SHORELINE CLEAN-UP

This article is a compilation of articles first published in the ISCO Newsletter starting with issue 517 and contributed by Mark Francis of Oil Spill Situations. It provides a refreshing insight into a shoreline clean-up with many helpful observations and useful information.

Mark Francis has been involved with the oil industry since 1975. He attended his first oil spill in 1976, the Tanker Elaine V incident. He became head of response for inland spills within the UK for British Petroleum E & P in 1980 for 10 years responding to well, storage tank and pipeline spills throughout the UK. Over the next 25 years he continued to build his international operations experience and has also specialised in spill response training, delivering IMO and other courses in more than 20 countries.

Photo by Mark Francis at Mavis Grind, Shetland, 1998.

The only place where the Atlantic Ocean and the North Sea can be seen together.

Frequently the only response to an oil spill is to wait until the oil arrives on the coast and be prepared for cleanup of the affected coastal environments.

Many of the methods of cleanup are efficient in the removal of oil from the environment, but they may have a heavy impact on the biological community several times worse than the oil itself.

Therefore, the form of cleanup is also a relevant factor upon considering the degree of impact of an oil spill.

It is important to begin to remove the oil from the coast as quickly as possible, because with the passage of time the oil loses its most volatile components and becomes more difficult to remove.

The oil will adhere ever more tightly to the rocky shores and to the different coastal environments, and may also be mixed with trash and other waste or simply be buried by sediments.

Our initial thought should be that the oil has caused damage to the environment to a lesser or greater extent. We now have to clean up this oil causing the minimum possible damage.

This can only be done with the close co-operation of oil spill response professionals and environmental agencies to arrive at the best solution to the problem.

It is the duty of the Planning Team to notify those in control of the strategy to be adopted.

The selection of the methods to be used is a very important stage in the response planning cycle.

To take the correct decision early can be very decisive during the later stages of cleanup.

Therefore it is important that the right people are selected for the planning team.

They need to receive prompt information about the spill and the weather conditions, knowledge of the logistical information in reference to the availability of personnel, equipment and materials.

All of these headings are part of a good contingency plan if there is one for the location.

Based on this information and local reconnaissance, the team will have the conditions to recommend to the Executive Command the most efficient strategy in order to minimise the impact to the environment and bring the response to a good conclusion, successfully and at an acceptable cost.

The response team needs to be able to justify their recommendations and clarify to the command any expected penalties, in the event other measures are taken.

Tides

Tides are the 6 hourly movement of the sea in and out. Tides are constant and are mainly caused by the gravitational pull of the moon.

Tidal Range (or intertidal zone): The difference or area between high tide and low tide. Some tidal ranges can only be a few meters, others can be several kilometers.

Spring Tides: When the moon and the sun are in complete alignment you get particularly high and low tides.

Neap Tides: When the moon and sun are aligned at right angles to each other so the gravitational pull of the moon and the sun are pulling in different directions. This makes for lower high and low tides.

We have to clean the shore doing the least amount of damage possible.

Knowing when high tide and low tide will be, as well as how high up the shore the water will come for safety reasons is important.

Also how low the water will go to allow the team to know when to stop cleaning thus reducing the damage to the sensitive life in the lower shore

These photos show the tidal range in 2 locations. Top is a steep contour and bottom is flat.

JUNE

		High Tide				Low Tide			
		AM	HT	PM	HT	AM	HT	PM	HT
01	Tue	11:59	6.1	--	--	6:04	0.5	6:01	1.0
02	Wed	12:26	6.7	12:49	6.0	6:44	0.7	6:45	1.3
03	Thur	1:13	6.5	1:39	6.1	7:26	0.9	7:33	1.5
04	Fri	2:00	6.3	2:28	6.2	8:12	0.9	8:27	1.6
05	Sat	2:47	6.1	3:16	6.4	9:00	0.9	9:27	1.6
06	Sun	3:35	6.0	4:05	6.7	9:51	0.8	10:27	1.5
07	Mon	4:25	6.0	4:54	7.0	10:42	0.6	11:24	1.2
08	Tue	5:16	6.0	5:43	7.3	11:32	0.4	--	--
09	Wed	6:07	6.1	6:32	7.6	12:17	0.9	12:21	0.1
10	Thur	6:57	6.2	7:21	7.9	1:08	0.6	1:11	-0.1
11	Fri	7:46	6.4	8:08	8.2	1:59	0.3	2:02	-0.3
12	Sat	8:34	6.5	8:56	8.3	2:48	0.0	2:52	-0.5
13	Sun	9:22	6.6	9:44	8.4	3:37	-0.2	3:42	-0.6
14	Mon	10:13	6.7	10:35	8.4	4:25	-0.4	4:33	-0.6
15	Tue	11:06	6.8	11:29	8.1	5:13	-0.5	5:25	-0.5
16	Wed	12:06	6.9	--	--	6:02	-0.5	6:18	-0.3
17	Thur	12:25	7.8	1:07	7.0	6:52	-0.5	7:16	0.0
18	Fri	1:21	7.6	2:06	7.2	7:45	-0.4	8:17	0.2
19	Sat	2:17	7.3	3:04	7.4	8:42	-0.3	9:23	0.4
20	Sun	3:13	7.0	4:00	7.5	9:40	-0.3	10:27	0.4
21	Mon	4:08	6.8	4:56	7.7	10:37	-0.2	11:28	0.3
22	Tue	5:04	6.6	5:52	7.7	11:33	-0.2	--	--
23	Wed	6:00	6.5	4:45	7.8	12:24	0.2	12:25	-0.2
24	Thur	6:53	6.4	7:36	7.8	1:17	0.2	1:16	-0.1
25	Fri	7:44	6.4	8:22	7.7	2:07	0.1	2:05	0.0
26	Sat	8:31	6.4	9:06	7.6	2:54	0.1	2:51	0.1
27	Sun	9:16	6.4	9:47	7.5	3:37	0.1	3:34	0.3
28	Mon	9:59	6.3	10:28	7.2	4:18	0.2	4:15	0.4
29	Tue	10:42	6.3	11:08	7.0	4:56	0.3	4:54	0.7
30	Wed	11:27	6.2	11:50	6.7	5:33	0.4	5:33	0.9

Knowing when the tide will turn will enable the clean-up team to work safely, also to retreat to a safe place and avoid being cut off or trapped with no exit point.

This is especially important in flat areas or muddy areas as the tide can rise faster than a man can run.

Many people have drowned collecting shellfish in flat areas because they have not been able to get to safety before the tide came in.

Tide tables like the one left show the times and heights of the tide for every day of the year.

These can be found at chandlers, marina shops or even as apps for Smartphone's.

If you cannot find one for the exact shore where you will be working, then looking at the tables for the nearest ports and adding or deducting minutes will get the answer.

Make sure you add a safety margin to the result until you know exactly when high or low tide will be.

box 3

SEGMENT	Segment ID: *WC 02*	Name of site: *Ramla bay*
Total Length: *600* m	Length surveyed: *600* m	
Start GPS: Lat: *36'03'41.58"N*	Long: *14'17'03.00"E*	Other ref:
End GPS: Lat: *35'46'08.02"N*	Long: *14'36'09.80"E*	Other ref:
Exposure: high / (medium) / sheltered / very sheltered / don't know		
Coastline type description (i.e. estuary, boulder beach, marsh, cliff coastline, port...): *Sandy beach and dunes between rocky headlands*		

Shoreline Clean-up Assessment Technique (SCAT)

These days it is unusual to have an oil spill event without various (SCAT) Shoreline Clean-up Assessment Technique teams doing surveys for future clean up or for info during and after the clean-up for the Planning team

When a spill occurs there are usually far too few people to quickly take on this part of the response but it is important, as it will inevitably save time and life in the decision as to what should be done first and how. This helps, operations, planning, safety, logistics and finance.

POSOW is a project co-financed by the EU under the Civil Protection Financial instrument developed in cooperation with ISPRA, Cedre, Sea Alarm and CPMR and coordinated by REMPEC the regional Centre of the Barcelona Convention. POSOW produced 4 free manuals designed for volunteers and all responders involved in onshore response who have little or no previous knowledge of shoreline geography and descriptions of shoreline oiling.

POSOW
Preparedness for Oil-polluted Shoreline cleanup and Oiled Wildlife interventions

I have borrowed some of the designs and wording as it is good to see simple designs showing how things work.

The cornerstone activity of SCAT is a shoreline assessment survey and its fundamental objective is to collect and document data on oiled shoreline conditions in rapid, accurate and systematic fashion.

Shoreline assessment surveys are based on several fundamental principles. These include:

- a division of the coastline into homogeneous geographic units or 'segments'
- the use of a standard set of terms and definitions for documentation
- systematic assessment of all shorelines in the affected area
- a survey team that is objective and trained
- the timely provision of data and information for decision making and planning.

The need for a coordinated and systematic shoreline assessment programme will be triggered by an incident leading to marine or coastal oil pollution.

The SCAT process includes eight basic steps:

1. Conduct reconnaissance survey(s).
2. Segment the shoreline.
3. Assign teams and conduct SCAT surveys.
4. Develop cleanup guidelines and endpoints.
5. Submit survey reports and shoreline oiling sketches to the ICS Planning Section.
6. Monitor effectiveness of cleanup.
7. Conduct post-cleanup inspections.
8. Conduct final evaluation of cleanup activities.

Field Equipment Check list

- Suitable maps of relevant shore segments and other relevant maps (e.g. road or topographical maps for access) or nautical charts of area. If necessary on waterproof writing paper
- Oiled Shoreline Assessment Forms
- Clipboard
- Spare blank writing paper or waterproof field notebooks (possibly waterproof)
- Stationery - pencils, markers, rulers, paperclips
- Compass or portable Global Positioning System (GPS) device
- Small shovel or spade
- Tape measure
- Digital camera
- Video camera and storage media (if required)
- Batteries, charged battery packs (for GPS, cameras)
- 10 cm and/or 25 cm long photo scale with 1 cm increments
- Communication device (e.g. radio or mobile telephone)

Surveyors should also have appropriate clothing and personal protective equipment for the conditions, for example:

- Rain gear, sun screen, hat, rubber boots, non-skid soles
- First aid kit
- Hand wipes/cleaner and rags for decontamination

Refreshments should be carried in remote locations

Survey steps and comments

Gain segment overview

Try to gain an overall perspective of the segment to be surveyed, either by viewing from an elevated position or, for shorter segments, walking its length.

Acquire a good perspective of the extent of shoreline oiling.

Make detailed observations - It is recommended to walk along the whole segment making general notes, returning to oiled areas that require more detailed documentation.

On longer segments it may be more efficient to carry out detailed note-taking as the team progresses along the shore.

Take photos/video - Photographs and video are very useful tools in documenting the shore's appearance. Ensure accurate notes of photograph or video locations are made.

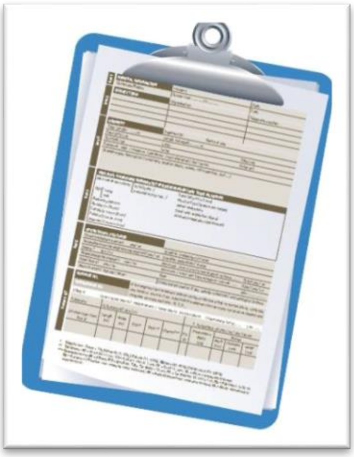
Use the reference numbers of images from the digital camera used. GPS can be used to identify photo locations if available and necessary.

Don't take too many photos - this is a case when quality is better than quantity. Think what the photo is for? Does it show the inclination of the shore for example?

Photographs should be taken to:

- record general views along and across the shoreline
- capture the appearance and location of oiled areas
- identify key environmental and changes features on the shoreline
- use a suitable scale in any view where the size of the picture is not obvious
- identify access routes or other operational features and on-going activities.

Do not forget to indicate the location of the view point on your sketch.



Draw sketch/annotate map - A sketch is a very important part of the assessment. The sketch complements photographs and is required to document oiling conditions on the form. The location of all key features should be marked.

Complete assessment form - The completed Oiled Shoreline Assessment Form provides all the detailed information on the oiling conditions.

Before departure from site

The team should review the assessments to ensure agreement on major points. As a minimum, there must be a consensus on the oil character and distribution.

Check that forms and sketch maps are complete. Ensure that all photographs and videos have been accurately logged.

Prevent secondary pollution by cleaning any oiled footwear prior to departure.

Check that all equipment, survey gear, personal items and, litter is taken before leaving the site.

Segments

The essential first step of a ground survey is to divide the coastline into planning and operational work units called 'segments'.

Within a given segment, the shoreline character will be relatively homogeneous (uniform) in terms of physical features and sediment type.

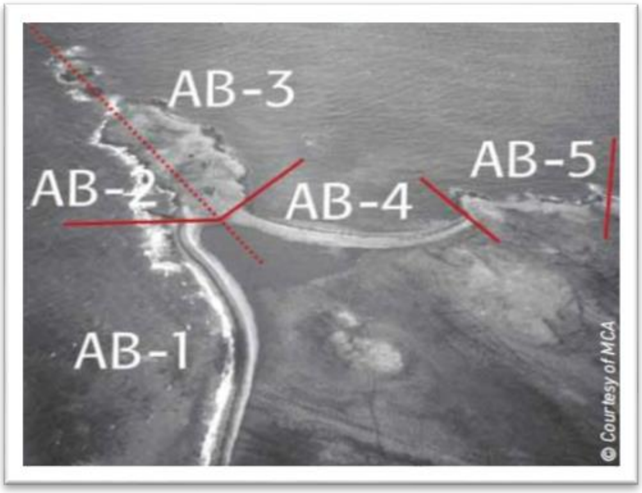
Boundaries between segments are established on the basis of prominent geological features such as a headland or presence of a river, changes in shoreline or substrate type, sometimes a change in oiling conditions, or establishment of the boundary of an operational area. Segment lengths are typically 200 - 2,000 m. If there are long stretches of uniform coast, segments may be established on the basis of operational features, such as access points, or simply by equal distances along the shore.

box 1	GENERAL INFORMATION	Incident: Nobiga	Date: 09/01/12
	Commune/Region	Survey time: 10:00 to 11:15	Tide: no tide

How to define segmentation

To assist in defining segments one can use:

- Topographical maps
- Environmental sensitivity maps, where they exist
- Satellite images, such as those freely available from Google Maps depending on the resolution of images available for the area.



Segmentation will be used throughout the response process.

These segments are the basis for the development of treatment plans. Ultimately, each segment of shoreline will be considered individually in both planning and operational stages.

Segment identification

Each segment should be given a unique identification code. There are no rules to how this is done but simple systems are effective e.g. a code for each municipality followed by sequential numbers for each segment within that municipality.

box 2	SURVEY TEAM	Organisation:	Telephone number:
	John Tullow	Environment Ministry	+12 345 6789
	Jose Ballesteros	Municipality	+12 456 7891

box 3	SEGMENT	Segment ID: WC 02	Name of site: Ramla bay
	Total Length: 600 m	Length surveyed: 600 m	
	Start GPS: Lat: 36°03'41.58"N	Long: 14°17'03.00"E	Other ref:
	End GPS: Lat: 35°46'08.02"N	Long: 14°36'09.80"E	Other ref:
	Exposure: high / medium / sheltered / very sheltered / don't know		
	Coastline type description (i.e. estuary, boulder beach, marsh, cliff coastline, port...): Sandy beach and dunes between rocky headlands		

Survey team members

The number of persons in a survey team and the number of teams required will depend on the circumstances of the incident. Generally a survey team comprises:

In practice, during the reactive phase, team members can be volunteers drawn from a wide variety of organisations. Typical candidates for shoreline survey teams, targeted by this manual can include

- Local authority or municipality representatives
- Civil protection or fire brigade personnel
- Conservation agency personnel
- Non-Governmental Organisations (NGOs)
- Polluter representatives.

It is advisable to get to know the coast intimately before people begin to start work on the clean-up

box 5	OPERATIONAL FEATURES		
	Direct backshore access? yes / no	Suitable: pedestrian / trucks	
	Accessible from the neighbouring segment? yes / no	Suitable: pedestrian / trucks	
	Debris ? yes / no	Not much / a lot / don't know / approx. volume:	Oiled? yes / no
	Algae/posidonia deposit? yes / no	Not much / a lot / don't know / approx. volume:	Oiled? yes / no
	Oiled fauna? yes / no	Type	Nbr: ....
	Uses: tourism / fishing / other:	Conservation: yes/no. If yes, specify: historical / archaeological /nature	

boxes 6 & 7	SURFACE OIL SUBSURFACE OIL	If the segment has relatively uniform oiling conditions along or across shore, complete one section: zone A. If not, subdivide the segment into as many zones as necessary and complete as many sections: B, C, D...									
	ZONE A	Level: upper beach / middle beach / lower beach (circle option)						If necessary: Long:			Lat: ......
	Substrate	6. Surface oil? yes / no						7. Subsurface oil: yes/no/don't know			
									Buried		
	(choose type from Box 4)	Length (m)	Width (m)	Distr*	Thick**	Charact***	Pit ID	Penetration depth (cm)	depth (cm)	thickness (cm)	water (cm)

See foot notes of the form for terminology used to estimate oil distribution (*), thickness (**) and oiling characterics (***)

* **DIstr**ibution: **Tr**ace < 1%; **SP**oradic (1-10%); **PA**tchy (11- 50%); **BR**oken (51-90%); **CO**ntinuous (91-100%)

** **ThIck**ness: **TO** = **T**hick **O**il >1 cm; **CV** = **C**o**V**er 1 mm to 1 cm; **CT** = **C**oa**T** <1 mm; **FL** = **F**i**L**m = transparent sheen

*** **Charact**eristics: **FR** = **FR**esh; **MS** = **M**ou**S**se; **TB** = **T**ar **B**alls <10 cm; **PT** = Tar **P**a**t**ties: 10 cm to 1 m; **PA** = **PA**tches:1 to 30 m; **SR** = **S**urface oil **R**esidue: non cohesive oiled sediment; **AP** – **A**sphalt **P**avement: cohesive mixture; **TA** = **TA**rry: almost solid weathered oil.

boxes 6 & 7

SURFACE OIL

SUBSURFACE OIL

If segment has relatively uniform oiling conditions along or across shore, complete one section: zone A. If not, subdivide the segment into as many zones as necessary and complete as many boxes: B, C, D....

ZONE A Level: upper beach / middle beach / lower beach (circle option)

Substrate	6. Surface oil? yes / no					7. Subsurface oil : yes / no / don't know				
								Buried		
(choose type in Box 4)	Length (m)	Width (m)	Distr*	Thick**	Charact***	Pit ID	Penetration depth (cm)	depth (cm)	thickness (cm)	water (cm)

The presence of sub-surface oiling can be due to:

- Penetration of oil to a certain depth in case of coarse sediments (Pebbles, gravel) or liquid oil
- Buried oil because of movements of beach material in rough conditions such as storms

This sub-surface oil can only be evaluated by digging pits or trench.
Such investigations should only be undertaken if buried oil is suspected.

Constructive and destructive beaches

Many beaches are constructive and destructive.

Constructive is when the waves have a strong swash which is the rush of seawater up the beach after the breaking of a wave and a weak backwash. Low waves in proportion to length are created in calm weather with a less powerful break on the shore and deposit of materials.

Destructive is when waves have a weak swash but a strong backwash is created in storm conditions. High waves in proportion to length, they break downwards with great force tending to erode the coast. This occurs when the wave energy is high and the wave has travelled over a long fetch.

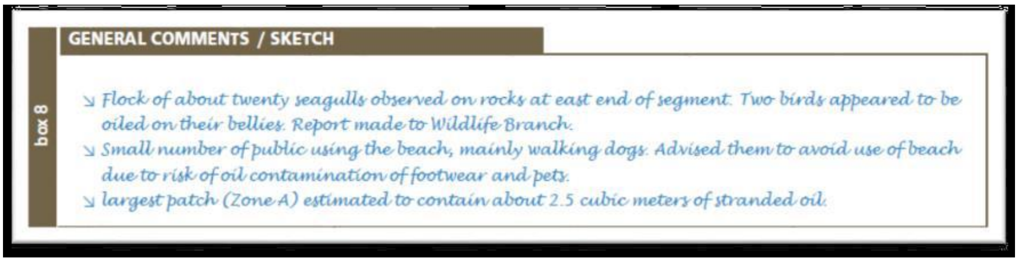
The problem arises especially on coarse grained sandy beaches.

During these periods oil can become buried in layers as in the photo above. It is always advisable to dig a hole to see if this has happened. Obviously to remove all the oil could generate huge quantities of waste so close coordination will be required.

Wave Terminology

Crest: The top of the wave.
Trough: The low area in between two waves.
Wavelength: The distance between two crests or two troughs.
Wave height: The distance between the crest and the trough.
Wave Frequency: The number of waves per minute.
Velocity: The speed that a wave is traveling. It is influenced by the wind, fetch and depth of water.

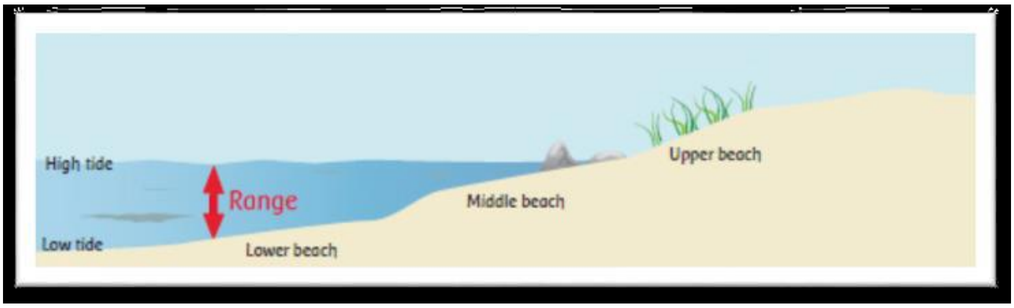
Swash: The movement of water and load up the beach.
Backwash: The movement of water and load back down the beach.


box 8

GENERAL COMMENTS / SKETCH

- Flock of about twenty seagulls observed on rocks at east end of segment. Two birds appeared to be oiled on their bellies. Report made to Wildlife Branch.
- Small number of public using the beach, mainly walking dogs. Advised them to avoid use of beach due to risk of oil contamination of footwear and pets.
- largest patch (Zone A) estimated to contain about 2.5 cubic meters of stranded oil.

Level (Tidal)



Level refers to the height of oil on the shore in relation to the tide. This information is important to evaluate the risk of oil remobilisation.
Length refers to the along-shore distance (parallel to the water's edge) of the oiled lines.

Width refers to the average across shore distance (perpendicular to the water's edge) of the oil band within a segment or zone.

Distribution represents the actual percentage of the surface that is covered by oil within a given area.

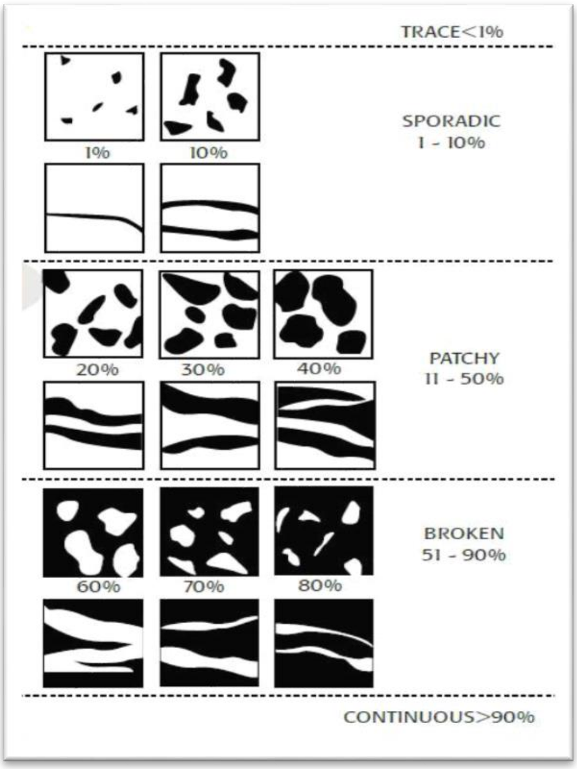
Shoreline Clean-up Assessment Technique (SCAT) - Continued

Percentage of coverage

This is probably the most difficult to estimate: the objective is not to provide an exact measurement of oil distribution, which is generally not homogenous, but to try to reach an average.

Level refers to the height of oil on the shore in relation to the tide. This information is important to evaluate the risk of oil remobilisation.

TR Trace < 1%
SP Sporadic 1 - 10 %
PA Patchy 11 - 50 %
BR Broken 51 - 90 %
CO Continuous > 90 %



Thickness

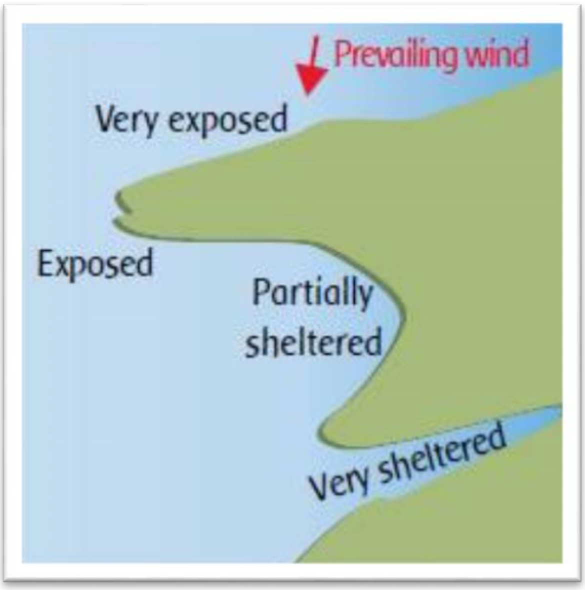
Refers to the average or dominant oil thickness within the segment or zone.

TO Thick oil (fresh oil or mousse > 1 cm thick)
CV Cover (oil or mousse from >0.1 cm to <1 cm on any surface)
CT Coat (visible oil <0.1 cm, which can be scraped off with fingernail)
FL Film (transparent or iridescent sheen or oily film)

This column provides a qualitative description of the form of oil.

FR Fresh oil (un-weathered, liquid oil)
MS Mousse (emulsified oil occurring over broad areas)
TB Tar balls (discrete accumulations of oil <10 cm in diameter)
TP Tar patties (discrete lumps or patches >10 cm diameter)
PA Patches (accumulation of oil > 1 m < 30 m)
SR Surface oil residue (non-cohesive, oiled surface sediments)
AP Asphalt pavements (cohesive, heavily oiled surface sediments)
TA Weathered tarry oil, almost solid consistency

Exposure



Approximate overall exposure rating of the upper shore (or oiling) parts of the segment:

Very exposed:

Sites which face into prevailing winds and recieve oceanic swell without and offshore breaks (Islands) for hundreds of kilometers.

Exposed:

Sites where strong onshore winds are frequent but also have a degree of shelter because of extensive shallow areas or other seaward obstructions.

Partially sheltered:

Sites with a restricted sea area over which the wind blows (Fetch) generally <10km.

They can face prevailing winds but with extensive shallow areas to seaward or may face away from prevailing winds.

Very sheltered:

Sites with a very restricted sea area over which blows (Fetch) generally <2km and which face away from prevailing winds or have obstructions such as reefs to seaward or are fully enclosed:

Characteristics of sediment and beach slopes depend on exposure.
Photo right shows a very exposed boulder beach (note the slope and rounded boulders as good indicators of high exposure).

Hydro dynamism

The higher the energy of the environment (high hydrodynamics), the more rapid cleanup of affected areas will be by natural processes, the more sheltered beaches will take much longer.

The degree of sheltering is in direct proportion to the vulnerability of the coastal ecosystems.

In ecology, as a rule, the more balanced and stable (sheltered) the environment, the greater the diversity of the species.

Granulometry

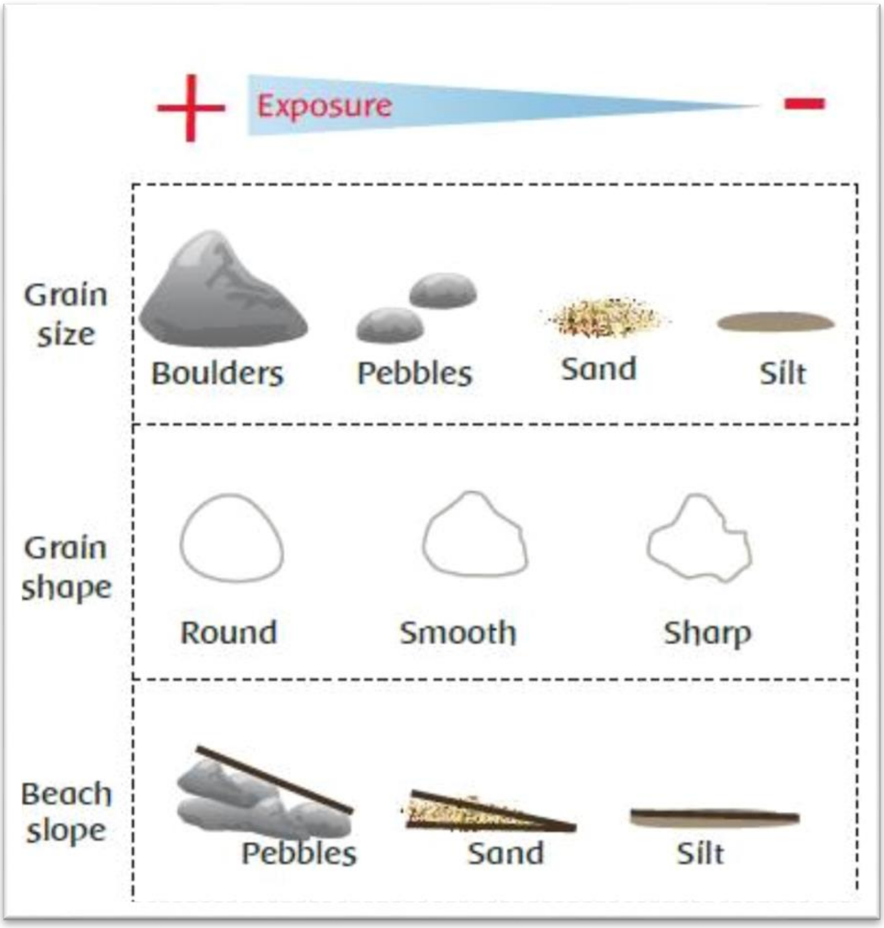
In accordance with the size of the grains, the percolation of oil will vary.

Basically, it will be greater when the grains of sediments are larger.

Thus, fine-grained beaches are less vulnerable to spills, since the greater compaction of the beach prevents the penetration of the oil.

Beaches with coarse sand, on the other hand, are highly vulnerable in this sense, where the oil can penetrate many centimeters.

There are so many combinations with the amount of shoreline sediment types and size along with various types of oil and oiling.



box 4

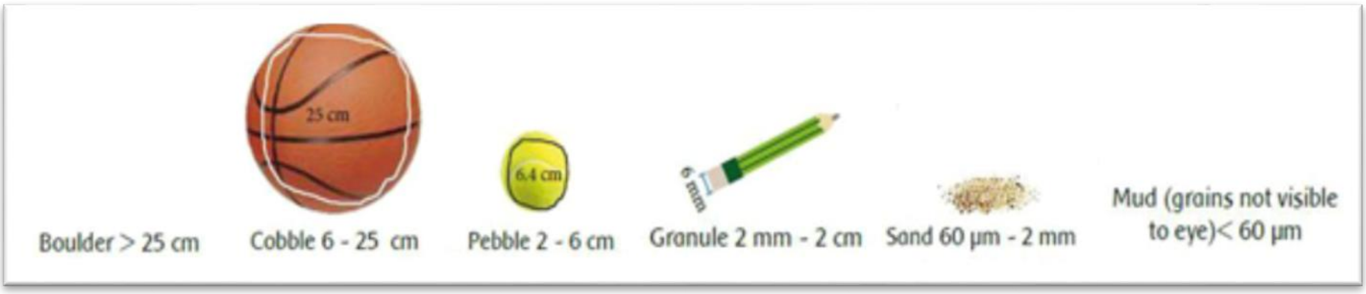
TOOL BOX: SHORELINE SUBSTRATE TYPE DESCRIPTION (NOT TO BE FILLED IN)

Man-made structures: solid (quay...) / permeable (rip-rap...)	Sand (60 µm to 2 mm)
Cliff: rocky / soft	Mud (<60 µm) (grains not visible)
Bedrock platform	Mixed sediments
Boulder (> 25 cm)	Sand with vegetation (dune)
Cobble (6 cm to 25 cm)	Mud with vegetation (saltmarsh)
Pebble (2 cm to 6 cm)	
Granule (2 mm to 2 cm)	

There are various scales for classifying sediments based on the grain sizes. For the purposes of shoreline assessment, broad categories have been used.

Use the box above as a guide to the size of sediment to determine the nature of the beach substrate.

Categories have been chosen based on their implications for shoreline cleanup techniques. Well-known visual references (tennis ball, pencil diameter) can help to determine the size of sediment grains



Rocky | Boulders | Cobbles | Shingle | Granular sand | Fine sand | Mud

Types of oiling

Below are some photos of some 12 types of oiling taken for a volunteer manual for people carrying out shoreline impact studies

1 Thick oil (TO) Cedre | 2 Cover (CV) OTRA | 3 Coat (CT) ITOPF

4 Film (FL) ITOPF | 5 Film (FL) Sheen Cedre | 6. Fresh (FR) liquid OTRA

7. Mousse (MS) ITOPF

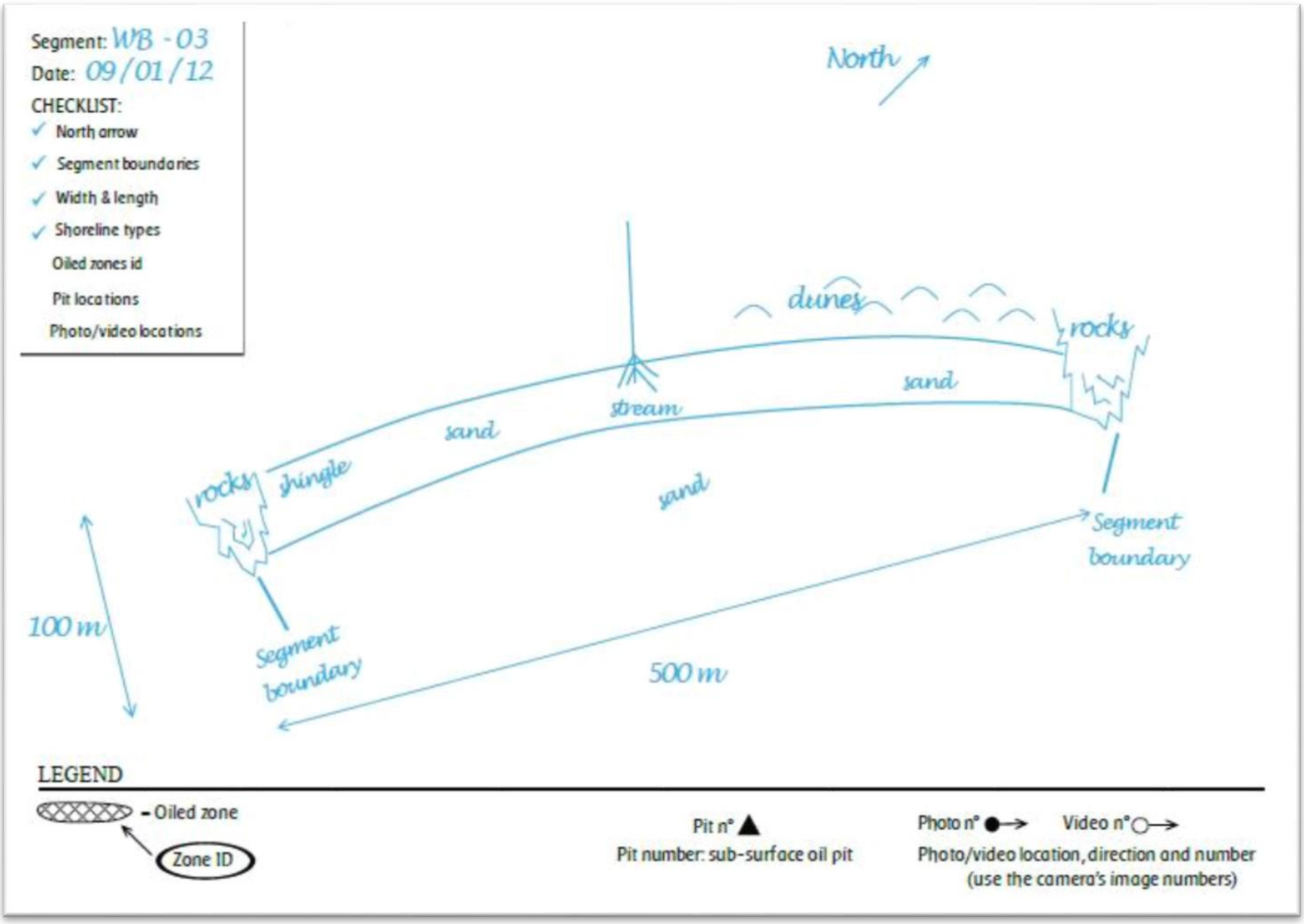
8. Tar Balls (TB) Cedre

9. Tar Patties (PT) ITOPF

10. Patches (PA) Cedre

11. Surface Oil Residue (SR) OTRA

12. Asphalt Pavement (AP) OTRA



General comments / sketch / Taking photographs

The second part of the Assessment Form is for general comments.

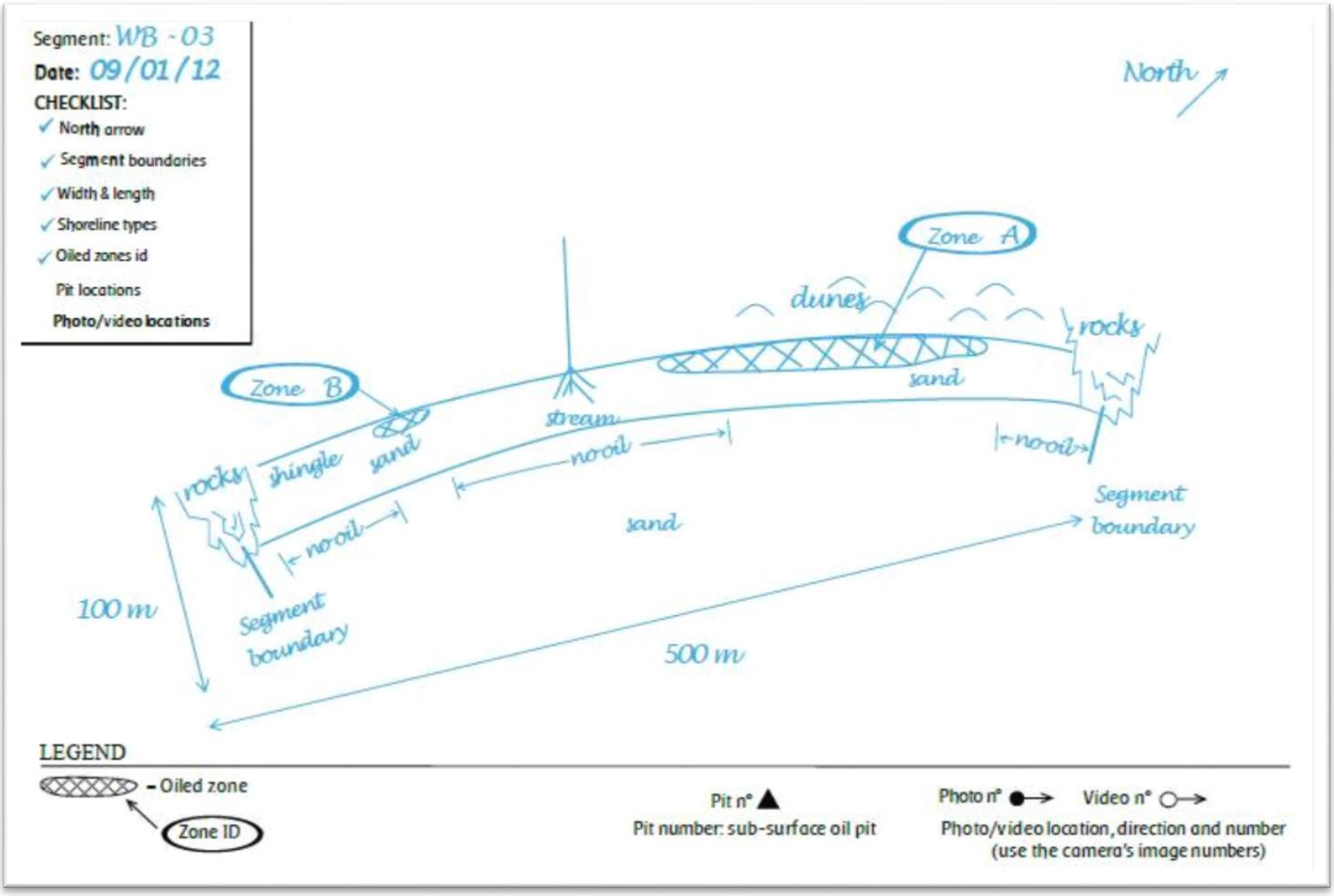
It is used to highlight particular points of interest or anomalies in the segment.

This may include comments relating to:

- actual or potential resource sensitivities observed or known to be present; including ecological, recreational, cultural, commercial or any other socio-economic interests
- any notable wildlife observations to be reported to oiled wildlife response manager, particularly any casualties
- estimates of volumes of oil within the segment, based on dimensions of stranded oil observed and recorded
- storm surges which may have deposited oil above the normal water mar

The field sketch is an important component of the shoreline assessment process for two principal reasons:

- it provides a focused picture of the oil distribution within the entire segment on a single piece of paper (or image)
- it adds discipline to the field observation process, because it forces the person doing the sketch to make detailed notes of all the relevant features.



It is necessary to mention at least:

- segment identification
- date
- orientation (north arrow)
- segment boundaries
- segment width and length
- shoreline type
- oiled zones id
- pit locations
- photo/video locations.

The surveyor should have gained an overview of the segment as their first task.

Drawing the sketch may come before or after the completion of the Assessment Form and taking photographs – this is largely a matter of preference and circumstances.

However, if it is done early in the survey, care should be taken to ensure key information such as photograph locations and any dug pits are annotated on the sketch before leaving the site.

Note that if there are two or more members in the survey team, the various activities can be carried out simultaneously.

Determine the dimensions of the segment. Place the length and width of the intertidal zone as well as some of the more conspicuous features, such as groins or seawall segments.

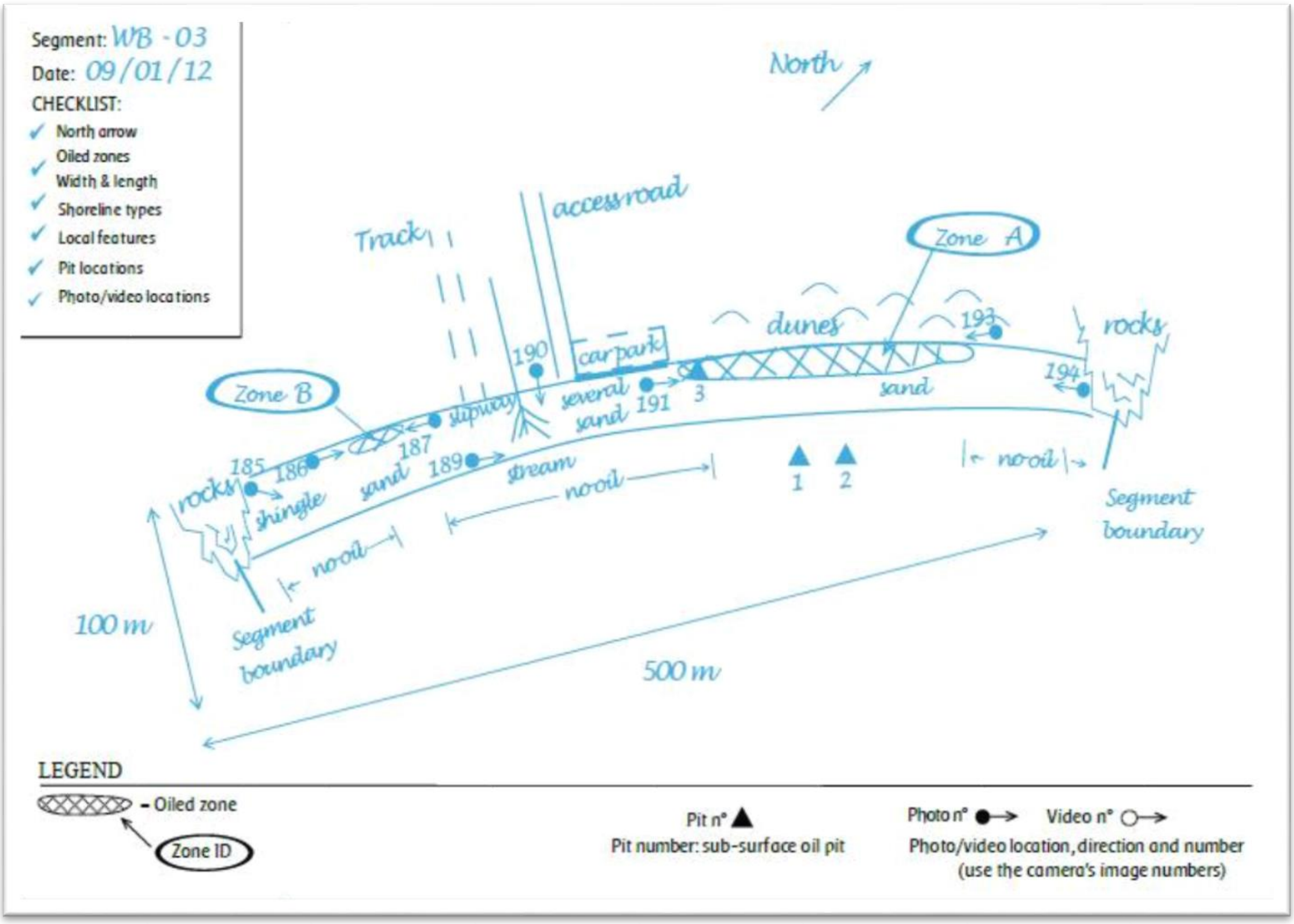
Using a pencil, indicate these measurements on the field sheet. Orient the longest dimension along the longest axis of the paper. Add a scale (use metric units) and a north arrow.

Lightly sketch in the outline of the intertidal zone or habitat being surveyed.

Show in final form (i.e. heavy pencil marks) the oiled zones, using a hatched pattern.

These zones should be the most conspicuous feature on the sketch, as shown below.

A letter is allocated to each oiled zone on the sketch that corresponds to the 'Zone ID'



Use the checklist to indicate:

- conspicuous features, such as fences and seawalls that would help identify the site; zones of vegetation and access points, such as roads and parking areas
- pits by a triangle, and give them a reference number that corresponds to the one on the Assessment Form. The triangle is filled in to represent oil found in the pit
- photograph locations by a dot with a connecting arrow indicating the direction in which the photo was taken

- location(s) where any video was recorded

General comments / Sketch / Taking Photographs (continued)

Photographs are very useful tools in documenting the shore's appearance. However, some discipline is needed and care should be taken not to take too many photographs, which is very easy to do with digital cameras.

Enough photographs should be taken to:

- Record general views along and across the shoreline
- Capture the appearance and location of oiled areas
- Identify key environmental and changes features on the shoreline
- Use a suitable scale in any view where the size of the picture is not obvious

Identify access routes or other operational features and on-going activities.

Do not forget to indicate the location of the view point on your sketch.

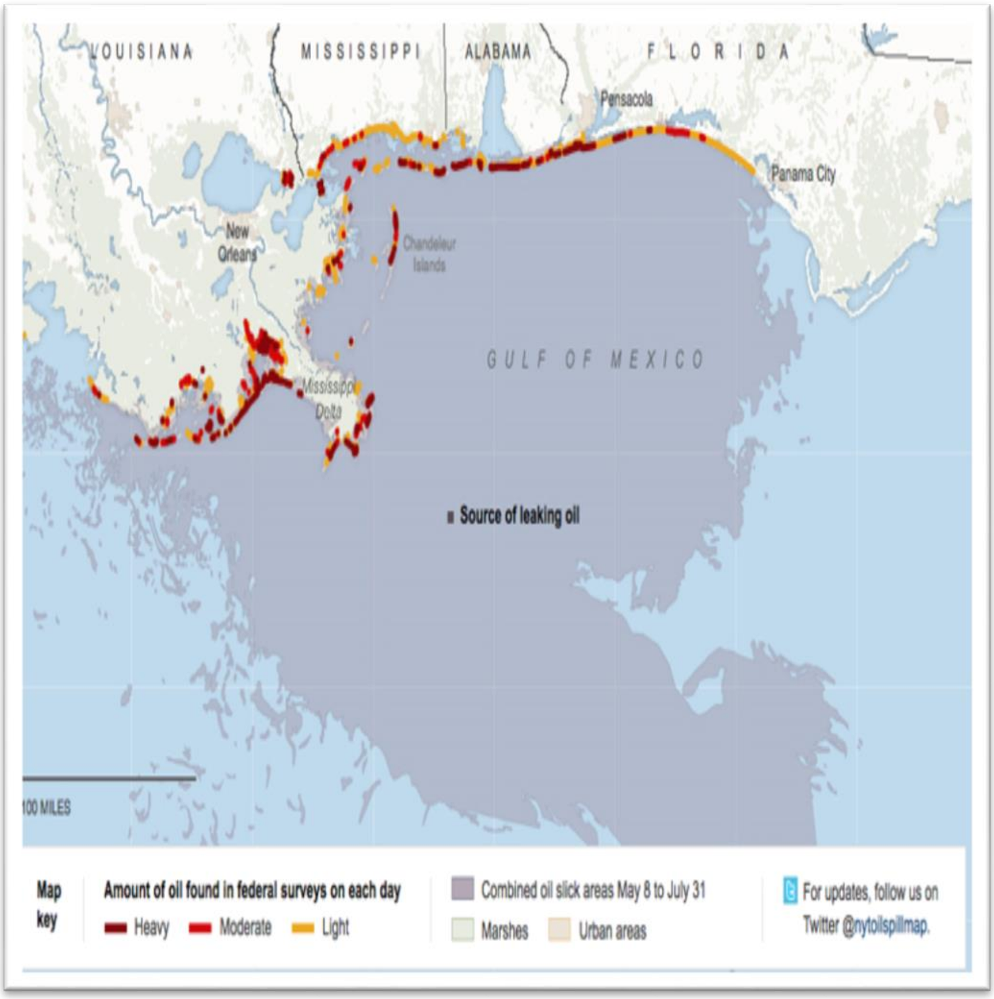
Most photographic management applications (e.g. Google Picasa, freely available) enable simple tagging of photograph sets and storage by date.

If photographs can be uploaded at the end of the survey or at least on the same day, this will aid their cataloguing and secure storage. It also frees memory within a camera for future photographs.

Accurate indication of photograph locations should be made on the segment sketch.

As a rule of thumb, if you have taken more than 20-30 photographs at one site, then you have probably taken too many.

Now with all the information gathered along the coastline we can put together a map like the one right showing the different types of shoreline and the degree of contamination in different areas.



The grey area of sea was not pure oil it was in the main just sheens which spread rapidly.

These grey areas are used by the media to show the public the extent of the problem.

This sells newspapers but has nothing to do with the amount of oil actually in the sea.

Principal directives of clean-up procedure

We break the cleanup into 3 phases:

Phase 1: Remove of heavy contamination and floating oil.

This stage is to collect floating oil which has reached the coast as quickly as possible to prevent it relocating on changing tides to contaminate other clean areas.

This may not be appropriate for environmentally sensitive shorelines where it would be better to allow the oil to migrate to less sensitive areas.

Phase 2: Remove moderate contamination stranded oil and oiled beach material.

This stage is done to stop any oil being mixed with sediments.

Both stages 1 and 2 are carried out using Booms, Skimmers, Pumps, Water flushing, Manual and Mechanical cleanup techniques.

Care must be taken to prevent oil being buried and to reduce the amount of beach material being removed with the oil.

Phase 3: Removal of lightly contaminated shorelines and a final polish / esthetic treatment of stains.

It is often difficult to decide at what stage of the cleanup to stop.

It is usually done by using such factors as the importance of the area, the time of the year and the rate at which natural cleanup is expected to take.

Anexhaustive final cleanup is normally done only in areas of high amenity and tourism.

This stage uses Absorbents, Chemicals, Bioremediation or Leave alone in very sensitive areas.

From the start we need to be thinking and putting into action the segregation of waste which will save time and money during and at the end of the cleanup. More on this subject under the waste tab.

This was written by Tosh Möller of ITOPF in 1987 and still holds true today - *"**90% of the oil is removed in 10% of the time and 10% of the cost; 10% of the oil is removed in 90% of the time and 90% of the cost**"*

The table shows how effort and costs increase as the amount of oil get smaller.

Stage	Quantity (Tonne)	Cost ($ per Tonne)
1	2,270	748
2	200	4,069
3	20	712,835
		T Möller et al 1987

In some cases we have to start the cleanup of the coastal areas with the oil still arriving in these areas, the impacts on the cleanup and efforts on the local communities will be greater. It is extremely demoralising for cleanup teams to clean an area only to see it impacted again. During both the Erika and Prestige incidents this happened as both ships sank and continued leaking for months.

The wetter zone of sand at the limit with the water of the sea is the region where the greatest numbers of organisms live. This is the most sensitive location in biological levels. In this region, then, the transit of people should be avoided and, principally, that of heavy vehicles, besides crushing the organisms present, it can cause greater penetration of oil in the sediments.

The hydrocarbon present in the location will be carried to the upper zone of the inter-tidal region by the action of the waves and tides themselves.

Booms can be positioned at angles to decrease the amount of spread along the shoreline and help concentrate the oil in one place.

The vegetation present in the upper band of the beach (supra littoral) generally is often damaged due to the transit of a large numbers of people and cleanup equipment.

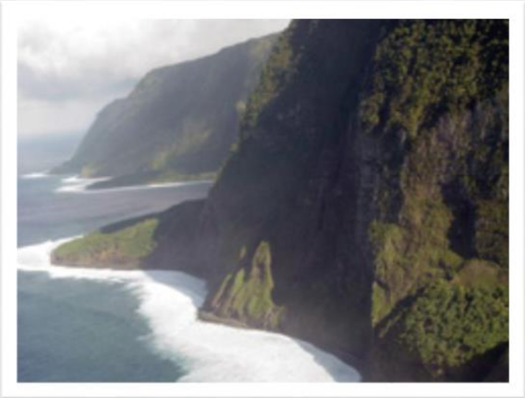
We should give special attention to these areas.

Note from Editor: In an earlier episode of this article Mark Francis referred to the 4 free manuals produced by POSOW designed for volunteers and all responders involved in onshore response who have little or no previous knowledge of shoreline geography and descriptions of shoreline oiling. He acknowledged his use of some of the POSOW material and wrote "I have borrowed some of the designs and wording as it is good to see simple designs showing how things work".

This acknowledgement should have been repeated in later episodes which contained excerpts from the POSOW manuals and we apologise for this omission. POSOW is a project co-financed by the EU under the Civil Protection Financial instrument developed in cooperation with ISPRA, Cedre, Sea Alarm and CPMR and coordinated by REMPEC the regional Centre of the Barcelona Convention. The POSOW Oiled Shoreline Assessment Manual can be downloaded HERE

Shoreline Types

Cliffs



These formations have taken millennia to construct and are often subject to high wave action.

Cliffs are very dangerous places to put human beings to work, especially during certain months.

When there is wave action the reflective wave in many cases will keep a slick some meters for impacting the cliffs, they also tend to be wet due to the wave so if there is contact with oil it does not tend to stick to the rock.

Great care needs to be taken from a safety point of view, information such as weather forecasts, tidal variations, etc. need to be known before these areas are approached.

This is one place where the supervision has to be done above the team of workers so that an overall view can be gained.

There is a real danger of people being stranded with a rising tide.

Supervisors that are with the group can often make the same mistakes as the group because of the lack of overall vision.

Note: Cleaning vertical cliffs will be a dangerous operation and should be confined to periods of calm weather and seas.

Further complications can arise in areas of substantial tidal movements.

Two or more boats should work in tandem or, if single boats are deployed, under shore supervision.

Due to the nature of the area experienced rock climbers have been used as this was the safest way to operate.

With the experience of many responses over the years on different shorelines with different oils.

Various tables have been put together showing what works well, more or less and not at all; Colour code key Green works well, Orange works but not as good as green and red is not recommended but may work in some circumstances.

 Response Cliffs	Light	Medium	Heavy
Natural Recovery	Green	Green	Orange
Water Flooding	Green	Green	Red
Cold water – Low pressure	Green	Green	Red
Manual Clean up	Orange	Orange	Green
Absorbents	Orange	Orange	Orange

Consult local ecologists about whether clean-up is necessary at all, and what the disadvantages of a leave alone action would be. If clean-up is necessary:

What to do:

- Hose affected areas with preferable heated water or high pressure water jets.

What not to do:

- Avoid abrasion of rock surface
- Avoid disturbing nesting birds on cliff faces

Note from Editor: This article was originally created for training course purposes. Having contributed the article for publication in the ISCO Newsletter, Mark Francis wishes to acknowledge here sources that provided information that he used in compiling this and future episodes in this series. In the sections dealing with shoreline types, the do's and don'ts were taken from Concawe report no. 9/81 Field Guide to Coastal Oil Spill Control and Clean-up Techniques and the tables are based on some found in the Field Guide for Oil Spill Response in Arctic Waters prepared for the Emergency Prevention, Preparedness and Response Group 1998.

Rocky coastlines

Rocky coastlines vary greatly in regard to their economic, recreational and educational value and their importance in the marine ecosystem.

Rocky coastlines include a broad variety of habitats and different communities, significantly in relation to their sensitivity and capacity for recovery following on spills of hydrocarbons.

In general terms, less sensitive coastlines, such as areas exposed to waves, have a greater potential for natural recovery.

Sheltered areas are much more sensitive to oil and also to the damage that can be caused by some clean-up techniques.

Due to potential variability, sensitivity and the high cost of cleanup, it is essential that contingency plans be sufficiently adaptable to different response options and adapted to the special peculiarities of each coastline.

Sensitivity maps, details of access to the coastlines and directives on how the cleanup will be performed, such as good communications between environmental assessors and those responsible for the cleanup.

Greater problems of oil spills on rocky coastlines are caused when the oil penetrates deeply into cracks and holes made by rock erosion and burrowing organisms.

In circumstances where residual oil could pose a threat to colonies of marine mammals, birds or where other techniques could cause greater damage or disturbance, it can be appropriate to use a natural absorbent, such as peat, for the removal of this oil to avoid it penetrating into these locations and affecting the organisms that live in the location.

For cleanup along rocky coastlines, low-pressure, ambient temperature sea water may be used to help remove oily residues.

Very thorough clean-up normally requires high pressure and will depend on how firmly the oil is adhering to the rock.

If the residual oil is adhering strongly to the rock and a very high degree of cleanup is required, it may be necessary to resort to hot high pressure water.

Be aware that such “aggressive techniques” will cause irreversible damage to the natural flora and fauna that is found on the rocky coastline and therefore these techniques should be only used as a last resort.

In many cases, it will be more appropriate to allow less aggressive natural processes to act, e.g. wave action.

Aggressive techniques may be used where justified by a large tourist presence. Remote sites can often be left to Mother Nature to clean up. Periodic assessment of the natural clean-up process is recommended.

Note that some rocky shorelines are difficult to clean and may release oil even after a thorough and time consuming clean-up operation.

Response Rocky Shores	Light	Medium	Heavy
Natural Recovery	Green	Green	Red
Water Flooding	Green	Green	Red
Cold water – Low pressure	Green	Green	Red
Warm / Hot water – Low Pressure	Red	Green	Orange
Cold water – High Pressure	Red	Red	Orange
Hot water – High Pressure	Red	Red	Orange
Manual Clean up	Orange	Orange	Orange
Vacuum	Green	Green	Orange
Absorbents	Orange	Orange	Red

What to do:

- Flush affected areas with cold sea water
- High pressure water jets only if avoidance of damage to flora and fauna not important
- Use sorbents in tidal pools at low tide
- Consider using skimmers at high tide
- Protect cleaned areas with booms
- Consider safety of personnel.

What not to do:

- Do not use fresh water
- Do not remove bedrocks

Boulders

These areas are treated very similarly to rocky shores, techniques include flushing with high volume low pressure water to release oil trapped between or under the boulders.

Rags, absorbent pads and de-greasing agents are used to clean the area, absorbent booms and pom-poms help contain the oil and stop it returning to the sea or re-oiling clean areas.

Note: Oil from Exxon Valdez can still be found over 20 years later, under and behind boulders more than 500 kms from the spill site.

What to do:

- Hand cleaning is possible although difficult and inefficient
- High pressure water jets on exposed surfaces

What not to do:

- Do not use fresh water

Response Boulders	Light	Medium	Heavy
Natural	Green	Green	Green
Water Flooding	Green	Green	Red
Cold water high pressure	Green	Green	Red
Warm/hot water high pressure	Red	Orange	Green
Manual clean up	Green	Green	Red
Absorbents	Orange	Orange	Orange

Cobbles

These areas produce problems from a penetration point of view. The type of oil and the inclination of the shoreline affects how far the oil will penetrate.

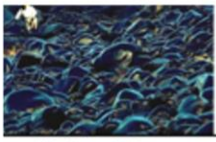
During large oil spills, with a mix of environmental and response personnel present, new techniques can be developed for cleaning areas such as this. It is a great opportunity to test new idea’s which cannot easily be done anywhere else.

During the Sea Empress incident we dug pits and sank skips into the shore, lined them with thick plastic sheets and washed the cobbles with de-oiling agents and water before replacing them where they came from on the shoreline.

In other areas the contaminated cobbles were moved to the surf zone over a period of 4 days for the sea and the fine sands to clean.

5 days later there was no significant contamination. This is known as clay-oil flocculation and allows the oil to be dispersed naturally.

Concrete mixer lorries were used to wash the cobbles with water and in some cases de-oiling agents, the released oil is skimmed off and the cobbles replaced. A good thing about this approach is the availability of these vehicles.



Response Cobbles & Stones	Light	Medium	Heavy
Natural Recovery	Green	Green	Red
Water flooding	Green	Green	Red
Cold water – Low Pressure	Green	Green	Red
Mechanical Clean up	Orange	Orange	Green
Sediment Transfer	Orange	Orange	Red
Manual Clean up	Orange	Orange	Orange
Vacuum	Green	Green	Red
Absorbents	Orange	Orange	Orange

What to do:

- Obtain ecological advice on the extent of optimal clean-up
- Take into consideration amenity use
- Use earth moving equipment to gather oiled gravel, clean on site in skips etc.
- Lightly oiled material may be moved to the surf zone where wave action will accelerate biodegradation
- Clean tidal pools with sorbents
- On site incineration would reduce material for transport. If permissable
- Attempt to restore the shore to its original formation and level
- Protect cleaned areas with booms
- Protect vegetation especially at access points

What not to do:

- Do not use fresh water
- Do not use de-oiling agents that will create oil/water emulsions
- Do not pile material higher than 1 metre

- Avoid excavating unaffected material
- Avoid disturbing subtidal flora
- Avoid burying oily material

In-situ Pit Washing of Oiled Cobbles

Pit washing was used for the first time during the Sea Empress incident to clean cobbles.

Large pits were dug to hold between 50 and 100 tonnes of material and lined with a heavy duty plastic liner. Cobbles were added and washed under high pressure water and an approved de-oiling agent (surface cleaner).

Oil could then be skimmed off the surface of the pit and the cleaned cobbles returned to the beach.

In some cases sunken skips were used as the pit. It should be noted that this method of cleaning cobbles removes only the bulk of the oil.

The remaining stained cobbles were not returned to the surface of the cobble zone but were buried to prevent re-oiling.

Shingle

The same problem of penetration exists as with cobbles.

Surf cleaning, pit washing and concrete mixing lorries can be used to great effect, though it was found that removing the fine material before washing reduced the cleaning time as it tends to retain the oil.

There is, as with all shoreline clean up, a need to stop before more damage than necessary is caused and nature is allowed to take over.

In sheltered areas bio-remediation has been tried by applying nutrients in the shoreline or spraying gelled versions, this is not a fast process but enhances the natural cleaning process.

Do's and **Dont's** are as for Cobbles

Shingle Washing Operations

During the Sea Empress incident in Wales, UK 1996 these innovative clean-up techniques proved very useful.

Creating the opportunity to try innovative techniques comes from governments that have unfortunately had many large oil spills to cleanup in recent years and are therefore open to trying different ideas.

Washing stations were set up at several locations.

These were established from readily available equipment such as cement mixers, skips, temporary tanks, conveyors and scaffolding.

Oiled material was fed into a lorry-mounted cement mixer and seawater with an approved de-oiling agent, or occasionally diesel, added.

However, later operations stopped the use of either de-oiling agents or diesel as it was found that these were not necessary.

Operating the cement mixer agitates the material and loosens the oil.

The mixture is then left to separate.

The oily water is then run-off into watertight skips or tanks and the oil removed by surface skimmers.

The cleaned shingle was then returned to the beach where it came from.

Treatment rates depend on the degree of oiling, the capacity of the cement mixer and the number of cement mixers used.

Cement mixers typically have a nominal capacity of 10 tonnes and, with a treatment cycle of 2 hours, some 50 tonnes per day can be treated.

However, more recent work suggests that treatment cycles of this length may not always be necessary.

Sandy beaches

On shores with coarse grained sand the waves bring the oil up the beach then the water sinks into the sand as it returns to the sea.

This action leaves the oil stranded in thin lines.

Unless great care is taken huge amounts of sand will be removed with very little oil.

This work is done with shovels or in some cases sorbent boom is strung out and rolls up the beach with the waves and picks up the oil on the outside of the boom.

Normally, oil can be removed manually from beaches of fine compacted sand without much difficulty, using hand tools and well-organised teams of workers.

In the event that it is necessary to use mechanical equipment to scrape off the contaminated sand or to transport recovered residues, it should always be done by experienced people.

Care must be taken not to remove excessive quantities of sand, thus generating a large quantity of material requiring off-site treatment and disposal.

Care should also be taken not to mix the oil deeply in the substrate.

Manual collection of oil is generally preferable to mechanical removal.

Final clean-up operations may include manual removal of tar balls or larger fragments of oil pancakes.

Response Coarse sand	Light	Medium	Heavy
Natural	Green	Green	Red
Water flooding	Green	Green	Red
Cold water - Low pressure	Green	Green	Orange
Mechanical	Red	Orange	Green
Sediment Transfer	Green	Orange	Red
Manual	Orange	Green	Green
Absorbents	Green	Orange	Red

Response Fine sand	Light	Medium	Heavy
Natural	Green	Green	Red
Water flooding	Green	Green	Red
Cold water - Low pressure	Green	Green	Orange
Mechanical	Red	Green	Green
Manual	Orange	Green	Green

What to do:

- Consider amenity usage of affected area, influence of season and ecological advice to determine degree of clean-up
- Bear in mind that oil may be buried and further clean-up may be necessary
- Herding agents may reduce oil adhering to the sand. Permission may be necessary
- Slightly oiled material may be moved to the surf zone where wave action will accelerate biodegradation
- Consider manual versus mechanical clean-up
- On site incineration would reduce material for transport if permitted.
- Attempt to restore the shore to its original formation and level
- Protect cleaned areas against being re-oiled with booms
- Arrange transport for oiled waste

What not to do:

- Do not use fresh water
- Do not over-clean
- Avoid people or vehicle traffic over contaminated areas
- Avoid excavating unaffected material
- Avoid burying oily material
- Avoid disturbing vegetation mainly at access points

Amenity beaches with installations

(Photo AP)

Depending on the type of sand, tourist beaches may have hundreds of thousands of foot prints on them.

Each one could be filled with oil as left so there is a serious need for supervision of cleanup personnel to reduce the amount of sand removed with the oil.

This becomes a time consuming job and many people will be picking up 3 or 4 times as much sand as oil while the supervisors back is turned.

What to do:

- Decide clean-up priorities in discussion with local operators, taking into consideration the season, weather conditions, etc.
- Remember re-oiling can occur
- Treat sandy beaches as described above
- Use anchored motor vessel's prop wash to move oil from inaccessible places (under jetties, etc.)
- Arrange for access to the beach to be restricted before and during clean-up operation
- High pressure jetting of slipways and other installations with hot water. If necessary use manual scraping

- Establish collection points and a disposal route for oiled waste

What not to do:

- Do not cover oiled sand with clean material
- Avoid if possible, secondary pollution from beach to roads

Mud flats

Many of the techniques used on other shorelines will do more damage to this environment than is necessary. The physical removal of oil may do great damage to sensitive substrates.

The use of chemicals may cause the penetration of the oil into the substrate, damaging plant and animal life.

The amount of invertebrate life held in this type of shore is enormous, with oil on the surface even the pressure of your footprint will push the oil down into this anaerobic substrate where the oil will remain a source of toxicity for many years causing problems for any life that encounters it.

These areas tend to be flat and extensive; the load bearing capacity is very low so vehicles should not be used.

Many people have been killed in these areas, they get stuck in the mud and cannot get out before the rising tide arrives. Note: These areas are highly sensitive and very dangerous. Safety is a high priority. Normally they should be left alone to allow natural cleaning to take place.

Responses Mud	Light	Medium	Heavy
Natural Recovery	Green	Green	Green
Water flooding	Green	Green	Red
Cold water – Low Pressure	Green	Green	Red
Manual Clean up	Red	Red	Orange
Vacuum	Green	Green	Red
Absorbents	Orange	Orange	Orange

What to do:

- Obtain ecological advice as to which areas should be treated
- In many cases a leave alone action will be the most desirable solution
- If possible patches of oil may be removed using skimmers adjusted to these conditions
- Sorbents may be used on isolated patches of oil if accessible
- Where approved light tools may be used (spades or shovels) for manual cleaning

What not to do:

- Do not use machinery
- Do force oil into the substrate (feet)
- Avoid excavating unaffected material

Mangroves

In tropical mangrove areas due to the low energy, oil degrades with great difficulty.

There are two types of mangrove areas.

The type on the left the breathing roots (pneumatophores) grow down into mainly mud based sediment whereas the type on the right grow up out of more stable sand sediments. Both are equally sensitive.

The type on the right are easier to flush with sea water.

The word mangrove refers to species of trees or shrubs which are salt tolerant.

They tend to grow on sheltered shores and estuaries in the tropics and some sub-tropical regions.

There are about 60 plant species which only grow in this habitat; there are many non-exclusive species too.

Mangroves are exceptionally adapted to growing in sea water. They remove the salt (desalinate) using a filtration process.

Mangrove roots typically grow in anaerobic sediment (without O_2) and receive oxygen from the air through through small pores (lenticels) on the aerial roots and trunks through aerating tissue.

The fallen mangrove leaves are broken down by bacteria, fungi and herbivores, and can sustain large populations of invertebrates and fish.

The calm waters in mangrove forests are ideal breeding and nursery grounds for young fish and shrimps, while the aerial roots, lower trunks and mud surface usually support oysters, snails, barnacles, crabs and other invertebrates.

The upper part of the mangrove trees is essentially a terrestrial environment with a fauna of birds, mammals and insects.

What to do:

- Obtain ecological advice as to which areas should be treated
- In many cases a leave alone action will be the most desirable solution
- Use flushing with high volume low pressure sea water
- If possible patches of oil may be removed using skimmers adjusted to these conditions
- Sorbents may be used on isolated patches of oil if accessible
- Where approved light tools may be used (spades or shovels) for manual cleaning

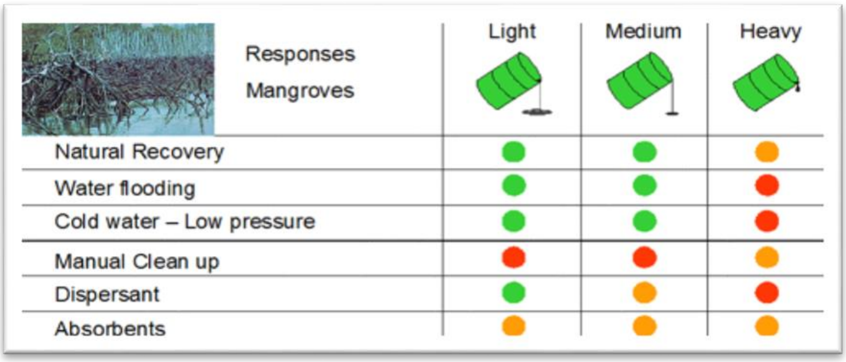
What not to do:

- Do not use machinery
- Do force oil into the substrate (feet)

- Avoid excavating unaffected material

Note: The amount of time needed for toxic elements to be flushed from mangrove areas depends on thy type of oil that has been spilt.

In some cases mangroves have been successfully replanted with excellent results



Salt Marshes

These are very low lying areas with little wave action but with many meandering branches in the water ways where the oil can be trapped during the falling tide as well as on the surface of the marsh which is covered at high tide.

In many cases harsh cleanup techniques have caused serious adverse effects persisting for many years.

In some cases the introduction of other plant species that can survive in the disturbed areas has aided recovery.

These oiled marshes can be a huge problem during bird migrations as they are major feeding areas. Gas guns, silhouettes of birds of prey and other scaring techniques have been successfully employed to keep birds away.

Air boats are useful in these areas as they do little damage although they make a lot of noise.

A clean-up may be performed with small groups of people, directed by professionals with relevant experience.

Absorbent materials should be used, preferably of natural origin, or blankets and booms as long as they are not left permanently in the affected area.

For the removal of significant oil accumulations, light skimmers with portable pumps can be used.

If is not recommended to use heavy equipment as a lot of damage will be caused by the wheels or tracks of these vehicles as seen in the bottom left photo.

The use of material such as trackway as in the photo top right spreads the load causing much less impact.

The destruction of areas within this habitat bottom right photo will allow space and time for invasive plants to take over thus upsetting the fragile balance in the area.

In some countries when that growth dies come back in the autumn, controlled burning is used. This burns off the oil and plant foliage but the roots in the water logged sediment will allow the plant to grow back in the spring.

Potentially this can remove over 90% of the oil with little or no damage to the salt marsh.

Note:
Although these areas may have little amenity use, they are often the more sensitive ecological areas and during certain months sustain large migratory bird populations.

Booming and skimming in creeks, and pumping of bulk oil from the marsh surface, depressions and channels. If logistically possible can be useful in removing large amounts of oil.

Low pressure water flushing may be justified where large quantities of oil have entered salt marsh areas.

Care should be taken to avoid the creation of unacceptable erosion.

The rapid deployment of sorbents, including before the oil actually reaches the marsh can reduce penetration of oil into sediments.

Thought has to be given to subsequent collection of oiled sorbent material for disposal.

In-situ burning of oiled vegetation has been used with varied results; in some cases this can cause more damage but in others it can be a good option at certain times of the year.

Burning in the winter has the advantage that much of the standing vegetation is dead, and the ground is likely to be relatively waterlogged. This helps protect underground systems from heat damage.

Because there is evidence that burning can increase sediment oil content, the method is likely to be more suitable in cases where the oil is firmly adhering to dead marsh vegetation (i.e. cases where there is little or no oil on the sediments).

Response Salt marshes	Light	Medium	Heavy
Natural	● (green)	● (green)	● (green)
Water Flooding	● (green)	● (green)	● (red)
Cold water low pressure	● (green)	● (green)	● (red)
Manual clean up	● (red)	● (red)	● (orange)
Insitu burning (dependent on season)	● (green)	● (green)	● (red)
Absorbents	● (orange)	● (orange)	● (orange)

What to do:

- Obtain expert ecological advice as to which areas should be treated
- In many cases a leave alone action will be the most desirable solution
- Protect with booms
- Propane guns (bird scarers) help keep birds away if oiling is inevitable
- Sorbents may be used (natural materials may not need to be recovered)
- If in doubt, minimise interference with natural cleaning processes
- Limited use of air boats or hovercraft may be acceptable
- Water flooding with low pressure sea water may help to remove oil
- Reinstate any access roads at the end of the operation

What not to do:

- Do not use machinery
- Avoid excavating unaffected material
- Do force oil into the substrate (foot or vehicle traffic)
- Avoid cleaning procedures that are purely cosmetic.

Estuaries

Note that spill damage, containment and clean-up operations may be very different in estuarine areas compared with other coastlines.

In particular, water in oil emulsions may sink on entering less saline waters.

It may also be necessary to take into consideration a multitude of commercial and economical factors, in addition to ecological and amenity aspects.

Large bodies of water flowing through small mouths cause very strong currents.

Photo below on right shows oil in Saudi Arabia during the 1990 gulf war - over 2 km inside the area with a tidal height of just half a meter.

What to do:

- Reduce by whatever means available the inflow of oil, (booms or closing lock gates)
- Use the outgoing tide to support cleaning operations
- Collect and recover floating oil as soon as possible
- In some countries dispersants may be used if permission has been granted
- Use inland techniques in the upper reaches of large river mouths
- Check backwaters and side streams for re-pollution

What not to do:

- Avoid over ambitious booming too far down stream
- Avoid damage to sea walls, dykes, etc., bearing in mind that tidal movements in estuaries can be more pronounced than at sea
- Do not obstruct local water traffic more than necessary

Small islands and deltas

What to do

- Seek advice from wildlife experts with respect to the extent of clean-up required
- Review whether booming of areas not yet affected by oil is necessary or feasible
- Collect and recover floating oil as soon as possible
- In some countries dispersants may be used if permission has been granted
- If necessary attempt manual clean-up

What not to do:

- Avoid disturbing the coastal formation and existing vegetation which could cause erosion

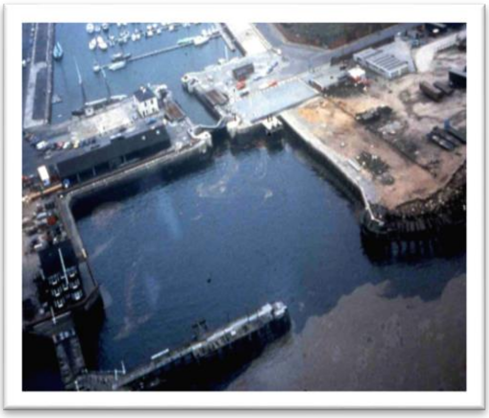
Marinas

I am not completely against the green organisations though they do tend to uses some people who are lacking in the grey matter department.

The photo on lower right shows a Greenpeace rubber boat dripping oil. This was taken during the Haven incident near Genoa, Italy.

Greenpeace decided to go boating in the oil then came back to a clean marina contaminating the boats but disappearing to let someone else clean up their mess.

Note: Spill damage will be mainly economical rather than ecological



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What to do:

- Minimise spreading of pollution into locks and docks
- In confined areas with a high risk of explosion or fire cover with fire fighting foam
- Use sorbents to collect floating oil
- In some countries dispersants may be used if permission has been granted
- Agree with owner or representatives as to what clean-up is mutually acceptable.
- Involve insurance experts (compensation)
- Hose down slipways and jetties with hot water with or without chemicals
- Arrange for cleaning boats by manual, jetting and mechanical means
- Establish disposal route for oily waste

What not to do:

- Avoid secondary pollution of roads, buildings, etc.

Fisheries and aquaculture

Note: If fish farms, oyster beds or harvestable fields of algae are affected the first priority should is to avoid further contamination.

Cleaning operations can often be more effectively organised by the operators of such ventures

Sorbents and other materials should be made available if required.

What to do:

- If possible immediately inform authorities and owners of sites at risk about the spill
- Consider deployment of protective/diversionary booms
- Advise them to move sensitive equipment, fish tanks, etc. out of the water or into protected areas
- Use sorbents to collect floating oil
- Agree with owner or representatives as to what measures are mutually acceptable.
- Arrange for cleaning boats by manual, jetting and mechanical means
- Involve insurance experts (compensation)
- Establish disposal route for oily waste

What not to do:

- Avoid damage to fish farms and specialised crop areas
- Avoid secondary pollution of roads, buildings, etc.

Industrial ports

Note: The direct damage will be mainly economical. Dispersion of smaller spills may be an established routine.

What to do:

- Prevent pollution spreading though locks, etc.
- Bear in mind the costs of a paralyzing ship movements in port
- In confined areas with a high risk of explosion or fire issue warnings and cover with fire-fighting foam
- If available, application of encapsulating media can reduce explosion risk of volatile spills
- In some countries dispersants may be used if permission has been granted
- Use sorbents and booms to protect uncontaminated vessels
- Where practicable use booms and skimmers to collect and recover oil
- Agree with owner or representatives as to what clean-up is mutually acceptable.
- Involve insurance experts (compensation)
- Hose down quays, seawalls, jetties, etc. with hot water with or without oil removing chemicals
- Dispersant gel may be effective if appropriate and permitted
- Arrange for cleaning vessels by manual, jetting and mechanical means
- Establish disposal route for oily waste

What not to do:

- Do not hose down earthwalls
- Avoid secondary pollution of quays, roads, buildings, etc.

Manmade structures

The degree of sensitivity in these areas sometimes depends on who lives there.

The white house in the photo belongs to a very wealthy and influential person so of course the sensitivity is very high.

Harbour walls, slipways, jetties and steps are normally cleaned with high pressure water and some use of oil removing chemicals. The released oil is caught with absorbents to avoid re-contaminating clean areas.

The technique was very successfully used to clean heavily oiled rock walls in Saudi Arabia after the Gulf War oil spill.

Note: If chemicals are used, consider using “solubilizer” types, such as d’limonene products that release adhering oil without emulsification. These are easily applied using knapsack type sprayers. If emulsifying detergents are used it will not be possible to recover the released oil.

Responses Manmade Structures	Light	Medium	Heavy
Natural Recovery	Green	Green	Red
Water flooding	Green	Red	Red
Cold water – Low Pressure	Green	Green	Orange
Hot / Warm water – Low Pressure	Red	Green	Orange
Cold water – High Pressure	Red	Red	Orange
Hot water – High Pressure	Red	Red	Orange
Manual Clean up	Red	Orange	Orange
Dispersant / Chemicals	Red	Orange	Red
Absorbents	Orange	Orange	Red

Close supervision is required as high pressure water can cut human tissue and damage eyes.

It can also cut sandstone walls which can then be eroded further by the sea.

In areas of rip rap as seen in the photo left, large quantities of oil can be held within the spaces between the blocks which may take months to clean.

Besides this, a cleanup with an excessive number of people could mean an impact greater than the oil itself on the environment.

There is also another aggravating factor:

in the event that the oil is buried by trampling into an anaerobic sediment, the oil, due to the lack of oxygen, will not be degraded easily by natural processes of weathering.

This will cause long lasting effects on the ecosystem.

Environmental and Other Considerations

From a purely ecological perspective, a major priority should be the effects of the hydrocarbons in the sediments, especially in relation to sheltered areas with reduced wave activity.

This is due to the fact that these sediments are more productive and will probably retain more hydrocarbons. They support the life of a great variety of marine worms, molluscs and crustaceans.

These animals could die if the oil penetrates into the sediments, as was the case with the spill of the Sea Empress 1996, when many amphipods, crustaceans and molluscs died due to the highly toxic oil sweeping across mud flats.

The recovery from contamination by hydrocarbons depends on the sensitivity of the species affected. After the spill of the *Sea Empress,* for example, the populations of molluscs that lived in the mud recovered over a period of just a few months, however the populations of amphipods only returned to normal after a year.

After a spill of hydrocarbons it is possible that opportunists, such as some of the species of worms, show a spectacular growth over a short period of time.

Adverse effects of contamination by hydrocarbons are also related to the persistence of hydrocarbons in the sediments. After the spill of the *Florida*, for example (Buzzards' Bay, USA, in 1969), the populations of a type of crab took more than seven years to recover and it was possible to correlate this with the persistence of hydrocarbons below the surface of the mud.

On the other hand, the recovery after the spill of the *Arco Anchorage* (Port of Los Angeles, USA, in 1985) after a year was already well advanced thanks to an effective response to the spill which helped to eliminate hydrocarbon in the sediments.

A reduction over the long term of fauna in the sediment can have an adverse effect on the birds and fish that use the marine areas for feeding and, in some countries, the persistence of oil on sandy beaches can affect the reproduction of turtles. Some cases have been registered of the deaths of seal pups and, in some cases, adult seals do not succeed in reproducing in zones contaminated by oil.

Oily material, which for one reason or another cannot be removed and remains in the sediment, may block the light of a considerable portion of the surface of the marshes and, consequently reduce its productivity. Besides this, it presents a source of contamination and a risk for the animals of this ecosystem.

The types of communities affected should also be taken into consideration, since many organisms possess the capacity to clean themselves, often living under natural conditions of stress they can succeed well in surviving an oil spill.

On the other hand, there are many species of organisms that may be seriously affected by an oil spill, with irreversible damage being caused to the community.

The local biological populations may also be presented as an important agent in the behavior of the oil in the sediment. Muddy beaches with fine-grained sand often host organisms adapted to living in galleries and tubes, which are physical means for the passage of oil and its consequent penetration to the lower layers of the sediment.

Looking at organization of clean-up operations and having considered all the relevant information - shoreline type, size, degree of exposure, angle, socio-economic issues, environmental issues, access, etc., we can go on to look at management issues.

Typically we need supervision at a ratio of 1 supervisor to 10 or maybe 15 operators. This depends on the performance capabilities of clean-up teams.

From my experience - Along with three others I had the charge of 250 women on a Mozambique beach during their civil war. The impacted beach was fairly flat with fine-packed sand; it was about 3 km. in length with a small mangrove area at one end and had been impacted with about 5000 tonnes of heavy fuel oil.

It was impossible to know at any one time how many of the women were working. Luckily they were very honest people. Many had small children or were in various stages of pregnancy. The young girls set up a creche. When a baby cried a girl would fetch mum, she would feed the baby and then go back to work. They were paid $1 and a bowl of rice per day. It was over too quickly, this job had a lasting impression on me.

On another occasion I was in charge of a shoreline clean-up in Southern Ireland. There was a cliff at the back of the beach which made access difficult. The shore was very rocky not allowing access from the sea.

Use of helicopter for access was a practical option. Initially the most expensive helicopter in the country was hired but we got a cheaper one as fast as we could from Scotland.

Oil and oily waste was removed in 1 tonne bags as underslung helicopter loads. I had people filling these bags but as time went on people began to fill the bags with clean rocks and sea weed because the money was good and they did not want it to finish.

We even had a couple of guys dressed in oily Tyvec suits who robbed a house near the cliff top and left their oily foot prints as a good clue for the police to look at the shoreline operation. They even stole a shotgun which at the time was punishable by a very heavy sentence. Hiring people is easy but controlling them can sometimes be very difficult. It all depends on where you are as to how the job needs to be supervised.

Manual Cleanup

One should take maximum care to remove the least amount of uncontaminated sediments and surviving animals and plants.

Manual removal, with shovels and rakes, for example, is adequate for small areas contaminated with hydrocarbons in places where it has not penetrated deeply.

It is a useful technique for cleaning up patches of oil, in the cases where the use of heavy equipment is limited by access, or when the machines could damage the structure of the beach.

The manual recovery of petroleum should be done only on the upper band of the beach (middle littoral upper and supra littoral). The procedure should be performed very carefully, removing the minimum amount of sand possible.

In order to do this you can use wooden scrapers, rakes, shovels, buckets, skimmers (not spades and hoes). Normally, several days of cleanup is necessary, since with each high tide, more oil in carried up.

The marine algae contaminated in low energy areas, can sometimes be removed.

In higher energy areas where the algae is continually wet the mucus membrane on the fronds tend to reject oil. This should not be touched as the more life left on a shoreline the faster it will recover.

The photograph on the right shows contaminated seaweed removed and awaiting final disposal during the Sea Empress clean up in Wales, UK 1996.

Now here is an alarming story that surfaced in France:

A stretch of beach near Lannion in Brittany in 2009 was closed because of concerns that large amounts of rotting seaweed could prove to be a fatal health hazard.

The seaweed *Ulva lactuca* more commonly known as sea lettuce wasgrowing abnormally fast in the region due to heavy nitrate pollution caused by intensive farming practices. The nitrates leach out of the soil and wash down in to the sea through local rivers.

Wave action then washes the seaweed on to the beach in large amounts up to a metre deep in so called 'green tides' where it starts to decompose, during the decomposition process highly toxic hydrogen sulphide gas is formed.

Because of it's the gooey nature a thick crust forms on the top of the rotting seaweed causing the gas to accumulate and become trapped inside the rotting mounds. When the crust is broken by stepping on it the trapped gas is released.

Local mayor René Ropartz took the decision to close the beach at Trédrez-Locquémeau when a rider lost consciousness and his horse was killed after riding across the rotting sea weed last week. A council worker was also being treated in a hospital at Lannion after collapsing and falling in to a coma while clearing the deadly weed.

Earlier this year several dogs were killed after walking over the rotting seaweed. Dogs and small children are particularly susceptible to the gas as they are lower to the ground and more likely to inhale larger amounts.

The problem is not isolated to the beach at Trédrez, other beaches along the western coast of France are from time to time affected by the seaweed, beach goers and dog walkers should take care to avoid mounds of rotting sea weed. It should also be noted that in some areas with strong tidal movement, or after storms, a thin layer of sand can be washed over the rotting seaweed concealing it from view.

All of the oil recovered removed from the beach should be contained, preferably in sealed drums or bags. Once the majority of the oil has been removed, the uses of natural absorbents such as peat, straw, etc or synthetic, are very efficient for the final clean-up of the beach.

These should be spread on the fringe of the infra littoral area (region closest to the water), always at low tide. With rise of the tide, the product acts for several hours and along the entire length of the inter-tidal zone. At high tide, the product should be removed manually, respecting in the same way the lower bands of the beach.

In locations with large quantities of trash, such as in ports or close to mangrove swamps, normally the manual removal of this trash is done using nets, in order to facilitate the removal of oil by means of another process. If this can be done before the oil arrives this greatly reduces the amount of waste to be disposed of.

This is a brief description of Hydrogen Sulphide (H_2S) - It is colourless with an odour commonly referred to as the smell of rotten eggs. It has a vapour density 1.189 (Air=1.0) and is heavier than air. It is highly explosive. Its auto ignition temp is 260 degrees C. Its solubility in water is 2.9 percent (2.9g/100 ml water at 20^0C). It is also extremely corrosive, destroying steel and rubber seals very quickly.

Effects of H_2S Note: Smell is only a temporary warning. The odour quickly becomes unnoticeable. Do not rely on your nose.

- 10,000 parts per million = 1 percent. 1 ppm: Can be smelled
- 10 ppm: Occupational Exposure Limit, for 8 hours: At very low concentrations of less than 10-100 ppm.
- 15 ppm: Occupational Exposure Limit, allowable for 15 minutes of exposure.
- 20 ppm: Occupational Exposure Limit, at this level workers must wear appropriate breathing apparatus.
- 100 ppm: the gas kills the sense of smell in 3-15 minutes and will cause you to cough or your eyes to water, possible headache, nausea, throat irritation.
- 200 ppm: your eyes and throat will begin to burn and you will get Headaches. Sense of smell lost rapidly.
- 300 ppm: Immediately Dangerous to Life and Health level. Positive pressure breathing apparatus required.
- 500 ppm: Loss of reasoning and balance with respiratory disturbances in 2 to 15 minutes.
- 700 ppm: Immediate unconsciousness. Death will result if not quickly rescued.
- 1000 ppm: Immediate unconsciousness. Causes seizures, loss of control of bowel and bladder, breathing will stop and death will result if not rescued promptly. Immediate resuscitation needed.

Comparison of H^2S with other lethal gasses will help you to understand the importance why you cannot work alone:

- Hydrogen Sulphide (H_2S) has a threshold limit of 20 ppm and a lethal concentration of 600 ppm.
- Hydrogen Cyanide (HCN) (used in Nazi gas chambers) has a threshold limit of 10 ppm and a lethal concentration of 300 ppm.
- Carbon Monoxide (CO) has a threshold limit of 50 ppm and a lethal concentration of 1,000 ppm.

You should have got the picture by now that when having to work in atmospheres where hydrogen sulphide is present you must have an understanding of why so much preparation and precautions need to be taken.

Water flushing

The saturation of ground with low pressure water (<10 psi) permits part of the oil to float off for later retrieval.

Water flushing applied to rocky shorelines will have impacts that depend on the pressure used.

Jetting at high pressures removes all of the biological community, aggravating even more the biological impact on the affected environment.

Low pressure water flushing with large volumes of sea water can be beneficial, if used with caution. This technique can be efficient in the removal of substantial quantities of oil from vegetation where vegetation is relatively stable and continuous.

Washing with running water of the affected rocky coastlines is a recommended technique as long as it does not cause more damage.

However, this technique should be utilized immediately after the areas have been affected by oil. If washing is delayed, it will not be an efficient method for removal of weathered oil that has already adhered to the substrate.

A perforated hose is placed in the location of contamination with the objective of saturating the sediment with water so that the oil floats off.

Liberated oil should be recovered immediately so that contamination of other areas does not occur.

Water should be pumped at low pressure. In porous sediments, the flow of water in the substrate will, because of density difference, carry the loose oil to the surface.

The viscosity of the oil will influence the success of the operation. Light oils will float off more easily than heavy oils.

We should always use water with the same physical-chemical characteristics as the place of the spill to reduce further damage.

High pressure water is typically between 100-1,000 psi. High-pressure spraying will be more effective in removing sticky or viscous oils.

If low volumes of water are used, absorbents can be placed directly below the treatment area to recover the oil as it runs off.

High pressure jet washing can be particularly effective for treating areas with firm sediments with low slope and rocky areas.

The use of low pressure water at ambient temperature minimizes damage to the structure of the sediments and to organisms that are present.

The photo (above) shows what is called an Omni boom, because it operates at so high a pressure a hydraulic arm has to be used.

Unless it is really necessary, the use of high pressure jet washing is not recommended.

As might be expected, high pressure jet cleaning can cause erosion, modifications of the substrate, physical harm to the plants and make the oil penetrate even more deeply into the sediments.

It is recommended that studies be made and expert advice be taken on the effect of this method on marshes and mangrove swamps before even considering its application.

High pressure can be used to remove oil that has adhered to hard substrates or to artificial structures.

In the photo (right) the black oil is floating on the surface but the fine light coloured sediments have been driven into the most sensitive zone of this shoreline thus doing more damage than the oil did when it arrived.

Jet cleaning is likely to cause erosion in other areas, causing great damage to the vegetation in areas such as mangrove swamps.

During washing care must be taken to ensure that oil does not flow into sensitive habitats. It should be recovered to prevent contamination of adjacent areas.

This technique should not be used directly on fixed algae or in inter-tidal areas.

Be aware of the adverse environmental effects of high pressure jetting. All of the fixed animals and plants in the zone of direct spraying will be removed, even when it is used correctly.

It can cause deeper contamination of the substrate or uncontaminated sediments. The technique is not viable for mud or clay sediments.

Habitats may be physically disturbed by traffic during the operations and these environments may be suffocated by the fine sediments washed over sensitive areas.

If collection methods are not effective, oil can contaminate sediments in adjacent areas. Inundation can cause loss of sediment and erosion of coastal contours and scrub vegetation.

Fine sediment can bury benthic organisms especially in the upper tidal zone.

Hot water

In this context hot water typically has a temperatures between 32°C and 77°C. At this temperature the removed oil will probably not re-adhere to the surface of substrates.

It can be used to remove oil from solid surfaces and man-made structures where removal of organic growth will not have any adverse consequences.

Hot water can and will kill animals and plants. Generally, marine organisms live adapted to a range of temperature, salinity and oxygenation. Living organisms have minimal tolerance to hot water.

Containment of run-off is necessary. If the containment of the area is not adequate, the run-off from hot water jet washing is likely to contaminate other areas.

During the Exxon Valdez spill, the use of high-pressure hot water was used as a cleanup technique and resulted in a greater impact and much longer periods of recovery for coastal organisms.

Typical sea temperatures range from 0º – 3º C so the use of hot water will make the shore look clean but effectively kills everything. The main impact of hot water jetting was the massive elimination of species that required many years to re-establish themselves.

Use of this technique came about more from media pressure to remove oil than from common sense. In many areas the natural cleaning in this area by wave action during the following winter would have done the job with far less environmental impact. This was evident during the following spring in areas that had not been treated during the previous year.

Hot water techniques are unlikely to result in an improvement in the recovery of the environment; fortunately we usually learn from our mistakes but public and media pressure can be powerful. Sometimes things get done to that should never be done but, by then, it is too late.

Steam cleaning

Steam clean-up is generally carried out with very hot water, with temperatures between 77°C and 100°C.

This method is very destructive and should only be applied in locations where no biological communities exist.

The effects of this technique are devastating, being capable of causing the complete death of an entire biological community.

The rate of recovery can be extremely slow.

In the event that small sections of the coastline are hot water or steam cleaned to remove oil from solid substrate or man-made structures, this technique should be used at low tide, so that the contaminated water may be contained and removed before the tide comes in.

From a safety point of view:

More than 11,000 workers helped clean up the Exxon Valdez oil spill - a new survey has found that up to one-third of these workers experienced health problems consistent with high exposure to oil, solvents and other chemicals used during the cleanup.

During steam cleaning operations masks should be used to avoid breathing in oil vapor. This can get into the lungs and result in health problems for many years after the event. This can be a real problem for many workers in clean-up operations.

Workers were often sent out to clean oil without proper training or protective equipment. While media and public attention focused on the thousands of oiled and dead seabirds, otters, and other wildlife, little attention was given to the harm done to the cleanup workers.

Provision of Personal Protective Equipment (PPE) for thousands of people for months of work in remote regions can be a logistical nightmare.

During the 2007 Hebei Spirit incident in South Korea, there were over 1 million people who wore PPE. Often it was worn for only one day then thrown it away as another group of workers would arrive the next day.

Absorbents

The utilisation of sorbent materials for the removal of oil normally is done manually.

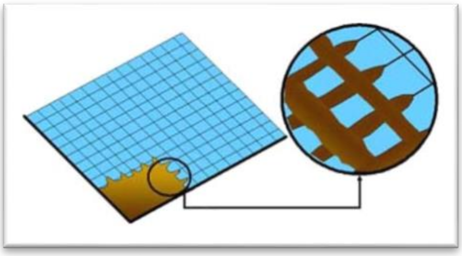
Sorbents may be defined as materials with the capacity to recover oil by means of absorption and/or adsorption.

There are three basic types of sorbents.

(1) Natural organic materials, such as cork, hay, fennel, sugar cane, coconut husks, and peat.

(2) Mineral materials such as vermiculite, perlite and volcanic ash;

(3) Synthetic organic sorbents, such as polyurethane foam and polypropylene fibres.



Synthetic sorbents normally show a greater capacity for the retention of oil and may be obtained in a variety of forms, including booms, pads, and sheets.

They normally have retention of up to 20 times oil to 1 times the weight of the sorbent. For recovery, the weight of an oil-soaked boom can be 20 times heavier.

Some absorbents may have been treated with oleophilic agents, or by controlled heating, to achieve an improvement in the capacity of the material to take up pollutant and to enhance its preference for picking up oil and rejecting water.

In shoreline clean-up the use of sorbents is often most appropriate during the final stages of the clean-up to aid in the removal of films and trapped pockets of oil in hollows and holes in rocks which are difficult to remove by other methods.

All synthetic sorbents must be recovered whereas natural ones can be left as long as they are not oil-contaminated.

It is important that synthetic granular sorbents are only used where they can be easily recovered. On windy days this can be difficult.

Booms and pads are simple to use and usually easily recovered. Because of this they are preferable to granular sorbents. Booms and pads are usually coloured blue or white and, when the wind catches them they can be blown all over the place. Retrieval can be time consuming and if not recovered they result in unwanted and unsightly waste.

The efficiency of sorbents depends on the type of material used in its make-up and the surface characteristics of the material.

Weathered oils and heavy fuel oils tend to adhere to the surface of absorbents rather than rather than being absorbed into the material. When you cut the boom open you find the outside black but the inside still clean. Even though they do not absorb heavy oils they can be very useful as a floating barrier to keep the oil from spreading.

Adsorbents

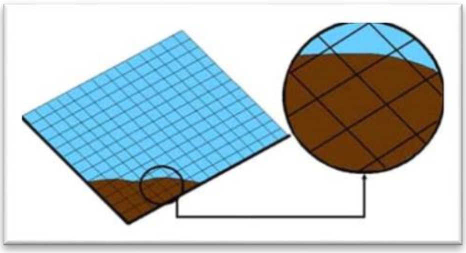
Oil sticks to the surface of adsorbent materials rather than being absorbed into it.

A different type of synthetic is required for this type of oil recovery, usually known as pompoms or oil snags. They consist of fine polypropylene fibres tied together to form pompoms. Multiple pompoms are sometimes attached to a rope for deployment or they can be used on their own. The multiple strands of polypropylene present a huge surface area for heavy oils to adhere to.

Thin strips of polypropylene can be tied together in balls and used for the recovery of heavy or emulsified oils; they are excellent for recovering oil caught in holes.

When used separately and allowed to escape can get into skimmer intakes causing pumps to stop.

They are also manufactured attached to ropes and used in shorelines in inter-tidal areas in much the same way as absorbents.



The greatest risk of negative impact on species arises from the possibility of ingestion and suffocation because of the nature of these materials, especially granulated absorbents. Generally, synthetic absorbents take more time or hardly degrade at all in the environment.

There are times, often in small ports or harbours, where small quantities of diesel are spilled from, for example, fishing boats. In such cases the use of absorbent boom or pads can provide all that is necessary to effect clean-up of the spill.

In some countries absorbent booms are used as a first response to all spills and very large quantities are used, raising the cost of the clean-up dramatically. In such cases, the use of booms and skimmers would have allowed recovery of oil/water residues which are much easier to dispose of. Instead, a sorbent-only approach results in tonnes of dirty absorbent boom which cost a fortune to purchase and will now will now cost a fortune to dispose of.

Insurance companies will only pay for reasonable expenditure.

"Frogmat" or Straw Carpet

This is a system invented by an eccentric Englishman called Ken Frogbrook and made from straw in a plastic net. It could be manufactured on sites using a huge machine where there was plenty straw available.

It was produced in long lengths of about 30 meters. The problem was that, having picked up oil and water, it became a seriously heavy object - A major problem to recover without it splitting and spilling its contents everywhere.

The "Frogmat" can be used as an access path to reduce damage and secondary pollution caused by people walking and tracking oil over shoreline terrain. It worked very well for this type of job.

This product got the backing of people like the actress Joanna Lumley who wanted to save the world at the time.

The "Frogmat" path was used in Shetland during the oil spill from MV Braer. Shortly after this she wanted to send the machine to Northern Russia for the Komi spill. Unfortunately there is very little straw available in either location.

Cutting vegetation

The cutting of plants covered with oil to less than 3cm above the sediment is a cleanup technique that results in direct physical destruction of the plant fibers.

This severely reduces the quantity of photosynthesizing tissue, except for in marshes during the time that the aerial portion of the plants dies to sprout again.

At the time of the cut, plants are more exposed to the toxic substances in the oil, increasing contamination and reducing immunity.

Cutting at the base of a plant increases penetration of the oil into the substrate, in addition to killing the plant itself. Areas where the plants are removed or trampled are also susceptible to erosion.

De-oiling Agents

The use of these materials should have the approval of the environmental authorities.

The technique has the objective of increasing the efficiency of the removal of the oil from contaminated substrates.

De-oiling agents, such as d'limonenes, act as solubilisers, breaking the adhesion of oil to substrates so that it can be easily be removed by hosing with water.

Some de-oiling agents are slightly toxic, but the main problem is that liberated oil (and de-oiling agent) can re-pollute if not contained and collected. Use of sorbents is often the most practical way to recover the liberated oil.

An advantage of the technique is that the wash-down process can be carried out in an effective way using water at a reduced pressure and hot water is not required.

Other de-oiling products such as oil spill dispersants work in a different way, dispersing the oil into surrounding seawater or assisting removal by sea energy as the tide comes in.

If the de-oiling product does not disperse the oil in the column of water, the liberated oil should be recovered from the surface of the water with sorbent booms.

The use of these clean-up techniques should be restricted in areas of high biological sensitivity.

The toxicity and the effects of the dispersal of the treated oil vary widely among the products. The selection of a product should always take into consideration its toxicity.

Many of these products have certificates of biodegradability and have reduced toxicological effects on organisms.

Oil spill dispersants applied on shorelines can sometimes increase the penetration of oil into the sediments or contaminate intact areas in the inter-tidal zone. Expert advice should be sought.

There is also evidence that dispersed oil has varying degrees of toxicity for plants.

According to the mixture, type of oil and dispersant, the problem of the application of dispersants occurs because often there is the bio-availability of the oil at the time of application.

Chemicals can be important in small clean-ups in littoral fringes in combination with low-pressure flushing but in general their use is not recommended. Chemicals alone are not efficient with emulsified oils or very viscous oils.

There is a need to perform experiments to test the toxicity and the efficiency of the different de-oiling chemicals available for the various types of oil that are transported along our coasts.

There are many de-oiling chemicals on the market made from oranges and lemons. They smell nice but in many cases quite large quantities have to be used to get better results than high pressure water jetting.

Gelling agents

Gelling agents transform the oil from the liquid state to a solid state. Polymers are applied at a rate of 10% to 45%, and can solidify the oil in minutes.

Unfortunately they tend to work considerably better in the laboratory than they do at the spill site.

In confined areas the use of gelling agents can impede the penetration of oil into cracks in the rocks, sediments and can reduce spreading.

Sometimes the oil will not completely solidify, unless the product is well mixed with the oil. Generally it is not used with very viscous oils.

These products are insoluble and have very low toxicity in the aquatic media. The oil that solidifies and is not recovered could have a longer impact because of the slower rates of weathering.

Physical disturbance of the habitat is very probable during application and recovery.

If the product is well applied there could be a reduction in the volume of water recovered during the operation and the solidified residues could be transported more easily.

Some countries accept disposal in sanitary landfills.

Mechanical removal

Mechanical removal is a method often employed on sandy coasts, on which the contamination is extensive and penetration is not very deep.

Normally, teams of beach cleaning personnel are deployed to remove the surface layer of contaminated oil. The thickness of the layer to be removed should never be thicker than the depth of penetration by the oil.

The sand contaminated with oil should be removed manually. We should be careful not to remove sand unnecessarily, because this increases the problem of waste disposal and can have an adverse effect on the properties of the beach.

The rapid removal of sediment is justified when short-term considerations are present, such as the need to clean a fishing beach or a beach with tourist activities or for the importance of re-establishing socio-economic activities.

Another consideration we should make is in reference to the constructive cycles of the beach. If at the time of the spill, a constructive period is underway, burial of contaminated sediments may take place and rapid oil removal may be considered.

Heavy vehicles can cause compaction of the sediment, causing the death of countless organisms due to crushing.

The movement of vehicles should preferentially be restricted to the driest part of the sand (Supra littoral). Routes used for vehicular access to beaches should be strictly controlled to minimize damage to dune systems and vegetation.

Bear in mind that in past incidents mountains of waste have been generated using heavy machinery, anything up to 30 times more beach material than oil. Imagine an impacted shoreline with 50,000m^3 of oil, this could become 1.5 million m^3 of oily waste.

Beach cleaning machines

These machines come in various sizes and can be very effective for the removal of tar balls especially on long stretches of beach.

Some types of beach cleaning machines take a “cut” of the beach surface and take this up on a moving conveyor screen.

Generally the systems work with revolving or agitating steel screens with differing hole diameters. When the sand and tar balls are picked up the clean sand is returned by gravity to the beach and the tar balls and any other rubbish are held inside.

When full it is towed to an area where it is emptied and contents are separated before final disposal.

Now let’s look at a beach cleaning option used during the Deepwater Horizon spill. Instead of using the machines which collect the tar balls and debris, sift the sand and replace it where it was we remove the sand with a few tar balls but wash it before replacing it, not always in the same place.

Intensive washing of sand removes any life (yes it is clean but it is also dead) and may suffocate life on the shoreline which it covers. This may take longer to recover.

Reworking sediment

Sometimes we have the opportunity to transport the sediment to a surf zone of the beach, so that with the rise of the tide, together with force of the breaking waves, a natural washing of the sediments takes place.

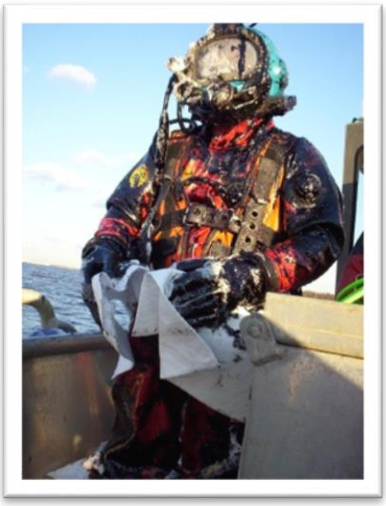
This technique is more appropriate for sand with a larger grain size or gravel that is lightly contaminated.

This technique also results in greater aeration of the sediment, besides mixing the sediment with the subsurface.

This movement of sediment is generally done with tractors and causes the compaction of the sediment, and the possibility of burying some organisms.

This movement of contaminated sediments can result in oil films on the water. This reworking can expose some organisms and have an adverse influence on their survival.

Sunken oil



Divers were used during a spill of heavy fuel oil from the barge Morris J Berman to remove the oil from the bottom. They used an air lift which is a pipe with compressed air entering near the bottom. Air rises in the pipe causing a reduction in pressure and thus lifting the oil to the surface.

In clear water work can be controlled to lift oil with the minimum possible amount of sediment.

In high sediment water where a diver has visibility of only a few centimeters this type of work is impossible, also in areas with currents in excess of 2 – 3 knots where the force of the current will make it impossible for the diver to remain on location.

If the current is too strong work can only be carried out during slack tide. In some cases this will only allow work for less than 20 minutes in every 6 hours.

The depth of water where the spill occurred is of critical importance.

If decompression operation is necessary a diver will need to be perfectly clean when going into a decompression chamber and breathing in part pure oxygen. We have known since the second world war that grease, oil and oxygen under pressure can explode very readily.

When oil sinks, we have few resources for its removal in this type of environment.

Dredging the bottom is capable of removing contaminated sediment but is not a selective technique and can cause a lot of damage to the biological community that has already been affected by the oil.

A large part of the biological community may be removed together with the sediment, for this reason dredging should generally be avoided.

In sheltered locations contaminated sub-sea environments can take a long time to return to a healthy state. Dredging in such situations may be considered. The contaminated sediment could be removed, enhancing possibilities for recovery and biological repopulation.

Sub-sea deposition of oil created a huge problem along the Lebanese coast after Israel bombed the Jiyyeh power plant in the war of 2006 spilling 25,000M^3 of heavy fuel oil.

The photo on left show a dredging operation after the 2013 Kalamazoo River oil spill in Michigan, USA.

Note from editor – In recent times R&D work has been carried out by the US Coast Guard to evaluate new techniques for sub-sea oil recovery. One example is a manned submarine-mounted suction system developed by Marine Pollution Control in Detroit, USA. Interested readers may also find the following links to API publications useful –

http://www.oilspillprevention.org/~/media/Oil-Spill-Prevention/spillprevention/r-and-d/inland/sunken-oil-ops-guide.pdf (large file will take a few minutes to download)

http://www.oilspillprevention.org/~/media/Oil-Spill-Prevention/spillprevention/r-and-d/inland/sunken-oil-technical-report-pp2.pdf

Natural clean-up

Wave action can be very effective currents and tides efficiently remove hydrocarbons from the coastal regions. [Photograph Clark Little]

Many techniques promote additional damage to the community being cleaned. Often, doing nothing, and allowing the environment to recover naturally, is the best procedure in terms of the environment.

For example, on rocky coastlines and areas of bluffs exposed to the action of waves, one should give priority to natural recovery.

In the *Braer* case (Shetland Isles UK), despite the large volume of oil spilled, the environment was only slightly affected by the oil. Natural clean-up was shown to be very efficient in this case involving a very light crude oil and severe storm weather conditions.

The oil in this case was a very light crude but the weather was close to hurricane force, this turned out to be the biggest natural dispersal demonstration to date, with some 84,000 tonnes of crude dispersed in less than two weeks.

But traces were later found in the sediments some 150 miles to the south near Fair Isle.

It is clear that the natural process of degradation by means of exposure to weather conditions can eliminate the oil rapidly in some coastal areas and that recovery may be completed in a few years depending on the viscosity of the oil.

However, the clean-up response should aim to significantly reduce the recovery time for the environment, so that economic and tourist concerns and, principally, worries about the effects on the wildlife can be minimised and problems resulting from complaints and claims from the affected parties can be reduced or avoided.

The choice of the available techniques and their application should be made very carefully, so that impacts are minimised.

In general terms, less sensitive coasts are those with greater potential for natural recovery such as areas heavily exposed to waves. These areas generally do not get cleaned up due to the danger to human life and it is probable that they will not suffer any long-term damage.

The sheltered coastal areas are more sensitive to oil spills and also are more sensitive to damage from some clean-up measures. To this end we try to work together to find the least damaging solutions to the environmental problem.

With all shoreline clean-up operations there is often a conflict between what people want done and what can be done. We have to concentrate on doing the best we can for the environment and the local population. This can lead to conflicts, some can be resolved and others cannot. Nothing is perfect.

Coastal areas also vary greatly in their value, whether in economic, recreational, educational terms or for conservation, and in their role in the marine ecosystem. Some of these environments deserve a considerable effort in terms of protection from oil spills. Due to great variability in sensitivity, potential and importance of their recuperation, it is essential that contingency plans are sufficiently flexible in order to structure response mechanisms and tailor them to the special conditions of each coastal region.

Burning in-situ

In some countries burning of debris on beaches before the oil arrived has dramatically reduced the amount of contaminated waste that would have had to be removed.

Such operations should be monitored in order to minimize the destruction of roots and reduce penetration of the oil deeper into the sediment.

Cutting only the superficial portions of plants impregnated with oil and preserving the rest of their structure will usually minimise longer term impacts on the plants.

The burning of oil and oily residues at the site itself should only be done if it is allowed by the relevant environmental authority.

Several factors influence the decision-making process for burning, such as the time of year, the type of vegetation, the plentifulness of the species and the level of water in the area.

In the event that burning is necessary, it should be carried out in a controlled location where there is no possibilities of creating an explosion.

Oils and residues with more than 30% of water are very difficult to burn. Heavier oils will sustain the burn but lighter oil will be needed to help with ignition. At the end of the process, there will be a small amount of residue that may require disposal

The heat produced by the burning has an impact on underlying sediment due to the increase in temperature, reducing its biological productivity.

In humid areas, the effect of the radiated heat is minimised. Another impact that should be condidered is the black smoke caused by the lack of sufficient oxygen in relation to the size of the fire.

Burning is sometimes an effective method of removing oil and contaminated vegetation of marshes allowing avoidance of damage from trampling.

Spartina marshes can resist an occasional burn. During the winter the aerial part of the plant dries out, but provided that the root system is not damaged the plants will recover and sprout again in the spring.

During the non-growing period the burn may be made without adversely affecting the sub-surface portion of the plant and can stimulate its re-sprouting. However, burning is not recommended during any other season.

[Note from Editor: ISCO members can find more detailed information about in-situ burning in an article by Dr Merv Fingas in the members' area of the ISCO website at www.spillcontrol.org . After logging in, look under "Technical & Reference" and select "Technical Articles"]

Example of an in-situ burn

Photos above - Empire Terminal after Katrina. Left during the burn approx. 90% of the oil burned and right 5 months after the burn

The marsh area was in its winter stage. Obviously there is a short term problem with air quality but the amount of damage that would have been cause by manual cleanup in the area would have caused much more damage to the marsh.

Careful consideration of Net Environmental Benefit is always made in these cases before any decisions are made.

[Note from Editor: A relevant and very interesting case history is available from NOAA. Click on the link below - https://usresponserestoration.wordpress.com/2015/08/25/10-years-after-being-hit-by-hurricane-katrina-seeing-an-oiled-marsh-at-the-center-of-an-experiment-in-oil-cleanup/]

Bio-remediation versus bio-augmentation

Bioremediation consists of the application of oil-degrading bacteria and/or nutrients to increase the natural biological breakdown of the oil.

This technique has generated considerable interest for more than two decades. It is not satisfactory for the use in large volumes of oil, but it is very useful during final clean-up and in the recuperation of degraded environments.

The addition of nutrients, nitrogen, phosphorus and potassium (NPK) are often necessary in order to stimulate the growth of the microbes.

This technique has great potential for the recuperation of contaminated environments.

When the concentration of hydrocarbons is above 10,000 mg/kg, biodegradation shows good results.

It is also necessary to have, in large quantities, the presence of interstitial air and oxygen. The nutrients will accelerate the growth of the bacteria that decompose the oil.

Spill site March 1999 Spill site July 1999 Spill site August 2000

This series of photographs show how well bioremediation works for inland oil spill sites, it is much more difficult on shorelines.

In the event the contaminated soil is in the subsurface, the bioremediation agent can be diluted in water for later irrigation of the contaminated environment.

The furrowing of the sediment facilitates the mixing. Packages of bioremediation agents generally have instructions for application.

Bioremediation agents may be applied to any type of coastal environment where access is permitted and the nutrients of the soil are deficient.

They are most effective in medium and combustible crude oils. The presence of asphaltenes tends to inhibit rapid biodegradation.

They also have little effect in the presence of light hydrocarbons, because these compounds evaporate quickly from the contaminated environment.

Some compounds, such as ammonia, may be toxic to the aquatic environment.

Their use in mangrove areas may alter the equilibrium of the system, causing an excess of nutrients and resulting in adverse effects on the environment.

After the application of the bioremediation agents, the environments should be regularly monitored.

Bio-augmentation consists of the application of bacteria to the environment to increase the natural degradation of the oil.

Research and experiments during oil spills show that the addition of cultures of specialised bacteria has little or no effect. These organisms generally develop very well in laboratories, but in the field the results have not proven to be satisfactory.

These bacteria do not develop rapidly due to the competition between the autochthonous bacteria that are much better adapted to the conditions of the local medium.

Not learning from the past

The main aim of an oil spill cleanup is to reduce the amount of damage done to the environment.

Back in the late 1960's when the first of major oil spills occurred from a tankers of over 100,000 tones up until the late 1980's, humans generally did not have the same thought for the environment that we have today.

Here are a few points where it seems some people do not read case histories and just make the same mistakes all over again.

Areas like this salt marsh in Northern France (left) were damaged in some cases beyond repair due to access by vehicles.

The plants that were destroyed left areas for invasive plant species to grow where they had never been before thus changing forever this area.

These days, if it is deemed necessary to use machinery in such areas there is a need to take care to cause the least damage.

This type of material (right) can be used. It is based on a military design which needed to be quick, easy and effective. It spreads the weight of vehicles and is later removed and taken to the next location.

Extreme actions are sometimes necessary, especially if you have a spill of 225,000 tonnes on the shoreline as in this case.

Enormous amounts of oily waste were often generated which took years to resolve but at the time people had little knowledge of the damage they were doing and were under pressure to be seen to be tackling the problem as quickly as possible.

Over the years we have learned techniques to reduce the amount of beach material removed and therefore the time and cost of the operation.

This photo (below) was taken during the Deepwater Horizon response showing that some of the lessons were not learned, or if they were they had, were not remembered.

Here you see excavators piling up sand whereas in the foreground you can see that there are just a few small tar balls.

I am sure the sand tonnage figures made another world record as they would have amounted to considerably more than 30 times the amount of sand to oil.

We have discussed the problems of cleaning manmade barriers such as riprap. The oil gets in between the concrete or rocks and takes a long time to come out.

Below (left) we have a bulldozer building a berm to stop to oil affecting the whole tidal area of the shore.

Here are 3 points to think about.

1. The action is making access to the oil much more difficult.

2. The sand will mix with the oil as it collapses with each high tide.

3. Was it necessary for the rocks to be mixed in too?

Now instead of just removing the oil the whole contaminated mixture will have to be treated.

We have used beach cleaning machines for years for removing tar balls. In some case there is a need to modify the screen in order to recover very small tar balls.

These machines are used daily around the world to remove the rubbish tourists leave behind. They pick up the rubbish and drop the sand where it came from.

There are other machines that pick up both tar balls and sand, inevitably mixing them together then dumping it in a heap for another machine to pick it up transport it to another location where it will be separated.

Unless there is a rigid system in place to record exactly where the sand came from it will not be put back in the right place.

Sand grains differ greatly in size from beach to beach and from the front to the back of a beach.

If sand from one beach is put on another it can cause local erosion.

This unit (below left) is powered by two diesel generators and a 4 million Btu propane boiler is used to heat water.

A wash takes 20 minutes and in an hour the unit can process 50 tons of sand to a sterile state. It covers an area 1/3 of a football pitch.

Of course this is not a mobile system and so all the sand from the area has to be transported to the processing site, greatly increasing the cost of the operation.

Big is not always best!

Washing sand until it is “really white” causes other problems.

Sandy shores have life in them, especially when close to the sea, Placing tonnes of clean white sterile sand back where it came from kills the life forms that survived both the oil and the clean-up.

Another system used in the past employed units that could be located on the beach to clean sand with high pressure sea water.

This may have been slightly slower but it did replace the material in the correct area and the marine life was not cooked.

Systems of this type (right) could be dismantled and reloaded on a truck for transport to the next location.

In another case oiled sand was washed 5 years after an oil spill. It could not be replaced on the shoreline but instead was used for construction work within a refinery.

The picture (left) shows oiled sand after 1, 2 and 3 washes.

This said, the judicious use of machines on beaches has a useful role and can often be used in support of manual operations.

This photo (below) that was titled "shoreline cleanup" could also be classed as "construction or destruction".

Take note of what was been done in the past that worked well and what did more damage than was necessary.

Remember that we are trying to remove the oil and to do the least amount of damage to an already damaged environment.

The less the damage done, the faster the environment will recover.
