THE REPUBLIC OF LEBANON

National Oil Spill Contingency Plan in the Lebanese Waters

VOLUME B

RISK ASSESSMENT

Version 1

February 2017

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Abbreviations

API	American Petroleum Institute
EDL	Electricité Du Liban
EEZ	Exclusive Economic Zone
HFO	Heavy Fuel Oil
ICS	Incident Command System
IPIECA	Global Oil and Gas Industry Association for Environmental and Social Issues
ITOPF	International Tanker Owners Pollution Federation
JMOC	Joint Maritime Operations Centre
LOI	Lebanese Oil Installations
MARPOL	International Convention for the Prevention of Pollution from Ships 73/78
NOSCP	National Oil Spill Contingency Plan
OPRC	Oil Pollution Preparedness Response and Cooperation Convention 1990
OPRL	Offshore Petroleum Resources Law
REMPEC	Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea.

Definitions

Activate – To place a unit on an active status, to begin a process or procedure to respond to an incident.

Affected Ministry – Ministry under whose jurisdiction a spill occurs

Alert – to make another party aware.

Contingency – A resource or process put in place as part of a plan to respond to an incident which has not yet occurred.

Dispersant – a product, comprising a surfactant and solvent, designed for the purpose of promoting the dispersion of oil in water and preventing recoalescence.

Exclusive Economic Zone – The exclusive economic zone (EEZ) extends seaward to a distance of no more than 200 nautical miles (370 km) out from its coastal baseline. The exception to this rule occurs when exclusive economic zones would overlap; that is, state coastal baselines are less than 400 nautical miles (740 km) apart. When an overlap occurs, it is up to the states to delineate the actual maritime boundary. In the EEZ, the coastal State has sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources; for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds. It has jurisdiction with regard to the establishment and use of artificial islands, installations and structures; marine scientific research; the protection and preservation of the marine environment;

Flashpoint – the temperature at which oil vapors will ignite, given a source of ignition.

Governorate Shoreline Response Plan – a plan put in place by coastal governorates to support shoreline protection and clean-up activities. These plans will be in support of the Disaster Response Framework, the National Oil Spill Contingency Plan (this plan) and other local facility oils pill response plans. They will focus on logistical support, manpower, transport and waste management resources.

Lead – The entity within a Unit with primary responsibility for the Units functions

Lead Agency - The authority within the national government designated under this plan as having responsibility for response to oil spill emergencies within their jurisdiction.

Leak – any release of hydrocarbon products from damage to a vessel, pipeline, valve, tank or another oil handling infrastructure.

Maritime Public Domain of the Republic of Lebanon – this includes all marine waters within Lebanese jurisdiction including the Territorial Sea and the Exclusive Economic Zone (EEZ)

Mobilize – To assemble and move people or resources to a new purpose or location in response to an incident.

Net Environmental Benefit Analysis – the assessment of the advantages and disadvantages of different oil spill clean-up responses, including comparison with each other and with natural clean-up.

National Operations Room – the National Operations Room (NOR) is a response room established at the presidency of the Council of Ministers (COM) to respond to National Disasters and Crisis according to a defined National Response Framework (NRF) for management crisis and disasters.

Oil - means petroleum in any form including crude oil, fuel oil, sludge, oil refuse and refined products.

Oil pollution incident (oil spill) - means an occurrence or series of occurrences having the same origin, which results or may result in a discharge of oil and which poses or may pose a threat to the marine environment, or to the coastline or related interests of one or more States, and which requires emergency action or other immediate response.

Offshore unit - Any fixed or floating offshore installation or structure engaged in gas or oil exploration, exploitation or production activities, or loading or unloading of oil.

Petroleum Activities - The planning, preparation, installation and execution of activities associated with a subsea Reservoir, such as Reconnaissance, Exploration, Production and exploitation, laying pipelines, Development of Facilities, Production from Reservoirs, Transportation, as well as cessation of any such activities and decommissioning of a Facility. Transportation of Petroleum in bulk by vessel and vehicle shall not be included.

Plan Custodian – the agency or ministry with responsibility for implementation and management of the National Oil Spill Contingency Plan.

Preparedness – action taken by a state, or private company to prepare for an oil spill

Public Maritime Domain – shoreline until furthest distance that the waves reach in the winter in addition to sandy and pebbly beaches, streams and lakes that are connected directly to the sea.

Response - Any actions taken to prevent, reduce, monitor or combat oil pollution

Sea ports and oil handling facilities - Those facilities which present a risk of an oil pollution incident and includes, inter alia, sea ports, oil terminals, pipelines and other oil handling facilities.

Sectoral Center – A response center established by the Affected Ministry to support any emergency response including oil spills.

Shall – a requirement of an agency, ministry or other entity to carry out an action or task to support the contingency planning process of response actions.

Ship - A vessel of any type whatsoever operating in the marine environment and includes hydrofoil boats, air-cushion vehicles, submersibles, and floating craft of any type

Support Agency - The entity assigned to provide assistance to the Unit Lead in support of the response

Territorial Sea – The area, also known as territorial waters, includes all waters from the national baseline out to 12 nautical miles from the baseline

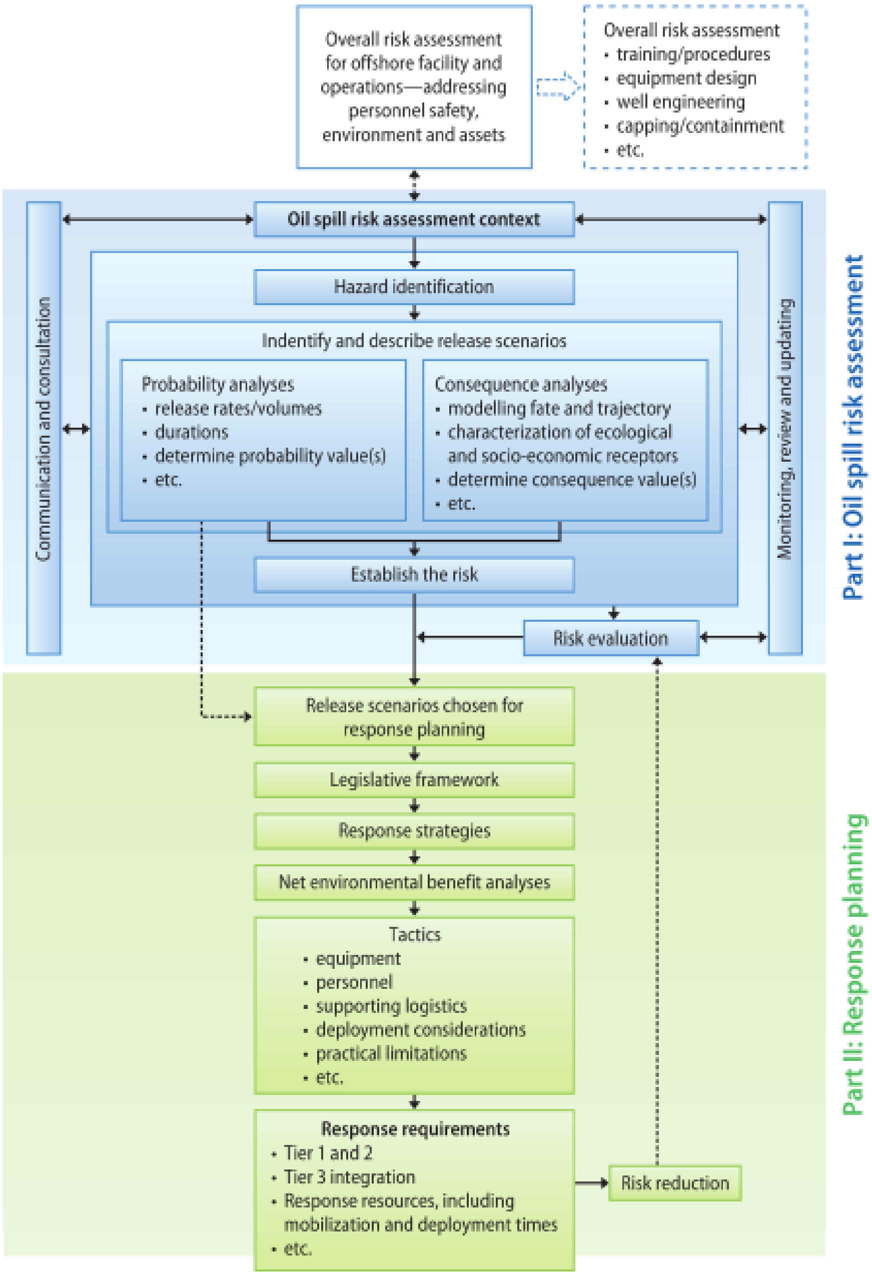
Tier – refers to the level of response required to combat a spill.

1 INTRODUCTION

Planning for any future event has inherent difficulties, particularly when it comes to oil spills, which may be relatively infrequent events. As such the Lebanese National Oil Spill Contingency Plan (NOSCP), in line with international best practice, follows a risk-based approach. The planning framework is based on identification and assessment of the risks, and then assessment of potential scenarios. Figure 1.1 below shows this process as a whole.

This volume describes the process that was carried out as part of the contingency planning process in Lebanon to identify and evaluate national risks, and then to use computer modelling to better understand the likely impacts of these risk scenarios, so that, ultimately, a response capability can be developed within the country to adequately respond to these types of events.

Figure 1.1: The contingency planning process (from IPIECA)



2 RISK ASSESSMENT

In line with the scope of the NOSCP, hazard identification and risk assessment covers threats to the marine environment from:

- Shipping activities within the Lebanese EEZ.
- Fuel import activities, including fuel storage at the coast.
- Spills originating from outside Maritime Public Domain of the Republic of Lebanon from shipping or other sources.
- Future exploration and production activities focusing on exploratory drilling.

For national strategic oil spill response planning, it is impossible to be specific in identifying hazards and response scenarios, as the location, oil types, weather, and environmental conditions cannot be predicted for all spills. Consequently, this hazard identification and risk assessment identifies the possible causes of spills. It covers the most likely events, as well as what can conceivably be envisaged as worst case in terms of possible oil types and the order of magnitude of possible volumes.

The **likelihood** of the incident occurring and **severity** of impact is then assessed (Table 2.1). In line with international best practice, this has been done qualitatively. It is clear that for non-specific scenarios and locations, this is the only approach which can be used. Each hazard is then given a risk score of likelihood multiplied by severity. Refer to Annex 1 for the details of spill hazard assessment.

Incidents from oil importing activities resulted in the highest risk scores, with a large spill from on shore oil storage tanks having a risk score of 15, whilst small operational spills had a score of 12. The impacts of tier 3 events were then assessed further through computer modelling (see Section 3).

Table 2.1: Definitions of likelihood and severity

Likelihood	
1	Remote (under 10^{-4} per year)
2	Unlikely (10^{-4} -10^{-3} per year)
3	Low (10^{-3} -0.01 per year)
4	Medium (0.01-0.1 per year)
5	Likely (0.1-1 per year)
Severity	
1	Negligible hazard to the environment
2	Minor hazard to the environment
3	Serious hazard to the environment + risk of legal action + local news
4	Major Hazard to the environment + high risk of legal action + regional news
5	Risk of catastrophic environment effects + legal action + national/international news

The risk assessment is a critical part of response planning at a national level, as well as at a local and regional level. Whilst this plan considers some of the probably worst case scenarios that may require mobilization of a national plan, it will be critical that operators and facilities carry out their own oil spill risk assessments, and, where necessary, oil spill modelling as part of their contingency planning process. Refer to Volume A for further guidance on the requirements for local and regional plans as part of this NOSCP.

3 OIL SPILL MODELLING

Oil spill modelling is used to forecast the fate and impact of an oil spill based on the properties of the oil and local prevailing conditions. It can be used as part of the contingency planning process to assist in predicting the potential impacts of spill scenarios, as well as during a response to predict the fate, weathering and potential impacts of an oil spill incident. For planning purposes, stochastic models are most widely used as they predict a geographical zone of potential impact for a spill scenario and the probability of impact for areas within that zone, along with associated timescales and potential concentrations or volumes. Each analysis uses the results of 100 runs, from which the probabilities are generated.

This plan uses the stochastic model in OilMAP (version number 6.10.3.2) to provide a statistical analysis of multiple trajectories of the same scenario simulated over a defined period of time i.e. a season or annually, using a database of historic or modelled hydrodynamic and wind data. The model used a 5-year data set for wind and currents, together with water and air temperatures generated results. For this assessment, the model was run for a minimum duration of 10 days for instantaneous releases. The blowouts were modelled for 74 days which is the estimated time to control the well plus an additional 10 days. Annex 2 gives details of the data used for the modelling.

The results of the modelling, in conjunction with sensitivity mapping (Volume D), are used to evaluate environmental and socio economic risks, both for planning scenarios, and in the event of a spill event. Modelling requirements for a spill in Lebanese waters will be managed by CNRS, through their remote sensing center, with support from other academic institutions.

As with all modelling software the results will depend on the quality of the data used to simulate environmental conditions; as well as the knowledge and experience of the individual manipulating the software and interpreting the results. When assessing model results, consideration should be given to its limitations and the inherent difficulties with predicting oil fate processes. Details of the modelling parameters used are given in Annex 2.

3.1 Objectives

As modelling is time consuming, and as, particularly at a national level, it is impossible to model all possible parameters, a range of scenarios have been selected to support the planning process in Lebanon. These are based on the results of the hazard identification and risk assessment and given in Table 3.1 below.

The objectives of the modelling exercise were:

1. To determine the impact of a worst case oil spill from a shipping incident in Lebanese waters, i.e. identify resources at risk.
2. To determine the impact of a worst case oil spill from exploration and production activities offshore Lebanon, i.e. identify resources at risk.
3. To determine the likelihood of a shoreline impact from worst case oil spills from Lebanon EEZ and the probability of oiling in sensitive areas.
4. To determine the time for shoreline impact and make an estimation of a likely time window for dispersant application from an incident offshore.

5. To determine the likelihood and impact of spills from outside Lebanese territorial waters impacting Lebanese shorelines.
6. To determine the likelihood of large spills impacting neighboring EEZ and country shorelines.

Table 3.1: Modelling scenarios

	Incident Type	Justification	Oil type	Location	Season	Oil Quantity
LEBANESE WATERS	Major leak from onshore storage tanks	Highest risk score of 15. The worst case location and oil type should be selected.	Heavy fuel oil	Zouk	Annual	50,000 tonnes
	Major shipping incident (inbound ship, close to shore)	Risk score high at 10. Worst case location and oil type.	Heavy fuel oil (test runs with lighter product)	Tripoli Zouk Zahrani	Annual	50,000 tonnes
	Major leak of condensate from offshore drilling (near to shore) blowout	Medium risk score of 8. A block close to shore would be considered the worst case scenario.	Condensate	South North	Annual	20,00 tonnes per day for 64 days
	Major leak of crude oil from offshore drilling (near to shore) blowout.	Medium risk score of 8. A block close to shore would be considered the worst case scenario.	Crude (API 24.8, ITOPF Group 3)	Central	Annual	20,00 tonnes per day for 64 days
OUTSIDE LEBANESE WATERS	Major shipping incident	After a land based spill, this is the highest score incident for spills from outside Lebanese Waters. Severity 4.	Azeri Crude (API 36.8 ITOPF Group 2)	En-route to Haifa, just outside EEZ	Annual	150,000 tonnes
	Spill from offshore drilling in waters of neighbouring countries to the South	After a land based spill, this is the highest score incident for spills from outside Lebanese Waters. Severity 4.	Test runs were undertaken. Currently only gas in these countries so this scenario was discounted for further analysis			

The scenarios and parameters selected were considered in order to represent the most likely and worst case conditions; however, there are some constraints of the modelling process that were considered:

- The dataset used is offshore data and will not take into consideration nearshore and shoreline currents and conditions. These are likely to be influenced by a variety of factors e.g. changes in water depth, temperature, water inflow, topography etc. and may be very different from conditions offshore. For this reason, only one of the coastal scenarios, namely a spill from an onshore storage facility from Lebanon, has been selected as it was considered that little reliable information can be deduced from the results and therefore they are indicative of scale only.
- To support national level strategic oil spill planning, it is not considered necessary, or possible, to run oil spill models at all potential spill locations. Therefore, the locations that were selected either represented the worst case scenario, or in the case of the onshore terminals, represented a geographical spread north (Tripoli), central (Zouk) and south (Zahrani).
- Using test scenarios, the modelling team deduced that there was little seasonal variation in results and therefore an annual average has been used. Similarly, it was determined that there was little impact of seasonal variations in water temperature and so an average temperature of 22^0C was used.
- Using test runs for the blowout scenario, the modelling team deduced that the impacts were worse if the spill was initiated from a surface, as opposed to a sub-surface location. Therefore, although a blowout may be subsea, this scenario has been modelled as a surface release.
- Oil types were not always specific to the regions, with similar oils selected as necessary.
- The model set up only allowed modelling 10 km outside of Lebanese EEZ. Therefore, only one scenario, that of a large shipping incident, was modelled outside waters. It was not considered beneficial to model incidents from offshore installations from bordering EEZ as all wells are currently gas only.

3.2 Results

This section presents the modelling results for 8 scenarios, including marine and shoreline impact, key environmental and socio-economic sensitivities, and the proposed response strategy.

As with all predictive modelling there are limitations and whilst the best quality data available has been used (see annex 2 as further data acquired, particularly with respect to coastal currents, becomes available these models should be revisited. Similarly in the event of a spill specific local conditions should be taken into account when running the models to assess likely impacts of real spills.

Key: **Source =** Source control, **Monitor** = Monitor and evaluate, **C&R** = Containment and recovery, **Disp** = Dispersant, **ISB** = In-situ burn, **Protect** = Protection of priority areas, **Shore** = Shoreline clean-up.

3.2.1 Scenario 1: Well blowout of condensate in the North

Scenario Reference: BO_02.
Incident: Well blowout of condensate, north.

Impacts:

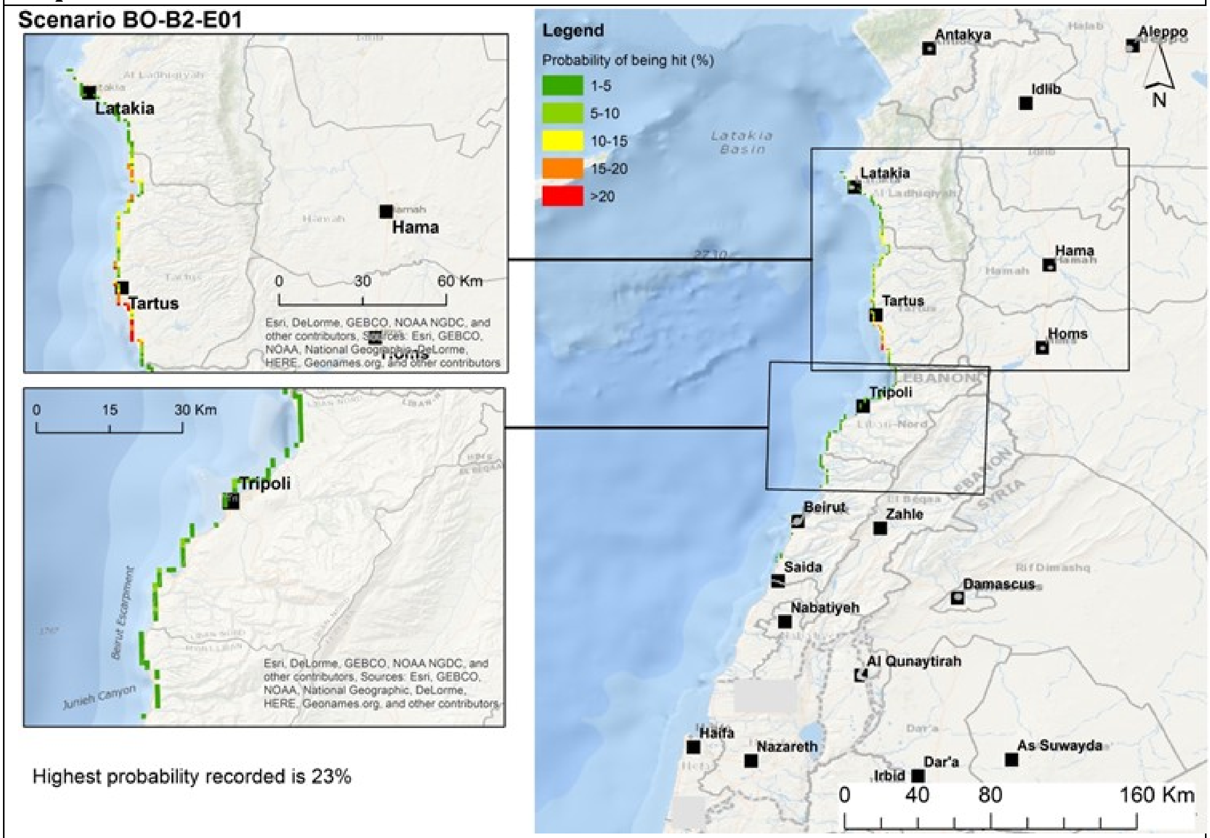


Figure 3.1: Assessment of shoreline impact of Scenario 1

Area of Shoreline Impact (Figure 3.1)	The modelling shows potential shoreline impact from approximately 40km south of Tripoli to Latakia (Syria) in the north. There is also a small area of potential impact to the north of Saida. In Lebanon the probability of shoreline impact is low, typically below 5%, with small areas with a 5-10% risk. There is a higher probability of shoreline oiling to the south of Tartus in Syria, where probabilities rise to above 20% for approximately a 10km stretch of coastline. The maximum probability recorded is 23%.

	Shoreline types impacted are varied, from rocky cliffs, to sandy beaches and rocky rip rap. Assessment of the shoreline typology shows that the following shoreline types maybe impacted: • Rocky shores – exposed, sheltered, wave cut platforms. • Sand and gravel beaches – fine, medium and mixed sand and gravel beaches. • Rip rap – manmade rocky areas installed as a sea defense. • Manmade structures – exposed and sheltered. • Cliffs • Tidal flats. Sensitivity mapping can be found in Volume D of this plan.
Area of Marine Impact – surface oiling	This scenario is close to the north EEZ border, and with currents and prevailing winds running from south to north, there is a high probability, 75-100% chance, that oil will cross into Syrian waters. International notification procedures will therefore be required. Total area of the highest probability of oiling, 75-100%, is 854 km². See Figure 3.2**.**

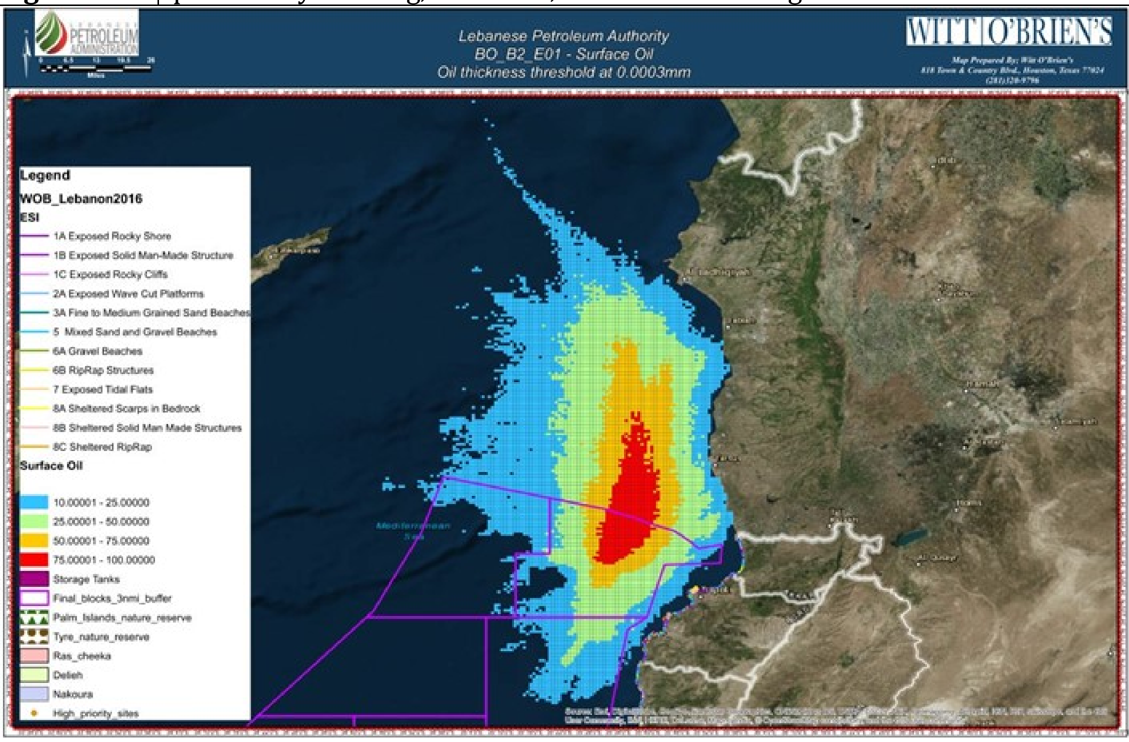


Figure 3.2: Surface oiling from Scenario 1

Key sensitivities **Environmental and socio-economic.**	**Protected Areas:** There is a low probability, i.e. below 10%, of the oil reaching the Marine Nature Reserve of Palm Islands, and the proposed coastal protection sites of: • Areeda Estuary • Enfeh Peninsula • Ras El Chekaa cliffs • Batroun Phoenician wall • Medfoun rocky area • Byblos • Nahr Ibrahim estuary • Beirut Port outer platform **High Priority Sites:** There are 10 high priority sites in the potential impact area, namely: • Terraces of Al Mina (ecological)

<table>
<tr><td></td><td colspan="7">• Salinas - wall promenade and our lady of Natour monastery (ecological and cultural)
• Ras Enfeh (ecological and cultural)
• Promontory cape and cliffs of Ras Chaqaa and Saydet El Nouriyeh Monastery (ecological and cultural)
• Selaata terraces (ecological)
• Historical center and fishing harbor of Batroun.
• Medfoun rocky area (ecological)
• Beaches to the south and north of Jbail (Jbail-Amshit) (ecological).
• Nahr el Kelb historical site and estuary (ecological and cultural).

Birds: Birds are likely to be threatened along the whole coastline. The Palm Nature Reserve is of international importance for birds (a RAMSAR site).

Ports: Tripoli is one of the largest ports in Lebanon. In addition, a number of small fishing or recreational harbors and marinas have a low probability of oiling. These include Batroun, Kfar Aabida, Jbail, Sarba and Bourj Hammound/Dora Port.

Fisheries: A 500m fisheries restricted zone extends from the shoreline along the entire Lebanese coastline. In addition specific aquaculture sites maybe impacted.

Key tourist sites: There are numerous tourist sites between Tripoli and Beirut; of note are the areas around Jounieh, Safra and Halat.

Coastal historical sites: There are a small number of coastal historical sites in this area, however it is unlikely that they will be impacted physically by oiling unless on the beach. These sites include Jbeil and Kesrouane.

Power plants: Deir Amar, Al Hraiche, Zouk</td></tr>
<tr><td>Response Strategy</td><td>Source
✓</td><td>Monitor
✓</td><td>C&R
✗</td><td>Disp
✗</td><td>ISB
✗</td><td>Protect
✓</td><td>Shore
✓</td></tr>
<tr><td>Oil Type</td><td colspan="7">This scenario has been run with condensate. This is a very light product with a specific gravity around 0.75 and very high evaporation rates, typically 100% will evaporate within 24 hours.</td></tr>
<tr><td>At Sea</td><td colspan="7">Dispersant use: Due to the high rates of evaporation of condensate, there is no net environmental benefit (NEB) in treating with dispersants.

Containment and recovery: Condensate is largely unsuitable for containment and recovery due to safety issues. It has low viscosity, which means it makes a very thin layer on the surface, and easy fragmentation of the slick is expected.</td></tr>
<tr><td>Shoreline</td><td colspan="7">Shoreline impact (Figure 3.3): First oiling is likely to be over the border in Syria, where oil may reach the shoreline between 48 and 120 hours (2-5 days) to the south of Tartus. There are three potential sites in Lebanon where oil is showing to hit first, with a time to beaching of between 120 and 240 hours, i.e. between 5 and 10 days. This would give ample time to mobilize resources to these areas and prepare for shoreline clean-up. The techniques to be used would depend on shoreline type. However, with a</td></tr>
</table>

	condensate, techniques are likely to be passive and safety of the public will be of prime importance.

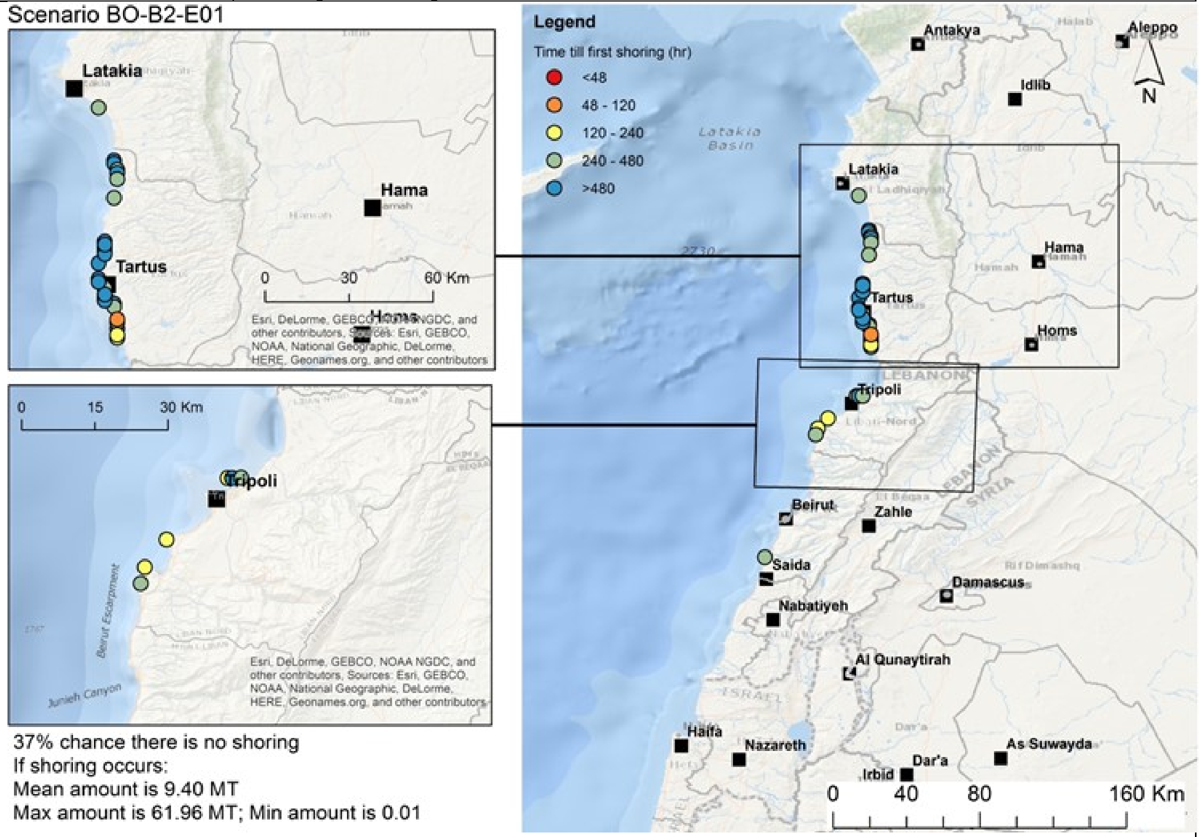


Figure 3.3: Time to shoreline impact for Scenario 1

3.2.2 Scenario 2: Well blowout of crude oil in the Center

Scenario Reference: BO_04
Model Parameters: Well blowout crude, central.

Impacts

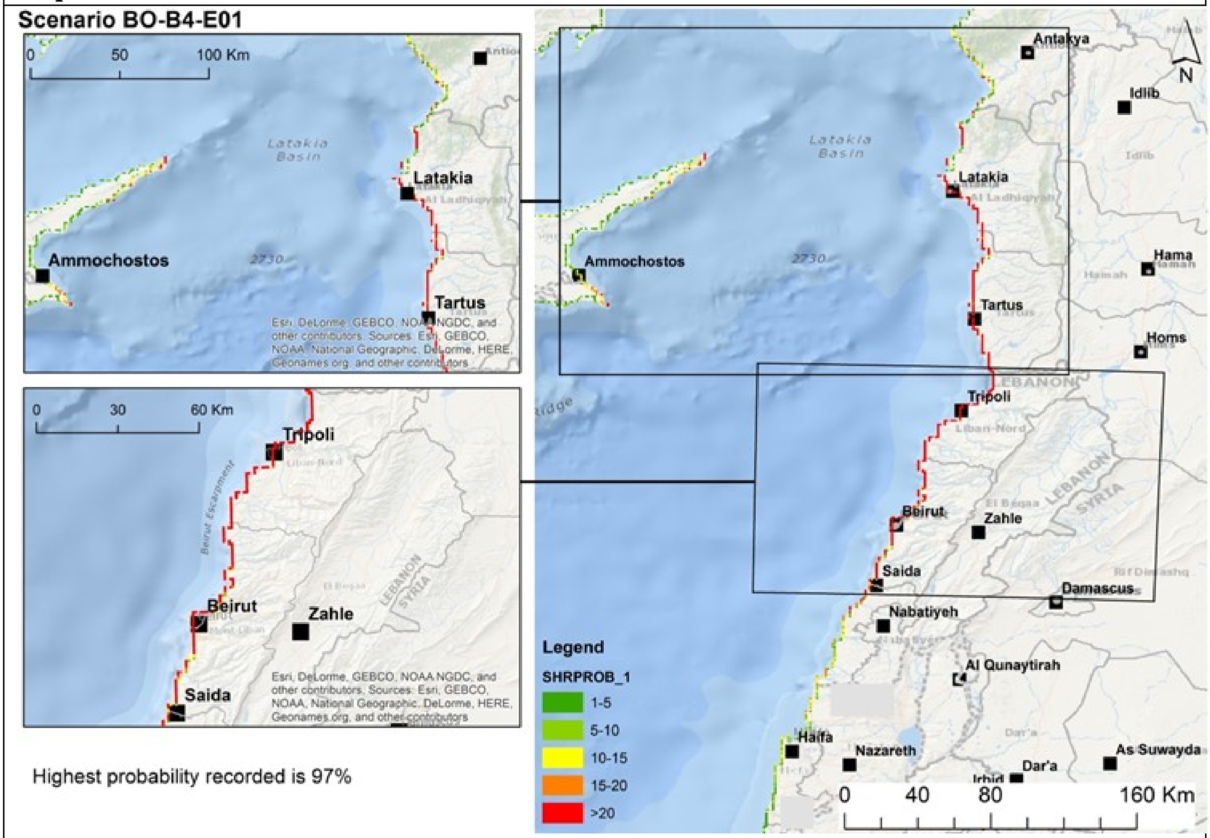


Figure 3.4: Assessment of shoreline impact of Scenario 2

Area of Shoreline Impact (Figure 3.4**)**	The modelling shows a large potential shoreline impact stretching along the entire Lebanese coastline and crossing country borders to the north, south as well as impacting Cyprus to the west. The highest probabilities, over 20% of shoreline impact, are from Saida in Lebanon to Latakia in Syria. Areas to the south of Saida have a much lower probability, below 10%. The highest probability recorded was 97%. As this spill scenario potentially impacts the whole coastline all shoreline types are at risk. These vary from rocky cliffs to sandy beaches and rocky rip rap.
Area of Marine Impact – surface oiling	In this scenario, the oil source is a location approximately mid way along the Lebanese coast. It is an ongoing spill of a relatively heavy crude and, therefore, the impacts would be the most significant of all the scenarios. The results show that there is a high chance, 75-100%, that oil will cross the northern EEZ boundary. Total area of oiling, for the highest probability of 75-100%, is 5044 km^2. See Figure 3.5.

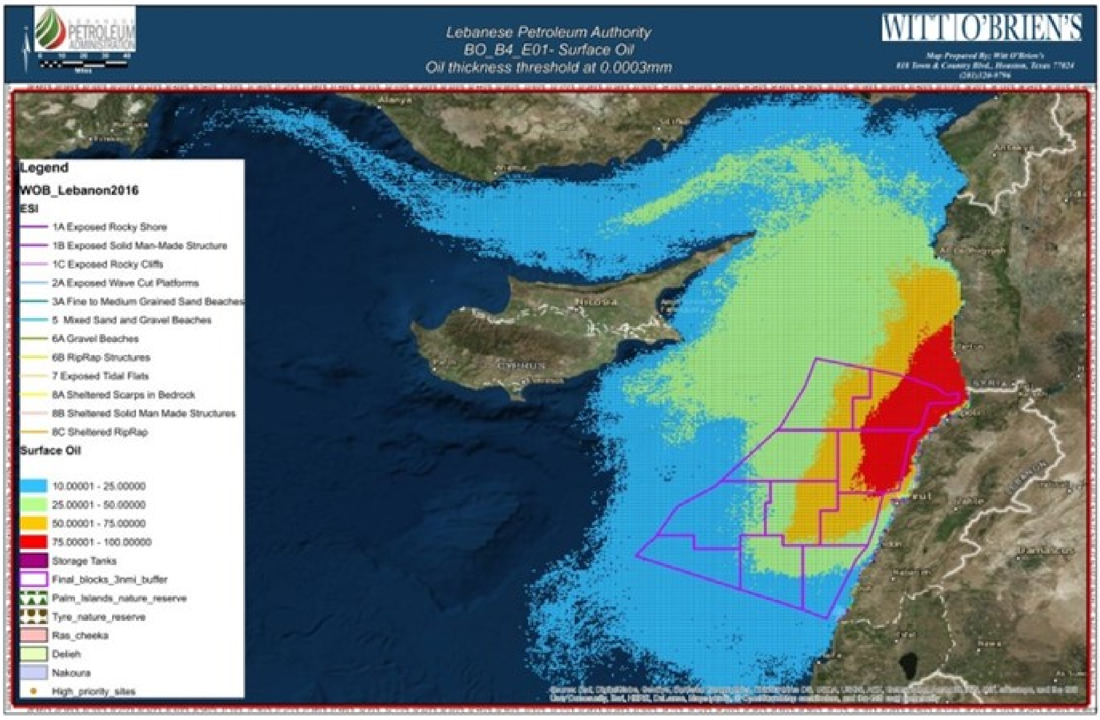


Figure 3.5: Surface oiling from Scenario 2

Key sensitivities

Environmental and socio-economic

As the whole coastline is potentially impacted by this spill scenario, only shoreline with the higher probabilities of above 20% are considered here.

Protected Areas: There is a significant chance of oil reaching, the Marine Nature Reserve of Palm Islands, and the proposed coastal protection sites of:

- Areeda Estuary
- Enfeh Peninsula
- Ras El Chekaa cliffs
- Batroun Phoenician wall
- Medfoun rocky area
- Byblos
- Nahr Ibrahim estuary
- Beirut Port outer platform
- Raoucheh cliffs and caves
- Damour estuary
- Awally estuary

High Priority Sites: There are 12 high priority sites in the potential impact area, namely:

- Terraces of Al Mina (ecological)
- Salinas - Wall promenade and our lady of Natour monastery (ecological and cultural)
- Ras Enfeh (ecological and cultural)
- Promontory cape and cliffs of Ras Chaqaa and Saydet El Nouriyeh Monastery (ecological and cultural)
- Selaata terraces (ecological)
- Historical center and fishing harbor of Batroun
- Medfoun rocky area (ecological)
- Beaches to the south and north of Jbail (Jbail-Amshit) (ecological)

<table>
<tr><td></td><td colspan="7">• Nahr el Kelb historical site and estuary (ecological and cultural).
• Sandy beach of Ramlet el-Baida in Beirut
• Damour river estuary
• The sea castle of Saida and underwater city, sea façade and old harbor

Birds: Birds are likely to be threatened along the whole coastline. The Palm Nature Reserve is of international importance for birds (a RAMSAR site).

Ports: Tripoli is one of the largest ports in Lebanon, further south Beirut Port also has a greater than 20% chance of oil beaching. In addition, a number of small fishing or recreational harbors and marinas may be impacted. These include Batroun, Kfar Aabida, Jbail, Sarba and Bourj Hammound/Dora, Minet el Hosn, and Saida ports

Fisheries: A 500m fisheries restricted zone extends from the shoreline along the entire Lebanese coastline. In addition specific aquaculture sites maybe impacted.

Key tourist sites: There are numerous tourist sites between Tripoli and Beirut. Of note are the areas around Jounieh, Safra and Halat. To the south, notable areas include Jiyeh and Jadra.

Coastal historical sites: There are a number of coastal historical sites along the coastline. In the region where the probability of oiling is about 20%, sites of interest are in Jbail, Jounieh, and Kesrouane.

Power plants: Deir Amar, Al Hraiche, Zouk Jiyeh.</td></tr>
<tr><td>**Response Strategy:**</td><td>Source
✓</td><td>Monitor
✓</td><td>C&R
✓</td><td>Disp
✓</td><td>ISB
✓</td><td>Protect
✓</td><td>Shore
✓</td></tr>
<tr><td>**Oil Type**</td><td colspan="7">This scenario has been run with a relatively heavy crude oil (API 24.8), ITOPF group 3. Although there would be some evaporation from this oil, it could also be expected that the volume would increase due to emulsification.</td></tr>
<tr><td>**At Sea**</td><td colspan="7">**Dispersant use:** Whilst fresh, it is possible that this oil may be amenable to dispersants. However, it is likely to weather and become viscous through rapid emulsification in the marine environment. Therefore, the window of opportunity for dispersant application will be reduced.

Containment and recovery: A containment and recovery operation will be possible with specialized booms and skimmers. Offshore oil storage will be required, as well as a process to deal with recovered oil and oily water. It should be noted that it is virtually impossible to contain all oil at sea, and a recovery rate of 5-10% would be considered exceptional.</td></tr>
<tr><td>**Shoreline**</td><td colspan="7">**Shoreline impact (**Figure 3.6**):** First oiling is likely to occur on the Lebanon-Syria border with the minimum time to shore shown as 33 hours. The areas first likely to be oiled are to the south of Tripoli, where oil typically beaches between 5 and 10 days. This would give ample time to mobilize resources to these areas and prepare for shoreline clean-up. However, the model showed that significant quantities of oil would</td></tr>
</table>

	beach, amounting to a mean quantity of 8487 tonnes. This represents a significant shoreline impact, requiring significant resources. The techniques to be used would depend on shoreline type.

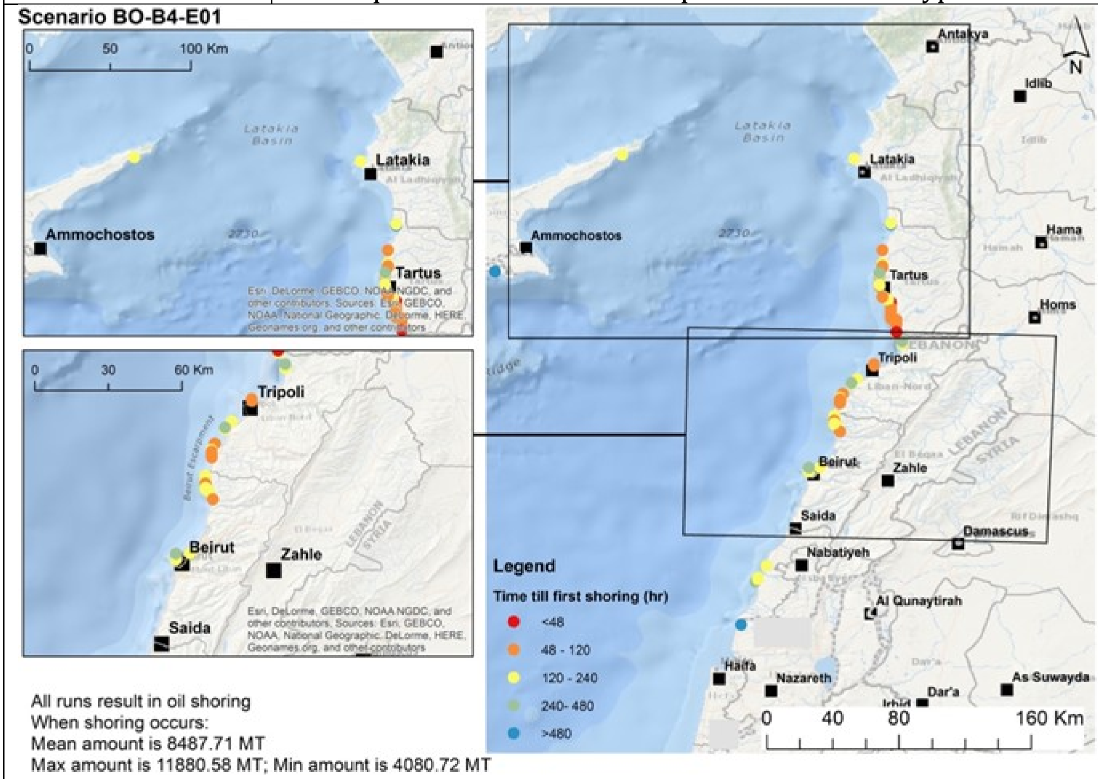


Figure 3.6: Time to shoreline impact for Scenario 2

3.2.3 Scenario 3: Well blowout of condensate in the South

<table>
<tr><th colspan="2">Scenario Reference: BO_09
Model Parameters: Well blowout condensate, south</th></tr>
<tr><td colspan="2">Impacts</td></tr>
<tr><td colspan="2">

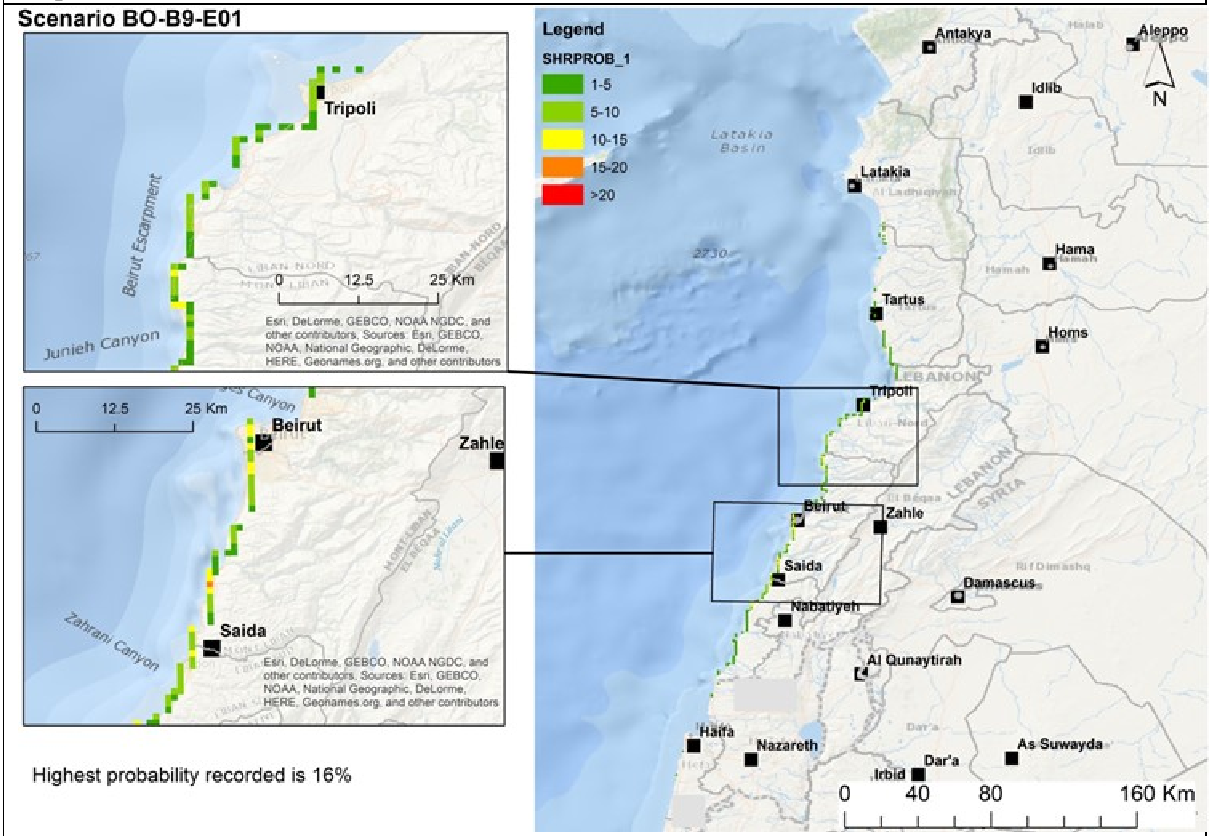


Figure 3.7: Assessment of shoreline impact of Scenario 3

</td></tr>
<tr><td>Area of Shoreline Impact (Figure 3.7)</td><td>The modelling shows potential shoreline impact for the majority of the Lebanese coastline, reaching Tartus in Syria to the north. However, the probabilities are generally low, below 10%, with a maximum recorded probability of just 16%. The coastline between Beirut and just south of Saida shows slightly increased probabilities of up to 15%, which are considered for assessment here.

Shoreline types impacted are varied, from rocky cliffs, to sandy beaches and rocky rip rap. Assessment of the shoreline typology shows the following shoreline types maybe impacted:
Rocky shores – exposed, sheltered
Sand and gravel beaches – fine, medium and mixed sand and gravel beaches
Rip rap – manmade rocky areas installed as a sea defense
Manmade structures – exposed and sheltered
Cliffs</td></tr>
<tr><td>Area of Marine Impact – surface oiling</td><td>This scenario is from a location to the south of the EEZ. With prevailing winds and currents pushing oil to the north, there is only a relatively low probability, a 10-25% chance, that oil will cross the international boundary to the south. Total area of oiling at the highest probability, 75-100%, is 509 km². See Figure 3.8.</td></tr>
</table>

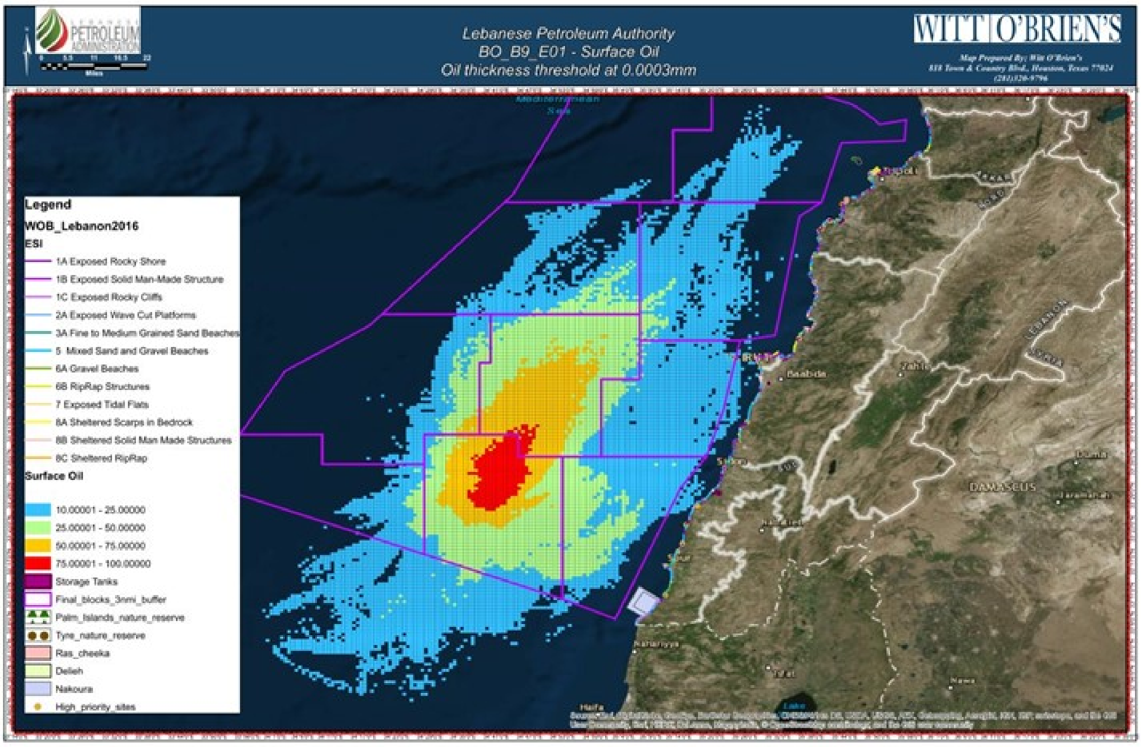


Figure 3.8: Surface oiling from Scenario 3

Key sensitivities **Environmental and socio-economic.**	**Protected Areas:** There is a low probability, i.e. below 10%, of the oil reaching the Marine Nature Reserve of Palm Islands, and the proposed coastal protection sites of Dalieh, Raoucheh cliffs and caves, Damour estuary, and Awally estuary. **High Priority Sites:** There are 3 high priority sites in the potential impact area, namely: • Ramelt el-Baida (ecological) • Damour estuary (ecological) • The sea castle of Saida, underwater city, sea façade and old harbor. (cultural) **Birds:** Birds are likely to be threatened along the whole coastline. **Ports:** Together with Tripoli, Beirut is the main port in Lebanon, with Saida port also handling commercial vessels as well as small fishing and recreational vessels. **Fisheries:** A 500m fisheries restricted zone extends from the shoreline along the entire Lebanese coastline. In addition specific aquaculture sites maybe impacted. **Key tourist sites:** There are numerous tourist sites between Beirut and Saida. Of note are areas around Khaldeh to the south of Beirut, beaches around Jiyeh, and Jadra further south. **Coastal historical sites:** There are a small number of coastal historical sites in this area. However, it is unlikely that they will be physically impacted by oiling, unless on the beach. Of note is the Saida sea castle. **Power plants:** Jiyeh.

Response Strategy:	Source ✓	Monitor ✓	C&R ✗	Disp ✗	ISB ✗	Protect ✓	Shore ✓
Oil Type	This scenario has been run with condensate. This is a very light product with a specific gravity of around 0.75 and very high evaporation rates. Typically, 100% will evaporate within 24 hours.						
At Sea	**Dispersant use:** Due to the high rates of evaporation of condensate, there is no net environmental benefit (NEB) in treating with dispersants. **Containment and recovery:** Once again, condensate is largely unsuitable for containment and recovery due to safety issues, as well as due to its low viscosity, making a very thin layer on the surface, and allowing easy fragmentation of the slick.						
Shoreline	**Shoreline impact (**Figure 3.9**):** First oiling is likely to be around Saida, with a further 3 sites along the coast which showed a time to first oil of between 5 and 10 days. This would give ample time to mobilize resources to these areas and prepare for shoreline clean-up. The techniques to be used would depend on shoreline type, however with a condensate techniques are likely to be passive and of prime importance will be safety of the public.						

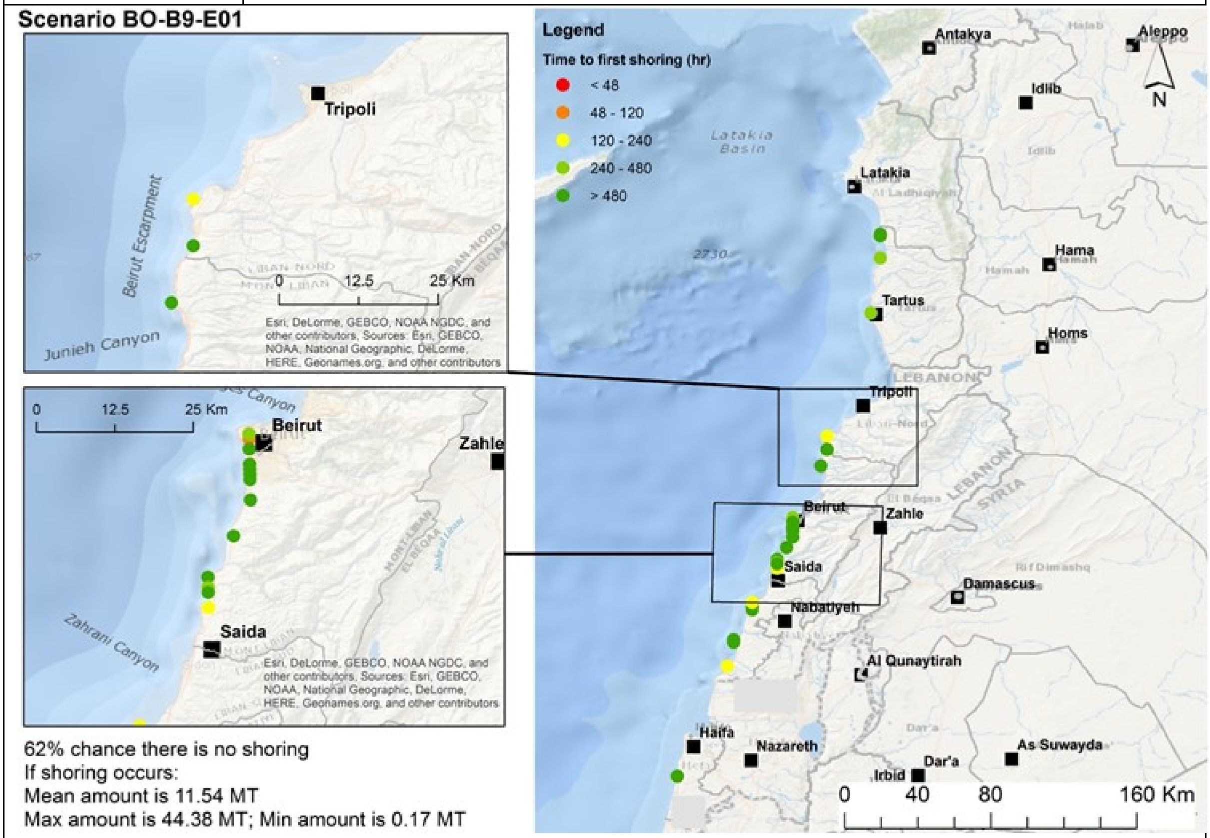


Figure 3.9: Time to shoreline impact for Scenario 3

3.2.4 Scenario 4: Oil release from storage tanks at the Zouk Terminal

Scenario Reference: ST_ZO
Model Parameters:

Impacts

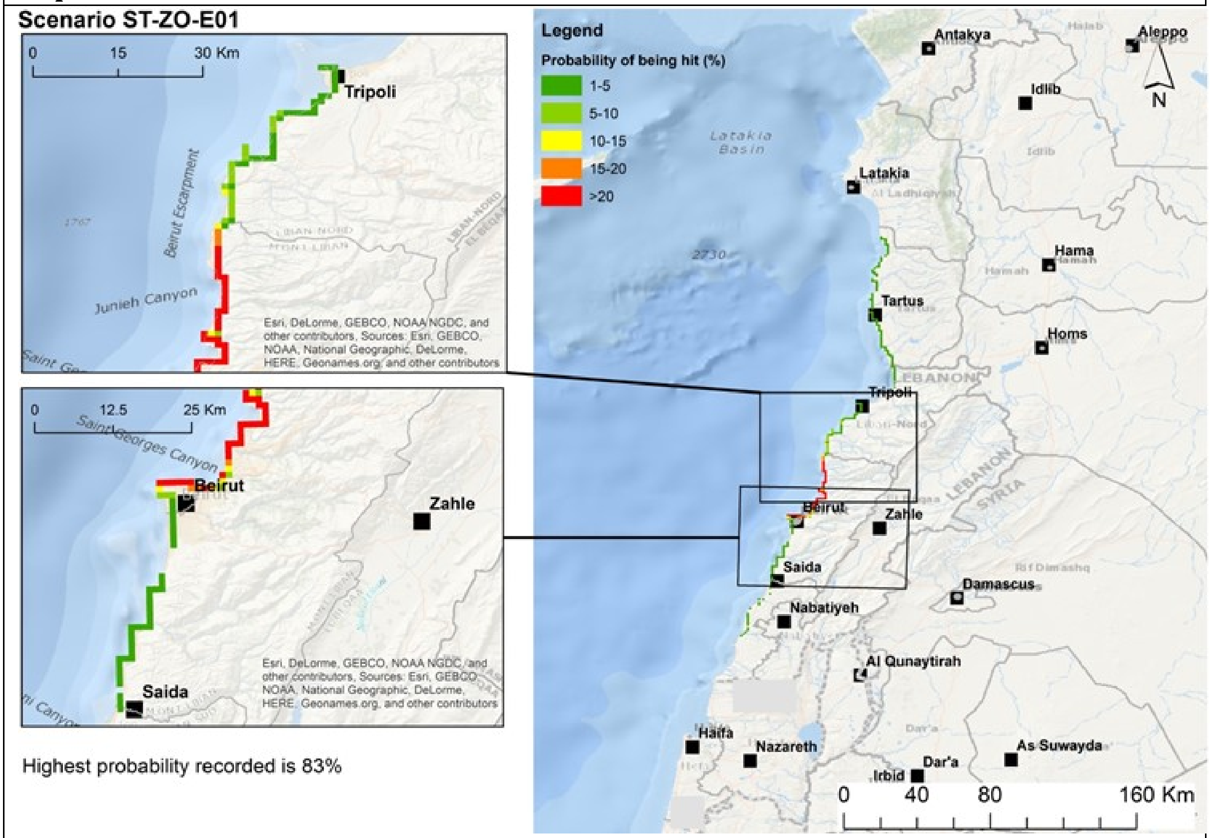


Figure 3.10: Assessment of shoreline impact of Scenario 4

Area of Shoreline Impact (Figure 3.10)	This scenario models the release of oil from the storage tanks at the Zouk terminal to the north of Beirut. As this is a land-based source, shoreline impact would be a certainty. However, areas of significant oiling should be relatively limited. Indeed, the model shows that the greatest probabilities of oiling, greater than 20%, are over a 40-50km section of coastline. Overall, the model shows possible beaching from south of Saida in the south of Lebanon and then over the border to the north into Syria. Shoreline types impacted are varied from rocky cliffs, to sandy beaches and rocky rip rap. Assessment of the shoreline typology shows that the following shoreline types maybe impacted: • Rocky shores – exposed, sheltered, wave cut platforms. • Sand and gravel beaches – fine, medium and mixed sand and gravel beaches. • Rip rap – manmade rocky areas installed as a sea defense. • Manmade structures – exposed and sheltered. • Cliffs • Tidal flats.
Area of Marine Impact – surface oiling	This scenario is from an onshore source. Due to the proximity to the shoreline, there is only a relatively small area of high probability surface oiling as much of the oil is likely to beach. Oil does not cross international boundaries. Total area of oiling at the highest probability, 75-100%, is 6 km^2. See Figure 3.11.

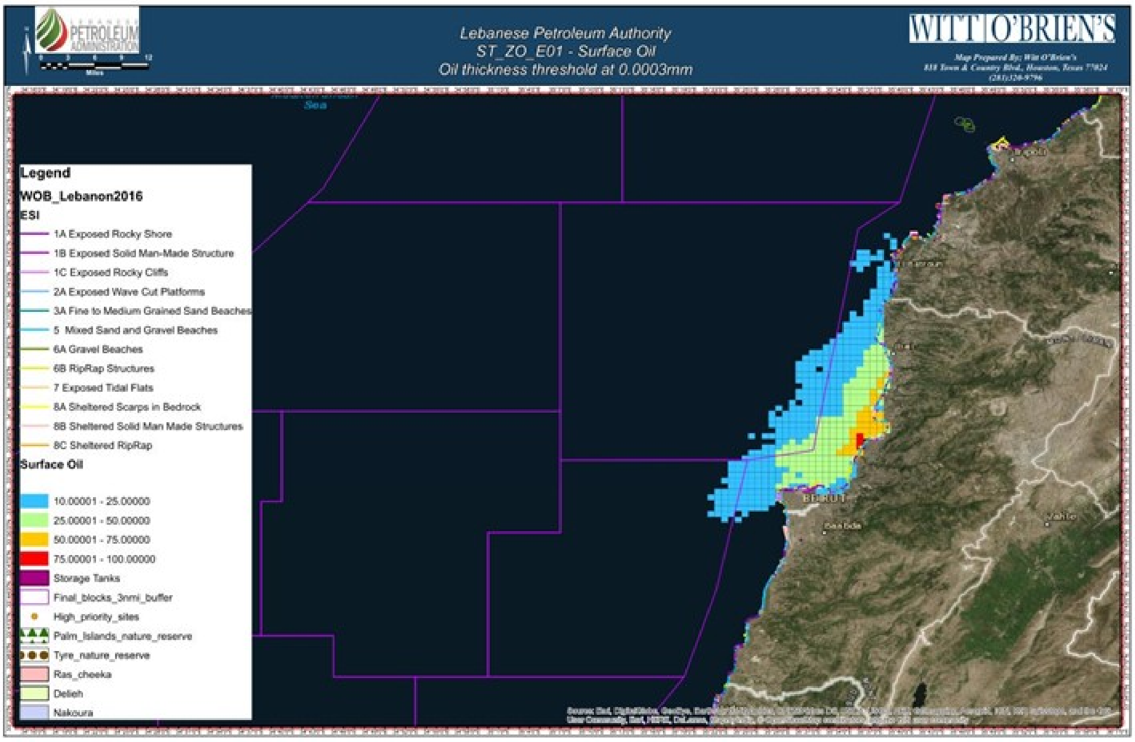


Figure 3.11: Surface oiling from Scenario 4

Key sensitivities **Environmental and socio-economic.**	As there is a clear area of higher probability (greater that 20%) which is close to the source of the spill, this area only is considered for assessment here. **Protected Areas:** The proposed marine protected areas of Beirut Port outer platform, Nahr Ibrahim estuary, Byblos, and Medfoun rocky area are at risk. **High Priority Sites:** There are 4 high priority sites in the potential impact area, namely: • Ramlet el-Baida (ecological) • Nahr el Kelb historical site and estuary (ecological and cultural) • Jbeil beaches (ecological) • Medfoun rocky area (ecological) **Birds:** Birds are likely to be threatened along the whole coastline. **Ports:** There is a probability greater than 20% of Beirut port being impacted by this spill scenario: In addition, a number of small fishing or recreational harbors and marinas may be impacted. These include Dora port, Sarba and Jbeil harbors **Fisheries:** A 500m fisheries restricted zone extends from the shoreline along the entire Lebanese coastline. In addition specific aquaculture sites maybe impacted. **Key tourist sites:** There are numerous tourist sites between Tripoli and Beirut. Of note are the areas around Jounieh, Safra and Halat. To the south notable areas include Jiyeh and Jadra.

<table>
<tr><td></td><td colspan="7">Coastal historical sites: There are a number of coastal historical sites along the coastline. In the region where the probability of oiling is about 20%, sites of interest are in Jbail, Jounieh, and Kesrouane.

Power plants: Zouk.</td></tr>
<tr><td>Response Strategy:</td><td>Source
✓</td><td>Monitor
✓</td><td>C&R
✗</td><td>Disp
✗</td><td>ISB
✗</td><td>Protect
✓</td><td>Shore
✓</td></tr>
<tr><td>Oil Type</td><td colspan="7">This scenario has been run with heavy fuel oil (API 11.5), making it an ITOPF group 4 oil. This oil is very persistent and, given the proximity to shore, an active shoreline clean-up will be key. Oil will be ashore in the areas to the north of Zouk (Beirut) within 48 hours which gives little time to prepare operations. Close to the terminal this will be immediate.</td></tr>
<tr><td>At Sea</td><td colspan="7">Dispersant use: Heavy fuel oil is generally not suitable for dispersants as its viscosity prevents the solvent breaking the interfacial tension. In addition, the relatively shallow water depths would exclude the use of dispersants due to the adverse impact to the biological environment.

Containment and recovery: A containment and recovery operation will be possible with specialized booms and skimmers. Specialized equipment will be necessary for recovery. Offshore oil storage will be required, as well as a process to deal with recovered oil and oily water. Stopping the source of the spill on land and ensuring that no further oil can enter the marine environment will dramatically minimize impacts.</td></tr>
<tr><td>Shoreline</td><td colspan="7">Shoreline impact (Figure 3.12): As this is a land based source, oil will be instantly on the shoreline. Where possible, everything should be done to stop oil at source and limit the movement of oil away from the shoreline, as this will limit its spread. Modelling shows that the oil would impact the areas with the highest probabilities of oiling within 48 hours. The mean quantity of oil to beach at a location is approximately 3000 tonnes. The fast response of the shoreline response teams will be key to effective clean-up. The techniques to be used would depend on shoreline type. However, heavy fuel oil will generally require a mechanical clean-up due to its viscosity and persistence.</td></tr>
</table>

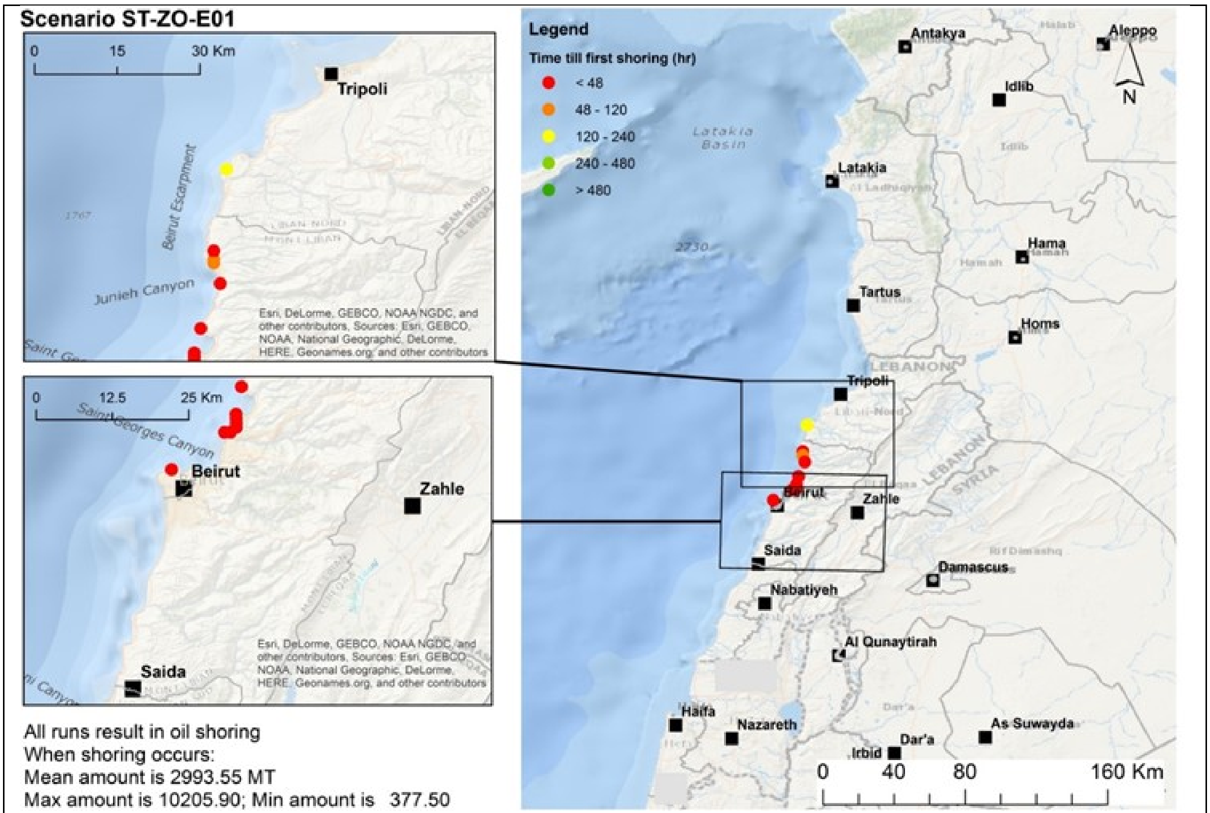


Figure 3.12: Time to shoreline impact for Scenario 4

3.2.5 Scenario 5: Oil spill outside of the Lebanese Waters

Scenario Reference: TA_ISR **Model Parameters:**
Impacts

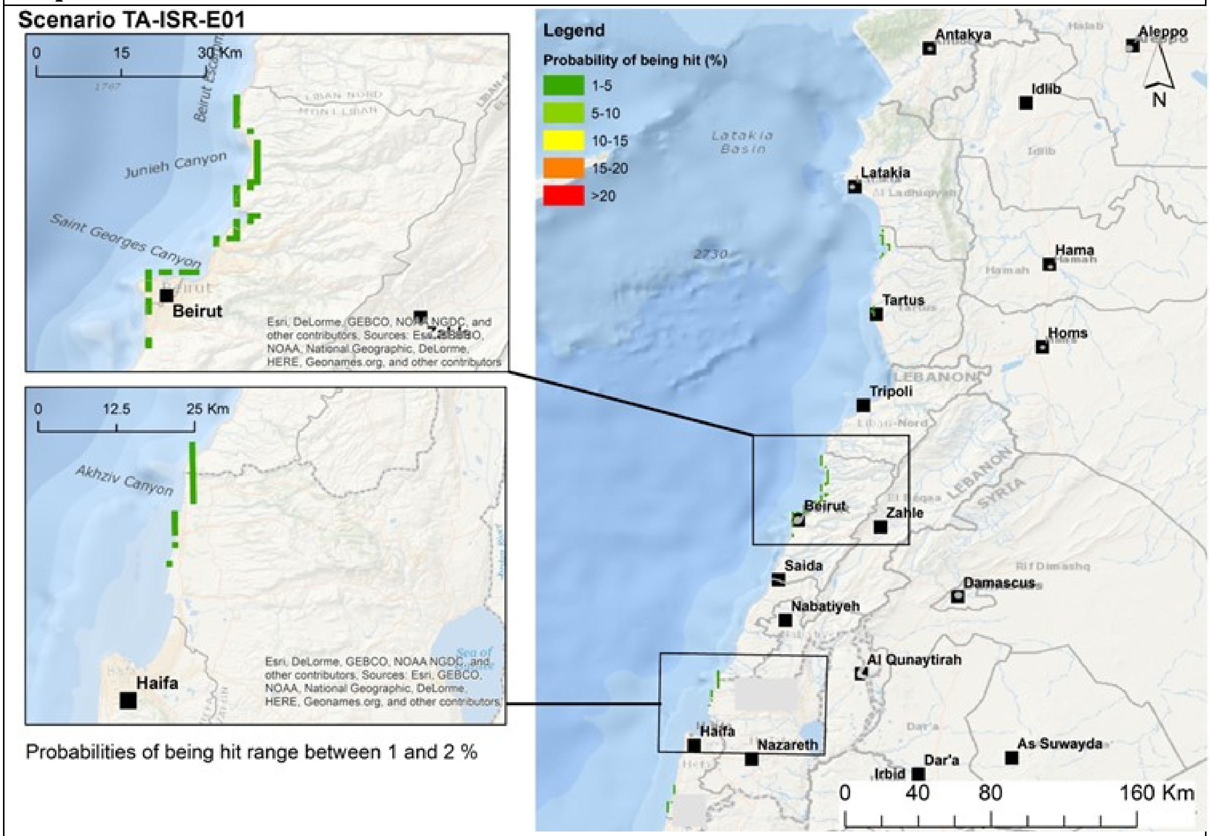


Figure 3.13: Assessment of shoreline impact of Scenario 5

Area of Shoreline Impact (Figure 3.13**)**	This scenario is a spill offshore and outside of Lebanese waters. However, there is a low chance, between 1 and 2% probability, of shoreline oiling in Lebanon and further to the north in Syria. In Lebanon, there are two main areas that show a small chance of oiling; firstly, a 40-50 km stretch of coastline to the north of Beirut, and secondly, a 20 km stretch of coastline north of the southern country border. These probabilities are so small as to be negligible.
Area of Marine Impact – surface oiling	The area of surface oiling with a greater than 10% probability is shown below. This is large area, and may cross into Lebanese waters. However, the oil is a relatively light product and will disperse and evaporate readily, which limits the total area of high probability. See Figure 3.14.

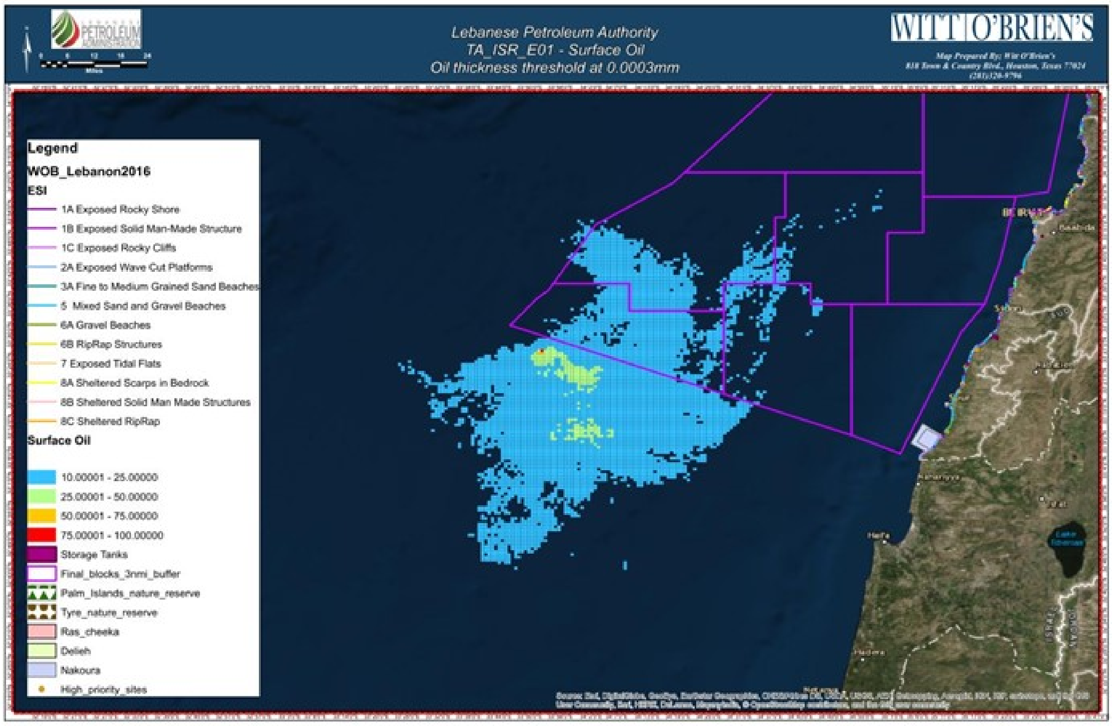


Figure 3.14: Surface oiling from Scenario 5

<table>
<tr><td>Key sensitivities Environmental and socio-economic.</td><td colspan="7">The very low probabilities for shoreline impact would make the shoreline a low priority for clean-up, with operations focused offshore.</td></tr>
<tr><td>Response Strategy:</td><td>Source ✓</td><td>Monitor ✓</td><td>C&R ✓</td><td>Disp ✓</td><td>ISB ✓</td><td>Protect ✓</td><td>Shore ✓</td></tr>
<tr><td>Oil Type</td><td colspan="7">This scenario has been run with a light crude oil (API 36.8), ITOPF group 2. This oil will readily evaporate and be dispersed in the marine environment. It would be amenable to dispersant use.</td></tr>
<tr><td>At Sea</td><td colspan="7">Dispersant use: Whilst fresh, this oil is likely to be amenable to dispersants. Whilst natural evaporation and dispersion is likely given suitable weather conditions, the application of dispersants would ensure that the chance of shoreline impact is reduced further, and that the total area of impact is reduced. The effectiveness of dispersant use should be carefully monitored.

Containment and recovery: A containment and recovery operation will be possible with specialized booms and skimmers. Offshore oil storage will be required, as well as a process to deal with recovered oil and oily water. This operation should be coordinated carefully with dispersant operations. It is not likely to clear up significant quantities of oil, offshore.</td></tr>
<tr><td>Shoreline</td><td colspan="7">Shoreline impact: Figure 3.15 below shows that if oil does come ashore, it is likely to do so within 5-10 days. The mean quantity of oil found to hit the shoreline in any one location was approximately 900 tonnes. Therefore, despite the chance of oiling being small, if there was oiling, the quantities could be significant and require active clean-up.</td></tr>
</table>

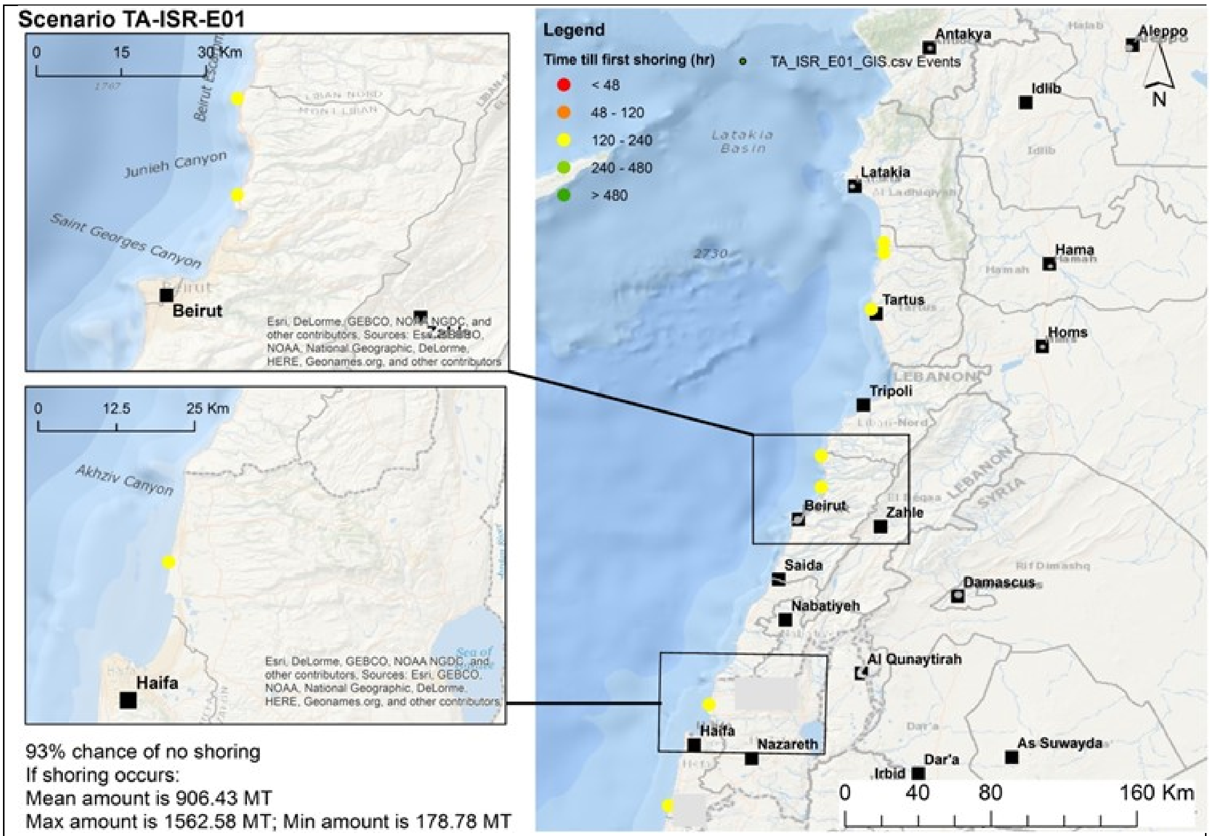


Figure 3.15: Time to shoreline impact for Scenario 5

3.2.6 Scenario 6: Oil from a tanker inbound for the terminal at Tripoli

Scenario Reference: TA_TR Model Parameters:	
Impacts	

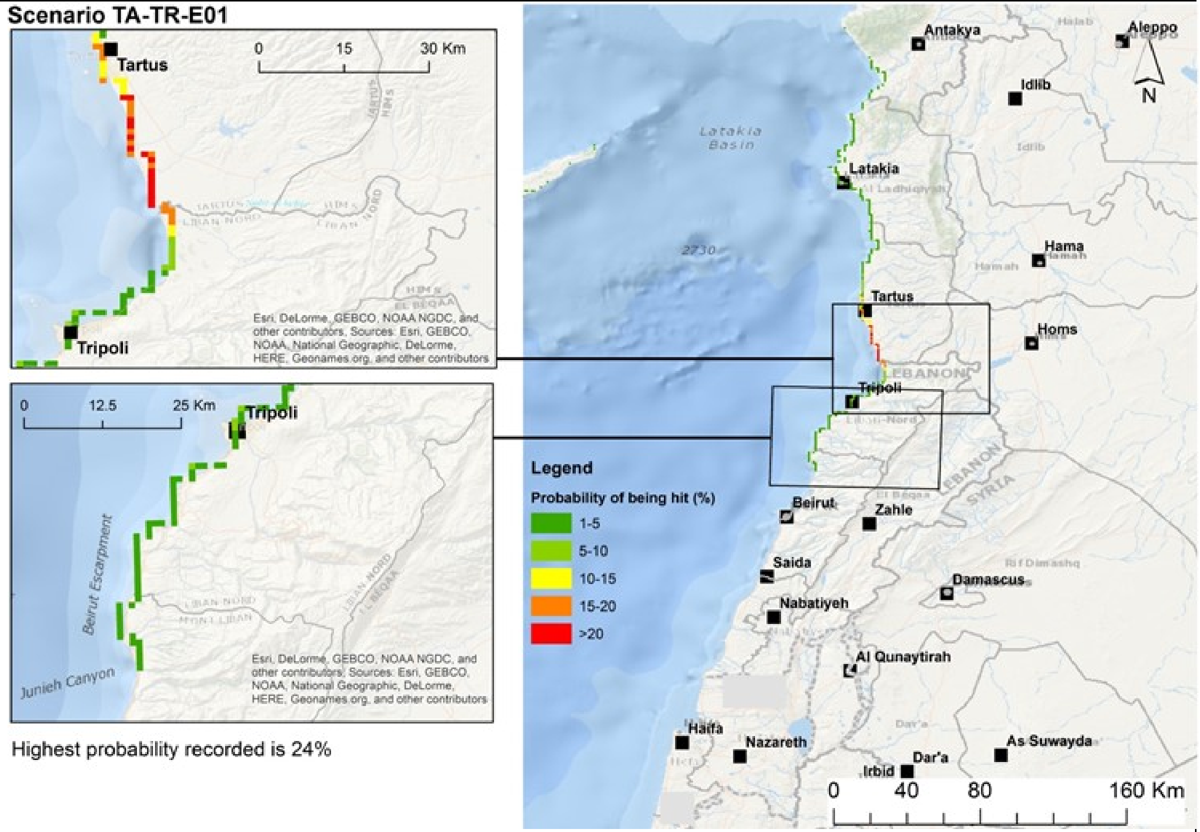


Figure 3.16: Assessment of shoreline impact of Scenario 6

Area of Shoreline Impact (Figure 3.16**)**	This scenario models the release of oil from a tanker inbound for the terminal at Tripoli, and hence close to the northern Lebanese borders. Consequently, the highest probabilities of shoreline impact are in Syria. In Lebanon, there are low probabilities of shoreline impact, generally below 5%, between the border in the north and Baachta, approximately 50km south of Tripoli. Shoreline types impacted are varied, from rocky cliffs to sandy beaches and rocky rip rap. Assessment of the shoreline typology shows the following shoreline types may be impacted: • Rocky shores – exposed, sheltered, wave cut platforms. • Sand and gravel beaches – fine, medium and mixed sand and gravel beaches. • Rip rap – manmade rocky areas installed as a sea defense. • Manmade structures – exposed and sheltered. • Cliffs. • Tidal flats.
Area of Marine Impact – surface oiling	Figure 3.17 below indicates that a relatively small area is most likely to be impacted, this is possible because the oil is a heavy product. Given exceptional weather conditions, the slick may fragment and spread more rapidly. There is a low probability, of between 10 and 25%, that the oil will cross international boundaries. Total area of oiling at the highest probability, 75-100%, is 1 km^2.

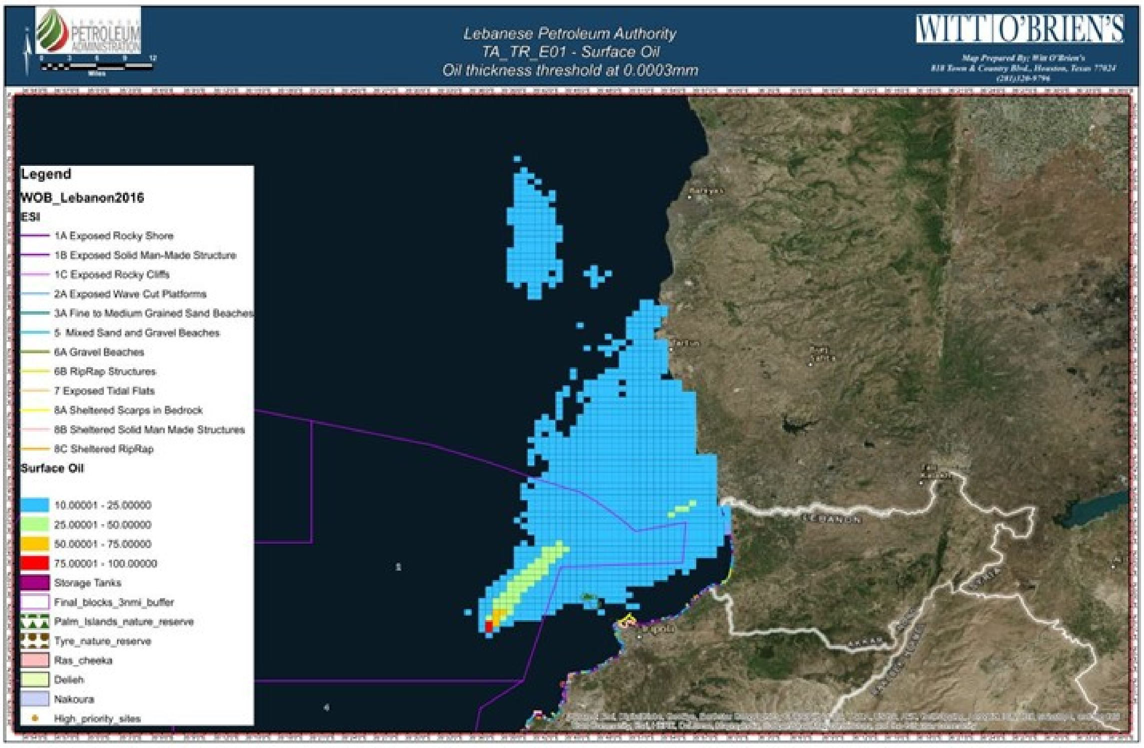


Figure 3.17: Surface oiling from Scenario 6

Key sensitivities

Environmental and socio-economic.

Although the probability of shoreline impact in Lebanon is low, generally less than 5%, given the proximity of the vessel casualty to the shoreline, a shoreline cleanup plan will be required. The key sensitivities are show here.

Protected Areas: The Palm Island Nature Reserve is a Marine Protected Area. In addition, there are a number of proposed sites, namely Areeda Estuary, Ras Cheeka, Enfeh Peninsula, Batroun Phoenician wall, Medfoun Rocky area and Byblos.

High Priority Sites: There are 7 high priority sites in the potential impact area, namely:

- Terraces of Al Mina (ecological)
- Salinas, wall promenade and our lady of Natour monastery (ecological and cultural)
- Ras Enfeh (ecological and cultural)
- Promontory cape and cliffs of Ras Chaqaa and Saydet El Nouriyeh Monastery (ecological and cultural)
- Selaata terraces (ecological)
- Batroun – historical center and fishing harbor (cultural)
- Medfoun rocky area (ecological)

Birds: Birds are likely to be threatened along the whole coastline. The Palm Nature Reserve is of international importance for birds (a RAMSAR site).

Ports: Tripoli is close to the spill area and a commercial port of national importance. In addition, a number of small fishing or recreational harbors and marinas may be impacted. These include Bebnine, Batroun and Kfar Aabida.

<table>
<tr><td></td><td colspan="7">Fisheries: A 500m fisheries restricted zone extends from the shoreline along the entire Lebanese coastline. In addition specific aquaculture sites maybe impacted.

Key tourist sites: There are numerous tourist sites to the south of Tripoli. Of note are the beaches around Balamand, Kfar Aabida, and south of Byblos at Halat and Safra.
Coastal historical sites: There are a number of coastal historical sites along this section of coastline, including Minieh-Dannieh to the north of Tripoli, and Jbail to the south.

Power plants: Deir Amar and Al Hraiche.</td></tr>
<tr><td>Response Strategy:</td><td>Source
✓</td><td>Monitor
✓</td><td>C&R
✓</td><td>Disp
×</td><td>ISB
×</td><td>Protect
✓</td><td>Shore
✓</td></tr>
<tr><td>Oil Type</td><td colspan="7">This scenario has been run with heavy fuel oil (API 11.5), making it an ITOPF group 4 oil. This oil is persistent in the marine environment. Accordingly, given the relative proximity to the shoreline, some impact would be considered realistic, albeit to the north in Syria.</td></tr>
<tr><td>At Sea</td><td colspan="7">Dispersant use: Heavy fuel oil is generally not suitable for dispersants as its viscosity prevents the solvent from breaking the interfacial tension. In addition, oil moving towards the shore may enter shallow water relatively quickly which would exclude the use of dispersants due to the adverse impact to the biological environment.

Containment and recovery: A containment and recovery operation will be possible with specialized booms and skimmers. Heavy fuel oil may become very viscous when weathered and specialized equipment will be necessary for recovery. Offshore oil storage will be required, as well as a process to deal with recovered oil and oily water.</td></tr>
<tr><td>Shoreline</td><td colspan="7">Shoreline impact (Figure 3.18): In the areas described, beaching may occur within 48 hours. Some sites to the south of Tripoli show that oil will impact within 2-5 days, giving time to monitor the fate of oil and prepare operations accordingly.

The mean quantity of oil to beach at a location is approximately 2500 tonnes. The fast response of shoreline response teams will be key to effective cleanup. The techniques to be used would depend on shoreline type. However, heavy fuel oil will generally require mechanical clean-up due to its viscosity and persistence.</td></tr>
</table>

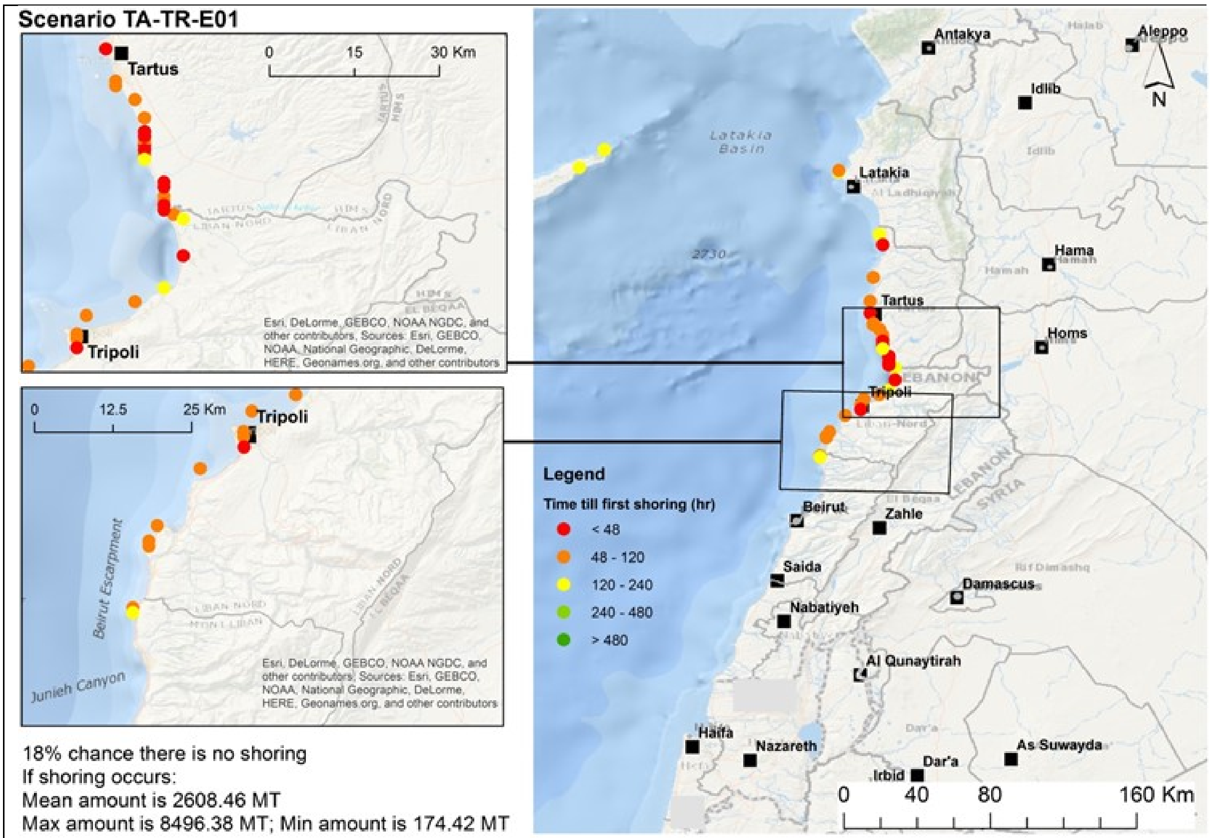


Figure 3.18: Time to shoreline impact for Scenario 6

3.2.7 Scenario 7: Oil from a tanker inbound for the terminal at Zahrani

Scenario Reference: TA_ZH
Model Parameters:

Impacts

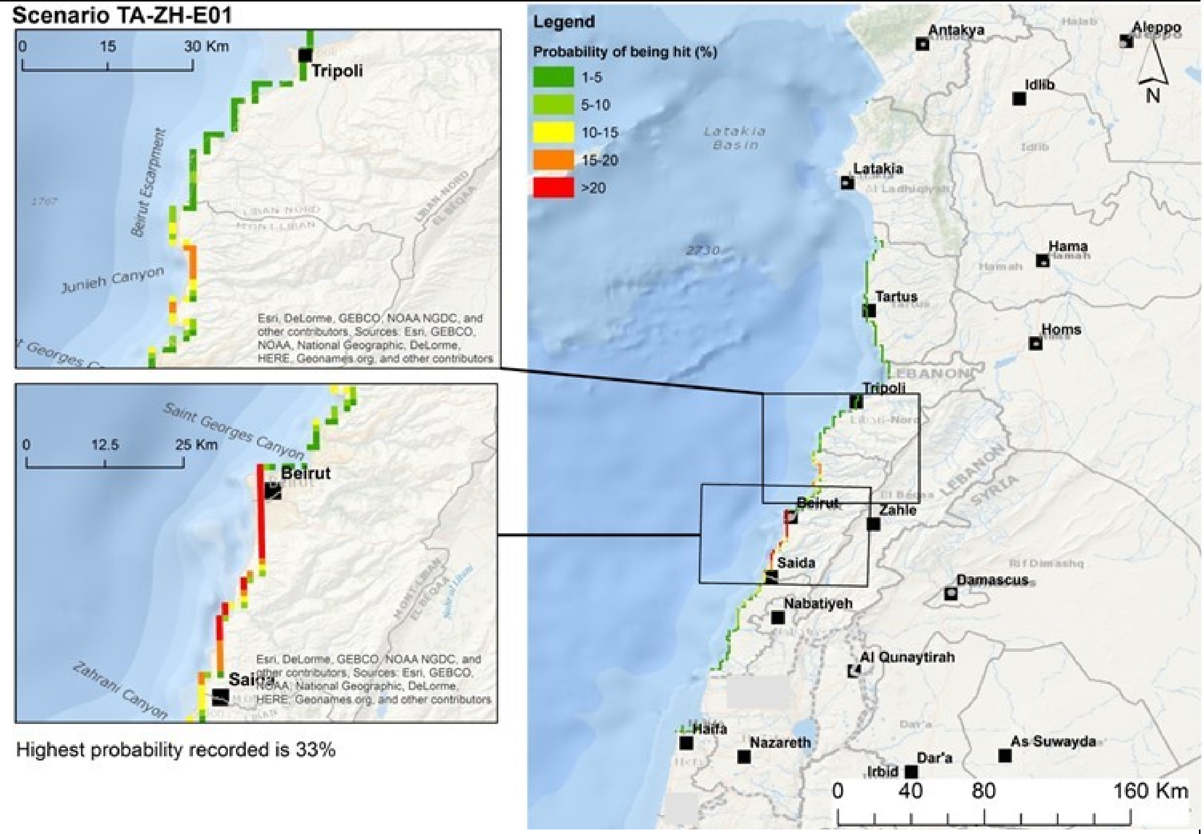


Figure 3.19: Assessment of shoreline impact of Scenario 7

Area of Shoreline Impact (Figure 3.19**)**	This scenario models the release of oil from a tanker inbound for the terminal at Zahrani. As with the other scenarios, oil moves to the north and hence the greatest probabilities of shoreline oiling are between Saida and Beirut, where probabilities are greater than 20%. The highest recorded probability was 33%. There is a low probability, typically below 10%, of beaching along the entire Lebanese coastline. This section, however, will focus on the impact area with a probability greater than 20%. Shoreline types impacted are varied, from rocky cliffs, to sandy beaches and rocky rip rap. Assessment of the shoreline typology shows that the following shoreline types maybe impacted: • Rocky shores – exposed, sheltered. • Sand and gravel beaches – fine, medium, and mixed sand and gravel beaches. • Rip rap – manmade rocky areas installed as a sea defense. • Manmade structures – exposed and sheltered. • Cliffs. •
Area of Marine Impact – surface oiling	The map shown below indicates that a relatively small area has a high probability (75-100%) of being impacted; this is likely to be because the oil is a heavy product. Given exceptional weather conditions, the slick may fragment and spread more rapidly. There is a low probability, between 10 and 25% chance, that the oil will cross international boundaries. The total area of oiling at the highest probability of 75-100% is 2 km² (See Figure 3.20).

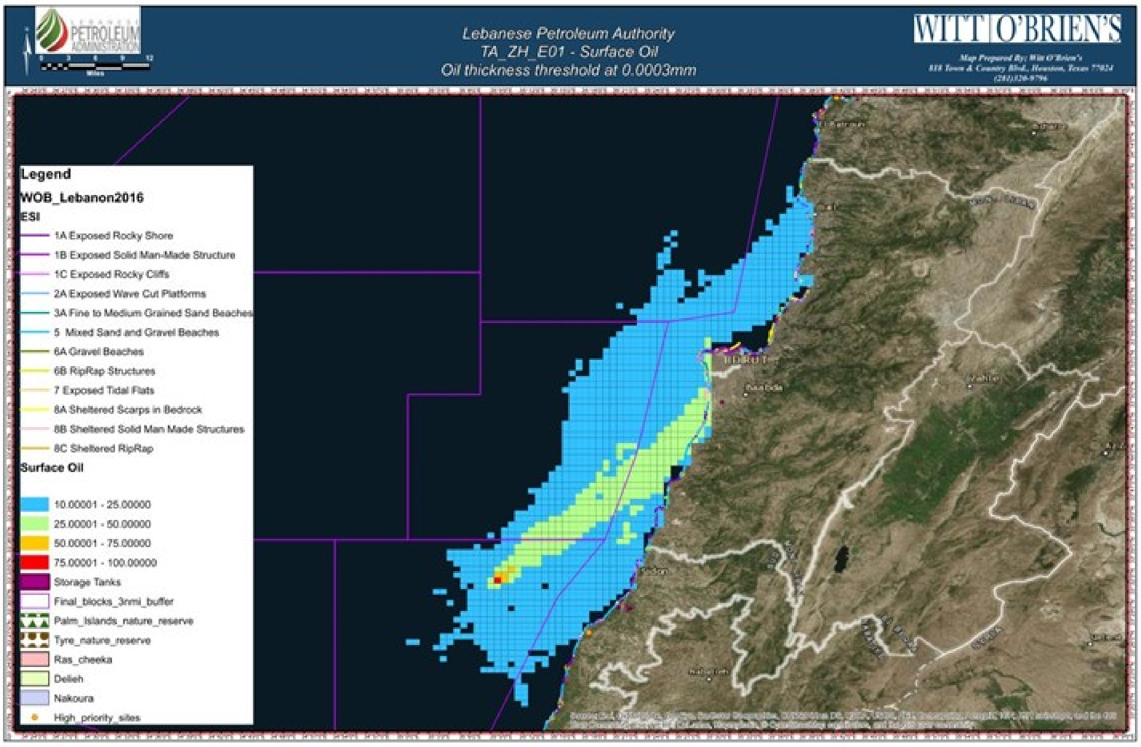


Figure 3.20: Surface oiling from Scenario 7

Key sensitivities **Environmental and socio-economic.**	**Protected Areas:** There is a low probability, i.e. below 10%, of the oil reaching the Marine Nature Reserve of Palm Islands, and the proposed coastal protection sites of Dalieh, Raoucheh cliffs and caves, Damour estuary, and Awaly estuary. **High Priority Sites:** There are 3 high priority sites in the potential impact area, namely: • Ramelt el-Baida (ecological). • Damour estuary (ecological). • The sea castle of Saida and underwater city, sea façade and old harbor (cultural). **Birds:** Birds are likely to be threatened along the whole coastline. **Ports:** Together with Tripoli, Beirut is the main port in Lebanon, with Saida port also handling commercial vessels as well as small fishing and recreational vessels. **Fisheries:** A 500m fisheries restricted zone extends from the shoreline along the entire Lebanese coastline. In addition specific aquaculture sites maybe impacted. **Key tourist sites:** There are numerous tourist sites between Beirut and Saida. Of note are areas around Khadle to the south of Beirut, beaches around Jiyeh, and Jadra further south. **Coastal historical sites:** There is a small number of coastal historical sites in this area. However, it is unlikely that they will be impacted physically by oiling unless on the beach. Of note is the Saida sea castle. **Power plants:** Jiyeh.

Response Strategy:	Source ✓	Monitor ✓	C&R ✓	Disp ✗	ISB ✗	Protect ✓	Shore ✓
Oil Type	This scenario has been run with a heavy fuel oil (API 11.5), an ITOPF group 4 oil. This oil is persistent in the marine environment and so given the relative proximity to the shoreline some impact would be considered realistic.						
At Sea	**Dispersant use:** Heavy fuel oil is generally not suitable for dispersants as its viscosity prevents the solvent from breaking the interfacial tension. In addition, oil moving towards the shore may enter shallow water relatively quickly, which would exclude the use of dispersants due to the adverse impact to the biological environment. **Containment and recovery:** A containment and recovery operation will be possible with specialized booms and skimmers. A heavy fuel oil may become very viscous when weathered, and specialized equipment will be necessary for recovery. Offshore oil storage will be required, as well as a process to deal with recovered oil and oily water.						
Shoreline	**Shoreline impact (**Figure 3.21**):** In these areas, beaching may occur within 48 hours, particularly in sites around Saida. Therefore, speed of deployment will be critical. The mean quantity of oil to beach at a location is approximately 3000 tonnes. The techniques to be used would depend on shoreline type. However, heavy fuel oil will generally require a mechanical clean-up due to its viscosity and persistence.						

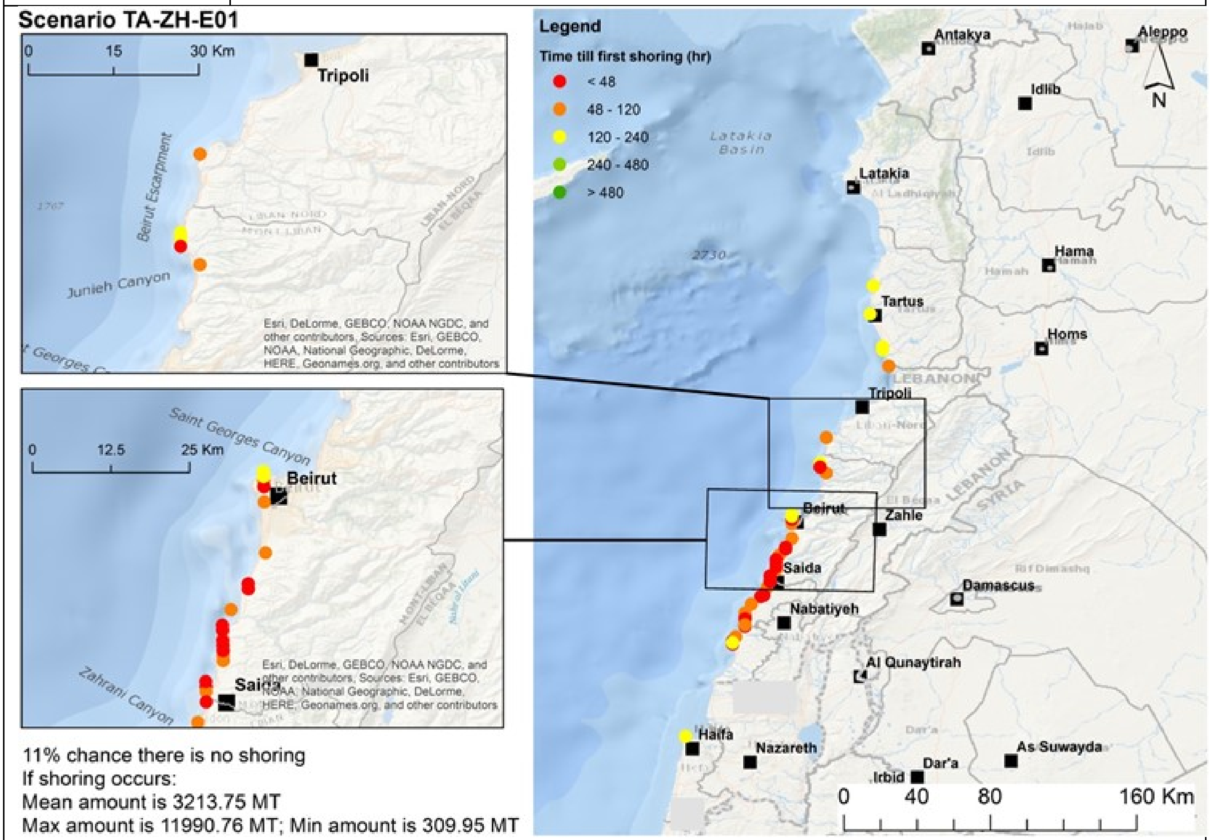


Figure 3.21: Time to shoreline impact for Scenario 7

3.2.8 Scenario 8: Oil from a tanker inbound for the terminal at Zouk

Scenario Reference: TA_ZO
Model Parameters:

Impacts

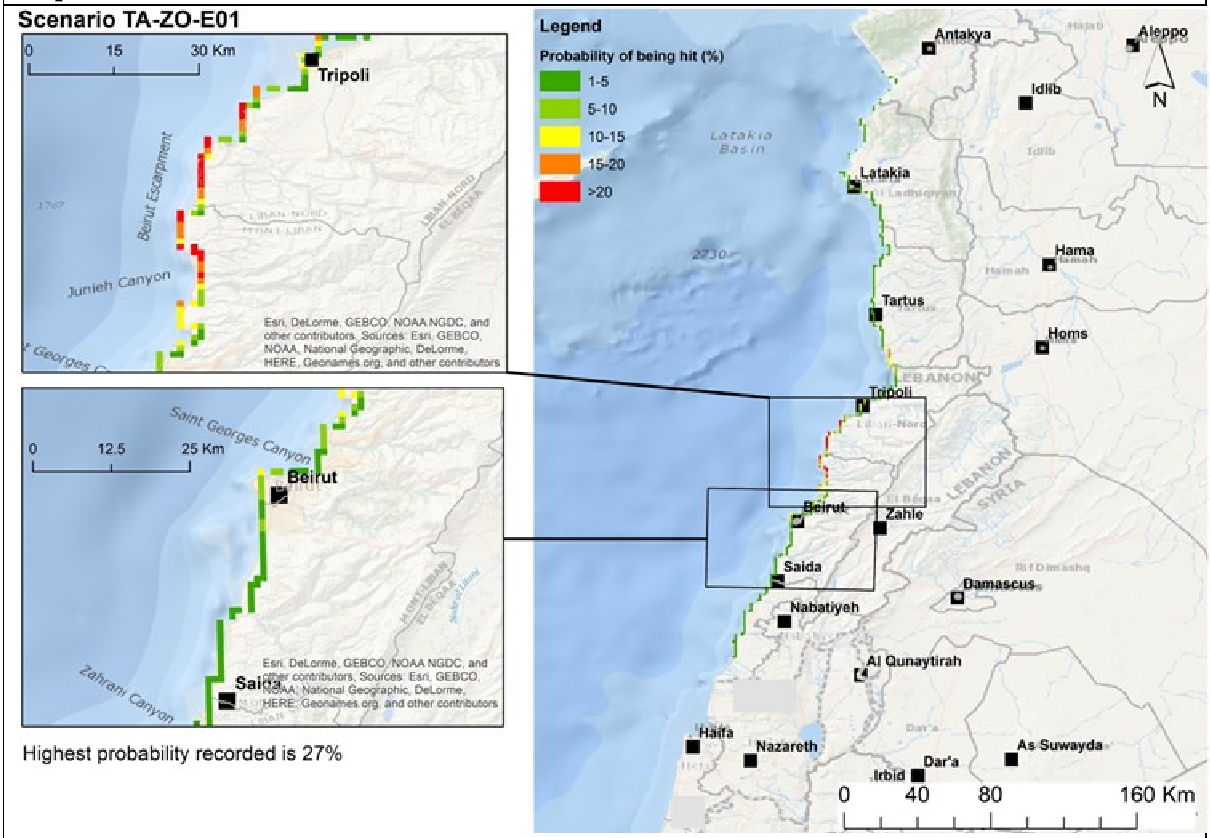


Figure 3.22: Assessment of shoreline impact of Scenario 8

<table>
<tr>
<td>Area of Shoreline Impact (Figure 3.22)</td>
<td>This scenario models the release of oil from a tanker inbound for the terminal at Zouk. As with the other scenarios, oil moves to the north and hence the greatest probabilities of shoreline oiling are between Beirut and Tripoli, where the probabilities are greater than 20%. The highest recorded probability was 27%. There is, however, a low probability, typically below 10%, of beaching along much of the Lebanese coastline from Tyre in the south and across the Syrian border in the north. This section, however, will focus on the impact area with a probability greater than 20%, between Baachta and just south of Tripoli.

Shoreline types impacted are varied, from rocky cliffs to sandy beaches and rocky rip rap. Assessment of the shoreline typology shows that the following shoreline types may be impacted:
• Rocky shores – exposed, sheltered.
• Sand and gravel beaches – fine, medium and mixed sand and gravel beaches.
• Rip rap – manmade rocky areas installed as a sea defense.
• Manmade structures – exposed and sheltered.
• Cliffs.
• Tidal flats.</td>
</tr>
</table>

Area of Marine Impact – surface oiling	The map shown below indicates that a relatively small area is most likely to be impacted. This is probably because the oil is a heavy product. Given exceptional weather conditions, the slick may fragment and spread more rapidly. There is a low probability, of between 10 and 25% chance, that the oil will cross international boundaries. The total area of oiling, at the highest probability of 75-100%, is 1 km^2 (Figure 3.23).

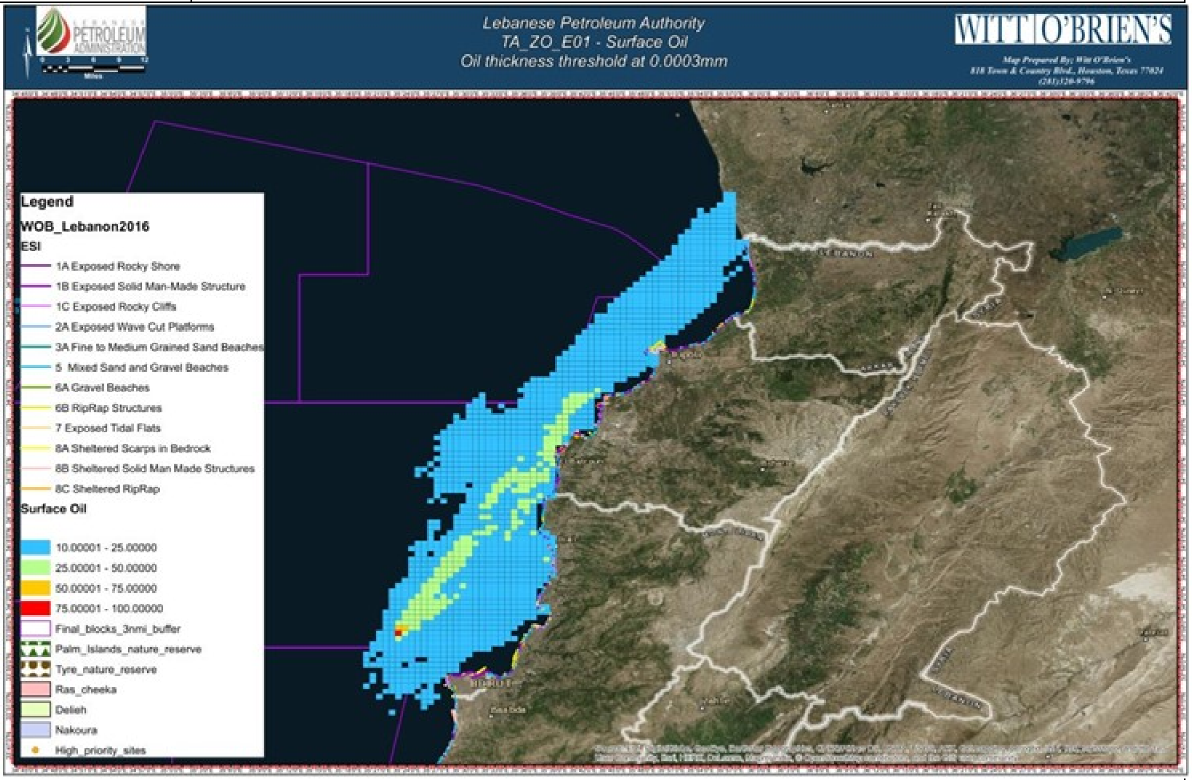


Figure 3.23: Surface oiling from Scenario 8

<table>
<tr><td>Key sensitivities

Environmental and socio-economic.</td><td>As there is a clear area of higher probability (greater that 20%), which is close to the source of the spill, this area only is considered for assessment here.

Protected Areas: The proposed marine protected areas of Enfeh Peninsula, Ras Cheeka Cliffs, and Batroun Phoenician wall are at risk.

High Priority Sites: There are 5 high priority sites in the potential impact area, namely:
Batroun historical center and fishing harbor (cultural)
Selaata terraces (ecological)
Ras Cheeka cliffs and Saydet El Nouriyeh monastery (ecological and cultural)
Ras Enfeh (ecological and cultural)
Salinas, wall promenade and our lady of Natour monastery (ecological and cultural).
Birds: Birds are likely to be threatened along the whole coastline.

Ports: There are relatively low probabilities, between 5-10%, of the main commercial ports of Beirut and Tripoli being impacted by this spill scenario. In addition, a number of small fishing or recreational harbors and marinas may be impacted. These include Batroun and Kfar.</td></tr>
</table>

<table>
<tr><td></td><td colspan="7">Fisheries: A 500m fisheries restricted zone extends from the shoreline along the entire Lebanese coastline. In addition specific aquaculture sites maybe impacted.
Key tourist sites: There are numerous tourist sites between Tripoli and Beirut. Of note are the areas around Jounieh, Safra and Halat.

Coastal Historical sites: There are a number of coastal historical sites along the coastline. In the above 20% section, these include the site at Jbail.

Power plants: Al Hraiche.</td></tr>
<tr><td>Response Strategy:</td><td>Source
✓</td><td>Monitor
✓</td><td>C&R
✓</td><td>Disp
×</td><td>ISB
×</td><td>Protect
✓</td><td>Shore
✓</td></tr>
<tr><td>Oil Type</td><td colspan="7">This scenario has been run with heavy fuel oil (API 11.5), an ITOPF group 4 oil. This oil is persistent in the marine environment. As such, given the relative proximity to the shoreline, some impact would be considered realistic.</td></tr>
<tr><td>At Sea</td><td colspan="7">Dispersant use: Heavy fuel oil is generally not suitable for dispersants as its viscosity prevents the solvent from breaking the interfacial tension. In addition, the relatively shallow water depths would exclude the use of dispersants due to the adverse impact to the biological environment.

Containment and recovery: A containment and recovery operation will be possible with specialized booms and skimmers. A heavy fuel oil may become very viscous when weathered, and specialized equipment will be necessary for recovery. Offshore oil storage will be required, as well as a process to deal with recovered oil and oily water. Stopping the source of the spill on land and ensuring that no further oil can enter the marine environment will dramatically minimize impacts.</td></tr>
<tr><td>Shoreline</td><td colspan="7">Shoreline impact (Figure 3.24): In these areas, beaching may occur within 48 hours, particularly in sites to the north of Beirut. The mean quantity of oil to beach at a location is approximately 3000 tonnes. The techniques to be used would depend on shoreline type. However, heavy fuel oil will generally require a mechanical clean-up due to its viscosity and persistence.</td></tr>
</table>

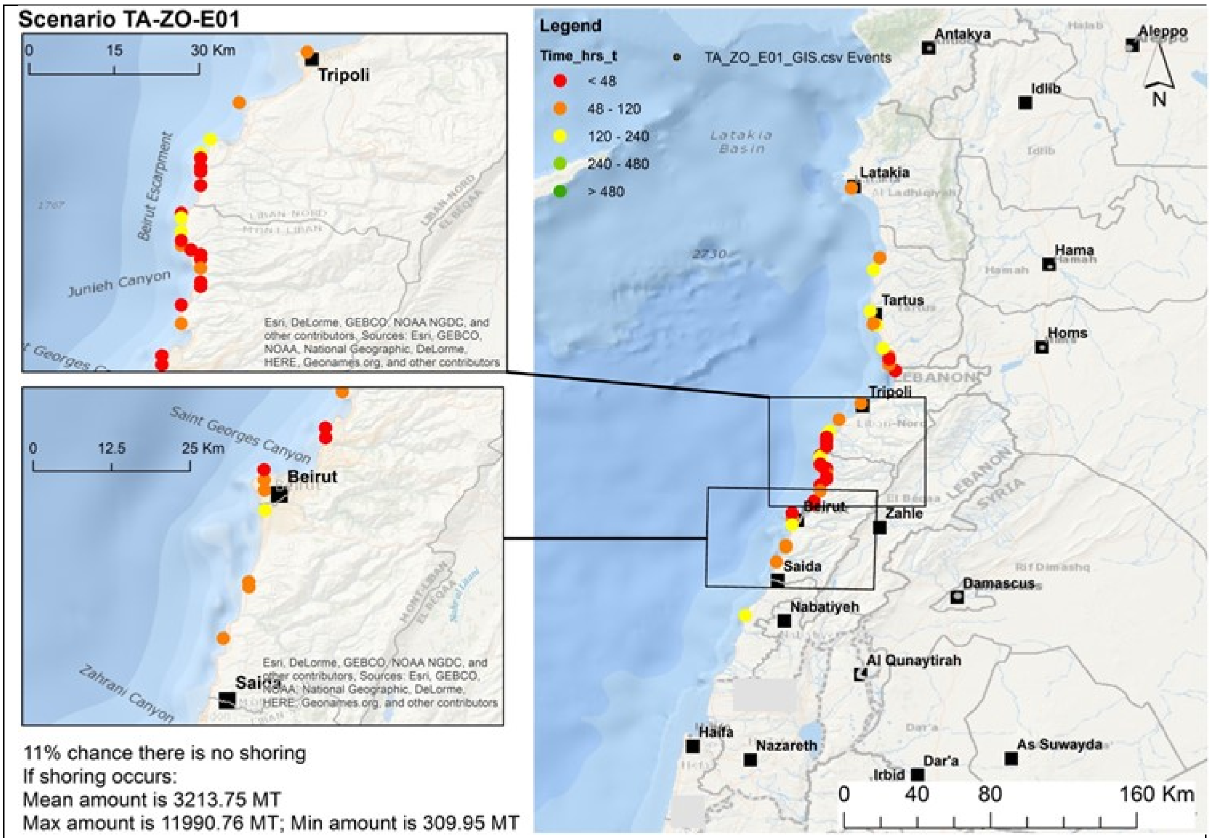


Figure 3.24: Time to shoreline impact for Scenario 8

3.3 Conclusion

A response strategy has been developed for each of the response scenarios that have been modelled, this is based on the strategies outlined in Volume A strategy selection and Volume D response guidance, but further developed to give consideration to the conditions of each spill. From assessment of these scenarios general guidelines for response can be identified for spills in Lebanese waters as well as for spills which may originate outside of the Lebanese EEZ. These are as follows:

Offshore well blowouts of a crude product would be the worst case scenario. In this case alongside **source control** preparations should be made for **monitoring and surveillance** and assessment of the effectiveness of **dispersant** use. Dispersant is the only strategy that may reduce the impact of oil beaching in the shoreline. **In-situ burning** may also be considered as well as **containment and recovery** operations. **Shoreline protection** and **shoreline clean-up** operations should also be mounted. For the scenario modelled the oil first beached within 48 hours.

An offshore well blowout of condensate shows only a small probability of shoreline impact. In addition, the condensate is a light product and so therefore rapid evaporation of close to 100% in 24 hours would be expected. Consequently, the only likely response action would be **source control** and **monitoring and surveillance**. In the unlikely event of the oil threatening the shoreline further actions may be required for some sensitive **shoreline protection** and **shoreline clean-up**. Coastal sensitivities such as fisheries may experience short term impacts.

Large spills from a heavy fuel oil close to shore i.e. from an on land source, or a tanker inbound to an import berth would require **source control** and **monitor and surveillance** operations. Dispersants are unlikely to be effective as heavy fuel oil is too viscous and in addition relatively shallow waters may threaten sea bed marine life. Consequently, focus will be on **protection of priority areas** and **shoreline clean-up** and well as **containment and recovery** at sea where possible.

Significant spills from outside Lebanese waters are most likely to come from a shipping incident, as currently all exploration and production activities in the region have found gas only. As with all spills the conditions are difficult to predict. A spill of a crude with the properties of an oil exported from Turkey through the BTC pipeline and then travelling south was chosen, and a location to the south of Lebanon as being the most likely and worst case. In the case the probability of significant oiling within Lebanese waters with low, with a shoreline impact even lower. In the event of this incident Lebanon would support the nation with jurisdiction wherever possible and respond at sea through **monitor and surveillance, dispersant** and **containment and recovery** operations within the EEZ as appropriate. If necessary **shoreline clean-up** operations should be undertaken.

Annex 1: Spill Hazard Identification

ASSESSMENT TEAM: S James (Lead), R Perry, R McAllister, C Wood

ASSESSMENT and REVIEW DATE(S): 23/11/2015, 24/11/2015 and 10/02/16

Technical Assumptions:

- Potential for flashing off and flammable gas cloud formation is considered as part of local safety and environmental impacts
- Realistic worst case scenarios and consequences are considered but not coincident failures (unless a direct common cause e.g. an attack on a tank farm may target more than one tank)
- At this stage only drilling activity has been included. Development and production activities will depend on the nature of future hydrocarbon finds and further analysis would be required in due course
- A continuation of the current level of security in the region is assumed. A sharp escalation in security risk would require a review. Many of the worst cases are based on targeted attack scenarios
- The inherent geography of the Eastern Mediterranean has been carefully assessed. Oil/hydrocarbon reaching any or all coastal locations are assumed to be highly sensitive according to one or more criteria i.e. it is assumed that there are potentially sensitive locations along the whole coast of Lebanon. The point sources of spills are very variable and so the modelling of trajectories to specific environmentally sensitive locations are not required or included at this stage. Location specific studies may be able to show a reduction in some of these risks for some limited scenarios but for the purposes of this risk assessment it is prudent to assume that any oil reaching shore will have very damaging consequences.
- Key data gaps which could improve the Risk Assessment are highlighted in Section 6.5 of the Gaps and Challenges Report. The current Risk Assessment data is considered sufficient for the purpose of creating the NOSCP but the closing of the gaps may refine some of the risk evaluations in future.

Risk Assessment Area/Source list/Description:

- Map of Blocks (Lebanon, other)
- Onshore inventories capable of affecting the marine environment (Lebanon)
- Shipping routes (Lebanon, other)

Table A1- 1: Spills from Lebanese waters

Area/Source inside Lebanese Control	Major Hazard Scenario summary + Initiating Event *Note 1	Major Spill Hazard Consequences (if no control measures) and risk analysis of highest risk events (consequence and likelihood) *Note 2		Engineering Controls affecting likelihood	Operational Controls affecting likelihood	Mitigation Measures and Methods (Oil Spill Contingency Response Tier 1-3)
Risk from Shipping Tankers - Persistent (HFO, Bitumen, heavy crude (historic only), etc.) APIC terminals and Power Stations Tankers - Non-Persistent	Collision, grounding, deliberate act (terrorism/war), hull failure (spontaneous, Tsunami, extreme weather is rare), internal fire/explosion Maximum tanker size Tripoli capability but not done for 200kte tankers Majority approx. 65kte (possible larger sizes to Zahrani and Tripoli) Security concerns e.g. terrorist speed boat are main likelihood (has happened off	Initiating Event =>LOC	Y/N	Double hull tankers only Shipping inspected under Mediterranean MOU on Port State Control Fuel stored in compartmented tanks	Strict controls on shipping (West to East) lanes and prohibition on fishing vessels (500m radius) Monitored by UNIFIL (Maritime/Naval Taskforce) and Lebanese armed forces (JMOC Radar capability) Compulsory piloting Deep water close to shore	Limited/unknown quality dispersant capability and effectiveness Lebanon signatory to Civil Liability convention but it excludes terrorism and acts of war i.e. would have long term economic impacts Tugs and recovery of stricken shipping (no currently agreed port of refuge)
		Sensitive locations - Beach, Marsh, River Inlet,	Y/N			
		Sea Surface	Y/N			
		Toxic Gas/Smell	Y/N			
		Fire/Explosion	Y/N			
		Plants, Birds, Fish, marine mammals risk	Y/N			
		Emergency Responders risk	Y/N			
		Employee/Contractor risk	Y/N			
		Public risk	Y/N			
		Business, Asset or Political risk	Y/N			

Area/Source inside Lebanese Control	Major Hazard Scenario summary + Initiating Event *Note 1	Major Spill Hazard Consequences (if no control measures) and risk analysis of highest risk events (consequence and likelihood) *Note 2	Engineering Controls affecting likelihood	Operational Controls affecting likelihood	Mitigation Measures and Methods (Oil Spill Contingency Response Tier 1-3)
(diesel, gasoline, light crude) APIC terminals Non-tankers – cargo ships and other shipping various fuel oils (HFO, diesel, other fuels) Passing ships to/from Suez (outside 200 mile zone)	Yemen in 6/10/2002 – Limburg 12-18Kte spill) Majority of crude oil imported by the Occupied Palestinian Territories is from Kurdistan pipeline to Ceyhan Turkey and then by tanker (e.g. 1mbbls or up to 200kte) to Ashkelon and close to Lebanese territorial waters (12miles) from shore but through Lebanese Exclusive Economic Zone).	Worst Case Discharge Volume (barrels) = 65,000te of heavy fuel oil within 1-2 miles of shore Likelihood x Severity =2x5 = 10 Worst Case passing ship Discharge Volume (barrels) = 200,000te of crude oil within 15 miles of shore Likelihood x Severity = 1x5 = 5 Most likely event from general shipping incident with loss of fuel = 500te. Likelihood x Severity = 2x4 = 8 Higher shipping volume in this case but less of terrorist target		Pre-reporting 24-36 hours in advance Movements done during day time Marpol 73/77 control on fuel discharges	Navy and civil defense support and equipment stockpiles International response support (via REMPEC, OSRL etc.)
Offloading buoys (single point moorings),	Collision with fixed jetties/equipment, Pipe/coupling failures during offloading, leak of fixed	Initiating Event =>LOC — Y/N Sensitive locations - Beach, Marsh, River Inlet, — Y/N	Asset Integrity and replacement programs unknown	Activities suspended in bad weather	No port contingency plans currently

Area/Source inside Lebanese Control	Major Hazard Scenario summary + Initiating Event *Note 1	Major Spill Hazard Consequences (if no control measures) and risk analysis of highest risk events (consequence and likelihood) *Note 2	Engineering Controls affecting likelihood	Operational Controls affecting likelihood	Mitigation Measures and Methods (Oil Spill Contingency Response Tier 1-3)
pipelines to shore Bunkering of any vessel in ports	pipework, sabotage, wrongly opened valve, overflow systems, fire/explosion in discharge lines	Sea Surface Y/N Toxic Gas/Smell Y/N Fire/Explosion Y/N Plants, Birds, Fish, marine mammals risk Y/N Emergency Responders risk Y/N Employee/Contractor risk Y/N Public risk Y/N Business, Asset or Political risk Y/N Worst Case Discharge Volume (barrels) = 2000 te/hr. worst case 2hours) = 4000 te Likelihood x Severity = 2x4 = 8 Most likely event = <7 te. Small leaks from couplings etc. Likelihood x Severity = 4x3 = 12		Security, procedures and observation by staff Ministry of Industry monitoring of Safe Systems of Work unknown (shortage of inspectors)	Tier 1 plans and spill response (e.g. Total terminal) Navy and civil defense support and equipment stockpiles Other APIC terminal and EDL contingency plans currently lacking?? Local authority contingency plans currently lacking International response support (via REMPEC, OSRL etc.)

Area/Source inside Lebanese Control	Major Hazard Scenario summary + Initiating Event *Note 1	Major Spill Hazard Consequences (if no control measures) and risk analysis of highest risk events (consequence and likelihood) *Note 2		Engineering Controls affecting likelihood	Operational Controls affecting likelihood	Mitigation Measures and Methods (Oil Spill Contingency Response Tier 1-3)
Risk from onshore spills to marine environment Onshore fuel storage tanks at APIC terminals, ports, power stations and industry (e.g. cement), transport and domestic storage	Failure of tank(s) or associate pipework systems. Some tanks are aging with unknown condition and un-bunded. Failure of connections during road tanker filling operations, ECW barges with generators refueled by road tankers. Holding tank overflow from receiving tank near coast line or with pathway to sea. Sabotage or terrorist attack on a tank -potential missile from some distance or airplane. Internal fire or explosion.	Initiating Event =>LOC	Y/N	Not all tanks have bunding. Bunded tanks are not all with 110% bunding. Low capability for inspection of fuel storage tanks and pipework. Aging tanks: Asset Integrity and replacement programs unclear currently	Local security and observation Internal Security Force (ISF) support and oversight Safe systems of work unclear currently	Tier 1 plans and spill response (e.g. Total terminal) Navy and civil defense support and equipment stockpiles Other APIC terminal and EDL contingency plans currently lacking Local authority contingency plans currently lacking International response support (via REMPEC, OSRL etc.)
		Sensitive locations - Beach, Marsh, River Inlet, Ground Water	Y/N			
		Sea Surface	Y/N			
		Toxic Gas/Smell	Y/N			
		Fire/Explosion	Y/N			
		Plants, Birds, Fish, marine mammals risk	Y/N			
		Emergency Responders risk	Y/N			
		Employee/Contractor risk	Y/N			
		Public risk	Y/N			
		Business, Asset or Political risk	Y/N			

Area/Source inside Lebanese Control	Major Hazard Scenario summary + Initiating Event *Note 1	Major Spill Hazard Consequences (if no control measures) and risk analysis of highest risk events (consequence and likelihood) *Note 2	Engineering Controls affecting likelihood	Operational Controls affecting likelihood	Mitigation Measures and Methods (Oil Spill Contingency Response Tier 1-3)
		Worst Case Discharge Volume (barrels) = total 100kte i.e. combined maximum tank size (25kte) for tank farm (e.g. Zouk current maximum 95kte HFO with 50Kte additional under construction; Jiyeh 107kte) – highly unlikely to exceed this during overfill scenarios. ECW barges hold 6kte. Likelihood x Severity = 3x5 = 15 Major attack or other catastrophic failures with fire/explosion			
		Most likely event = <5te. Small leaks from pipework etc. May not reach the sea Likelihood x Severity = 4x2 = 8			

Risk from drilling	Loss of well control with failure of blow out preventer (BOP) Pipework and casing failures Loss of containment of the following with likelihood of finding (water depth 1000-2000m): Gas (probable) Condensates (probable) Light Crudes (possible) Heavy Crudes (unlikely) Fate of gas and condensate leaks subsea	Initiating Event =>LOC	Y/N	Blowout Preventer Gas and condensate specific measures	Drilling operations and safety program and plans	License holders/drillers to develop: Environmental Impact Assessment Risk Assessment Oil spill contingency plans Drilling emergency response plans Other mitigations: Open hole collapse? Capping Stack (2-3 weeks) or relief well (2-3 months)
		Sensitive locations - Beach, Marsh, River Inlet, ~~Ground Water~~	Y/N			
		Sea Surface	Y/N			
		Toxic Gas/Smell	Y/N			
		Fire/Explosion	Y/N			
		Plants, Birds, Fish, marine mammals risk	Y/N			
		Emergency Responders risk	Y/N			
		Employee/Contractor risk	Y/N			
		Public risk	Y/N			
		Business, Asset or Political risk	Y/N			

		INDICATIVE Worst Case Discharge Volume Gas, condensates = 200m3 per day (worst case 60 days) Likelihood x Severity = 2x4 = 8 INDICATIVE Light crudes (barrels) = 5000m3 per day light crude (worst case 60 days). Likelihood x Severity = 1x5 = 5 likelihood would increase in the event of a find of light crudes			Consider burning/flaring mechanisms Navy and civil defense support and equipment stockpiles International response support (via REMPEC, OSRL etc.)
		Most likely event = <10m3 of condensate with gas leak. Likelihood x Severity = 4x2 = 8			

Table A1- 2: Spill from sources outside Lebanese control

Area/Source outside Lebanese Control	Major Hazard Scenario summary + Initiating Event *Note 1	Major Spill Hazard Consequences (if no control measures) and risk analysis of highest risk events (consequence and likelihood) *Note 2		Engineering Controls affecting likelihood	Operational Controls affecting likelihood	Mitigation Measures and Methods (Oil Spill Contingency Response Tier 1-3)
External Risk from Shipping Maximum tanker size of 240kte using Suez Canal (approx. 200 miles from Lebanese waters) Tankers - Persistent (HFO, Bitumen, heavy crude)	Collision, grounding, deliberate act (terrorism/war), hull failure (spontaneous, Tsunami, extreme weather is rare), internal fire/explosion Majority of crude oil imported by the Occupied Palestinian Territories is from Kurdistan pipeline to Ceyhan Turkey and then by tanker (e.g. 1mbbls or up to 200kte) to Ashkelon and close to Lebanese territorial waters (12miles) from shore but through Lebanese Exclusive Economic Zone).	Initiating Event =>LOC	Y/N	Double hull tankers only Shipping inspections and standards (Port State Control) Fuel stored in compartmented tanks	Security and shipping controls in Egyptian and international waters Lebanese JMOC monitoring of shipping movements close to Lebanese waters.	Navy and civil defense support and equipment stockpiles International response support (via REMPEC, OSRL etc.)
		Sensitive locations - Beach, Marsh, River Inlet,	Y/N			
		Sea Surface	Y/N			
		Toxic Gas/Smell	Y/N			
		Fire/Explosion	Y/N			
		Plants, Birds, Fish, marine mammals risk	Y/N			
		Emergency Responders risk	Y/N			
		Employee/Contractor risk	Y/N			
		Public risk	Y/N			
		Business, Asset or Political risk	Y/N			

Area/Source outside Lebanese Control	Major Hazard Scenario summary + Initiating Event *Note 1	Major Spill Hazard Consequences (if no control measures) and risk analysis of highest risk events (consequence and likelihood) *Note 2	Engineering Controls affecting likelihood	Operational Controls affecting likelihood	Mitigation Measures and Methods (Oil Spill Contingency Response Tier 1-3)
Tankers - Non-Persistent (diesel, gasoline, light crude) Non-tankers – cargo ships and other shipping various fuel oils (HFO, diesel, other fuels) Passing ships to/from Suez (outside 200 mile zone)	Maximum tanker size to/from Occupied Palestinian Territories currently assumed to be 300Kte into Ashkelon	Severities are reduced due to greater distance to Lebanon Worst Case Discharge Volume (barrels) = 300,000te of heavy crude Likelihood x Severity = 2x4 = 8 Most likely event from general shipping incident with loss of fuel = 500te. Likelihood x Severity = 2x2 = 4 Unlikely to impact in Lebanon			
External Offloading activities, pipelines to shore	Collision with fixed jetties/equipment, Pipe/coupling failures during offloading, leak of fixed pipework, sabotage, wrongly opened valve, overflow	Initiating Event =>LOC — Y/N Sensitive locations - Beach, Marsh, River Inlet, ~~Ground Water~~ — Y/N Sea Surface — Y/N Toxic Gas/Smell — Y/N	Dictated by others	Dictated by others	Navy and civil defense support and equipment stockpiles International response support

Area/Source outside Lebanese Control	Major Hazard Scenario summary + Initiating Event *Note 1	Major Spill Hazard Consequences (if no control measures) and risk analysis of highest risk events (consequence and likelihood) *Note 2		Engineering Controls affecting likelihood	Operational Controls affecting likelihood	Mitigation Measures and Methods (Oil Spill Contingency Response Tier 1-3)
Bunkering of any vessel in ports	systems, fire/explosion in discharge lines	Fire/Explosion	Y/N			(via REMPEC, OSRL etc.)
		Plants, Birds, Fish, marine mammals risk	Y/N			
		Emergency Responders risk	Y/N			
		Employee/Contractor risk	Y/N			
		Public risk	Y/N			
		Business, Asset or Political risk	Y/N			
		Severities are reduced due to greater distance to Lebanon Worst Case Discharge Volume (barrels) = 2000 te/hr. worst case 2hours) = 4000 te Likelihood x Severity = 2x3 = 6				

Area/Source outside Lebanese Control	Major Hazard Scenario summary + Initiating Event *Note 1	Major Spill Hazard Consequences (if no control measures) and risk analysis of highest risk events (consequence and likelihood) *Note 2		Engineering Controls affecting likelihood	Operational Controls affecting likelihood	Mitigation Measures and Methods (Oil Spill Contingency Response Tier 1-3)
		Most likely event = <7 te. Small leaks from couplings etc. would not affect Lebanon Likelihood x Severity = 4x1 = 4=				
External Risk from onshore spills to marine environment Onshore fuel storage tanks at terminals, ports, power stations and industry	Failure of tank(s) or associate pipework systems. Holding tank overflow from receiving tank near coast line or with pathway to sea. Sabotage or terrorist attack on a tank - potential missile from some distance or airplane. Internal fire or explosion.	Initiating Event =>LOC	Y/N	Dictated by others	Dictated by others	Tier 1 plans and spill response (e.g. Total terminal) Navy and civil defense support and equipment stockpiles International response support (via REMPEC, OSRL etc.)
		Sensitive locations - Beach, Marsh, River Inlet, Ground Water	Y/N			
		Sea Surface	Y/N			
		Toxic Gas/Smell	Y/N			
		Fire/Explosion	Y/N			
		Plants, Birds, Fish, marine mammals risk	Y/N			
		Emergency Responders risk	Y/N			
		Employee/Contractor risk	Y/N			
		Public risk	Y/N			
		Business, Asset or Political risk	Y/N			

Area/Source outside Lebanese Control	Major Hazard Scenario summary + Initiating Event *Note 1	Major Spill Hazard Consequences (if no control measures) and risk analysis of highest risk events (consequence and likelihood) *Note 2	Engineering Controls affecting likelihood	Operational Controls affecting likelihood	Mitigation Measures and Methods (Oil Spill Contingency Response Tier 1-3)
		Severities are reduced due to greater distance to Lebanon INDICATIVE Worst Case e.g. Ashkelon, Discharge Volume (barrels) = total 500kte Total storage of 1.9 million m3 at each of Haifa (10 miles from Lebanese border) and Ashkelon Likelihood x Severity = 2x5 = 10			
		Most likely event = <5te. Small leaks from pipework etc. May not reach Lebanon Likelihood x Severity = 4x1 = 4			

Area/Source outside Lebanese Control	Major Hazard Scenario summary + Initiating Event *Note 1	Major Spill Hazard Consequences (if no control measures) and risk analysis of highest risk events (consequence and likelihood) *Note 2		Engineering Controls affecting likelihood	Operational Controls affecting likelihood	Mitigation Measures and Methods (Oil Spill Contingency Response Tier 1-3)
	Loss of well control with failure of blow out preventer (BOP) Drilling, production or pipeline Pipework failures: Gas (probable) Condensates (probable) Light Crudes (possible) Heavy Crudes (unlikely)	Initiating Event =>LOC	Y/N	Dictated by others	Dictated by others	Dictated by others Capping Stack (2-3 weeks) or relief well (2-3 months) Navy and civil defense support and equipment stockpiles International response support (via REMPEC, OSRL etc.)
		Sensitive locations - Beach, Marsh, River Inlet, ~~Ground Water~~	Y/N			
		Sea Surface	Y/N			
		Toxic Gas/Smell	Y/N			
		Fire/Explosion	Y/N			
		Plants, Birds, Fish, marine mammals risk	Y/N			
		Emergency Responders risk	Y/N			
		Employee/Contractor risk	Y/N			
		Public risk	Y/N			
		Business, Asset or Political risk	Y/N			

Area/Source outside Lebanese Control	Major Hazard Scenario summary + Initiating Event *Note 1	Major Spill Hazard Consequences (if no control measures) and risk analysis of highest risk events (consequence and likelihood) *Note 2	Engineering Controls affecting likelihood	Operational Controls affecting likelihood	Mitigation Measures and Methods (Oil Spill Contingency Response Tier 1-3)
Sea currents west to east along North Africa cost and circulation from west of Cyprus. External Risk from drilling and production to south of Lebanon (Occupied Palestinian Territories and Egypt) offshore. Activity is with gas and condensate Distance from Libya is very high (excluded)		Severities are reduced due to greater distance to Lebanon INDICATIVE Worst Case Discharge Volume Gas, condensates = 1000m3 per day (worst case 60 days)			
		Severities are reduced due to greater distance to Lebanon INDICATIVE Worst Case Discharge Volume Gas, condensates = 1000m3 per day (worst case 60 days)			
		Most likely event = <10m3 of condensate with gas leak. Would not reach Lebanon. Likelihood x Severity = 4x1 = 4			

Note 1: Initiating Event guide words LOC = Loss of Containment:

- LOC from Well Operations
- LOC via impact, rupture or other leak/failure of fixed pipework or vessel including flanges and manways
- LOC from deliberate act (e.g. terrorism, sabotage, oil theft)
- LOC from natural disaster (e.g. earthquake, tsunami, hurricane)
- LOC due to poorly made temporary connection or flexible hose (e.g. refueling vehicles or ships)
- LOC via punctured/ruptured vessel or packaging (e.g. drum, bags, IBC, road tanker, ship)
- LOC via wrongly opened valve or system isolation
- LOC via flare, vent or overflow pipe
- LOC via pressure relief system
- Unwanted/uncontrolled chemical reaction (e.g. well cleaning agents)
- Internal fire or explosion in a pipeline, vessel or container

Note 2:

Risk Assessment is for the overall hazardous event amalgamating the sub-scenarios. Likelihood and severity are on 1-5 scale giving overall risk 1-25. Likelihood scores are all relative however a guide on severity is as follows:

Likelihood:

1 = Remote; 3 = Low; 5 = Likely

Severity:

1 = Negligible hazard to the environment
2 = Minor hazard to the environment
3 = Serious hazard to the environment + risk of legal action + local news
4 = Major Hazard to the environment + high risk of legal action + regional news
5 = Risk of catastrophic environment effects + legal action + national/international news

Annex 2: Modelling Data Inputs

Metocean data used for Lebanon runstock is as follows.

1. Wind

ECMWF ERA-Interim

ERA-Interim is a reanalysis of the global atmosphere covering the data-rich period since 1979 (originally, ERA-Interim ran from 1989, but the 10 year extension for 1979-1988 was produced in 2011), and continuing in real time. The ERA-Interim atmospheric model and reanalysis system uses cycle 31r2 of ECMWF's Integrated Forecast System (IFS), which was introduced operationally in September 2006, configured for the following spatial resolution:

- 60 levels in the vertical, with the top level at 0.1 hPa;
- T255 spherical-harmonic representation for the basic dynamical fields;
- A reduced Gaussian grid with approximately uniform 79 km spacing for surface and other grid-point fields.

The atmospheric model is coupled to an ocean-wave model resolving 30 wave frequencies and 24 wave directions at the nodes of its reduced 1.0° x 1.0° latitude/longitude grid. Documentation of the IFS is published on the ECMWF website at http://www.ecmwf.int/research.

The ERA-Interim data assimilation and forecast suite produces:

- Four analyses per day, at 00, 06, 12 and 18 UTC;
- Two 10-day forecasts per day, initialized from analyses at 00 and 12 UTC.

The analysis produced at 00 UTC on a given day involves observations taken between 15 UTC on the previous day and 03 UTC on the present day; the analysis at 12 UTC involves observations between 03 UTC and 15 UTC.

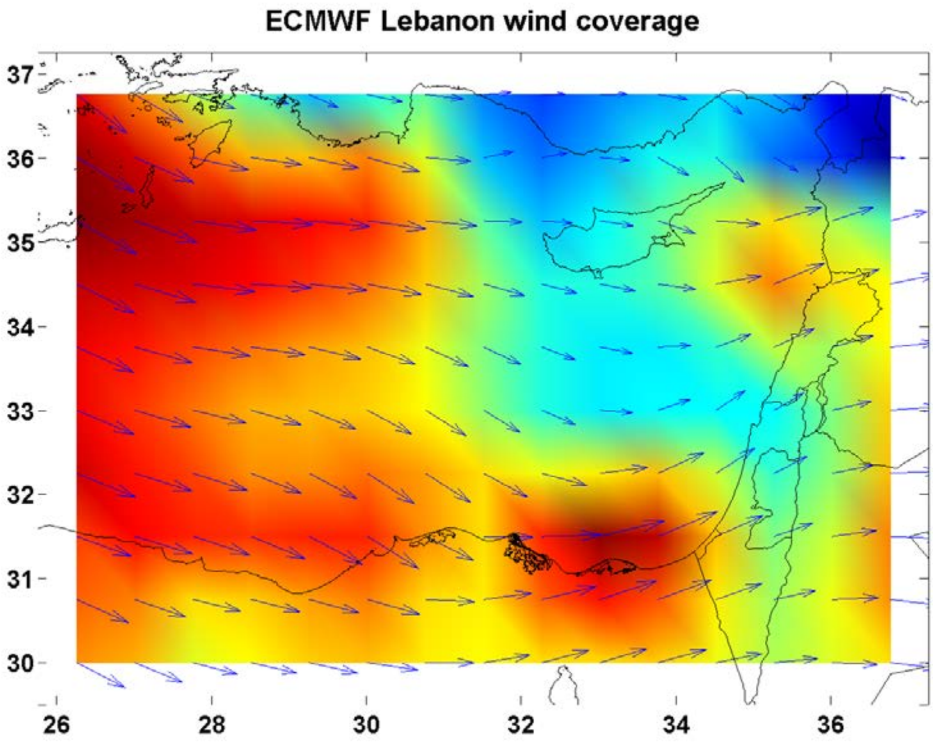
Unless specified otherwise, forecast data on pressure levels (levtype=pl in MARS) and for the surface and single level parameters (levtype=sfc) are archived at the 28 ranges, or steps, of 3-, 6-, 9-, 12-, 15-, 18-, 21-, 24-, 30-, 36-, 42-, 48-, 60-, 72-, 84-, 96-, 108-, 120-, 132-, 144-, 156-, 168-, 180-, 192-, 204-, 216-, 228-, and 240-hours from the twice daily forecasts at 00 and 12 UTC. Forecast model level data (levtype=ml) are archived at 3-, 6-, 9-, and 12-hour ranges from 00 and 12 UTC. Forecast data are not available for fields on isentropic (levtype=pt) and PV = ±2 PVU (levtype=pv) levels. On the ECMWF Data Server forecasts are only available for surface and single level fields and only up to a range of 12-hours.

Fields from the atmospheric model are archived either at the full T255 spectral resolution or on the corresponding N128 reduced Gaussian grid, depending on their basic representation in the model. Fields from the coupled ocean-wave model are saved on its reduced 1.0° x 1.0° latitude/longitude grid.

The N128 reduced Gaussian grid is symmetric about the equator, with a north-south separation which is close to uniform in latitude, with a spacing of about 0.703125°. There are 128 points aligned along the Greenwich Meridian from equator to pole. The number of points in the east-west varies with latitude, with uniform grid spacing along a particular line of latitude. This spacing is 0.703125° in most of the tropics.

A comprehensive documentation of the ERA-Interim reanalysis system has been published as an open-access article in the Quarterly Journal of the Royal Meteorological Society, and can be downloaded from http://onlinelibrary.wiley.com/doi/10.1002/qj.828/abstract .

Figure A2- 1: ECMWF Lebanon wind coverage



2. Currents

Mediterranean Sea Physics Reanalysis

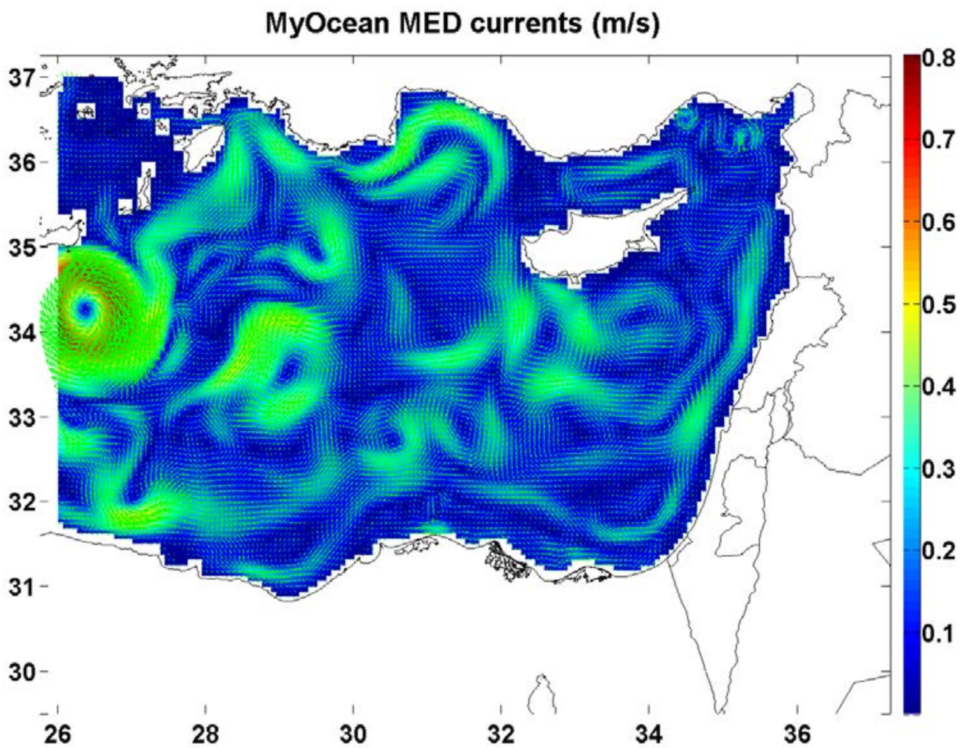
The Mediterranean Forecasting System, physical reanalysis component, is a hydrodynamic model, supplied by the Nucleus for European Modelling of the Ocean (NEMO), with a variational data assimilation scheme (OceanVAR) for temperature and salinity vertical profiles and satellite Sea Level Anomaly along track data. The model horizontal grid resolution is 1/16° (ca. 6-7 km) and the unevenly spaced vertical levels are 72.

The OGCM (Ocean General Circulation Model) code is NEMO-OPA (Nucleus for European Modelling of the Ocean-Ocean Parallelise) version 3.2 (Madec et al 2008). The code is developed and maintained by the NEMO-consortium. The model is primitive equation in spherical coordinates. NEMO has been implemented in the Mediterranean at 1/16° x 1/16° horizontal resolution and 72 unevenly spaced vertical levels (Oddo et al., 2009). The model is located in the Mediterranean Basin and also extend into the Atlantic in order to better resolve the exchanges with the Atlantic Ocean at the Strait of Gibraltar. The NEMO model is nested, in the Atlantic, within the monthly mean climatological fields computed from ten years of daily output of the 1/4° x 1/4° degrees global model (Drevillon et al., 2008). Details on the nesting technique and major impacts on the model results are in Oddo et al., 2009. The model uses vertical partial cells to fit the bottom depth shape.

The model is forced by momentum, water and heat fluxes interactively computed by bulk formulae using the 6-h, 0.75° horizontal-resolution ERA-Interim reanalysis fields from the European Centre for Medium-Range Weather Forecasts (ECMWF) and the model predicted surface temperatures (details of the air-sea physics are in Tonani et al., 2008). The water balance is computed as Evaporation minus Precipitation and Runoff. ERA-Interim Precipitations (6-h, 0.75° horizontal-resolution) were considered. The evaporation is derived from the latent heat flux while and the runoff are provided by monthly mean datasets: the Climate Prediction Centre Merged Analysis of Precipitation (CMAP) Data (Xie and Arkin, 1997); the Global Runoff Data Centre dataset (Fekete et al., 1999) for the Ebro, Nile and Rhone and the dataset from Raicich (Raicich, 1996) for the Adriatic rivers (Po, Vjosë, Seman and Bojana). The Dardanelles inflow is parameterized as a river and the climatological net inflow rates are taken from Kourafalou and Barbopoulos (2003). The data assimilation system is the OCEANVAR scheme developed by Dobricic and Pinardi (2008). The background error correlation matrix is estimated from the temporal variability of parameters in a historical model simulation.

Background error correlation matrices vary seasonally and in 13 regions of the Mediterranean Sea, which have different physical characteristics (Dobricic et al 2006). The mean dynamic topography used for the assimilation of SLA (Sea Level Anomaly) has been computed by Dobricic et al. (2005). The assimilated data include: sea level anomaly, sea surface temperature, in situ temperature profiles by VOS XBTs (Voluntary Observing Ship-eXpandable Bathythermograph), in situ temperature and salinity profiles by argo floats, and in situ temperature and salinity profiles from CTD (Conductivity-Temperature-Depth). Satellite OA-SST (Objective Analyses-Sea Surface Temperature) data are used for the correction of surface heat fluxes with the relaxation constant of 60 W/m2K1.

Figure A2- 2: MyOcean MED currents (m/s)



Model Parameters

Oil concentration thresholds: The threshold for oil concentration for display is 0.3µm for surface oiling and 0.001mm for shoreline oiling. The surface oil measurement has been selected in line with the UK guidance for modelling. This figure is in line with the Bonn Agreement color code for oil spill concentrations show in Table A2- 1 below, essentially sheens are not being included as these are very low concentrations. This code is published in The Bonn Agreement Aerial Operations Handbook.

Table A2- 1: BONN Agreement Color Code

OIL APPEARANCE TABLE			
No	OIL APPEARANCE DESCRIPTION	MINIMUM VOLUME m^3 / km^2	MAXIMUM VOLUME m^3 / km^2
1	SHEEN	0.04	0.30
2	RAINBOW	0.30	5.00
3	METALLIC	5.00	50.0
4	DISCONTINUOUS TRUE COLOUR	50.0	200
5	TRUE COLOUR	200	>200

Oil Types: The behavior and fate of oil in the marine environment is notoriously difficult to predict, however some assumptions can be made based on the API. The API for the oil types used for the modelling are shown in Table A2- 2.

Table A2- 2: API of oil types used for modelling

Scenario	Oil Type	API – ITOPF Group
Shipping incident outside Lebanese waters	Azeri Crude	36.8 – ITOPF Group 2
Well blowout North, well blowout south	Condensate	57.5 – ITOPF Group 1
Inbound tanker Tripoli, Zouk, Zahrani. Land based spill	Heavy Fuel Oil	11.5 – ITOPF Group 4
Well blowout central	Crude oil	24.8 – ITOPF Group 3

Seasonality: OilMAP allows statistic models to be run using seasonal or annual data. Test runs were undertaken to ascertain the impact of season on the behavior and fate of oil in Lebanese waters and although there were small differences in the evaporation percentages this was not considered significant. Consequently, the scenarios were modelled using annually averaged data.

Similarly test runs were carried out to ascertain the impact of any seasonal variation in water temperature, and again it was found that any difference in fate was only 1-2% and therefore considered insignificant and so water temperatures were averaged annually.