Section 9412

Non-Floating Oils Spill Response Tool

Table of Contents

Section **Page**

9412 Non-Floating Oils Spill Response Tool 9412-1

9412.1 Introduction 9412-1
9412.2 Decanting.. 9412-6
9412.2.1 Proposed Heavy Oil Decanting System 9412-7
9412.2.1.1 Multi-Stage Setting 9412-7
9412.3 Environmental Considerations 9412-10
9412.3.1 Introduction 9412-10
9412.3.2 Environmental Sensitivity Considerations for Water Column and Bottom 9412-10
9412.3.3 Generic Impacts from Various Containment and Recovery Cleanup Methods... 9412-12
9412.3.4 Net Environmental Benefit Analysis Process for Sunken Oils 9412-14
9412.4 Permits.. 9412-15
9412.A Attachment A 9412A-1
9412.A1 Initial Assessment.. 9412A-1
9412.A2 Attachment A: Non-Floating Oils Response Documentation of Considerations Form 9412A-3
9412.B Attachment B.. 9412A-1
9412.B1 Example ICS-234 Work Analysis Matrix. Non-Floating Oil Contain and Recover Spilled Material – Non-floating Oil Detection (Operational).. 9412A-1
9412.B2 Example ICS-234 Work Analysis Matrix, Non-floating Oil Contain and Recover Spilled Material – Non-floating Oil Recovery (Operational) 9412A-7
9412.B3 Example ICS-207 showing the incorporation of a Non-Floating Oil Branch into the Operations Section 9412A-14
9412.C Attachment C.. 9412A-1
9412.C1 API Technical Report 1154-1, Sunken Oil Detection and Recovery 9412A-1
9412.C2 API Technical Report 1154.2. Sunken Oil Detection and Recovery Operational Guide 9412A-1

9412

Non-Floating Oils Spill Response Tool

9412.1 Introduction

The increased handling of oils that sink or may weather and sink requires a shift in the way oil spill response is conducted in the Northwest. Traditionally, response has focused on containing and recovering surface floating oil through the use of booms and skimmers. Oils that sink or become suspended in the water column cannot be successfully combated with these techniques.

Recovery of submerged oil once released to the environment is even more difficult than floating oil. Priority should be given to preventing, minimizing, and containing these types of oil spills at their source. Additionally, since many oils may initially float, rapid and aggressive surface oil recovery efforts should be pursued when safe in the early phase of a spill.

The following definitions apply for the purpose of this response tool:

- "Submerged oil" describes any oil that is in the water column, below the water surface, including oil that is in temporary suspension due to turbulence and will refloat or sink in the absence of that turbulence. This includes spilled oil that has neutral or near-neutral buoyancy and that is intermittently submerged below the water surface for a significant proportion of time in the prevailing sea conditions.
- "Sunken oil" describes spilled oil that is on the bottom of the water body. The negative buoyancy may be due to the high density of the oil, density increase caused by oil "weathering," or the adherence of sediment or sand to the spilled oil. The sediment or sand may, in some circumstances, come into contact with the spilled oil while it is on the surface or during stranding of spilled oil on a coastline or river bank with subsequent remobilization. In low current conditions, sunken oil in shallow waters may pool in depressions on the bottom or be moved along the bottom by prevailing currents. At higher current speeds, the spilled oil may be dispersed as relatively large, but still non-buoyant, droplets.
- "Non-floating oil" can be used to describe oils that have become either submerged or sunken. The United States Coast Guard defines non-floating oils as "heavy oils and Group V oils that exhibit qualities which could, due to the oil characteristics, weathering, environmental factors or how they are discharged, potentially cause the oils to submerge or sink. Examples of

these types of oils include, but are not limited to, Diluted Bitumen (dilbit), Group V Residual Fuel Oils Low American Petroleum Institute Oil, Asphalt, and Asphalt Products."

Attachment A contains guidance on Initial Assessment for non-floating oils, including a form that may be used to document conditions.

Attachment B contains:

- B.1 Pre-populated, example ICS-234 (Work Analysis Matrix) forms to be used in tactical decision making for the containment and recovery of non-floating oil;
- B.2 A Sample ICS-207 showing the incorporation of a Non-Floating Oil Brank into the Operations Section.

Attachment C contains technical guidance on sunken oil detection and recovery technologies (Table 9412.1).

Detection	Recovery
Sonar Systems	Suction Dredge
Underwater Visualization Systems	Diver-directed Pumping and Vacuuming
Diver Observations	Mechanical Removal
Sorbents	Sorbent/ Vessel-Submerged Oil Recovery System (V-SORs)
Laser Fluorosensors	Trawls and Nets
Visual Observations	Manual Removal
Bottom Sampling	Agitation/Refloat
Water-column sampling	
Induced Polarization	

Attachment C also contains links to:

- C.1 Sunken Oil Detection and Recovery, American Petroleum Institute (API) Technical Report 1154-1.[1]
- C.2 Sunken Oil Detection and Recovery Operational Guide, AP Technical Report 1154-2.[2]

The API report identifies and documents current best practices and alternative technologies possessing the potential to more effectively detect, contain, and recover sunken oil, defined as the accumulation of bulk oil on the bottom of a water body. The technical report includes summaries and lessons learned for 36 case studies of oil spills where a significant amount of the oil sank. For each technology, it includes a detailed description of the method, advantages and

[1] American Petroleum Institute, February 2016, *Sunken Oil Detection and Recovery, API Technical Report 1154-1*, First Edition, API Publishing Services, Washington, DC.
[2] American Petroleum Institute, February 2016, *Sunken Oil Detection and Recovery Operational Guide, API Technical Report 1154-2*, First Edition, API Publishing Services, Washington, DC.

disadvantages, and summary tables—the kinds of information needed to select the most effective approaches to sunken oil detection and recovery.

API Technical Report 1154-1 contains 10 sections as follows:

Section 1: Introduction, Purpose, and Background
This section introduces the topic and states the purpose, which is to:

- identify and document current best practices and proven technologies possessing the potential to more effectively 1) detect, delineate, and characterize, 2) contain, and 3) recover sunken oil, defined as the accumulation of bulk oil on the bottom of a water body; and
- recommend research and development for the highest potential new technologies.

This report builds on all previous works, as well as recent spill experiences and testing of new technologies, to support improved spill planning, preparedness, and response. The goals are to 1) present the technical background in this technical report for planning and training, and 2) provide a more operationally effective decision support guide to be used during emergency responses.

Section 2: Sunken Oil
This section provides guidance on when to expect spilled oil to sink, either initially or later due to processes such as weathering and sediment interactions. It includes a chart to help determine if the oil can sink initially based on its density or API gravity and the salinity of the receiving water. It also includes a chart that shows how turbulence and sediment interaction can cause a floating oil to submerge or sink over time. Summaries for 38 spills, where a significant amount of the oil sank or submerged, describe the conditions of the spill, the methods used to detect and recover the sunken oil, and lessons learned.

Section 3: Techniques for Sunken Oil Detection, Delineation, and Characterization
The following techniques for sunken oil detection, delineation, and characterization are discussed in this section: 1) sonar systems; 2) underwater visualization systems; 3) diver observations; 4) sorbents; 5) laser fluorosensors; 6) visual observations by trained observers; 7) bottom sampling; and 7) water-column sampling. For each technique, the advantages and disadvantages are summarized. The uses and limitations of all sunken oil detection, delineation, and characterization techniques are summarized, and a matrix is provided to assist in evaluation of detection techniques for specific spill conditions. There is also a section on considerations for sunken oil detection in rivers and under extreme cold conditions.

It is important to note that oftentimes multiple detection, delineation, and characterization methods should be used, in combination and/or in sequence. All remote detection methods require ground truthing, or need bottom sampling to determine the oil thickness on the bottom or determine the oil's viscosity and thus pumpability.

Section 4: Techniques for Sunken Oil Containment
This section is very short because there are few proven methods to prevent the remobilization of sunken oil on the bottom when turbulence and currents increase. The results of the many methods attempted to prevent the spread of oiled sediments during the response to the 2010 Enbridge Pipeline spill in the Kalamazoo River are summarized, although it is important to note that this spill, like all spills, represents just one set of conditions. Research and development are needed to determine if there are effective methods to contain sunken oil for a range of spill conditions.

Section 5: Techniques for Sunken Oil Recovery
The following techniques for sunken oil recovery are discussed in this section: 1) suction dredge; 2) diver-directed pumping and vacuuming; 3) mechanical removal; 4) sorbent/V-SORs; 5) trawls and nets; 6) manual removal; and 7) agitation/refloat. For each technique, the advantages and disadvantages are summarized. The uses and limitations of all sunken oil recovery techniques are summarized, and a matrix is provided to assist in evaluation of recovery techniques for specific spill conditions. There is also a section on considerations for sunken oil recovery in rivers and extreme cold conditions.

It is important to emphasize that, because sunken oil often becomes mobilized during a response, recovery of sunken oil must be closely coupled with detection to increase overall effectiveness.

Section 6: Diving in Contaminated Water
Commercial divers often play a critical role in the success of sunken oil detection, delineation, characterization, and recovery operations, and diver safety is of paramount importance. This section summarizes the regulatory requirements for dive operations in contaminated water and safety checklists.

Section 7: Waste Stream Management
Waste generation during sunken oil recovery operations is a very important consideration in both the selection of the removal method and the types of waste stream treatment methods to be implemented. This section provides guidance on best practices for handling the oil, liquids, and solids generated during a sunken oil response.

Section 8: Government Regulations to be considered
This section briefly outlines the state and federal government regulations that may apply to sunken oil response actions, such as protection of cultural resources, species listed under the Endangered Species Act, and permitting for dredging.

Section 9: Research and Development Recommendations
This section includes recommendations for research and development to advance the state of the practice in sunken oil response.

Section 10: Literature Cited and Suggested Readings
This section includes all of the references cited in the report and suggested further readings.

The API Operational Guide, Report 1154-2 contains the following sections:

Section 1: Introduction and How to Use This Guide

Section 2: Determine the Potential for the Oil to Sink under the Spill Conditions
This section provides guidance on when to expect that an oil may sink, either initially or later due to processes such as weathering and sediment interactions. It includes a chart to help determine if an oil can sink initially based on its density or API gravity and the salinity of the receiving water. It also includes a chart that shows how turbulence and sediment interaction can cause a floating oil to submerge or sink over time.

Section 3: Select Sunken Oil Detection, Delineation, and Characterization Techniques
This section includes a checklist of the types of information you will need about the oil and spill conditions to start evaluating which sunken oil detection options may be effective for the spill. There is a list of action items to guide the development and approval of a sunken oil detection plan. It also includes tabular summaries of the advantages and limitations of possible options, along with a matrix to guide selection of the best combination of options.

It is important to note that oftentimes multiple detection, delineation, and characterization methods should be used, in combination and/or in sequence. All remote detection methods require ground truthing or need bottom sampling to determine the oil thickness on the bottom or determine the oil's viscosity and thus pumpability.

Section 4: Determine if there are Feasible Sunken Oil Containment Techniques
This section notes that containment of sunken oil may not always be feasible. It includes summaries of the advantages and limitations of possible options under mostly low-flow conditions.

Section 5: Select Sunken Oil Recovery Techniques
This section includes a checklist of the types of information you will need about the oil and spill conditions to start evaluating which sunken oil recovery techniques may be effective for the spill. There is a list of action items to guide the development and approval of a sunken oil recovery plan. It also includes

tabular summaries of the advantages and limitations of possible recovery techniques, along with a matrix to guide selection of the best combination of techniques.

Section 6: Waste Stream Management
Because waste generation during sunken oil recovery operations is a very important consideration in both selection of the removal method and the types of waste stream treatment methods to be implemented, this section provides guidance on best practices for handling the oil, liquids, and solids generated during a response.

Section 7: Safety Considerations
Safety is of paramount importance during all phases of sunken oil detection and recovery, as it is during any response. Therefore, this section includes safety considerations throughout the response. It also includes a checklist of the issues to consider when developing a plan to conduct sunken oil detection and recovery operations, including:

- general safety;
- equipment mobilization and heavy lift operations;
- hydraulic submersible pumps and transfer operations;
- diving operations.

9412.2 Decanting

Submerged oil pumping operations utilize water as a carrier device to transport oil while performing recovery, a necessary function that results in the accumulation of a large amount of water in the storage tanks. Depending on the nature of the oil, the benthic environment, and the efficiency of the pump and its nozzle, a large load of sediment or sediment-loaded oil may be unavoidably collected. Separation of the oil-water-sediment mixture collected during underwater oil recovery can become a limiting factor in the operation and overall throughput of the recovery system. The decanting system must be designed accordingly to handle these waste streams.

The wide range of oil types and environmental conditions that could be encountered during submerged oil recovery operations requires a strategy for devising different types of decanting systems to suit different types of submerged oil spills, based on an inventory of components (tanks, heaters, pumps, filters) that could be drawn together using standard interfaces (compatible fittings, hoses, etc.). The attributes that must be considered for a decanting system intended especially for submerged oil recoveries are as follows:

- The ability to separate out sediment and other solids.
- The ability to separate oils of varying density and viscosity from either seawater or fresh water, including the ability to collect both the oil fraction that remains heavier than water and the fraction that refloats during the process.
- The ability to configure the system appropriately for different types of recovered spill and on different recovery platforms.

- The ability to avoid or resist clogging due to suspended sediment or high-viscosity oil, or a combination of both; general ease of maintenance and low power requirements.
- Resistance to the chemical effects of different types and grades of recovered oil.
- The ability to operate satisfactorily under the anticipated motions (wave activity) of the recovery platform. Recovery platforms are often platforms of opportunity and the range of ship motion environments is fairly broad even though the environment anticipated for recovery operations is usually modest compared with rough weather for a seagoing ship.
- Settling and decanting can be quite sensitive even to modest platform motions and can then become a bottleneck in the overall system throughput.
- Security against the possibility of becoming a secondary spill source.
- Safety of personnel, system reliability, and low costs for acquisition and operation are considered highly important design criteria.

In situ oil on the sea floor may be either intrinsically denser than water, or it may be on the bottom because it adheres to or becomes mixed with sediment. When disturbed or agitated, whether by the natural environment or the recovery process, some fraction of the oil may refloat, while some fraction may remain heavy enough to settle out. In either case, the difference in density between water and oil may be small, so that settling proceeds rather slowly.

9412.2.1 Proposed Heavy Oil Decanting System

9412.2.1.1 Multi-Stage Setting

For a variety of reasons, multi-stage decanting systems are often used. As one example, a four-stage decanting system was used in the Delaware River (Athos) submerged oil recovery. Most of the oil refloated. On that site, a series of three 4,000-gallon fractionation tanks were used for decanting the oil. The first tank was used for collection and the second and third for settling. A skimmer was placed on the top of the second tank to recover oil for transfer to storage. Sorbent snares were placed on top of the third tank to recover any remaining residual oil. Finally, water was pumped from the third 4,000-gallon tank through a 350-gallon polishing tank filled with sorbent oil snares and then discharged into a boomed area alongside the work barge, with additional sorbent snares floated in it.

When a significant fraction of the oil is intrinsically denser than water, or adheres more strongly to the sediments with which it was in contact, then settling will result in material on the bottom of each tank. For this reason, floating skimmers and floating sorbent snares on the top will not be able to concentrate or capture all of the oil. A general-purpose system must include a way to remove heavier oil and sediments from the tank bottoms, as well as refloated oil from the tops. Submersible pumps can be suspended at a variable depth within each tank in a cascade, discharging into the next stage. By appropriately setting the depth of the intake, the pump can be used to transfer water to the next stage of the settling cascade or to transfer oil to a storage tank.

The processing at each stage may be conducted either continuously or in batches, depending on:

- The size and depth of the tank,
- The amount of flow disturbance at the inlet,
- The number of parallel processes available, and
- The relationship between desired processing rate and available settling rate.

As mentioned above, this quantity varies with density difference, the volume ratio (water and oil) taken up in the collection process, and the amount of remixing taking place due to platform motions.

If the system is set up as a modular system, then the critical stage can be duplicated and the bottleneck relieved. For example, if a large quantity of oil is refloated at the first stage, then the number of oleophilic skimmers in the first stage tank(s) can be increased. By contrast, if less of the oil is refloated, then the collecting tank(s) will tend to become more "bottom heavy" and require more frequent clean-out of the bottoms. This could be accommodated by shifting one or more tanks into the collecting role, so that the available settling area is increased at that point in the process, and the amount of surface skimming is reduced. The depth setting on the intakes of the pumps transferring effluent from one stage to the next can also be adjusted to accommodate different volumes of refloated oil. Figure 9412-1 shows a recommended decanting system design using the following stages.

Stage 1 – Solid Separation

Solid separation in tank 1 using baffles, filters, and/or gravity settling; the time required will depend on the nature of the solids. Liquid portion is pumped to tank 2. Solids will need to be removed from the bottom of the tank. Tank 1A may need to be replaced with tank 1B (tank 1B put into service) for this to be accomplished. This operation may require the introduction of heavy machinery to aid in efficient solid waste management (i.e., the use of a crane with clam bucket or an excavator appropriately outfitted), as well as placement of appropriate secondary solid waste containers at the site.

Stage 2 – Liquid Phase Separation in Tank 2

Separate oil from water using aeration, heating, and/or gravity separation. In most cases, some oil will sink and some will float.

Stage 3 – Collection of Oil

Floating oil can be collected from tank 2 using skimmers and/or sorbent snares and pumped to or placed in tank 3. Sunken oil will need to be removed from the bottom of the tank. Tank 2A may need to be replaced with tank 2B for this to be accomplished.

Stage 4 – Collection of Water

Water (middle layer between floating and sunken oil needs to be pumped from tank 2 into tank 4.

Stage 5 – Polishing of Water

Water in tank 4 can be polished using filters or oil absorbent systems and returned to the environment. Typical filtration systems applied to oil spill decanting operations include sand and carbon filtration units, specialized bag/chamber filtration methodologies, and some custom designed filter devices that fit on the end of discharge hoses. In each case, the selection process for specifying the filter media should be based on compatibility with the type of oil that will be encountered. It is also important to ensure that the filter methodology selected allows for the required flow rate of the system as a whole, a decision factor that may require multiple banks of filters to ensure that a bottleneck condition does not occur at this final step in the process, resulting in shutting down operations to clear space in tanks ahead of the filtration process.

Stage 6 – Disposal

Disposal of oil, oiled debris, and decontaminated sand/sediments.

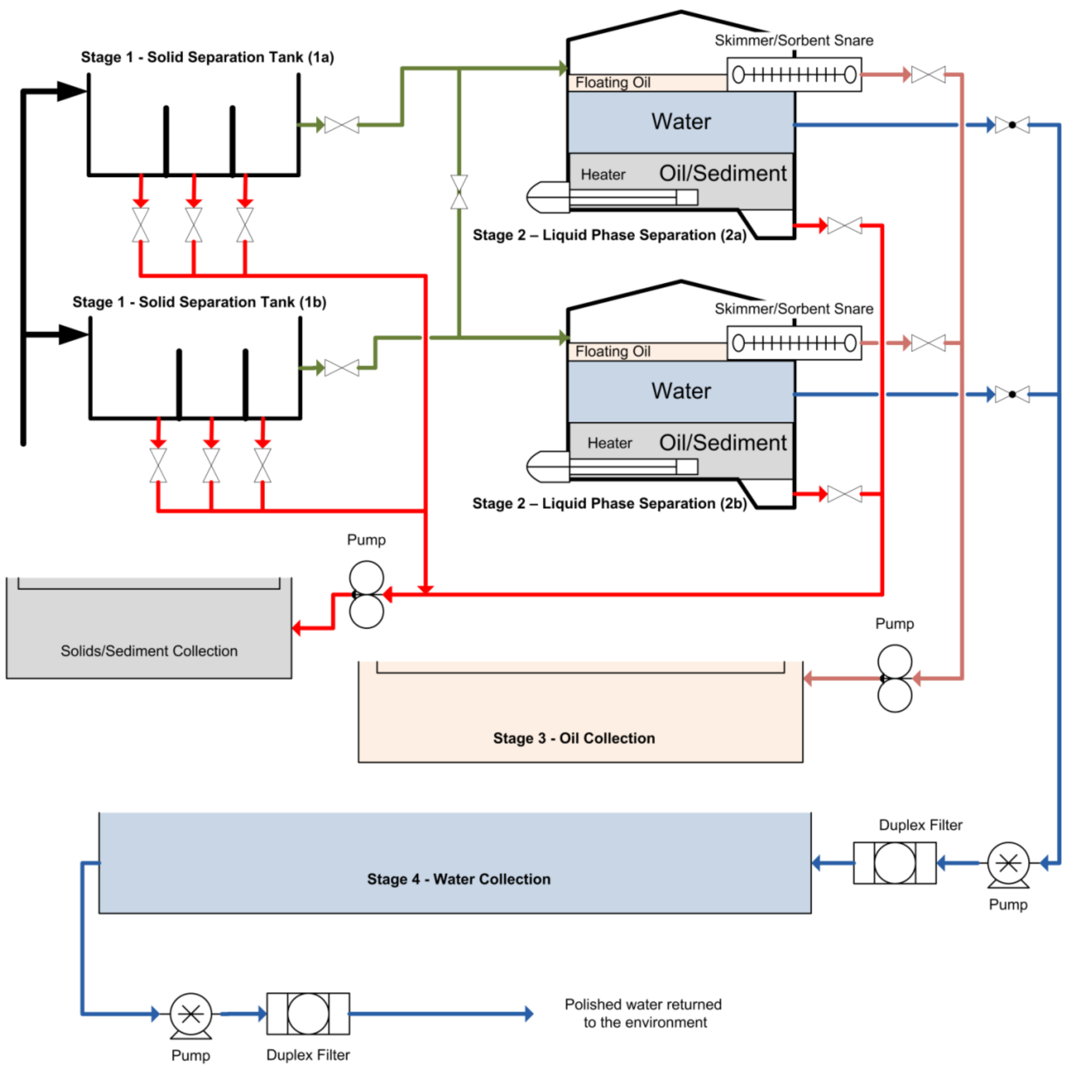

Figure 9412-1 Recommended Decanting System

Logistics and costs are reduced if the material can be stored/staged on land, compared with using barges for temporary storage and separation. Time can be of concern because oil that is still fluid can be re-mobilized by storm waves, increased river flow following heavy rains, or ship traffic.

9412.3 Environmental Considerations

9412.3.1 Introduction

Non-floating oil spills pose a substantial threat to water-column, benthic, and aquatic resources, particularly where significant amounts of oil have accumulated on the substrate. Sunken oil recovery techniques have the potential to cause more damage than the original oiling. Consideration should be given to conducting a Net Environmental Benefit Analysis (NEBA) prior to recovery operations. However, unlike surface and shoreline cleanup situations, there is very little in the way of protocols and information sources to support NEBA for submerged and sunken oil. This is partially due to the relative infrequency of these spills and the small number of cases in which cleanup has been conducted.

Even though information to support the NEBA process for submerged and sunken oil is not as widespread as for surface spills, there are NEBA concepts that could be considered.

9412.3.2 Environmental Sensitivity Considerations for Water Column and Bottom

Just as there are different shoreline types, each with different ecological values and degrees of difficulty in cleanup, so too are there different water column types and bottom types that should be considered when undertaking cleanup operations for submerged and sunken oil. Factors that should be considered include:

- Ecological Sensitivity – Although each section of bottom will have unique characteristics, some generalizations can be made regarding the ecological sensitivity of bottom types similar to the classifications assigned to shoreline types. Bottom types will range from the most ecologically sensitive and important, such as submerged aquatic vegetation (seagrass beds, eelgrass beds, and kelp forests), to the less important such as rocky substrate, sand, and mud. Probably the least sensitive bottom types are sand and mud bottoms in areas that already suffer from pollution such as industrial areas. Note that the National Oceanic and Atmospheric Administration Environmental Sensitivity Index maps will generally delineate sensitive bottom habitats that are in shallower water adjacent to the shoreline. The Environmental Unit, National Oceanic and Atmospheric Administration Scientific Support Coordinator, and state resource trustees can provide information on bottom resources.
- Persistence of Oil on the Bottom – The persistence of oil on the bottom depends on the permeability/porosity of substrate, the oil's density (buoyancy), and the adhesion properties of the oil. Persistence is also a function of bottom turbulence and currents. If the oil is in an ecologically

sensitive area, the persistence of the oil warrants more timely removal action. If the oil is likely to remain in an area of little ecological significance, then removal actions can be more intrusive and pursued at a slower pace.

- Proximity of Sensitive Resources – As with surface spills, it is important to consider the current location of the oil and environmental sensitivity, but also the sensitivity of locations where the oil might be transported.
- Geographic Response Plans are a good resource for information on sensitive natural, cultural, and biological resources.
- Threatened and Endangered Species and their Designated Critical Habitats – Marine mammals, birds and benthic invertebrate and fish communities may be directly disturbed by removal of oil from the bottom; they may be injured or disturbed by response vessels and equipment; and they may be contaminated if oil is re-suspended in the water column, and their food sources may be contaminated or reduced.
- Historic/Archeological Resources –There may be historic and archeological resources below the water that have not been located and charted, which may be uncovered and disturbed by cleanup operations. The State Historic Preservation Officer and local officials should be consulted before dredging or other intrusive cleanup operations are undertaken on the bottom in areas of historic interest, or if wrecks or other artifacts are known or encountered during the operation.
- Safety Hazards – Safety hazards such as electrical cables, underwater pipelines, and unexploded ordinance should be indicated on navigation charts. Port authorities, the United States Army Corps of Engineers, and local utility companies can provide more detailed information on infrastructure on the bottom. Some areas of the bottom (e.g., Superfund sites) may have toxic contaminants present in the sediments which would best be left undisturbed. The United States Environmental Protection Agency and state and local environmental agencies should be consulted regarding the presence of these sites.

Table 9412-1 Resources at Risk Consideration for Floating vs Non-Floating Oil Spills

Resources at Risk	Risks from Spills on Non-floating Oils Compared to Spills of Floating Oils
Rocky Shores (-)	Less oil is likely to be stranded, but oil that is stranded is usually stickier and thicker
Beaches (-)	Viscous oils are less likely to penetrate porous sediments. Oil is often stranded as tar balls, which are easy to clean up on sand beaches. Chronic recontamination is possible for months.
Wetlands and Tidal Flats (-)	Less oil coats vegetation. Because the oil does not refloat with the rising tide, any oil stranded on the lower intertidal zone will remain, thus increasing risk to biota. Cleanup of oil from these environments is very difficult, and natural recovery takes longer.
Water Surface (-)	Less oil remains on the water surface. Oil tends to form fields of tar balls. Potential for chronic impacts from refloated oil over time is high.

Resources at Risk	Risks from Spills on Non-floating Oils Compared to Spills of Floating Oils
Water Column (+)	Oil can increase exposure as it mixes in the water column. Risks increase if oil refloats after separation from sediments. When submerged, slow weathering of the more toxic components can be a chronic source of risk.
Benthic Habitats (++)	Risks are significantly increased for areas where heavy oils accumulate on the bottom. Slow weathering rates further increase the risk of chronic exposures. Smothering and coating can be heavy. Bioavailability varies with oil and spill conditions.
Birds (-)	Less oil remains on the water surface, so direct and acute impacts are lower. There is a high probability of chronic impacts from exposure to refloated oil and restranded tar balls on shores after storms.
Fish (+)	Risks are increased to all fish (including mid-water species), especially benthic or territorial fish, in areas where oil has accumulated on the bottom.
Shellfish (++)	Risks are increased to all shellfish, especially species that spend most of their time on the sediment surface (e.g., mussels, lobsters, crabs). Risk of chronic exposure from bulk oil, as well as the slow release of water-soluble polynuclear aromatic hydrocarbons, is high.
Marine Mammals (-)	Less oil remains on the water surface, and the potential for contamination of marine mammals on shore is lower. Oil in the water column is not likely to have an impact on highly mobile species. Benthic feeders (such as gray whales) could be exposed from accumulations on the bottom, which would weather slowly.
Water Intakes (++)	Oil mixed into the water column would pose serious risks to water treatment facilities. Closures are likely to be longer.
Fisheries (+)	Risk of taint, whether real or perceived, to a fishery product reducing or eliminating it as a viable product, e.g. temporary disruption of the geoduck Asian market.
Riparian Zones (+)	Oil that is stranded or is present on oiled debris that has been deposited on banks and islands can pose a risk to wildlife. The weathering timeline of persistent, heavier oils increases the risk of wildlife contact exposure to oil residue. Prolonged cleanup activities can increase erosion and habitat disturbance on river banks due to increased boat traffic and the presence of workers and equipment.
Note: (-) indicates a reduction in risk. (+) indicates an increase in risk. Actual risks for a specific spill will be a function of the composition and properties of the spilled oil and environmental conditions at the spill site.	

9412.3.3 Generic Impacts from Various Containment and Recovery Cleanup Methods

Just as with shoreline cleanup techniques, subsurface and bottom cleanup techniques and technologies have collateral environmental impacts that warrant consideration. NEBA weighs the positive environmental risks associated with leaving the oil and allowing for natural attenuation against the impacts associated with the available detection and recovery options.

The impact of generic detection and recovery techniques used to date is described below:

- Manual Removal by Divers – divers locate and remove smaller concentrations of oil using hand tools or sorbents. The technique is effective but slow and labor intensive. It is best used with limited quantities of oil in shallower water and in places where sensitive bottom resources are involved. Damage to the local environment is minimized as long as oil is accessible and visibility allows location of the oil patches or globs.
- Diver or Remotely Operated Vehicle Directed Bottom Vacuuming/Pumping – Oil is removed from the bottom using vacuum heads/pumping devices that are directed by divers or Remotely Operated Vehicle operated from the surface. Oil is removed, but significant quantities of water, bottom sediment, and marine organisms can be removed as well, with the amount depending on the precision with which the intake nozzle is manipulated. The level of environmental impact increases with the amount of sediment and marine organisms disturbed and/or removed.
- Bottom Nets and Trawls – The damage associated with use of these devices to collect oil on or near the bottom can be serious, as they will disrupt or destroy bottom habitat and are likely to capture organisms that are less mobile and cannot escape.
- Dredging – Mechanical dredging using dedicated vessels and equipment is the quickest and most thorough method of removing oil from the bottom, but also the most intrusive and environmentally damaging. It is typically used in removing large quantities of semi-solid petroleum products from bottom environments of limited ecological value (although it might be used selectively in a sensitive environment to quickly remove the oil before it is mobilized and spread to a wider area.
- Capping – Capping involves covering the contaminated area with an impermeable layer of material to isolate it from the environment. It has been used as a remediation technique for contaminated sediments and dredge spoil in cases where removal is impractical or would only spread the contamination.
- Monitored Natural Attenuation – As with surface and shoreline cleanup operations, the “no action” alternative should always be considered, particularly when the impact of the oil appears minimal in relation to the habitat disruption and aquatic organism mortality associated with removal. No action leaves the removal of the oil to natural biodegradation on the bottom.

Additional techniques, including environmental clamshell, manual shovel pits, bottom sampling, agitation/refloat, enhanced passive sediment accumulation, should always be evaluated for the potential disturbance of bottom habitats as well as the resulting increased turbidity associated with sediment re-mobilization and the potential impact to the water column downstream and to downstream locations.

Generally, less intrusive techniques (e.g., manual collection by divers and diver-directed vacuuming) are better suited to sensitive environments unless urgent removal is the overriding consideration.

9412.3.4 Net Environmental Benefit Analysis Process for Sunken Oils

Table 9412-3 shows some of the decision factors and tradeoffs involved in the NEBA process for sunken oils. The variety of situations encountered in sunken oil spills, the limited information on bottom configuration and habitat, and the lack of experience and information on the effectiveness and impacts of cleanup techniques preclude straightforward and prescriptive protocols for making quantitative net environmental benefit determinations. However, there are strategic decisions that can be defined and decision factors that can be identified. These strategic decisions include the speed with which the oil must be removed, the amount of damage to the environment that can be accepted with rapid removal, and the longer-term environmental impact that can be tolerated by delaying recovery or leaving the oil in the environment.

Potential exposure pathways to be considered include:

- Aqueous Exposure: Inhalation/ingestion of whole oil droplets, dissolved components, or suspended particulates in the water column.
- Sediment Exposure: Exposure to globules or residual oil in sediments.
- Physical Trauma: Trampling, mechanical impact from equipment, impacts from removal.
- Physical Oiling/Smothering: Direct contact with oil/oil residues.
- Indirect: Food web, ingestion of contaminated food, increased water column turbidity, increased noise, impacts associated with boat traffic, sediment smothering, bank erosion, loss/displacement of prey.

Table 9412-3 Decision Factors and Tradeoffs in the Net Environmental Benefit Analysis Process

Decision	Factors Involved	Tradeoffs
<u>Urgency of Cleanup</u> – How quickly must the submerged/sunken oil be removed from the environment?	▪ Amount of oil spilled ▪ Possibility of re-suspension and transport ▪ Sensitivity of the surrounding area	More rapid but intrusive cleanup options such as vacuuming and dredging will likely disrupt and/or destroy the habitat and organisms in the immediate vicinity of the oil, but may prevent subsequent damage to adjacent habitat and resources that may be even more sensitive.
<u>Acceptable Impact for Short-Term Removal</u> – What is the level of environmental	▪ Amount and type of oil involved (small amounts of heavy, semi-solid oil are easier to remove than large amounts of liquid, neutrally buoyant oil)	Often the tradeoff involves choosing the most expeditious and effective technique that the bottom habitat can

Decision	Factors Involved	Tradeoffs
impact that can be accepted in effectively and expeditiously removing the oil from the bottom?	▪ Intrusiveness of the technique (e.g., selective removal of larger concentrations by divers vs. complete removal by dredging) ▪ Sensitivity of the environment (susceptibility to collateral damage by removal technique)	tolerate. A coral reef may require manual removal by divers or careful diver-directed vacuuming. A mud bottom in an industrial port area may easily tolerate dredging.
<u>Acceptable Impact of Delayed Removal or No Action</u> – Is it more environmentally beneficial in the long run to employ a less damaging cleanup technique or simply leave the oil for natural biodegradation?	▪ Amount of oil ▪ The persistence and toxicity of the oil in the environment ▪ The sensitivity of habitats and organisms that may be impacted by the oil over time ▪ Long-term transport and fate of the oil is important ▪ Whether the habitat is likely to be repopulated by organisms from adjacent areas	The tradeoff here is balancing the damage prevented in the short-term by foregoing intrusive cleanup options against the longer-term impact of leaving the oil in the environment.

Consider the no action alternative: if sinking oil impacts sensitive subsurface habitats such as eelgrass beds, kelp beds, or shellfish beds, careful evaluation must be done prior to implementing response strategies such as dragging sorbent equipment over the sea or river bottom or extensive dredging.

The discussion of possible negative impacts from proposed response techniques should be coordinated by the Environmental Unit in consultation with appropriate trustee agencies; state and local organizations also need to be consulted for any underwater sensitive or archeological sites. Each spill will be different, and the Unified Command will need to determine whether to initiate recovery actions and what techniques to use.

An assessment of the proposed detection and recovery technique effects on wildlife and the bottom environment should be considered on a case-by-case basis. Additionally, use of sonar or laser may be limited by the presence of marine mammals or other endangered species.

9412.4 Permits

Refer to Section 9401, "Northwest Area Contingency Plan Permit Summary Table" for a list of state, federal, and local applicable permits that may be applicable to submerged oil responses.

9412.A Attachment A

9412.A1 Initial Assessment

Once a spill occurs involving heavy oils or oils that may weather and sink, responders must assess the situation and gather as much of the following information as possible to determine the best response methods.

1) Oil spill characteristics
   a) Type of receiving water body (salt, fresh, brackish)
   b) Type(s) of oil spilled, including specific gravity and viscosity. Examples oi oils that may weather and sink include:
      i) Slurry oils
      ii) Heavy fuel and crude oils
      iii) Bunker intermediate fuel oils
      iv) Residual fuel oils
      v) Heavy crude oils
      vi) Synthetic fuels
      vii) Diluted bitumen
      viii) Carbon black
   c) Volume of oil spilled
   d) Located of spill, including distance from port
   e) Area of potential spill impacts
   f) Time of spill to determine how long the oil may have been in the environment
2) Water environment
   a) Depth
   b) Temperature
   c) Visibility
   d) Current – surface and at depth
   e) Bottom types
   f) Bathymetry
   g) Debris
   h) Sediment load/turbidity of water
   i) Waves
3) Other environmental considerations
   a) Weather conditions
4) Response methods available
   a) Detection – related to visibility/bottom type/debris
   b) Delivery method – related to topography/depth/visibility/environment
   c) Recovery method – related to a specific location and environmental conditions characteristics of the oil, availability of equipment, and logistical support for the cleanup
   d) Decanting/polishing/storage – related to distance from port/debris/bottom type/weather effects
5) Logistics
   a) Equipment requirements
      i) Shoreside staging
      ii) On-water staging

b) Equipment availability
    i) Government equipment available
    ii) Primary response contractor equipment available
    iii) Salvage equipment available
    iv) Availability of other private assets that are not dedicated to oil spill response
    v) Backup equipment/spares availability
c) Time to mobilize equipment on site
d) Transit time – personnel and equipment
e) Availability of skilled operators/workers

9412.A2 Attachment A: Non-Floating Oils Response Documentation of Considerations Form

This form is intended to be used as a tool to document incident specific information regarding response options for non-floating oil. The significance of the information below and how it impacts response options can be found in Section 9412.

Oil Spill Characteristics

Type(s) of oil spilled,____

Volume of oil spilled _________gallons

Time of release __:__ 24-hour Source is secured___ or still leaking ___ Leak rate __________
specific gravity ___________

API_____________________

Viscosity________________ centistokes = $1mm^2.S^{-1}$

Density at 15o C ____________g/ml

Location of spill, Latitude __._________ degrees, Longitude -___.________degrees

Distance from port ____________ nautical miles

Water body of potential spill impacts_______________________________________

Type of receiving water body (salt__ fresh___ brackish___)

Surface temperature_________ Density_________ g/ml_

Max depth of basin_________ Ft/meters/fathoms

Visibility__________ Ft/meters

Sediment load/turbidity of water Low ___Med.____ High__

Surface current max speed __ kts Flow direction____

Bottom current max speed___kts___ Flow direction_____

Bottom type Rock___ Boulders,___ Gravel,__ Sand___ Mud__ Clay__ Other specify________

Bottom slope Steep____ Moderate___ Gradual ___ Flat____
Benthic –submerged aquatic vegetation___ shellfish bed__ Other specify________
Sensitivity of bottom community Low ____ Med. ____ High_____
Debris that will likely be recovered with sunken oil _Type ____Size______

Other Environmental Considerations

Weather conditions – Wind speed ____kts, Wind direction_____

Air Temp- Expected high____ Low___

Wave height___ ft. Wave direction____

Skies, Clear_____ Partially overcast_____ Fully overcast______

Describe the response Methods Available
For detection – related to visibility/bottom type/debris
____
____
____
____
____

For recovery method- related to a specific location and environmental conditions, characteristics of the oil, availability of equipment, and logistical support for the cleanup____
____
____
____
____

For decanting/polishing/storage – related to distance from port/debris/bottom type/weather effects____
____
____
____
____

Logistics – Describe the logistic of fielding the response including the equipment requirements, shoreside and on-water staging, equipment availability, backup equipment/spares availability, time to mobilize equipment and personnel on site, availability of skilled/trained operators/workers.

____
____
____
____
____
____

9412.B Attachment B

9412.B1 Example ICS-234 Work Analysis Matrix. Non-Floating Oil Contain and Recover Spilled Material – Non-floating Oil Detection (Operational)

<table>
<tr><td colspan="3"></td><td>WORK ANALYSIS MATRIX
ICS 234-CG</td></tr>
<tr><td colspan="2">1. Incident Name</td><td colspan="2">2. Operational Period
From: To:</td></tr>
<tr><td>3. Operation's Objectives
DESIRED OUTCOME</td><td>4. Strategies
HOW</td><td colspan="2">5. Tactics/Work Assignments
WHO, WHAT, WHERE, WHEN</td></tr>
<tr><td>Contain and Recover Spilled Material – Non-floating Oil Detection (Operational)</td><td>_____Use Sonar Systems

Examples include side scan sonar, multi-beam echo sounder, sub bottom profiler, and 3D scanning sonar.</td><td colspan="2">Strategy_____

Who___________________________

What___________________________

Where__________________________

When___________________________

Equipment______________________</td></tr>
<tr><td></td><td>_____Underwater Visualization Systems including cameras and video

Examples include camera with resolutions of greater than 15 megapixels, sediment profile camera and acoustic cameras.</td><td colspan="2">Strategy_____

Who___________________________

What___________________________

Where__________________________

When___________________________

Equipment______________________</td></tr>
<tr><td></td><td>_____Diver Observations

API technical report on sunken</td><td colspan="2">Strategy_____

Who___________________________

What___________________________</td></tr>
</table>

			WORK ANALYSIS MATRIX ICS 234-CG
1. Incident Name		2. Operational Period From: To:	
3. Operation's Objectives DESIRED OUTCOME	4. Strategies HOW	5. Tactics/Work Assignments WHO, WHAT, WHERE, WHEN	
	oil detection and recovery, specifically section 6.0, entitled "Diving in Contaminated water." Capabilities such as: surface supplied, mixed gas, saturation systems, one-atmosphere suites or submersibles.	Where____________________________ When_____________________________ Equipment_________________________	
	_____Towed or Stationary Sorbents Sorbents attached to chains that are dragged on the bottom and sorbents suspended in the water column or places in cages.	Strategy_____ Who______________________________ What______________________________ Where_____________________________ When______________________________ Equipment_________________________	
6. Prepared by: (Operations Section Chief)	7. Date/Time:		

WORK ANALYSIS MATRIX Page _1_ of _2_ ICS 234-CG
(Rev 11/12)

WORK ANALYSIS MATRIX FORM INSTRUCTIONS (ICS FORM 234-CG) Rev. 8/05

Purpose. The Work Analysis Matrix is designed to help select the best strategies and tactics to achieve the operational objectives. This optional form assists staff in carrying out incident objectives by outlining the who, what, where, when, and how of the response. The tactics from this form carry forward to the "Work Assignment" on the ICS-215. Another purpose of the ICS-234 is that it presents alternative (or what-if) strategies and tactics to respond to bad weather, sudden changes in operational conditions, etc. This form is simply a formalized version of how most OSCs tend to think in order to turn objectives into tactical field work.

Preparation. The Work Analysis Matrix, if used, is usually completed by the Operations Section Chief and Planning Section Chief prior to the Tactics Meeting.

Distribution. All completed original forms must be submitted to the Documentation Unit.

Item #	Item Title	Instructions
1.	Incident Name	Enter the name of the incident
2.	Operational Period	Enter the time interval for which the form applies. Record the start and end date and time.
3.	Operational Objectives	Enter the relevant Operational Objectives from the ICS 202, with numbers
4.	Strategies	Enter all strategies that could be used to meet the objective ("how")
5.	Tactics/Work Assignments	Enter details, including as much as possible, who, what, where, and when, of work assignments to carry out Operational Strategies
6.	Prepared By	Enter the name and position of the person preparing the form
7.	Date/Time	Enter the date and time (24-hour format) the form was prepared

		WORK ANALYSIS MATRIX ICS 234-CG
1. Incident Name	2. Operational Period From: To:	
3. Operation's Objectives DESIRED OUTCOME	4. Strategies HOW	5. Tactics/Work Assignments WHO, WHAT, WHERE, WHEN
Contain and Recover Spilled Material – Non-floating Oil Detection (Operational)	_____Use Laser Floumeters The unit is towed close to the bottom.	Strategy_____ Who____________________________ What____________________________ Where___________________________ When____________________________ Equipment________________________
	_____Visual Observations by Trained Observers Preferred capabilities are water surface and aerial observations.	Strategy_____ Who____________________________ What____________________________ Where___________________________ When____________________________ Equipment________________________
	_____Bottom Sampling Example of capabilities includes sediment grab, core samplers, wading depth shovel pits and agitation methods.	Strategy_____ Who____________________________ What____________________________ Where___________________________ When____________________________ Equipment________________________
	_____Water Column Sampling	Strategy_____ Who____________________________

<table>
<tr><td colspan="2"></td><td>WORK ANALYSIS MATRIX
ICS 234-CG</td></tr>
<tr><td>1. Incident Name</td><td colspan="2">2. Operational Period
From: To:</td></tr>
<tr><td>3. Operation's Objectives DESIRED OUTCOME</td><td>4. Strategies HOW</td><td>5. Tactics/Work Assignments WHO, WHAT, WHERE, WHEN</td></tr>
<tr><td></td><td>Examples include fluorometers and mass spectrometers that are towed in the water column.</td><td>What____________________________

Where___________________________

When____________________________

Equipment_______________________</td></tr>
<tr><td>6. Prepared by: (Operations Section Chief)</td><td>7. Date/Time:</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="2"></td><td></td></tr>
</table>

WORK ANALYSIS MATRIX Page _2_ of _2_ ICS 234-CG
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5.	Tactics/Work Assignments	Enter details, including as much as possible, who, what, where, and when, of work assignments to carry out Operational Strategies
6.	Prepared By	Enter the name and position of the person preparing the form
7.	Date/Time	Enter the date and time (24-hour format) the form was prepared

9412.B2 Example ICS-234 Work Analysis Matrix, Non-floating Oil Contain and Recover Spilled Material – Non-floating Oil Recovery (Operational)

			WORK ANALYSIS MATRIX ICS 234-CG
1. Incident Name		2. Operational Period From: To:	
3. Operation's Objectives DESIRED OUTCOME	4. Strategies HOW		5. Tactics/Work Assignments WHO, WHAT, WHERE, WHEN
Contain and Recover Spilled Material – Non-floating Oil Recovery (Operational)	_____Suction Dredge Dredging through use of pumps to hydraulically remove and transport the oil, oiled sediments and oiled debris.		Strategy_____ Who___________________________ What___________________________ Where_________________________ When__________________________ Equipment______________________
	_____Diver-directed Pumping and Vacuuming Pumping capabilities refer to the use of centrifugal or positive-displacement type pump at or below the water surface with a diver directed hose. Vacuuming refers to a vacuum truck or unit above the water surface either on shore or on a vessel/barge that		Strategy_____ Who___________________________ What___________________________ Where_________________________ When__________________________ Equipment______________________

		WORK ANALYSIS MATRIX ICS 234-CG
1. Incident Name	2. Operational Period From: To:	
3. Operation's Objectives DESIRED OUTCOME	4. Strategies HOW	5. Tactics/Work Assignments WHO, WHAT, WHERE, WHEN
	creates a vacuum. Diver direct.	
	_____Mechanical Removal Example include excavators, clamshell dredges, environmental dredge buckets, or other machinery used to grab, scoop or pick up sunken oil, oiled sediments and oiled debris.	Strategy_____ Who___________________________ What___________________________ Where__________________________ When___________________________ Equipment______________________
	_____Sorbent/V-SORs Sorbents attached to chains in the water column that are dragged on the bottom to recover viscous oil.	Strategy_____ Who___________________________ What___________________________ Where__________________________ When___________________________ Equipment______________________
6. Prepared by: (Operations Section Chief	7. Date/Time:	

WORK ANALYSIS MATRIX Page _1_ of _2_ ICS 234-CG
(Rev 11/12)

WORK ANALYSIS MATRIX FORM INSTRUCTIONS (ICS FORM 234-CG) Rev. 8/05

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Contain and Recover Spilled Material – Non-floating Oil Detection (Operational)	_____Use Laser Floumeters The unit is towed close to the bottom.	Strategy_____ Who_____________________________ What_____________________________ Where___________________________ When_____________________________ Equipment________________________
	_____Visual Observations by Trained Observers Preferred capabilities are water surface and aerial observations.	Strategy_____ Who_____________________________ What_____________________________ Where___________________________ When_____________________________ Equipment________________________
	_____Bottom Sampling Example of capabilities includes sediment grab, core samplers, wading depth shovel pits and agitation methods.	Strategy_____ Who_____________________________ What_____________________________ Where___________________________ When_____________________________ Equipment________________________

		WORK ANALYSIS MATRIX ICS 234-CG
1. Incident Name	2. Operational Period From: To:	
3. Operation's Objectives DESIRED OUTCOME	4. Strategies HOW	5. Tactics/Work Assignments WHO, WHAT, WHERE, WHEN
	_____Water Column Sampling Examples include fluorometers and mass spectrometers that are towed in the water column.	Strategy_____ Who____________________________ What____________________________ Where___________________________ When____________________________ Equipment________________________
6. Prepared by: (Operations Section Chief)	7. Date/Time:	

WORK ANALYSIS MATRIX Page _2_ of _2_ ICS 234-CG
(Rev 11/12)

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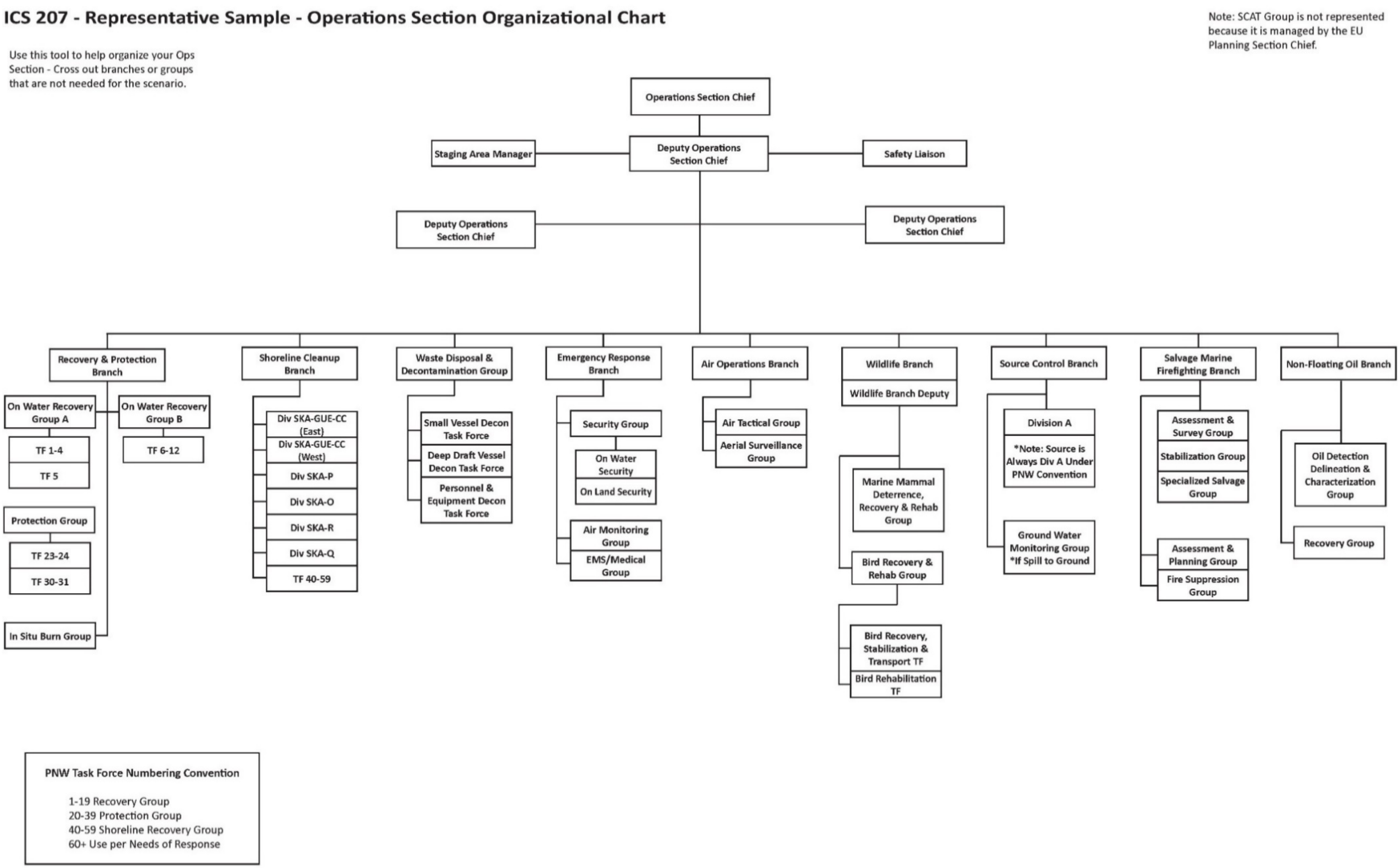
9412.B3 Example ICS-207 showing the incorporation of a Non-Floating Oil Branch into the Operations Section



9412.C Attachment C

9412.C1 API Technical Report 1154-1, Sunken Oil Detection and Recovery

The API Technical report can be found here: http://www.oilspillprevention.org/~/media/Oil-Spill-Prevention/spillprevention/r-and-d/inland/sunken-oil-technical-report-pp2.pdf

9412.C2 API Technical Report 1154.2. Sunken Oil Detection and Recovery Operational Guide

The API Technical report can be found here: http://www.oilspillprevention.org/~/media/Oil-Spill-Prevention/spillprevention/r-and-d/inland/sunken-oil-ops-guide.pdf