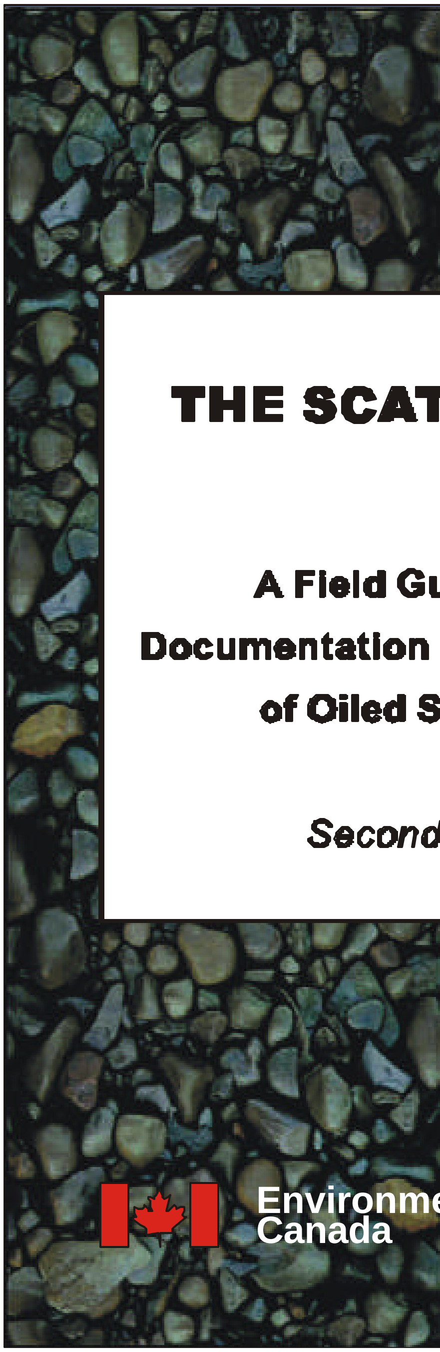

THE SCAT MANUAL

A Field Guide to the Documentation and Description of Oiled Shorelines

Second Edition

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A Field Guide to the Documentation and Description of Oiled Shorelines

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May 2000

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PREFACE TO SECOND EDITION

The Shoreline Cleanup Assessment Team (SCAT) approach and documentation protocols were developed initially more than ten years ago during the *Nestucca* and *Exxon Valdez* spill response. Subsequently, Environment Canada developed generic second-generation SCAT protocols to standardize the documentation and description of oiled shorelines (Owens and Sergy, 1994). In recent years, SCAT has become an integral component of spill response in Canada, the USA and several other countries. It has been used on many spills, in a variety of ways, and modified by SCAT teams to meet a range of specific spill conditions. This experience identified a number of items or areas in need of update, modification or clarification and led to the production of this revised "SCAT Manual". This second edition has incorporated the experience of recent usage and also endeavors to address divergences that have occurred due to adaptation by different agencies and on different spills.

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THE SCAT FIELD MANUAL

What is SCAT ?

As part of an oil spill response, Shoreline Cleanup Assessment Teams (SCAT) systematically survey and document the affected area to provide a rapid and accurate geographic picture of shoreline oiling conditions. The information is used to develop real-time decisions regarding shoreline treatment and cleanup operations.

SCAT surveys have become an important standard component of spill response management in North America. They may be applied to spills in both marine coastal and freshwater environments. The survey uses a set of specific and standard terminology to describe and define shoreline oiling conditions. However, the SCAT process itself is a flexible approach and the assessment activities are designed to match the individual spill conditions (see the case studies described in Section 2.3).

Basic principles that govern a SCAT survey are:

- ***a systematic assessment of all shorelines in the affected area***
- ***a division of the coast into geographic units or 'segments'***
- ***a set of standard terms and definitions for documentation***
- ***a team of interagency personnel to represent the various interests of the responsible party, land ownership, land use, land management, or governmental responsibility***

The systematic approach provides for consistent data collection. This allows a comparison of data and observations between different sites and between different observers. These data also provide the basis for cleanup evaluation. In most surveys, the SCAT teams complete forms and sketches for each segment in the affected area. A standard Shoreline Oiling Summary form has been developed for documentation and this basic form often is modified for different environmental or spill conditions. Frequently, the SCAT teams are asked to provide recommendations or advice regarding appropriate cleanup methods and also to define constraints or limitations on the application of cleanup techniques, so that the treatment operations do not result in additional damage to the shore zone.

SCAT surveys provide a geographic or spatial description and documentation of the shoreline oiling conditions. In cases where the same section of coast is surveyed repeatedly, should oiling conditions persist for a lengthy period of time, or when a systematic time-series of oiling conditions at one or more locations is required, a monitoring program can use the same procedures, terms and definitions as the SCAT survey.

The Field Guide

The first complete manual for SCAT surveys was developed by Environment Canada (1992), followed by production of a more simplified Field Guide (Owens and Sergy, 1994). Other agencies have adopted the approach and produced similar field forms and manuals (e.g., European Commission – Jacques *et al.*, 1996: NOAA, 1998a). This second edition of the SCAT manual (May 2000) builds on recent applications during spill operations. The guide uses this experience to update the standard field forms. This revision process has been interactive with the U.S. National Oceanographic and Atmospheric Administration (NOAA) so that the revised field forms recommended by Environment Canada and NOAA are directly compatible in format and content.

SCAT survey procedures are flexible and this manual provides guidelines for the design of a survey program to fit a wide range of spill situations. The scope and scale of a shoreline assessment survey is governed by a range of parameters that include: the coastal character and configuration, the type and amount of spilled oil, the size of the affected area, and the needs of the response organization. The application of the SCAT approach on numerous spills worldwide has provided experience which is reflected in the guidelines and recommendations presented in this manual.

Format of the Field Guide

PART 1   PROCEDURES AND FORMS

1.1 PURPOSE AND OBJECTIVES OF SCAT

Shoreline Cleanup Assessment Team (SCAT) surveys conducted by trained SCAT teams provide information to build a spatial or geographic picture of the regional and local oiling conditions. The objective of the survey program is to describe and document the shoreline oiling conditions accurately and in a format that can be easily interpreted and applied by planners and decision makers.

This information on shoreline conditions provided by the SCAT survey team(s) is used in the decision process to:

- identify oiled and non-oiled areas
- describe location, character, and amount of stranded oil
- evaluate operational and logistical factors
- establish shoreline treatment priorities
- establish treatment standards or criteria
- propose treatment or cleanup methods

The information on shoreline oiling conditions is presented using a set of ***standard terms and definitions***, so that the potential for misunderstanding or misinterpretation is minimized. In this manner, the shoreline oiling condition terms "heavy" or "light" have a specific definition rather than reflecting a general descriptive opinion. The use of this defined terminology also enables a direct comparison to be made between segments and can be used to define how conditions change through time within the same segment.

1.2 PLANNING A SCAT SURVEY

Some of the ingredients for a successful SCAT program include:

- suitable ***training*** and calibration for observers and the SCAT Coordinator
- ***appropriate segmentation*** of the shoreline
- ***flexibility*** to adapt the basic concept for individual spill conditions and oiling characteristics
- procedures that are as ***simple*** as possible, yet provide sufficient information to meet the requirements of the decision makers, planners and operations crews

- a process that is ***efficient*** to ensure that information is processed and communicated in a timely manner
- establishment of a ***data management*** system early in the program
- ***integration*** of key players who represent the response team

1.2.1 Scope of SCAT Surveys and Programs

SCAT surveys can be conducted:

- on spills of different oil types, and with different types of shoreline oiling conditions
- on spills of different sizes, from small to large
- in different environments, including marine, freshwater and terrestrial
- by different methods, both aerial and ground level
- in various levels of detail, from simple single-discipline surveys to complex programs with geomorphological, ecological and cultural resource components

SCAT information describes:

- the ***shoreline types and coastal character*** (see Section 3.1.3)
- real-time shoreline ***oiling conditions***
- real-time ***environmental, cultural, archaeological, human use, or economic issues or constraints*** that might affect operations activities in an oiled segment or at staging locations

This real-time assessment is different from the information that may be available from pre-existing maps or databases as it is current at the time of the spill response operation and probably more accurate in terms of the level of detail on a segment-by-segment basis.

The design of a SCAT program considers:

- the ***size and character of the affected area*** (see Section 1.2.2)
- the individuals or the ***representatives*** who will participate (see Section 1.2.3)
- if the survey team is responsible for the development of ***treatment or cleanup recommendations*** (see Section 2.1.2)
- if the survey team is responsible for the ***development of treatment or cleanup standards*** or ***criteria recommendations*** (see Section 2.1.3)

1.2.2 Scale and Method of Surveys

Shoreline surveys can be conducted by different methods and at different scales depending on the size of the affected area, the character of the coastal area, and the level of detail that is required.

Survey Method	Key Objectives
Aerial Reconnaissance	• define the overall scale of the problem to develop regional objectives • mapping or documentation not required
Aerial Survey	• systematically document or map to (i) create segments, (ii) develop regional strategies and plans, and (iii) define lengths of oiled shorelines
Systematic Ground Survey	• systematically document shoreline oiling conditions in all segments within the affected area
Spot Ground Survey	• systematically document shoreline oiling conditions for selected segments within the affected area

AERIAL RECONNAISSANCE

Purpose: to make specific observations, but not to map or document the oiling conditions, so that relatively large areas can be covered in a relatively short time period.

Aerial reconnaissance can provide a general picture on the extent and character of the oiled shorelines (see also Section 1.3.3). This information is critical to develop regional objectives and to define the overall scale of the potential response operation.

AERIAL SURVEY

Purpose: to prepare a map or maps that show the locations of stranded oil and the distribution and character of that oil.

An aerial survey documents the oiling conditions in a systematic manner (see also Section 1.3.3). Aerial surveys, which typically use videotape mapping techniques, can cover an extensive area to provide a level of detail of sufficient accuracy for mapping purposes. This information is the foundation for the development of regional strategies and plans, for segmentation of the shoreline, and for the definition of lengths of oiled shoreline in terms of shoreline types and the oil character.

A systematic low-level aerial videotape survey may be the only practical method available to survey some areas with inaccessible shorelines or on coasts where access is limited or difficult.

SYSTEMATIC GROUND SURVEY

Purpose: to systematically document shoreline oiling conditions in all segments within the affected area and to complete shoreline oiling summary forms and generate sketch maps for each segment.

A ground survey team or teams systematically assess each segment in the affected area to accurately determine the location, character and amounts of surface and subsurface oil (see also Section 1.3.4). Shoreline oiling summary forms are completed, sketch maps generated and photographs or videotapes record the oiling conditions.

If more than one survey team is in the field, or if the assessment team(s) do not have sufficient time to complete a field summary or report, a SCAT Coordinator or SCAT data manager should be responsible for this activity so that the information is produced and distributed to Planning and Operations in a timely manner.

SPOT GROUND SURVEY

Purpose: to systematically document oiling conditions for selected segments within the affected area and to complete shoreline oiling summary forms and generate sketch maps for those segments.

A spot ground survey can focus on specific locations if the aerial reconnaissance or the systematic aerial survey identifies discontinuous oiling conditions or if treatment or cleanup is planned only for selected segments within the affected area. Shoreline oiling summary forms are completed, sketch maps generated and photographs or videotapes record the oiling conditions. In some cases (see, for example, the *Buffalo 292* case study in Section 2.3), a simplified survey approach may involve a spot ground assessment with a verbal report of the oiling conditions. When observations are reported in this manner, the use of standard terms and definitions becomes an essential part of the communications process.

Number of SCAT Teams

A common question is how to define an appropriate level of effort for a SCAT ground survey field program. On a small spill, or one that is very restricted in area, if the affected segments can be covered in one day by one team, then usually that is all that is required. As the size of the affected area increases, the requirement for more teams depends on the complexity of the affected area and the required turn-around time for the information. If Planning or Operations require data for an area to prepare the assignments for the next day, then the appropriate scale is "**however many teams it takes to cover that area in time to provide the information**".

A small scale operation would be, for example, a spill that affects less than 50 km of coast or a length of coast that can be surveyed in one to two days with one or two teams. A larger area or longer coast survey probably would involve more field teams and office-based data management support. In addition, it is important to consider a situation that might involve rapidly changing (day to day) oiling conditions that would require multiple teams to resurvey the same segments on a regular basis. Areas where access or alongshore movement is difficult, or where buried or penetrated oil requires the digging of pits and trenches, can take considerably more time to survey than a straight, flat, wide, sand beach segment. De Bettencourt *et al.* (1999) suggest three general scales for a SCAT program:

- a small spill where the size and complexity require ***one to three field teams*** who can provide information in a simple format and communicate this by telephone or radio (see *Nestucca* and St. Petersburg Beach case studies — Section 2.3)
- an intermediate scale where as many as ***five teams*** may be required to cover the affected area, using standard forms; this scale would require a data management component (see Komi pipeline and *New Carissa* case studies — Section 2.3)
- a large or complex spill incident that would require ***many integrated and calibrated SCAT teams*** (see *Exxon Valdez* case study — Section 2.3)

1.2.3 Participation in SCAT

The management of a spill response operation is a cooperative effort that involves national, regional, and local government agencies, as well as the organization responsible for the spill or a response contractor acting on behalf of that organization. Many government agencies have a legal responsibility for the coastal zone, and non-governmental organizations or local land owners or managers have a direct interest in the condition of the shorelines. The information that is collected by the SCAT teams is of interest to many or all of these agencies or groups and often they wish to be represented on the field surveys.

Practical considerations limit an assessment team to two or three, and occasionally four or five participants. The ideal composition of a team would combine:

- an individual with ***oil spill experience*** and ***SCAT training*** who can identify and document oil on the shore from the air or on the ground
- an individual familiar with the ***coastal ecology*** of the affected area and who can document the impacts of the oil and can recommend priorities, and cleanup end points
- in areas where the potential exists for ***archaeological or cultural resources,*** a ***specialist*** who can advise on precautions and constraints to protect those resources
- a representative from the ***operations*** group who can identify feasibility issues, logistical constraints and solutions, and who can evaluate the types of resources and level of effort that might be required for cleanup or treatment of a segment

For the efficiency of a field survey, it is important to have a local knowledge of the coastal region and often it is possible to include this with one or more of the team assignments. For example, a government agency biologist familiar with the affected area would be a valuable member of a field team.

First Nations representatives or other land owners and managers also can provide a local knowledge and understanding of issues and priorities that contributes to the knowledge base generated by the SCAT team.

When more than one team is in the field, or if the field team is in a remote location and cannot return daily to report their observations, a SCAT Coordinator provides the link between the field teams and the spill management team.

When it not possible for agency or other representatives to participate directly in the field surveys, for practical or other reasons, a review team or committee can be established to develop recommendations for priorities based on the information generated by the field teams (e.g., Knorr *et al.*, 1991).

1.3 FIELD ACTIVITIES

1.3.1 Shoreline Segmentation

The essential first step is to divide the coast into working units called segments, within which the shoreline character is relatively homogeneous in terms of physical features and sediment type. Each segment is assigned a unique location identifier. Segment boundaries are established on the basis of prominent geological features (such as a headland), changes in shoreline or substrate type, a change in oiling conditions, or establishment of the boundary of an operations area.

Segment lengths are small enough to obtain adequate resolution and detail on the distribution of oil, but not so small that too much data are generated. Most segments in oiled areas would be in the range of 0.2 – 2.0 km in length.

A common mistake is to place the boundary in the middle of a stream, river, or inlet. As a “rule of thumb”, where there is a stream, river, or an inlet at the coast, it is preferable to make that stream, river, or inlet a separate segment so that it has its own physical and ecological identity. In some cases, it may be appropriate to have two separate segments, one for each side of the channel, so that data users then do not have to decide if the observed oiling conditions refer to one or other or both sides of the entrance/outlet.

A second “rule of thumb” for segmentation is to divide the coast on the basis of practical aspects that can be used by Planning or Operations teams to deploy cleanup crews. On a long, uniform coast, a segment may be either centered on access points, with a boundary midway between two access points, or defined on the basis of distance and marked with flags.

SEGMENTS are: • distinct alongshore sections of shoreline which can be used as operation units • relatively homogeneous in terms of physical features and sediment type • identified by a unique location code • bounded by prominent geological or operational features, or by changes in shoreline type, substrate type or oiling conditions
SUB-SEGMENTS are created if: • ***alongshore oiling conditions vary*** significantly within a pre-designated segment, • ***alongshore oiling conditions change*** through time within a segment during a spill incident, or • there is an ***operational division boundary*** within a segment.

Segments are identified by a numbering scheme. In the case of a survey covering an extensive area an alpha-numeric scheme may be appropriate, with an alphabetical prefix keyed to a geographic place name (e.g., AH = Arichat Harbour) followed by a number based on an alongshore sequence (AH-24). Segmentation may already exist as part of a pre-spill planning exercise or sensitivity mapping database (see Section 2.2.1). If this is the case, the segments should be reviewed for suitability alongshore because the segment boundaries may need to be adapted to existing spill conditions. Predesignated segments could be subdivided if oiling conditions vary significantly alongshore within the segment. Subdivisions can be identified by a suffix, e.g., AH-24A, AH-24B.

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

Variations in across-shore oiling conditions are documented on the Shoreline Oiling Summary forms as **ZONES**. For consistency, zones are numbered from the lower sections of the shore zone up the intertidal zone to the backshore (see examples in Section 3.2).

1.3.2 Field Equipment Checklist

The following is a checklist of equipment that can be used by the field teams.

<u>Survey Gear</u>

- waterproof paper (8½" x 11") for field forms, sketch maps, field notebooks (waterproof)
- job aids (see Section 3.2)
- office supplies; pencils, paper, waterproof markers, rulers, paperclips, clipboard
- segment maps and base sketch maps (if available), topographic or nautical charts of area
- compass, liquid filled, 1-degree graduations, Brunton types are preferable if bearings are recorded
- shovels; folding or clam, preferably, with the pick on the backside
- Global Positioning System (GPS) receiver (hand held, portable)
- tape measure or range finder (hand held, 0-500 m or greater range)
- 35mm or digital camera with date back
- film, water-tight film bags, Kodachrome (slide), Kodacolor (print) or equivalent recommended, generally, the use of Ektachrome near water is not appropriate
- video camera and videotapes, if required
- batteries, charged battery packs (for cameras, radios, etc.)
- photo scale with 1-cm increments, 10 cm long for close-ups
- day pack (water-proof)
- communication equipment (hand-held 2-way radio(s), VHF Marine (5 watt), cellular phones)

Survival Gear
- first aid kit, water
- shotgun & shells; 12-gauge pump, slugs & buckshot, if needed for protection
- personnel flotation device (PFD)/exposure suit, floater suit/float coat
- for remote areas, EPIRB (Emergency Position Indicating Radio Beacon) and survival equipment (hunter's survival kit or better)

Personal Gear
- rain gear
- sun screen, hat, rubber boots, non-skid soles
- gloves & liners, waterproof, work type; high quality

1.3.3 Aerial Surveys

The purpose of an ***aerial reconnaissance*** is to provide an overview of the distribution of the oil. Detailed observations and mapping are not required, in most cases, although as much information should be recorded as is possible within the scope and time frame of the survey.

An aerial reconnaissance requires prior experience as this technique relies heavily on the ability of the observer(s) to identify substrate materials and oil and to distinguish oil from the many other materials of similar colour and texture that occur naturally on the shoreline (lichen, mussel beds, heavy mineral deposits, stranded seaweed or sea grasses, peat, etc.).

Typical steps for an ***aerial reconnaissance*** include:

- define the low-tide window
- decide on area or segments to be surveyed, the flight line direction and associated logistics
- collect all necessary equipment and supplies
- review existing information and data
- brief all team members on the survey's objectives, methodology, and safety concerns
- take photos (or record videotapes if planned)

- fill in flight-line maps, appropriate forms, etc., record GPS waypoints, or take notes to be able to complete forms later
- discuss assessments / major observations prior to return from the survey
- finalize and copy all maps, forms, field notes and photo/ tape logs
- submit copies to the SCAT Coordinator or Data Manager
- file a daily report form with the SCAT Coordinator
- review day's activities, discuss improvements, and prepare for next day, if necessary

The purpose of an ***aerial survey*** is to systematically document the oiling conditions. Experienced observers can distinguish oil while flying at low altitudes (less than 100 m) and low speeds (less than 150 km/hr). Aerial surveys, which typically use videotape mapping techniques, can cover an extensive area and generate very detailed information for databases and shoreline maps. This information is the foundation for the development of regional strategies and plans, for segmentation of the shoreline, and for the definition of lengths of oiled shoreline in term of shoreline types and the oil character.

Aerial videotape surveys require prior experience as this technique relies heavily on the ability of the observer to identify substrate materials and oil characteristics continuously and to record this information on the audio channel of the recorder while using the tape or digital camera to record the section of shoreline that is being described by the commentary. An experienced assistant provides support to change tapes and log locations or to manage the automatic processing of GPS way points. Mapping from the videotapes can provide a level of detail on the order of meters if the flight height and speed are suitable and if the commentary and videotape imagery are of suitable quality. The data are only as good as the flying conditions permit and as the experience and skill of the camera operator/commentator.

Key elements of a successful ***aerial videotape mapping survey*** include:

- flight-path planning with respect to (tidal) water levels, sun angles, and flying altitude
- communication with the pilot regarding flying height and distance from shore to minimize camera work (e.g., use of the zoom lens) and to ensure complete coverage
- a “rule of thumb” that a point on the ground passes through the video image for approximately six seconds
- accurate flight-line data that are linked to the tapes (for example, automatic GPS data logging)
- ground calibration where it is difficult to distinguish shoreline features
- continuous commentary using the video image as the background for the observations that are documented on the audio channel
- open-window or open-door for the camera and a mouth-microphone for the observer (to minimize wind sounds)

The procedures are described in more detail by Owens and Reimer (1991).

1.3.4 Ground Surveys

In general, a ground survey should be a coordinated effort between the Planning and Operations sections to ensure that the areas to be covered represent the regional priorities and also provide information for upcoming (e.g., following day) operations activities.

General elements of a ground survey include:

<u>Pre-Survey Planning</u>

- Divide shoreline into segments, or adapt existing segmentation (see Section 1.3.1)
- Create segment numbering scheme (match to Operations divisions or vice-versa)
- Decide on segments to be surveyed based on survey priorities, logistics, and low-tide window, and associated logistics

- Select alternate areas in case weather conditions prevent access to primary target(s)
- Collect all necessary equipment and supplies
- Review existing information and data
- Brief all team members on objectives, methodology, forms, and safety concerns

<u>On-Site Activities</u>

- Conduct segment overview; gain an overall perspective
- Complete observations and measurements of the segment
- Take photos and/or videotapes
- Draw sketch maps
- Fill in required forms, or take appropriate notes to be able to complete forms later
- Discuss assessments / major observations prior to departure

<u>Post-Survey Activities</u>

- Finalize and copy all forms, maps, field notes and photo/ tape logs
- Submit copies to the SCAT Coordinator or Data Manager
- File a daily report form with the SCAT Coordinator
- Review day's activities, discuss improvements, and prepare for next day, if necessary

Specific details of the on-site activities within each segment include:

<u>Segment Overview on Arrival</u>

- On arrival at the site, traverse the entire segment by skiff or helicopter, or if operating from a vehicle, view the segment from an elevated vantage point in the backshore to:
  - verify if the pre-determined 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 working from vessel or aircraft, conduct a radio check before departing and agree on calls, channels, and ETA's (estimated times of arrival) with the captain or pilot.

Survey Strategy

- Once on shore, the team 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 of ecological or cultural resource features.
  - On short segments: walk the entire segment while making general observations and then return to areas that require more detailed documentation.
  - On long segments: it is more efficient to make extensive notes as team members progress along the shore, to avoid backtracking.
- Site activities consist of systematic observing, collecting and documenting of the information on field forms, sketches, maps, and by photo and videotape recording (VTR) methods.
- Completion of the Shoreline Summary Form (Section 1.5) focuses on the physical aspects of the shoreline and the oiling conditions (typically, the mid- and upper-intertidal zones).
- If present, an ecologist would focus on the biological environment, and typically would concentrate near the lower intertidal/swash zone (usually the most ecologically productive area).
- If present, an archaeologist would typically focus on the supratidal and backshore regions, as this is where most archaeological or cultural features would be found.

- If operations or agency personnel are present on the assessment team, then they can assist in a variety of ways (e.g., photos, measuring, documentation, digging pits, etc.) as well as assessing operations features such as access, potential staging areas, safety issues etc.
- Sketch maps are generated (see Section 1.6) and photos/videotapes taken.

Prior to Departing the Site

- As a team, review the individual assessments and discuss treatment or cleanup options, to ensure nothing has been overlooked, and reach agreement on major points. At a minimum there must be a consensus on oil character and distribution.
- Check that forms and sketch maps are complete and consistent, or ensure that adequate notes and measurements have been taken to complete them later.
- Ensure that all photographs and videotapes have been accurately logged in the field notes and that all of the documented and unusual features of the segment have been photographed.
- Check that all equipment, survey gear, personal items, and litter are taken when leaving the site.

1.3.5 Monitoring Programs

As part of the SCAT program, repetitive surveys can be used to provide a temporal picture of changes in oiling conditions. Monitoring surveys can be conducted to:

- Document conditions where oil continues to wash ashore over an extended time period (weeks or longer)
- Assess changes in shoreline oiling conditions over time (days to months) which result from treatment and cleanup activities (by man) and/or natural self-cleaning processes
- Evaluate the effectiveness (performance and effects) of treatment decisions and options which were applied to oiled shorelines
- Investigate environmental processes which affect the fate, behaviour and effects of oil or of treatment methods on shorelines

The basic steps of a monitoring program are to:

- Identify the extent of the area to be repeatedly surveyed
- Select areas or transects to be monitored and the monitoring time interval
- Place backshore markers that will remain for the duration of the monitoring
- Establish the survey procedures and develop appropriate forms to record the measurements and observations

Time-series monitoring usually involves a set of repetitive observations and measurements that are taken in a consistent and systematic manner, at a known point or points, over selected time intervals. Typically, the observation and measurement points are on fixed transects or across-shore profile lines and beach elevation surveys are measured in conjunction with oil monitoring. Stakes, rebar, or other types of resistant material are used to mark the transects and may be surveyed relative to each other and to a common datum (vertical reference point).

One option for beach profiles is to use the pole and horizon method to obtain 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. 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.

Oil cover estimates can be obtained by observing the surface oil distribution, to the nearest 5%, over a 2.5-m swath on either side of a transect line which runs perpendicular to the shoreline. Estimates require some care, particularly in lightly oiled areas where there is a natural tendency to over-estimate. One approach to offset this tendency is to consider the size of the non-oiled or clean area, rather than the amount of oil. A second concept is to envision herding all of the surface oil into one corner of the square and then to estimate the percent cover. A visual aid for estimating oil distribution is given in Figure 3.1. Where elevation measurements are also being made, a preferred method is to take both elevation and oil/sediment observations along the transect at fixed 2-m intervals. The estimate thus refers to the percent cover observations on the surface within a 10-m square area, positioned by the location on the transect.

If oil distribution maps or summary tables use category limits of 10, 50 and 90% oil cover then it is important that either (1) category limits be defined specifically, for example 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 observer records only to the nearest 5% (e.g., 45 or 55%). The latter is preferred as this provides more accurate information.

As an example of the application of SCAT procedures to a monitoring program, the design developed for the BIOS experiment involved a series of regular and systematic observations, measurements, and sampling of the oiling conditions and sediments along staked transects. This approach generated data for the comparison of surface oil distribution, oil character and oil thickness over a ten-year period on a 800-m section of shoreline that was oiled by a nearshore controlled release of Lagomedio crude. The concept of documenting surface oil distribution in terms of percent cover (referred to as "equivalent area") was first developed on this project. Further information can be found in Humphrey, *et al.* (1992).

Another example is the *New Carissa* incident in Oregon, where tar balls were washed ashore from the stern section that remained in the nearshore over the winter of 1999-2000. A time series of shoreline oiling conditions was generated by repetitive surveys of tar ball frequency and size that were carried out at regular intervals along two segments that were subdivided by backshore markers placed at half-mile intervals (Owens *et al.*, 2000) (see also the case study in Section 2.3).

1.3.6 Field Documentation

Basic steps in the collection and documentation of on-site field data are summarized in Figure 1.1 (also see Section 1.3.4).

FIELD DOCUMENTATION ACTIVITY SUMMARY
• Reconnoiter the site to gain an overview perspective • Define segment (sub-segment and zones) boundaries • Describe shoreline type and character within the segment • Describe surface oiling conditions • Describe subsurface oiling conditions • Draw sketch or map • Take photos or video • Review forms and discuss major observations with team

Figure 1.1 Basic steps of on-site field data collection.

SCAT programs are designed so that the scale of the field activities and the type of information that is collected are appropriate for the spill incident. A modification of the standard SCAT forms or the development of new SCAT forms may be part of the design.

However, oversimplification of the forms can result in the deletion of key information items that would allow accurate reconstruction of the oiling conditions. In establishing the field program and defining data collection procedures, several essential components should be included (Figure 1.2).

When more than one SCAT team is fielded or multiple surveys are conducted over the same areas, repetition, calibration, and consistency in reporting by field observers are important components of data accuracy.

ESSENTIAL SCAT DATA

General
- location, date, time, and segment code
- information on team members

Surface Oil Conditions
- location and tidal zones
- length and width of oiled section or segment described
- location of oil relative to tidal zones or lake/river levels
- distribution (percent surface cover to nearest 5 or 10%)
- oil thickness
- oil character

Subsurface Oil Conditions
- location and area (length and width) of penetrated or buried oil
- pit or trench locations and depths
- thickness of clean sediment on buried oil
- thickness of sediment to base of penetrated/buried oil

Field Sketch Map
- scale, North arrow, GPS coordinates
- surface oil locations and characteristics (abbreviations)
- pit and trench locations
- access, staging, and safety or operational concerns

Photographs and/or Video

Figure 1.2 Essential components of a SCAT data set.

Without the data listed in Figure 1.2, it is difficult to provide accurate estimates of the volume and type of oil to be recovered or treated by the operations crews. In addition, attempts to estimate shoreline oil volumes, or budgets, are doomed to inaccuracy if the data are not complete and systematic. For example, if the oil distribution box for a “Patchy” surface oil cover is checked, the actual range may be any number between 11 and 50%. Typically, an individual reading data to calculate oil volumes would have little choice but to assume a mid-point value (which would be 30.5% in this case) and so the calculation could be inaccurate by as much as 20% for the volume of oil for that particular shoreline data set. Simplification in the field description that uses categories, rather than actual observed values or measurements, reduces the quality and accuracy of the information that is collected. In turn, this makes an estimation of the amount of oil to be recovered very difficult for the planning team and greatly reduces the accuracy of any attempts to develop oil budgets or waste management estimates. Some guidelines or “rules of thumb” for the collection and documentation of shoreline oiling conditions are provided in Figure 1.3.

1.4 RESULTS

1.4.1 Data Management

Field activities are of little value to decision makers or planners if the information is not available quickly. Data management activities can be carried out by the SCAT field team for small scale or single-team surveys, or on incidents where there is sufficient time to organize and present a summary of the observations. But if the scale of the field activities involves several SCAT teams, a data bottle-neck most likely will be created without a committed data management system.

Often, and particularly in the early stages of a spill response, the information from the field teams is used to plan cleanup activities for the following day. This information probably would be required by late afternoon or early evening to be of value in the planning process. In these circumstances, field teams may be required to

SCAT DOCUMENTATION "RULES OF THUMB"
• The role of the SCAT is to be the "eyes and ears" for the Planning and Operations teams. • Record, on a form or in a field note book, any and all information required to later recreate the character and location of the oil. • Define practical segments, based on either the physical shore-zone character, oiling conditions, or operational units. • Be more, rather than less, detailed and do not categorize (i.e., enter the actual value of **15%** for Distribution, not **Patchy;** enter the value **15 m** for Width of Oiled Band, not **>3 m**). • Always make a sketch (or draw a map or on a map if you cannot sketch too well) to indicate important features and the location of the oil. • If there is not a standard term or definition that fits an observed feature, define and describe the feature. • Look around and identify advantages or constraints that might help or hinder the field cleanup crew.

Figure 1.3 SCAT documentation "Rules of Thumb".

communicate key information by telephone or radio to a person who can collate and process the data. In other circumstances, particularly after the initial response phase, the planning process may be several days ahead of operations.

One role of the data manager is to collect and review the incoming field forms, sketches and other information (films, videotapes etc.) as they are received and to log or distribute the information. The review should involve a quality check to make sure that all sections of the forms have been completed and that the information appears reasonable and consistent. Any questions regarding missing information or apparent inconsistencies should be discussed with the field teams before the next field assignment. After the quality control is complete, forms are copied and distributed and key information usually is transferred to tables or computer data files.

Discussions of data management are provided by Lamarche *et al.* (1998), Lamarche and Owens (1997), Lamarche and Tarpley (1997), and Williams *et al.* (1997).

1.4.2 Data Outputs

Data generated by SCAT surveys may be combined and used in a variety of ways:

Length, by itself, is mainly useful for initial regional-scale scoping and operational planning.

***Length x Width = Total Oiled Area*.** This value can be used in planning cleanup operations and in monitoring changes through time.

***Length x Width x Distribution = Surface Oil Cover*.** This is a measure of the actual surface area which is covered by oil, i.e., the total oiled area x % coverage (also known as "equivalent area" oiled). This value is useful when trying to quantify the degree of oiling or to monitor changes and oil removal rates.

Depth of Burial or ***Penetration*** measurements assist in the selection of cleanup options and predictions of oil persistence.

Depth x Surface Area = Oiled Sediment Volume that might have to be handled in cleanup.

Oil Volume calculations require oil concentration data in combination with the knowledge of oiled sediment volume or equivalent area oiled, or oil loading data, together with sediment porosity/retention estimates.

Rating the Degree of Oiling

In the case of a small spill or when information is required quickly to plan operations, a summary of the more detailed field observations may be required by the planners. This summary should be simplistic, but accurately reflect oiling conditions. Figure 3.2 is an example of a Surface Oil Category matrix that combines the width of the oiled area with the surface oil distribution using standard terms and definitions. This index can be used to provide spill managers with a concise measure of the oiling conditions for each segment and can be summarized verbally from the field.

Such indices generate a single-value, site-to-site relative comparison that provides a perspective to describe, summarize or compare multiple areas or long sections of oiled coast in an easily understandable manner. The rating can be adjusted to the local conditions.

The two indices described in this manual are:

Surface Oil Cover Category = width x surface distribution of the oil (see Figure 3.2)

Surface Oil Category = (width x distribution) x thickness of the oil (see Figure 3.3)

These indices are a rating of the degree of oiling in that segment (Very Light, Light, Moderate, or Heavy). Typically, the rating category is combined with alongshore length, (e.g., “Segment AB-1 has 20 m of ‘heavy’ surface oiling”).

As the scale of the affected area and the size of the response operation increases, the information outputs usually become more sophisticated. Entry of the field data into spreadsheets enables a data manger to provide summary data sets and maps that could be used both to support the planning process and the cleanup operations or to track the progress of an operation (Lamarche *et al.*, 1998: Lamarche and Owens, 1997: Lamarche and Tarpley, 1997: and Williams *et al.*, 1997).

In general, the types of data and graphics that can be generated from the SCAT data base would include:

- maps of shoreline types, coastal character
- segment oiling conditions
- surface oil volumes, changes in volume through time
- SCAT field survey status
- treatment recommendations
- cleanup-treatment status

as well as tables of:

- lengths of oiled shoreline (by oil rating and/or by shoreline type)
- lengths treated (by oil rating and/or treatment method).

Examples of data outputs for tar ball frequencies, concentrations, and oil volumes calculated from a long-term SCAT tar ball monitoring program are described by Owens *et al.* (2000a).

1.5 SHORELINE OILING FORMS

A set of standard Shoreline Oiling Summary (SOS) forms are presented in this section. These can be modified to reflect the specific shoreline or oiling conditions of a spill, bearing in mind the essential SCAT data as listed in Figure 1.2. The standard generic forms relate to temperate tidal coastal environments. Adaptations for large lake, arctic, mangrove, or coral environments and for winter conditions are described in Section 2.2.2. Terms and definitions are summarized in Section 1.5.2 and detailed in Section 3.1.1 and 3.1.2. Diagrams, photographs and job aids are presented in Section 3.2. The forms can be downloaded from the internet (contact the authors for web site information).

The content and layout of the SOS forms and the terms and definitions correspond closely to those recommended by NOAA. There are some minor differences in approach but there is now a high level of similarity and compatibility in the latest versions of the forms presented in this Section. This topic is discussed by Owens *et al.* (2000b).

FORM	SECTION
Shoreline Oiling Summary (SOS)	1.5.1
Summary of Terms and Definitions	1.5.2
"Short" SOS	1.5.3
Tar Ball Shoreline Oliling Summary	1.5.4
Wetland Oiling Summary	1.5.5
Tidal Flat Oiling Summary	1.5.6

1.5.1 Shoreline Oiling Summary (SOS) Form

Primary Use

- On spills where surface or sub-surface oiling conditions are variable between or within segments and where detailed information is appropriate

Instructions

Complete Boxes 1, 2, 3, 4, and 5

Box 6

IF NO SURFACE OIL IS PRESENT:

- check the NO box in OIL CHARACTER

IF SURFACE OIL IS PRESENT:

STEP 1 **Decide if the segment has relatively uniform along-shore and across-shore oiling conditions:**
- if YES, then go to STEP 2;
- if NO, then need to subdivide the segment into as many alongshore SUB-SEGMENTS and/or across-shore ZONES (see Section 1.3.1) as necessary for an accurate description, then go to STEP 2.

NOTE: use a separate form for each sub-segment

STEP 2 **Define the location (Tidal Zone), Oil Cover, Oil Thickness, Oil Character and primary and any secondary (in parentheses) Substrate Type (Subst. Type) for each zone in the segment or sub-segment in which oil is observed** (for terms and definitions see the following pages and Section 3).

STEP 3 **Draw sketch map(s) (see Section 1.6) to locate sub-segments, zones and oiled areas: take photographs or videotapes.**

Box 7

IF NO SUB-SURFACE OIL IS PRESENT:

- check the NO box in SUB-SURFACE OIL CHARACTER and go to STEP 6

IF SUB-SURFACE OIL IS PRESENT:

STEP 4 Decide if the segment has relatively uniform alongshore and across-shore sub-surface oiling conditions

- if YES, then go to STEP 5
- if NO, then need to subdivide the segment into as many alongshore SUB-SEGMENTS and/or across-shore ZONES as are necessary for an accurate description, then go to STEP 5

NOTE: use a separate form for each sub-segment

STEP 5 Define the location (Tidal Zone),Ttrench/Pit Depth, Oiled Zone depth, Oil Character, and Substrate Type(s) for each trench or pit (for terms and definitions see following pages and Section 3)

STEP 6 Note comments in ***Box 8.***

STEP 7 Take photographs or videotapes.

SHORELINE OILING SUMMARY (SOS) FORM — for Spill Page of

1 GENERAL INFORMATION Date (dd/mm/yy) Time (24h): standard/daylight Tide Height

Segment ID:

Operations Division: hrs to hrs rising / falling

Survey by: Foot / ATV / Boat / Helicopter / Overlook / ________ Sun / Clouds / Fog / Rain / Snow / Windy / Calm

2 SURVEY TEAM # _______ name	***organization***	***contact phone number***

3 SEGMENT Total Segment Length __________________ m Segment Length Surveyed __________________ m

Start GPS: LATITUDE ___________deg. _____________min. LONGITUDE ____________deg. ___________min.

End GPS: LATITUDE ___________deg. _____________min. LONGITUDE ____________deg. ___________min.

Differential GPS Yes / No

4A SHORELINE TYPE ***select only one primary (P) oiled shoreline type and any secondary (S)***

BEDROCK : ____ ***MAN-MADE SOLID :*** ____ ***SEDIMENT BEACH :*** Sand ___ ***SEDIMENTS FLATS :*** Mud Flats ___

cliff/vertical ___ sloping ___ platform ___ Pebble-Cobble ___ Boulder ___ Sand Flats ___ Sand-Gravel ___

Winter Only: Ice Foot ____ Snow ___ Mixed Sand-Gravel ___ ***MARSH :*** ___ Peb-Cob ___ Boulder ___

4B COASTAL CHARACTER ***backshore character — select only one primary (P) and any secondary (S)***

CLIFF or HILL _____ : est. height _________ m Beach ___ Delta ___ Tidal inlet ___ Marsh/Wetland ___

slope: gentle (<5 deg) ___ medium ___ steep (>30 de Barrier beacl ___ Dune ___ Channel ___ other ______________

5 OPERATIONAL FEATURES debris Y / N oiled? Y / N debris amount: _______ bags OR ________ trucks

direct backshore access Y / N suitable backshore staging Y / N

alongshore access from next segment Y / N access restrictions ___________________________

6 SURFACE OILING CONDITIONS ***begin with "A" in the lowest tidal zone***

OIL ZONE ID	TIDAL ZONE				OIL COVER			OIL THICKNESS					OIL CHARACTER								SUBST. TYPE(S)
					Length	*Width*	*Distrib.*														
	LI	MI	UI	SU	m	m	%	PO	CV	CT	ST	FL	FR	MS	TB	PT	TC	SR	AP	NO	
A																					

7 SUBSURFACE OILING CONDITIONS ***use letter for ZONE location plus Number of pit or trench - e.g., "A1"***

TRENCH or PIT NO.	TIDAL ZONE				MAX. PIT DEPTH	OILED ZONE	SUBSURFACE OIL CHARACTER							WATER TABLE	SHEEN COLOUR	CLEAN BELOW	SUBST. TYPE(S)
	LI	MI	UI	SU	cm	cm-cm	SAP	OP	PP	OR	OF	TR	NO	cm	B, R, S, N	Yes / No	

8 COMMENTS ***(cleanup recommendations — ecological/recreational/cultural/economic issues & constraints — wildlife obs.)***

Sketch Yes/No **Photos** Yes/No (Roll # _____ Frames______) **Video Tape** Yes/No (tape #______) ver. 05/00

1.5.2 Summary of Terms and Definitions

The standard terms and definitions presented in this section provide a summary explanation for completion of the standard SOS form. Complete definitions and terms are provided in Section 3.1.

Tidal Zone (Box 6 and 7)

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

Surface Oil Cover (Box 6)

Length refers to alongshore distance of oiled shoreline within a segment or zone.

Width refers to the average across-shore distance of the intertidal oil band within a segment or zone. If multiple across-shore bands are grouped, then width represents the sum of their widths.

Surface Distribution represents the actual percent of the surface covered by oil, within a fixed area (see Figure 3.1–visual aid to estimate oil distribution). In the event of grouped multiple bands, distribution refers to the average oil conditions for the zone.

Surface Oil Thickness (Box 6) — Refers to the average or dominant oil thickness within the segment or zone. It is described according to the following categories.

- **PO Pooled or Thick Oil** — generally consists of fresh oil or mousse accumulations >1 cm thick.
- **CV Cover** — >0.1 cm and ≤1 cm thick.
- **CT Coat** — >0.01 cm and ≤0.1 cm thick . Can be scratched off with fingernail on coarse sediments or bedrock.
- **ST Stain** — ≤0.01 cm thick. Cannot be scratched off easily on coarse sediments or bedrock.
- **FL Film** — transparent or translucent film or sheen.

Surface Oil Character (Box 6) — Provides a qualitative description of the form of the oil.

- **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** — discrete balls, lumps or patches on a beach or adhered to the substrate. Tar ball diameters are generally <10 cm.
- **PT Tar Patties** — discrete lumps or patches >10 cm diameter which are on a beach or adhered to the substrate.
- **TC Tar** — weathered coat or cover 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.
- **NO No Oil Observed**.

Substrate Type (Box 6 and Box 7)

- **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/Silt** (< 0.06 mm dia.)
- **A Anthropogenic**/Manmade

Sub-surface Oiled Zone (Box 7) — refers to the vertical width or thickness of the oiled sediment (sub-surface) layer when viewed in profile by digging a pit or trench. The top and bottom boundaries of the lens are recorded. The bottom boundary is equal to the maximum depth of oil penetration. The top boundary may equal 0 (the beach surface) or a greater number depending on whether clean sediments have been deposited on top of the oiled sediment. See Figure 3.4 and Section 3.1.2 for guidance on surface and sub-surface differentiation.

Sub-surface Oil Character (Box 7) — provides a qualitative description of the character and/or quantity of the oil.

- **SAP Sub-surface Asphalt Pavement** — cohesive mixture of weathered oil and sediment situated completely below a surface sediment layer (record thickness).
- **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 Oil Residue as a cover** (> 0.1 – 1 cm) or **coat** (0.01 – 0.1 cm) of oil on sediments and/or some pore spaces partially filled with oil. Can be scratched off easily with fingernail on coarse sediments or bedrock.
- **OF Film or Stain** (< 0.01 cm) of oil residue on the sediment surfaces. Non-cohesive. Cannot be scratched off easily on coarse sediments or bedrock.
- **TR Trace** — discontinuous film or spots of oil on sediments, or an odour or tackiness with no visible evidence of oil.
- **NO No Oil** — no visible or apparent evidence of oil.

Sheen Colour

- S Silver
- R Rainbow
- B Brown
- N None

1.5.3 "Short" Shoreline Oiling Summary (SOS) Form

Primary Use

- On spills where surface or sub-surface oiling conditions are relatively uniform in segments.

Instructions

- Complete Boxes 1, 2, 3, 4, and 5.

Box 6

IF NO SURFACE OIL IS PRESENT:

- Write "0" in the last row of "Surface Oil Distribution".

IF SURFACE OIL IS PRESENT:

STEP 1 Circle appropriate Tidal Zone, define the Oil Band Width and Length — circle appropriate box for Oil Distribution, Oil Thickness, and Oil Type (terms and definitions are provided on the previous pages and in Section 3).

IF SUB-SURFACE OIL IS PRESENT:

STEP 2 Indicate Depth of Penetration or Depth of Buried Layer.

Box 7

Repeat if more than one oiled zone in the segment.

STEP 3 Draw sketch map(s) (see Section 1.6) to locate sub-segments, zones and oiled areas: take photographs or videotapes.

"SHORT" SHORELINE OILING SUMMARY (SOS) FORM — for Spill Page ___ of ___

1 GENERAL INFORMATION Segment ID: Operations Division:	Date (dd/mm/yy)	Time (24h): standard/daylight hrs to hrs	Tide Height rising / falling

Survey by: Foot / ATV / Boat / Helicopter / Overlook / | Sun / Clouds / Fog / Rain / Snow / Windy / Calm

2 SURVEY TEAM # ______ ***name***	***organization***	***contact phone number***

3 SEGMENT ***Total Segment Length*** __________________ ***m*** ***Segment Length Surveyed*** ___________________ ***m***

Start GPS: LATITUDE ______ deg. ______ min. LONGITUDE ______ deg. ______ min.

End GPS: LATITUDE ______ deg. ______ min. LONGITUDE ______ deg. ______ min.

Differential GPS Yes / No

4A SHORELINE TYPE ***select only one primary (P) oiled shoreline type and any secondary (S)***

BEDROCK : ____ ***MAN-MADE SOLID :*** ____ ***SEDIMENT BEACH :*** Sand ___ ***SEDIMENT FLATS :*** Mud Flats ___

cliff/vertical ____ sloping ____ platform ____ Pebble-Cobble ___ Boulder ___ Sand Flats ___ Sand-Gravel ___

Winter Only: Ice Foot Snow Mixed Sand-Gravel ***MARSH :*** ___ Peb-Cob Boulder ___

4B COASTAL CHARACTER ***backshore character — select only one primary (P) and any secondary (S)***

CLIFF or HILL : ____ : est. height _______ m Beach ___ Delta ___ Tidal inlet ___ Marsh/Wetlanc___

slope: gentle (<5 deg)___ medium___ steep (>30 deg)___ Barrier beach ___ Dune ___ Channel ___ other _____________

5 OPERATIONAL FEATURES debris Y / N oiled? Y / I debris amount: _______ bags OR _______ trucks

direct backshore access Y / N suitable backshore staging Y / N

alongshore access from next segment Y / N access restrictions

6 ZONE ID __________ ***Description of Oil Conditions in Supra / Upper / Mid / Lower Intertidal Zone (circle one)***

Oil Band	Surface Oil Distribution	Surface Oil Thickness	Surface Oil Type	Subsurface Oil *Penetration*	Subsurface Oil *Burial*
Width **Length**	< 1%	Film	Fresh Liquid	< 1 cm	***Clean Layer :***
	1 - 10%	Stain	Mousse	1 - 5 cm	
m x m	11 - 50%	Coat	Tarballs	5 - 10 cm	cm
SEDIMENT TYPE(S) :	51 - 90%	Cover	Tar Patties	> 10 cm	***Oiled Layer :***
	91 - 100%	Pooled	Asphalt Pavement		
	________ %	cm	other	cm	________ cm

7 ZONE ID__________ ***Description of Oil Conditions in Supra / Upper / Mid / Lower Intertidal Zone (circle one)***

Oil Band	Surface Oil Distribution	Surface Oil Thickness	Surface Oil Type	Subsurface Oil *Penetration*	Subsurface Oil *Burial*
Width **Length**	< 1%	Film	Fresh Liquid	< 1 cm	***Clean Layer :***
	1 - 10%	Stain	Mousse	1 - 5 cm	
m x m	11 - 50%	Coat	Tarballs	5 - 10 cm	________ cm
SEDIMENT TYPE(S):	51 - 90%	Cover	Tar Patties	> 10 cm	***Oiled Layer :***
	91 - 100%	Pooled	Asphalt Pavement		
	________ %	cm	other	cm	cm

8 COMMENTS ***(cleanup recommendations—ecological/recreational/cultural/economic issues & constraints—wildlife obs.)***

(for ALL sub-segments record: sub-segment ID, length, length surveyed,and GPS start/end fixes)

Sketch Yes/No **Photos** Yes/No (Roll # _________ Frames_______) **Video Tape** Yes/No (tape #_____) ver. 05/00

1.5.4 Tar Ball Oiling Summary Form

Primary Use

- On spills where only tar balls or tar patties wash up on the shore or where there is only oiled debris.

Instructions

- Complete Boxes 1, 2, 3, 4, and 5.

Box 6

IF NO TAR BALLS, TAR PATTIES, OR OILED DEBRIS ARE PRESENT:

- circle "NO" in AREA 1 in the first row, ***AND***
- Complete the second, third, and fourth rows in AREA 1 to define the Tidal Zone, Length and Width of the area that is covered by the "NO" observations.

IF TAR BALLS/ PATTIES, OR OILED DEBRIS ARE PRESENT:

STEP 1 Decide if the area has relatively uniform oiling conditions;

- if YES, then only "AREA 1" is completed;
- if NO, then need to complete as many AREA columns as are necessary for an accurate description.

STEP 2 Define Tidal Zone, Length and Width of the area in which oil is observed for each AREA column.

NOTE: If the tar balls or patties are in a band that is only a few centimeters wide, such as along the last high-water swash line, then use "1 cm" or "10 cm" as the band width — the remainder of the intertidal zone would have a separate AREA column with NO OBSERVED TAR BALLS.

STEP 3 Estimate the concentration (average number per square meter) **of tar balls or patties in the area;**

- this is the crucial observation, as this number will be multiplied by the *width x length* defined in Step 2 to obtain an "estimated total number of tar balls" (which in turn will be used to calculate the oil volume);
- if very few tar balls or patties are present, indicate the total number of tar balls observed, followed by the word "total".

STEP 4 Estimate the average size and largest size of tar balls or patties in the area;

- this value will be used to calculate the oil volume.

STEP 5 Draw sketch map(s) to locate oiled areas: take photographs or videotapes.

TAR BALL OILING SUMMARY FORM — for _____________Spill Page _____ of _____

1 GENERAL INFORMATION Segment ID: Operations Division:	Date (dd/mm/yy)	Time (24h): standard/daylight hrs to hrs	Tide Height rising / falling
Survey by: Foot / ATV / Boat / Helicopter / Overlook /		Sun / Clouds / Fog / Rain / Snow / Windy / Calm	

2 SURVEY TEAM # ____ ***name***	***organization***	***contact phone number***

3 SEGMENT ***Total Segment Length*** __________________ ***m*** ***Segment Length Surveyed*** ____________________ ***m***

Start GPS: LATITUDE ______ deg. ______ min. LONGITUDE ______ deg. ______ min.

End GPS: LATITUDE ______ deg. ______ min. LONGITUDE ______ deg. ______ min.

Differential GPS Yes / No

4A SHORELINE TYPE ***select only one primary (P) oiled shoreline type and any secondary (S)***

BEDROCK : ____ ***MAN-MADE SOLID :*** ____ ***SEDIMENT BEACH :*** Sand ___ ***SEDIMENT FLATS :*** Mud Flats ___

cliff/vertical ___ sloping ___ platform ___ Pebble-Cobble ___ Boulder ___ Sand Flats ___ Sand-Gravel ___

Winter Only: Ice Foot ____ Snow ___ Mixed Sand-Gravel ___ ***MARSH :*** ___ Peb-Cob ___ Boulder ___

4B COASTAL CHARACTER ***backshore character — select only one primary (P) and any secondary (S)***

Cliff or Hill: ____ : est. height _______ m | Beach ___ Delta ___ Tidal inlet ___ Marsh/Wetland ___

slope: gentle (<5 deg) medium steep (>30 deg) | Barrier beach ___ Dune ___ Channel ___ other

5 OPERATIONAL FEATURES debris Y / N oiled? Y / N debris amount: _______ bags OR ______ trucks

direct backshore access Y / N suitable backshore staging Y / N

alongshore access from next segment Y / N access restrictions ____________________

6 TARBALL CONDITIONS	***AREA 1***	***AREA 2***	***AREA 3***
Tar Balls Observed ?	YES ? NO ?	YES ? NO ?	YES ? NO ?
Oiled Debris Observed ?	YES ? NO ?	YES ? NO ?	YES ? NO ?
Tidal Zone (LI – MI – UI – SU)			
Length (m) Approximate alongshore length of of shore in segment in which tarballs/oiled debris are observed			
Width (m) Across-shore width of the band on the shore in which tarballs/oiled debris are observed			
Average Number of Tar Balls Within Area (e.g. 2 per sq.m. within band; 3 per 100 m alongshore; 6 total within area, etc.) *Be specific*			
Average Size of Tar Balls (cm)			
Size of Largest Tar Ball (cm)			
Type of Tar Balls	Weathered ? Sticky ?	Weathered ? Sticky ?	Weathered ? Sticky ?
Tar Balls Collected ?	YES ? NO ?	YES ? NO ?	YES ? NO ?

7 COMMENTS ***(cleanup recommendations — ecological/recreational/cultural/economic issues & constraints — wildlife obs.)***

(for ALL sub-segments record: sub-segment ID, length, length surveyed,and GPS start/end fixes)

Sketch Yes/No **Photos** Yes/No (Roll # ________ Frames________) **Video Tape** Yes/No (tape #_____) ver. 05/00

1.5.5 Wetland Oiling Summary Form

Primary Use

- On spills where a wetland or marsh has been oiled.

Instructions

- Complete Boxes 1, 2, 3, 4, and 5

Box 6

IF NO SURFACE OIL IS PRESENT:

- check the NO box in OIL CHARACTER

IF SURFACE OIL IS PRESENT:

STEP 1 Decide if the area has relatively uniform oiling conditions:
- if YES, then go to STEP 2;
- if NO, then need to subdivide the segment into as many alongshore or area SUB-SEGMENTS and/or across-shore ZONES (see Section 1.3.1) as necessary for an accurate description, then go to STEP 2.

NOTE: use a separate form for each sub-segment

STEP 2 Define the location (Tidal Zone), Oil Cover, Oil Thickness, Oil Character and Oiled Plant Parts for each Zone in the segment or sub-segment in which oil is observed (for terms and definitions see the previous pages and Section 3).

STEP 3 Complete cross-section in Box 8 and draw sketch map (see Section 1.6) to locate sub-segments, zones, cross section, and oiled areas: estimate total oiled area.

Box 7

IF NO SUB-SURFACE OIL IS PRESENT:

- indicate by circling “N” and go to STEP 6

IF SUB-SURFACE OIL IS PRESENT:

circle “Y” and :

STEP 4 Decide if the segment has relatively uniform alongshore and across-shore sub-surface oiling conditions

- if YES, then go to STEP 5
- if NO, then need to subdivide the segment into as many alongshore SUB-SEGMENTS and/or across-shore ZONES as are necessary for an accurate description, then go to STEP 5

NOTE: use a separate form for each sub-segment

STEP 5 Mark sub-surface oil location(s) on sketch map, assign a location number and describe sub-surface oiling in comments (Box 8) or field note book. Define the tidal zone, penetration depth, and oil character for each location (for terms and definitions see previous pages and Section 3).

STEP 6 Take photographs or videotapes.

WETLAND OILING SUMMARY FORM — for ____________________________ Spill Page of

1 GENERAL INFORMATION | Date (dd/mm/yy) | Time (24h): standard/daylight | Tide Height
Segment ID:
Operations Division: hrs to hrs rising / falling
Survey by: Foot / ATV / Boat / Helicopter / Overlook / __ | Sun / Clouds / Fog / Rain / Snow / Windy / Calm

2 SURVEY TEAM # ___ ***name***	***organization***	***contact phone number***

3 SEGMENT ***Total Segment Length*** _______________ ***m*** ***Segment Length Surveyed*** _______________ ***m***
Start GPS: LATITUDE ___________deg. ___________min. LONGITUDE ___________deg. ___________min.
End GPS: LATITUDE ___________deg. ___________min. LONGITUDE ___________deg. ___________min.
Differential GPS Yes / No

4A WETLAND TYPE ***select only one primary (P) oiled wetland type and any secondary (S)***
Saltwater Marsh ______ Bottomland Hardwood forest ______
Brackish Marsh ______ Freshwater Swamp ______
Freshwater Marsh ______ Other ______________________

4B VEGETATION CHARACTER
Dominant Vegetation Type(s):

5 OPERATIONAL FEATURES suitable backshore or alongshore staging Y/N
direct backshore access Y / N access restrictions Y/N
alongshore access from next segment Y / N (note access constraints below in COMMENTS)
surface bearing capacity suitable for: personnel / marsh vehicles / other : (circle only those applicable)

6 SURFACE OILING CONDITIONS
Enter oil on Substrate versus Vegetation on different lines, using (S) or (V) after the Zone ID (e.g., "A S" for sediment, "A V" for Vegetation). Indicate the position of each ZONE on the cross-section below.

OIL ZONE ID	TIDAL ZONE				OIL COVER			OIL THICKNESS					OIL CHARACTER								OILED PLANT PARTS
					Length	*Width*	*Distrib.*														
	LI	MI	UI	SU	m	m	%	PO	CV	CT	ST	FL	FR	MS	TB	TP	TC	SR	AP	**NO**	All B T S L F *

7 SUBSURFACE OILING CONDITIONS IS SUBSURFACE OIL PRESENT ? **Y / N**
If "Y", describe in Comments Section (Box 8) and indicate location on cross-section
* Base, Trunk, Stem Leaf, Flower

8 COMMENTS ***(cleanup recommendations — ecological/recreational/cultural/economic issues & constraints — wildlife obs.)***
Approx. TOTAL OILED Area
_____________hectares

CROSS-SECTION SKETCH **show:** high tide level (HT)
low tide level (LT)
surface oil
subsurface oil
key vegetation zones
scale

supratidal zone intertidal zone

(for ALL sub-segments record: sub-segment ID, length, length surveyed,and GPS start/end fixes)

Sketch Yes/No **Photos** Yes/No (Roll # _______ Frames_______) **Video Tape** Yes/No (tape #_____) ver. 05/00

1.5.6 Tidal Flat Oiling Summary Form

Primary Use

- On spills where where a wide, flat, intertidal area has been oiled.

Instructions

- Complete Boxes 1, 2, 3, 4, and 5

Box 6

IF NO SURFACE OIL IS PRESENT:

- check the NO box in OIL CHARACTER

IF SURFACE OIL IS PRESENT:

STEP 1 Decide if the area has relatively uniform oiling conditions:

- if YES, then go to STEP 2;
- if NO, then need to subdivide the segment into as many alongshore or area SUB-SEGMENTS and/or across-shore ZONES (see Section 1.3.1) as are necessary for an accurate description, then go to STEP 2.

NOTE: use a separate form for each sub-segment

STEP 2 Define the location (Tidal Zone), Oil Cover, Oil Thickness, Oil Character and indicate if the surface sediments are Wet or Dry for each zone in the segment or sub-segment in which oil is observed (for terms and definitions see the previous pages and Section 3).

STEP 3 Complete cross section in Box 8 and draw sketch map (see Section 1.6) to locate sub-segments, zones, cross section, and oiled areas: estimate total oiled area.

Box 7

IF NO SUB-SURFACE OIL IS PRESENT:

- indicate by circling “N” and go to STEP 6

IF SUB-SURFACE OIL IS PRESENT:

- circle “Y” and:

STEP 4 Decide if the segment has relatively uniform alongshore and across-shore sub-surface oiling conditions

- if YES, then go to STEP 5
- if NO, then need to subdivide the segment into as many alongshore SUB-SEGMENTS and/or across-shore ZONES as are necessary for an accurate description, then go to STEP 5

NOTE: use a separate form for each sub-segment

STEP 5 Mark sub-surface oil location(s) on sketch map, assign a location number and describe sub-surface oiling in comments (Box 8) or field note book. Define the tidal zone, penetration depth, and oil character for each location (for terms and definitions see previous pages and Section 3).

STEP 6 Take photographs or videotapes.

TIDAL FLAT OILING SUMMARY FORM — for __________________________ Spill Page ____ of ____

1 GENERAL INFORMATION Segment ID: Operations Division:	Date (dd/mm/yy)	Time (24h): standard/daylight hrs to hrs	Tide Height rising / falling
Survey by: Foot / ATV / Boat / Helicopter / Overlook / ________		Sun / Clouds / Fog / Rain / Snow / Windy / Calm	

2 SURVEY TEAM # ______ *name*	*organization*	*contact phone number*

3 SEGMENT ***Total Segment Length*** __________________ ***m*** ***Segment Length Surveyed*** __________________ ***m***

Start GPS: LATITUDE ______________ deg. ______________ min. LONGITUDE ____________ deg. _____________ min.

End GPS: LATITUDE ______________ deg. ______________ min. LONGITUDE ____________ deg. _____________ min.

Differential GPS Yes / No

4A TIDAL FLAT TYPE ***select only one primary (P) oiled tidal flat type and any secondary (S)***

Mud	_______	Pebble-Cobble	_______	Sand Waves	Y / N
Sand	_______	Boulder	_______	Incised Channels	Y / N
Sand-Gravel	_______			Boulder Barricade	Y / N

4B COASTAL CHARACTER ***backshore character — select only one primary (P) and any secondary (S)***

Cliff or Hill: ____ : est. height _______ m	Beach ___ Delta ___ Tidal inlet ___ Marsh/Wetland ___
slope: gentle (<5 deg)__ medium__ steep (>30 deg)___	Barrier beach ___ Dune___ Channel ___ other ____________

5 OPERATIONAL FEATURES suitable backshore or alongshore staging Y/N

direct backshore access Y / N access restrictions Y/N

alongshore access from next segment Y / N (note access constraints below in COMMENTS)

surface bearing capacity suitable for: personnel / vehicles / other____________________________ (circle only those applicable)

6 SURFACE OILING CONDITIONS ***begin with "A" in the lowest tidal zone***

OIL ZONE ID	**TIDAL ZONE**				**OIL COVER**			**OIL THICKNESS**					**OIL CHARACTER**									**SEDS.**	
					Length	*Width*	*Distrib.*															W E T	D R Y
	LI	MI	UI	SU	m	m	%	PO	CV	CT	ST	FL	FR	MS	TB	TP	TC	SR	AP	**NO**			

7 SUBSURFACE OILING CONDITIONS IS SUBSURFACE OIL PRESENT ? **Y / N**

If "Y", describe in Comments Section (Box 8) and indicate location on cross-section

8 COMMENTS ***(cleanup recommendations — ecological/recreational/cultural/economic issues & constraints — wildlife obs.)***

Approx. TOTAL OILED Area

_______________hectares

show: high tide level (HT)
low tide level (LT)
surface oi
subsurface oil
key zones
scale

CROSS-SECTION SKETCH

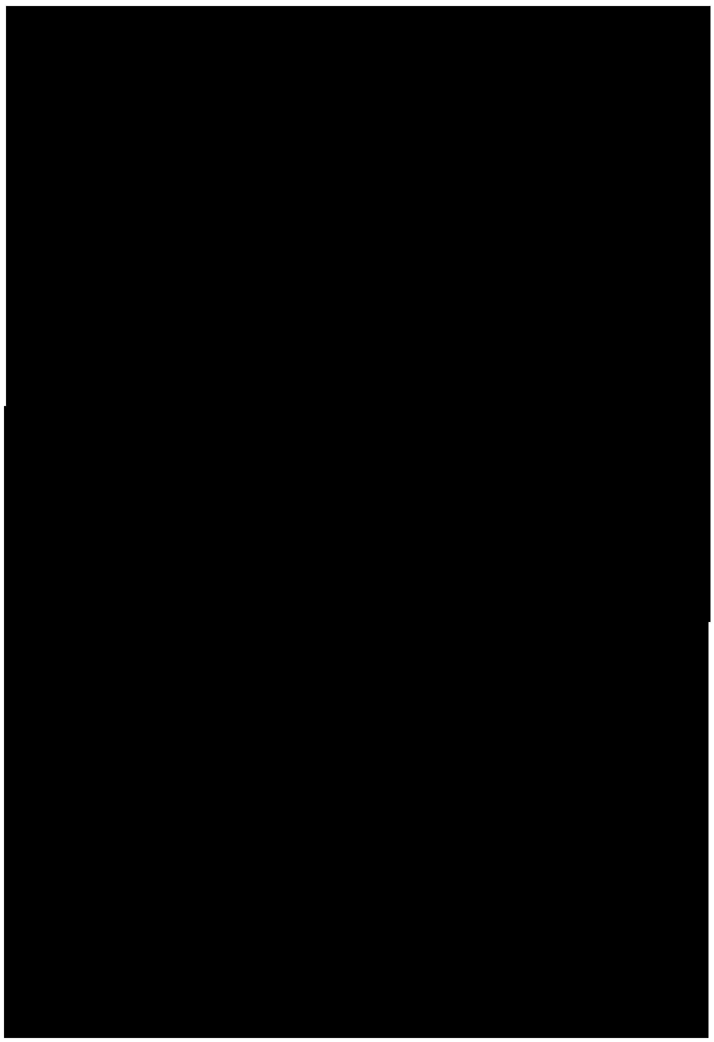
(for ALL sub-segments record: sub-segment ID, length, length surveyed,and GPS start/end fixes)

Sketch Yes/No **Photos** Yes/No (Roll # _________ Frames________) **Video Tape** Yes/No (tape #_____) ver. 05/00

1.6 Sketch Maps

A sketch map is drawn for each segment to identify the physical layout of the shoreline and the location of the oil, samples, pits and photographs. (Note: within a segment it is also valuable to locate areas of buried oil by flags or stakes so that operation crews can easily locate this oil). Aerial photographs or small-scale maps can be traced to create a base map for the sketches in order to enhance their accuracy and scale. If only a portion of the segment is sketched or several sketch maps are drawn for a site, include a sketch location map to indicate how the sketches match or overlap. Some guidelines of sketch map drawings are:

- Include north arrow, segment number, approximate scale, segment and sub-segment boundaries, HWL/LWL (high water or high-tide level: low water or low-tide level), major features, and landmarks.
- Oil conditions should be shown as shaded areas (designation corresponds to SOS forms).
- An alphabetic designation is given to each oiled area on the sketch that corresponds to a letter designation for the ZONE on the field form or field notes. Indicate the dimensions for each oiled area, as well as the percent oil cover estimates, oil character and substrate.
- Indicate pits by a triangle, and give them a numerical designation that corresponds to the one on the SOS form. The triangle is filled in to represent oil found in the pit, an open triangle is used if no oil is found.
- Notes about biota within oiled areas — nesting locations etc.
- Show photograph locations by a dot with a connecting arrow indicating the direction in which the photo was taken, with frame number/roll number on sketch.
- Indicate location(s) where a videotape was recorded.



Figure

PART 2 APPLICATIONS

2.1 SPILL MANAGEMENT APPLICATIONS

2.1.1 SCAT and the Spill Management Organization

The SCAT activities are part of the Planning Section in the Incident Command System (ICS) that has been adopted for many response operations (Figure 2.1). If more than one field team is deployed, a SCAT coordinator usually is required to communicate with other units in the Planning Section and with the Shoreline Operations Supervisor in the Operations Section. This link with Operations is important in the development of practical, effective, and efficient treatment or cleanup options. Often, the coordinator provides direct input for field cleanup activities that are carried out on the following day (Lamarche *et al.*, 1998: Lamarche and Tarpley, 1997: Martin *et al.*, 1997). Field reports and data summaries are provided to the Situation Unit, where they are available to other interested users, and to the Documentation Unit for archiving.

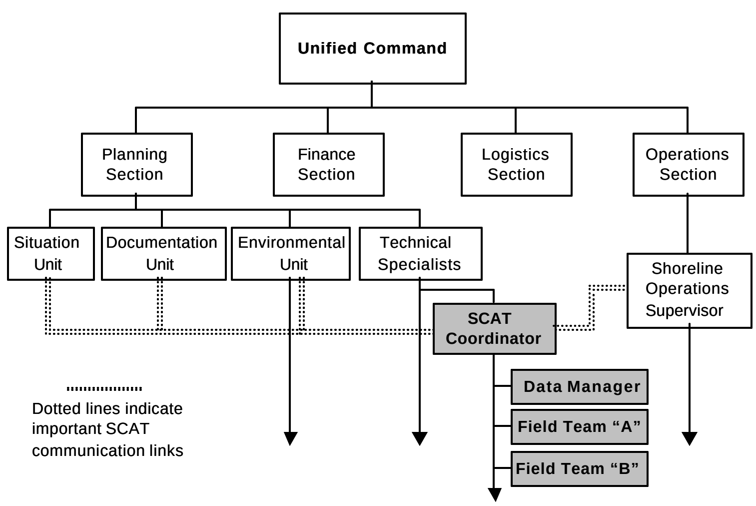


Figure 2.1 Typical ICS — SCAT organization diagram.

Shoreline oiling information is used by decision makers and planners to establish:

- regional response priorities
- regional and segment treatment or cleanup objectives
- treatment or cleanup strategies and methods
- acceptable levels of treatment (standards and criteria for a “sign off”)

The flow of information through the decision process is presented graphically in Figure 2.2. This idealized cycle indicates how the SCAT process provides input to aspects of a response operation by:

- initially helping to define the regional scale and scope of the problem
- providing planning information for the response operation
- setting site-specific guidelines for cleanup crews to follow in the field
- completing the decision cycle for shoreline treatment

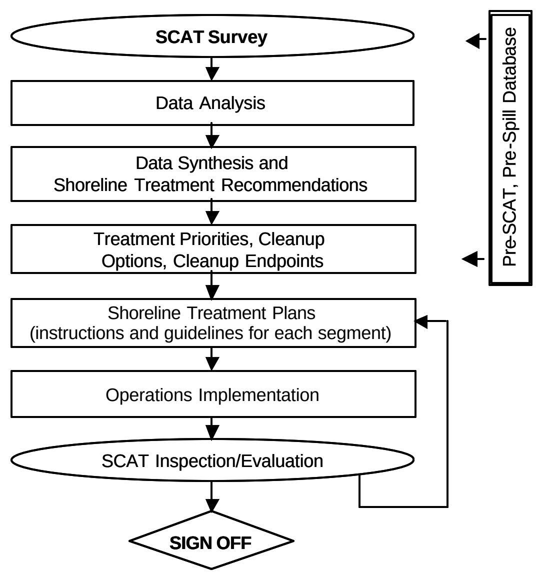


Figure 2.2 Example of SCAT within the spill management cycle.

On some spills, a Shoreline Assessment survey may be carried out at the same time as shoreline surveys that are part of a Natural Resource Damage Assessment (NRDA) program. These NRDA surveys usually are, and should be, a separate activity (NOAA, 1998a), although the SCAT data and information may be used as part of the damage assessment.

2.1.2 Treatment and Cleanup Recommendations

The information generated by the SCAT survey(s) is a basic component of the decision process for setting regional response priorities, cleanup objectives and acceptable levels of treatment. The decision process involves a number of steps beginning with the initial collection of information on the shoreline oiling conditions (see Figure 2.3).

Recommendations for treatment or cleanup techniques can be made by the SCAT team in the field (see example below, Figure 2.4) or by discussions following the field survey that might involve representatives from the Operations Section, government agencies, and local organizations. Field manuals that provide guidance for this decision process have been developed by Environment Canada for the Atlantic Provinces, the Great Lakes, and Arctic regions (see Environment Canada 1996a, 1996b, 1998 and also Section 3.1.4).

2.1.3 Treatment Levels and Cleanup Criteria

Treatment standards, or cleanup “end points”, are based on an accurate knowledge of the initial oiling conditions and the character of the stranded oil that is provided by the SCAT survey. The decision to end the treatment or cleanup of an oiled segment should be based upon goals, standards, or levels of effort that are established before the operation begins. Definition of these treatment standards provides the operations supervisors with a clear objective so that they can tailor their activities towards a known point of completion and provides an inspection team with criteria upon which to evaluate the treatment results.

Gather & Assess Information & Data	• Define regional distribution of oiled shorelines (e.g., aerial VTR survey) • Segment shorelines and assess (local - segment) oiling conditions - ground SCAT survey(s)
Define Objectives	• Identify acceptable treatment levels • Establish segment (local) treatment objectives, priorities and treatment levels
Develop Strategy	• Establish segment (local) treatment strategy(ies) to meet the segment treatment objectives
Select Response Options	• Define acceptable and available procedures and techniques that can achieve the treatment objectives and strategies
Evaluate Response Feasibility	• Identify environmental (physical), ecological, and logistical constraints that might affect the proposed operations • Evaluate the Net Environmental Benefit of the proposed actions • Evaluate the practicality and ability of the proposed operations and procedures to achieve the segment (local) treatment objectives and strategies • Evaluate the need to redefine an objective or strategy if the original proposed actions cannot be conducted in a safe or effective manner
Prepare Shoreline Treatment Plans	• Develop a long-range regional shoreline treatment/cleanup plan • Prepare individual segment (or group-of-segments) treatment/cleanup plans.

Figure 2.3 Shoreline treatment decision process.

SCAT Survey Team
Summary Cleanup Recommendations

DATE: 4 March 99

SUMMARY PREPARED BY: EHO **POSITION:** SCAT Manager

Location	Observations	Remarks
D-1 Yaquina Bay	ran 50 boat transects across the bay from the mouth east to the "green tanks"	no tar balls or sheens observed
A-2	oiled beach grass along high-water area - has coats and stains when gloved hand inserted into grass - approx. 1 bag/yard	manual cleanup recommended along approx. 1000 yards
A-4	tar balls (TB) on drift line ave. size 1" and frequency of 10-20/yd^2; 1 bag/10 yards	manual cleanup recommended
B-1	TB ave. size <0.5" along 1-2 ft wide swash line and frequency range from low of 1/yd^2 to max. of 50/yd^2 ; brown and rainbow sheen	manual cleanup recommended for some sections with high TB frequency
B-2	TB on drift line ave. size <0.25" along 1-2 ft wide swash line and frequency range from low of 1/yd^2 to max. of 10/yd^2 ; silver sheen	no action required
N-5 and N-6	no oil observed in surf zone or on beach (response to citizen report)	no action required

Figure 2.4 Example of daily summary report and shoreline cleanup recommendations from the NEW CARISSA incident, Oregon, 1999.

Typically the establishment of the cleanup criteria is a joint decision by the spill management team and is agreed by the responsible party. Probably, there will be range of criteria that may depend upon:

- the shore type (bedrock, sea walls, sand beaches, marshes, etc.)
- the environmental character of the segment and the habitat value
- the use of the segment (wildlife refuge, residential area, park, remote area, etc.)
- operational factors (access, staging, techniques feasibility, etc.)
- the degree of oiling
- the anticipated rate of natural cleaning

Treatment standards or cleanup end points may vary from one area or segment to another and may include:

- no visible oil
- oil is at background levels
- residual oil releases do not affect ecological resources or human health
- residual oil does not cause a loss of aesthetic value and/ or amenity use
- oil is no longer sticky or rubs off
- further removal would damage the habitat

Often a step or phased approach is developed that involves an initial inspection, that typically will involve members of the SCAT team(s), to establish that the treatment criteria or cleanup standards have been met. This may be followed by a later inspection to ensure that the segment remains in an acceptable condition (Michel and Benggio,1999). These post-cleanup inspections often rely on the SCAT data to provide a picture of the oiling conditions through time.

Shoreline Treatment and/or Cleanup Operations	• Segments are treated or cleaned following the guidelines, and possibly constraints, provided in the Shoreline Treatment Plan
▼	
Post-Treatment Survey or Inspection	• Inspection team (may involve SCAT personnel) establish that "end point" criteria or treatment standards for the segment have been met
▼	
Possible Second-Phase Survey or Inspection	• Inspection team (may involve SCAT personnel) ensures that shoreline conditions in the segment remain acceptable
▼	
"Sign Off"	• Spill management team (e.g., Unified Command) approves that no further shoreline treatment or cleanup activities are required within the segment

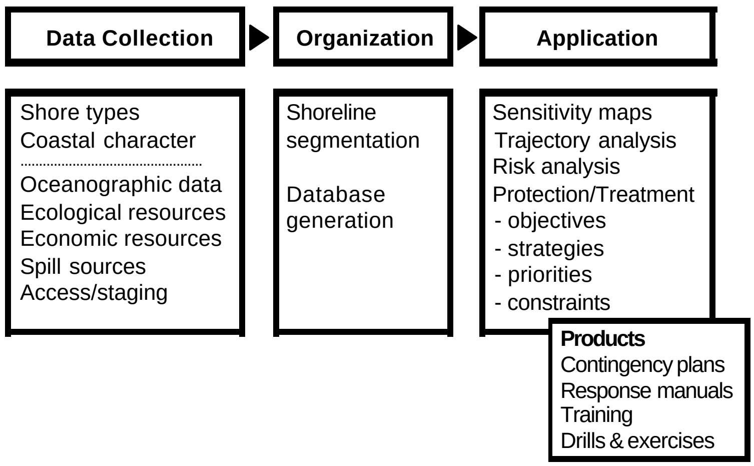
2.2 OTHER APPLICATIONS OF SCAT

2.2.1 Pre-Spill SCAT Surveys

Pre-spill mapping projects can be coupled to the SCAT process by creating shoreline segments and acquiring basic physical shoreline data on shoreline types and coastal character so that key elements of the SCAT database are in place at the time of an incident. This data can be integrated with a GIS digitized shoreline layer so that maps with the segment boundaries and other shoreline features can be generated to support field surveys.

The following examples indicate where the SCAT approach has provided direct input for regional-scale spill response planning and shoreline sensitivity mapping.

Coastal mapping of Atlantic Canada is based on the division of approximately 34,000 km of coastline into more than 12,500 individual segments. The physical shore-zone characteristics, human use activities, and coastal resources are part of a data base



that has been integrated with the Canadian National Sensitivity Mapping Program to produce a digital environmental resource sensitivity mapping system base on GIS technology as well as hard-copy maps (Percy *et al.*, 1997). The mapping procedure also includes the definition of segment protection and cleanup objectives and strategies.

The SCAT approach also is the basis for the Alyeska Pipeline (SERVS) mapping program for the Prince William Sound in Alaska. The initial shore-zone segmentation and mapping is based on low-altitude video-tape surveys and the data base is the foundation for the shoreline layers of the Graphical Resource Database that has been designed to support oil spill response planning and response operations (O'Brien *et al.*, 1995). Similar surveys, based on low-altitude video-taping, have been carried out to provide both reconnaissance- and detailed-scale shoreline mapping for Sakahlin Island, Russia, and in the Arabian Gulf (Bahrain and Qatar). In Oa'hu, Hawaii, a SCAT training program led to an interagency segmentation and mapping ground survey project conducted by representatives of local government agencies, the federal government and industry operators in that region to provide input for area response plans (Owens, 1999).

2.2.2 SOS Forms for Different Environments

The Shoreline Oiling Summary (SOS) forms presented in Section 1.5 are generic in nature and applicable for the description of shoreline oiling conditions on many shoreline types and habitats. However, some environments have different characteristics which require modifications to the basic form. With this in mind, this section highlights adaptations that may be applied for several specific environments.

LARGE FRESHWATER LAKES

Surveys of oil spills on the shorelines of large lakes, such as the Great Lakes of North America, can use most elements of the generic SOS form. Only the following three modifications are necessary.

1. Replace Box 1 "Tide Height" with "Water Level"

Water Level
above / below ?
the monthly mean
rising / falling ?

2. Replace Box 4A with the shoreline types that are defined by Environment Canada (1996b).

4A SHORELINE TYPE (for USZ)	***select only one primary (P) oiled shoreline type and any secondary (S)***					
Bedrock: Cliff ____ Shelving ____	Sand Beach	___	Cobble	___	Sand/Barrier Lagoon	___
Exposed Sediment Bluff: _________	Pebble Beach	___	Boulder	___	Delta Mud Flat	___
Manmade: Impermeable _________	Pebble-Cobble	___	Fringe Wetland	___	Manmade Permeable	___
Winter Only: Ice Snow	Mixed Sd-Gravel		Broad Wetland		Low Vegetated Bank	

3. In Box 6 and 7, replace "Tidal Zone" with "Swash Zone".

SWASH ZONE		
LSZ	USZ	SSZ

Key:

LSZ Lower Swash Zone — the area between the mean annual water level and the lowest annual water level, the lower approximate one half of the zone of wave activity.

USZ Upper Swash Zone — the area between the highest annual water level and the mean annual water level, the upper approximate one half of the zone of wave activity.

SSZ Supra-Swash Zone — the area above the highest annual water level that only occasionally experiences wave activity, as during a storm event.

ARCTIC SHORELINES

For application to arctic regions it is necessary to make only the following three modifications:

1. In Box 1 (GENERAL INFORMATION) add:

SEASON: Open Water / Freeze-Up Transition / Frozen Period / Breakup-Thaw

2. Add the three arctic shoreline types in Box 4A

peat shorelines___ tundra cliffs___ inundated low-lying tundra___

3. In Box 5 insert:

Depth of Active Layer ________ cm

This depth is measured from the beach surface to the top of frost table or permafrost and varies through the summer and also across-shore. If a “frost-table profile” is measured, this information should be included as a sketch.

WINTER SHORELINES (with ICE and/or SNOW)

1. In Box 1 (GENERAL INFORMATION) add:

SEASON: Open Water / Freeze-Up Transition / Frozen Period / Breakup-Thaw

2. Insert a new Box 4C:

4C SHORELINE SNOW AND ICE CHARACTERISTICS (for oiled zone)
ICE : wet/thawing ___ dry ___ ice floes_____ ice coat _____ ice foot ______
SNOW : wet/thawing ___ dry ___ fresh dry snow ___ slush _____ snow thickness ______ cm blowing snow Y / N
NEARSHORE : open water ____ broken ice ______ shorefast ice ______ tidal cracks __________

Ice and snow on shorelines are discussed in more detail in EPPR (1998) Sections 4.11.3 and 4.11.14.

3. In Box 5 insert:

Depth of Active Layer ________ cm

4. Delete Box 7

MANGROVES

The description of oil in mangroves can use the Wetland Oiling Summary form (Section 1.5.5) with the following type of modification to Box 4A.

4A MANGROVE FOREST TYPE
fringing mangrove ___ dwarf forest ____ overwash forest ____ riverine forest ____ basin forest ____

Definitions for these mangrove forest types are provided by Getter *et al.* (1984).

CORAL

Oil may become stranded on the exposed coral ***reef crest*** or ***reef flats*** during periods of low astronomical or meteorological tidal water levels. Modify Box 4.

4A CORAL REEF CHARACTER
fringing reef ____ atoll ____

4B BACKSHORE CHARACTER: Indicate one Primary (P) and all appropriate Secondary (s)
lagoon___ sea grass beds___ mangrove forest ___
sand beach ___ pebble-cobble beach___ boulder beach___ man-made solid ___

4C CORAL TYPES
Dominant Coral Types:

Box 5 could be modified to focus on boat access issues such as:

Distance from nearest Dock/Boat Launch site: Water Depths: Accuracy of Charts: etc.

Box 6 could be developed with the following Oiling Characteristics:

6 SURFACE OILING CONDITIONS									
ZONE	**ELEVATION ABOVE WATER AT LOW TIDE**	**OIL COVER**			**OIL THICKNESS**	**OIL CHARACTER**	**CORAL STRESS***		
		L	**W**	**%**			**BL**	**MO**	**MU**

** BL - Bleaching : MO - Mortality : MU - Mucosing*

As coral is impermeable, Box 7 is unnecessary.

RIVERS, STREAMS, and CREEKS

A primary aspect of surveys of a river or stream is the requirement to distinguish between the two banks.

- For ***large rivers***, a team surveys only one bank at a time and the observations are recorded on a modified SOS form — RIVER SHORELINE SOS FORM.
- For ***small rivers, streams, or creeks,*** where both channels of a segment (or reach) are surveyed by a single team, it is appropriate to record information for each stream bank side-by-side on the same form (a STREAM SHORELINE SOS FORM). Begin by completion of the Left Bank Surface Oiling Conditions (Box 6-L), then complete for the Right Bank (Box6-R).

1. For Large Rivers Replace Box 1 “Tide Height” with “LEFT/ RIGHT BANK” (the river bank is always defined facing downstream).

   For Small Rivers, Streams, or Creeks, Replace Box 1 “Tide Height” with “Water Level”.

Water Level
low — mean — bankfull — overbank
falling — steady — rising

2. Box 4 for Large Rivers could be developed as follows:

4A RIVER BANK TYPE	***select only one primary (P) oiled river bank type and any secondary (S)***			
BEDROCK : ____ ***MAN-MADE SOLID :*** ____	***UNCONSOLIDATED :***	Clay ___	Mud ___	Sand ___
cliff/vertical ____ sloping ____ platform ____	Mixed Sand-Grave ___	Pebble-Cobble ___	Boulder ___	Rubble ___
Winter Only: Ice Foot ____ Snow ____	Marsh/Swamp ___	Peat ___	Vegetated ___	Shell Hasl ___
4B RIVER CHARACTER	***select as appropriate***			
CLIFF or BLUFF : ____ : est. height _______ m	canyon ___	confined or leveed channel ___	flood plain valley ___	
slope: gentle (<5 deg) medium steep (>30 deg)	straight ___	meander ___	anastamosed ___	braided ___
4C CHANNEL CHARACTER	***circle or select as appropriate***			
est. width : < 1m 1–10 m 10–100 m >1000m ______m	**est. water depth :** <1 m 1-3 m 3-10 m >10 m ____ m			
shoal(s) present Y / N **point bar present** Y / N	**bar-shoal substrate** : silt / sand / gravel / cobble / boulder / bedrock / debris			
seasonal water level: low / mean / bank full / overbank flow	**est. change over next 7 days :** falling — same — rising			

Box 4 for Small Rivers, Streams, and Creeks could be developed as follows:

4A STREAM BANK TYPE	***select only one primary (P) oiled stream bank type and any secondary (S) if banks are different, then indicate by P-L and S-R etc.***					
BEDROCK : ____	***MAN-MADE SOLID :*** ____		***UNCONSOLIDATED :***	Clay ___	Mud ___	Sand ___
cliff/vertical ____	sloping ____	platform ____	Mixed Sand-Gravel ___	Pebble-Cobble ___	Boulder ___	Rubble ___
Winter Only: Ice	Snow		Marsh/Swamp	Peat	Vegetated	Shell Hash
4B STREAM CHARACTER	***select as appropriate — indicate Left (L) or Right (R) bank if appropriate***					
CLIFF or BLUFF : ____ : est. height _______ m			canyon ___	confined or leveed channel ___		flood plain valley ___
slope: gentle (<5 deg)___	medium___	steep (>30 deg) ___	straight ___	meander ___	anastamosed ___	braided ___
4C STREAM CHARACTER	***circle or select as appropriate***					
est. width : <1 m 1–10 m >10m _______ m			**est. water depth :** <1 m 1–3 m >3m ____ m			
shoal(s) present Y / N	**point bar present** Y / N		**bar-shoal substrate** : silt / sand / gravel / cobble / boulder / bedrock / debris			
channel form: cascade	rapids	pool	riffle	glide	jam	other

Key:

4A: **Vegetated** — equivalent to Great Lakes shore type definition.

4B: **Braided Channel** — the channel splits into many smaller interlaced channels with multiple bars and shoals

Anastomosed Channel — (or *anabranched channel*) — a channel that has split into two or more well-defined channels that re-converge downstream.

4C: **Est. Width** and **Est. Water Depth** both relate to the water in the channel.

3. In Boxes 6 and 7 the River Bank Zone and Stream Bank Zone definitions are:

MS MID-STREAM

– shoal(s) or bar(s) exposed in the channel and separated from the river bank (a ***Point Bar*** is attached to the river bank)

LB LOWER BANK

– exposed only during low flow conditions

UB UPPER BANK

– under water only during bank full river stage

OB OVERBANK = flood plain

– inundated only during flood conditions

2.2.3 Other SCAT Shoreline Forms

The Environment Canada SCAT Manual (1992) and the First Edition of this Field Guide (Owens and Sergy, 1994) included a series of forms that can be used to document shoreline ecology (SES), human use (HUS), and cultural resources (CRE) (e.g., Mobley *et al*., 1990). In practice, these forms have not been used on spills since the *Exxon Valdez* SCAT survey program and are not included in this Second Edition. These forms were developed initially because of the requirement to document these types of information on a specific spill response. If similar types of forms are appropriate and developed to support an assessment survey, it is advisable to include the information defined in Boxes 1 and 2 of the SOS forms.

A variety of standard forms can be developed to assist in the organization and documentation of the SCAT activities. These could include:

- daily team report forms
- daily segment treatment recommendations
- document tracking forms
- photograph logs
- videotape logs

2.2.4 SCAT Surveys for Nearshore Submerged Oil

A SCAT team may be requested to provide recommendations for locating or tracking oil that has submerged or sunk in nearshore shallow waters, as this oil may pose a threat to the adjacent shorelines. Oil that is more dense than the nearshore water can sink and collect in low areas, such as the troughs that are a common feature of nearshore bar systems on open coasts (Michel *et al.*, 1995).

Survey methods for submerged or sunken oil include (Castle *et al*., 1995):

- visual inspection from aircraft or boats
- visual observations by divers along predefined transects
- sampling by dropping sorbents attached to a weighted line

More sophisticated techniques, primarily for deeper waters, could involve the use of remote operated vehicles with video cameras.

The purpose of this type of nearshore survey is the same as for an onshore survey and would involve the:

- identification of oiled and non-oiled areas
- description of the location, character, and amount of submerged or sunken oil
- evaluation of the operational options and logistical factors
- establishment of recovery or treatment priorities
- establishment of recovery or treatment standards or criteria
- recommendation of recovery or treatment methods

2.2.5 Computer Technology Applications

The traditional field methods for a SCAT survey involve the use of paper forms and notebooks. Technology applications that have been developed to support these field activities include:

- electronic SCAT forms (Simececk-Beatty and Lehr, 1996)
- wireless links (radios and cellular phones) (Rubec *et al*., 1996 and 1998)
- hand-held or laptop computers and satellite links
- accurate distances can be measured quickly with a laser range-finder
- location information for segment boundaries or specific features can be provided by hand-held (non-differential) Global Positioning Systems (GPS)
- video cameras or digital cameras provide a method of immediate capture and replay (video systems can replay directly onto a lap-top or large computer without the requirement for a television monitor)

Data management and information displays can benefit from many off-the-shelf computer applications as well as custom-designed spill management tools (e.g., Lamarche *et al.*, 1998: Williams *et al.*, 1997). The most important computer applications involve:

- entry of information and data into electronic files or a database
- data summary generators
- report generators
- GIS maps

2.3 CASE STUDIES

Case studies provide a means of describing the application of SCAT principles to a range of different spill situations. Additional examples to those briefly described below can be found referenced in Owens, 1999.

Nestucca British Columbia 1989	two teams with representatives from government agencies and a First Nations tribal council assessed 500 km of affected coasts by helicopter with spot ground inspections; the same teams conducted the post-treatment inspections
Exxon Valdez Alaska 1989-1993	initial aerial videotape mapping survey that covered 8000 km of affected coasts, systematic ground surveys (1989), spot ground surveys (1990-1993), and a long-term monitoring program
Arrow Nova Scotia 1992	post spill systematic ground survey to define locations and amounts of oil remaining 22 years after the incident
St. Petersburg Florida 1993	a systematic survey of 20 km of sand beaches that involved the delineation of buried oil layers, the assessment of cleanup options, and the development of cleanup recommendations
Komi Pipeline Russia 1995-1996	adaptation of the SCAT concept for rivers and streams
Buffalo 292 Texas 1996	two-phase SCAT survey: initial systematic ground survey followed by tar ball survey in remote areas
New Carissa Oregon 1999-2000	two-phase SCAT survey: initial systematic ground survey followed by tar ball monitoring over a 12-month period
Ossa 2 pipeline Bolivia 2000	two-phase aerial videotape surveys: initially to locate and map surface oil for cleanup in a river flood-plain region, followed by post-cleanup documentation surveys

The *Nestucca* Spill Response — British Columbia, 1989

Oil became stranded over a 3-week period along the 500-km length of western Vancouver Island. Initial information on the distribution and degree of shoreline oiling in this remote and largely inaccessible region was often incomplete and sketchy. An interagency shoreline evaluation team (SET) that involved a representative from the government, the responsible party, and the local First Nation tribal council was created to locate oil, evaluate the degree of oiling and recommend appropriate cleanup methods. Standard reporting forms and oil cover definitions were introduced to provide a consistent information base from which response decisions could be developed (Owens, 1990). This 3-week survey involved two 3-person helicopter-supported field teams and the same SET teams conducted the post-treatment inspections.

The *Exxon Valdez* Spill Shoreline Assessments — Alaska, 1989-1993

Following the spill from the *Exxon Valdez*, the initial spring 1989 SCAT (Shoreline Clean Advisory Team) survey covered approximately 1500 km of coast in Prince William Sound and over 4000 km of coastline in the Gulf of Alaska (Owens and Teal, 1990). The affected areas were divided into 549 and 600 segments respectively. 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. An initial low-altitude, videotape mapping survey provided information on the shoreline locations where oil had washed ashore. As the oil moved farther away from the initial spill site this aerial assessment became a key element and provided a focus for the ground survey teams that followed. Over 8,000 km of coast were surveyed by the aerial mapping teams. The 1989 systematic ground survey involved a geologist, ecologist and archaeologist. The subsequent 1990, 1991 and 1992 surveys visited segments in which oil remained after the 1989 cleanup program and after the natural cleaning by winter wave action. These SCAT teams included agency, operations, and land manager representatives in addition to the geologist and ecologist

(Neff *et al.*, 1995). The information base was shared and used by (i) all decision-makers to develop a regional strategy, (ii) the planning team to develop the response strategy, (iii) the logistics team to develop support plans, and (vi) operations to implement the shoreline treatment program.

A site monitoring program was initiated early in the response and data were collected from a wide range of shoreline types and for different degrees of oiling to provide a detailed picture of the changing shoreline conditions. A total of 28 multi-transect sites were monitored throughout the area by geologists and ecologists on a regular basis from the spring of 1989 to the fall of 1990. The methodology and results have been described by Owens (1991).

The *Arrow* Post-Spill Survey — Nova Scotia, 1992

A survey of Chedabucto Bay, Nova Scotia, was carried out in the summer of 1992 to assess the presence and character of any residual oil from the 1970 *Arrow* spill (Owens *et al.*, 1993). The 305 km of originally oiled coastline was subdivided into 505 segments, of which 419 segments (248 km) were surveyed by foot. The standard SOS form was used and the only data collected related to the physical shoreline character and, where present, the observed oiling conditions. The lengths of the segments varied between 75 m and 4.4 km, but 70% of the segments were in the range >300 m and <1000 m.

The total length of shoreline on which oil or oiled sediments were observed was 13,300 m, or 5.37% of the total surveyed shoreline. Of this total, 868 m (6.5% of the total oiled shoreline length) had a HEAVY cover (based on width and distribution parameters) and 77% was described as having either a LIGHT or VERY LIGHT cover. The difference between the total length of oiled shoreline and the length of shoreline with heavy versus light degrees of oiling illustrates the point that the total length of oiled shoreline alone is a poor measure of the actual oiling conditions.

The St. Petersburg Beach Spill Response — Florida, 1993

A spill from a barge/freighter collision at the entrance to Tampa Bay resulted in the oiling of approximately 20 km of ocean shore in the St. Petersburg Beach area. Shortly after the oil was stranded on the beach berm, it was buried by the deposition of a layer of clean sand during a high tide. The application of the assessment process to document the location and amount of surface and subsurface oil was relatively simple. Surface observations were made and pits dug to locate and describe sub-surface oil on 92 across-shore transects, spaced 0.1 mile apart, along three sand beaches, which were separated by tidal inlets. Areas of buried oil were marked by surveyor's flagging to assist cleanup crews in the removal of this sub-surface oil (similar segmentation and flagging techniques were used on the *Buffalo 292* spill response described below).

The results showed that no surface oil remained on the Madeira Beach section but that sub-surface oil was present on 19 of the 24 transects (Owens *et al.*, 1995). The average width of the buried sub-surface oil layer was 2.9 m, the average depth 23 cm and the average thickness of the buried oil layer was 1.3 cm. At four of the transects the oiling was observed to be in the high concentration OP category (see Section 3.1.2). By contrast, on the St. Petersburg Beach section, OP was observed on 10 of the 25 transects but the average depth of the oil was less (12 cm). This data set was used to assess the treatment options and to calculate (1) the resources that would be required, (2) the time to completion, and (3) the volume of material to be removed from each of the three beaches, and disposed, if manual or mechanical cleanup (graders and front-end loaders) methods were used.

This survey, although brief in time and limited in scale and scope, involved the two fundamental elements of the shoreline assessment process by the use of standard terms and definitions and by the systematic approach to data collection. This information was a key element in the decision-making process that eventually recommended the mechanical removal of the buried oil layer.

The Komi Pipeline Spills — Russia, 1995-1996

The SCAT approach was applied to over 50 km of stream and river banks that had been oiled from a series of pipeline spills in the Russian sub-arctic (Sienkiewicz and Owens, 1996). Operational units on the order of 2 to 4 km in length were relatively uniform in physical character and subdivided into segments that were marked by stakes at intervals of approximately 200 m. The segment boundaries were located on 1 inch to 25 m scale maps developed from satellite imagery captured in May 1995. Local scientists were trained in the methodology, standard terminology was developed and translated, and the English and Russian versions of the form were identical in layout so that they could be completed in either language. Pre-treatment and post-treatment surveys were carried out and the information was entered into a data base to produce computer maps and graphic displays of both cleanup progress and post-treatment oiling conditions.

The *Buffalo 292* Spill Response — Texas, 1996

The SCAT surveys carried out during this response operation demonstrate the flexibility of the process and also the value of an available pool of pre-trained field personnel (Martin *et al.*, 1997). The initial shoreline assessment phase, which lasted for the first twelve days after the incident, involved systematic surveys in which segments were revisited every second day as oil continued to wash ashore. Buried oil was marked by surveyor's flags so that these could be easily found and removed by the cleanup crews.

As the oil began to move along the coast, the scale of operations extended to more than 250 km from the original release point. On these distant shorelines the oil stranded as tar balls and the oiling conditions typically were "trace" (less than 1%) to "sporadic" (1-10%), and were in a band 0.3 to 3.0m wide at irregular intervals along the coast. The systematic surveys were no longer appropriate and a second-phase approach was developed in which the segments were redefined at one-mile intervals and the oil condition information was transmitted from the field teams by cellular phone so that they did not have to return to base each day after the survey.

The New Carissa Spill Response — Oregon, 1999-2000

The initial field methods applied to shoreline assessment after the spill followed standard SCAT reporting procedures. Within a few days, the amount of oil on the shoreline diminished significantly and the standard method proved to be too insensitive and a Beach Assessment Reporting form was developed to provide an appropriate method for recording the frequency and character of stranded tar balls. This form is the basis for the Tar Ball Oiling Summary form in this Field Guide.

Shoreline surveys were continued for more than 12 months and the results presented as weekly oil distribution maps for the duration of the cleanup operations (March to September) and as tables and histograms of the daily (1) frequency (number of tar balls/m^2), (2) volume (gallons) , and (3) "normalized tar ball concentration per unit area" (gm/m^2) of tar balls (Owens *et al.*, 2000a). Large oiling or re-oiling events often masked smaller changes in oil conditions on the shoreline and this problem was resolved by plotting the daily values on semi-logarithmic scale histograms.

The Ossa 2 Pipeline Spill — Bolivia, 2000

Oil was spilled into the Rio Desaguadero during the high flood waters of the rainy season and spread over a distance of 250 km downstream. Aerial surveys were conducted for two separate purposes. First, low-altitude videotaping along closely-spaced flight lines, with an integrated Global Positioning System, was used to locate, accurately position, and map surface oil deposits for cleanup in an extensive flood plain region that covered several hundred hectares. Secondly, after cleanup operations had been completed, low-altitude videotape surveys of the entire affected area provided documentation that the cleanup standards had been achieved.

PART 3 SUPPORT MATERIALS

3.1 TERMS AND DEFINITIONS

The standard terms and definitions presented in this section provide an explanation for completion of the SOS forms and a basis for a systematic description of shoreline and oiling conditions. Some modification may be appropriate based on local or regional geographic conditions or upon the specific character of spilled and/or stranded oil.

3.1.1 Surface Oiling Conditions

Surface oiling conditions are described in terms of length, width, distribution, thickness and character of the oil within a specific tidal zone. This information is recorded for each segment, sub-segment or zone within the survey area (see Section 1.3.1 for information on segmentation). These data may be further combined to summarily rate the degree of oiling (see Section 1.4.2).

Length refers to alongshore (parallel to the shoreline) distance of oiled shoreline within a segment, sub-segment or zone.

Width refers to the average across-shore (perpendicular to shore) distance of the intertidal oil band within a segment, sub-segment or zone. If multiple across-shore bands are grouped, then width represents the sum of their widths. The actual oiling width can also be categorized by the following groups.

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

Surface Distribution represents the actual percent of the surface which is covered by oil, within a fixed area. A visual aid to surface distribution is provided in Figure 3.1. In the event of grouped multiple bands, distribution refers to the average oil conditions for the zone. The actual oil distribution measurements can also be categorized or grouped.

Trace (TR)	<1%	**Broken (BR)**	51–90%
Sporadic (SP)	1–10%	**Continuous (CN)**	91–100%
Patchy (PT)	11–50%		

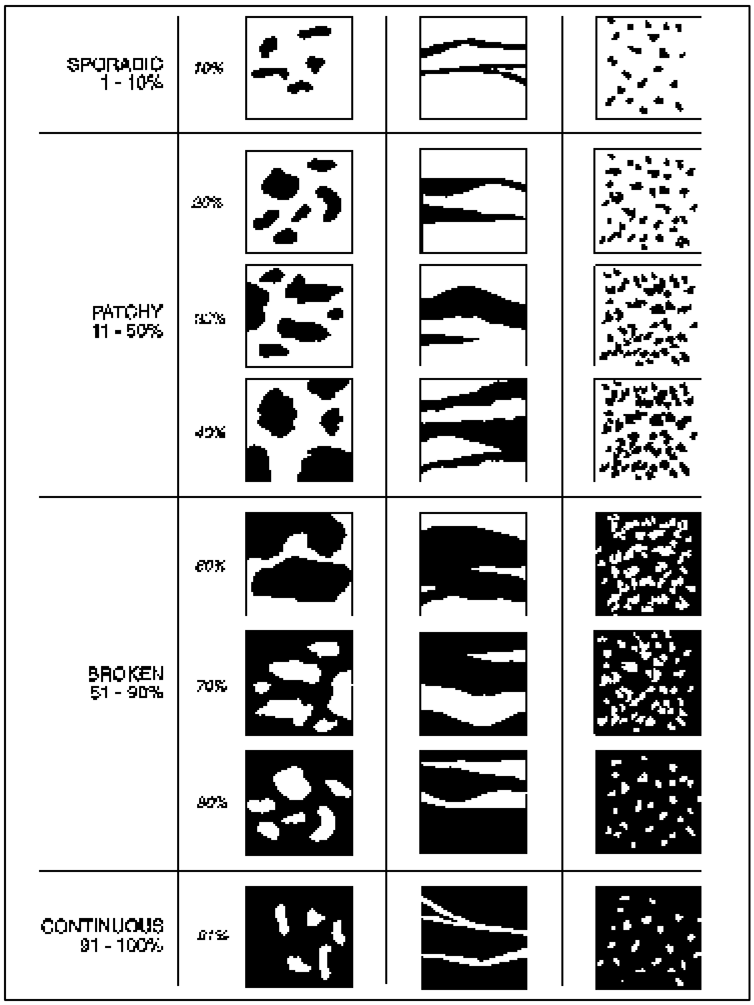


Figure 3.1 Visual aid for estimating oil distribution percentiles.

Surface Oil Thickness refers to the average or dominant oil thickness within the segment or zone. It is described according to the following categories.

- **PO** **Pooled or Thick Oil** — generally consists of fresh oil or mousse accumulations >1 cm thick
- **CV** **Cover** — >0.1 cm to ≤1 cm thick
- **CT** **Coat** — >0.01 cm and ≤0.1 cm thick. Can be scratched off with fingernail on coarse sediments or bedrock
- **ST** **Stain** — ≤0.01 cm thick. Cannot be scratched off easily from coarse sediments or bedrock
- **FL** **Film** — transparent or translucent film or sheen

Surface Oil Character provides a qualitative description of the form of the oil.

- **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** — discrete oil balls on a beach or adhered to rock or coarse-sediment substrate. Tar ball diameters are generally <10 cm
- **PT** **Tar Patties** — discrete patties of oil on a beach or adhered to the substrate. Tar patties are generally >10 cm
- **TC** **Tar** — weathered coat or cover 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** — consists of a cohesive mixture of oil and sediments
- **NO** **No Oil Observed**

Oiled Debris — can consist of logs, rubbish and flotsam stranded on the shoreline, dead animals or vegetation and spill response items such as sorbents, booms, snares etc.

Summarizing the Degree of Oiling

Several of the above data can be combined to create indices to rate the degree or relative severity of oiling in a particular segment. Potential indices are depicted below.

		Width of Oiled Area			
		Wide	**Medium**	**Narrow**	**Very Narrow**
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

Figure 3.2 Surface Oil Cover category (width x distribution data).

		Surface Oil Cover Category			
		Heavy	**Moderate**	**Light**	**Very Light**
Thickness	**Pooled > 1.0 cm**	Heavy	Heavy	Moderate	Light
	Cover >0.1-1.0 cm	Heavy	Heavy	Moderate	Light
	Coat >0.01-0.1 cm	Moderate	Moderate	Light	Very Light
	Stain/Film ≤0.01 cm	Light	Light	Very Light	Very Light

Figure 3.3 Surface Oil Category (Surface Oil Cover category x thickness data).

3.1.2 Sub-Surface Oil Conditions

Sub-surface oil is usually described in terms of depth of penetration or thickness of the buried oil lens, and a qualitative description of the character or relative concentration of oil.

Oil Character (Sub-surface)

- **SAP** **Sub-surface Asphalt Pavement** — cohesive mixture of weathered oil and sediment situated completely below a surface sediment layer (record thickness)
- **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** **Oil Residue as a Cover** (>0.1– 1 cm) or **Coat** (>0.01 – 0.1 cm) of oil on sediments and/or some pore spaces partially filled with oil. Can be scratched off easily with fingernail on coarse sediments or bedrock
- **OF** **Film or Stain** (<0.01 cm) of oil residue on the sediment surfaces. Non-cohesive. Cannot be scratched off easily on coarse sediments or bedrock
- **TR** **Trace** — discontinuous film or spots of oil on sediments, or an odour or tackiness with no visible evidence of oil
- **NO** **No Oil** — no visible or apparent evidence of oil

Sheen Colour

- **S** **Silver** (NOAA equivalent = silver)
- **R** **Rainbow** (NOAA equivalent = first colour or bright colour)
- **B** **Brown** (NOAA equivalent = dull or dark colour)
- **N** **None** (NOAA equivalent = none)

Sheen colour may be roughly indicative of the oil layer thickness and quantity.

Silver Sheen	<0.0001 mm thick	<100 L oil/km^3/km^2 (<0.1 m^3/km^2)
Rainbow Sheen	0.0001-0.001 mm thick	100-1000 L oil/km^3/km^2 (0.1-1.0 m^3/km^2)
Brown Sheen	>0.001 mm thick	>1000 L oil/km^3/km^2 (0.1-1.0 m^3/km^2)

Oiled Zone (Sub-surface) refers to the vertical width or thickness of the oiled sediment (sub-surface) layer when viewed in profile by digging a pit or trench. The top and bottom boundaries of the lens are recorded. The bottom boundary is equal to the maximum depth of oil penetration. The top boundary may equal 0 (the beach surface) or a greater number depending on whether clean sediments have been deposited on top of the oiled sediment.

Due to problems associated with defining the beach surface when differentiating between what is considered surface and sub-surface, the following guides have been developed and further illustrated in Figure 3.4.

- Fine sediments (pebble/granule/sand/mud) and/or fine mixed sediments; the sub-surface begins at 5 cm below the beach surface. For the purpose of measurement, the beach surface is the 0 cm reference level.
- Coarse Sediments (pebble/cobble/boulder) and armoured beaches; the sub-surface begins at the bottom of the first layer of surface material (i.e., disregard the surface layer). For the purpose of measurement, the beach surface reference point (0 cm) begins at this same level.
- Asphalt Pavement; Where AP exists on the surface, the sub-surface begins at the underside of the pavement. For the purpose of measurement, the beach surface reference point (0 cm) begins at the top surface of the pavement.

3.1.3 Other Terms

Intertidal Zone

LI **Lower Intertidal Zone** — the lower approximate one third of the intertidal zone

MI **Mid Intertidal Zone** — the middle approximate one third of the intertidal zone

UI **Upper Intertidal Zone** — the upper approximate one third of the intertidal zone

SU **Supratidal Zone** — the area above the mean high tide that occasionally experiences wave activity. Also known as the splash zone

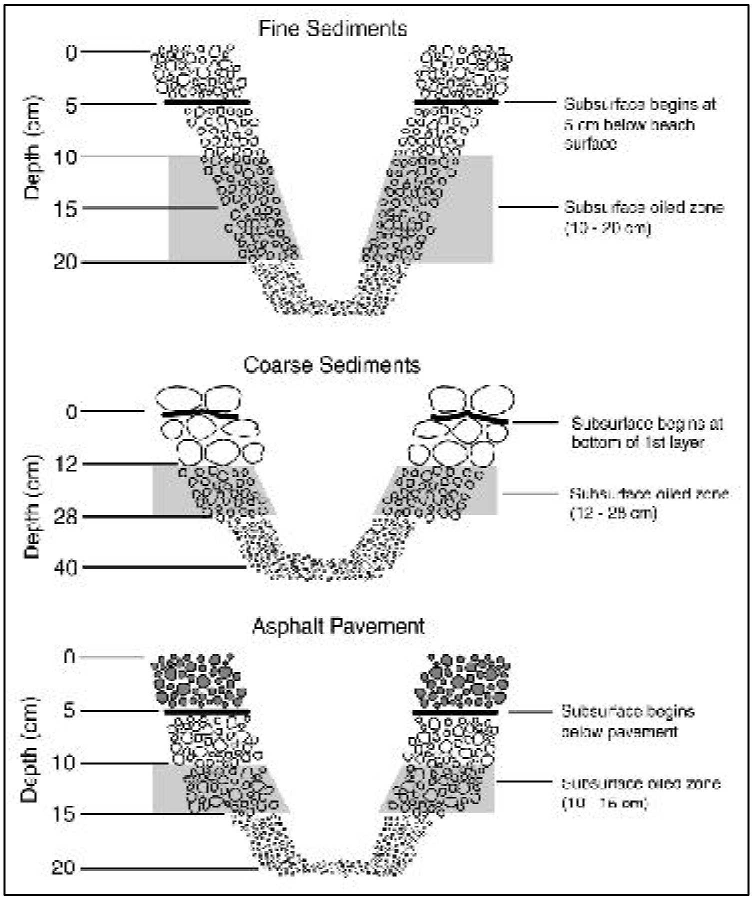


Figure 3.4 Sub-surface definitions.

Water Levels

High Water Mark — the higher limit of the tidal water level

Mean High Water Mark — the higher limit averaged over a time period

Spring High Water Mark — the higher limit of spring tides

Neap High Water Mark — the higher limit of neap tides

Non-Tidal Shoreline Zone

LSZ **Lower Swash Zone** — the area between the mean annual water level and the lowest annual water level, the lower approximate one half of the zone of wave activity

USZ **Upper Swash Zone** — the area between the highest annual water level and the mean annual water level, the upper approximate one half of the zone of wave activity

SSZ **Supra-Swash Zone** — the area above the highest annual water level that only occasionally experiences wave activity, as during a storm event

Riverine Terms

MS **Mid-stream** — shoal(s) or bar(s) exposed in the channel and separated from the river bank (a ***Point Bar*** is attached to the river bank)

LB **Lower Bank** — exposed only during low flow conditions

UB **Upper Bank** — under water only during full river stage

OB **Overbank** = flood plain — inundated only by over-bank flow during flood conditions

3.1.3 Shore Types and Coastal Character

The character of the shore zone, the behaviour, fate and persistence of stranded oil, and the types of cleanup or treatment methods that are appropriate are primarily a function of the substrate materials. In describing a segment, it is important to distinguish between the shoreline type (Section 4A on the SOS Form) and the coastal character (Section 4B on the SOS Form).

SHORELINE TYPE
refers to the character of the upper intertidal (foreshore) or upper swash zone. This is the area where the oil usually becomes stranded and where the treatment or cleanup activities take place.

COASTAL CHARACTER
refers to the form of the shore zone as a whole and includes the area inland and seaward of the intertidal zone. This is the area where operations activities to implement the treatment or cleanup take place, and defines access constraints to the foreshore (intertidal) and backshore (supratidal) zones as well as the potential for staging areas adjacent to the segment that is to be cleaned.

The basic parameter that defines the shoreline type is the MATERIAL that is present in the intertidal zone. The presence or absence of sediments is a key factor as this will determine whether oil is stranded on the surface of a substrate or can penetrate and/or be buried.

SOLID SHORELINES
such as bedrock outcrops or man-made sea walls, are stable and impermeable.

UNCONSOLIDATED SHORELINES
such as beaches and deltas, are mobile and permeable.

Within these two fundamental shoreline types, further subdivision is based on the character of the substrate materials. The twelve Environment Canada Marine Shoreline Types are listed in Table 3.1 along with the equivalent Marine Shoreline Habitats that are used by NOAA and API.

The shoreline types that are used for the Canadian Great Lakes shorelines differ slightly from those in Table 3.1 in order to reflect the environmental conditions that typify this region and also to take into account the shoreline types that are used by NOAA for this area, as the international boundary follows five of the connecting water ways (St. Mary's River: St. Clair River: Detroit River: Niagara River: and the St. Lawrence River) and bisects five of the lakes (Superior: Huron: St. Clair: Erie: and Ontario). The following Table 3.2 is provided to match (1) the Environment Canada Great Lakes Shoreline Types with (2) the NOAA Shoreline Types that are used for the U.S. portion of the Great Lakes shorelines and (3) the API Freshwater Habitat Types (NOAA/API, 1995).

Ice and snow on the shoreline significantly alter the physical character of the substrate and, most importantly, can change the surface permeability. A solid impermeable bedrock shore with a layer of snow has a permeable surface layer, and a pebble beach with an ice cover has an impermeable surface.

> The ice and snow modifiers given for Box 4C on the SOS forms, described in Section 2.2.2, are an essential part of the description of the shoreline type for marine coasts, large lakes, rivers and streams.

The shoreline types for rivers and streams are based on the character of the substrate materials and are the same as described for marine coasts. A "River Character" qualifier is added to indicate the general features of the segment or reach and describes the morphology of the river or stream (see Section 2.2.2).

Table 3.1 Environment Canada Marine Shoreline Types

Environment Canada Marine Shoreline Types	API - NOAA Marine Shoreline Habitats
NON-PERMEABLE	
Bedrock	Exposed or Sheltered Rocky Cliffs, Wave-Cut Platform, or Reef Flats
Man-Made Solid Structures: Ice	Exposed or Sheltered Sea Walls or Piers
PERMEABLE	
Sand Beaches	Fine-Grained, Fine- to Medium-Grained, or Coarse-Grained Sand Beaches
Mixed Sediment (Sand-Gravel) Beaches	Mixed Sand and Gravel Beaches
Pebble-Cobble Beaches	Gravel Beaches
Boulder Beaches	Gravel Beaches: Riprap
Mud Tidal Flats	Exposed or Sheltered Tidal Flats
Sand Tidal Flats	Exposed or Sheltered Tidal Flats
Salt Marshes	Marshes
---	Mangroves
ARCTIC	
Peat Shorelines	Eroding Peat Scarps
Inundated Low-Lying Tundra Shorelines	Inundated Low-Lying Tundra
Tundra Cliffs	Sand

Table 3.2 Environment Canada Great Lakes Shoreline Types

Environment Canada Great Lakes Shoreline Types	NOAA ESI Great Lakes Shoreline Habitats	API Freshwater Habitat Types
1 Bedrock cliff	1A Exposed rocky cliffs 8A Sheltered scarps in bedrock	Bedrock
2 Man-made solid & Ice	1B Exposed, hard man-made shorelines 8B Sheltered man-made structures	Man-made structures
3 Shelving bedrock	2 Shelving bedrock shores	*in* Bedrock
4 Exposed sediment bluffs	3 Eroding scarps in unconsolidated sediments 8A Sheltered scarps in unconsolidated sediments	---
5 Sand beach a) depostional b) erosional/transitory	4 Sand beaches	Sand
6 Sand barrier with lagoon	4 Sand beaches	---
7 Coarse-sediment beach a) pebble b) pebble-cobble c) cobble	6 Gravel beaches	Gravel
8 Riprap	6B Riprap revetments, groins, and jetties	*in* Man-made structures
9 Boulder beach	6 Gravel beaches	*in* Gravel
10 Mixed-sediment beach	5 Mixed sand and gravel beaches	Mixed sand and gravel
11 Low vegetated banks	9A Sheltered vegetated low banks	Vegetated shorelines
12 Delta mud flats	7 Exposed flats 9B Sheltered sand/mud flats	Mud
13 Wetlands a) fringing b) broad	10A Fringing wetlands 10B Extensive wetlands	Wetlands

3.1.4 Shoreline Treatment and Cleanup Methods

The treatment or cleanup methods that may be used on oiled shorelines can be grouped into four basic strategies:

Physical Methods

- ***washing, recovery, and disposal*** (techniques 2 – 8)
- ***removal and disposal*** (techniques 9 – 13)
- ***in-situ treatment*** (techniques 14 – 16)
- ***chemical & biological treatment*** (techniques 17 – 20)

Environment Canada provides information on the applications and limitations of these methods for the different shoreline types in a series of shoreline treatment cleanup manuals and guidelines (Environment Canada 1996a, 1996b, 1998; EPPR 1998). These field guides identify a total of twenty shoreline techniques which are presented in the following Table 3.3 (adapted from API/NOAA, 1995) in the context of the relative potential impact of each technique on the twelve shoreline types in the absence of oil.

Table 3.3 Summary of Shoreline Treatment Methods

3.2 JOB AIDS

3.2.1 Photographic Examples of Surface Oil Distribution (Oil Cover)

An example that shows a ***continuous (95%)*** *oil distribution above the normal tidal zone, i.e., the supratidal zone (**SUTZ**), of this sand beach and a* ***trace (<1%)*** *distribution on all of the intertidal zone on the beach face slope (**LITZ-MITZ-UITZ**).*

Farther along the same sand beach, there is no oil in the supratidal zone and here the oil distribution, averaged over the distance that can be viewed, would be described as:

- ***trace*** *distribution* ***(<1%)*** *in the lower one-third of the intertidal zone (****LITZ****),*
- ***continuous*** *distribution* ***(100%)*** *in the middle one-third (****MITZ****), and*
- ***patchy*** *distribution* ***(35%)*** *in the upper one-third of the intertidal zone (****UITZ****).*

*This boulder beach has a **continuous (100%)** distribution in the upper intertidal zone (**UITZ**).*

This aerial view of the mixed sand-pebble-cobble beach in the lower half of the photograph has:

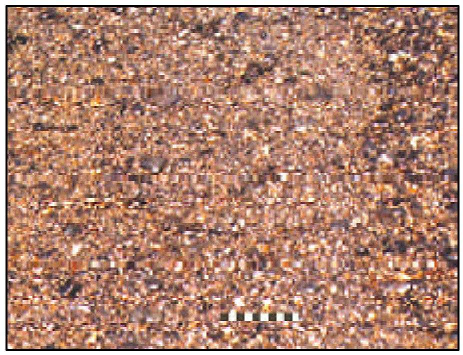
- ***<10% (sporadic)** oil distribution in the **LITZ**,*
- ***100% continuous** in the **MITZ** and **UITZ**, with*
- ***no visible oil** in the **SUTZ**.*

3.2.2 Sediment Grain Size

Grain Size Scale

Description (Wentworth Scale)		Grain Diameter (mm)
Boulder		>256
Cobble		64 - 256
Pebble		4 - 64
Granule		2 - 4
Sand	Very Coarse	1 - 2
	Coarse	0.5 - 1.0
	Medium	0.25 - 0.5
	Fine	0.125 - 0.25
	Very Fine	0.0625 - 1.125
Silt		0.004 - 0.625
Clay		0.00024 - 0.004

Granule
(scale is 10 cm long)

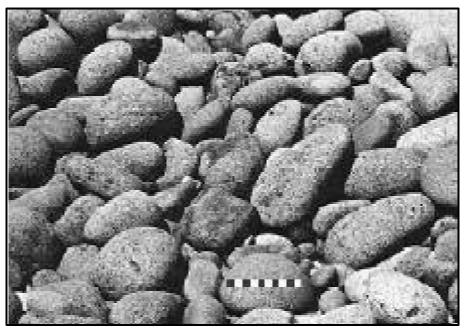


Pebble
(scale is 10 cm long)

Pebble-Cobble
(scale is 10 cm long)

Mixed Sediment
(Sand, granule, pebble, and cobble — scale is 10 cm long)

Cobble
(scale is 10 cm long)



Boulder

3.2.2 Photographic Examples of Shoreline Types

Bedrock

Boulder

Cobble Beach

Pebble-Cobble Beach

Mixed Sediment Beach *(sand and gravel)*

Sand Tidal Flat

Mud Tidal Flat

Ice Foot

3.3 REFERENCES

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3.4 CONVERSIONS

Length

1 centimetre	=	0.394 inches
1 inch	=	2.54 cm
1 foot	=	0.3048 metres
1 kilometre	=	0.6214 statute miles
1 kilometre	=	0.5399 nautical miles
1 metre	=	3.281 feet
1 nautical mile	=	6076 feet
1 nautical mile	=	1.852 kilometres
1 nautical mile	=	1.1508 statute miles
1 statute mile	=	1.609 kilometres

Area

1 acre	=	43,560 feet ^{2}
1 acre	=	0.4047 hectares
1 hectare	=	2.471 acres
1 hectare	=	10,000 metres ^{2}
1 square kilometre	=	0.3861 miles ^{2}
1 square mile	=	640 acres
1 square mile	=	2.60 kilometres ^{2}
1 square naut. mile	=	848.8 acres
1 square naut. mile	=	1.326 statute miles ^{2}

Volume

1 barrel (U.K.)	=	35 Imperial gallons (approximate)
1 barrel (U.S.)	=	42 US gallons (approximate)
1 barrel (U.S.)	=	5.6 feet ^{3} (approximate)
1 barrel (U.S.)	=	159 litres (approximate)
1 barrel (U.S.)	=	0.16 metres ^{3} (approximate)
1 cubic foot	=	6.2288 Imperial gallons
1 cubic foot	=	7.4805 US gallons
1 cubic foot	=	0.1781 US barrel

1 cubic foot	=	28.316 litres
1 cubic foot	=	0.02832 metres ^{3}
1 cubic inch	=	16.39 centimetres ^{3}
1 litre	=	0.22 Imperial gallons
1 litre	=	0.2642 US gallons
1 litre	=	0.00629 US barrels
1 litre	=	0.03532 feet ^{3}
1 litre	=	1000 centimetres ^{3}
1000 litres	=	1 metre ^{3}
1 cubic metre	=	220.0 Imperial gallons
1 cubic metre	=	264.172 US gallons
1 cubic metre	=	6.289 US barrel
1 cubic metre	=	35.31 feet ^{3}
1 cubic metre	=	1000 litres
1 Imperial gallon	=	1.2009 US gallons
1 Imperial gallon	=	0.02859 US barrels
1 Imperial gallon	=	0.1605 feet ^{3}
1 Imperial gallon	=	4.546 litres
1 millilitre	=	1 centimetre ^{3}
1 US gallon	=	0.83268 Imperial gallons
1 US gallon	=	0.02381 US barrel
1 US gallon	=	0.13368 feet ^{3}
1 US gallon	=	3.7853 litres

Speed

1 knot	=	0.514 cm/second
1 knot	=	1.688 feet/second
1 knot	=	1.15 st. miles/hour
1 st. mile/hour	=	0.869 knots
1 st. mile/hour	=	0.45 metres/second
1 metre/second	=	1.95 knots
1 metre/second	=	3.28 feet/second
1 metre/second	=	2.24 st. miles/hour