Subsurface Oil Detection and Delineation in Shoreline Sediments

Phase 2—Field Guide

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Contents

List of Figures

Field Guide for Subsurface Oil Detection and Delineation in Shoreline Sediments

1.0 Introduction

When oil strands on a dynamic shoreline, unless it is removed immediately, there is potential for:

- burial due to shifting beach sediments;
- mixing with underlying sediments; or
- penetration into porous sediments.

These processes result in subsurface accumulations consisting of:

- continuous layer(s) of solid or emulsified oil;
- discontinuous deposits; or
- oil saturated sediments.

In such cases, the detection and delineation of subsurface oil is required to ensure complete documentation of oiling and the development of recommendations for treatment end points and recovery or treatment techniques to achieve these end points. There are different stages at which subsurface detection observations are desirable:

- initial delineation;
- following significant events (such as, storms; post-treatment);
- during monitoring of the progress and effectiveness of treatment;
- detection of changes over time in oil characteristics which might impact recovery operations; and
- post-treatment inspections.

A key factor when choosing survey techniques is to compare detection efficiencies.

Although there exist a variety of survey techniques for vertical delineation of subsurface oiling, there are currently no proven efficient methods for horizontal detection and delineation of subsurface oil. Current accepted tactics, such as pitting, trenching and auguring, provide a relatively small data point regarding the horizontal distribution and character of subsurface deposits.

2.0 Objectives of the Field Guide

- Provide emergency responders and planners with practical guidance on the selection and use of currently accepted tactics for the detection, description, delineation and documentation of subsurface of oil in shoreline sediments.

- Provide a mechanism for consideration and field testing of new and developing tactics.

3.0 Format

The Field Guide is divided into three sections which should be reviewed sequentially:

- **Identification of Applicable Tactics (4.0)**

- **Survey Design Plan (5.0)**

- **Tactical Implementation (6.0)**

Attachment A discusses **horizontal and vertical positioning** and describes **beach profiling**, which is a tool that can document the horizontal and vertical positions of subsurface oil deposits and can provide a time-series picture of elevation changes on beaches with known subsurface oil.

Attachment B provides a “User’s Matrix” for **tactics that are either in development or are not universally accepted** at this time. These tactics may be considered in the screening of applicable options.

4.0 Identification of Applicable Tactics

A 5-step process is presented to identify appropriate detection and delineation tactics. Figure 4.1 provides a screening tool intended for the initial evaluation process (Step 1). Two matrices (Figures 4.2 and 4.3) summarize the key variables that affect the applicability and usefulness of the current accepted techniques (Step 5).

<u>STEP 1: Evaluate Tactical Feasibility</u>

The first step involves a preliminary screening of what can and cannot be attempted on a particular shoreline in terms of physical access and what type(s) and level of mechanical equipment could be used. Three classes are included:

- suitable for manual tactics (that is, access by foot);

- limited mechanical tactics (access with low surface pressure equipment only), and

- unlimited tactics (access with most mechanical equipment is feasible).

Considerations include access and trafficability as an initial step for the elimination of tactics that are unlikely to be feasible or practical. Figure 4.1 provides guidance for this initial screening.

STEP 2: Evaluate Existing Surface Oiling and Sedimentary Processes

This step involves field observations of the current shoreline oiling conditions, typically undertaken as part of a Shoreline Cleanup Assessment Technique (SCAT) survey program to systematically document surface and subsurface oiling.

Beaches change constantly in response to wave and wind processes at the shorelines, particularly during storm events. Changes can include rapid erosion, accretion, and the redistribution of sediments and subsurface oil. Understanding these processes and the accurate location of subsurface features is important.

Factors to consider include:

- **Penetration Potential:** Typically penetration is determined by the oil character, the smallest grain size of sediments in a beach, and water content.
- **Burial Mechanisms:** Consider how the oil came ashore (calm or high wave energy conditions; discrete slicks or scattered tar balls; etc.) as this provides information on the manner in which oil has been deposited.
- **Presence and Location of Existing Surface Oil:** Surface oiling may indicate areas where oil may have been buried, has been reworked into the subsurface by wave action, or has penetrated into the sediments.
- **Recent and Prevailing Coastal Processes:** Evaluate the recent and current shore-zone processes which control sediment reworking, sand accretion by wave action or alongshore transport.
- **Requirement for Beach Profiling Survey:** If a short-term data set (weeks) on beach elevation changes would be informative, determine appropriate profile locations, spacing and survey frequency.
- **Erosion/Accretion Status:** Evaluate whether the beach is currently undergoing accretion or erosion.
- **On-going Beach Restoration Projects:** Identify any local or nearby recent or current beach nourishment, dredging and/or bypassing activities as these can affect the sediment regime.

STEP 3: Identify Field or Operational Constraints

There may be regional or local issues, related to environmental concerns, land use, land management or land ownership that potentially could limit detection and delineation activities.

STEP 4: Consideration of Developing or New Tactics

This Field Guide focuses on accepted tactics but consideration should be given to other potential techniques that may be applicable and could be field tested.

For additional options see Attachment B and Section 5, “Developing Technologies” in Subsurface Oil Detection and Delineation in Shoreline Sediments, API 2012. These developing technologies and tactics include service dogs, gas detection instruments and a range of geophysical tools.

STEP 5: Identify Candidate Tactic or Tactics

Based on the information gathered in Steps 1 to 4, use Figures 4.2 and 4.3 (User’s Guide Matrices A and B) on the following pages to facilitate selection of best-fit tactic(s). No one tactic is likely to meet all of the desired operational characteristics, such as horizontal and vertical delineation, survey speed, etc. Cost and urgency factors may affect the final selection.

	TACTICAL FEASIBILITY	Manual (Foot Access Only)									Limited Mechanical (Low Surface Pressure Tracks/Flotation Tires)									Unlimited Mechanical (Most Equipment Feasible)								
	GRAIN SIZE	Clay/Silt			Sand/ Granules			>Granules			Clay/Silt			Sand/ Granules			>Granules			Clay/Silt			Sand/ Granules			>Granules		
	DEPTH (m)	<0.5	0.5-2.0	>2.0	<0.5	0.5-2.0	>2.0	<0.5	0.5-2.0	>2.0	<0.5	0.5-2.0	>2.0	<0.5	0.5-2.0	>2.0	<0.5	0.5-2.0	>2.0	<0.5	0.5-2.0	>2.0	<0.5	0.5-2.0	>2.0	<0.5	0.5-2.0	>2.0
POTENTIAL TACTIC	Pits/Trenches/ Manual *	x	-		x	-		x			x	-		x	-		-			x	-		x	-		x	-	
	Pits/Trenches/ Mechanical *										-	-		-	-		-	-		x	x		x	x		x	x	
	Coring Manual	x	x	-	x	x	-				x	x	-	x	x	-				x	x	-	x	x	-	-		
	Coring Mechanical										-	-	-	-	-	-				x	x	x	x	x	x	x	x	x
	Coring- Vibratory										-	-	-	-	-	-				x	x	x	x	x	x	-	-	-
	Water Jet	x	x	x	x	x	x				x	x	x	x	x	x				x	x	x	x	x	x	-	-	-

Green: Potential Tactic
Yellow: Potential Tactic under Limited Conditions

Figure 4.1 Physical Conditions – Screening Tool

Key:	Applicable	Potentially Useful	Not applicable

	Excavation			Cores			Water Jets
	Manual	Mechanical	Snorkel	Manual	Auger/Probe	Vibrate	
Subsurface distribution							
Vertical	Applicable	Applicable	Potentially Useful	Applicable	Applicable	Applicable	Potentially Useful
Horizontal	Potentially Useful *(trenches)*	Potentially Useful *(trenches)*	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Depth (m)							
<0.5	Applicable	Applicable	Applicable	Applicable	Not applicable	Not applicable	Applicable
0.5–1.0	Applicable	Applicable	Not applicable	Applicable	Applicable	Applicable	Applicable
1.0–2.0	Not applicable	Potentially Useful	Not applicable	Potentially Useful	Applicable	Applicable	Applicable
>2.0	Not applicable	Not applicable	Not applicable	Potentially Useful	Applicable	Applicable	Applicable
Sub-water table	Potentially Useful	Potentially Useful	Potentially Useful	Applicable	Applicable	Applicable	Potentially Useful
Moisture							
Dry	Potentially Useful	Potentially Useful	Not applicable	Applicable	Applicable	Applicable	Applicable
Damp	Applicable	Applicable	Not applicable	Applicable	Applicable	Applicable	Applicable
Saturated (wet)	Not applicable	Not applicable	Applicable	Not applicable	Applicable	Applicable	Applicable
Grain size							
Clay/silt	Applicable	Applicable	Potentially Useful	Potentially Useful	Applicable	Potentially Useful	Potentially Useful
Sand/granules	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
>Granules	Potentially Useful	Applicable	Potentially Useful	Not applicable	Potentially Useful	Potentially Useful	Potentially Useful

Figure 4.2 User's Guide Matrix A – Physical Factors

	Excavation			Cores			Water Jets
	Manual	Mechanical	Snorkel	Manual	Auger/Probe	Vibrate	
Oil character							
Fresh							
Emulsion							
Weathered							
Tar balls							
Pavement							
Sensitivity							
Presence (ONLY)							
Depth discrimination							
Layer discrimination							
Tar/SRBs							
Trace Level – Sub-visible							
Time and cost							
Survey speed							
Relative cost							

Figure 4.3 User's Guide Matrix Part B – Oiling Conditions and Survey Requirements

5.0 Survey Design Plan

5.1 Survey Plan Objectives and Strategy

The survey objectives are to:

- detect, delineate and describe the subsurface distribution of oil in shoreline sediments,
- understand the controlling penetration, reworking and depositional processes,
- understand the likely behaviour and fate of any subsurface oil,

in order to:

- recommend treatment end points,
- identify and monitor the progress of appropriate treatment strategies and tactics to achieve these goals, and
- confirm that end points have been met.

Precise or complete delineations may not be necessary to guide the overall shoreline response strategy and may not be feasible in many cases (particularly horizontal delineation), or relevant for more than a few days in many cases due to the dynamic nature of shoreline oiling and coastal processes.

The development of an incident-specific survey plan would be based on real-time conditions that involve many variables. Subsurface oil survey plans are therefore developed on a case-by-case, and often site-by-site, basis. The following guidelines are presented to assist in the development of survey plans.

5.2 Subsurface Oil Detection and Delineation Survey Plan Preparation

Initially establish who prepares and contributes to the plan and who approves the design. The outline should include guidance on the time lines (i.e. urgency) and the information review and decision process for end point and treatment recommendations.

5.3 Guidelines to Determine Representative Survey Density and Locations (Vertical and Horizontal)

- Survey requirements are different for:
    - discrete (**continuous**) accumulations, such as buried layers or pavement, which can be surgically excavated, for example, following the 1993 Tampa Bay spill, as opposed to,
    - widespread scattered (**discontinuous**) deposits, which could require bulk excavation and centralized treatment, for example, during Operation Deep Clean on the Deepwater Horizon response.

- The plan should address re-surveying frequency if there is a requirement to monitor changes in subsurface oiling due to natural attenuation or following treatment activities.
- The level of spatial detail (the survey density) would depend largely on the treatment techniques and the end point criteria.

5.4 Elements of the Survey Plan

The Subsurface Oil Survey Plan should address the following elements:

- Description of the tactic(s) and staging areas to be used in the investigation, including and waste disposal (if any),
- Health & Safety Plan, including personnel and equipment decontamination,
- Proposed location and density of observations,
- Location control (horizontal and vertical),
- Detections or accuracy levels for oil character (visual observations or oil concentration data),
- Calibration requirements for observers or equipment,
- Requirements for beach profiling to document beach elevation or changes in surface topography,
- Documentation, data management and reporting (Shoreline Oiling Summary forms, GPS waypoints, GIS data management, map and data report production), and
- Review and revision of Survey Plan at response stages, including the development and use of Key Performance Indicators (KPIs) for subsurface oil treatment activities.

6.0 Tactical Implementation

The tables in this Section describe the following individual tactics:

6.1 EXCAVATION: Manual Pitting
6.2 EXCAVATION: Mechanical Pitting
6.3 EXCAVATION: Manual Trenching
6.4 EXCAVATION: Mechanical Trenching
6.5 EXCAVATION: Shallow-water Snorkel Observations and Pitting
6.6 CORE SAMPLING: Hand Coring
6.7 CORE SAMPLING: Auger and Direct Push Coring
6.8 CORE SAMPLING: Vibratory Coring
6.9 JETTING: Water Jet Probes

6.1 EXCAVATION: Manual Pitting

Description: Manual excavation of observation pits.

Manpower and Equipment:

- Typically a minimum 2-person (SCAT) team
- Shovels
- GPS
- Camera and photo scale
- Measuring and recording tools (tape, forms etc.)

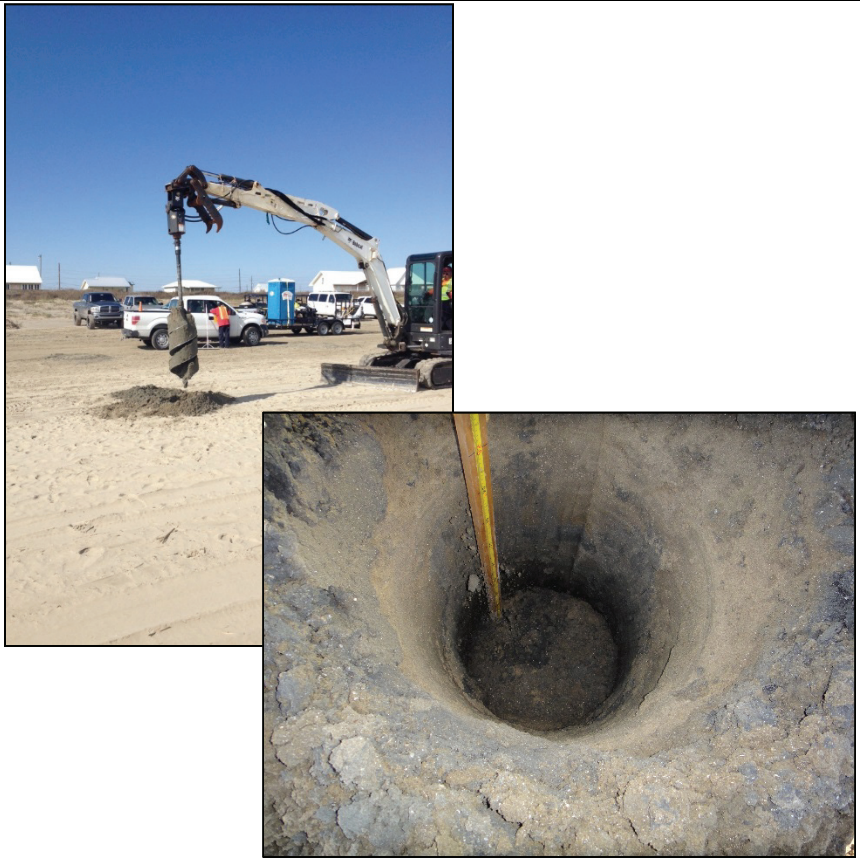
Operations Guidance:

- A simple and commonly-used technique.
- Typical pits are 0.5 to 0.75 m (1.5 to 2.5 ft) in diameter.
- Pits are generally extended to the beach groundwater table.
- Scraping the pit walls with the sharp edge of the shovel improves the ability to discern oil layering and sedimentary structures.
- Survey (pit) density depends on the uniformity of the subsurface oil, but typically dug in transects perpendicular to the shore.
- The selection of pit locations can be aided by consulting surface oiling maps (where oil has subsequently become buried) along with beach profile data, the combination providing both horizontal and vertical delineation of potential oiling.
- Pits should be back-filled as soon as observations are complete.
- Generally feasible on any beach with foot access.

Limitations:

- Pit observations only provide spot data; many pits may be required to adequately locate and delineate the extent and nature of subsurface oiling, particularly when oiling is irregular.
- Labor-intensive and time-consuming in cases where oil is buried to a significant depth and/or many pits are required.
- Pit observations are generally limited to sediment above the water table, and excavation is not possible during high tides.

6.2 EXCAVATION: Mechanical Pitting



Description: Mechanical excavation of observation pits.

Manpower and Equipment:

- ☐ Operator
- ☐ Observers/SCAT team
- ☐ Mechanical auger or small backhoe
- ☐ GPS
- ☐ Camera and photo scale
- ☐ Measuring and recording tools (tape, forms)

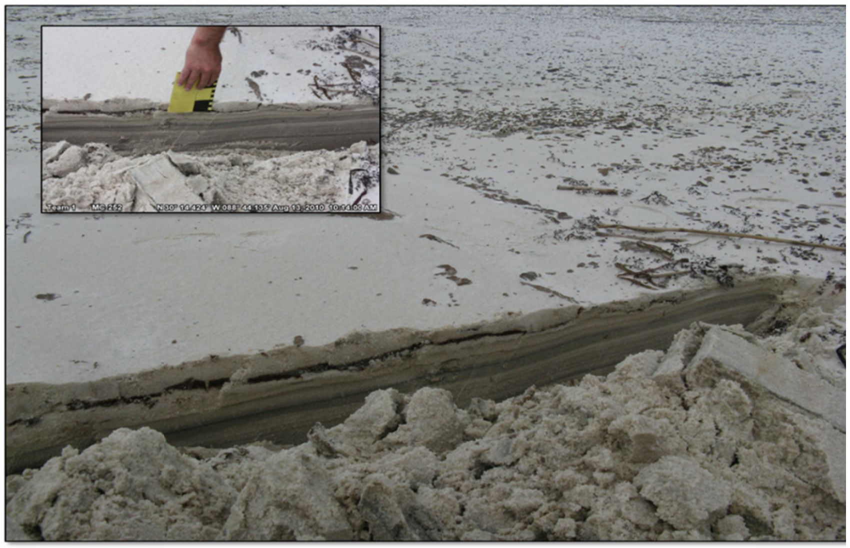
Operations Guidance:

- Used where manual pitting is too slow or strenuous.
- Typical pits are up to 1 m (3 ft) in diameter.
- Pits are generally extended to the beach groundwater table.
- Observing material on the auger bit and scraping the pit walls with the sharp edge of the shovel improves the ability to discern oil layering and sedimentary structures.
- Survey (pit) density depends on the uniformity of the subsurface oil, but typically dug in transects perpendicular to the shore.
- The selection of pit locations can be aided by consulting surface oiling maps (where oil has subsequently become buried) along with beach profile data, the combination providing both horizontal and vertical delineation of potential oiling.
- Pits should be back-filled as soon as observations are complete.

Limitations:

- Pit observations only provide spot data: many pits may be required to adequately detect and delineate the extent and nature of subsurface oiling, particularly when oiling is irregular.
- Moderately time-consuming in cases where oil is buried to a significant depth and/or many pits are required.
- Pit observations are generally limited to sediment above the water table, and excavation is not possible during high tides.
- Suitable access and appropriate bearing capacity (trafficability) for mechanical equipment.

6.3 EXCAVATION: Manual Trenching



Description: Manual excavation of observation trenches.

Manpower and Equipment:

- Typically a minimum 2-person (SCAT) team
- Shovels
- GPS
- Camera and photo scale
- Measuring and recording tools (tape, forms)

Operations Guidance:

- Preferable to pits, trenching allows observations of larger cross-sections of the beach although the longer, unsupported sidewalls are more susceptible to slumping or caving.
- Typical trenches are up to 1 m (3 ft) in width or shovel width.
- Trenches are generally extended to the beach ground water table.
- Scraping the trench walls with the sharp edge of the shovel improves the ability to discern oil layering and sedimentary structures.
- The selection of trench locations and frequency can be aided by consulting surface oiling maps (where oil has subsequently become buried) along with beach profile data, the combination providing both horizontal and vertical delineation of potential oiling.
- Trenches should be back-filled as soon as observations are complete.

Limitations:

- Although preferred over single-point pit observations, trenching observations only provide spot data.
- Extremely labour intensive and more time-consuming than pitting: unlikely to be feasible over long sections of beach due to time and manpower requirements.
- Trenching is generally limited to damp or fine-grained sediment above the water table and excavation is not possible during high tides.

6.4 EXCAVATION: Mechanical Trenching

Description: Mechanical excavation of observation pits.

Manpower and Equipment:

- Operator
- Observers/SCAT team
- Backhoe or commercial trenching equipment
- GPS
- Camera and photo scale
- Measuring and recording tools (tape, forms)

Operations Guidance:

- Used where manual trenching is too slow or strenuous, mechanical trenching can provide a rapid cross-section of subsurface conditions.
- Typical trenches are up to 1 m (3 ft) in width.
- Trenches are generally extended to the beach ground water table.
- Scraping the trench walls with the sharp edge of the shovel improves the ability to discern oil layering and sedimentary structures.
- The selection of trench locations and frequency can be aided by consulting surface oiling maps (where oil has subsequently become buried) along with beach profile data, the combination providing both horizontal and vertical delineation of potential oiling.
- Trenches should be back-filled as soon as observations are complete.
- Safety – do not stand in trenches.

Limitations:

- Although preferred over single-point pit observations, trenching observations only provide spot data.
- Trenching is generally limited to damp or fine-grained sediment above the water table and excavation is not possible during high tides.
- Suitable access and appropriate bearing capacity (trafficability) required for mechanical equipment.

6.5 EXCAVATION: Shallow-water Snorkel Observations and Manual Pitting

Source: USCG

Description: Manual evaluation of shallow sub-surface oiling.

Manpower and Equipment:

- Typically a 3-person (SCAT) team
- Land or vessel-based support
- Shovels
- Snorkel gear and wet/dry suits with PFDs
- GPS
- Camera and photo scale
- Floating platform
- Recording tools (waterproof paper forms or notebook)

Operations Guidance:

- Enables the detection and delineation of subsurface oil mats and other accumulations in the lower intertidal and adjacent shallow sub-tidal zone, up to 1 m in water depth.
- Shovels are used by SCAT-trained observers to dig a shallow pit, then bring the disturbed sediment to the surface to make oiling and sheen observations.

Limitations:

- Observations are spot data down to less than 0.5 m in the sediments and may be semi-disturbed.
- Many pits may be required to adequately detect and delineate the extent and nature of subsurface oiling, particularly when oiling is irregular.
- Data collection is very slow and physically exhausting.
- Requires a calm wave environment.
- Requires several support and safety personnel for each team.

6.6 CORE SAMPLING: Hand Coring

Description: Manual collection of undisturbed vertical sediment samples

Manpower and Equipment:

- Typically a minimum 2-person (SCAT) team
- Simple tubes or push tube sampler(s)
- GPS
- Camera and photo scale
- Measuring and recording tools (tape, forms)
- Decon equipment to prevent sample cross-contamination

Operations Guidance:

- Used to detect and define the vertical distribution of subsurface oil, and/or allow sample collection for analysis.
- Sampling is relatively rapid, and equipment is easy to use, including:
  - Simple tubes pushed into the sediment and removed to obtain a column of sediment;
  - Manual push tube-type samplers equipped with a piston device or closable vent to create suction and improve sample retention;
  - Push-and-hammer driven tubes;
  - Tubes with core catchers or flap calves to minimize sample loss (Can be equipped with extension handles and used in submerged parts of the intertidal zone);
  - Hand soil samples equipped with small bucket augers, for examination of samples in increments.

Limitations:

- Core samples only provide spot data, with a smaller sample size than pits or trenches: many cores may be required to adequately detect and delineate the extent and nature of subsurface oiling, particularly when oiling is irregular.
- Samples typically are limited to less than 0.6 m (2 feet) in depth, and/or above the water table.
- Oil might spread along the tube length during coring, potentially making delineation difficult.

6.7 CORE SAMPLING: Auger and Mechanical Direct Push Coring

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Description: Mechanical collection of undisturbed vertical sediment samples

Manpower and Equipment:

- Trained drill operators
- Observers/SCAT team
- Truck- or ATV-mounted augers or direct push sampling rigs
- Tube samplers or core barrels with spoon samplers
- GPS
- Camera and photo scale
- Measuring and recording tools (tape, forms)
- Decon equipment to prevent sample cross-contamination

Operations Guidance:

- Auger or sampling rigs can be used to take deeper, undisturbed samples.
- Thin-wall tube samplers and core barrels with spoon samplers can be pressed or driven within the advancing hollow-stem auger to obtain undisturbed samples that can be examined in the field or shipped to a laboratory for analysis.
- Time consuming and generally used for post-emergency monitoring and analysis, rather than emergency phase delineation.

Limitations:

- Augers and cores are spot data: many augers holes or cores pits may be required to adequately detect and delineate the extent and nature of subsurface oiling, particularly when oiling is irregular.
- Time consuming and not generally practical for large scale emergency response support.
- Suitable access and bearing capacity (trafficability) required for mechanical equipment.
- Operators need to be trained for effective coring.
- Oil might spread along the tube length during coring, potentially making delineation difficult.
- Limited availability of equipment.

6.8 CORE SAMPLING: Vibratory coring

Description: Sampling of undisturbed vertical sediment using vibration

Manpower and Equipment:

- 2 or 3 person (SCAT) team
- Vibratory corers (“vibracores”)
- Sampling tube
- GPS
- Camera and photo scale
- Measuring and recording tools (tape, forms)
- Decon equipment to prevent sample cross-contamination

Operations Guidance:

- Vibratory corers contain a cement vibrator or other mechanism which causes the sample tube to vibrate, allowing unconsolidated sediments to move and the device to penetrate downward under gravity.
- Vibracorers are equipped with a core liner and core catcher to keep the sediment in the liner and a tower to extract the core.
- Small units are capable of collecting 5 to 10 cm (2 to 4 inch) cores to a depth of 3 m (10 feet).
- Larger vibra-coring equipment is available, but is less suited to sediment beaches and is likely to experience operational problems. Vibration causes some compaction of sediments, thereby causing some shortening of the core and the potential loss of depth control precision.

Limitations:

- Cores are only spot data: many cores may be required to adequately detect and delineate the extent and nature of subsurface oiling, particularly when oiling is irregular.
- Coring is time consuming and not generally practical for large scale emergency response support.
- Core shortening can limit the accuracy of depth measurements.
- Suitable access and bearing capacity (trafficability) required for mechanical equipment.
- Operators need to be trained for effective coring.
- Oil might spread along the tube length during coring, potentially making delineation difficult.
- Limited availability of equipment.

6.9 JETTING: Water Jet Probes

Description: Use of water jet probes to detect and delineate subsurface oil

Manpower and Equipment:

- Typically a 2-person operating team
- Observers/SCAT team
- Galvanised pipe
- Portable centrifugal water pump
- Flexible hose
- GPS
- Camera and photo scale
- Measuring and recording tools (forms)

Operations Guidance:

- Water jet probes are commonly used to measure sediment thicknesses on coarse-grained beaches.
- Although not common in oil spill response, water jets have successfully been used to delineate subsurface shoreline oil on spills.
- The pipe is inserted into the sediment vertically and the water jet blasts the sand below it upwards along the length of the pipe. Because of the cutting action of the jet, the pipe typically sinks by gravity.
- Cuttings reaching the surface are examined for the presence of oil, with depth approximated by the length of pipe inserted.
- In some cases, harder oil deposits can be detected by resistance and their depth measured more accurately.

Limitations:

- Probes are spot data: many probes may be required to adequately detect and delineate the extent and nature of subsurface oiling, particularly when oiling is irregular.
- Does not allow for accurate characterization of undisturbed oil and has less vertical depth accuracy than other techniques.
- Requires a source of water.

Further Information on Detection and Delineation Techniques:

API 2013. *Subsurface Oil Detection and Delineation in Shoreline Sediments*, Phase 1 - Final Report, API Technical Report 1149-1, Washington DC, September, 46 pp.

Pitting and Trenching

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Owens, E.H., and Sergy, G.A. (2000) *The SCAT Manual: Field Guide to Documentation and Description of Oiled Shorelines*. Ottawa: Environment Canada.

Water Jet Probes

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Beach Profiling

Emery, K.O. (1961) A simple method of measuring beach profiles. *Limnology and Oceanography*, Vol. 6, pp. 90–93.

WHOI Sea Grant Program (2000) *Marine Extension Bulletin. Beach and Dune Profiles: An Educational Tool for Observing and Comparing Dynamic Coastal Environment*. http://www.whoi.edu/seagrant/page.do?pid=52235&tid=282&cid=88638

Real Time Kinematics (RTK) Surveys

http://www.resourcesupplyllc.com/pdfs/RTKBasics_SurveyGradeGPS.pdf

http://publications.usace.army.mil/publications/eng-manuals/EM_1110-1-1005_sec/EM_1110-1-1005_Sections/c-9.pdf

ATTACHMENT A: Horizontal and Vertical Positioning

Horizontal position:

Historically, the location of observations has been plotted manually on maps or aerial photos. Current GPS technology allows the collection of accurate horizontal and vertical locations, and the recording of survey track lines and way pointed coordinates. Survey grade GPS equipment can also provide computerized profiling and 3-dimensional mapping capabilities. Hand held GPS units typically contain track logging capability which records movements of the unit over time. Units can be time synchronized to shoreline observations and photography. Data can be downloaded to a GIS system for data management and map production on a daily basis.

Vertical position:

Vertical positioning can be recorded by direct depth measurements in pits or trenches.

Subsurface observations can be indexed to shoreline elevations, or profiles that are surveyed across the beach perpendicular to the water line. Beach profiles can be surveyed using tapes, stakes and hand levels, and in some cases using surveying equipment, such as automatic levels.

Figure A.1 is an example of a time-series of profiles on a beach where oil was buried by summer accretion. The purple and green profiles show the effect of a period of strong wave action that lowered the beach to pre-oiling elevations except in those sections of the profile indicated by the three red horizontal bars.

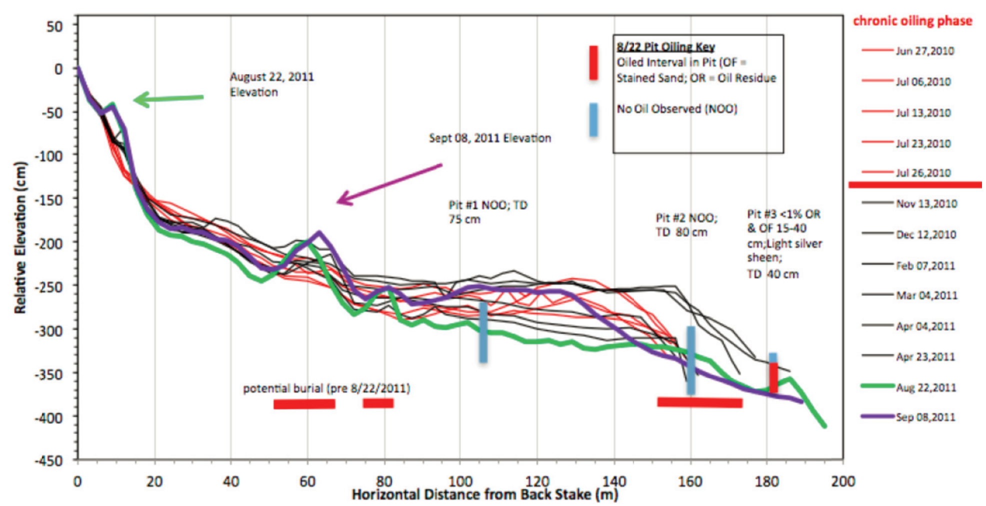

Figure A.1 Time Series of Beach Profiles Across a Beach with Subsurface Oil

Current technology permits rapid and highly accurate profiling and development of 3-dimensional maps using Real Time Kinematic (RTK) satellite surveying technology. This technology can provide centimeter-level accuracy. Ideally, a control point (benchmark) with a fixed geodetic location (latitude, longitude and state plane coordinates) is established and a known elevation or datum (e.g. NAVD 88) is established for each survey location. A portable transceiver is set at each survey point, with data transmitted back to the base unit. The ability to quickly resurvey and compare profiles can be extremely valuable.

ATTACHMENT B: Additional New or Developing Tactics That May Be Considered

Developing Technologies

These include equipment/tactics which have been used historically with success, but not used with sufficient frequency to be considered as accepted practice. Equipment/tactics may also include developed technology which has not been applied extensively, or at all, to subsurface oil detection or delineation. These equipment/tactics include, but are not limited to:

- Push Probes: Simultaneous multi-parameter vertical sensing using mechanical equipment. Vertically continuous observations at point locations.

- Service Dogs: Have been used for detection and tracing of vapor plumes emitted by subsurface oil deposits at very low detection levels. Not vertically discriminating, but capable of rapid horizontal coverage.

- Geophysical: Promising techniques include electromagnetic profiling, electrical resistivity profiling, and ground penetrating radar. Techniques allow continuous vertical and horizontal delineation under applicable conditions. Capable of rapid area coverage.

- Surface Gas: Continuous horizontal detection of lighter hydrocarbon gases, H_2S and oil degradation products. Not vertically discriminating, but capable of rapid horizontal gas quantification.

Procedure for Emergency Response Consideration

Candidate tactics can be identified using Figure B.2. In most cases, some level of field testing or demonstration would be appropriate to validate the performance of the tactic for the specific spill incident. This validation typically requires the preparation of a test plan to describe the tactic to be evaluated and identify a suitable demonstration location, as well as the development of performance indicators by which the tactic can be evaluated. Should the tactic prove feasible, its use could then be scaled up as necessary to meet the needs of the situation.

ATTRIBUTES	Existing Procedures			Developing Technology (Potential)			
	Excavation	Cores	Jetting	Push Probes	Service Dogs	Geophys-ical	Surface Gas
Delineation (Horizontal)	Yellow	Red	Red	Red	Green	Green	Green
Delineation (Vertical)	Green	Green	Yellow	Green	Red	Yellow	Red
Survey Speed	Red	Red	Yellow	Yellow	Green	Green	Green
Oil Character	Green	Green	Yellow	Green	Red	Red	Red
Relative Cost	Yellow	Red	Yellow	Yellow	Yellow	Green	Green

- **Green** indicates a favourable application;
- **Yellow** indicates that the strategy may be effective, depending on circumstances, and
- **Red** indicates important limitations or “not applicable”.

Figure B.1 Comparison of the Attributes of Accepted Existing and Developing (or Potential) Technologies

	Service Dogs	In situ Sensor Probe	Geophysics GPR	Geophysics EM / ER	Gas Detectors
Depth (m)					
< 0.5	√	?	?	?	√
< 1.0	√	?	?	√	√
< 2.0	√	√	√	√	√
> 2.0	√	√	√	√	√
Oil Character					
Fresh	√	√	√	√	√
Emulsion	√	√	√	√	?
Weathered	√	√	√	√	?
Tar balls	√	√	?	√	?
Pavement	√	√	√	√	?
Subsurface Distribution					
Vertical	-	√	?	√	-
Horizontal	-	-	√	√	√
Moisture					
Dry	√	√	√	?	√
Damp	√	√	?	√	√
Saline	√	√	-	√	√
Saturated (wet)	-	?	-	-	?
Grain size					
Clay/Silt	?	√	√	√	?
Sand/granules	√	√	√	√	√
>Granules	√	√	√	√	√
Sensitivity					
Presence (ONLY)	√	√	-	?	√
Depth Discrimination	-	√	√	?	-
Layer Discrimination	-	√	√	?	-
Tar / SRBs	√	?	?	?	?
Sub - Water table	-	√	-	-	-
Trace Level - Subvisible	?	?	-	-	?

√ = tactic operational under most conditions
? = tactic operational in most cases, subject to incident condtions,
– = tactic of limited applicability or not generally applicable

Figure B.2 Subsurface Oil Detection and Delineation Tactics – Developing Technologies

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