SELECTION AND USE OF SHORELINE TREATMENT ENDPOINTS FOR OIL SPILL RESPONSE

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ABSTRACT

Shoreline treatment or shoreline cleanup endpoints are specific criteria assigned to a segment or unit of oiled shoreline or river bank that are used to define when sufficient treatment effort has been completed for that segment or unit. In effect, the endpoints are the practical definition of 'clean' for that particular segment of shoreline in that particular spill. The selection of appropriate and practical end points is part of the net environmental benefit evaluation in the decision process that is conducted during the development of the shoreline treatment plan. Endpoints affect the selection of response strategies and tactics, provide a target for the operations team, and are a standard against which the achievement of treatment can be compared so that closure can be achieved. This paper addresses endpoints in the context of the oiled-shoreline treatment decision process. The concepts and principles involved in the selection of endpoint criteria and measurement techniques are described. Explanations and examples are provided that can be used as a framework to guide and structure this vital element of the decision-making process. Three fundamentally different approaches to define and measure endpoints are identified; these being based on (a) analytical measurements, (b) judgements of impact assessment or (c) visual field measurements of the quantity and nature of oil. A step-wise guide is presented that can be used as a tool to assist in the selection of descriptors and phasing for endpoints based on qualitative/quantitative field observations using SCAT (Shoreline Cleanup Assessment Team) terminology.

INTRODUCTION

Establishing treatment endpoints for an oil spill response is an important and integral part of the management decision-making process, operational response, and completion of treatment. The determination of an appropriate endpoint standard has, on occasion, been a difficult and controversial task and many discussions have revolved around the question "how clean is clean?" Nevertheless, whether purposely, by default, or through neglect, decisions to establish endpoint standards have been made on every spill to date. Once defined, the endpoint itself is achieved by human intervention (treatment) techniques or by allowing natural cleaning or attenuation processes to alter and remove the oil without intervention. The question of when to end a response operation is pivotal at the outset of a response as this determines the level of effort required by the operations personnel.

The issue of cleanup effort and cleanup standards has been discussed frequently and notably in recent years by Baker (1997), Dicks et al., (2002), Michel and Benggio (1999), Tebeau (1995), and the US Coast Guard (USCG, 2002) among others. Although a number of discussion papers, philosophical frameworks, and simple endpoint summaries have been prepared, there are no existing national or international treatment criteria and standards or any agency-specific procedures that provide sufficient detail to have broad application. Owens and Sergy (2003) concluded that it is not feasible to have a single, detailed decision-making methodology for endpoints that is relatively simple and practical, yet comprehensive and universally applicable. As the circumstances of each spill are different, the endpoints must meet the specific conditions of the event. Nevertheless, there are fundamental generic concepts, principles and directions that can be applied, as well as explanations and examples that can be used as a framework for this vital decision-making process. Such reference information has been recently presented by Environment Canada (Sergy and Owens 2007) in order to provide guidance to those tasked to select or measure treatment endpoints for oiled shorelines. Those materials, concepts and principles are presented herein.

DEFINITION OF ENDPOINTS

Shoreline treatment or shoreline cleanup[1] endpoints are defined by Sergy and Owens (2007) as specific criteria assigned to a segment[2] or unit of oiled shoreline that stipulate when sufficient treatment effort has been completed for that segment or unit. In effect, the endpoints are the practical definition of 'clean'[3] for that particular segment of shoreline in that particular spill. The endpoints are a standard against which treatment activities can be evaluated. 'Clean' has been achieved when the pre-defined endpoints have been attained and the specified treatment of that segment of oiled shoreline has reached the agreed objective or goal.

PURPOSE OF ENDPOINTS

The primary reasons for assigning shoreline treatment endpoints are to:

- assist the spill management team in selecting treatment objectives and techniques for a specified area or segment of shoreline before the response operation begins;
- provide Operations supervisors with a clear objective or target so they can tailor their activities towards a known point of completion; and
- provide an inspection team with criteria and standards with which to evaluate the condition of the shoreline and the results of the treatment activities with respect to the response objectives.

Other important benefits of developing endpoints are to:

- facilitate recognition and assessment of the various environmental, social, and economic factors that should be considered in the shoreline treatment decision-making process and assist in selecting appropriate and practical response options; and
- facilitate recognition of the concerns of the various responsible parties and stakeholders and attempt to create a consensus between them. An effective and successful response is far more likely when all parties share the same expectation of what must be accomplished.

GENERAL METHODS FOR MEASURING ENDPOINTS

Treatment endpoints are grouped into the following categories based on the approach or methodology that is used.

1. Qualitative Field Observations are used to describe the presence or absence of stranded oil and/or the character of such oil, e.g., no observed oil (NOO), no mobile oil, no oiled debris, or no rainbow sheens. The determination of this type of endpoint is relatively easy and rapid with a simple descriptive output. Direct observations can be supplemented with still or videotape camera images taken from the air or on the ground. Qualitative field observations have been used at many spills and are common components of the chosen set of endpoints. Instructions on setting endpoints based on qualitative field observations are provided later in this paper.

2. Quantitative Field Measurements and Observations are based on visual measurements and observations of the quantity of oil. These methods have been widely used in many response operations. Measurements taken include one or more numerical standards, such as the extent of the oiled area, the percentage of surface oil distribution, oil coverage, oil thickness, and oil volume. Sometimes the standards are also keyed to the type of oil or a specific location. This visual measurement approach is a rapid and straightforward procedure with simple descriptive and numerical outputs that provide clear guidelines and targets for operations field supervisors. The measurement standards and terminology are often the same as those typically used in the Shoreline Cleanup Assessment Technique (SCAT) process (Owens and Sergy, 2000; 2004). Instructions on setting endpoints based on quantitative field measurements and observations are provided later in this paper.

3. Analytical Measurement Methods typically require the collection of representative field samples of various media and subsequent analysis using instruments in a laboratory. Analytical measurement approaches to endpoints include (a) chemical analyses for measuring the concentration of oil or specific chemicals, (b) toxicological analyses for measuring the response of test organisms to toxic effects, and (c) organoleptic analyses to determine human detection of offensive odours. In addition to laboratory analysis, a limited selection of field analytical tools can be used to measure endpoints. Although not common, analytical measurement methods can play a role in specific or unusual circumstances. Most analytical criteria, however, have been developed as health standards related to chronic issues rather than to acute ones. The analytical approach is often impractical in terms of collecting representative samples and generating results in a timely manner in order to evaluate whether the endpoints are met. Further details on the use of endpoints based on analytical measurement methods are described in Owens and Sergy (2003).

4. Interpretive Impact Assessment Methods develop treatment endpoints based on an evaluation of system impacts. These methods can include environmental, social, economic, and/or cultural factors (Dicks *et al*. 2002). The approach can vary greatly in complexity. At one level it can involve a detailed, multi-factor synthesis using a combination of qualitative, quantitative, and/or descriptive indicators and can use techniques similar to those applied for environmental impact assessment studies. On the other hand, it can be a subjective judgement call against a simple criterion based on the evaluator's own experience. The method is basically one of interpretative assessment rather than quantitative measurement and it therefore has the greatest degree of personal subjectivity. Further details on the use of impact assessment endpoints are provided later in this paper.

Endpoints based on qualitative and/or quantitative field measurements are recommended as a first option. This approach has been used on many spills and is suitable for almost all spills.

There are less common scenarios, for example in wetlands, where some type of impact assessment method is required or preferred. It is recommended, whenever feasible, to keep the process relatively simple with clear principles.

1 The terms 'treatment' and 'cleanup' refer to the method or technique by which the objective will be met. Although the two terms are often used interchangeably, treatment is commonly interpreted as the broader range of response options, and includes natural recovery without human intervention. On the other hand, if response crews physically remove oil from the site, this is clearly a cleanup tactic.

2 'Segments' are distinct alongshore sections of shoreline that can be used as operational units, and within which the shoreline character is relatively homogeneous in physical features and types of sediment. Segments are bounded by prominent geological or operational features, or by changes in shoreline type, substrate, or oiling conditions. See "The SCAT Manual" (Owens and Sergy, 2000) for further discussion on this topic.

3 There is no consensus in defining the term 'clean' or the concept of 'how clean is clean' (Baker, 1997). As a working definition, 'clean' is defined by the treatment endpoints, which are in turn set by the treatment objectives.

THE ENDPOINT DECISION PROCESS

The framework and fundamentals of the shoreline oil spill decision process is described in Owens and Sergy (2008). Although this process typically involves a range of decisions and actions, the components can be broadly organized and addressed in a logical and sequential order. Endpoints should be set early in the process, as part of the planned response phase which defines the treatment objectives (Figure 1). These criteria lay the groundwork for the selection of treatment tactics and development of the shoreline treatment plan. It is critical that operational end points be established quickly as these targets determine the level of operational effort in the response.

Establishing treatment endpoints is usually a joint decision made by the spill management team and the responsible government agencies, with input from the responsible party when the spill is from a known source. The mechanics of the process depend on the organization of the spill management team. Often the initial draft of treatment endpoints is prepared by the spill management team, at which point the broader group of stakeholders typically are brought into the decision-making process.

The process of determining an appropriate endpoint ranges from a relatively simple one to one that is difficult and complex and involves several rounds of negotiation. It often requires a compromise due to the wide range of factors that come into play and the varied interests of the national, regional, and local government agencies, political groups, the media, and the local population that live in or use the affected area. Despite this, endpoints must be established for every spill, either generically or for individual segments.

The selection of endpoints is influenced by a variety of issues and criteria. These include:

- the type of shoreline, i.e., bedrock, sea walls, sand beaches, wetlands, or marshes;
- the value of the habitat or use of the segment and the timing of that use, i.e., wildlife refuge, residential area, industrial area, seal haul-out, park, or remote area;
- operational feasibility, i.e., access, staging, resources and effectiveness of techniques;
- the degree and type of oiling;
- the Net Environmental Benefit of treatment;
- the anticipated rate of natural cleaning; and
- environmental influences such as weather and sea states.

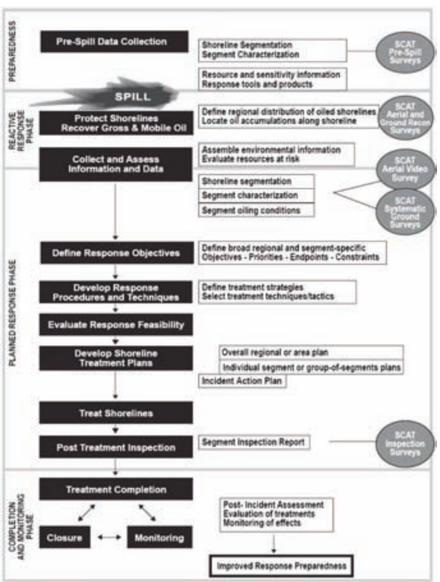

FIGURE 1 THE SHORELINE OIL SPILL DECISION PROCESS (SERGY AND OWENS, 2007)

BASIC PRINCIPLES FOR ENDPOINT SPECIFICATION

Rules-of-Thumb

1. Shoreline treatment endpoints can be applied at different scales of coverage. Endpoints are most often set at three levels:
   (i) a universal scale, whereby certain endpoints apply to the entire affected spill area and all segments in the region must meet these minimum criteria;
   (ii) a cluster scale that applies endpoints to groupings of different types of habitats, shorelines, or land use;
   (iii) a detailed scale that describes specific endpoints for each individual shoreline segment or shoreline unit.
2. Different criteria and standards apply to different segments of shoreline.
3. Individual endpoints, even the same ones, can be applied to different environmental components, for example, to water, vegetation, surface and subsurface sediments, and intertidal zones, depending on variations in land use or the distribution of species. The endpoints for each segment can thus be further focused or compartmentalized within that segment.
4. Each shoreline segment or unit must ultimately have its own 'set' of endpoints, whether they are generic or unique. These endpoints can be a combination of different types of standards and they can apply to specific environmental components of that segment.
5. It is possible to have more than one 'set' of treatment endpoints within one shoreline segment when the treatment plan is based on the use of a number of sequential treatment actions or methods.
6. The practical requirements for completing the endpoint measurement must be taken into consideration, e.g., level of precision, level of effort, turnaround time, and safety issues.
7. There is no uniform or standard approach that can be applied universally. Treatment criteria and endpoints vary from one spill to another, depending on the unique features of the incident. Treatment criteria and endpoints also vary within a single response operation as impacts and risks are often not uniform within the affected area.
8. The endpoint definition must be concise, clear, and understandable as ambiguities could lead to misinterpretations in the field by operations and/or the inspection team.
9. Even with a clearly defined standard, the spill management team may still need to make a judgement call or reach a compromise.

Endpoint Modifiers

While caveats and operational constraints are often attached to treatment plans, they can also be attached to specific endpoints. Operational constraints typically involve factors related to treatment feasibility and safety. Caveats are typically related to environmental issues, e.g., "No visible (submerged) oil in reeds, unless further oil recovery dislodges new-growth reed shoots". Exclusion clauses can also be used, e.g., "No surface oil except ….".

Feedback between Decision-Makers and Operations

Those who develop and set treatment endpoints should work in cooperation with the shoreline treatment operations team, to validate both the value and the feasibility of the initial endpoint selection and to be responsive to adjustments if required. Despite having clear endpoints, sometimes the 'Lowest Practicable Level of Contamination' (LPLC) must be considered during treatment of shoreline types, e.g., when a divergence develops between the endpoint and the original objective of treatment due to logistics or when feasibility or safety factors prevent operations personnel from achieving the desired objective. This scenario would require a reassessment of the response objectives and endpoints as well as the response techniques.

CALIBRATION AND VISUALIZATION OF ENDPOINT DEFINITIONS

It is critical that ALL parties have the same understanding of endpoints and an appreciation of the anticipated appearance of the final treated shoreline. Those who will be measuring endpoints must have the ability and experience to make that determination. This includes those who conduct the post-treatment inspection survey, the planners, the operations team, the incident commander, the responsible party (if one is involved), and the landowners or managers.

Orientation, calibration, and/or training sessions should be planned and integrated into the response program particularly to:

- show stakeholders how the different shoreline endpoints appear visually;
- provide consistency between members of the post-treatment inspection survey and between those representing the interests of stakeholders and the responsible party; and
- provide operations, from the crew chief level upwards, with some appreciation of the issues, clear instructions on the endpoint(s) for each segment, and a reasonable level of skill to judge when the endpoint has been attained. The field crew chief must be skilled enough to guide and train the team to meet and not exceed the appropriate endpoints.

Examples of calibration and training tools include (a) textual descriptions of endpoints, (b) visual job aids, (c) actual/real samples of 'cleaned' beaches to match the various endpoints and serve as benchmarks for calibration and training, and (d) trial-run inspection surveys (these may be 'calibration exercises').

Exercising Judgement

The visual determination of an endpoint is not always straightforward despite the use of clear and simple definitions. In this regard, photographs or other graphic examples may be valuable. It may not be practical or feasible to strictly adhere to the absolute 'letter of the law'. A judgement call may be required for unforeseen circumstances, minor divergences of the endpoint definition or/and the amount of deviation that will be allowed or accepted. The inspection teams should be aware of the need to consider these discretionary actions during calibration runs.

THE ROAD TO COMPLETION

As a result of treatment activities or natural removal processes, at some point the conditions within each shoreline segment will approach or achieve the specific endpoints pre-established for that segment of shoreline. A process must be established to assess and verify whether this endpoint condition has been attained and to permit treatment operations either to demobilize for that location, to move elsewhere, or to proceed to the next stage of treatment. This process becomes a formal agreement or documented decision when a stage or phase in treatment is completed and the next stage can begin and eventually the process is completed. If endpoints have not been clearly defined before the treatment program, this process could become a contentious stage in the response.

A typical process would begin with a pre-assessment by monitors from the operations team and/or the management team environmental advisors to determine if the standard measure of 'clean', i.e., the endpoint, has been or is being attained. When operations provide notice that the endpoints have been achieved, a post-treatment inspection survey is typically conducted by the SCAT team and/or an inspection team. This inspection survey should represent the interests of both the responsible parties and stakeholders. This post-treatment inspection survey team evaluates either that:

- the endpoint criteria/treatment objectives have been met [this is sometimes referred to as the point when No Further Treatment (NFT) is required (Owens *et al.* 2005)]; or
- the endpoint criteria have not been met and recommendations are made as to where work is required and what needs to be done to pass inspection.

The survey team's observations and recommendations must be documented in some consistent format, (see examples in Owens et al. 2005; Sergy and Owens 2007). The team must be empowered to agree or disagree in the field that the endpoint has been reached using the pre-defined criteria. There must be a definition as to what constitutes team agreement and which members are involved in the decision, i.e., some may be observers only. If there is a minority position within the team or from outside stakeholders, then that position or viewpoint should be noted and steps taken to address legitimate concerns.

The process for formally terminating treatment for each segment varies with the organizational and command structure in place for the particular spill. In some cases, for example, the post-treatment inspection team may have the authority to make this decision in the field whereas in other cases they may provide a recommendation to the spill management team who would then approve the recommendation or conduct the final inspection. Note that treatment plans based on sequential treatment methods may require a phased inspection process to assess whether each stage of treatment, i.e., each set of endpoints, is complete.

Endpoints based on interpretive impact assessment methods - minimum regret strategies - vary from the procedure outlined above. In these cases, the cessation of treatment is a judgement call made by the treatment specialist or environmental monitor based on pre-defined indicators. Such a decision would typically be based on the premise that further treatment could cause unacceptable environmental damage.

Typically, segments are inspected and assigned an NFT status as they become eligible. During a large spill when significant time has passed between completion of operations and inspection, regulators should consider whether a follow-up inspection would be appropriate to ensure that shoreline conditions have not changed.

Events after 'No Further Treatment' Status is Reached

The inspection and spill management teams interpret the NFT concept to mean that endpoint criteria/treatment objectives have been met and that treatment operations on that segment can be demobilized. Practically speaking, demobilized operations eventually lead to a completion of the active response and treatment phase. If there is a lack of agreement or consensus, it is important to qualify and clarify unresolved issues at this step. These unresolved issues can be documented in the shoreline treatment plan, on the inspection report, or during the closure process.

The path from NFT to final closure may be direct or staged. The latter case usually involves a monitoring function to detect whether there is a change of conditions that would trigger re-assessment of treatment and alert the spill management team accordingly.

Post-treatment Monitoring Stage

As part of the SCAT and/or spill response program, repetitive shoreline monitoring surveys can provide a temporal picture of changes in oiling conditions. This monitoring may be part of the staged progress towards closure. Monitoring can be used to:

- document conditions where oil continues to wash ashore over an extended time period, e.g., chronic re-oiling such as from submerged oil;

- ensure that shoreline conditions in the segment remain acceptable and/or that the endpoints continue to be maintained, e.g., exposed shorelines are dramatically affected by seasonal processes, especially during the storm season, which may expose subsurface oil that had previously not been observed;
- assess changes in oiling conditions over time (days to months) that result from treatment and cleanup activities (by people) and/or natural self-cleaning processes, e.g., that self-cleaning meets the expectations on a particular segment;
- evaluate the effectiveness (performance and effects) of treatment decisions and options that were applied; and
- investigate environmental processes that affect the fate, behaviour, and effects of oil or of treatment methods.

The Re-oiling Predicament

The process of final inspection and approval is generally not implemented while mobile or potentially remobilized oil remains a threat. Understandably, it is difficult to conclude completion of treatment when further oiling is still possible. Re-oiling is likely to occur if not all surface slicks are contained yet. Some shoreline treatment operations or natural removal processes have the potential to remobilize stranded oil. In addition, the presence of submerged or sunken oil can present chronic and/or unexpected re-oiling scenarios.

Recurring oiling or re-oiling of a treated shoreline has occurred in several spills. In such cases, the process must be adjusted. A common compromise is an interim inspection or assessment that indicates to operations that the segment attained endpoint status at that time. This decision allows resources to be deployed to other sites and leaves a process in place for monitoring and recovering new oil on that segment. Final inspection and approval is not scheduled until it is demonstrated that there is no possibility of re-oiling or some agreement is reached to address the re-oiling scenario. As mentioned earlier, post-treatment monitoring of completed shorelines on a longer term may also be appropriate to check for unacceptable re-oiling.

STEP-BY-STEP GUIDE TO DEFINING ENDPOINTS BASED ON QUALITATIVE AND QUANTITATIVE FIELD OBSERVATIONS

The following guide can be used as a tool to assist in the selection of terms and descriptors, and phasing for endpoints based on qualitative/quantitative field observations using SCAT (Shoreline Cleanup Assessment Team) terminology (Owens and Sergy, 2000; 2004).

Endpoints Founded On Qualitative Field Observations

These are descriptive, non-numerical standards based on the presence or absence of oil with optional descriptors on character and/or behaviour and/or location of oil. A "yes/no" judgement on attainment of the endpoint is made by direct visual observations at ground level and/or aerial observations and/or photography.

- ➲ **Complete Step 1 and 2 below.**
- ➲ Repeat as many times as necessary to establish a set of endpoints.

Endpoints Founded On Quantitative Field Observations and Measurements

These numerical-descriptive endpoints are based on the presence of oil that exceeds specified conditions with regard to location, surface distribution, size/area, thickness, and character of the oil. One or more of the conditions are numerical. The conditions are identical to the standard terminology for describing oiling conditions in the SCAT approach. Note: As discussed in the SCAT references, the parameters 'distribution', 'width', and 'size' can be combined into categories to rate the degree of oiling, e.g., "heavy, moderate, light". This practice is NOT recommended for the purpose of setting endpoints.

- ➲ **Complete Step 1 + Step 2 + [Step 3 and/or Step 4 and/or Step 5]***.
- ➲ Repeat as required to complete a set of endpoints.

*Steps 3, 4, and 5 add the numerical criteria.

For Surface Oil, the endpoint definition would take a form similar to the following.

No Observed **Oil character** (at/on) **Location** with >
Step 1 *Step 2*
Thickness (and/or) **Distribution** (and/or) **Size**
Step 3 *Step 4* *Step 5*

- ➲ ***Step 1*** Describe oil character, for example: Oil • Fresh oil • Sticky oil • Mobile oil • Oil residue • Tar balls • Oiled debris
- ➲ ***Step 2*** Select a location, or combination of locations, to which this condition applies. For example;
  - all locations, i.e., applies everywhere in that segment,
  - or a specific shore zone, e.g., Lower intertidal zon • Mid-intertidal zone • Upper intertidal zone • Supratidal zone,
  - or a standard shoreline type, e.g., Bedrock platform ,
  - or type of habitat/use, e.g. mouth of stream used by anadromous fish,
  - or type of substrate, e.g., Rock • Unconsolidated • Boulder • Cobble • Pebble • Granule • Sand • Mud/silt/clay • Organic/Peat/Soil • Live Vegetation • Man-made solid • Man-made permeable,
  - or another user defined location, for example, stems or reeds.
- ➲ ***Step 3*** If applicable; select the maximum thickness of surface oil using standard SCAT definitions, e.g., Thick • Cover • Coat • Stain • Film.
- ➲ ***Step 4*** If applicable; select maximum surface oil distribution (% of surface covered by oil) using standard SCAT approach and terms.
- ➲ ***Step 5*** If applicable; specify the size of the area to which this condition applies in terms of along-shore length, and/or across-shore width, and/or diameter.

For Subsurface Oil, the endpoint definition would take a form similar to the following.

No Observed **Oil character** (at/on) **Location** with >
Step 1 *Step 2*
Depth/Thickness (and/or) **Size**
Step 3 *Step 4*

- ➲ ***Step 1*** Describe oil character/concentration using standard SCAT definitions, e.g. Oil • Oil-filled pores • Partially-filled pores • Cover • Coat • Stain Film • Trace

➲ ***Step 2*** Select location or combination of locations to which this condition applies. Follow the instructions for Step 2 of surface oil.

➲ ***Step 3*** If applicable; describe allowable conditions in terms of vertical distribution, or example the maximum depth of penetration or burial and/or maximum thickness of oiled lens.

➲ ***Step 4*** If applicable; specify the maximum area to which this condition applies in terms. Follow the instructions for Step 5 of surface oil.

Examples of Endpoints

Some examples of endpoints following the above process are listed below. Similar actual endpoints used at various spills can be found in Owens and Sergy (2003).

Examples of qualitative field observation endpoints:

- NO visible surface oil
- NO mobile oil
- NO sticky oil/oiled debris that could contact/effect wildlife
- NO oil on sand beaches in front of resorts
- NO oil in the mid- or upper intertidal zone
- NO recoverable floating oil

Examples of quantitative field observations endpoints:

- NO surface oil with > 50% coverage and >3 mm thick and 50 cm diameter in size
- NO oil >20% surface distribution and >10 m long on mixed sediment shorelines
- NO surface oil as 'cover' >1 m wide and >3 mm thick
- NOT more than 2 tar balls > 2 cm in diameter per $20m^2$
- NO oil over 0.01 cm thick and 30% coverage on bedrock
- NO oil on sand >5% distribution as 'stain'
- NO oil on >30% distribution of *Carex sp*.
- NO fresh or sticky oil on >10% of vegetation stems
- NO oil with >20% distribution as 'coat' on cobble fronting First Nation land
- NO subsurface oil >10 cm deep

Treatment Endpoints by Interpretive Impact Assessment

Interpretive Impact Assessment Methods develop treatment endpoints based on an evaluation of impacts or risk of impacts on the system. They can include environmental, social, economic, and/or cultural factors. Typically, this approach could address the following types of questions.

- Is the remaining oil likely to have an unacceptable ecological, aesthetic, recreational, or economic impact?
- Will further oil removal cause environmental damage?
- Are the costs of further cleanup or treatment excessive in relation to the threat or benefit?

The concept of using risk assessment to make go and stop decisions on oil spill treatment has been in place for decades. Different methods have been developed and applied, but all have a similar theme or intent.

Common terms that embody the concept include:

- As Low As Reasonably Practical (ALARP);
- Minimum regret strategy;
- Lowest Practicable Level of Contamination (LPLC);
- Net Environmental Benefit Analysis (NEBA).

The ALARP principle is that the residual risk shall be "as low as reasonably practicable". In the UK the equivalent phrase is "so far as reasonably practical" (SFARP). Both are regarded as best common practice of judgement in the evaluation of the balance of risk and benefit. LPLC is a legal term defined in Alaskan state law which requires that spillers clean up a discharge until the "lowest practicable level of contamination" is achieved. The State of Alaska determines the lowest practicable level of contamination based on several items including protection of human health, safety, and welfare, and of the environment; the nature and toxicity of the hazardous substance; the extent to which the substance has migrated or is likely to migrate; and the natural dispersion, attenuation, or degradation of contamination. NEBA is one of the better known impact assessment methods and has been well described by Baker (1995) and IPIECA (2000). The NEBA approach typically considers different levels of treatment or cleanup, i.e., concentrations of remaining oil, levels of cleanup effort, and environmental intrusion, and relates these to oiling conditions in the context of (a) potential risks to human health, (b) potential risks to activities related to human use, (c) environmental recovery rates, and (d) potential collateral or ancillary effects.

Whatever the name or method, an important and common constant is that interpretive impact assessment methods all are subject to personal judgement. The actual technique can vary greatly in detail and complexity. It can involve a detailed, multi-factor synthesis using a combination of qualitative, quantitative, and/or descriptive indicators and may use techniques similar to those in environmental impact risk assessment studies. On the other hand, it can be a subjective judgement call based on a simple criterion and the evaluator's own experience.

Using a Simplified Impact Assessment Endpoint

Although endpoints based on qualitative and/or quantitative field measurements are generally recommended as the first option, there are circumstances when some type of impact assessment method is required or preferred. It is recommended, whenever feasible, to keep the process relatively simple with clear principles. A simplified impact assessment endpoint determination could be used when:

- there is a concern that further treatment will cause unacceptable impact or damage over and above that of the oil;
- it is difficult to define those boundaries based on oil concentration/distribution measurements and/or precise textual or visual depictions;
- it is possible to isolate the indicator or simplify the decision, for example, "no visible submerged oil in reeds, unless further oil recovery dislodges unacceptable number of new-growth shoots".

It is usually environmental impact that is the issue of concern, with wetlands/marshes being the classic example. However, there can also be critical social, economic, or cultural concerns that trigger a situation-specific assessment.

Whatever the situation, the impact assessment endpoint is usually characterized as requiring:

1. a judgement call (a stop-cleanup decision) be made by an experienced assessor/technical specialist; and/or
2. relatively close monitoring during the treatment phase.

CONCLUSIONS

1. Shoreline treatment or shoreline cleanup endpoints are specific criteria assigned to a segment or unit of oiled shoreline that stipulate when sufficient treatment effort has been completed for that segment or unit.
2. Treatment endpoints are a highly important and integral element of an oil spill response. Endpoints:
   - affect the selection of response strategies and tactics;

- are a known point of completion a target - for the operations team; and
- are a standard against which the achievement of treatment can be compared so that closure can be achieved.

3. The selection of appropriate and practical end points is part of the net environmental benefit evaluation conducted early in the decision process and as part of the development of the shoreline treatment plan.
4. The endpoint selection process facilitates inclusion of the various environmental, social, and economic factors that should be considered in the shoreline treatment decision-making process and the concerns of the various responsible parties and stakeholders.
5. There are different approaches to define and measure endpoints based on based on (a) analytical measurements, (b) judgements of impact assessment or (c) visual field measurements of the quantity and nature of the oil using SCAT terminology.
6. Different approaches to define and measure endpoints have advantages and disadvantages for any given set of circumstances and may be used in some form or combination on the same response operation**.** Endpoints based on qualitative and/or quantitative field measurements are recommended as a first option. This approach has been used on many spills and is suitable for almost all spills.
7. Each shoreline segment or unit must ultimately have its own ‘set’ of endpoints, whether they are generic or unique. These endpoints can be a combination of different types of standards and they can apply to specific environmental components of that segment.
8. It is critical that all parties have the same understanding of endpoints and an appreciation of the anticipated appearance of the final treated shoreline.
9. A process must be established to assess and verify whether this endpoint condition has been attained and to permit treatment operations either to demobilize for that location, to move elsewhere, or to proceed to the next stage of treatment.

BIOGRAPHY

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REFERENCES

Baker, J.M., (1995). Net Environmental Benefit Analysis for Oil Spill Response. In *Proceedings International Oil Spill Conference,* American Petroleum Institute, Pub. No. 4620, Washington, DC, pp. 611–614.

Baker, J.M., (1997). Differences in Risk Perception: How Clean is Clean? Issue paper prepared for the *1997 International Oil Spill Conference*, American Petroleum Institute, Technical Report IOSC-006, Washington, DC, 52 p., 1997.

Dicks, B., H. Parker, K. Purnell, and R. Santner, (2002). Termination of Shoreline Cleanup - A Technical Perspective”. In *Proceedings of the Technical Lessons Learnt from the Erika Incident and Other Oil Spills,* CEDRE, Brest, 12 p.

IPIECA, (2000). Choosing Spill Response Options to Minimize Damage (NEBA). In *IPIECA Report Series*, Volume 10, International Petroleum Industry Environmental Conservation Association, London, UK, 20 p.

Michel, J. and B. Benggio, (1999). Guidelines for Selecting Appropriate Cleanup Endpoints at Oil Spills, In *Proceedings International Oil Spill Conference*, American Petroleum Institute, Publication Number 4686B, Washington, DC, 591-595.

Owens, E.H. and G.A. Sergy, (2000). *The SCAT Manual - A Field Guide to the Documentation and Description of Oiled Shorelines*, Second Edition, Environment Canada, Edmonton, AB, 108 p.

Owens, E.H. and G.A. Sergy, (2003). Treatment Criteria and Endpoint Standards for Oiled Shorelines and Riverbanks, Manuscript Report EE-171, Environmental Protection Service, Environment Canada, Ottawa, ON.

Owens, E.H. and G.A. Sergy, (2004). *The Arctic SCAT Manual: A Field Guide to the Documentation of Oiled Shorelines in Arctic Environments*, Environment Canada, Edmonton, AB, 172 p.

Owens, E.H., H.A. Parker-Hall, G.S. Mauseth, A. Graham, T. Allard, P.D. Reimer, J.W. Engles, S. Lehmann, J. Whitney, S. Penland, C. Williams, and C. Wooley, (2005). Shoreline and Surveillance Surveys on the *M/V Selendang Ayu* Spill Response, Unalaska Island, Alaska, *Proceedings of Twenty-eighth Arctic Marine Oilspill Program (AMOP) Technical Seminar*, Environment Canada, Ottawa, ON, pp. 509-525.

Owens, E.H. and Sergy, G.A. 2008. A Shoreline Response Decision-Making Process. *Proceedings International Oil Spill Conference,* American Petroleum Institute, Washington DC, *(this edition).*

Sergy, G.A. and E. H. Owens, (2007). Guidelines for Selecting Shoreline Treatment Endpoints for Oil Spill Response. Emergencies Science and Technology Division, Environment Canada, Ottawa, ON, 30 p.

Tebeau, P.A., (1995). Effectively Managing Level of Effort in Oil Spill Cleanup: Resolving the ‘How Clean is Clean’ Issue, In *Proceedings International Oil Spill Conference*, American Petroleum Institute, Publication Number 4620, Washington, DC, 663-666.

USCG, (2002). *Marine Safety Manual: Response - Oil Spill Response Policy and Operations: Response Operations: Patterns of Response*, United States Coast Guard, Vol. IX. Section 5.A.2.h.(3),Washington, DC, , 5-25.