of limpets, starfish, crabs, and other animals.

A large species of acorn barnacle (*Semibalanus cariosus*) occurs in this zone, often in dense patches that may include some large specimens of *Balanus glandula*. Predators that specialize in eating mussels and barnacles include the two whelks mentioned above, plus a larger whelk (*Nucella lamellosa*), and the sea stars *Pisaster ochraceus* and *Leptasterias hexactis*. (*Pisaster* are the large, stiff, usually purple or orange sea stars often seen clustered in crevices in middle or lower zones. *Leptasterias* are small six-rayed stars usually hidden beneath boulders). Another whelk found in this zone is *Seariesia dira*, which preys on a variety of species and also scavenges dead or injured animals. A large black chiton (*Katharina tunicta*) may be abundant in this zone, especially in tidepools and in beds of *Hedophyllum*. The shore crab *Hemigrapsus nudus* occurs beneath boulders, occasionally on the open coast, but more abundantly in more sheltered areas. Another shore crab (*H. oregonensis*) is abundant under rocks in more sheltered areas, and also makes burrows in mid-intertidal mud flats and channel banks in salt marshes. Sea anemones (*Anthopleura* spp. and *Tealia* spp.) occur in pools and crevices in this zone as well as lower on the shore.

D.2.4 Lower Intertidal Zone

This zone is characterized by long periods of submersion and shorter periods of exposure to air. As such, it is a more benign environment for marine organisms, similar to the constantly submerged subtidal zone, and is accordingly occupied by a much greater variety of species than the zones discussed above. The distinction between exposed shorelines and semi-exposed or sheltered shorelines becomes less significant in this zone. Many of the species found in the middle intertidal zone have vertical ranges that overlap with the lower zone. Also, some of the mobile animals make diurnal or seasonal migrations between the zones, as discussed previously.

Algae typically dominate most of the substrate in the lower intertidal zone. Large brown algae occur here, particularly kelps such as *Laminaria* spp., *Costaria* *costata*, *Agarum* sp., *Egregia mensiesii*, and the bull kelp *Nereocystis luetkeana*. Other genera of brown algae found here include *Desmaristis, Cystoseira, Alaria*, and *Pterygophora*. A great variety of red algae occur here, many in the same genera as described for the middle zone, plus several species of coralline red algae, which are species with tissues hardened by calcium carbonate. Corallines are usually pink or purple and may be erect and articulated (*Corallina, Bossiella, Calliarthron*), or flat and crustose (*Lithothamnion*). Prominent green algae of the lower zone are sea lettuce (*Ulva* spp.) and "dead man's fingers" (*Codium fragile*). Flowering sea grasses (*Phyllospadix scouleri* and *Zostera marina*) may occur here, the former on exposed shores and the latter in sheltered areas.

A bewildering variety of animal species may be found in the lower intertidal zone on rock shorelines. In addition to *Pisaster* and *Leptasterias*, several more species of sea stars are prominent residents of the lower intertidal zone, including the leather star (*Dermasterias imbricata*), the sun star (*Solaster stimpsoni*), the huge sunflower star (*Pycnopodia helianthoides*), the blood star (*Henricia leviuscula*), and *Evasterias troschillii*. Other echinoderms in this zone are sea urchins (*Strongylocentrotus droebachiensis, S. franciscanus, and S. purpuratus*), and several species of sea cucumbers and brittle stars.

Sessile animals of the lower intertidal zone include sponges, anemones (all the species from the middle intertidal zone, plus several more), bryozoans, hydroids, ascidians, and barnacles (*Semibalanus cariosus*). Molluscan grazers include chitons (*Katharina, Tonicella*, several species of *Mopalia*, and the gumboot *Cryptochiton stelleri*), limpets (*Notoacmea scutum, Acmaea mitra, Diodora aspera*) and snails of the genera *Margarites, Homalopoma*, and *Calliostoma*. Predators of the lower intertidal zone, in addition to sea stars and *Nucella lamellosa*, include several large whelks and other snails such as *Fusitriton, Ceratostoma, and Ocenebra*, crabs (*Cancer productus, Pugettia producta*), sea slugs, octopi, polychaetes, nemerteans, flatworms, and numerous fishes that either reside intertidally (clingfishes, sculpins, gunnels, pricklebacks) or enter to feed at high tide, then leave as the tide recedes.

D.2.5 Soft-bottom Bays, Lagoons, and Estuaries

Zonation is not as readily apparent in this type of habitat as it is in rocky areas. A typical lagoon or mudflat area has a central channel or pond area, which may be subtidal or intertidal, and which is the main pathway for water entering or leaving the lagoon as the tide rises and falls. Sediments near the mouth where water movement is greatest are likely to be sandy, whereas finer silts and muds predominate where there is less active water movement. Lagoons and estuaries are seasonally important feeding grounds for many benthic fishes (especially sharks, rays, and skates) and are used as nursery areas for many nearshore fishes, including commercially important flatfishes and others.

Beds of eelgrass (*Zostera marina*) may be extensive in lower intertidal and subtidal areas, on either sand or mud bottoms. The eelgrass provides a vertical dimension to the otherwise flat, featureless bottom, allowing a variety of invertebrates, epiphytic plants, and fishes to live on or among the blades and rhizomes. Sand dollars (*Dendraster excentricus*) and juvenile dungeness crabs (*Cancer magister*) may be abundant within eelgrass beds. Eelgrass is also an important food for many grazing invertebrates and for some migratory waterfowl, particularly brant.

Eelgrass usually dies off in winter, and regrowth occurs mainly from the root-like rhizomes, which persist. Many invertebrates (shrimp, snails, sea slugs, and others) have reproductive cycles that are closely linked to the seasonal cycles of the eelgrass. The dead eelgrass is itself a crucial component of the detritus in lagoons and estuaries, providing nutrition for many infaunal and epibenthic animals (filter- and deposit-feeding clams, mussels, worms, shrimp, etc.), and eelgrass-derived nutrients exported from lagoons and estuaries may be important components of the nutrient base for primary producers (algae) in nearshore waters of the open sea. Sea lettuce (*Ulva* spp.) and *Enteromorpha* sp. (another leafy green alga) may also be seasonally abundant in lower intertidal and subtidal zones of lagoons and estuaries.

Above the eelgrass zone there is often a wide area of intertidal mud or sandflat, corresponding roughly to middle or higher intertidal zones, as defined for rock shorelines. In this zone there may be no topographic relief and no attached algae other than a film or mat comprised of a mixture of diatoms, green and blue-green algae . Beneath the sediment surface, however, may be a rich infaunal community of invertebrates, especially clams, snails, shrimp, polychaete worms, sipunculids, and echiuroids.

The supratidal zone may also have a seasonally abundant surface film or mat comprised of a mixture of green and blue-green algae and diatoms, but stands of pickleweed (*Salicornia* sp.), a flowering plant, may also occur here. In brackish marshes other flowering plants usually associated with freshwater marshes may be found, including bullrushes, cattails, and sedges.

D.3 EFFECTS OF OIL AND CLEANUP ACTIVITIES ON INTERTIDAL ECOLOGY

From an ecological perspective, exposed high wave-energy shorelines often experience relatively minor impacts from oil spills due to the significant natural cleaning from wave action and to the resilient nature of the biota. Wave refraction from cliffs and rock outcrops also tends to prevent oil from contacting these shorelines. In the case of unstable, high wave-energy beaches, there are few biota in the area to become impacted.

For sheltered, low wave-energy beaches, evidence suggests that cleanup may not be environmentally beneficial even when using techniques considered to be less destructive. To date, large-scale studies of major spills (i.e., the Santa Barbara Channel well blowout in 1969, the "Amoco Cadiz" spill off France in 1978, and the "Ixtoc I" well blowout off Mexico in the Bay of Campeche in 1979) have all shown that, with or without cleanup, long-term environmental damage to intertidal areas has been minimal or non-existent. Large numbers of sessile plants and animals may be killed, usually in the early stages of a spill, by suffocation or direct toxicity, but large annual, seasonal and spatial variability in these populations is the rule, and most species have the ability to re-colonize denuded shores. Additionally, bare space for larval settlement is usually a resource in short supply. Species that do not have planktonic larval stages (i.e., certain starfish and crustaceans that brood their young, and snails that lay eggs which develop directly into miniature adults) are potentially more vulnerable to spilled oil due to the longer time required for recolonization of an area from which they have been eliminated. However, these are generally mobile animals that spend most of their time lower on the shore than the sessile species and that are capable, to some extent, of avoiding spilled oil by moving away from it.

High pressure washing, excavation of sediments, cutting oiled algae, overturning cobbles and boulders, and human traffic that accompany these cleanup activities all cause mortality of intertidal organisms. This mortality is in addition to effects resulting from the spilled oil itself and, in some instances, may actually delay the restoration of pre-spill ecological conditions.

Lagoons, estuaries, and salt marshes are generally considered to be more vulnerable to impacts from spilled oil and cleanup efforts than more exposed shorelines. The absence of wave action means that stranded oil may persist for a long time, especially if it becomes buried in the soft sediments. Plant detritus, in addition to being an important production pathway for fishes and many other organisms, may be an important agent by which oil is retained in these areas. Adverse impacts on marsh plants may destabilize channel banks and creek morphology, which could affect utilization of these areas by important fishery species (Kennedy, 1982). Once oil becomes incorporated in intertidal sediments in marshes and lagoons it is very difficult to remove without causing significant destruction to the intertidal community, and it may be better to leave it alone. The best strategy commonly is to devote the greatest effort to preventing oil from entering these areas, by using booms, skimmers, and other technology, including use of dispersants, before oil reaches the mouth of an estuary or lagoon.

D.4 INFLUENCE OF ECOLOGICAL CONSIDERATIONS ON CLEANUP

Cleanup operations can be affected by ecological considerations in several ways including a determination that the cleanup may prove more environmentally damaging than the no action alternative. In some cases, less efficient but more environmentally acceptable techniques may be required. Time constraints for environmental sensitivities are the primary factor in establishing cleanup priorities. In these areas, there are often critical dates in the reproductive or behavioural cycles of key species. Also, stable substrata (cliffs and bedrock reefs) are often associated with nearby colonies of nesting seabirds or nesting sea lions that are easily disturbed and whose reproductive success may be harmed by nearby human activity. In addition, most ecological considerations are related to protection of the lower intertidal zone which is typically less affected by the oil because the zone is exposed for a shorter time than higher zones, tends to remain wet, and is commonly coated by a slippery film of algae and bacteria serving to minimize the adhesion of oil. Generally, constraints are imposed which require that cleanup be conducted only at mid-tide levels or above when the healthy and/or previously unaffected lower intertidal zone is under water. This constraint is more likely to be imposed in areas where the lower intertidal zone has particularly rich flora and fauna.

ARCHAEOLOGY

E.1 GENERAL OVERVIEW

Archaeological sites located in the intertidal zone and adjacent backshore ("near upland") may be at risk following an oil spill. Sites may be disturbed directly as oil comes ashore or by treatment activity designed to clean sections of the oiled shoreline. Available information on cultural resource sites can be compiled and evaluated prior to an incident (Dickens, et.al., 1990; Wainwright et. al., 1992). If this compilation has not been completed for an oiled area, the initial onshore response effort may be delayed as these tasks would have to be performed before any onshore activity can be initiated. This requirement applies also to the physical and biological components of the SCAT program.

A full range of cultural resources typical of coastal environments are present along the BC shoreline; however, most areas of coastal BC have not been surveyed systematically, resulting in perhaps thousands of archaeological sites that remain undocumented. Published and unpublished reports are available for much of coastal BC, but detailed information on specific sites by region is variable. These reports, however, are centralized and available through the Archaeology Branch, Government of British Columbia.

Important site survey, protection, and monitoring procedures have been established in response to the *Exxon Valdez* oil spill in Prince William Sound and the Gulf of Alaska (Mobley and Haggarty 1989; Mobley et al 1990; Haggarty et al 1991; Betts et al 1991; Haggarty and Wooley 1992). These procedures would form a baseline response for the protection of cultural resources in the event of an oil spill along the British Columbia coast. A system of site type codes, similar to that developed for sites for the *Exxon Valdez* project, would have to be developed for the BC coast so that site information can be entered in abbreviated form on the CRE form and protected during the review process. The purpose of site codes is make review committees aware of the presence of sensitive cultural resources in the segment without releasing specific information about either the type of resource present or its location.

Provincial and Federal (pending) laws, enacted to protect cultural resources, require that qualified professional archaeologists be employed to ensure that cultural resources are protected during an oil spill emergency. Laws that require the protection and conservation of cultural resources exist in Canada and the United States and, despite national and regional variation, are similar in scope and intent.

In British Columbia, archaeological and paleontological resources are protected and conserved under the provincial **Heritage Conservation Act** (1979 R.S.B.C., Chapter 165). The provisions of the Act apply to archaeological sites located on private as well as public lands. Sites are protected through designation as "Provincial heritage sites" (section 4), or simply by virtue of being of particular historic or archaeological value (section 6). Protected sites may not be "destroyed, excavated, or altered without a permit issued by the Minister or his designate". The Act empowers (section 7) the Minister to order a "site survey" or a "site investigation" if an archaeological site is thought to be at risk from a proposed development or other land-altering activity. Site surveys are designed to assess the archaeological significance of land or other property and to determine the presence of archaeological sites already protected or which warrant protection under the Act. Site-specific investigations are designed to recover archaeological information which might otherwise be lost due to pending site alteration or destruction from natural or human agencies.

Federal legislation in Canada is currently in the consultation draft stage. The **Proposed Act Respecting the Protection of the Archaeological Heritage of Canada** applies to all lands owned by the Government of Canada and is intended to protect archaeological resources from being destroyed or illegally exported. In addition, the proposed legislation would ensure that all burial sites are protected and that human remains would be treated with dignity and respect, shipwrecks could be protected as soon as five years after their loss or abandonment, Crown ownership of archaeological artifacts and scientific specimens would be clearly defined, and that a permit system with the necessary regulations, guidelines and procedures would be implemented to ensure that archaeological projects would have technical and scientific merit. This legislation would greatly enhance the protection of cultural resources throughout Canada.

E.2 IDENTIFICATION AND CHARACTERISTICS OF RESOURCES

The identification and documentation of archaeological sites in a coastal environment requires training and experience different from inland environments. Knowledge of coastal cultures, particularly the range of adaptive strategies employed to exploit seasonally-available resources, is an essential component of the site discovery process. This type of knowledge is enhanced by direct experience; walking a wide range of shorelines, from exposed outer coast areas to sheltered inner coast environments.

The key to understanding past occupation and use of a particular coastal landscape is the intertidal zone. As human groups occupy and use sections of shoreline to exploit marine resources, these activities leave traces in both the intertidal zone and the near uplands. Sections of shoreline need to be "read" by examining first the intertidal zone for signs of access to the near uplands and then the tree fringe for signs of occupation and use. In the intertidal zone, modification may take the form of clearing areas or "runs" for canoe or kayak access. Stream channels and small embayments are examined for evidence of fish trap structures, wooden stakes or stone wall fish traps. In the near uplands, surface and subsurface deposits indicative of permanent settlements or seasonal camps can be observed. Caves and rock shelters are examined for evidence of use as habitation places and burial places. Rock outcrops and boulders are checked for rock art, either petroglyphs (rock carvings) or pictographs (rock paintings).

E.3 PREDOMINANT COASTAL CULTURAL RESOURCE TYPES

Known Resources in British Columbia. Significant cultural resources located along the BC coast include:

- places where people lived or camped in the past;
- subsurface cultural deposits, such as shell or refuse middens, typically found in and around a settlement or camping place. These deposits generally consist of whole or fragmentary shell remains; mammal, bird, and fish bone; artifacts, complete or fragmentary; features, such as hearths, post molds, etc.; charcoal; fire-cracked rock; etc.

- standing or collapsed structures or ruins, such as house remains, totem poles, cabins, mining structures, homesteads, shipwrecks, etc.;
- rock art, fish trap, culturally-modified tree sites;
- marked or unmarked graves which may be Native or non-native in origin; and
- complete or fragmentary artifacts used for fishing, hunting, and gathering activities and typically made of stone, ivory, bone, shell, wood, or metal.

The wide range of archaeological site types known from coastal environments has been condensed into nine categories: six Native (Table 12) and three non-Native (Table 13) cultural resource categories.

TABLE 12. NATIVE CULTURAL RESOURCES CATEGORIES

Category	Description
General Activity:	Commonly referred to as shell middens, these sites are characterized by the presence of molluscan remains and usually contain mammal, bird, and fish bone; artifacts; features; charcoal; fire-cracked rock; etc. Included in this category are settlement or "village" sites and camp sites. These sites normally occur in the tree fringe.
Fish Trap:	Fish trap sites, usually located in the intertidal zone, are represented by wooden stakes in stream channels, mouths or deltas; and stone wall alignments along sections of shoreline, including stream mouths and deltas.
Burial:	Human burial sites often contain associated grave goods and are usually located in relict sea caves or rock shelters but also can occur in open areas. The location of these sites in the tree fringe is never divulged due to their extremely sensitive nature.

Rock Art:	Petroglyphs (rock carvings), pictographs (rock paintings), or a combination of the two forms, occur in many different coastal environmental settings on rock faces, boulders, or in caves and rock shelters. These sites can occur in both the tree fringe and the intertidal zone.
Tree Resource:	These sites often exhibit a wide range of cultural modification, including bark stripping, slab removal, plank removal, etc. and occur in the tree fringe unless associated with a drowned forest.
Isolated Find:	Sites in this category include isolated canoe runs, canoe preforms, cairns, etc. and can be located in both the tree fringe and the intertidal zone.

TABLE 13. NON-NATIVE CULTURAL RESOURCES CATEGORIES

Category	Description
Structure:	This category includes sites with standing or collapsed structures, including homesteads, commercial activities, camps, etc. and sites usually are located in the tree fringe.
Feature:	Feature sites, usually located in the tree fringe, include the remains of graves or cemeteries, cairns, and historic trails.
Artifact:	The remains of ships, mechanical equipment, etc. are included in this category. Historic artifacts can occur in both the tree fringe and the intertidal zone.

E.4 GENERAL EFFECTS OF OIL AND CLEANUP OPERATIONS ON RESOURCES

The effect of an oil spill on cultural resources can be addressed from both a vulnerability and sensitivity perspective. Site vulnerability measures the potential for direct impact from oil whereas site sensitivity is a measure of the potential for disturbance from shoreline treatment. The potential impact of an oil spill on cultural resources is far greater from treatment activities than from oiling. A "no treatment" decision generally has far less impact on cultural resources than a decision to treat oiled sections of shoreline.

Many sites may not be directly impacted by oil. Typically, these sites are located in the near and far uplands (up to 1 km inland). Sites located in the intertidal zone or sites in the near upland (backshore) that are eroding into the supratidal zone are vulnerable to impact from oil. Determining the sensitivity of a particular site to treatment is a function of site location, type of site, type of treatment, and intensity of treatment activity. Normally, sites located in the intertidal zone and near upland are very sensitive to treatment while sites located in the near upland are usually less sensitive. Burial places, no matter where they are located, also are very sensitive in this regard. Sensitivity to treatment increases as the type of treatment changes from manual to mechanical and as treatment intensity increases. The greater the number of people deployed to treat a section of shoreline, then the greater the site sensitivity. These and other less important factors are taken into account when evaluating the potential impact of oil and treatment activities on cultural resources. The primary impacts of cleanup operations on cultural resources are through disturbance, inadvertent removal during mechanical or manual excavation of oiled sediments, inadvertent destruction from heavy equipment or personnel movement on shorelines, or theft.

E.5 EFFECTS OF IDENTIFIED RESOURCES ON CLEANUP

Cultural resources present in the area of an oil spill are taken into account by placing an appropriate level of constraint on work orders for individual shoreline segments. Five archaeological constraints have been developed to protect sensitive cultural resources and to permit treatment to proceed as planned.

The **Deferred Constraint** is applied to work orders where no treatment is planned. This constraint intentionally makes no reference to the presence or absence of cultural resources, noting only that an archaeological assessment is necessary should any treatment activity be planned.

The **Holding Constraint** is applied to work orders where an archaeological survey is required before an evaluation can be made and before a formal archaeological constraint is applied to the work order. The constraint is used only as a temporary or holding measure pending completion of the archaeological survey.

The **Standard Constraint** is applied to work orders where planned treatment would not adversely affect known cultural resources present in the segment. This constraint is applied to segments which have been thoroughly surveyed. Standard constraints are applied with the understanding that if any undiscovered cultural resources are detected during treatment, they would be reported to the Archaeological Program Director by the Operations Supervisor.

The **Consultation and Inspection Constraint** is applied to work orders where planned treatment may adversely impact known cultural resources present in the segment. The "consultation" aspect of the constraint enables the field archaeologist to exercise professional judgment regarding future treatment events in the segment after an initial on-site consultation and inspection has been conducted with the Operations Supervisor and agency monitors. This constraint requires that the field archaeologist communicate with the Operations Supervisor, either by phone or in person, to make sure that the Supervisor is aware of the reason for the constraint and to ensure that the planned treatment would not impact the cultural resources present in the segment. The field archaeologist does not have to be present during treatment if cultural resources are not likely to be impacted by the treatment activity.

An integral part of the consultation and inspection constraint is the scope of work, written by the Archaeological Program Director. The scope of work outlines the specific activity the field archaeologist follows in implementing the constraint specific to that segment.

The **On-Site Monitoring Constraint** is applied to all work orders in segments containing highly visible and/or very sensitive cultural resources, such as rockshelter burials. The On-Site Monitoring Constraint states that no treatment activity can take place in a segment without an accredited archaeologist present during treatment. This constraint provides the highest degree of protection for cultural resources during shoreline treatment. The scope of work for segments requiring on-site monitoring often is very specific and allows little room for modification in the field.

The application of these five constraints, over a wide range of treatment situations, worked effectively in Alaska following the *Exxon Valdez* spill to allow the required treatment to proceed without adversely affecting the cultural resources present.

DATA REDUCTION

APPENDIX F: DATA REDUCTION

F.1 OBJECTIVE

The primary objective of data reduction is to transfer the field information into a database system, such as a Geographical Information System (GIS). This enables information collected by the field crews to be used interchangeably to track and to evaluate, in a variety of different ways, the impacts, treatment and recovery of the affected areas. New advances in multi-media computer applications will probably permit the linkage of still photographs, videotapes, and other records to the GIS in the near future. In the event of a spill the existing GIS/database structure available for the BC coast can probably be modified to handle the data produced by shoreline surveys.

F.2 GENERAL OVERVIEW

A GIS is a relational database, which can store, analyze and retrieve information, linked to a graphic package which can display data in a geographic format (i.e., maps). The GIS can use the SCAT data to map shoreline oil conditions throughout the spill area and to provide maps for the specific shoreline types, shoreline geomorphology, wave-exposure levels, sensitive areas, and species habitats as necessary. The GIS can be used to calculate lengths of oiled shoreline, either in total or by category, for the entire affected area or for specific regions. It can compare current shoreline oil conditions with previous conditions to evaluate the effectiveness of cleanup operations and natural processes. The GIS also can overlay various oil conditions, shoreline type, and energy level information and predict the consequent oil behavior due to natural processes.

The database can be used to display permutations of the data similar to the GIS, but in tabular form. Information, such as the shoreline length for each oil category within each segment, can be tabulated, and oil conditions before and after cleanup can be displayed as across-shore oil cover profiles.

F.3 EQUIPMENT

The hardware and software are the two important elements of a GIS system. Hardware includes the computer, graphic monitor, digitizing table, plotter and is used to input, store, process, display, and output digital maps and data. Software refers to the computer programs that perform operations such as data retrieval and data management.

F.3.1 Hardware

Both hardware and software are constantly being updated. At the time this manual was prepared the primary hardware components for a functional system could include:

- Work station with disk and tape drives for storage running under Unix and support DOS window,
- 386-25 MHz IBM-compatible personal computers with 16-megabytes of extended memory, general spreadsheet, and database operations under DOS environment or equivalent ANIX or MacIntosh equipment,
- An E-size (33-by-43 inch) digitizing table for input and editing,
- E-size pen plotters and E-size electro-static plotter for map output,
- High-speed printers for general information output, and
- A high-speed modem for data transferring through phone lines.

F.3.2 Software

Major supporting software could include:

- A modular geographic information system that combines a geographic analysis and modeling capability with an interactive system for entry, management, processing, and computer display of spatial data,
- A micro- or mini-computer based GIS package that allows the user to add full function automated mapping, facility management, and geographic information system capabilities,

- A micro-computer-based relational database management system that can store the detailed SCAT data and provide a user-friendly, menu-driven interface for all related data manipulation and management.

F.4 DATA OPERATION PROCEDURES

In general, data operation procedures can be performed under three basic steps:

- Base map preparation
- Related data overlays
- Database development

F.4.1 Base Map Preparations

The BC Ministry of the Environment has much of the British Columbia coastline digitized into a GIS, and other computerized basemaps exist. If a spill should occur in an area which lacks coverage, or if the existing coverage is not sufficient, overflights of areas can be performed to provide an updated shoreline configuration. Results of the aerial survey can then be used to produce a high precision (1 cm = 100 m) base map as a shoreline database for the GIS. These base maps can be directly imported and/or translated to the related GIS systems for further data operations.

F.4.2 Other Related Data Overlays

There are a number of basic data components of the GIS and databases: oil, geology, ecology, archaeology and human uses. Each data set is entered into both the GIS and/or database either directly or through an electronic transfer of information.

Oil Distribution. The oil information is entered into the GIS from the oil distribution maps by overlaying the maps directly on top of the corresponding digitized sections of the shoreline base map in the GIS. Segment boundaries and boundaries of each oil category are marked and identified on the digitized shoreline. The GIS can then approximate the lengths of each segment and oil category within the segment. Other information such as type of oil, cover, depth of penetration, sediment type, etc., also can be entered into the GIS to allow mapping and calculation of individual or combined lengths. With the exception of the calculated lengths, this information also can be entered into the database manually or by electronic transfer from the GIS. Generally, the data from the various Shoreline Oiling Summary (SOS/MOS) forms are entered manually into the database because it takes less time than the GIS data entry. Data can be entered directly from these forms or entry forms can be developed following their format with the desired information. The calculated lengths from the GIS are transferred later once they become available.

Coastal Geology. The coastal geology or geomorphology of each segment or area is entered into the database and GIS in much the same way as the shoreline oil information, except that the original maps are interpreted from the aerial videotape surveys instead of the ground surveys. This occurs primarily because the videotape surveys provide a more consistent and better overall perspective on shoreline geology.

Coastal Ecology. The coastal ecological information obtained in the field from the ground surveys could also be mapped and entered into the GIS. The location of sensitive areas often are derived from both field observations and existing databases or documents. Examples of sensitive areas in BC are eagle nests; fish/shellfish spawning habitats and streams; pinniped haul outs, pupping and molting areas; hatcheries; and commercial, sport and subsistence fishing areas. Other field data, including impacts, species distribution, wildlife observations, recovery potential and treatment constraints/considerations, are entered into the database directly from the data entry forms. Specific data entry forms for ecological information can be developed following the same format as the ecological summary (SES and MES) forms.

Coastal Archaeology. The coastal archaeological information can be entered in a separate database due to the sensitivity of the information. The GIS can be used to show locations of archaeological sites and to provide general information on each site. This information is restricted through the use of pass words. The information could be entered into a database by the staff archaeologists familiar with the program using field information, therefore no data forms would be necessary. Information, such as the archaeological constraints for each segment, often is provided in a spread sheet to assist operations in planning and to ensure that monitors are on site during treatment where required.

F.4.3 Database Development

Various SCAT databases for surface and subsurface oil information, ecological and archaeological data could be developed to store the detailed and non-geographic information. This database information usually is not suitable or not required for the GIS operations. Such data, including oil distribution, tidal zone, oil character, crew members, etc., are entered into a database system for other, non-geographical uses. By developing these databases, further data analyses can be performed to provide data summary tables, graphs, reports, etc. for a wide range of uses.

GLOSSARY

aerial reconnaissance survey — A shoreline survey to assess the overall magnitude of the spill and to identify oiled shoreline areas.

anadromous — A stream or river used by fish (such as salmon) to migrate from the sea to breed in fresh water.

ARCH — Archaeologist.

armouring or *armour layer* — A surface layer or veneer of well-packed or imbricated coarse clasts that overlie finer sediments. This veneer prevents erosion or reworking of the underlying beach sediments.

asphalt pavement — Cohesive mixture of weathered oil and sediment.

AutoCAD — Design and drafting program (software) for desktop computers, made by Autodesk, Inc. (CAD - Computer Assisted Drafting).

backshore — The upper zone of the beach between the high-water line of mean spring tides and the upper limit of shore zone processes. This zone is affected by waves only during severe storms or unusually high tides.

berm — A shelf or terrace on the backshore of the beach, above the neap high tide level.

Beta — Commercial name for a brand of 3/4 inch-format video-tape system.

biota — The animal and plant life of a region; flora and fauna, collectively.

calibration — A training process which ensures consistency among OGs, ECOs, and ARCHs when making observations and qualitative descriptions.

camcorder — Portable self-contained video camera and video-tape recorder.

characterization of oil — Oil description based on weathering:

- Fresh: unweathered, low-viscosity oil or fuel
- Mousse: emulsified oil (oil and water mixture)
- Mousse pattie: distinct patch or pattie ≤1 m - >0.1 m in diameter
- Tar ball: <0.1 m in diameter
- Tar coat: very weathered coating of tarry oil, with an almost solid consistency
- Surface oil residue: non-cohesive mixture of oil and fine-grain surface sediments
- Asphalt pavement: cohesive mixture of weathered oil and sediment

classifications of oil — Oil description based on thickness:

- Pooled/Thick: >1 cm thick
- Cover: ≤1 cm to >1 mm thick
- Coat: ≤1 mm to >0.1 mm thick; can be scratched off with a fingernail
- Stain: ≤0.1 mm thick; cannot be scratched off easily
- Film: transparent or translucent film or sheen

clinometer — A simple apparatus for measuring vertical angles, particularly dips, by means of a pendulum or spirit level and circular scale.

CRE form — Cultural Resource Evaluation form.

data back — Attachment for a still-frame camera which imprints the date and time on the image.

data reduction — The process of entering field information into a database for analysis to produce charts, graphs, tables, figures for interpretation.

deposition — The process by which rock-forming material (i.e. beach sediment) is laid down by any natural agent (e.g. waves).

desiccation — The process by which water is removed from a substance.

ECO — Ecologist.

emulsified oil — Oil that has mixed with water.

flight-line maps — Maps that show the path that was flown by a plane or helicopter during an aerial survey.

geomorphology — The form of the earth or of its surface features.

GIS — Geographical Information System; relational software that combines a database with a graphic display (usually maps).

ground survey — Comprehensive assessment and documentation of shoreline conditions from the ground.

ground truth — The activity that involves checking video or photographic survey data on the ground to confirm aerial visual observations, or to better assess the presence or extent of oil distribution or character.

HUS form — Human Use Summary form.

indicator species — A species peculiar to a specific environment which can be used to identify that environment.

interstices — Openings or spaces in a rock or soil; pores.

keystone species — A species whose activities have a disproportionately large effect, relative to its abundance.

kts — Knots; a unit of speed equal to one nautical mile per hour, approximately 1.15 statute miles per hour, 1.85 kilometers per hour.

lower intertidal zone (LI) — Lower third of intertidal zone.

m — Metres.

mailrun manifest or *package manifest* — A tracking form for mail packages, in case these are lost or misplaced; one form is sent with the package, another is kept on file with the field crew.

MES form - Marsh Ecological Summary form.

middens — A dunghill or refuse heap, particularly associated with a primitive habitation.

middle intertidal zone (MI) — Middle third of intertidal zone.

MOE - Ministry of Environment, Lands and Parks

MOS form — Marsh Oiling Summary.

NTR — "No Treatment Recommended."

neap tides — Tides that occur when the gravitational pull of the sun is at right angles to, and therefore opposes, the pull of the moon. Tidal range is reduced during neap tides. Neap tides occur twice each month during the first and last quarter of the moon.

OG — Oil Spill Geologist.

Operations — Organization that is responsible for spill cleanup; or its representative.

pinniped — Seal genus.

REET - Regional Environmental Emergencies Team

recruitment — Renewal or restoration of organisms to an affected area.

SCAT — Shoreline Cleanup Assessment Team.

sensitivity - The degree to which a species, site, area or resource is perceived to be important and to be at risk from oil or from response (cleanup) operations.

SES form — Shoreline Ecological Summary form.

sessile — Describes a plant or animal that is permanently attached to a substrate and is not free to move about.

shoreline segmentation — The process that divides the shoreline into segments to provide more detailed documentation of a section of shoreline and to reference the location of oiled areas.

sketch map — A hand-drawn map of a shoreline section that shows the location of major features, data points, and other relevant information about the site.

skiff — A boat with a flat bottom.

SLR — Single lens reflex (still-frame camera).

SOS form — Shoreline Oiling Summary form.

spring tides — Tides that occur when the gravitational pull of the sun is in the same direction as, and therefore reinforces, that of the moon. Tidal range increases during spring tides, which occur twice each month at the new and full moons.

storm berm — Similar to neap berm but formed at a higher elevation of material thrown up or deposited during spring high tides or storms.

substrate — (Geological) the materials which constitute, in this case, the coastal zone; or (biological) the surface to which a fixed organism is attached, subdivided as follows:

	Diameter (grain size)
Bedrock	------
Boulder	>256 mm
Cobble	64-256 mm
Pebble	4-64 mm
Granule	2-4 mm
Sand	0.06-2 mm
Mud/Silt	<0.06 mm
Vegetation	------

supratidal zone (SU) — Area or zone above intertidal zone, above the mean high tide level.

transect — Line across a beach, usually perpendicular to the shoreline, that is repeatedly surveyed. Usually spaced 20 m apart, extending from the backshore to the water line.

U-Matic — Commercial name for a brand of 3/4 inch video-tape system.

uplands — A general term for an extensive region of high ground, especially far from the coast or in the interior of a country.

upper intertidal zone (UI) — Upper third of intertidal zone.

VHF — Very High Frequency (radio).

VHS — 1/2 inch video-tape format, standard in North America and Japan.

videotape recording survey — A systematic aerial videotape recording (often referred to as VTR) survey which provides documentation on the extent of oiling and character of the shorezone.

viscosity — The property of a substance to offer internal resistance to flow; its internal friction.

VOX microphone — Voice-activated mouth microphone.

vulnerability - The potential that resources or activities which are sensitive (q.v.) may be impacted by the oil or by the response (cleanup) operations.

weathering — The process of biological, chemical and physical change associated with spilled oil.

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FORMS (BLANK)

APPENDIX I - BLANK FORMS, EXPLANATIONS AND CODES

I.1 INTRODUCTION

Included in this appendix are the various field forms and instructions for their use, including explanations of the abbreviations and codes that would be needed in the field during surveys. The forms and explanations have been separated into four "packets" which can be removed and copied as needed.

I.2 SURFACE OILING FORMS, DATA SHEETS AND FORM/CODE EXPLANATIONS

SHORELINE OILING SUMMARY (SOS) FORM
MARSH/WETLANDS OILING SUMMARY (MOS) FORM
SKETCH LOCATION MAP
PHOTO LOG LABELS
SHORELINE/MARSH OILING SUMMARY (SOS/MOS) FORM EXPLANATIONS
SHORELINE/MARSH OILING SUMMARY (SOS/MOS) FORM CODES
METHODS USED TO DESCRIBE SURFACE OIL CONDITIONS
INITIAL SURFACE OIL COVER MATRIX
SURFACE OIL CATEGORIZATION MATRIX
SUBSURFACE OIL CATEGORIZATION MATRIX
SUBSURFACE OIL DEFINITIONS

I.3 ECOLOGY FORMS, DATA SHEETS AND FORM/CODE EXPLANATIONS

SHORELINE ECOLOGICAL SUMMARY (SES) FORM
MARSH/WETLANDS ECOLOGICAL SUMMARY (MES) FORM
SHORELINE/MARSH ECOLOGICAL SUMMARY (SES/MES) FORM EXPLANATIONS

I.4 HUMAN USE, CULTURAL RESOURCE, AND ARCHAEOLOGICAL FORMS, AND FORM EXPLANATIONS

HUMAN USE SUMMARY (HUS) FORM
CULTURAL RESOURCE EVALUATION (CRE) FORM
BC ARCHAEOLOGICAL SITE INVENTORY FORM
HUMAN USE SUMMARY (HUS) FORM EXPLANATIONS
CULTURAL RESOURCE EVALUATION (CRE) FORM EXPLANATIONS
BC ARCHAEOLOGICAL SITE INVENTORY FORM EXPLANATIONS

I.5 GENERAL ANCILLARY FORMS

DAILY REPORT FORM
MAIL RUN MANIFEST
FIELD FORM FOR MONITORING (TRANSECT DATA)

SECTION I.2

SURFACE OILING FORMS, DATA SHEETS AND FORM/CODE EXPLANATIONS

BC SHORELINE OILING SUMMARY (SOS) FORM

Page ____ of _____

1. GEN
Segment ID:________________________
Survey Date: ____________
Survey Time: ________ to ________ PST PDT
Tide Level ________ to ________
Surveyed from: Foot / Boat / Helicopter
Weather: Sun / Clouds / Fog / Rain / Snow

2. CREW
Crew No:________________________
OG:________________________
ECO:________________________
ARCH:________________________
Operations:________________________ for________
Provincial:________________________ for________
Federal:________________________ for________
Land Manager:________________________ for________

3. SHORE
Overall Classification for UITZ- Select One
Bedrock: Cliff_____ Platform_____
Manmade: Permeable_____ Impermeable___
Marsh/Wetlands_____
Sediment Beach:
Boulder-Cobble_____ Sand_____
Pebble-Cobble_____
Sand-Gravel_____
Sediment Flat:
Boulder-Cobble_____ Sand____
Pebble-Cobble_____ Mud_____
Sand-Gravel_____
Secondary Shore Type:
Backshore Type:

4. LAND
Predominant Substrate: Artificial(permeable Y/N) ____% Rock____% Rock & Sediment____% Sediment____% Organics/Fines____%
Slope Low_____% Medium_____% High_____% Vertical_____%
Wave Exposure: Low / Medium / High
Total Estimated Segment Length: m
Total Estimated Length Surveyed: m
Access Restrictions:

5. OIL
Total Pavement: ________________ sq.m by ________________ cm
Patties / Tarballs________________________bags
Oiled Debris? Yes/No
Debris/Amount:
Logs______________ Vegetation______________
Rubbish____________ Other______________

6. SURFACE OILING

LOC	AREA		DIST	SURFACE OIL													ZONE				SHORE SLOPE	SURFACE SEDIMENT TYPE
	LENGTH m	WIDTH m		THICKNESS					CHARACTER													
				PO	CV	CT	ST	FL	FR	MS	TB	TC	SR	AP	NO	DB	SU	UI	MI	LI	V H M L	

Distribution (DIST): C = 100-91%; B = 90-51%; P = 50-11%; S = 10-1%; T = <1%

Photo Roll #____________________Frames__________

7. SUBSURFACE OIL

PIT NO.	PIT ZONE				PIT DEPTH cm	OILED ZONE cm-cm	CLEAN BELOW (Y / N)	SUBSURFACE OIL CHARACTER						WATER LEVEL cm	SHEEN COLOR*	SURFACE-SUBSURFACE SEDIMENTS
	SU	UI	MI	LI				AP	OP	PP	OR	TR	NO			

* SHEEN COLOR: B = BROWN; R = RAINBOW; S = SILVER; N = NONE

8. OG COMMENTS

BC MARSH/WETLANDS OILING SUMMARY (MOS) FORM

Page _____ of ______

1\. GEN

Segment ID:______________________
Survey Date: ______________
Survey Time: ________ to ________ PST PDT
Tide Level ________ to ________
Surveyed from: Foot / Boat / Helicopter / Hovercraft
Weather: Sun / Clouds / Fog / Rain / Snow

2\. CREW

Crew No:______________________
OG:______________________
ECO:______________________
ARCH:______________________
Operations:______________________ for________
Provincial:______________________ for________
Federal:______________________ for________
Land Manager:______________________ for________

3\. SHORE

Overall Classification for UITZ - Select One
Bedrock: Cliff_____ Platform_____
Manmade: Permeable_____ Impermeable_____
Marsh/Wetland_____
Sediment Beach:
Boulder-Cobble_____ Sand_____
Pebble-Cobble_____
Sand-Gravel_____
Sediment Flat:
Boulder-Cobble_____ Sand____
Pebble-Cobble_____ Mud_____
Sand-Gravel_____
Secondary Shore Type:
Backshore Type:

4\. MARSH

Intertidal Zone: Sand Tidal Flat ________% Mud Tidal Flat ________% Gravel Beach ________% Rock Platform ________%
Marsh Edge (seaward): Artificial______% Vegetation______%
Manmade Levee______% Creek Bank______% Other______%
Est. Total Marsh Edge Length (inc. creeks):_____m
Est. Marsh Edge Length Surveyed (inc. creeks):_____m
Supratidal Zone: Est. Area of Marsh Vegetation _________ hect. Est. Length of Marsh Fringe _________ m
Access Restrictions:

5\. OIL

Oiled Debris? Yes/No
Total Pavement: ________________ sq.m by ________________ cm
Patties/Tarballs________________________ bags
Debris Amount:
Logs______________ Vegetation______________
Rubbish______________ Other______________

6\.

S	LOC	AREA		DIST	SURFACE OIL													ZONE				* PART OF PLANT			SURFACE SEDIMENT TYPE
U		LENGTH	WIDTH		THICKNESS					CHARACTER															
R		m	m		PO	CV	CT	ST	FL	FR	MS	TB	TC	SR	AP	NO	DB	SU	UI	MI	LI	H	S	L	
F																									
A																									
C																									
E																									
O																									
I																									
L																									
I																									
N																									
G																									

Distribution (DIST): C = 100-91%; B = 90-51%; P = 50-11%; S = 10-1%; T = <1%

* H = Head; S = Stem; L = Litter

Photo Roll # ____________________ Frames ________

7\.

S	PIT NO.	PIT ZONE				PIT DEPTH	OILED ZONE	CLEAN BELOW	SUBSURFACE OIL CHARACTER						WATER LEVEL	SHEEN COLOR*	SURFACE-SUBSURFACE SEDIMENTS
U																	
B		SU	UI	MI	LI	(cm)	(cm-cm)	(Y/N)	AP	OP	PP	OR	TR	NO	(cm)		
S																	
U																	
R																	
F																	
A																	
C																	
E																	
O																	
I																	
L																	

* SHEEN COLOR: B = BROWN; R = RAINBOW; S = SILVER; N = NONE

8\. OG COMMENTS

OG_________________________

SEGMENT____________________

DATE______/______/______

PAGE ______of______(packet total)

CHECKLIST:

- __N Arrow
- __Oil Dist.
- __Width
- __Length
- __% Cover
- __Class
- __Approx. Scale
- __Segment Bndry
- __Substrate Character
- __Pit Locations
- __Photo Locations
- __Est. HWL/LWL

LEGEND

Ⓐ 2 x 20 m
FR/CT/75

Ⓐ = Location; 2 x 20 m = Dimensions
FR/ = Oil Character (Fresh)
CT/ = Oil Classification (Coat)
75 = Oil Coverage (%)

1 △ Pit–No Subsurface Oil

2 ▲ Pit–Subsurface Oil

ℓℓℓℓ Oiled Vegetation

1 ●→ Photo location, direction, and number

PHOTO LOG

Photographer____________________
Date__________ Time__________
Segment No._____ Log Frame No._____
Location____________________
Comments____________________

Roll No._______ Neg. No._______
Control No._______ (Office Use Only)

Photographer____________________
Date__________ Time__________
Segment No._____ Log Frame No._____
Location____________________
Comments____________________

Roll No._______ Neg. No._______
Control No._______ (Office Use Only)

Photographer____________________
Date__________ Time__________
Segment No._____ Log Frame No._____
Location____________________
Comments____________________

Roll No._______ Neg. No._______
Control No._______ (Office Use Only)

Photographer____________________
Date__________ Time__________
Segment No._____ Log Frame No._____
Location____________________
Comments____________________

Roll No._______ Neg. No._______
Control No._______ (Office Use Only)

Photographer____________________
Date__________ Time__________
Segment No._____ Log Frame No._____
Location____________________
Comments____________________

Roll No._______ Neg. No._______
Control No._______ (Office Use Only)

Photographer____________________
Date__________ Time__________
Segment No._____ Log Frame No._____
Location____________________
Comments____________________

Roll No._______ Neg. No._______
Control No._______ (Office Use Only)

Photographer____________________
Date__________ Time__________
Segment No._____ Log Frame No._____
Location____________________
Comments____________________

Roll No._______ Neg. No._______
Control No._______ (Office Use Only)

Photographer____________________
Date__________ Time__________
Segment No._____ Log Frame No._____
Location____________________
Comments____________________

Roll No._______ Neg. No._______
Control No._______ (Office Use Only)

SHORELINE/MARSH OILING SUMMARY (SOS/MOS) FORM EXPLANATIONS

Field	Explanation
1. General	
Page 1 of __	Indicate the total number of pages in the shoreline oiling summary data package including sketch maps, oil distribution maps, notes, etc..
Segment ID.	Enter the appropriate number.
Survey Date	Enter the date of the assessment (D-M-Y).
Survey Time	Enter the time period of the assessment (24 hour clock), circle appropriate standard or daylight savings time abbreviation.
Tide Level-	Enter the tide level range during assessment (from tide curves).
Surveyed From	Circle the appropriate term(s) that describe all means used to survey the segment.
Weather	Circle the appropriate term(s) that describe the weather conditions during the survey.
2. Crew	
Crew No.	Indicate the survey crew number.
Crew Members	Enter person's name corresponding to their position,and the name of the agency representative, and in the blank after "for" write the agency abbreviation.
3. Shore	
Overall Classification-UITZ	Check the appropriate term from the following list that best describes the overall classification of the UITZ.

Primary Shoreline Classifications:

Bedrock:
- Cliff
- Platform
- Cemented sediment
- Reef

Man-made:
- Permeable
- Impermeable

SHORELINE/MARSH OILING SUMMARY (SOS/MOS) FORM EXPLANATIONS

Field — **Explanation**

Sedimented:
- Beach:
  - Boulder-cobble
  - Pebble-cobble
  - Sand-gravel
  - Sand
- Tidal Flat:
  - Boulder-cobble
  - Pebble-cobble
  - Sand-gravel
  - Sand
  - Mud
  - Evaporite (Sabkha)

Vegetated:
- Marsh
- Wetland
- Mangrove
- Tundra

Secondary Shore Type

Enter the term from the following list that best describes the secondary shore type.

<u>Secondary Shore Types:</u>
Any of the above (primary), plus;

Boulder barricades
Pocket beaches
Delta
Barrier island

Backshore Type

Enter the term from the following list that best describes the backshore region.

<u>Back Shore Modifiers:</u>

Cliff:
- Rock
- Unconsolidated

Man-made
Low relief:
- Open
- Wooded

Water bound:
- Bay
- Marsh
- Inlet
- Lagoon
- Dunes

SHORELINE/MARSH OILING SUMMARY (SOS/MOS) FORM EXPLANATIONS

4. Land

Field	Explanation
Predominant Types	Enter percentage of predominant shoreline type(s) within segment (SOS only) - sum equals 100%.
Shoreline Zone	Enter percentage of each zone (MOS only) - sum equals 100%.
Slope	Enter percentage of each shore slope type (see "SOS/MOS Codes" table) that occurs within segment (SOS only) - sum equals 100%.
Wave Exposure	Enter average wave exposure within segment (see Wave Exposure Matrix) (SOS only).
Marsh Edge	Enter percentage of predominant marsh edge type(s) within segment (MOS only) - sum equals 100%.
Est. Segment/ Marsh Edge Length	Enter estimated length of segment/marsh edge (MHWM).
Total Est. Length Surveyed	Enter the total estimated length of shoreline/marsh edge surveyed within that segment.
Supratidal Zone	Enter the estimated area of supratidal marsh meadow/vegetation and estimated length of marsh fringe (HHWM)(MOS only).
Access Restrictions	Summarize potential access restrictions to treatment crews (shallow tidal flats, rocky nearshore, no helo access, etc.).

5. Shoreline Oil Conditions

Field	Explanation
Total Pavement	Enter total area and average thickness of all pavement in segment for cleanup planning.
Patties/Tarballs	Estimate total number of recoverable bags of patties/tarballs for cleanup planning.
Oiled Debris?	Circle appropriate response.
Debris/Amount	Enter estimated amount of each type of oiled debris present.

SHORELINE/MARSH OILING SUMMARY (SOS/MOS) FORM EXPLANATIONS

Field	Explanation
6. Surface Oiling	
Location No.(LOC)	Assign a letter to each oil category area within the segment and reference on sketch map.
Area	Enter the width and length of the oiled area in metres.
Zone	Check the appropriate box which corresponds to the shoreline zone(s) where oil occurs.
Distribution (DIST)	Enter appropriate percent cover descriptor for that area (see explanation on SOS form - C,B,P,S,T).
Oil Thickness	Check appropriate box(es) with an "X" for each oil thickness observed in that area.
Oil Character	Check appropriate box(es) with an "X" for each oil character observed in that area.
Shore Slope	Enter the appropriate shoreline slope for that area (V,H,M,L) (SOS only-see SOS/MOS Codes).
Plants	Check the appropriate box indicating the height of oiled ring on exposed parts of vegetation, H - head, S - stem, L - litter (MOS only).
Surface Sediment	Enter the code(s) for the predominant type(s) of sediments in that area separated by back slashes in decreasing order of frequency (C/P/R) (see SOS/MOSCodes).
Photo Roll	Enter the roll # and the frames on the film that were shot at the site in the blank provided.
7. Subsurface Oil	
Pit No.	Enter the number of the pit, which should be assigned sequentially as they are dug and referenced on the sketch map.
Pit Zone	Check the appropriate shoreline zone box where the pit is located.
Pit Depth	Enter the total depth of the pit in cm.
Oiled Zone	Enter the depths from the surface for the interval within the pit that oil occurs (see "SOS/MOS Codes" for definition of subsurface oil). Separate oiled intervals in the same pit should be listed on separate lines.
Clean Below	Enter yes (Y) or no (N) if the pit depth has extended beyond the bottom of the oiled zone.

SHORELINE/MARSH OILING SUMMARY (SOS/MOS) FORM EXPLANATIONS

Field	**Explanation**
Sub. Oil Character	Check only the box which best represents the oil found in that pit or interval. If no oil is found check the NO box.
Water Level	Enter the depth to groundwater, if present, in the pit in cm.
Sheen Color	Enter the color of any sheen that appears on groundwater, if present, in the pit (see sheen color key on form).
Surface-Subsurface Sediments	Enter the types of surface and subsurface associated with the pit. Surface sediment type(s) should be listed first followed by a dash and the subsurface sediment type(s) (C/P - P/G/S) (see "SOS/MOSCodes" table).
8. <u>Comments</u>	
OG Comments	Provide a brief description of the overall physical nature of the shoreline and the extent and degree of oil conditions. This is one of the most important and useful pieces of information on the form. On the MOS form include notes about plant/species type (annuals, perennials, shrubs, etc.). Indicate the maximum and/or average thickness of AP, if any.

SHORE (Box 3)

Primary Shoreline Classifications:

- Bedrock:
  - Cliff
  - Platform
- Sedimented:
  - Beach:
    - Boulder-cobble
    - Pebble-cobble
    - Sand-gravel
    - Sand
- Vegetated:
  - Marsh
  - Wetland
- Man-made:
  - Permeable
  - Impermeable
- Tidal Flat:
  - Boulder-cobble
  - Pebble-cobble
  - Sand-gravel
  - Sand
  - Mud

Secondary Shore Types: Any of the above, plus;

- Pocket beaches
- Delta
- Barrier island

Back Shore Modifiers:

- Cliff:
  - Rock
  - Unconsolidated
- Man-made
- Low relief:
  - Open
  - Wooded
- Water bound:
  - Bay
  - Marsh
  - Inlet
  - Lagoon
- Dunes

LAND (Box 4)

Shore Slope

Low	A shore with a slope of 30 degrees or less
Medium	A shore with a slope between 31 and 60 degrees
High	A shore with a slope between 61 and 90 degrees
Vertical	A vertical or near vertical shoreline (>90 degrees)

LAND (continued)

Wave Exposure

Fetch Distance	**Fetch Window - Degrees** <45	 45 - 120	 121-180	 >180
< 5 km	Low	Low	Low	Low
5 - 10 km	Low	Medium	Medium	Medium
10 - 50 km	Medium	Medium	High	High
> 50 km	High	High	High	High

SURFACE OILING (Box 6)

A four-fold rating has been developed for describing surface oil conditions on the shoreline. These conditions are :

- Heavy,
- Moderate,
- Light, and
- Very Light.

Two steps are involved in the ground survey assessment of surface oiling.

STEP ONE:
Determine Width of Oil Band and Distribution of Oil According to the Following Criteria:

Oil Width

Represents the average width of the oiled area or band in the shoreline segment. If multiple bands or areas occur across-shore, width represents the sum of their widths.

Wide	> 6 m
Medium	> 3 m and ≤ 6 m
Narrow	> 0.5 m and ≤ 3 m
Very Narrow	≤ 0.5 m

SURFACE OILING (continued)

Oil Distribution (DIST)

Represents the % of the surface within a band or area covered by oil. In the event of multiple bands, distribution refers to the term that best represents the oil conditions for the segment. A visual illustration to assist in estimating oil distribution is included on the following page.

Trace (T)	<1%
Sporadic (S)	1 - 10%
Patchy (P)	11 - 50%
Broken (B)	51 - 90%
Continuous (C)	91 - 100%

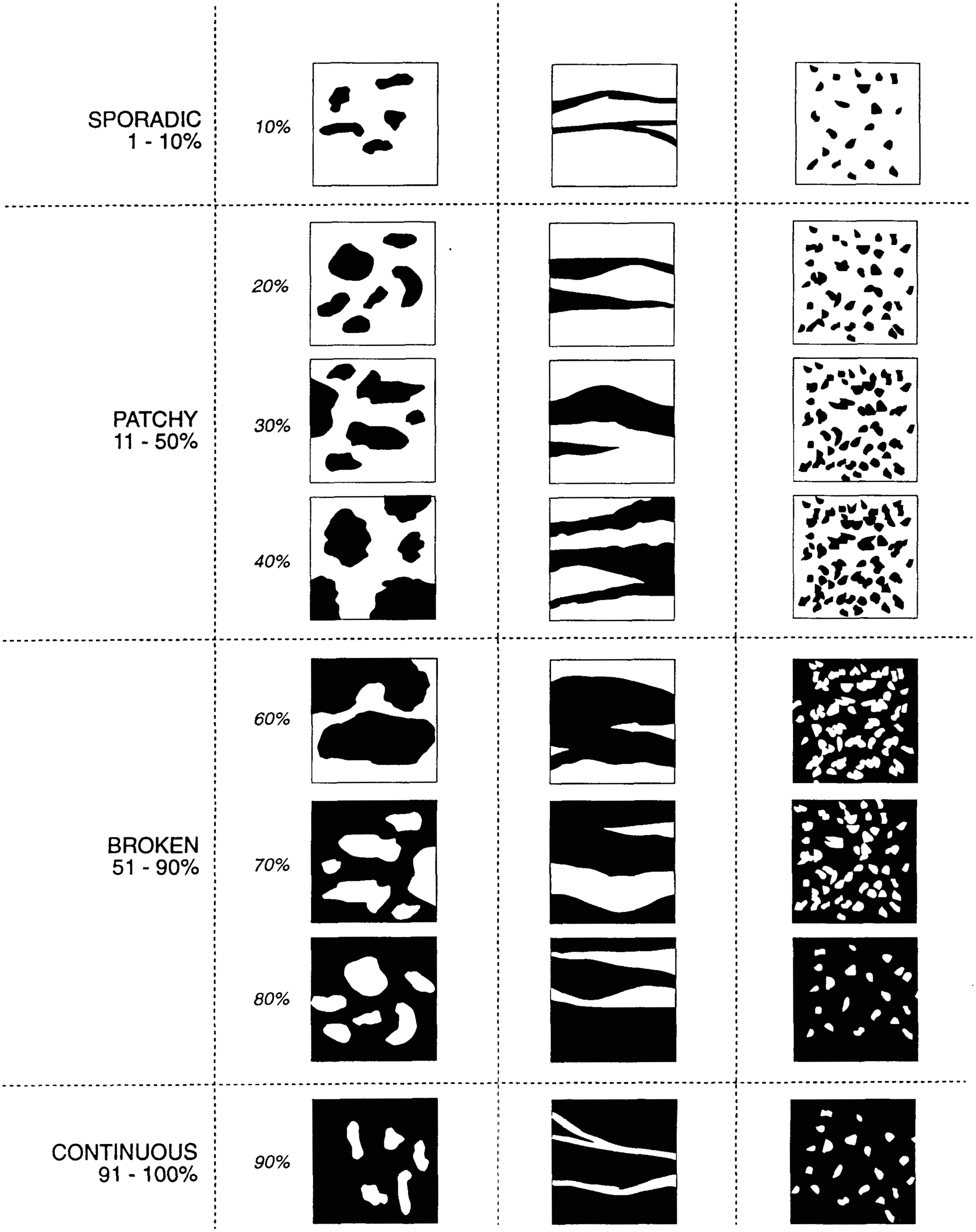
The above two parameters are combined in the Initial Surface Oil Cover Matrix to determine the initial surface oil cover category (degree of oiling).

STEP TWO:
Determine Oil Thickness According to the Following Criteria:

Oil Thickness
Refers to the average or dominant oil thickness within a band or area.

PO	Pooled or Thick Oil - Generally consists of fresh oil or mousse accumulations >1.0 cm thick.
CV	Cover - ≤1.0 cm and >0.1 cm thick coating on coarse sediments and in interstices.
CT	Coat - ≤0.1 cm and >0.01 cm thick coating on coarse sediments. Can be scratched off with fingernail.
ST	Stain - ≤0.01 cm thick coating on coarse sediments. Cannot be scratched off easily.
FL	Film - transparent or translucent film or sheen.

The thickness is then combined with the result of step one (from the Initial Surface Oil Cover Matrix) in the Surface Oil Categorization Matrix to determine the surface oil category.


SPORADIC
1 - 10%
10%
PATCHY
11 - 50%
20%
30%
40%
BROKEN
51 - 90%
60%
70%
80%
CONTINUOUS
91 - 100%
90%

STEP 1: Width of oil band (m) 3 - 6 m (Medium)

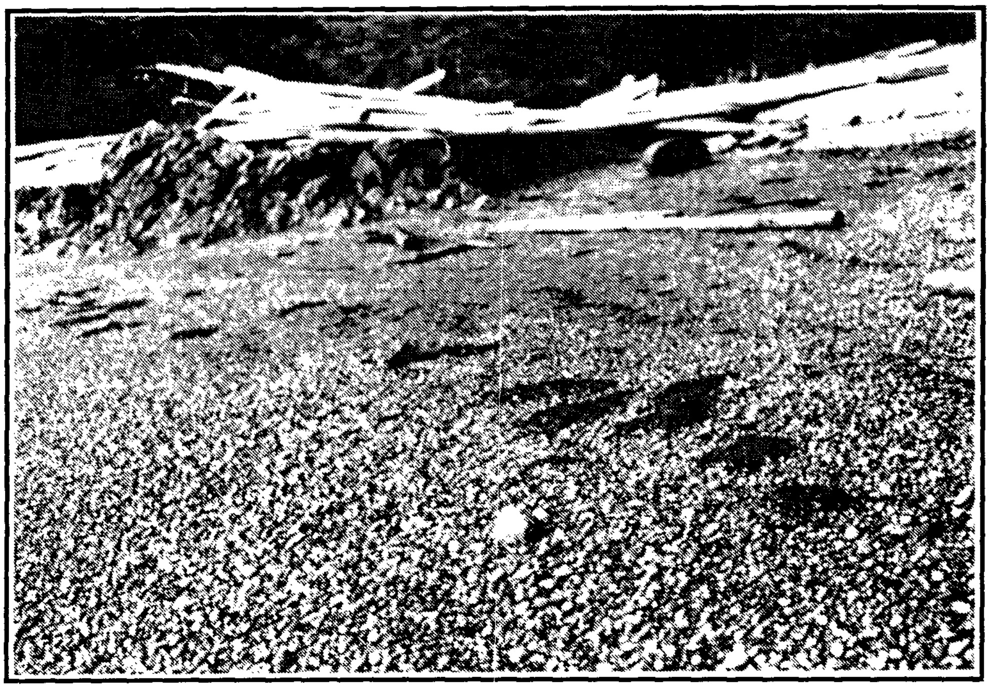
plus Distribution of oil (%) 70 % (Broken)

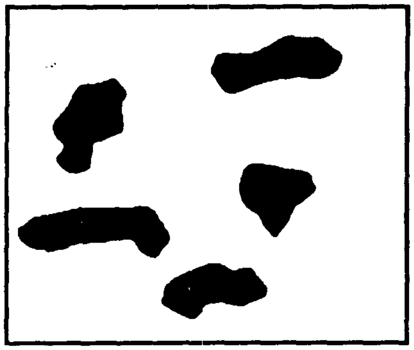
equals Initial surface oil cover Heavy

STEP 2:

plus Thickness of oil (cm) > 1.0 cm (Thick)

equals Surface oil category Heavy





STEP 1: Width of oil band (m) 2 m (Narrow)

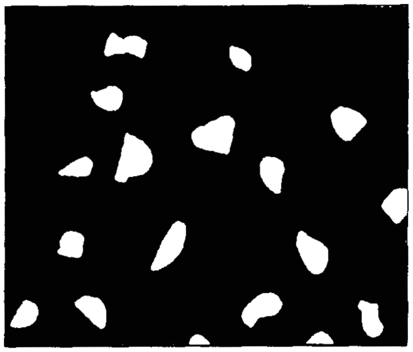
plus Distribution of oil (%) < 10 % (Sporadic)

equals Initial surface oil cover Very Light

STEP 2:

plus Thickness of oil (cm) > 1.0 cm (Thick)

equals Surface oil category Light



STEP 1: Width of oil band (m) 3 - 6 m (Medium)

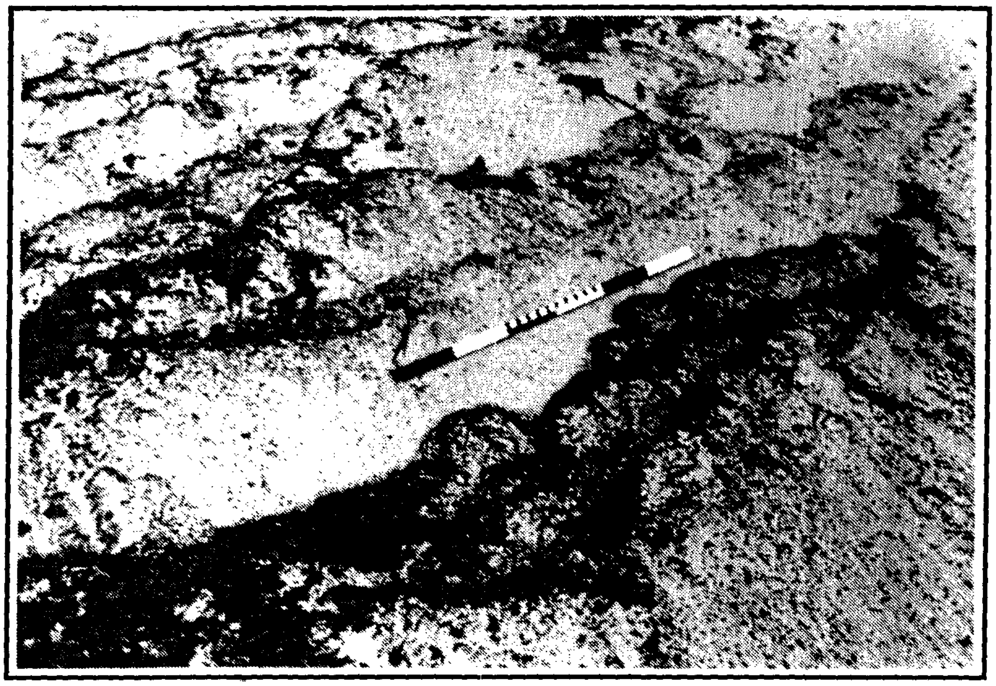
plus Distribution of oil (%) 95 % (Continous)

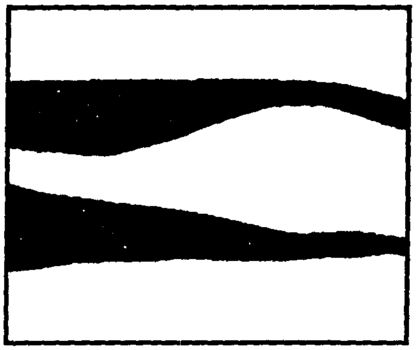
equals Initial surface oil cover Heavy

STEP 2:

plus Thickness of oil (cm) > 1.0 cm (Thick)

equals Surface oil category Heavy





STEP 1: Width of oil band (m) 3 - 6 m (Medium)

plus Distribution of oil (%) 20 % (Patchy)

equals Initial surface oil cover Moderate

STEP 2:

plus Thickness of oil (cm) 0.3 cm (Cover)

equals Surface oil category Heavy

SURFACE OILING (continued)

Oil Character/Debris Type

FR	Fresh - unweathered, low viscosity oil.
MS	Mousse - emulsified oil (oil and water mixture) existing as patches or accumulations, or within interstitial spaces.
TB	Tar Balls or Mousse Patties - discrete balls or patties on a beach or adhered to rock or coarse-sediment shoreline. Diameters of tar balls and mousse patties are generally <0.1 m and ≤1.0 m to ≥0.1 m, respectively.
TC	Tar - weathered coat or cover (see Oil Thickness) of tarry, almost solid consistency.
SR	Surface Oil Residue - Consists of non-cohesive, oiled, surface sediments, either as continuous patches or in coarse-sediment interstices.
AP	Asphalt Pavement - cohesive mixture of oil and sediments (the OG must indicate the maximum and/or average thickness on the form in the comments section).
NO	No Oil Observed .
DB	Debris - can consist of logs, vegetation, rubbish or general debris. Includes spill response items (sorbents, boom, snares, etc.) LG = logs VG = vegetation RB = rubbish, garbage (man-made materials)

SURFACE AND SUBSURFACE OILING (Boxes 6 & 7)

Intertidal Zone

SU	Supratidal Zone - the area above the mean high tide that occasionally experiences wave activity. Also known as the splash zone.
UI	Upper Intertidal Zone - the upper approximate one third of the intertidal zone.
MI	Mid Intertidal Zone - the middle approximate one third of the intertidal zone.
LI	Lower Intertidal Zone - the lower approximate one third of the intertidal zone.

SOS/MOS FORM CODES (continued)

Surface/Subsurface Sediment Type

R	Bedrock outcrops
B	Boulder (> 256 mm dia.)
C	Cobble (64 - 256 mm dia.)
P	Pebble (4 - 64 mm dia.)
G	Granule (2 - 4 mm dia.)
S	Sand (0.06 - 2 mm dia.)
M	Mud (< 0.06 mm dia.)
A-W	Manmade - Seawall (impermeable)
A-R	Manmade - Rubble or open concrete (permeable)
A-P	Manmade - Pilings

SUBSURFACE OIL (Box 7)

Sheen Color

B	Brown
R	Rainbow
S	Silver
N	None

SUBSURFACE OIL (continued)

Subsurface Oil Character/Relative Oil Concentration[*]

Refers to a qualitative description of the degree of oil filled pore spaces.

AP	Asphalt Pavement - cohesive mixture of weathered oil and sediment situated completely below a surface sediment layer(s).
OP	Oil-Filled Pores - pore spaces in the sediment matrix are completely filled with oil. Often characterized by oil flowing out of the sediments when disturbed.
PP	Partially Filled Pores - pore spaces filled with oil, but generally does not flow out when exposed or disturbed.
OR/C	Cover (0.1 - 1.0 cm) or Coat (0.01 - 0.1 cm) of oil residue on sediments and/or some pore spaces partially filled with oil .
OR/S	Stain (0.01 cm) or film oil residue on the sediment surfaces. Non-cohesive.
TR	Trace - discontinuous film or spots of oil on sediments, or an odor or tackiness with no visible evidence of oil.
NO	No Oil - no visual or apparent evidence of oil.

A four-term rating system has been developed for describing subsurface oil conditions. The terms are Heavy, Moderate, Light, and Very Light. The above parameter combines with the depth of penetration or thickness of the buried oil lens in the Subsurface Oil Categorization Matrix to determine the subsurface oil category.

---

[*] Due to the problems associated with differentiating between what is considered surface and subsurface oil for oil character categories such as interstitial MS, surface SR, AP, subsurface OP and OR that begins at the surface, etc. the following definitions have been developed:

- Fine Sediments (P,G,S,M); Subsurface begins at 5 cm below the surface. If a pit were to reveal oiling in sand from the surface down to 20 cm, the upper 5 cm would be classified as surface oil and the remainder as subsurface. However, the oiled interval still would be shown as 0 to 20 cm.
- Coarse Sediments (C,B); Subsurface begins at the bottom of the surface material (i.e. where the top layer of cobbles or boulders contact the underlying layer of sediments.
- Asphalt Pavement; Where AP exists on the surface, the subsurface begins at the bottom of the pavement.

A visual explanation of these definitions is shown in the "Subsurface Oil Definitions" sketch.

Methods Used to Describe Surface Oil Conditions

Length	Presence or absence only
Length - Width	A measure of total oiled area
Length - Width - Distribution	Indicates oil cover (equal to the Equivalent Area - Owens et al., 1987) *
Length - Width - Distribution - Thickness	Estimates the amount of oil **

* see Initial Surface Oil Cover Matrix

** see Surface Oil Categorization Matrix

INITIAL SURFACE OIL COVER MATRIX

		Width of Oiled Areas			
		Wide >6 m	Medium 3 - 6 m	Narrow 0.5 - 3 m	Very Narrow <0.5 m
Oil Distribution	Continuous 91 - 100%	*Heavy*	*Heavy*	*Moderate*	*Light*
	Broken 51 - 90%	*Heavy*	*Heavy*	*Moderate*	*Light*
	Patchy 11 - 50%	*Moderate*	*Moderate*	*Light*	*Very Light*
	Sporadic 1 - 10%	*Light*	*Light*	*Very Light*	*Very Light*
	Trace < 1 %	*Very Light*	*Very Light*	*Very Light*	*Very Light*

SURFACE OIL CATEGORIZATION MATRIX

		Initial Categorization of Surface Oil *			
		Heavy	**Moderate**	**Light**	**Very Light**
Average Thickness	**Thick or Pooled > 1 cm**	*Heavy*	*Heavy*	*Moderate*	*Light*
	Cover 0.1 - 1.0 cm	*Heavy*	*Heavy*	*Moderate*	*Light*
	Coat 0.01 - 0.1cm	*Moderate*	*Moderate*	*Light*	*Very Light*
	Stain/Film <0.01 cm	*Light*	*Light*	*Very Light*	*Very Light*

* from Initial Surface Oil Cover Matrix

SUBSURFACE OIL CATEGORIZATION MATRIX

		Depth of Penetration or Thickness of Oil Lens			
		> 30 cm	21 - 30 cm	11 -20 cm	0 - 10 cm
Relative Oil Concentration	OP	*Heavy*	*Heavy*	*Heavy*	*Moderate*
	PP	*Heavy*	*Moderate*	*Moderate*	*Light*
	OR	*Moderate*	*Moderate*	*Light*	*Light*
	TR	*Light*	*Very Light*	*Very Light*	*Very Light*

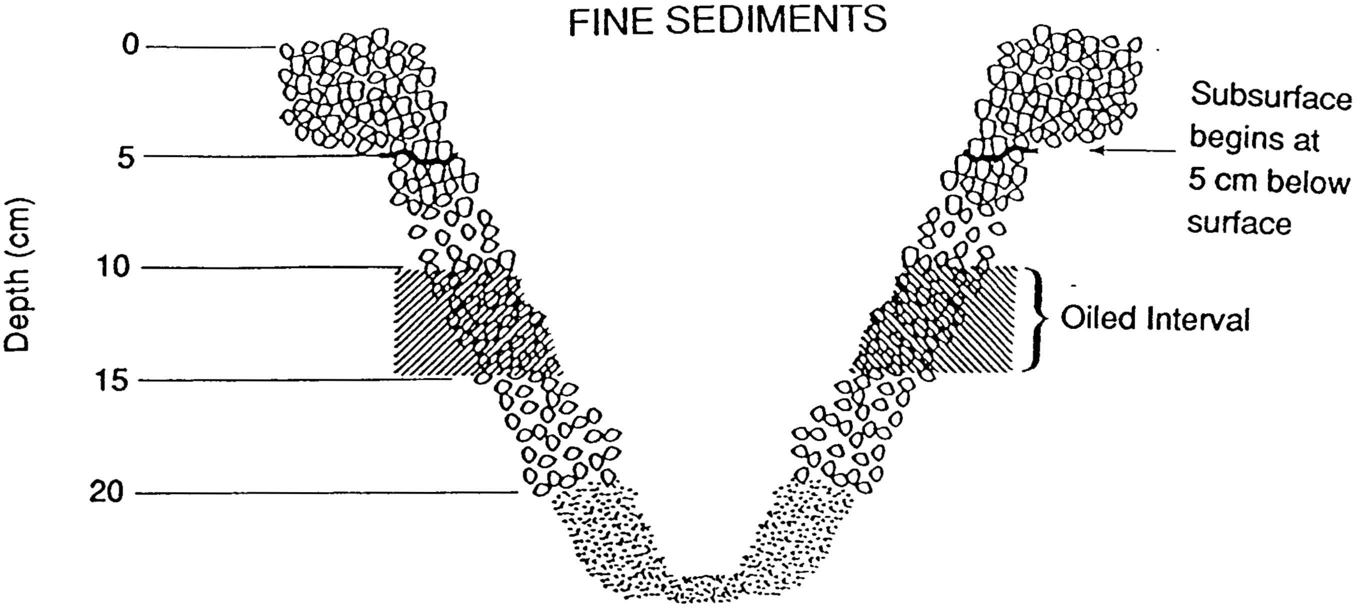
OP = Oil-filled pore spaces

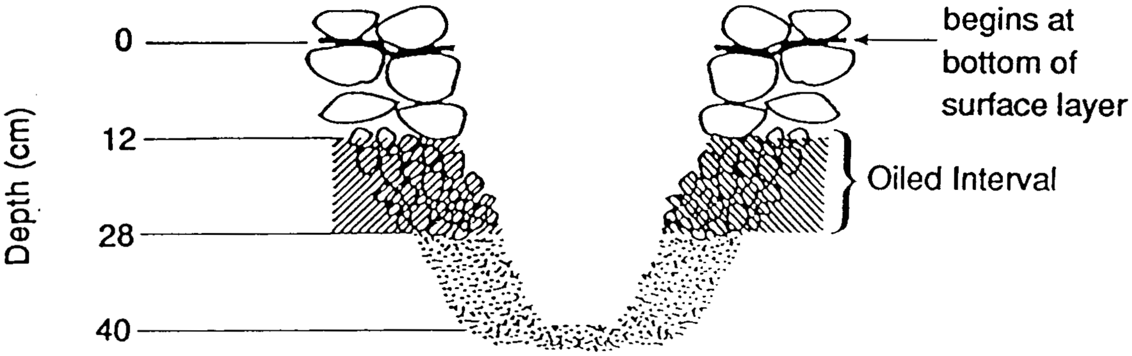
PP = Partially filled pore spaces

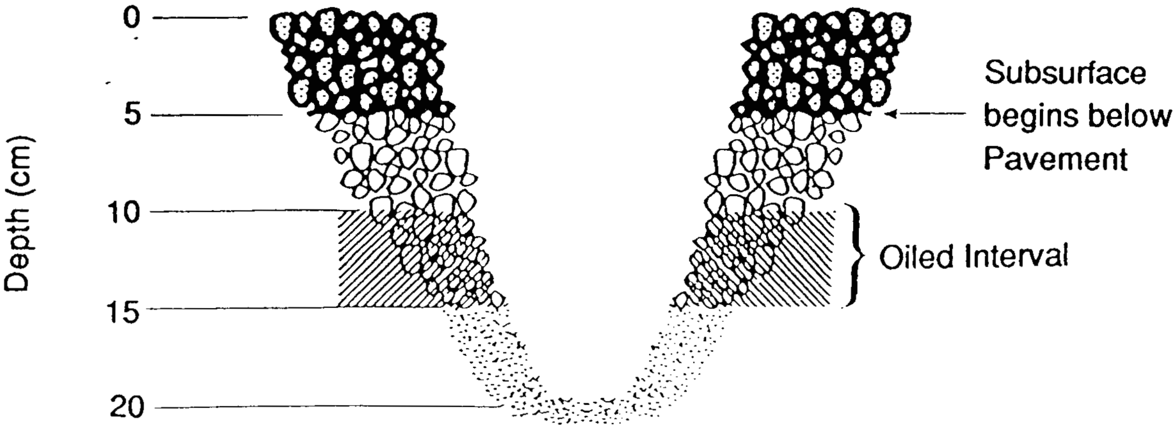
OR = Oil residue

TR = Trace

SUBSURFACE OIL DEFINITIONS


FINE SEDIMENTS


COARSE SEDIMENTS


ASPHALT PAVEMENT

SECTION I.3

ECOLOGY FORMS, DATA SHEETS AND FORM/CODE EXPLANATIONS

BC SHORELINE ECOLOGICAL SUMMARY (SES) FORM

1 Segment No.________ Ecologist____________ Crew No.__________ Page ___ of ____

Date__________ Time____ to____ PST/PDT Photos: Roll________ Frames ____ to ____

2 **CROSS- CHECK OF ATLAS/DATABASE SENSITIVITY INFORMATION**

3 **HABITATS (% of SEGMENT)**

Stable and Rocky Substrates	**Unstable & Non-rock Substrates**
Outer Coast-Protected________	Outer Coast-Protected Sand/Granule________
Open Coast________	Open Coast Sand/Granule/Cobble________
Bay/Estuary________	Bay/ Estuary Sand Flat________
Pilings/Artificial-Protected________	Bay/Estuary Salt marsh (complete MES)________
Pilings/Artificial-Exposed________	Bay/Estuary Mud Flat________
	TOTAL 100%

4 **SPECIES** (use boxes for stable substrates; comment sections for non-rock or unstable substrates)

UITZ Note: C = % cover; M = % of population that is adversely affected by oil; R = % of population that are recent recruits (post-spill)

Fucus	*Ulva*	*Postelsia*	*Littorina*	Limpets	Barnacles				
C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R

Comments: (include comments on location of oil and causes of mortality)

MITZ

Halosaccion	Mussels	Sea star	Anemones	Limpets	Barnacles				
C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R

Comments: (include comments on location of oil and causes of mortality)

LITZ

Laminaria	*Iridaea*	*Alaria*	*Chiton*	Whelks	Sea Star				
C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R	C/M/R

Comments: (include comments on location of oil and causes of mortality)

5 **Shallow Subtidal Zones**

Nereocystis	*Laminaria*	*Zostera*							
as__m band __m offshore	__m band __m offshr	__m band __m offshr	__m band __m offshr	__m band __m offshr	__m band __m offshr	__m band __m offshr			

Comments:

6 **Wildlife Observations**

Taxa	Abundance	Resident	Nesting	Oil coated	Taxa	Abundance	Resident	Nesting	Oil coated
		y / n	y / n	y / n			y / n	y / n	y / n
		y / n	y / n	y / n			y / n	y / n	y / n

7 **Ecological Constraints on Cleanup (check one)**

Standard	Deferred	Holding	Consultation Required	Onsite Monitor

Comments on ecological constraints:

8 **General Comments** (attach additional sheet if needed)

SHORELINE/MARSH ECOLOGICAL SUMMARY (SES/MES)
FORM EXPLANATIONS

Shoreline Ecological Summary (SES) Form

1. Fill in the top section of general information:

   - Segment number
   - Date (D-M-Y)
   - Time (24 hour clock, circle daylight or standard)
   - Crew number
   - Name of the ecologist
   - Photographs collected

2. Cross check information from existing sensitivity atlases and databases with actual conditions. This section should be used for comments on the existing information.

3. Describe the abundance of different coastal ecosystems in the segment. The abundances should total to 100%.

4. Tabulate information on the general character and state of indicator species along the shore in the **SPECIES** section. The form concentrates on sessile algae and animal species which are common in the tidal zones and which can be readily surveyed in the course of the SCAT survey. If necessary, the list of indicator species can be modified during the early stages of a survey. Fill in the names of additional indicator or important species in the extra boxes provided.

   The form requests three numbers (%) for each indicator species within the intertidal zones:

   - **C** is an indication of abundance and can be recorded as either percent **cover,** or individuals per square meter, at the option of the SCAT technical coordinator;
   - **M** is a measure of percent dead individuals, **mortality**; and
   - **R** is percentage of individuals in the most recent **recruiting** class.

   Include specific comments under each shore zone. Comments should include any conclusions about the causes of mortality and the observations which support this conclusion.

5. Supply information on nearshore **shallow subtidal zones.** Since this area is permanently under water it cannot be observed at the same level of detail possible for intertidal areas. The chief indicators chosen for shallow subtidal areas are macroalgae, which can be observed during the survey. Observations on the macroalgae are limited to presence or absence, width

of the algal zone, and distance of the zone offshore. Additional boxes are provided for important additional species.

6. In the **WILDLIFE OBSERVATIONS** section, fill in taxonomic information on:

   - species observed, together with information on their abundance;
   - if the taxa is resident or not;
   - if the species is nesting or denning; and
   - if any individuals are oiled.

   This section can be made quantitative with timed counts at the start, middle, and end of the segment at the discretion of the SCAT technical coordinator.

7. Choose and circle one of the five classes of **ECOLOGICAL CONSTRAINTS** on cleanup activities included on the form. The constraints include two routine categories (Standard and Deferred) and three special categories (Holding, Consultation Required, and On-site Monitor) defined as follows: write in comments, if necessary.

   - **STANDARD CONSTRAINTS** are applied if they are sufficient to safeguard the ecological community for the work that is planned;
   - **DEFERRED CONSTRAINTS** are applied to segments where no oil is present and/or no treatment is planned;
   - **HOLDING CONSTRAINTS** are applied as a tempory measure for sites where treatment is planned, but where the ecological survey is incomplete and/or further survey work is considered necessary;
   - **CONSULTATION CONSTRAINTS** are applied where standard treatment could adversely affect the biological community; and
   - **ON-SITE MONITORING CONSTRAINTS** are applied where high sensitivity or highly vulnerable areas require the presence of an on-site ecological monitor during cleanup.

   Under actual spill conditions, most segments should receive Standard or Deferred constraints.

8. Include general comments on observations.

9. <u>Sketch Maps</u>.
   Prepare field maps of the shoreline to identify the locations of various indicator species, their abundance and state relative to oil location(s). If there in no ARCH on the team, an attempt also can be made to locate human use areas or man-made structures.

BC MARSH/WETLANDS ECOLOGICAL SUMMARY (MES) FORM

1 Segment No.____________ Ecologist____________________ Crew No.____________________ Page _____ of _____

Date____________________ Time______ to _______ PST/PDT Photos: Roll ________________ Frames _____ to _____

2 CROSS- CHECK OF ATLAS/DATABASE SENSITIVITY INFORMATION

3 SUBSTRATE %

Gravel________________ Sand______________ Mud______________ Organic/Peat_______________

4 DOMINANT VEGETATION

Taxa	% of Stand	Flowering	Seeding	Dormant /Dieback	Stems Oiled	Leaves Oiled	Roots Oiled	Zone
Zosteraceae		y / n	y / n	y / n	y / n	y / n	y / n	
Salicornia spp		y / n	y / n	y / n	y / n	y / n	y / n	
Glyceria spp.		y / n	y / n	y / n	y / n	y / n	y / n	
Suaeda		y / n	y / n	y / n	y / n	y / n	y / n	
Armeria		y / n	y / n	y / n	y / n	y / n	y / n	
Atriplex spp.		y / n	y / n	y / n	y / n	y / n	y / n	
Festuca spp.		y / n	y / n	y / n	y / n	y / n	y / n	
Juncus spp.		y / n	y / n	y / n	y / n	y / n	y / n	
Ulva		y / n	y / n	y / n	y / n	y / n	y / n	
Fil.Green Algae		y / n	y / n	y / n	y / n	y / n	y / n	
__________		y / n	y / n	y / n	y / n	y / n	y / n	
__________		y / n	y / n	y / n	y / n	y / n	y / n	

Comments:

5 ASSOCIATED ANIMAL SPECIES

Invertebrates

Taxa	Abundance	Comments	Taxa	Abundance	Comments
Bivalves			Gastropods		
Burrowing shrimp			Crabs		
Amphipods					

Wildlife Observations

Taxa	Abundance	Resident	Nesting	Oil coated	Taxa	Abundance	Resident	Nesting	Oil coated
		y / n	y / n	y / n			y / n	y / n	y / n
		y / n	y / n	y / n			y / n	y / n	y / n
		y / n	y / n	y / n			y / n	y / n	y / n
		y / n	y / n	y / n			y / n	y / n	y / n
		y / n	y / n	y / n			y / n	y / n	y / n
		y / n	y / n	y / n			y / n	y / n	y / n

6 Ecological Constraints on Cleanup

Standard	Deferred	Holding	Consultation Required	Onsite Monitor

Comments on ecological constraints:

7 General Comments

(attach additional sheet if needed)

SHORELINE/MARSH ECOLOGICAL SUMMARY (SES/MES) FORM EXPLANATIONS (concluded)

Marsh Ecological Summary (MES) Form

1. The MES form begins with a top section which is identical to that used for the SES form. Fill in Segment No., ECO, Crew No., Date, Time (circle EST for eastern standard time, EDT for eastern daylight time), Photo roll and frame Nos., and No. of pages.

2. As with the SES form, this is followed by a section for cross-checking information from existing sensitivity atlases and databases with actual conditions. This section should be used for comments on the existing information and can be used in conjunction with maps from the atlases/databases.

3. Characterize the substrate of the salt-marsh. The choices given are sand, mud, and organic/peat; in most cases these should total 100%, but in some cases coarser sediment may be present and this should be noted.

4. Tabulate information on primary producers in the salt-marsh in the section on **DOMINANT VEGETATION** . The table requests information on the:

   - abundance of species in the stand;
   - whether the plants are flowering, seeding or dormant; and
   - whether oil has affected the stems, leaves or roots.

   If necessary this list of indicator species can be modified during the early stages of survey.

5. Include information on invertebrates, birds, and mammals present in the marsh in the section on **ASSOCIATED ANIMAL SPECIES**.

6. Choose and circle the appropriate **ECOLOGICAL CONSTRAINT** using the definitions listed above for the SES form. Add additional comments if necessary.

7. Write general comments about additional observations, information, etc.

8. Sketch Maps.
   Prepare field maps of the shoreline to identify the locations of various indicator species, their abundance and state relative to oil location(s). If there in no ARCH on the team, an attempt also can be made to locate human use areas or man-made structures.

SECTION I.4

HUMAN USE, CULTURAL RESOURCE EVALUATION AND ARCHAEOLOGICAL SITE INVENTORY FORMS, AND FORM EXPLANATIONS

BC HUMAN USE SUMMARY (HUS) FORM

General Information:

Observer/Recorder:____________________

Date:________ Location: ________________ Crew:________________

Segment #:________________ Length:____________ Width:____________

Access Information:

Existing access: Vehicle / Pedestrian

Type: Paved / Gravel / Dirt / Other____________________

Limitations:____________________

Distance to nearest road access: <10 metres 10-1000 metres >1000 metres

Creation or expansion of road access possible: Yes / No

Limitations:____________________

Human Use Information:	Season and Level of Use (L,M,H)					
Type of Activity:	All Year	Summer	Spring	Fall	Winter	Potential Impact
Subsistance						
Agricultural						
Residential						
Recreational						
Industrial						
Commercial						
Natural (no specific use)						

Potential Effects of Oil:

____

____

____

____

____

Comments/Contacts:

____

____

____

____

____

____

____

____

BC CULTURAL RESOURCE EVALUATION (CRE) FORM

Observer/Recorder:____

Date:____________________ Segment:_______________________ Length:_________________________

SURVEY TECHNIQUE:

[ ] Air (A) ______% [ ] Boat (B) ______% [ ] Ground (G) ______%
(Indicate Type on Segment Map)

Surface Visibility: [ ] Good [ ] Obscured _______% By __________________________

Survey Area - Beach: ______m (l) by ______m (w)
Survey Area - Trees: ______m (l) by ______m (w)

Survey Time: Started__________ Ended__________

Comments:____

CULTURAL RESOURCES:

Sites (Borden #/Temp ID): ____

Site Type (Site #W/Borden Codes): ____
Beach Zone: ____
Tree Fringe: ____

Probability of Undiscovered Sites in Subidivision: [ ] L [ ] M [ ] H
Survey Method and Site Probability:
Shore Profile: ____
Fresh Water Sources: ____
Sea Exposure: ____
Access/Safety: ____

CONSTRAINT CONSIDERATIONS:

Recommended Constraint: (check one)	Deferred	Holding	Standard	Consultation and Inspection	On-Site Monitoring

RECORDS:

PERSONNEL
Name:________________________________ Notebook:____________________ Dates:_______________
Name:________________________________ Notebook:____________________ Dates:_______________
Name:________________________________ Notebook:____________________ Dates:_______________
Name:________________________________ Notebook:____________________ Dates:_______________
PHOTOGRAPHS
Roll:________________________________ Frames:____________________ Dates:_______________
Roll:________________________________ Frames:____________________ Dates:_______________
Roll:________________________________ Frames:____________________ Dates:_______________
VIDEOTAPES
Tape:______________________________ Time:_____:_____/_____:_____ Dates:_______________

ATTACHMENTS:

[ ] Segment Map
[ ] Notebook Pages [ ] Photo Logs
[ ] Site Forms for ____

BRITISH COLUMBIA

ARCHAEOLOGICAL SITE INVENTORY FORM

Site No. ________ - ________

Map ______ / ______ / ______

Identification

1. Borden No. ____________ 2. Temporary No. ____________

3. Site Name ____________

Location

4. Location ____________

5. Access ____________

6. Latitude ______ ° ______ ' ______ " N 7. Longitude ______ ° ______ ' ______ " W

8. UTM ______ / ______ E ______ N ______ 9. Air Photo ____________

10. Map ______ / ______ / ______ 11. Other Map ____________

Land Status

12. Legal Description ____________

13. Protection Status ____________

14. Owner ____________

15. Municipality ____________

16. Regional District ____________

17. Ethnolinguistic Area

Site No. ________ - ________

Site Description

18. Site Type

19. Site Dimensions: L ________ m W ________ m

20. Cultural Strata

21. Depth of Cultural Strata: Max ________ Min ________ Med ________

22. Non-Cultural Strata

23. Archaeological Culture

24. Dates

25. Features

26. Present Condition

27. Future Condition

Site No. ________ - ________

Environment

28. Vegetation Zone ____________________

29. Site Vegetation ____________________

30. Drainage ____________________

31. Landforms ____________________

32. Elevation (a)________ m ASL (b) ____________________

Investigations and Collections

33. Collector ____________________ Permit ________

____________________ Permit ________

34. Excavator ____________________ Permit ________

____________________ Permit ________

35. Significant Artifacts ____________________

36. Collections ____________________

37. Photo Record ____________________

38. Published References ____________________

39. Unpublished References ____________________

40. Informant ____________________

41. Recorder ____________________ Date: ____ / ____ / ____

____________________ Date: ____ / ____ /

HUMAN USE SUMMARY FORM (HUS) EXPLANATIONS

Field	**Explanation**
General	
Observer/Recorder	Enter the name of the ARCH or person(s) recording.
Survey Date	Enter the date of the assessment (D-M-Y).
Location	Enter the name of the location or nearest name representing the location.
Crew	Indicate the survey crew number.
Segment #	Enter the appropriate number.
Length	Enter the estimated length of the shoreline segment (m).
Width	Enter the estimated width of the segment, or surveyed area (m).
Access	
Existing Access	Circle vehicle if the segment can be accessed by land vehicle, Circle pedestrian if the segment can only be accessed by foot.
Type	Circle the condition of the existing access, or write in the appropriate condition.
Limitations	Enter any potential limitations of the existing access route, such as heavy equipment, bridge size or limits, or blockage by waterways.
Distance to nearest road	Circle the appropriate distance range to existing road access.
Possibility of Creating Access	Circle yes if it would be possible to build or expand road access to the site, circle no if this is not feasible.
Limitations	Enter any limitations for creating road access such as ecological constraints, waterways, or vegetation.
Human Use	
Season and Level of Use	Indicate either L(low), M(medium), or H(high) in the appropriate season column to indicate the level of seasonal use for the site for each activity listed below: Subsistence - Used for means necessary to maintain life. Agricultural - farming of produce, livestock.

HUMAN USE SUMMARY FORM (HUS) EXPLANATIONS

Field	Explanation
	Residential - Private residence (seasonal or year-round), Indian reservation, subdivision, trailer park.
	Recreational - Park (National, provincial, city, private, historic), campground, picnic area, public fishing/shellfish, swimming beach, scuba diving (including underwater parks), windsurfing, hunting, boat ramps, kayaking, hiking/bicycling trails, scenic overlook, arboretum.
	Industrial - factory, oil pier, container terminal/cranes, naval shipyard, shipbuilding, dry storage, grain terminal.
	Commercial - Commercial or tribal mariculture, marinas, moorage landings/slips/buoys, marine terminal, ferry landing, customs port of entry, water intake, restaurant, shop, aquarium.
	Natural - no specific human use; also wildlife refuge or preserve.
Potential Impact	Indicate the estimated level of impact (Low, Medium, High) for each human use listed. Enter any relevant comments that could assist in assessing impact on human use activities or structures in comments section below.
Potential Effects of Oil	Write comments concerning any type of human use that could be affected by oil at the site, or any man-made structures such as bulk heads, rip-rap, piers, seawalls, bridges.
Comments/Contacts:	Write additional comments; also note names of contacts made or agencies to contact regarding the site.

CULTURAL RESOURCE EVALUATION (CRE) FORM EXPLANATIONS

Field	Explanation
General	
Observer/Recorder:	Enter name.
Date:	Enter date of field evaluation (D-M-Y).
Segment:	Enter segment number.
Length:	Enter length of segment (m).
Survey Techniques: [ ] Air (A) ___% [ ] Boat (B) ___% [ ] Ground (G) ___%	Indicate (x) all survey modes employed and percentage of shoreline unit covered by each technique.
Surface Visibility: [ ] Good ___% [ ] Obscured ___% [ ] By __________	Indicate (x) visibility of surface; if obscured, indicate percentage and source (*Fucus*, drift, oil, etc.).
Survey Area Beach:	Record length and width of beach area surveyed in ___m (L) by ___ (W) meters.
Survey Area Trees:	Record length and width of tree fringe surveyed in ___m (L) by ___ (W) meters.
Survey Time: ________ Started ________ Ended	Record time (24hr clock - indicate standard or daylight savings time) when survey began and ended.
Comments:	Describe survey procedure, indicating coverage limitations and observations on cultural resources.
Cultural Resources	
Sites (BORDEN/Temp ID):	Record known sites using existing designations (Borden nos.) and temporary field numbers assigned to new sites..
Site Type: Beach Zone Tree Fringe	Record site types observed in the beach and fringe zones.
Prob. of Undisc. Sites:	Indicate the probability (Low, Medium, High) of undiscovered sites in the segment.
Survey Method:	

CULTURAL RESOURCE EVALUATION (CRE) FORM EXPLANATIONS

Field	Explanation
Shore Profile	Characterize the alongshore profile of the segment.
Freshwater Sources	Indicate number of water sources and record on segment map.
Sea Exposure	Characterize degree of exposure to water (exposed, semi-exposed, protected).
Access/Safety	Comment on access and safety considerations for segment.
<u>Constraint Considerations</u>	Comment on important factors to be considered in determining the level of constraint necessary for protection of cultural resources. Circle the recommended constraint category.
<u>Records</u>	
Personnel:	
Name	Enter name of archaeologist(s) conducting evaluation
Notebook	Record notebook and page numbers containing information on segment
Date	Record date(s) of entry (D-M-Y)
Photographs:	
Roll and Frame	Record roll and frame number(s) for all photographs taken in segment
Date	Record date(s) of videotapes (D-M-Y)
Videotapes:	
Name	Enter name of archaeologists conducting videotaping
Time	Record time on video camera counter
Date	Record date(s) of videotapes (D-M-Y)
Attachments:	Indicate (x) all attachments that accompany this form; record site number for attached site forms
[ ] Segment Map	
[ ] Notebook Pages	
[ ] Photo Logs	
[ ] Site Forms	

TYPES OF ARCHAEOLOGICAL CONSTRAINTS

Category	Archaeological Constraint
Deferred:	If treatment is planned, **a cultural resource evaluation is required prior to shoreline treatment.**
Holding:	Cultural resource survey in progress. **Shoreline treatment cannot proceed** until field data have been assessed and a formal archaeological constraint entered on the shoreline evaluation form.
Standard:	**If cultural resources are uncovered** during shoreline treatment, stop work in the vicinity, mark the location of the find and **contact the Archaeological Program Director immediately.**
Inspection:	Consultation and inspection with an **accredited archaeologist is required prior to treatment.** Specific on-site monitoring requirements will be determined at that time.
Monitor:	**An archaeological monitor is required on-site during shoreline treatment.**

BC ARCHAEOLOGICAL SITE INVENTORY FORM EXPLANATIONS

IDENTIFICATION

Field		Explanation
1.	Borden No.	Leave blank. An alpha-numeric number (e.g. DcRv-3) is assigned by the B.C. Archaeology Branch after site forms have been submitted.
2.	Temporary No.	Enter a temporary site number (e.g. DcRv-T15) in the field, prior to issuance of a Borden No. by the Archaeology Branch.
3.	Site Name	Enter a name for the site. Use of Native placenames is preferred.
4.	Location	Describe exact location of the site, using general to specific reference points.

LOCATION

5.	Access	Describe the best method for relocating the site in the field; this information should complement locational information.
6.	Latitude	Calculate site location to the nearest second.
7.	Longitude	Calculate site location to the nearest second.
8.	UTM	Calculate site location on the Universal Transverse Mercator Grid present on most NTS maps.
9.	Air Photo	Record all appropriate air photos that show site location.
10.	Map	Record appropriate 1:50,000 NTS map on which site is located.
11.	Other Map	Enter name, number, issuing agency, and scale of other maps relevant to the site.

BC ARCHAEOLOGICAL SITE INVENTORY FORM EXPLANATIONS

Field	Explanation
LAND STATUS	
12. Legal Description	Enter full legal description of land parcel relevant to the site.
13. Protection Status	Leave blank. Information on the protection of a site by legal means is entered by the Archaeology Branch.
14. Owner	Enter name and address of owner of the property on which the site is located.
15. Municipality	Enter the name of the town or village (if unincorporated), or the name of the municipality (if incorporated) from list in the "Form Guide".
16. Regional District	Enter the name of the Regional District from list in the "Form Guide".
17. Ethnolinguistic Area	Enter the appropriate ethnolinguistic unit from map and list in the "Form Guide".
SITE DESCRIPTION	
18. Site Type	Enter type, subtype, and descriptor terms for site from typology for prehistoric and historic sites presented in "Form Guide".
19. Site Dimensions	Enter maximum length and width of site (m).
20. Cultural Strata	Describe the strata containing cultural materials from top to bottom and the basal sterile deposits.
21. Depth of Cultural Strata	Enter the total combined depth of all cultural and non-cultural strata from top to bottom in (m).
22. Non-Cultural Strata	Describe the colour, composition, and texture of the naturally-deposited (non-cultural) strata typical of the area surrounding the site.

Field		Explanation
23.	Archaeological Culture	Record the archaeological culture(s) thought to be represented at the site and note the stratigraphic context of each culture.
24.	Dates	Record the age of the site as determined by absolute and relative dating methods.
25.	Features	Enter the types and numbers of major features (cultural remains which normally cannot be removed without destroying them) at the site and describe the most significant features in detail.
26.	Present Condition	Describe the present condition of the site, year of assessment, depth range (m), and primary source of disturbance.
27.	Future Condition	Enter year of assessment, source, and probable date of disturbance, and person or agency responsible if source is human in origin.
28.	Vegetation Zone	Enter appropriate Biogeoclimatic Zone heading from list provided in the "Form Guide".

ENVIRONMENT

29.	Site Vegetation	Enter the names of the dominant flora at the site under Tree, Shrub, and Herb headings, list flora from most to least abundant, use common names followed by Latin names in parentheses, and note any significant vegetation patterns.
30.	Drainage	Enter the drainage associated with the site from map and list provided in the "Form Guide".

BC ARCHAEOLOGICAL SITE INVENTORY FORM EXPLANATIONS

Field		Explanation
31.	Landforms	Describe briefly the significant topographical, geological, and terrain features in the general area of the site.
32.	Elevation	Record (a) the elevation of site above sea level (m), and (b) other elevations of significance to the site, including elevations above local topographic features such as highways, valley bottoms, and lakes.

INVESTIGATIONS AND COLLECTIONS

33.	Collector	Enter the names and Permit numbers of past surface collectors from previous site survey forms or other immediately available sources, including the present project if cultural materials were collected.
34.	Excavator	Record all excavations of the site, including name, Permit number, and year of investigation if no Permit was issued for the work.
35.	Significant Artifacts	Record artifacts and other cultural materials of outstanding significance and, if known, identify the associated archaeological culture or stratum number of each.
36.	Collections	Enter the name and Permit number of the Surface Collector or Excavator of the site and provide information on the method of investigation; an estimate of the percentage of the site area collected, tested, or excavated; the repository for the collection; and catalogue numbers of cultural materials recovered from the site.
37.	Photo Record	Enter the photographer's name, date (y/m/d), location, and roll and frame number(s).

BC ARCHAEOLOGICAL SITE INVENTORY FORM EXPLANATIONS

Field		Explanation
38.	Published References	Reference all publications specifically related to the site by name, year, title, and, if applicable, journal title, publisher, and page numbers.
39.	Unpublished References	Enter relevant Permit or Ministerial Order reports, unpublished theses, manuscripts, etc.
40.	Informant	Record the names and addresses of any persons having special knowledge about the site.
41.	Recorder	Enter the names and dates (y/m/d) of all records of the site starting with the earliest record.

SECTION I.5

GENERAL ANCILLARY FORMS

MAILRUN MANIFEST

Submit to Command Centre

Vessel/Aircraft Tail No.: ____________________

Date: ____________________

Captain/Pilot: ____________________

Crew No.: ____________________

OG/Operations Rep.: ____________________

SEGMENTS IN PACKET -

DAILY REPORT

TO: Submit to Command Centre

cc. Operations

Survey Crew No.: ______________

OG: ______________

Vessel/Helo: ______________

Date: ______________

SEGMENT NO.	LOCATION	SURVEY COMPLETED (Yes/No)	PAPERWORK COMPLETED (Yes/No)

Plans for tomorrow:

Comments/Needs:

Pg______of______

BEACH ELEVATION AND OIL COVER MONITORING FORM

Date (D/M/Y): ____________________ Location: ____________________________________

Time Start (24hr): ___________ Low Tide Time: ________(PST) Transect #: __________

Azimuth___________(mag) Distance from Azimuth Controlling Stake______________m

Azimuth between Stake ____________and ____________is N___________degrees (mag)

Observer: ____

DISTANCE	ELEVATION	OIL COVER	COMMENTS/PIT INFORMATION:

By:___________________