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Guidelines on implementing spill impact mitigation assessment (SIMA)

A technical support document to accompany the IPIECA-IOGP guidance on net environmental benefit analysis (NEBA)

Oil spill preparedness

THE GLOBAL OIL AND GAS INDUSTRY ASSOCIATION FOR ENVIRONMENTAL AND SOCIAL ISSUES

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About this report

The term 'net environmental benefit analysis' and its acronym, NEBA, have been used extensively over the years. It describes a process used by the oil spill response community for guiding selection of the most appropriate response option(s) to minimize the overall impact of spills on the environment and other shared values. In 2015, IPIECA and IOGP jointly published a Good Practice Guide (GPG) that conceptually describes the incorporation of NEBA into oil spill response strategy development (IPIECA-IOGP, 2015a). In the wake of this publication, the development team felt that a more detailed 'how to' guideline was also required, and has cooperated with the American Petroleum Institute (API) to produce this report.

Concurrently, the oil and gas industry began a debate on the appropriate use of the acronym, NEBA. Given that the selection of the most appropriate response action(s) has in practice been guided by more than just environmental considerations, the industry is seeking to transition to a term that better reflects the process, its objectives, and the suite of shared values which shape the decision-making framework, including ecological, socio-economic and cultural aspects.

Industry has consulted directly with non-industry stakeholders who have expressed support for transitioning to a more appropriate term. The oil and gas industry is thus introducing the term 'spill impact mitigation assessment' (SIMA) as a replacement for NEBA. The industry recognizes that the transition from NEBA to SIMA will take some time, but believes that it is important to begin the process of more accurately describing this long-standing practice and its objectives. For the purposes of this document, all references to SIMA should be understood to mean NEBA in its broader context. At appropriate points in time, other publications will be updated to replace the term NEBA with SIMA. The aim is that other stakeholders will adopt a similar approach to institutionalize this more accurate and descriptive term over time.

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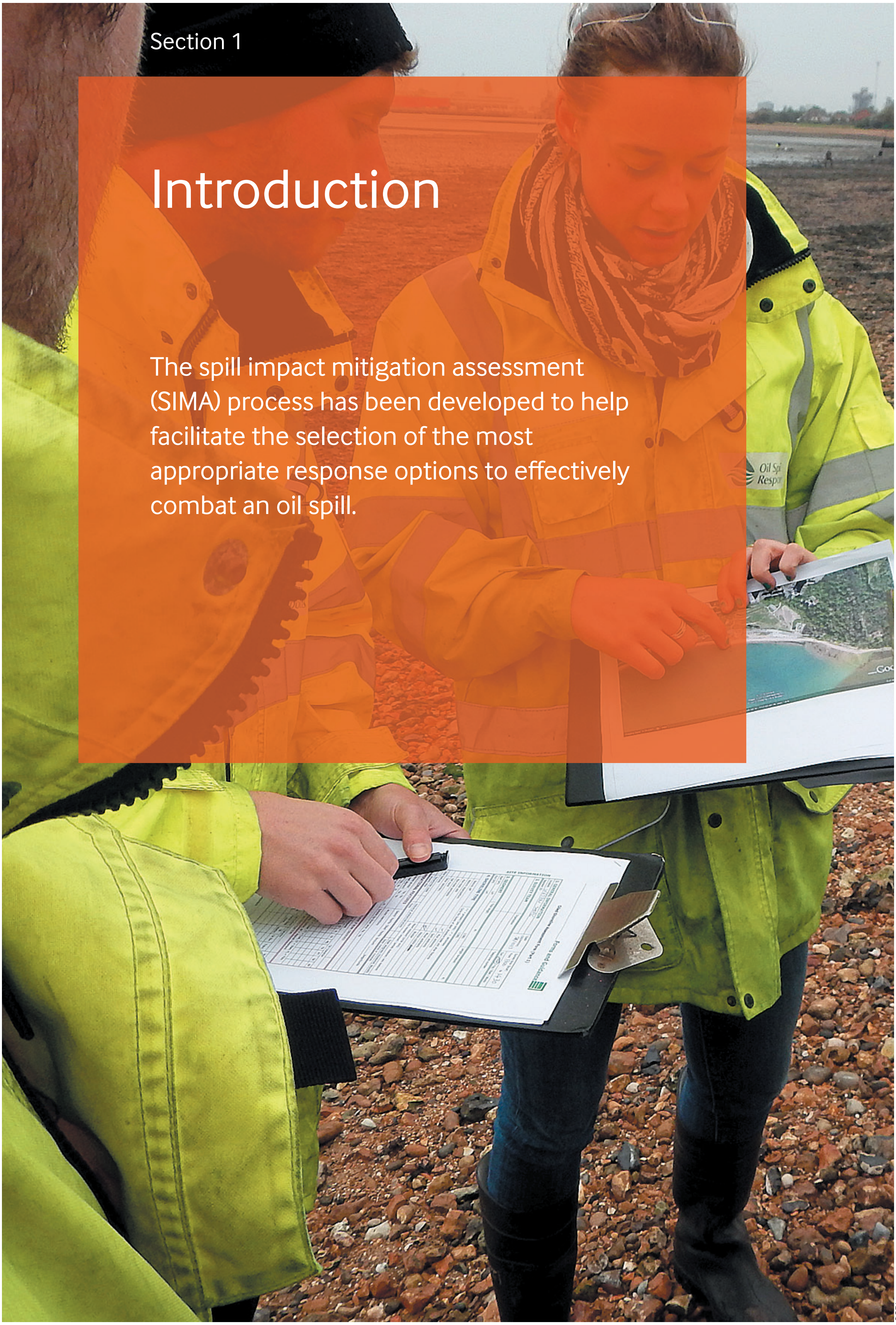
Section 1

Introduction

The spill impact mitigation assessment (SIMA) process has been developed to help facilitate the selection of the most appropriate response options to effectively combat an oil spill.



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Introduction

Minimizing the ecological, socio-economic and cultural impact of an oil spill through the development of a safe and effective response strategy is the primary aim of those responsible for contingency plans and incident management. Strategy is defined as the utilization of a single response option, or combination of options, to effectively combat an oil spill. The selection of the most appropriate response option(s) typically involves the consideration of various factors and trade-offs, which can be complicated and overwhelming. Therefore, a structured spill impact mitigation assessment (SIMA) process has been developed to help facilitate response option selection and support strategy development. The SIMA process is described in this document and was informed by the 2015 IPIECA-IOGP GPG on oil spill response strategy development using NEBA (IPIECA-IOGP, 2015a).

In some jurisdictions, the oil spill response strategy is largely determined or prescribed by national policy, regulation or guidance. In others, the operator of the individual asset or activity is required to develop a strategy that minimizes oil spill impacts. For the latter, the SIMA process described in this document can be used to identify and compare the potential effectiveness and collateral impacts of candidate response options, enabling a qualitative and transparent determination of the most appropriate strategy. For the former, this SIMA process can similarly be used to dispute prescriptive or predetermined response strategies if the operator believes alternative strategies are more protective of the environment.

Given the broad range and scale of oil spill planning scenarios, diverse perceptions of the value of ecological, socio-economic and cultural sensitivities and the innate realities of oil spill response field operations, no single SIMA methodology is suitable, or indeed appropriate, for application in all situations. It is important to note that the SIMA process described herein is primarily applicable to larger or higher consequence oil spill incidents or scenarios where multiple spill response options are being considered. For smaller, lower consequence spills where only one or two response options are contemplated or feasible, a formal SIMA is generally not warranted.

Safety first

Protecting the health, safety and welfare of responders and the local community underpins the consideration of all response activities. Operations should have due regard for the safety of responders in carrying out deployments, and for the potential exposure of both response personnel and the wider public to spilled oil and associated hazards.

There are situations where the safety benefits or concerns associated with a response option may become the dominant driver of strategy development. If a response option could not be safely undertaken in the context of a particular scenario, it would not be considered feasible and would therefore be excluded from that scenario's SIMA.

Below: it is essential that all personnel engaged in clean-up activities observe the necessary safety requirements and are equipped with appropriate personal protective equipment.

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Additionally, in actual incidents where response strategy decisions must be made under time-constraints, an abbreviated SIMA process may be required that relies primarily or solely on the best available professional judgement/expert opinion. An abbreviated SIMA may generally follow the process described herein, or a different process, depending on the incident's circumstances. The methodology described in this document has the potential to be used within any national framework.

SIMA PROCESS SUMMARY

The SIMA process is described in detail in Section 2 but can be summarized in four stages:

1. Compile and evaluate data for relevant oil spill scenarios including fate and trajectory modelling, identification of resources at risk and determination of feasible response options.
2. Predict outcomes/impacts for the 'no intervention' (or 'natural attenuation') option as well as the effectiveness (i.e. relative mitigation potential) of the feasible response options for each scenario.
3. Balance trade-offs by weighing and comparing the range of benefits and drawbacks associated with each feasible response option, including no intervention, for each scenario.
4. Select the best response option(s) to form the strategy for each scenario, based on the combination of techniques that will minimize the overall ecological, socio-economic and cultural impacts and promote rapid recovery.

NOTE: The use of SIMA for more than one scenario is only applicable during contingency planning. In a real incident there will only be one release scenario, i.e. the actual spill, for which this SIMA or a similar process will be used.

This SIMA methodology is not a process that quantifies the potential impacts of an oil spill. Rather, it assesses the relative impact mitigation potential of candidate response options, to choose those that will most effectively minimize the overall consequences of a spill.

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A SIMA will often include a list of sensitive ecosystems and areas considered vulnerable to impacts, such as shorelines.

The guidelines in this document focus primarily on the *Predict outcomes* and *Balance trade-offs* stages of a SIMA, as they are generally the most complex and are often emotive within the wider community due to misunderstandings about the effectiveness of response options and potential drawbacks. There may also be differing or conflicting stakeholder opinions of the relative value of ecological, socio-economic or cultural resources at risk. SIMA provides a transparent framework to consider and balance these values as well as the consequential trade-offs of using the feasible response options—recognizing their potential benefits, limitations and drawbacks—compared to no intervention.

Figure 1 on page 8 identifies the four stages of SIMA and summarizes their primary components.

Figure 1 Summary of the SIMA methodology described in this report

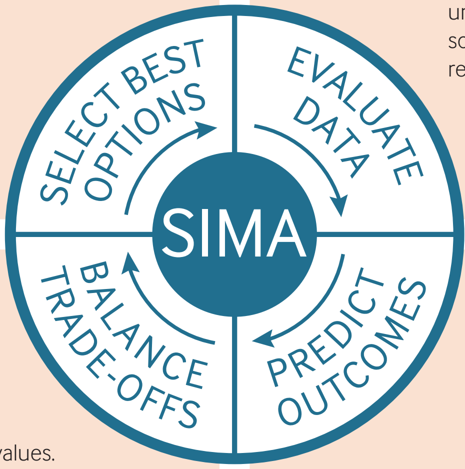
Stage 4: Select best options

The best combination of response options is selected to create an appropriate reponse strategy. It is recommended that SIMA utilizes the complete response toolkit, including:

- No intervention
- At-sea containment and recovery
- Surface dispersant
- Subsea dispersant
- Controlled in-situ burning
- Shoreline booming

Stage 1: Evaluate data

- A selection of credible potential release scenarios is chosen.
  - Oil fate and trajectory modelling is undertaken, and data on ecological, socio-economic and cultural resources evaluated.
    - Resources at risk are determined, and the feasible response options identified.



Stage 3: Balance trade-offs

- Dialogue with key stakeholders provides the opportunity to explain potential trade-offs or to obtain new inputs on resource sensitivities and values.
- The total impact mitigation score and ranking for each response option is agreed.

Stage 2: Predict outcomes

- The potential relative impact of the spill on each resource at risk is assessed for the 'no-intervention' option.
- A preliminary prediction is made of how each feasible response option will modify the impact when compared with no intervention.

WHO IS INVOLVED IN THE SIMA?

SIMA presents the opportunity, within limits depending on the context, to build consensus-based response strategy among industry, government authorities and key stakeholders from the wider community. The personnel who may be actively involved in the SIMA, or be consultees, will vary greatly depending on the spill scenario circumstances and locality.

Where SIMA is undertaken in support of contingency plans, a variety of subject matter experts (SMEs) may be engaged in the process (e.g. modellers, environmental and other specialists, and experienced responders). Consultations may also take place with key representatives of potentially affected stakeholder groups (e.g. fishing, tourism and local community) and relevant authority representatives, including regulators and resource trustees (e.g. nature conservation agencies). The specific make-up of the people involved in the dialogue will depend on the spill scenarios, the local setting and the ecological, socio-economic or cultural resources threatened.

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Shoreline sensitivity assessment exercise in the UK as part of an effort to develop a shoreline response strategy.

Oil spill incidents often attract significant interest from the media and the public; those directly affected by a spill should be promptly and properly informed.

Shoreline sensitivity assessment being carried out in Tanzania during a sensitivity mapping workshop supported by IMO/IPIECA and managed by the Tanzanian National Environment Management Council.

Where possible, appropriate stakeholder groups should be consulted over the identification of resources at risk to help assess the relative potential for impacts from a spill. The wider community is also likely to have an active interest in how the ability of each response option to modify impacts and promote recovery is determined. The engagement of stakeholder group representatives in choosing response options has been practiced through planning approaches such as the Consensus Ecological Risk Assessment (Aurand *et al.*, 2000), with which the methodology described herein is aligned.

In the case of incident response SIMAs carried out during actual spills, the group of people involved is likely to be streamlined due to time constraints and consist of a small cohort of SMEs. The SIMA process will be undertaken through the existing emergency management structure and will consider stakeholder and community concerns to the extent practicable. Alignment and liaison with authorities may be required, where the response is led by an industry team, but all dialogue and decision making will need to be expedited. The dynamic nature of incidents is such that undue delays could result in both a SIMA's conclusions and the resulting strategic decisions having little practical value.

WHEN SIMA MIGHT BE USED

The SIMA process can be used during pre-spill planning and/or incident response as follows:

Pre-spill planning

When SIMA is used during the contingency planning process, it provides an unhurried, consensus-based approach incorporating dialogue with relevant stakeholders. SIMA conducted during contingency planning not only develops the most effective response strategy for each planning scenario; it also helps to determine the subsequent provisioning of suitable response equipment and supporting logistics. The SIMA process brings transparency and credibility by documenting and demonstrating how potential response options have been analysed and incorporated into each strategy. This facilitates community/stakeholder engagement and helps set realistic expectations for the effectiveness of response options. Further information and guidance on contingency planning is available in the IPIECA-IOGP GPG entitled *Contingency planning for oil spills on water* (IPIECA-IOGP, 2015b) and the API *Guidance on offshore oil spill response plans* (API, 2013).

Incident response

For responses to incidents where a scenario is covered by contingency plans that incorporate SIMA as described above, the following process can be used:

- Select the planning scenario that most closely matches the incident circumstances, along with its associated response strategy, as a starting point.
- Validate or adjust as needed the assumptions and considerations used in the planning SIMA to account for actual incident conditions (this can be a dynamic use of SIMA throughout the response).
- Confirm the applicability of the pre-determined response strategy or adjust as necessary.

For some incidents, parameters may not match a scenario where a SIMA was completed as part of the contingency planning process (e.g. a 'passing shipping' casualty). To avoid delays that may result in greater impacts, an abbreviated version of the process outlined in this document can be followed. This will generally involve reduced reliance on stakeholder consultation and empirical data along with a greater reliance on expert opinion and professional judgement while maintaining the same SIMA principles. Unlike the more consensus-oriented SIMA undertaken during contingency planning, the process is likely to be embedded into the emergency response and implemented through an incident management system.

In abbreviated cases, as the incident progresses, subsequent cycles of the SIMA process can incorporate data derived from monitoring the effectiveness of chosen response options and from sources either unknown or unavailable in the previous stages. The amount of stakeholder engagement also increases and becomes more formal. As the resolution of the SIMA increases, further layers of detail are created and the response strategy is adjusted.

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In-situ burning is just one of a variety of potential at-sea response options that may be identified for inclusion in the contingency plan during the SIMA process.

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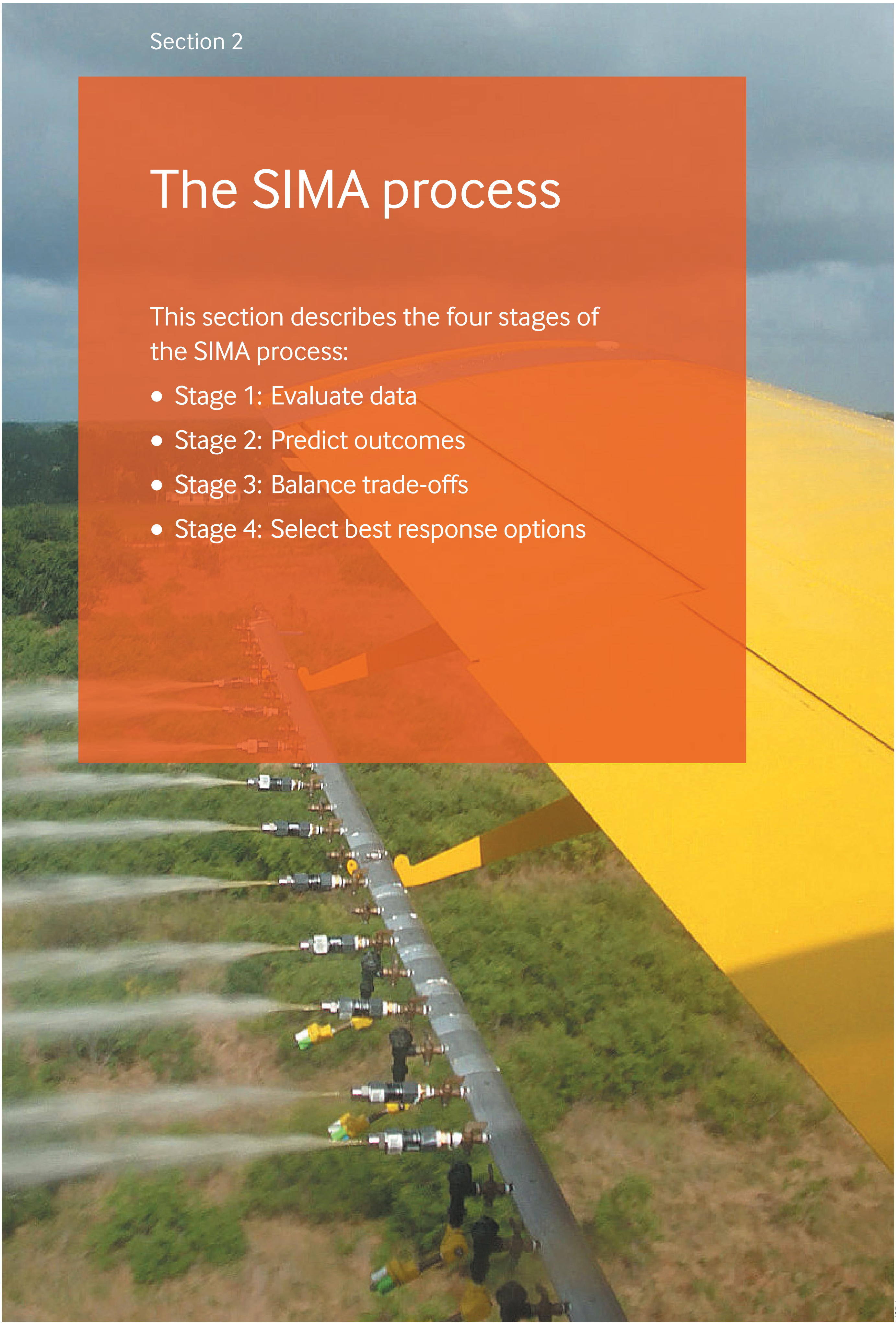
When responding to an offshore incident it is essential to remember that high seas conditions have the potential to present a significant hazard to vessel operations.

Section 2

The SIMA process

This section describes the four stages of the SIMA process:

- Stage 1: Evaluate data
- Stage 2: Predict outcomes
- Stage 3: Balance trade-offs
- Stage 4: Select best response options



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The SIMA process

STAGE 1: EVALUATE DATA

Defining the scenario

It is fundamental practice within contingency planning to identify a suitable selection of credible potential accidental oil release scenarios. In accordance with the tiered response approach, planners aim to define a group of scenarios that collectively represent the range of spill risks and response challenges for a particular asset or operation. Typically, only a worst credible case discharge will be considered; this ensures that adequate response capabilities are available across all response tiers and are able to deal with the risk assessment's most significant event. Smaller event scenarios may also be chosen to refine response capabilities and tactics at lower response tiers. Additionally, for operators with multiple facilities, assets or operations in a relatively small area, a single scenario or set of scenarios may be developed that is representative of all potential sources in the area. Further information on scenario planning is available in IPIECA-IOGP, 2013a.

Incident and oil information

A number of parameters define each planning scenario:

- location;
- oil type and properties;
- volume of release;
- duration of release; and
- prevailing hydrodynamic and metrological conditions.

For some locations it may be suitable to consider separately the same release parameters at different times of year or seasons.

Oil fate and transport

Oil fate and trajectory modelling, incorporating the above parameters, is typically used to identify the potential geographical area of impact for each chosen scenario. Stochastic (or probabilistic) modelling is particularly useful for SIMA, as it uses hydrodynamic and historical meteorological data to provide likelihoods of particular areas being oiled. Stochastic modelling can also be used to identify coastal areas with a greater likelihood of being impacted by significant quantities of oil. The baseline for modelling is the 'no Intervention' case (also called natural attenuation), in which no response actions are undertaken.

Deterministic (single run) modelling can, if conducting a more quantitative SIMA, also be used to predict the migration path of the floating oil, its surface thickness, in-water oil concentrations and/or shoreline oiling (time to shoreline and extent of oiling) for a specific spill scenario, under a specific set of prevailing conditions. This can support a SIMA's stochastic outputs or be used for predictions during incident response. In both cases, time to shoreline impact is helpful for determining the feasibility of implementing shoreline protection measures prior to impact and/or possible locations for response capability.

Identification of resources at risk

Oil spills have the potential to impact a variety of ecological, socio-economic and cultural resources. These resources may have varying degrees of sensitivity to oil spills and value to the local community. Information on sensitive resources and their locations is typically found in the literature and may have been consolidated within environmental and social impact assessments (ESIAs) and oil spill sensitivity mapping projects. Input from the local community is generally required to identify their most valued resources. Further information on identifying and mapping sensitive resources for oil spill planning and response purposes can be found in the IPIECA-IMO-IOGP Good Practice Guide entitled *Sensitivity mapping for oil spill response* (IPIECA-IMO-IOGP, 2012).

Oil spill trajectory modelling is used in conjunction with sensitive resource maps to identify the locations and resources that are at risk of being impacted, or are vulnerable to impacts, for each scenario. In some cases, resources may be listed in the SIMA even if there is little or no likelihood of their becoming oiled.

This will either be because the local community needs reassurance that the resource has been considered due to its perceived high value, or because another scenario may be under consideration which risks impacting the resource. Note that a resource may be *sensitive* to oil impacts but it may not be *vulnerable*. The latter takes into account possible exposure pathways, i.e. whether a resource is likely to be affected by spilled oil.

Ecological resources are often assessed at the broad habitat level (rather than at the species level), and socio-economic and cultural resources assessed in similarly broad compartments (for example maritime recreation, commercial fishing and tourism can be combined into the socio-economic compartment) rather than evaluating each component individually. Where there are particular concerns about specific resources (e.g. endangered species, important breeding areas or sites of wildlife aggregations), these can be included collectively in the high value resource compartment, or may contribute individually to the SIMA process. However, increasing the complexity of the SIMA can become time-consuming; analysing resources at greater detail should only be undertaken when it is reliably expected to bring significant change to the SIMA's outcome and alter strategy development.

The list of agreed resource compartments will be self-evident within the SIMA matrix. However, it is useful to summarize discussions that took place concerning the dialogue to reach agreement, including the organizations involved. This information can be annexed to the SIMA matrix as part of the supporting documentation.

ITOPF

Determining potential response options

The potential at-sea response options are typically:

- no intervention (natural attenuation);
- on-water containment and recovery;
- subsea dispersant injection;
- surface dispersant application;
- controlled in-situ burning; and
- shoreline booming (used as anchored exclusion, diversion or deflection barriers).

These options should be evaluated against each scenario's incident circumstances (oil type, volume and characteristics, prevailing wind and wave conditions, available logistical support, etc.) to determine their deployment feasibility. A shortlist of the feasible response options is then prepared for each scenario and carried forward in the SIMA process. It is emphasized that the at-sea response strategy is likely to comprise a suite of the available options, deployed variously at different locations and times through the incident. The SIMA assists in prioritizing which options to use where and when. It does not automatically lead to choosing one option with the mutual exclusion of others.

Separate SIMAs may be conducted for shoreline cleanup and possibly shoreline protection operations. These are inherently different from the other on-water response options, and it may be necessary to address specific questions within a particular scenario, i.e. which techniques should be used at a specific beach or sensitive area. In these cases, the response options will be adjusted to incorporate the most appropriate techniques, with the SIMA methodology otherwise remaining the same. Existing published guidance can be used when assessing the ways in which different shoreline cleanup techniques can mitigate impacts across the range of different shoreline types (NOAA, 2010; POSOW, 2013). The SIMA methodology can also be used for freshwater or inland spill scenarios wherein a different set of response options would be evaluated.

Oil spills have the potential to impact a variety of ecological, socio-economic and cultural resources, such as this aquaculture site, which may be especially sensitive to smothering and oil toxicity.

STAGE 2: PREDICT OUTCOMES

The next stage in the SIMA process is to predict the outcomes—i.e. the relative impacts on resources at risk—for each scenario, using the 'no intervention' case as a baseline. The feasible response options are then evaluated, based on the extent to which they mitigate, exacerbate or do not alter the 'no intervention' outcome. Although each response option may individually alter the outcome to varying degrees, no single option is likely to be fully effective. Combinations of different options, utilized in different geographic locations and possibly at different times are usually necessary. The comparative matrix shown below can be used to facilitate the evaluation of individual candidate response options; it is not feasible to aggregate the outcomes of multiple options using this methodology. It may be beneficial to engage relevant stakeholders at this stage of the process, though it is more usual to undertake this during the next stage—*Balancing trade-offs*.

A hypothetical offshore surface oil spill has been used to develop the example matrix shown in Figure 2. The use of subsea dispersant is not, therefore, feasible for this scenario.

Figure 2 The formulation of a comparative matrix used to facilitate the evaluation of candidate response options for a surface spill

The orange labels denote the different processes involved in building the matrix—each process is discussed in detail on the following pages.

SIMA Stage 2: Predict outcomes (1. Resource compartments; 2. Relative impact assessment; 3. Predict the effectiveness and impact modification potential of the various response options)

SIMA Stage 3: Balance trade-offs (4. Impact modification factors; 5. Total impact mitigation score and ranking)

1. Resource compartments	NO INTERVENTION: Potential relative impact	A	CONTAINMENT AND RECOVERY: Impact modification factor B1	CONTAINMENT AND RECOVERY: Relative impact mitigation score A x B1	SURFACE DISPERSANT: Impact modification factor B2	SURFACE DISPERSANT: Relative impact mitigation score A x B2	SUBSEA DISPERSANT	CONTROLLED IN-SITU BURNING: Impact modification factor B4	CONTROLLED IN-SITU BURNING: Relative impact mitigation score A x B4	SHORELINE BOOMING: Impact modification factor B5	SHORELINE BOOMING: Relative impact mitigation score A x B5
Seabed	None	1	0	0	0	0	Not feasible for a surface spill	0	0	0	0
Lower water column	None	1	0	0	0	0		0	0	0	0
Upper water column	Low	2	1	2	-2	-4		0	0	0	0
Water surface	Medium	3	1	3	3	9		2	6	0	0
Air	Medum	3	1	3	2	6		1	3	0	0
Shorelines		3	1	3	3	9		2	6	1	3
Saltmarsh	*High*	*4*	*1*		*3*			*2*		*1*	
Estuarine mudflats	*High*	*4*	*1*		*3*			*2*		*1*	
Sandy beaches	*Low*	*2*	*1*		*3*			*2*		*2*	
High value resources	Low	2	0	0	1	2		0	0	1	2
Socio-economic		4	1	4	2	8		1	4	3	12
Boat harbour	*Medium*	*3*	*1*		*2*			*1*		*2*	
Water recreation	*High*	*4*	*1*		*2*			*1*		*3*	
Cultural	None	1	0	0	2	2		1	1	1	1
		Total impact mitigation score:		15		32			20		18
		Ranking:		**4th**		**1st**			**2nd**		**3rd**

The processes involved in constructing the example matrix shown in Figure 2 include:

1. Determining resource compartments.
2. Assessing the potential relative impact.
3. Predicting the effectiveness and impact modification potential of the various response options. This predictive process provides the basis for the allocation of the *impact modification factors* for each response option and resource compartment combination during the next stage.
4. Allocating the impact modification factors.
5. Determining the total impact mitigation scores and ranking of response options.

These five points are discussed in detail below and under *Stage 3: Balance trade-offs* on pages 17–20. They are individually labelled on Figure 2 for easy reference.

Determining resource compartments

It is recommended that the following resource compartments are included in the matrix for this scenario (note that these compartments may be amended or expanded as discussed under *Assessing the potential relative impact*, below):

- Seabed—relatively deep water so no benthic impact expected.
- Water surface—considerable floating oil is present along with a moderate number of seabirds and marine mammals being threatened.
- Water column—minimal naturally-dispersed oil in the water column and few sensitive aquatic receptors present in the area.
- Air—moderate concentrations of VOCs in the air above the slicks, which poses a potential threat to responders and marine mammals and birds.
- Shorelines—significant shoreline oiling is anticipated which includes several environmentally-sensitive marshes and estuaries.
- High value resources—high amenity sand beach near town is not environmentally sensitive but is of particular importance to the small local community.
- Socio-economic—significant oiling of boat harbour is anticipated.
- Cultural—no cultural or historical resources are present.

Figure 3 on page 16 shows the initial development of the comparative matrix, incorporating the above resource compartments,

Assessing the potential relative impact

The initial task in SIMA Stage 2—the *Predict outcomes* stage—is to assess the impact of the 'no intervention' option for each planning scenario. This serves as the reference or base case, against which the benefits or drawbacks of the candidate response options are assessed. Drawing on the data compiled in SIMA Stage 1—*Evaluate data* —the relative levels of impact of each spill scenario's 'no intervention' option on ecological, socio-economic and cultural resources at risk are determined. Broad resource compartments (as discussed previously) are preferred and generally provide adequate detail for a SIMA. Complex scenarios could require further breakdown and evaluation of additional compartments.

Where a scenario has the potential to impact specific resources which may be of particularly high ecological significance or value to the affected community, these resources can be combined under the 'high value resources' compartment to facilitate additional consideration in the comparative matrix.

Alternatively, they can be listed as sub-compartments under the 'high value resources' compartment, or under an associated general resource compartment. However, if multiple individual resources/sub-compartments are listed under one of the general resource compartments, their relative impact and impact mitigation rankings/scores should be averaged to avoid the total impact mitigation scores being disproportionately biased toward those resources.

For most SIMAs, relative impact levels of 'none to insignificant' (short form 'none'), 'low', 'medium' and 'high' may be used. Complex scenarios may assign more refined levels (e.g. none, low, medium, high, extreme) or may use more quantitative metrics. Additional levels should only be considered where there is a reliable expectation that this refinement will make a significant change to the SIMA's outcome, i.e. if doing so would result in a material alteration to strategy development. A further discussion of how relative impact levels may be assigned can be found in Appendix 1.

It is useful to summarize salient factors relating to assessment of potential relative impacts, including any use of the techniques described in Appendix 1. This becomes an integral part of the SIMA documentation process.

The relative impact levels are then allocated a score (column A in Figure 3). These may be scores of 1, 2, 3 and 4 for none, low, medium and high impact, respectively. If there is significantly elevated concern for resources that experience greater impacts, it may be preferred to weight the scores of the higher impact levels, for example increasing the medium and high impacts scores to 4 and 6, respectively.

Predicting the effectiveness and impact modification potential of the various response options

A preliminary prediction is made of how each feasible response option will modify the impact when compared with the 'no intervention' case. This involves consideration of the probable effectiveness of each response option. Effectiveness should be considered in the context of the specific scenario and each resource compartment's exposure routes. It is a function of various factors, including the oil type, weathering and spill volume, sea state, encounter rate (i.e. the rate at which a response option can treat spilled oil) and logistical considerations. These are discussed further in Appendix 2, where the listed benefits of a response option tend to include the factors leading to higher effectiveness and, conversely, the listed drawbacks reduce it.

This preliminary prediction provides the basis for the allocation of *impact modification factors* for each response option and resource compartment combination during the next stage (see the following page).

In some cases, it may be beneficial to identify preliminary or draft impact modification factors as a starting point, prior to engaging with relevant stakeholders during the 'balance trade-offs' stage.

Figure 3 Assembling the comparative matrix begins with the inclusion of the selected resource compartments; a potential relative impact and associated score is then assigned to each resource in the case of 'no intervention'

RESOURCE COMPARTMENTS	NO INTERVENTION		CONTAINMENT AND RECOVERY		SURFACE DISPERSANT		SUBSEA DISPERSANT	CONTROLLED IN-SITU BURNING		SHORELINE BOOMING	
	Potential relative impact		Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score		Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score
		A	B1	A x B1	B2	A x B2		B4	A x B4	B5	A x B5
Seabed	None	1					Not feasible for a surface spill				
Lower water column	None	1									
Upper water column	Low	2									
Water surface	Medium	3									
Air	Medum	3									
Shorelines		3									
Saltmarsh	*High*	*4*									
Estuarine mudflats	*High*	*4*									
Sandy beaches	*Low*	*2*									
High value resources	Low	2									
Socio-economic		4									
Boat harbour	*Medium*	*3*									
Water recreation	*High*	*4*									
Cultural	None	1									
Total impact mitigation score:											
Ranking:											

STAGE 3: BALANCE TRADE-OFFS

Allocating the impact modification factors

An *impact modification factor* is used to indicate the degree to which the 'no intervention' impacts are altered by each response option. Figure 4 shows the impact modification factors now added to the comparative matrix in columns B1, B2, B4 and B5. If a response option mitigates the impacts on a particular resource compartment, then a positive number is entered. Conversely, if the response option exacerbates the impacts or creates a new impact, a negative number is entered. These numbers reflect the degree of impact modification according to Table 1, i.e. if the degree of change relative to 'no intervention' is minor, moderate or major then a positive or negative 1, 2 or 3 is entered, respectively. Impact modification factors are further discussed in Appendix 2.

Table 1 Impact modification factors

IMPACT MODIFICATION FACTOR	DESCRIPTION
+3	Major mitigation of impact
+2	Moderate mitigation of impact
+1	Minor mitigation of impact
0	No or insignificant alteration of impact
-1	Minor additional impact
-2	Moderate additional impact
-3	Major additional impact

Depending on the anticipated level of stakeholder engagement, it may be appropriate to canvass their inputs at this point in the process. This could help avoid protracted discussions with stakeholders later in the process.

Figure 4 Development of the comparative matrix continues with the addition of the impact modification factors—these are now included in columns B1, B2, B4 and B5

RESOURCE COMPARTMENTS	NO INTERVENTION		CONTAINMENT AND RECOVERY		SURFACE DISPERSANT		SUBSEA DISPERSANT	CONTROLLED IN-SITU BURNING		SHORELINE BOOMING	
	Potential relative impact		Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score		Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score
		A	B1	A x B1	B2	A x B2		B4	A x B4	B5	A x B5
Seabed	None	1	0		0		Not feasible for a surface spill	0		0	
Lower water column	None	1	0		0			0		0	
Upper water column	Low	2	1		-2			0		0	
Water surface	Medium	3	1		3			2		0	
Air	Medum	3	1		2			1		0	
Shorelines		3	1		3			2		1	
Saltmarsh	*High*	*4*	*1*		*3*			*2*		*1*	
Estuarine mudflats	*High*	*4*	*1*		*3*			*2*		*1*	
Sandy beaches	*Low*	*2*	*1*		*3*			*2*		*2*	
High value resources	Low	2	0		1			0		1	
Socio-economic		4	1		2			1		3	
Boat harbour	*Medium*	*3*	*1*		*2*			*1*		*2*	
Water recreation	*High*	*4*	*1*		*2*			*1*		*3*	
Cultural	None	1	0		2			1		1	
Total impact mitigation score:											
Ranking:											

It useful to summarize dialogue relating to the allocation of impact modification factors. This may include reference to how the operational and technical benefits and drawbacks of response options were allocated. In some cases, there may be technical features of a response option that are not intuitive and require explanation. For example: (1) burning fresh oil can destroy volatile compounds that would otherwise present an air pollution hazard, and would need to be balanced against the creation of a visible smoke plume; and (2) chemically dispersed oil droplets may be less likely to adhere to suspended sediment, compared to naturally dispersed ones. The summary would also note the organizations involved in the discussions, and would form part of the SIMA documentation process.

Determining the total impact mitigation scores and ranking of response options

The *potential relative impact* score (column 'A' in the example matrix) for each resource compartment under the 'no intervention' option is multiplied by the associated *impact modification factor* for each response option (columns B1, B2 etc.) to create a *relative impact mitigation score* for each combination of resource compartment and response option. These scores are entered in columns A x B1, A x B2, A x B4 and A x B5 of the matrix (see Figure 5) and represent the relative change that each response option is likely to have in the level of impact on each resource. Since the relative impact mitigation score is derived from a *qualitative* ranking of impacts, the score should **not** be taken as a *quantitative* measure of impact. It is recommended that scores are rounded to units in cases of averaging (such as the shorelines and socio-economic rows in Figure 5.

Figure 5 The relative impact mitigation scores are calculated and entered in the matrix (columns AxB1, AxB2, AxB4 and AxB5); a colour scheme may also be introduced to provide a visual reference for the relative scores of impact mitigation (see legend above)

RESOURCE COMPARTMENTS	NO INTERVENTION		CONTAINMENT AND RECOVERY		SURFACE DISPERSANT		SUBSEA DISPERSANT	CONTROLLED IN-SITU BURNING		SHORELINE BOOMING	
	Potential relative impact		Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score		Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score
		A	B1	A x B1	B2	A x B2		B4	A x B4	B5	A x B5
Seabed	None	1	0	0	0	0	Not feasible for a surface spill	0	0	0	0
Lower water column	None	1	0	0	0	0		0	0	0	0
Upper water column	Low	2	1	2	-2	-4		0	0	0	0
Water surface	Medium	3	1	3	3	9		2	6	0	0
Air	Medum	3	1	3	2	6		1	3	0	0
Shorelines		3	1	3	3	9		2	6	1	3
Saltmarsh	*High*	*4*	*1*		*3*			*2*		*1*	
Estuarine mudflats	*High*	*4*	*1*		*3*			*2*		*1*	
Sandy beaches	*Low*	*2*	*1*		*3*			*2*		*2*	
High value resources	Low	2	0	0	1	2		0	0	1	2
Socio-economic		4	1	4	2	8		1	4	3	12
Boat harbour	*Medium*	*3*	*1*		*2*			*1*		*2*	
Water recreation	*High*	*4*	*1*		*2*			*1*		*3*	
Cultural	None	1	0	0	2	2		1	1	1	1
			Total impact mitigation score:								
			Ranking:								

To provide a visual reference of the potential impact mitigation associated with each response option, and to emphasize that the process is not quantitative, users of the matrix may wish to adopt a colour code for the relative scores of impact mitigation. This provides an intuitive scale of impact mitigation, from major impact mitigation (dark green) through to major impact increase (red):

8 to 12	dark green	Major mitigation of impact
3 to <8	green	Moderate mitigation of impact
>0 to <3	light green	Minor mitigation of impact
0	white	No or insignificant change
>-3 to <0	yellow	Minor increase in impact
>-8 to -3	orange	Moderate increase in impact
-12 to -8	red	Major increase in impact

Figures 5 (page 18) and 6 (below) show how such a colour scheme would be applied to the relative impact mitigation scores in the matrix.

The scores for each response option are then totalled at the base of the matrix, as shown in Figure 6. These totals are qualitative predictions of the degree to which each option mitigates the scenario's overall impact (i.e. compared to no intervention). The total scores can then be used to rank the relative ability of each response option to mitigate impacts and enhance recovery. This ranking promotes an objective comparison of the options when balancing trade-offs. It is important to note that the total scores do not have a direct mathematical relationship (i.e. a score of +20 does not mean an option will achieve twice the mitigation as one scoring +10).

Totals should only be used for comparative purposes within each specific SIMA. Furthermore, the ecologically-based compartments outnumber the socio-economic and cultural ones in the example given. This skews the total towards ecological concerns. In many scenarios this may be appropriate but it should be taken into account when interpreting the matrix to select the best response options.

Figure 6 Finally, the relative impact mitigation scores are totalled along the base of the matrix for each response option to provide a ranking of the ability of each response option to mitigate impacts and enhance recovery

	NO INTERVENTION		CONTAINMENT AND RECOVERY		SURFACE DISPERSANT		SUBSEA DISPERSANT	CONTROLLED IN-SITU BURNING		SHORELINE BOOMING	
RESOURCE COMPARTMENTS	Potential relative impact		Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score		Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score
		A	B1	A x B1	B2	A x B2		B4	A x B4	B5	A x B5
Seabed	None	1	0	0	0	0	Not feasible for a surface spill	0	0	0	0
Lower water column	None	1	0	0	0	0		0	0	0	0
Upper water column	Low	2	1	2	-2	-4		0	0	0	0
Water surface	Medium	3	1	3	3	9		2	6	0	0
Air	Medum	3	1	3	2	6		1	3	0	0
Shorelines		3	1	3	3	9		2	6	1	3
Saltmarsh	*High*	*4*	*1*		*3*			*2*		*1*	
Estuarine mudflats	*High*	*4*	*1*		*3*			*2*		*1*	
Sandy beaches	*Low*	*2*	*1*		*3*			*2*		*2*	
High value resources	Low	2	0	0	1	2		0	0	1	2
Socio-economic		4	1	4	2	8		1	4	3	12
Boat harbour	*Medium*	*3*	*1*		*2*			*1*		*2*	
Water recreation	*High*	*4*	*1*		*2*			*1*		*3*	
Cultural	None	1	0	0	2	2		1	1	1	1
	Total impact mitigation score:			15		32			20		18
	Ranking:			**4th**		**1st**			**2nd**		**3rd**

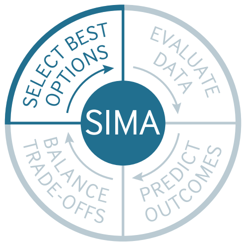
The balancing of trade-offs can be the most contentious element of the SIMA. Diverse or conflicting opinions may arise concerning a multitude of questions surrounding the importance of impacts on differing resources, such as fisheries versus tourism, shorelines versus water column or wildlife versus community recreation. SIMA aims to mitigate the overall impacts of the spill, and this involves balancing the trade-offs of impacts between the various resources. A fundamental principle is that if a response option increases the impact on a resource, it will only be deployed if this impact is more than outweighed by the mitigation of the impacts on other resources.

The relative impact mitigation scores generated previously already incorporate the relative benefits and drawbacks of each option and, as such, should preclude the need to further balance trade-offs. This is particularly true if the concerns and values of potentially affected stakeholders were incorporated in the *Predict outcomes* process (SIMA Stage 2). In some cases, additional dialogue may be needed with key stakeholders and government authorities to better explain the trade-offs already incorporated into the comparative matrix, or to obtain new inputs on resource sensitivities or values. This will either validate the outcomes or may lead to re-evaluation and adjusting the inputs to the matrix.

Pressures can also be felt, both during contingency planning and during the course of an incident, to either undertake or avoid certain response options. Such pressures are likely to be driven by public perceptions and political considerations, rather than technical understanding. Typically, they result in calls for actions that may be unrealistic, such as the excessive use of shoreline protection booms, possibly in areas not under threat from spilled oil, and an anti-dispersant or anti-burning position that is not based on factual considerations of the ability of these options to mitigate the overall impacts. SIMA is designed to help overcome these perceptions by presenting a transparent case for appropriate and technically valid response options, through the balancing of trade-offs. The comparative matrix provides a transparent representation and record of how resources and response options have been assessed and prioritized.

Dialogue with stakeholders can be emotive, so maintaining objectivity must be emphasized. The discussions should be pragmatic and initially focus on the relative significance of any stakeholder's concerns raised by the matrix's outputs. The results of those discussions can then be used to determine whether, and to what extent, inputs to the matrix (e.g. amendments to either the potential relative impact or the impact modification factors) need to be altered to adequately address each concern. In some cases, additional resource compartments or individual resources may need to be added to the matrix and evaluated/scored in the same manner as the others.

STAGE 4: SELECT BEST RESPONSE OPTIONS

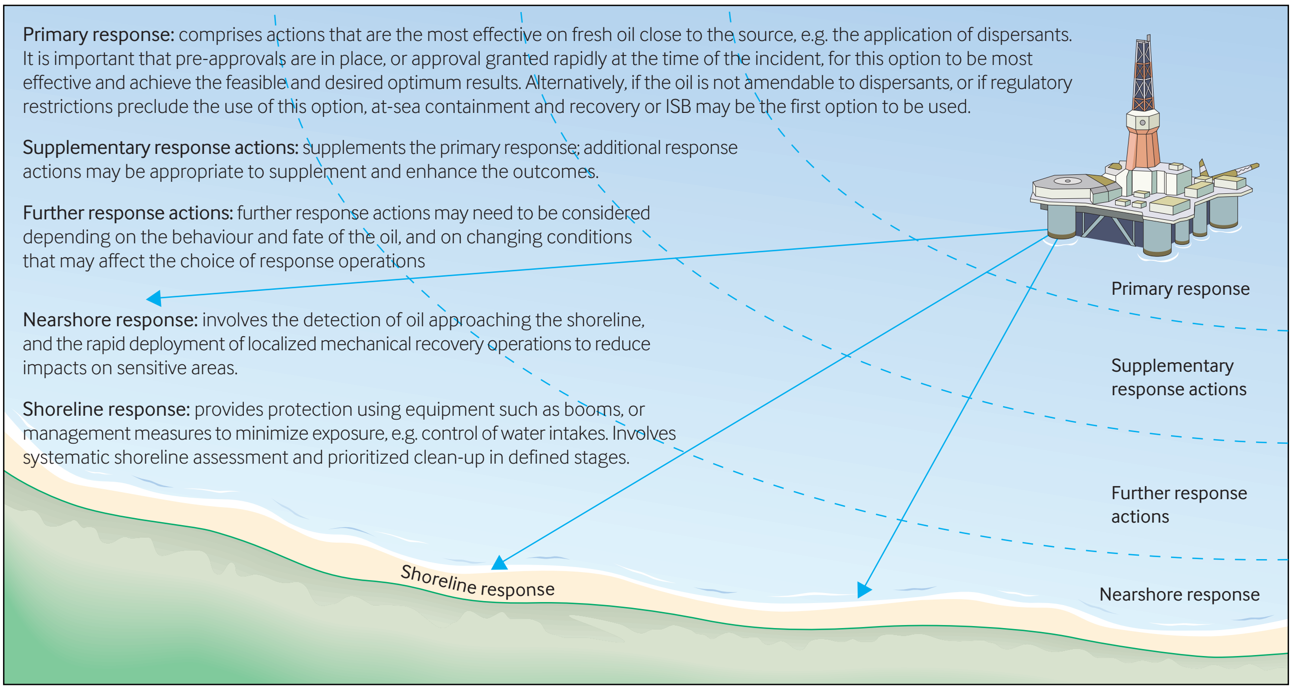


The finalized comparative matrix developed in the *Balance trade-offs* stage is used to objectively select the best response option(s) to be implemented for each scenario. This generally involves selecting the option or options with the largest impact mitigation score. In some cases, the choice may be obvious while others may require further dialogue between the involved parties, as described previously for the *Balance trade-offs* stage.

The proposed deployment of chosen options can be described in various ways. An approach bringing clarity to the tactical optimization and implementation of strategy is the 'concept of operations' (see Figure 7 on page 21), indicating zones or locations where specific response options are to be used (e.g. at the source, in the vicinity of an offshore release, further from release in open waters, nearshore and shoreline) and when they are likely to be deployed.

Dispersant spraying from a vessel-mounted spraying arm.

Figure 7 Optimized response options—sometimes referred to as the 'concept of operations'



In the example scenario represented by the matrix on the previous pages, the surface dispersant option receives the largest mitigation score (+32) and would be expected to provide the greatest reduction in the overall impact on resources at risk. The strategy would therefore legitimately consider surface dispersants as the primary response tool. In the 'concept of operations', dispersants would be used to treat the spill where the oil is fresh and forms relatively coherent slicks—i.e. close to the source—to maximize effectiveness and minimize net impacts. The remaining response options would be positioned to remove oil that may escape dispersant treatment and migrate beyond the application area. This would include protecting sensitive areas should any remaining oil threaten nearby shorelines. The tactical practicalities of where these other options might be effectively deployed would need consideration by contingency planners or incident managers during strategy development.

Once a scenario's strategy is defined in space and time, the planning process serves to identify the equipment, trained personnel, logistics and incident management system that will be required to implement the relevant tactics and operations. This will be integrated within the tiered preparedness and response model to ensure timely and effective capability that is commensurate to the risk and can evolve to meet an incident's needs (IPIECA-IOGP, 2014a).

DOCUMENTING THE SIMA

The SIMA methodology involves various discussions among the participants, to achieve consensus on the selection of resource compartments, assessment of potential relative impact and allocation of impact modification factors. The agreed outcomes are represented by the matrix in a clear and transparent manner. However, organizations and individuals who have not been directly involved in the SIMA process may question or challenge some of the matrix inputs.

Questions may be anticipated and addressed through the provision of explanatory notes annexed to a SIMA matrix. The notes are likely to focus on those inputs to the matrix that generated the most dialogue in order to reach consensus. The notes would also reference scenario details, spill modelling used, sources of environmental data, any use of sub-matrices to assess potential relative impact, non-intuitive technical issues that influenced allocation of impact modification factors and the identification of those organizations involved in the discussions.

REGULATORY ISSUES

In some countries, selected response options are closely regulated to ensure that they are only used during appropriate circumstances and with suitable equipment and support. It is recommended that any SIMA utilizes the full response toolkit, so that the recommended response strategy is grounded in the best available technical approach. The authorities may subsequently deny approval to use certain response options but may also grant waivers based on the impact mitigation potential determined in the SIMA.

In some jurisdictions there may be either an absence of existing regulations or lack of regulatory clarity with regard to certain response options. This could affect the feasibility of their implementation, authorization for use, or their effectiveness. Gaps in regulation may include:

- approval of dispersant products and authorization of their use (IPIECA-IOGP, 2014b);
- procedures for permitting controlled in-situ burning;
- approval of herding agents and authorization of their use;
- requirements relating to monitoring the operational effectiveness of response options; and
- rules regarding the decanting of oily water, to maximize at-sea storage of recovered oil (IPIECA-IOGP, 2013b).

In the unusual case that the regulations in a particular jurisdiction unequivocally rule out the use of a particular response option, that option should be excluded from the SIMA process. However, the default case is that all feasible options should be evaluated, i.e. options should not be screened out unless the regulations state unequivocally that they cannot be used. Where clear regulation does not exist for all response options, it is recommended that engagement with regulators ensues. This engagement would not only promote the best response options for a given scenario but also the development of suitable regulation. Thus the SIMA process can become a driver of an improved legislative framework for future oil spill preparedness.

Glossary

Glossary

BTEX	Acronym representing Benzene, Toluene, Ethylbenzene and Xylene; these are volatile aromatic components present to varying degrees in different oils. They raise both human health and environmental toxicity concerns.
Effectiveness	The degree to which a response option will achieve the desired results.
Feasibility	A consideration of which response tools and techniques are viable and safe given the expected climatic and operational conditions.
No intervention	The situation whereby no response is undertaken and the theoretical consequences of a scenario are estimated to create a baseline for comparison. The removal of oil from the environment and its recovery is left to natural attenuation in this case.
PAH	Polycyclic aromatic hydrocarbons
Resource compartment	The categorization of threatened ecological, socio-economic and cultural resources for the purposes of the SIMA assessment. Compartments may be tailored and subdivided to reflect specific scenarios but typically include the following:

Compartment	*Description*
Seabed	The benthic zone comprising the seabed and the life dwelling on or within it
Lower water column	The body of water extending from above the seabed to within around 10 m of the surface
Upper water column	The top few metres of the water, typically extending to 10 m depth
Water surface	The surface of the water and the marine life that regularly resides on it or uses the top few centimetres as its habitat
Air	The atmosphere above the water
Shorelines	Different beach types, typically divided into ten categories (from rocky to sedimentary) based on sensitivity to oil
High value resource(s)	Specific species, habitats or features that warrant particular weighting or concern in the SIMA process
Socio-economic	The combination of varied social and economic factors that may be affected
Cultural	Resources that have archeological, religious or broader cultural relevance to the community

Response options	The potential options available to combat oil spills, often referred to as the response toolkit/toolbox and generally comprising dispersant application (subsea or surface), controlled in-situ burning, at-sea containment and recovery, and shoreline protection/cleanup. The options may be further subdivided by operating environment, e.g. offshore versus nearshore containment and recovery.
Response strategy	The combination of response options that are proposed or utilized to combat an oil spill. These options may evolve through an incident and vary in both time and location of their deployment.
Response technique	A specific type of response option, e.g. sediment relocation for shoreline cleanup, or J-boom configuration for at-sea containment and recovery.
VOC	Volatile organic compounds

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References and further reading

References and further reading

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Appendices

Appendix 1: Relative impact levels

IMPACT RANKINGS AND THRESHOLDS

When evaluating potential impacts as a result of an oil spill, it is often necessary to establish a scaled impact ranking system ('low' through 'high') and thresholds below which resource impacts are considered to be insignificant. For the purposes of this SIMA methodology, 'insignificant' and 'no predicted' impacts are combined under the 'none' ranking. These thresholds and rankings may be derived from previous spill observations and monitoring results, subject matter experts (SMEs) and/or literature reviews. Care should, however, be taken when using previous spill or literature data as it can be misleading. For example, aquatic toxicity derives not only from in-water oil concentrations but also from the duration of exposure. Many of the oil toxicity laboratory studies in the literature have used 48- or 96-hour exposure regimes that do not reflect real-world spill scenarios where oil concentrations often decrease rapidly over time due to natural dispersion and dilution. Such studies may, therefore, overestimate the toxicity potential of dispersing surface spills, or may underestimate it for subsea scenarios near the source where a continuing release may result in increasing concentrations.

The threshold and categorization of impacts do not need to be precise but should be reasonable and justifiable in the context they are being used. Additionally, there may be a tendency for concerned stakeholders to rank everything as 'high', but discussions should remain pragmatic and keep in mind that impact levels are relative to those predicted for other resources and are not meant to be quantitative for each compartment.

RANKING RESOURCE IMPACTS

When scaling impacts to resources for the 'no intervention' option, it is often desirable, particularly for abbreviated SIMAs, to use SMEs to qualitatively rank the potential relative impacts as 'none' (including insignificant), low, medium or high, based on their knowledge and experience. Ideally, impact rankings should also consider the significance of the impact in terms of the impact degree and extent (quantity or proportion of the resource threatened) as well as the resource recovery time or impact duration. For situations where a spill has only minor impacts on a small proportion of a resource that is able to recover from the detrimental effects relatively quickly, this would warrant a low impact ranking. Conversely, significant impacts on a large proportion of a resource that is expected to recover slowly would be ranked as having high impact.

The combination of trajectory modelling and the location of resources at risk underpins the consideration of oil exposure pathways and evaluation of the extent of potential resource impacts. The aim is to determine whether a resource is, or will be, exposed to the oil and, if so, to what degree/extent, in qualitative and/or relative terms. To that end, additional considerations for ranking relative resource impacts for the 'no intervention' option are provided below for selected resource compartments. The intent is to provide examples of a more detailed ranking process to help inform the development of scenario or spill-specific ranking criteria when applying this SIMA methodology.

The impact rankings for the various resource compartments should address and incorporate the expected time frame for the resource to recover to pre-spill conditions. A matrix (see example in Figure A1.1) may be used to combine the predicted degree and extent of impact with the recovery period to generate the overall impact ranking to be used in the SIMA's comparative matrix. The recovery period ranges in the example matrix are, however, hypothetical. Separate, resource-specific recovery period matrices will often be required.

Figure A1.1 Example of a matrix used to determine relative ecological resource impact

		Recovery period Slow ← → Rapid			
		>5 years	3–5 years	1–3 years	<1 year
Impact degree and extent	High	High	High	High	Medium
	Medium	High	Medium	Medium	Low
	Low	Medium	Low	Low	Low

Important note: The scaling used in both the rows and columns is not absolute and can be varied to meet the context of a particular SIMA. The aim is to choose scales that reasonably reflect relative levels of impact between different resources that match the local context and priorities.

Figure A1.2 Example of a matrix used to determine initial impact

		Level of exposure			
		Very high	High	Medium	Low
Percentage of regional population present	>50%	High	High	High	Medium
	20–50%	High	Medium	Medium	Low
	<20%	Medium	Low	Low	Low

In cases where reliable data concerning the population density and abundance of key ecological resources are available, it may be possible to refine the process. An additional matrix could be used to determine the 'impact degree and extent' ranking used in Figure A1.1. An example is provided in Figure A1.2, where information concerning the estimated percentage of a population within a region is factored with the level of potential oil exposure of this population. The output from this matrix is then used as an input in Figure A1.1.

WATER COLUMN IMPACTS

The degree to which aquatic species residing in the water column are impacted is generally dependent on the dissolved concentrations and toxicity of the oil's more soluble components, the sensitivity to oil of the exposed aquatic species and as the exposure duration. Lighter oils generally contain higher concentrations of the more toxic components (BTEX and 2- or 3- ring polycyclic aromatic hydrocarbons (PAH)) which, in turn, are more soluble than many of the less toxic components. Sensitivity of aquatic species to dissolved oil components varies between species and their life stage at the time of the spill. For example, most fish in their larval stage have a much higher sensitivity to oil than adult fish.

The extent of oil spill impacts on water column species is dependent on the depth, extent and temporal exposure of oil distribution/concentration, as well as the density/number of aquatic species (biodensity or biomass) within the impacted area. For surface spills the dissolved oil components are generally limited to the upper 3–5 metres of the water column and mostly remain in close proximity to the floating oil. The BTEX and PAH components are relatively volatile and can readily evaporate within a short time frame. For subsea releases the water column in the vicinity of the oil plume would likely contain elevated concentrations of dissolved oil components, diluting as the plume extends from the source.

When ranking potential impacts on the water column resource compartment, a surface spill of lighter oil that covers a large area of a water body containing early life stage aquatic species that are known to inhabit the upper few metres of the water column would likely receive a 'high' water column impact ranking. The same would be true for a subsea release of light oil where sensitive aquatic species are present at depths which may be exposed to the plume in the vicinity of the release. A 'high' ranking may also be appropriate for spills that impact a significant proportion of the population of one or more aquatic species resulting in an extended recovery period. Conversely, smaller spills of less soluble/toxic oils in areas without significant numbers of early life stage or other highly sensitive aquatic species in the impacted portion of the water column would likely receive a 'none' or 'low' impact ranking.

WATER SURFACE IMPACTS

For the purposes of this document, potential water surface impacts include those that affect any biota that inhabit the water surface and could be impacted by the spill. The biota is generally limited to seabirds, marine mammals (dolphins, whales, seals, etc.) and sea turtles but in some cases can include vegetation such as kelp or sargassum (including free-floating mats) which can provide an important habitat for a number of aquatic organisms.

Spills covering a substantial portion of the surface of a water body where large numbers of seabirds have been observed rafting on the surface, and significant numbers of marine mammals or turtles are known to inhabit the area at that time of year, could warrant a 'high' impact rating. Alternatively, smaller spills further offshore where birds, marine mammals or other surface dwelling receptors are not observed or known to frequent the area would likely be ranked with a 'none' or 'low' impact rating.

SHORELINE IMPACTS

For many marine spills, one of the primary objectives is to prevent as much of the floating oil as possible from reaching the shorelines, as the stranded oil can persist for long periods of time. Shorelines often serve as habitats for a variety of marine and coastal flora and fauna. Consequently, the focus of associated SIMAs often involves evaluating the trade-offs of the drawbacks of various response options against their potential effectiveness (benefits) in preventing or minimizing shoreline oiling. For the purposes of this document, the shoreline resource compartment is limited to ecological impacts. Socio-economic or possibly cultural impacts associated with the coast are included in those respective resource compartments.

When assessing the relative impact ranking of potential shoreline impacts for a given spill scenario, the primary considerations are the:

- presence of ecological habitats that are particularly valuable or vulnerable to oil spills;
- potential degree and extent of shoreline oiling; and
- anticipated persistence if no shoreline cleanup is conducted.

Because sandy beaches often have limited biological abundance and productivity, they typically warrant a 'low' relative impact ranking. Even though exposed, high-energy rocky shorelines generally have a diverse and productive intertidal community, they also typically receive a 'low' ranking due their resilience to oil impacts and short-term oil persistence. However, shoreline areas with highly productive estuaries/marshes, bird rookeries, fish spawning grounds, etc. and a predicted high degree of oiling and long-term persistence (typically low energy and/or sheltered areas) would generally receive a 'high' impact ranking.

SOCIO-ECONOMIC AND CULTURAL IMPACTS

Socio-economic resources can encompass a variety of activities that often include:

- commercial, recreational and subsistence fishing;
- tourism;
- recreational water sports and beach use;
- areas of spiritual or historical significance;
- commercial shipping; and
- seawater abstraction points or intakes.

For economic resources it may be possible to use estimates of financial losses incurred by a fishery or port closure, or by the tourism industry, etc. as a direct correlation to the degree of the impact. Alternatively, a surrogate measure for the significance of socio-economic impacts could be utilized to estimate the relative impact, such as total number of beach resorts oiled and fishing boats kept in port due to closures of affected fishing areas.

Regardless of what metrics are used, the relative impact ranking should be based on the significance of the aggregated potential socio-economic impacts on the affected community. If the local/regional economy is heavily dependent on commercial fishing, tourism etc., and the spill is predicted to significantly impact those industries, then a 'high' relative impact ranking may be warranted. Conversely, if the nearshore area/shorelines only experience limited recreational fishing or beach use, a 'low' ranking would likely be appropriate. Some businesses, such as desalination or power plants with water intakes, may be critical to a local population's well-being, leading to allocation of 'high' potential impact.

Cultural resources (e.g. sacred land areas, ancient buildings or artefacts) may be given very high value by the local population. If such resources exist and are of concern, the threshold for impacts may be exposure to oiling or disturbance from proposed response options and the rankings based on the potential degree or extent of each.

Care needs to be taken with how the ranking criteria for both socio-economic and cultural resource impacts are set, as they are listed alongside the ecological resource impacts when the comparative impact matrix is populated. Again there is no absolute scaling; this will be set through a judgement that takes into account the local context and priorities.

Appendix 2: Impact modification factors

Assigning impact modification factors is a critical component of the SIMA. If a response option reduces the impacts on a particular resource compartment relative to 'no intervention' then a positive number is entered whereas if the option increases the impacts, then a negative number is entered. If the degree of change is minor, moderate or major then a positive or negative 1, 2 or 3, respectively, is assigned (see Table A2.1).

The nature and degree to which each response option may modify impacts is dependent on various parameters. Table A2.2, indicates the main benefit and drawback/limitation parameters for each response option. Generally, the identified benefits will contribute to a positive mitigation and drawbacks/limitations may lead to either a reduced positive contribution, primarily due to a decrease in effectiveness, or additional impact. The extent of mitigation or additional impact is primarily derived from the response community's experience in dealing with historical spills, supported by controlled tests and field trials. Assigning impact modification factors requires significant inputs from response professionals and is dependent on the context of the scenario (including oil type and fate, spill size, weather conditions and geography).

Table A2.1 Impact modification factors

IMPACT MODIFICATION FACTOR	DESCRIPTION
+3	Major mitigation of impact
+2	Moderate mitigation of impact
+1	Minor mitigation of impact
0	No or insignificant alteration of impact
-1	Minor additional impact
-2	Moderate additional impact
-3	Major additional impact

Table A2.2 Parameters affecting impact modification factors

RESPONSE OPTION	BENEFITS	DRAWBACKS AND LIMITATIONS
At-sea containment and recovery	• Removes oil with minimal environmental impact • Effective for recovering a wide range of spilled products • Large 'window of opportunity' • Minimal collateral impacts • Greatest availability of equipment and expertise • Recovered product may be reprocessed	• Inherently inefficient and often very slow • Difficult to recover a significant percentage of the oil in larger spill cases • Inefficient and impractical on thin slicks • Decreased effectiveness in inclement weather or higher seas • May recover a high proportion of water • Requires storage capability and subsequent treatment/disposal for recovered material • Labour and equipment intensive
Controlled in-situ burning	• Rapid removal of large amounts of oil • Much less oil left for disposal • High efficiency rates (up to 98–99%)	• Black smoke perceived as a significant impact on people and the atmosphere • Limited 'window of opportunity' for spills on open water

continued ...

Table A2.2 Parameters affecting impact modification factors (continued)

<table>
<tr><th>RESPONSE OPTION</th><th colspan="2">BENEFITS</th><th colspan="2">DRAWBACKS AND LIMITATIONS</th></tr>
<tr><td>Controlled in-situ burning (continued)</td><td colspan="2">• Less equipment and labour required; specialized equipment (boom) is transportable by air
• No recovered oil storage or disposal requirements (except possibly for burn residue)
• Effective over a wide range of oil types and conditions
• Reduced vapours at the water surface through oil removal improves responder safety</td><td colspan="2">• Need to capture and contain sufficient volume of oil and increase slick thickness for in-situ burning to be effective
• Effectiveness diminishes for heavier oils and as oil weathers
• Presents a potential risk to offshore wildlife
• Burn residue can be difficult to recover (may sink from burns of very heavy oils)
• Localized reduction of air quality
• Potential for secondary fires during inland use
• Ineffective in inclement weather or high seas</td></tr>
<tr><td>Surface dispersant application</td><td>• Lower manpower and logistical requirements than other response options
• Can be applied over a broad range of weather conditions
• Higher encounter rate compared to other surface options</td><td rowspan="2">• Reaches and treats significantly more oil than other response options
• Speeds up oil removal from the water column by enhancing natural biodegradation
• Removes or reduces surface oil slicks
• Reduces the amount of oil that spreads to the shoreline
• No recovered oil storage or disposal requirements
• Reduced vapours at the water surface</td><td>• May not work on high viscosity fuel oils in calm, cold seas
• May have a limited 'window of opportunity' for use as oil weathers</td><td rowspan="2">• Does not directly collect the oil from the environment but instead disperses it into the water column where it can be biodegraded.
• Potential effects of dispersed oil on marine life dwelling in the water column (short-lived and localized exposures are anticipated)
• Potential market confidence-based economic impact on fishing industries if the public misunderstands the potential effects of dispersant on seafood</td></tr>
<tr><td>Subsea dispersant application</td><td>• Continuous operations, day and night, are possible
• Can be applied in all but very severe weather conditions
• High encounter rate</td><td>• Slower mobilization time compared to surface application</td></tr>
<tr><td>Shoreline protection</td><td colspan="2">• Can protect targeted shoreline sites when other options are not feasible or totally effective
• Equipment is often readily available and easily deployed where conditions are favourable
• More effective in sheltered waters
• Possible to develop, test and verify boom deployment configurations and equipment requirements at priority sites during contingency plan development and implementation</td><td colspan="2">• Difficult to deploy and anchor booms in strong currents
• Breaking waves reduce booms function
• Booms require regular maintenance due to tides and wind changes
• Practical limitations to length of boom that can be deployed—cannot protect large areas of coastline
• Deflects or diverts oil to other areas, if no recovery systems deployed</td></tr>
</table>

Appendix 3: Examples of comparative matrices

Appendix 3 provides four examples of comparative matrices to illustrate how the various inputs (resource compartments, response options, potential relative impacts and impact modification factors) may either vary or be adapted between scenarios to fit the context.

In each example the colour codes used for the relative impact mitigation scores are as shown in Figure A3.1.

Figure A3.1 Legend indicating the colour codes used for the relative impact mitigation scores in the comparative matrices on pages 39–42

8 to 12	Major mitigation of impact
3 to <8	Moderate mitigation of impact
>0 to <3	Minor mitigation of impact
0	No or insignificant change
>-3 to <0	Minor increase in impact
>-8 to -3	Moderate increase in impact
-12 to -8	Major increase in impact

The SIMA process described in this publication is primarily applicable to larger or higher consequence oil spill incidents or scenarios where multiple spill response options are being considered. For smaller, lower consequence spills where only one or two response options are contemplated, a formal SIMA is generally not warranted.

MARINE TERMINAL RELEASE

SCENARIO	
Location	Marine terminal within relatively sheltered inlet/estuary
Incident	Discharge hose failure
Oil type	Medium/heavy crude oil (API° 29.3, specific gravity 0.88)
Volume of release	150 m^3
Duration of release	3 minutes
Prevailing conditions	Summer conditions, maximum tidal range is 0.5 m giving maximum local currents of 0.2 ms^{-1}
Scenario setting	Spilled oil is predicted to move from the terminal to threaten adjacent estuarine and coastal shorelines within 1–2 hours. The shorelines and nearshore areas support both important ecological (saltmarsh and shallow coral) and socio-economic (power station and recreation) features.

RESOURCE COMPARTMENTS	NO INTERVENTION		CONTAINMENT AND RECOVERY		SURFACE DISPERSANT		SUBSEA DISPERSANT	CONTROLLED IN-SITU BURNING	SHORELINE BOOMING	
		Potential relative impact	Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score			Impact modification factor	Relative impact mitigation score
		A	B1	A x B1	B2	A x B2			B5	A x B5
Seabed	Low	2	2	4	-2	-4	Not feasible	Not feasible	0	0
Lower water column	None	1	0	0	0	0			0	0
Upper water column	Low	2	1	2	-2	-4			0	0
Water surface	Medium	3	3	9	3	9			0	0
Air	Low	2	0	0	0	0			0	0
Shorelines		3	2	6	1	3			1	3
Mangroves	*High*	*4*	*2*		*1*				*2*	
Sandy beaches	*Low*	*2*	*2*		*1*				*1*	
Rocky shores	*Medium*	*3*	*2*		*1*				*0*	
High value resource										
Coral reef	High	4	2	8	-2	-8			1	4
Socio-economic		4	2	8	-1	-4			2	8
Power station intake	*High*	*4*	*2*		*-1*				*3*	
Scuba diving	*High*	*4*	*2*		*-1*				*0*	
Cultural	None	1	0	0	0	0			1	1
			Total impact mitigation score:	37		0				16
			Ranking:	**1st**		**3rd**				**2nd**

SELECTING BEST OPTIONS

The matrix indicates that containment and recovery provides the highest mitigation potential. Sheltered sea conditions and summer weather are favourable to on-water recovery, and the relatively heavy oil would have reduced spreading. Recovery and storage systems would need to take into account the viscous nature of the oil. Response capability would need to be available for rapid mobilization and deployment, i.e. situated close to the terminal.

Shoreline booming brings specific benefit to the power station intake and would be focused on its protection. Consideration would be given to storing suitable booms and installing permanent anchor points at the facility. Surface dispersant is not a viable option due to its reduced effectiveness on heavier oil, and the shallow waters limiting dilution, hence there is poor likelihood of net impact mitigation.

SUBSEA OFFSHORE RELEASE

SCENARIO	
Location	Offshore exploration platform
Incident	Loss of well control
Oil type	Light crude oil
Volume of release	3,000 m^3 per day = 60,000 m^3
Duration of release	20 days
Prevailing conditions	Summer
Scenario setting	Spilled oil is predicted to migrate towards the shoreline and strand after 3 days at the earliest. The well is located in 1000 m water depth. Offshore waters are heavily used as a seabird feeding area. The shorelines support both important and varied ecological, socio-economic and cultural features.

RESOURCE COMPARTMENTS		NO INTERVENTION	CONTAINMENT AND RECOVERY		SURFACE DISPERSANT		SUBSEA DISPERSANT		CONTROLLED IN-SITU BURNING		SHORELINE BOOMING	
		Potential relative impact	Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score
		A	B1	A x B1	B2	A x B2	B3	A x B3	B4	A x B4	B5	A x B5
Seabed	Low	2	0	0	0	0	-1	-2	0	0	0	0
Lower water column	Low	2	0	0	0	0	-2	-4	0	0	0	0
Upper water column	Low	2	0	0	-2	-4	3	6	0	0	0	0
Water surface	Medium	3	1	3	2	6	3	9	2	6	0	0
Air	Low	2	1	2	2	4	3	6	1	2	0	0
Shorelines		3	1	3	2	6	3	9	1	3	0	0
Wetland	*High*	*4*	*1*		*2*		*3*		*1*		*0*	
Rocky shores	*High*	*4*	*1*		*2*		*3*		*1*		*0*	
Sandy beaches	*Low*	*2*	*1*		*2*		*3*		*1*		*1*	
Socio-economic		4	1	4	2	8	2	8	1	4	2	8
Coastal tourism	*High*	*4*	*1*		*2*		*3*		*1*		*2*	
Inshore aquaculture	*High*	*4*	*1*		*2*		*3*		*1*		*3*	
Mid-water fisheries	*Low*	*2*	*0*		*0*		*-2*		*0*		*0*	
Desalination intake	*High*	*4*	*1*		*2*		*3*		*1*		*3*	
Maritime recreation	*High*	*4*	*1*		*2*		*3*		*1*		*0*	
Cultural	Medium	3	1	3	2	6	3	9	1	3	1	3
		Total impact mitigation score:		15		26		37		18		11
		Ranking:		**4th**		**2nd**		**1st**		**3rd**		**5th**

SELECTING BEST OPTIONS

The matrix's totals indicate that subsea dispersant injection provides the highest mitigation potential; it will take some days to mobilize this response option. The application of surface dispersant provides the second highest level of mitigation and can be rapidly mobilized using both aerial and vessel systems. Therefore, dispersant application will be the primary response option. Sea conditions and weather are favourable to both controlled in-situ burning (ISB) and at-sea containment and recovery, though the scale of the release limits the mitigation potential of both options, mainly due to the encounter rate. ISB reduces vapours in the breathing zone above the water surface for both wildlife and responders. Both options would be considered as supplementary, i.e. combating oil that is not successfully dispersed. Shoreline booming brings specific benefits to the power station intake and aquaculture sites and would be prioritized towards these resources.

TANKER RELEASE

SCENARIO	
Location	Busy shipping lane, 10 km offshore
Incident	Tanker in collision with other vessel
Oil type	Light crude oil
Volume of release	700 m^3
Duration of release	1 hour
Prevailing conditions	Winter conditions, rough seas
Scenario setting	Spilled oil is predicted to migrate towards the coastline and strand within 24 hours. The coast is relatively sparsely populated but includes a national park that attracts visitors throughout the year.

RESOURCE COMPARTMENTS	NO INTERVENTION		CONTAINMENT AND RECOVERY		SURFACE DISPERSANT		SUBSEA DISPERSANT	CONTROLLED IN-SITU BURNING		SHORELINE BOOMING	
	Potential relative impact		Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score		Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score
		A	B1	A x B1	B2	A x B2		B4	A x B4	B5	A x B5
Seabed	None	1	0	0	0	0	Not feasible for a surface spill	0	0	0	0
Lower water column	None	1	0	0	0	0		0	0	0	0
Upper water column	Medium	3	1	3	-2	-6		0	0	0	0
Water surface	Medum	3	1	3	3	9		1	3	0	0
Air	Medium	3	0	0	2	6		1	3	0	0
Shorelines	High	4	1	4	3	12		1	4	2	8
High value resource											
Bird roosting	High	4	1	4	3	12		1	4	-1	-4
Socio-economic	Medium	3	1	3	3	9		1	3	2	6
Cultural	Low	2	1	2	3	6		1	2	2	4
Total impact mitigation score:				19		48			19		14
Ranking:				**joint 2nd**		**1st**			**joint 2nd**		**3rd**

SELECTING BEST OPTIONS

The matrix indicates that surface dispersant provides the highest mitigation of impacts. Other offshore options are severely limited by the rough sea conditions. Controlled in-situ burning is unlikely to be approved inshore due to safety concerns. At-sea containment and recovery will be limited to the more sheltered nearshore areas, as a supplementary on-water response option. While shoreline booming has relatively low mitigation scores, it is likely to be utilized to a limited degree where access and feasibility allow. Care would need to be taken with any shoreline operations in the vicinity of the bird roosting area, where disturbance by cleanup crews could exacerbate impacts.

SHORELINE OILING

SCENARIO	
Location	Sand beach
Incident	Stranded oil
Oil type	Medium crude oil
Volume of release	30 m^3 extending over 1 km of beach
Duration of release	Calm seas, good access to the beach
Prevailing conditions	Fresh oil has stranded along the beach in a band up to 5 m width and up to 1 cm thickness. The beach is used as a turtle nesting and seal haul out. There is a hotel and public recreation area at one end of the beach and a backshore petrified forest.
Scenario setting	For this specific location a set of feasible cleanup techniques is considered. The SIMA matrix has been adapted to compare these techniques, taking into account both their impacts (e.g. through physical disturbance or mixing oil into the sediment) and ability to remove oil and thereby promote recovery. Due to this shoreline segment representing a small geographic area, relative impacts on key individual resources of concern were assessed, rather than the resource compartments used in the previous examples.

RESOURCE COMPARTMENTS	NO INTERVENTION		MANUAL REMOVAL		DEBRIS REMOVAL		FLOODING (DELUGE)		SORBENTS		MECHANICAL REMOVAL	
	Potential relative impact		Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score	Impact modification factor	Relative impact mitigation score
		A	B1	A x B1	B2	A x B2	B3	A x B3	B4	A x B4	B5	A x B5
Invertebrates	Low	2	1	2	0	0	1	2	0	0	-2	-4
Sea turtles	High	4	2	8	1	4	2	8	1	4	-3	-12
Shore birds	Medium	3	2	6	2	6	1	3	1	3	1	3
Seal haulout	Medum	3	2	6	1	3	1	3	1	3	1	3
Recreation	Medium	3	3	9	2	6	2	6	1	3	2	6
Petrified forest	Low	2	1	2	0	0	0	0	0	0	-2	-4
			Total impact mitigation score:	33		19		22		13		-8
			Ranking:	**1st**		**3rd**		**2nd**		**4th**		**5th**

SELECTING BEST OPTIONS

The matrix indicates that manual removal provides the highest mitigation and would be adopted as the primary cleanup technique. Both debris removal and flooding (deluge) would also be considered, the former reducing and minimizing waste and the latter targeting the heaviest oil deposits. Use of sorbents would be limited due to disposal issues and mechanical removal would be avoided as it exacerbates the overall impacts and would require access through the backshore petrified forest. Once the bulk oil removal has taken place, the matrix may be revisited to assess the continued validity of the techniques and mitigation potential for lower oiling conditions.

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Through its member-led working groups and executive leadership, IPIECA brings together the collective expertise of oil and gas companies and associations. Its unique position within the industry enables its members to respond effectively to key environmental and social issues.

energy API

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IOGP International Association of Oil & Gas Producers

IOGP represents the upstream oil and gas industry before international organizations including the International Maritime Organization, the United Nations Environment Programme (UNEP) Regional Seas Conventions and other groups under the UN umbrella. At the regional level, IOGP is the industry representative to the European Commission and Parliament and the OSPAR Commission for the North East Atlantic. Equally important is IOGP's role in promulgating best practices, particularly in the areas of health, safety, the environment and social responsibility.

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