# Non-Floating Oil Assessment & Response Plan

TRANSMOUNTAIN

# NON-FLOATING OIL ASSESSMENT AND RESPONSE PLAN



This document will be updated from time to time. If you wish to receive notification of updates, please send an email to emergency_management@transmountain.com requesting to be notified when a new version of the document is available online. Manual holders, as indicated on the distribution list, will receive updates automatically as required.

# Table of Contents

# Plan Maintenance

## Responsibility

Development and maintenance of the Non-Floating Oil Assessment and Response Plan is the responsibility of the Trans Mountain Manager, Emergency Management. Accountability for the Plan is as follows:

- The document is owned by the Emergency Management Program as a supplemental plan to the Emergency Response Plan (ERP).
- The administrative management for the Non-Floating Oil Assessment and Response Plan will occur through the Emergency Management Program.

## Plan Revisions

All requests for change must be made through the Manager, Emergency Management using the Revision Request Form located in this section of the manual.

## Revisions after Release or Exercise

In the event that Trans Mountain experiences a release (worst case or otherwise), or conducts an exercise or training session, the effectiveness of the ERP and its supplemental plans will be evaluated and updated as necessary.

## Changes in Operating Conditions

If a new or different operating condition develops, or if new information which would substantially affect the implementation of the ERP and its supplemental plans is identified, then Trans Mountain will modify these to impacted Plans to address such changes.

# Revision Request Form

| | |
|---|---|
| Requested by: | Date: |
| Dept./Agency: | Phone No.: |
| Revision Type: ___ Addition ___ Deletion ___ Correction | |
| Manual Section: | Page: |
| Revision (attach separate sheet if necessary): | |
| | |
| | |
| | |
| | |
| | |
| | |
| Signature of Requestor: | |
| Send to: Manager, Emergency Management<br>Trans Mountain<br>2700-300 - 5th Avenue S.W.<br>Calgary, AB T2P 5J2 Canada<br>Fax: (403) 514-6401 | |

| **To be completed by Manager, Emergency Management** | |
|---|---|
| Date Received: | Comments: |
| Date Reviewed: | |
| Issued as Revision: Y/ N | |
| If No, reason for rejection: | |
| | |
| | |
| | |
| | |
| | |
| Signature Manager, Emergency Management | |

## Control Sheet

| Revision Number | Date of Revision | Change(s) | Name |
|---|---|---|---|
| 1 | April 2018 | New Supplemental Plan | K. Malinoski |
| 2 | Oct 2018 | Rebranding from Kinder Morgan to Trans Mountain | K. Malinoski |
| 3 | March 2020 | Plan name changed to Non-Floating Oil Assessment and Response Plan;<br>Section 1.2, Scope of the Plan revised to include Westridge Marine Terminal;<br>Section 2.1, Definitions updated to include additional terms;<br>Section 3.1.1, Description of uSCAT added;<br>Section 4.0, Incorporation of uSCAT into the Incident Command System;<br>Section 5.0, Addition of Table describing the factors affecting the potential of non-floating oil | K. Malinoski |
| 4 | December 2020 | Section 2.2, Fate and Behaviour of Oil, and Section 6.2, Product Assessment, revised to include description of Oil Fact Sheets;<br>Section 2.2, Fate and Behaviour of Oil revised to include temperature rates;<br>Section 10.4, Winter Considerations added;<br>Section 10.4, Secondary Water Sources removed;<br>Appendix II Product Fact Sheets added | K. McLernon |
| 5 | April 2022 | Section 1.2, Refined the scope<br>Section 8.2, corrected reference to Self Contained Under Water Breathing Apparatus (SCUBA)<br>Additional Product Fact Sheets added | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |

# 1.0 INTRODUCTION

## 1.1 Purpose of the Plan

The purpose of the Non-Floating Oil Assessment and Response Plan is to provide guidance for the initial assessment and response actions to released oil that is at risk of, or has become, non-floating within an inland water environment. This Plan will be used until an incident specific non-floating oil response plan can be implemented. The Non-Floating Oil Assessment and Response Plan is not intended to limit the discretion of responders to choose appropriate response actions to meet the site-specific circumstances presented at a release.

When oil is released into a waterbody it's physical and chemical characteristics can change due to the environmental factors it may interact with. While the likelihood of oil becoming non-floating is low the Non-Floating Oil Assessment and Response Plan is intended to provide response tactics to meet this potential.

## 1.2 Scope of the Plan

The Non-Floating Oil Assessment and Response Plan addresses non-floating oil containment and recovery for a release that occurs in freshwater environments focusing on the assessment, plume tracking, containment, and recovery of non-floating oil within several types of waterbodies (river, lake) with low, medium, and high-water flows.

In the event of a release to a marine environment within Canadian jurisdiction, the Non-Floating Oil Assessment and Response Plan will be used initially until such time as an incident specific non-floating oil plan can be developed. The incident specific non-floating oil plan will be developed in conjunction with third party contractors listed in the Confidential Appendix of the applicable Emergency Response Plan.

## 1.3 Regulatory Scope of the Plan

The Non-Floating Oil Assessment and Response Plan is a supplemental plan of the Trans Mountain Emergency Response Plan (ERP). The Non-Floating Oil Assessment and Response Plan has been developed to proactively address the potential of non-floating oil resulting from a release.

Within Canada, and specific to the areas in which Trans Mountain operates, there are currently no planning or regulated response requirements for non-floating oil. Within Washington State, the Washington State Administrative Code (WAC) Chapter 173-182 Oil Spill Contingency Plan, outlines planning standards for oils that have the potential to submerge or sink. Trans Mountain adheres to these requirements by maintaining a state approved Emergency Response Plan and contacted oil spill response services from an approved Primary Response Contractor.

Additional tools to assist with responding to non-floating oil are contained within the Northwest Area Contingency Plan (NWACP) 9412 Non-Floating Oil Spill Response Tool.

# 2.0 UNDERSTANDING NON-FLOATING OIL

*See Appendix I for a list and description of definitions.*

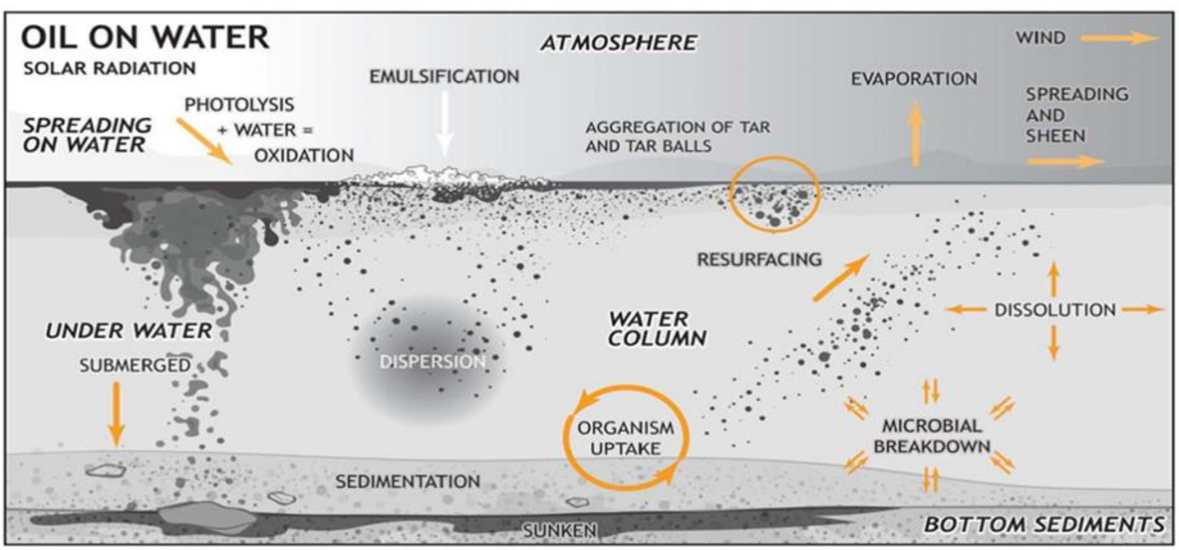
## 2.1 Challenges with Non-Floating Oil

Non-floating oil poses detection, containment, and recovery challenges that floating oil does not. Floating oil is readily observable and forms into identifiable plume models that can be anticipated, tracked, and recovered using conventional techniques. Non-floating oil is not readily observable and due to a myriad of environmental factors, product often disappears from one area only to reappear in another. Due to the many challenges posed by non-floating oil tactics for its containment and recovery cannot be set out in a standardized plan but rather requires the integration of multiple techniques based on the site-specific environmental factors and the specific type of oil or oil-containing product released.

## 2.2 Fate and Behavior of Oil

When oil is initially released into an aquatic environment, several processes can affect the behaviour and fate of that oil. Oil has the potential to become non-floating if the density is greater than that of the water into which it has been released.

There are a number of factors that may increase the density of oil causing it to become non-floating. Evaporation of the lighter components in the oil may increase the density and potentially allow the oil to become non-floating. Current speed and viscosity of the oil may cause the formation of oil droplets, which then can become non-floating oil. Oil droplets may interact with suspended sediment or other debris, which in turn will sink due to the increased density.




Non-floating oil tends to weather at a slower rate than floating oil and may move within the water column due to changes in water temperature, currents, wave action, changing sedimentation, and seasonal flow fluctuations, further complicating recovery efforts. Loss of lighter ends (weathering) may slow down at lower temperatures, offsetting some of the temperature effect on viscosity. The evaporation rate at 5ºC/41ºF is approximately 1/3 of what it is at 30ºC/86ºF.

The ability to track, contain, and recover non-floating oil is dependent on the physical and chemical properties of the oil, the properties of the receiving waters and other material dispersed in the water column or bottom of the waterbody.

See Appendix II for Oil Fact Sheets for information regarding behaviour in certain temperatures.

# 3.0 NON-FLOATING OIL RISK ASSESSMENT

Trans Mountain has evaluated the risk of non-floating oil based on the products shipped, the environmental conditions present with operating areas, and the anticipated time it may take for a released product to exhibit sunken and submerged behavior. Rapid deployment of on-water recovery is the best strategy to prevent floating oil from becoming non-floating. The operational actions of this philosophy follow the four response principles:

- Control the source of the release;
- Prevent the released oil from entering a waterbody;
- Contain, intercept, and promptly recover oil from the water surface; and
- Remove oil stranded on the shoreline before it can be remobilized.

Trans Mountain recognizes that it is vital to match response planning to the risks posed by non-floating oil. Using this plan, Trans Mountain has developed a process for the detection, containment, and recovery of non-floating oil.

## 3.1 Underwater Seabed Assessment Technique (uSCAT)

An integral component of Non-floating Oil Risk Assessment is uSCAT. uSCAT is a variation of the Shoreline Cleanup Assessment Technique (SCAT) developed to deal specifically with non-floating oil.

uSCAT principles can be applied to all types of oil, release volumes, conditions, and environments. uSCAT supports planning, decision making, and operational response to nearshore non-floating oil by providing Unified Command with information and advice based on scientific evidence, experience, and informed judgement.

Both uSCAT and SCAT aim to deliver consistent scientifically defensible data critical to a best-practice response. The primary tenets of uSCAT are:

- A systematic assessment of the affected or potentially affected area. The seabed is divided into physically discrete areas (seabed units) for purposes of surveys, documentation, and various planning and operational response activities.
- Standardized terms and definitions are used for documentation and data entry.
- Survey teams are composed of objective and trained specialists tasked to gather data in an objective and unbiased manner for the use of all parties.
- Provision of support to management of the incident, from the initial response phase to the completion phase of treatment activities, inspections, and monitoring.

The basic functions of uSCAT are:

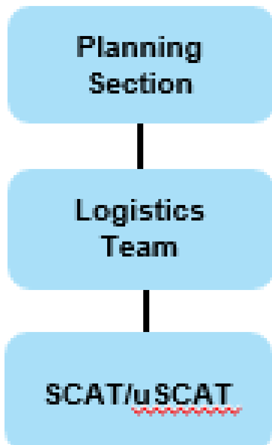
- Predicting risk;
- Collection of field data on sunken oil and waterbody bottom conditions;
- Data management and assessment;
- Supporting treatment decision-making; and
- Supporting operations and completion of recovery activities.

The *uSCAT Technical Reference Manual: Underwater Seabed Cleanup Assessment Technique for Sunken Oil* provides a standardized approach for the detection, assessment, and documentation of non-floating oil.

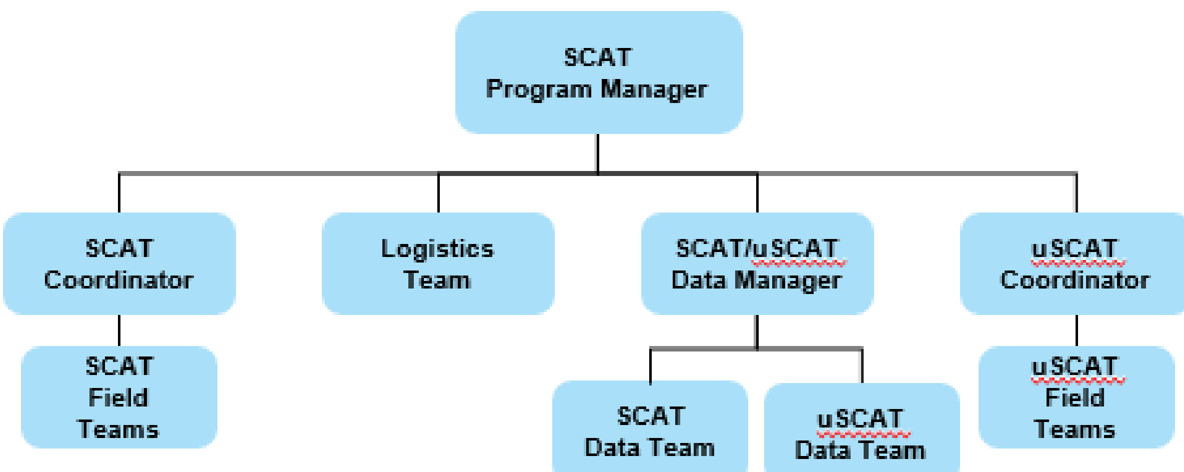
# 4.0 ROLES OF UNIFIED COMMAND

Based upon the incident, and wherever possible, Trans Mountain's Incident Management Team aims to establish a Unified Command structure for emergency response. Unified Command sets the direction of response activities including the development and implementation of strategic decisions, endorsement of incident action plans, and approval for ordering and releasing resources. Unified Command will utilize the Environment Unit, and potentially the "Science Table", to provide guidance and direction in weighing the environmental cost/benefit of various countermeasures to be used in combating non-floating oil.

## 4.1 SCAT/uSCAT Organization within the Incident Command System




uSCAT operates in a similar manner to SCAT, working within the Environmental Unit of the Planning Section.




As uSCAT operates in a similar fashion as SCAT, they are combined into the same Branch in the Planning Section

# 5.0 NET ENVIRONMENTAL BENEFIT ANALYSIS

As applied to Trans Mountain incidents, Net Environmental Benefit Analysis (NEBA) is a formal process to evaluate the risks and benefits of certain proposed cleanup strategies and techniques. NEBA is a performance metric that weighs many factors—both operational and environmental—against the cleanup endpoints established by the Unified Command.

The proposed recovery of non-floating oils is a good example of a situation where a rational assessment of the environmental trade-offs associated with cleanup techniques is required. The Environment Unit will initiate a NEBA request to vet counter-measure techniques. NEBA must proceed in a rapid systematic manner to be effective, given the time sensitivity of tracking and recovering non-floating oil.

This analysis will consider:

1. Specific treatment options appropriate to the response;
2. Potential for successfully implementing those options;
3. Environmental trade-offs attached to each technique; and
4. Types of treatments that can be authorized within the existing regulatory framework.

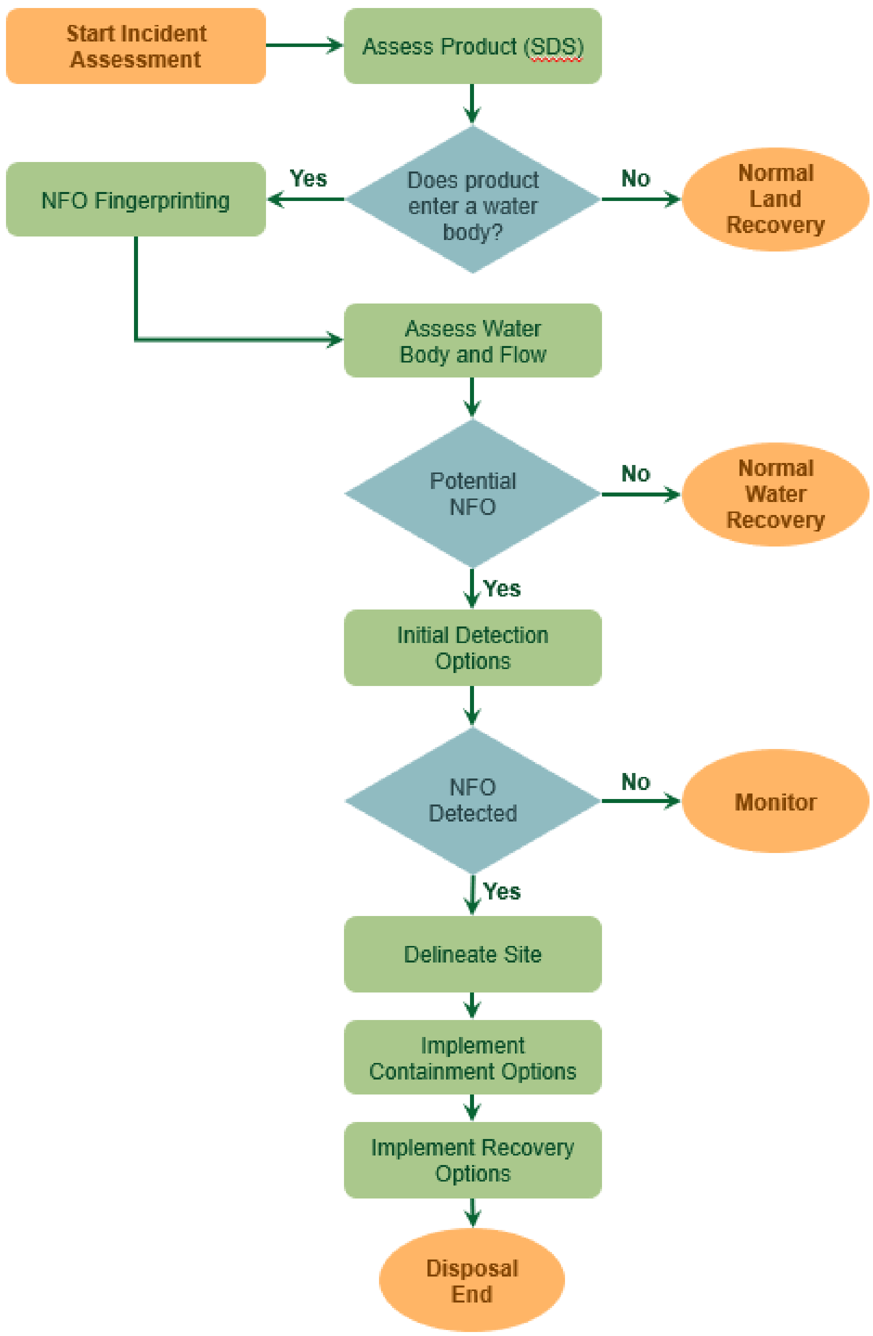
| **Factors Affecting the Non-Floating Potential of Oil** | **Effects** |
|---|---|
| Oil Composition | Oils show a wide range of compositions. At one end of the range are lighter oils that are generally more volatile, soluble, and toxic, and consequently are of low density and viscosity. At the other end are heavier oils that are generally denser, more vicious, less toxic and less volatile, and consequently are more environmentally persistent. In comparison to lighter oils, the heavier oils are more prone to becoming non-floating due to their physical and chemical properties. |
| Density | The density of the receiving water and the oil are key factors in the oil's susceptibility to sink. An oil will generally submerge in water if its density is greater than that of receiving water. Oil heavier than receiving water will sink immediately unless maintained suspended through turbulence. A portion of oil that is slightly less dense than receiving waters eventually may submerge due to weathering and/or sediment entrainment. |
| Weathering | Weathering is the percent mass loss of oil over time and is caused by evaporation, biodegradation, natural dispersion, adhesion to materials, interaction with mineral fines, emulsification, dissolution, photo-oxidation, and sedimentation. |
| Viscosity | Viscosity is a fluid's resistance to flow where high viscosity oils flow less easily than low viscosity oils. Light oils are generally of low viscosity and heavy oils are generally of high viscosity. |
| Temperature | Temperature affects the density of an oil and also affects the rate at which the oil will weather (NRC 1999); higher temperatures cause lower oil densities and faster weathering (evaporation), and lower temperatures increase density and reduce evaporation rates. |

# 6.0 NON-FLOATING OIL ASSESSMENT

## 6.1 Initial Assessment

After a release occurs, an assessment to understand the potential for the product to become non-floating oil will occur. Responders must assess the situation and gather information to determine the best method for the detection, containment, and recovery of non-floating oils. The following chart will be used to assist responders in making decisions with respect to the development of a site specific non-floating oil plan.

**Response to Non-Floating Oil for Inland Waters**



### 6.2 Product Assessment

The incident assessment begins by identifying the product released and understanding its potential fate and behavior. All incidents commence with a health and safety evaluation typically supported by a Safety Data Sheet (SDS) that identifies the physical properties and hazards of the product released. SDSs for all products shipped by Trans Mountain can be obtained from the Trans Mountain Control Centre or the Trans Mountain SDS Vault (internal website).

The product name (i.e., crude oil, fuel oil, gasoline, diesel, diluted bitumen, etc.) will offer the first indication of the oil's potential to become non-floating. Specific gravity (SG) values will likely appear in the Physical and Chemical Properties section. It is most probable that the SG value will be given in reference to water (water = 1.0). The product density need not always equal or exceed water density for an oil to become conditionally non-floating; therefore, all products should be treated as though they have the potential to become non-floating. See Appendix II for Oil Fact Sheets for information specific to products[1] shipped by Trans Mountain.

## 7.0 NON-FLOATING OIL FINGERPRINT

It is important to ensure that identified non-floating oil is actually associated with the incident and not from previous contamination. During the development of the site-specific Sampling and Monitoring Plan (SMP), there will be consideration given for the positive identification of the responsible party's (RP) non-floating oil. Trans Mountain will establish a non-floating oil fingerprint as part of the SMP utilizing qualified experts. Lack of fingerprinting has the potential to cause confusion and delay detection and recovery operations associated with the incident.

### 7.1 Waterbody Assessment

During the initial assessment, the waterbody will be assessed for potential conditions that may encourage oil to become non-floating. This assessment involves an evaluation of the aquatic environment as it is the combination of environmental factors, rather than any single factor, that encourages oil to become non-floating. The responder will utilize the *Non-Floating Oils Response Planning Form* for identifying the release characteristics, water environment, other environmental considerations, the response methods available, and the logistical requirements of the response, as this will aid in the development of the incident-specific non-floating oil plan.

[1] Note: The Oil Fact Sheets do not represent all products shipped by Trans Mountain.

**Non-Floating Oils Response Planning Form**

| **Oil Release Characteristics** |
|---|
| Type(s) of oil released: ________________________________ |
| Volume of oil released: ________ *bbl* ________ *m*$^3$ ________ *litres* ________ *gallons* |
| Time of release: _______ *(24-hr)* ☐ Source secured ☐ Still leaking Leak rate: _____ |
| Specific gravity: ________________________ API: ________________________ |
| Viscosity: ________ *centistokes = 1mm*$^2$ *.S-1* Density at 15°C: ________ *g/ml* |
| Location of release: Latitude: _________ Longitude: _________ Distance from port: __________ |
| **Water Body Characteristics** |
| Waterbody of potential release impacts: ________________________________ |
| Type of receiving water body: ☐ Lake ☐ River ☐ Small ☐ Large |
| Surface temperature: Density: _______ *g/ml* Max. depth of basin: _______ *m (ft)* |
| Sediment load/turbidity of water: ☐ Low ☐ Med ☐ High Visibility: _______ *m (ft)* |
| Surface current max speed: _______ *km/hr* Flow Direction: ____________________ |
| Bottom current max speed: _______ *km/hr* Flow Direction: ____________________ |
| Bottom type: ☐ Rock ☐ Boulders ☐ Gravel ☐ Sand ☐ Mud ☐ Clay<br>☐ Other (specify): ________________________________ |
| Bottom slope: ☐ Steep ☐ Moderate ☐ Gradual ☐ Flat |
| Submerged aquatic vegetation: ________________________________ |
| Sensitivity of bottom community: ☐ Low ☐ Med ☐ High |
| Type of debris: ____________________ Size of debris: ____________________ |

**Other Environmental Considerations**

Weather conditions: Wind speed: ______ *km/hr* Wind direction: ______________________

Air temp – expected: ☐ High ☐ Low

Skies: ☐ Clear ☐ Partially overcast ☐ Fully overcast

Wave heights: ___ *m (ft)* Wave Direction: _____ River current speed: ______ *km/h (mi/h)*

**Describe the Response Methods Available**

Detection methods: ______________________________________________

______________________________________________

______________________________________________

______________________________________________

Containment methods: ______________________________________________

______________________________________________

______________________________________________

______________________________________________

Recovery methods: ______________________________________________

______________________________________________

______________________________________________

______________________________________________

**Logistics**

Describe the logistic of fielding the response including the equipment requirements, shore side and on-water staging, equipment availability, backup equipment/spare availability, time to mobilize equipment and personnel on site, availability of skilled/trained operators/workers:

______________________________________________

______________________________________________

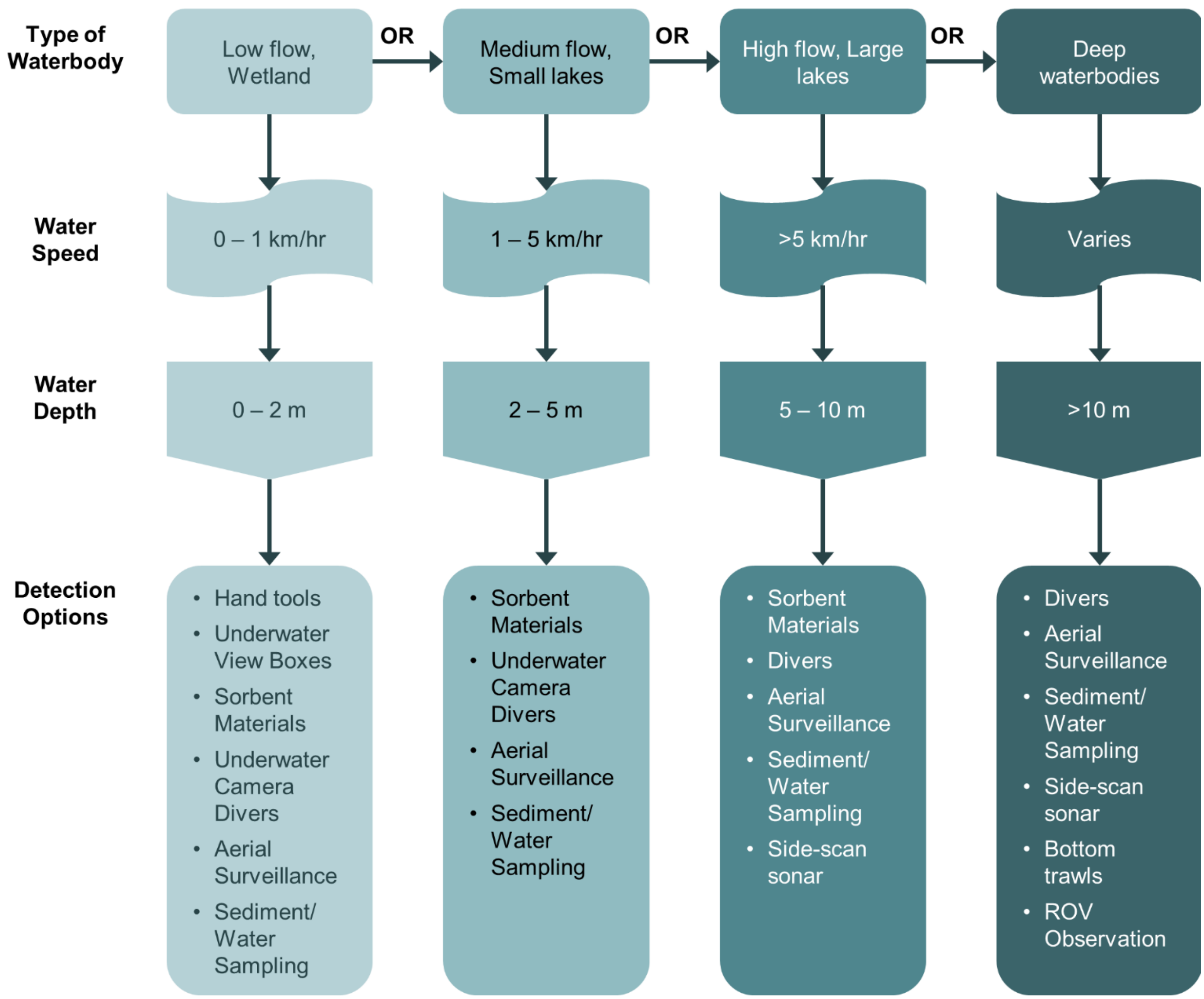
______________________________________________

# 8.0 DETECTION OF NON-FLOATING OIL

## 8.1 Detection Considerations

The detection of non-floating oil poses significant challenges to a response despite technological improvements. The following chart identifies the types of detection methods available based on the type of waterbody being evaluated.

**DETECTION CONSIDERATIONS**



## 8.2 Detection Methods

### Hand Tools

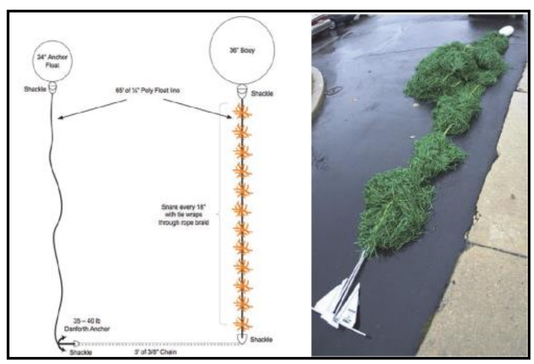

Hand tools such as dip nets, rakes, or shovels can be used to obtain a materials sample from the bottom of the waterbody to identify if there is non-floating oil. These tools can be covered with sorbent material to further aid the identification of non-floating oil.

### Underwater View Boxes

Underwater view boxes may be used from dry land or a boat. View boxes eliminates the water surface glare and allows viewing as far as water clarity and light permit. The ability to see below the surface of the water may allow the responder to visually identify non-floating oil.

### Sorbent Materials

Sorbents are used to absorb oil but not water. They come in different sizes and shapes and can be dipped/bounced along the bottom of a watercourse, suspended in the water column, or placed inside gabion baskets to catch non-floating oil. They can be pom-pom type materials that are strung together and submerged. Sorbents are used for both detection and recovery.




### Underwater Camera

An underwater camera is designed for use under the surface of the water. The camera is usually a conventional type enclosed in a casing to withstand water pressure. Preferably the camera will include a correction lens to compensate for aberrations caused by the water. Images can then be analyzed by the responder to determine if there is non-floating oil present.

### Divers

Divers are utilized for both the identification of non-floating oil and for recovery. During the detection phase divers may utilize snorkel gear in low flow and shallow water or may use Self Contained Under Water Breathing Apparatus (SCUBA) for deeper and faster water. The decision to utilize divers must only come after a thorough safety analysis of the diving environment has occurred. All laws applicable to SCUBA will be followed and the safety of the diver and/or snorkeler is the primary concern. SCUBA divers will be certified and have specialized training in the detection of non-floating oil. During the detection phase, divers will visually identify areas where non-floating oil is accumulating or has the potential to accumulate.

### Aerial Surveillance

There are several aerial surveillance options available to responders. The simplest and most cost effective being Unmanned Aerial Vehicle (UAV). As technology improves the ability to detect oil using an UAV becomes more and more feasible. The UAV can be outfitted with specialized cameras including laser sensors, infrared cameras, and LIDAR. In addition to UAVs, traditional aircraft (fixed wing or helicopter) may be used with similar detecting devices to the UAV.

### Sediment and Water Sampling

Sediment and water sampling can be used to assist with the identification of non-floating oil as well as the extent of the impact from an incident. Trans Mountain has a Sampling and Monitoring Plan that will be implemented during an incident to assist with the identification of non-floating oil.

### Side-scan Sonar

A side-scan sonar device (which may be towed from a boat) emits conical or fan-shaped pulses down toward the river/lake bottom across a wide-angle perpendicular to the path of the sensor through the water. The intensity of the acoustic reflections from the river/lake bottom of this fan-shaped beam is recorded in a series of cross-track slices. When stitched together along the direction of motion, these slices form an image of the sea bottom within the swath (coverage width) of the beam. The sound frequencies used in side-scan sonar usually range from 100 to 500 kHz; higher frequencies yield better resolution but less range. Depending on the resolution, the side-scan sonar may be able to detect accumulations of non-floating oil resting on the bottom of a river or lake.

### Bottom Trawls

Bottom trawling is trawling (towing a trawl, which is a fishing net) along the bottom of a river or lake. It is also referred to as "dragging". Trawling can be used in both detection and recovery and involves the dragging of a net comprised of sorbent material allowing the responder to both detect and recover non-floating oil at the same time.

### ROV Observation

A remotely operated underwater vehicle (ROV) is a tethered underwater mobile device. This meaning is different from remote control vehicles operating on land or in the air. ROVs are unoccupied, highly maneuverable, and operated by a crew aboard a vessel. They are common in deep water industries such as offshore hydrocarbon extraction. ROVs can be used in both the detection phase and recovery phase depending on how they are equipped. During detection ROVs can provide high resolution images and sediment samples for the responders to analyze to determine the presence of non-floating oil.

## 8.3 Recommendations for Detection

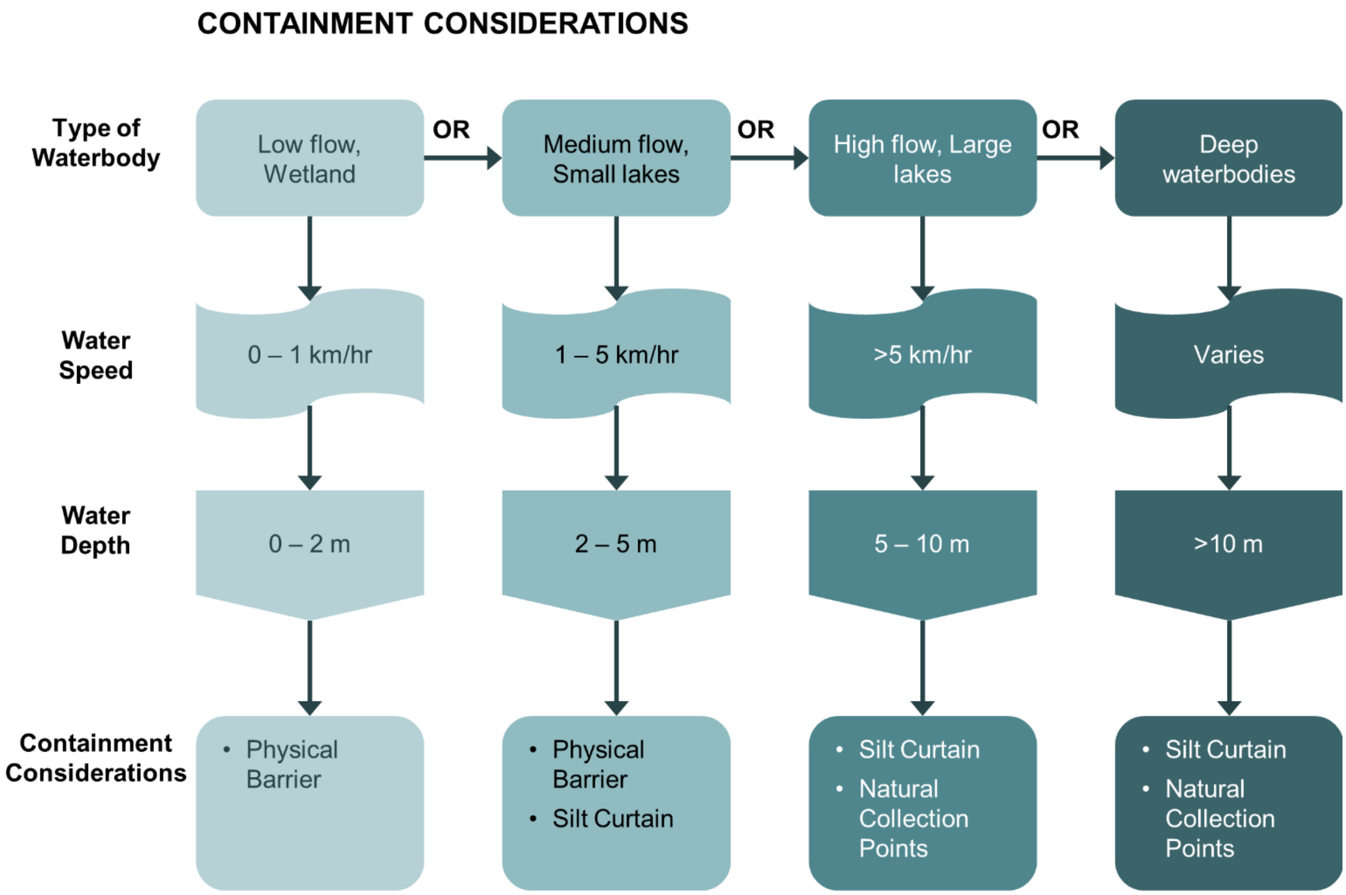
As detection methods vary in complexity and success rates, it is always best to consider the following when determining the detection method to be used:

- Attempt the simplest method that addresses the amount of oil being detected first.
- Use sophisticated methods for deep and large amounts of oil. Use models if available to determine the search area and the potential amount of oil that may be recoverable.
- Sonar can search a wide area, but processing must be timely and resolution sufficient.
- Confirm with vendors the total resolution (i.e., the size of the patch of oil that can be detected), amount of time to search any area, and amount of time to process the data.
- Operators of laser systems also need to define the area covered, estimate the patch size, and process the data.
- Minimize the amount of time between the detection and collection phases of the response.

# 9.0 CONTAINMENT OF NON-FLOATING OIL

## 9.1 Containment Considerations

Containment can prevent further spreading by concentrating the product to make it easier to identify and recover non-floating oil. The following diagram outlines the containment methods recommended based on the type of waterbody.



## 9.2 Containment Methods

### Physical Barrier

A physical barrier is most effective in low flow water bodies and consists of utilizing materials to physically stop the spread of non-floating oil. Examples of a physical barrier include a creek guard with pom-pom material to absorb the non-floating oil particles and droplets. Another example is silt fencing, which prevents the migration of the product.

### Silt Curtain

There are several types of silt curtains. Some can be suspended below containment boom on the surface. Others can be silt fencing, which is weighted to optimally collect non-floating oil in the water column.

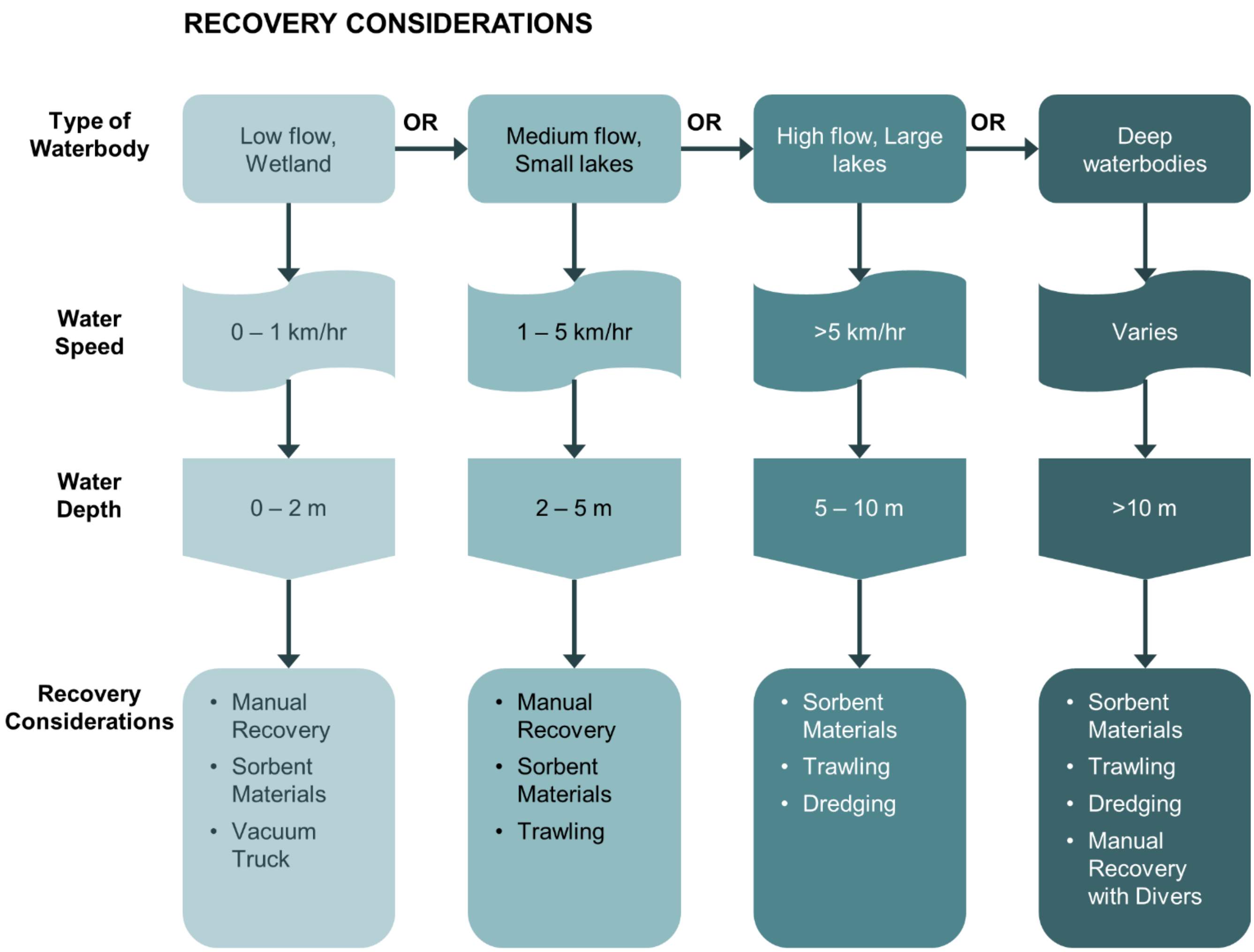
### Natural Collection Points

Natural collection points are areas within a deep waterbody or a high-flow waterbody where debris and other material collects due to changes in flow allowing for suspended solids to drop out of the water column or bottom debris to naturally collect. Low lying areas or depressions in the lake/river bottom may also serve as a natural collection point. Oil and oiled debris will also deposit in these types of formations from which it can be recovered.

# 10.0 RECOVERY OF NON-FLOATING OIL

## 10.1 Recovery Considerations

The selection of the recovery method is dependent on the specific location and environmental conditions during the release, the characteristics of the oil and its state of weathering, the interaction of the oil with sediments and the potential environmental impacts of implementing the recovery techniques, particularly in sensitive environments. The following diagram shows the options for recovery based on the water type, speed, and depth.



## 10.2 Recovery Methods

### Manual Recovery

Similar to detection of non-floating oil, hand tools such as dip nets, rakes, or shovels can be used to recover non-floating oil. These tools can be covered with sorbent material to further aid the recovery of non-floating oil.

### Sorbent Materials

Sorbents are used to absorb oil but not water. They come in different sizes and shapes and can be dipped/bounced along the bottom of a watercourse, suspended in the water column, or placed inside gabion baskets to catch non-floating oil. They can consist of pom-pom type materials that are strung together and submerged. Sorbents are used for both detection and recovery.

### Trawling

Bottom trawling is trawling (towing a trawl, which is a fishing net) along the bottom of a river or lake. It is also referred to as "dragging". Trawling can be used in both detection and recovery and involves the dragging of a net comprised of sorbent material allowing the responder to both detect and recover non-floating oil at the same time.

### Dredging

When large quantities of non-floating oil are encountered, dredging is often the most effective way of recovering it. Large volumes of water, oil, and sediment are typically generated in the dredging process and must be handled, stored, and disposed of as the recovery operation proceeds. When dredging, accurate vertical control of the dredge depths is critical to minimizing the amount of dredged material and the amount of clean sediment recovered with oiled sediments.

### Manual Recovery with Divers

During the recovery phase, divers are utilized to vacuum accumulated product or deploy air lift or negative pressure pumping. Air lift involves pumping air into an area of concentrated non-floating oil and re-floating it so it can be recovered on the surface. Negative pressure pumping involves a positive displacement pump to create negative pressure and draw only the material in. Using a diver for this type of operation will require a diver who has experience with this type of recovery.

## 10.3 Protection of Water Intakes

Water intakes are used for collecting water from different sources (rivers, lakes, reservoirs, etc.). The water from these sources has many uses including drinking water, agricultural irrigation, and animal care. There are multiple types of water intakes:

- Submerged intake structures
- Exposed intake structures
- Wet intakes
- Dry intakes
- River, reservoir, lake and canal intakes

Water intakes will primarily be protected in two ways, a combination of which is likely required. Each situation will call for a different response. The response tactic selected should be appropriate to the water source. The priority for water source protection will always follow this prioritization listing:

- Water sources for human consumption
- Water sources for animal consumption
- Water sources for agricultural irrigation
- Water sources for other uses

**Isolation of the Water Intake**

To isolate a water intake, follow the steps below.

1. Install a semi-impermeable skirt system (X-TEX Fabric) surrounding the water intake.

2. Back blow the water intake pipes with compressed air.
3. Install an air curtain around the water intake along with surface containment immediately downstream of the air curtain to deflect product away from the water intake.
4. Install a river boom around the surface of the water intake to prevent contamination and staining of the structure.
5. Install an aqua dam around the water intake to prevent contact with line.

**Removal of the Water Intake**

Removal of the water intake involves the physical removal of the water intake from the waterbody. This type of water intake is typically used in agricultural or alternate water uses.

## 10.4 Winter Considerations

Frozen conditions on waterbodies can serve to facilitate recovery operations by providing a solid working platform over the oil and by creating natural barriers, which can be used to contain and immobilize oil. However, frozen conditions can also obstruct recovery operations. Downward-growing ice may quickly encapsulate oil under ice; additionally, there may be many under-ice pockets where oil can accumulate in natural depressions, providing access for recovery. Prior to commencing any activity over a frozen waterbody, the type, strength, and thickness of the ice must be established. Refer to the specific Geographic Response Plan for detailed information on calculating type, strength, and thickness of the ice.

## APPENDIX I – DEFINITIONS

| | |
|---|---|
| **Floating oil** | Describes oil that is on the surface of the water and remains buoyant. |
| **Non-floating oil** | Describes oil that has been either submerged or sunken. |
| **Submerged oil** | Describes any oil that is not floating at or near the surface. |
| **Sunken oil** | Describes oil that sinks to the bottom of the water column due to specific gravity and resides on the bottom of the waterbody. |
| **Stranded oil** | Describes oil that has been deposited on the shoreline. |

# APPENDIX II – PRODUCT FACT SHEETS

Information within the fact sheets reflect results from laboratory bench-scale and flume testing at meso-scale under specific conditions. Results from actual releases in the environment may diverge from the data presented. The fact sheets were developed as a tool for responders to help determine appropriate countermeasures. Each incident is unique and the fate and behaviour of an oil will depend upon environmental conditions at the time of the incident.

**Disclaimer**

These fact sheets do not purport to address any or all hazards with responding to releases of crude oil or similar products. Proper Personal Protective Equipment should always be worn. Consult SDS.

**Source:** SL Ross Environmental Research Ltd. (2020) Comparison of the Behaviour of Spilled Conventional and Non-Conventional Oils through Laboratory and Meso-Scale Testing: Full Data Report.

# ALBIAN HEAVY SYNTHETIC (AHS): An unconventional heavy sour partially upgraded, 19.6°API (60°F/15.6°C)

TRANSMOUNTAIN

## What to Expect

**Freshwater:** Once in the fresh aqueous environment AHS will float initially. Based on 5-day testing in a flume tank, evaporative losses over the first day in warm (20°C) water conditions will cause the density to increase to a point close to that of fresh water which increases the risk of submergence. This time is extended up to a couple of days for cold (0°C) water conditions.

**Marine Environment:** Based on 5-day testing in a flume tank with sediment laden water, AHS is expected to initially float. However, as the oil weathers it increases its bulk density and consequently increases the risk of submergence in a matter of days at warmer temperatures (20°C range) as the density begins to approach that of the marine environment. No submergence was observed during the 5-day testing. Weathering processes slow under cooler temperatures.

**Additional Highlights:** Rapid weathering under warm conditions (near 20°C) will cause the density to increase close to that of fresh water – increasing the risk of submergence. This process slows if the environmental conditions are cooler. AHS can rapidly become too viscous to emulsify because of weathering. However, if it encounters an energetic freshwater or marine environment before it becomes very viscous, some emulsification is possible. Rapid response using spill countermeasures would be needed to counter risk of submergence. Evaporative losses of approximately 15-20% by volume would be expected within the first few hours of a spill, tapering off to 20-25% loss by the first few days depending upon the environmental conditions.

## Oil Properties

**Initial (fresh) Flash Point:** lower than -10°C
**Weathered (24% loss) Flash Point:** 30°C

**Initial (fresh) Pour Point:** -33°C
**Weathered (27% loss) Pour Point:** 12°C

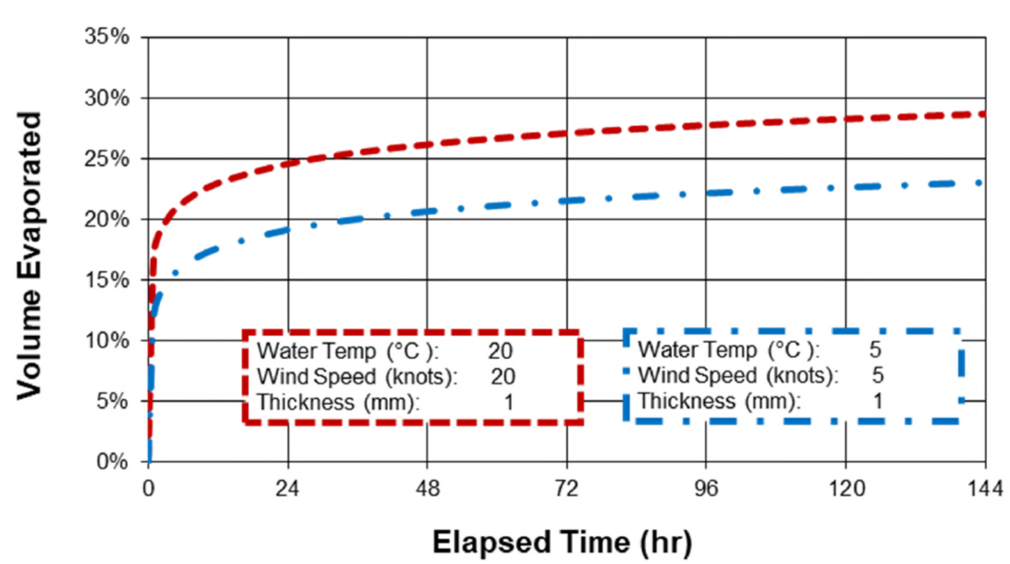
**Initial Density (g/cm3)**
**@ 0°C:** 0.948 **@15°C:** 0.937 **@20°C:** 0.933

**Initial Viscosity (cP)**
**@ 0°C:** 809 **@15°C:** 229 **@20°C:** 172

## Evaporation Potential

SLROSM (SL Ross Model) outputs of two scenarios are shown to the right:

*Actual evaporation will depend upon specific spill conditions encountered such as the volume of oil, water and air temperatures, and wind speed.*




## Emulsification Potential

If AHS encounters an energetic freshwater or marine environment while it is still fresh or lightly weathered (to approximately 20% volumetric loss), some emulsification is very likely (stable or meso-stable). Depending on the environment (turbulent water, warm conditions), AHS can rapidly weather and quickly become too viscous to emulsify further.

A meso-stable emulsion is brown and viscous, a water content ranging from 35%–83%, and a viscosity increase of up to 45x the parent oil. A stable emulsion is a brown gel/semi-solid, with water contents in the 65%–93% range, and viscosity increase on the order of 1000x the parent oil on average.

## Interaction with suspended sediment and shorelines

AHS demonstrated a low propensity of interaction with suspended sediment in fresh water and marine water, so Oil-Mineral Aggregate (OMA) formation is expected to be low or unlikely. This oil displayed high adhesion properties, with residues persisting for extended periods of time on simulated shorelines (beach substrates) subjected to repeated wave action. This oil would have low risk for remobilization after impacting shorelines (dependent upon local conditions). Lightly weathered AHS would have a comparatively low tendency to penetrate deep into sandy or cobble shorelines. Penetration would slow and become increasingly limited as the oil weathers and becomes more viscous. Impacts from weathered oil would be expected to remain at or very near the surface.

## Oil Weathering

*Results presented below are actual measurements from Flume Tank Testing.*

### Submergence Potential

**Fresh Water – Oil/Emulsion Density Range (g/mL)**

| | Sediment | Time | | | | |
|---|---|---|---|---|---|---|
| Temp | (ppm) | 0hr | 6hr | 24hr | 48hr | 120hr |
| ~0° | 0 | 0.948 | 0.966 | 0.979 | 0.997 | 1.001 |
| 20°C | 0 | 0.933 | 1.003 | 1.010 | 1.013 | - |

**Legend**
Low <0.96 g/ml
Mid 0.96 - 0.98 g/ml
High >0.98 g/ml
Fresh water density: 1.000 g/mL approx.

**Marine Water – Oil/Emulsion Density Range (g/mL)**

| | Sediment | Time | | | | |
|---|---|---|---|---|---|---|
| Temp | (ppm) | 0hr | 6hr | 24hr | 48hr | 120hr |
| ~0° | 0 | *No test conducted under this condition, expected to float* | | | | |
| 20°C | 1000 | 0.933 | 1.011 | 1.017 | - | 1.023 |

**Legend**
Low <0.99 g/mL
Mid 0.99 – 1.01 g/mL
High >1.01 g/mL
Ocean water (35% salt) density: 1.026 g/mL approximately

### Viscosity

**Fresh Water – Oil/Emulsion Viscosity Range (cP)**

| | Sediment | Time | | | | |
|---|---|---|---|---|---|---|
| Temp | (ppm) | 0hr | 6hr | 24hr | 48hr | 120hr |
| ~0° | 0 | 800 | 34,000 | 56,000 | 59,000 | 91,000 |
| 20°C | 0 | 130 | 72,000 | 310,000 | 347,000 | - |

## What to Expect

**Freshwater:** Once in the fresh aqueous environment, AWB will initially float. Based on 5-day testing in a flume tank, evaporative losses resulted in the density starting to increase, and within the first few days was reaching that of water. Oil may begin shedding neutrally buoyant droplets or blobs into the water column.

**Marine Environment:** AWB is expected to remain floating for significant periods of time allowing for rapid response operations.

**Additional Highlights:** Initial rapid evaporative losses in warm conditions (near 20°C), which slow by the first 24-hour mark. Depending on the environment, AWB can rapidly become too viscous to readily emulsify due to evaporative losses.

However, if it encounters an energetic Freshwater or marine environment before it becomes highly viscous, significant emulsification is possible. Evaporative losses of approximately 15-20% by volume would be expected within the first few hours of a spill, tapering off to 25-30% loss by the first few days depending on the environmental conditions.

## Oil Properties

**Initial (fresh) Flash Point:** lower than -10°C
**Weathered (27% loss) Flash Point:** 33°C

**Initial (fresh) Pour Point:** -36°C
**Weathered (27% loss) Pour Point:** 12°C

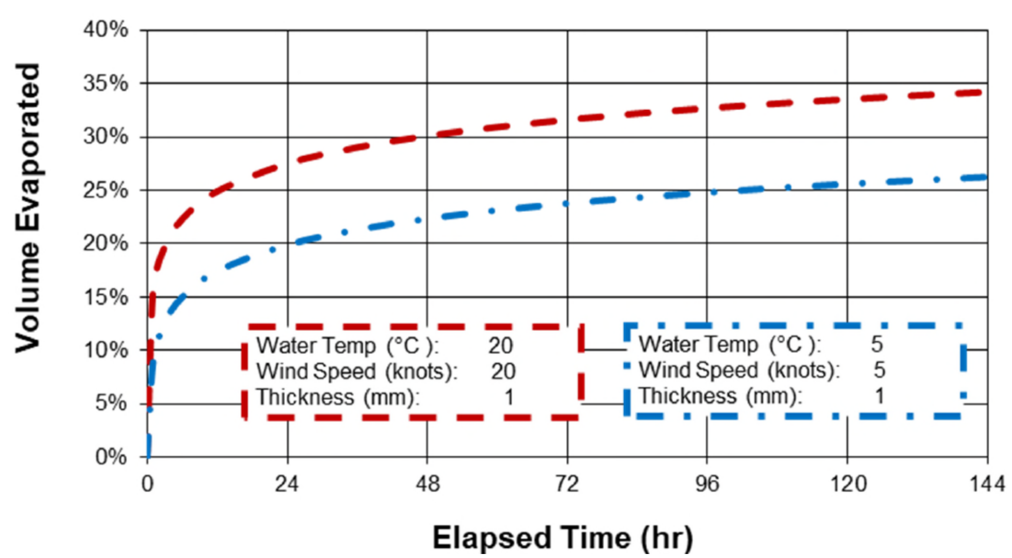
**Initial Density (g/cm3)**
**@ 0°C:** 0.929 **@15°C:** 0.918 **@20°C:** 0.914

**Initial Viscosity (cP)**
**@ 0°C:** 2100 **@15°C:** 450 **@20°C:** 275

## Evaporation Potential

SLROSM (SL Ross Model) outputs of two scenarios are shown to the right:

*Actual evaporation will depend upon specific spill conditions encountered such as the volume of oil, water and air temperatures, and wind speed.*




## Emulsification Potential

If AWB encounters an energetic freshwater or marine environment before it becomes viscous, weak emulsification is probable (entrained emulsion likely). Depending on the environment (turbulent water, warm conditions), AWB can rapidly weather due to evaporative losses and other processes, and become too viscous to emulsify further. A resultant increase in viscosity and volume of emulsion would occur with emulsification. An entrained water emulsion looks black, may have a water content approaching 40%, and a viscosity increase of up to 10x the parent oil. The degree of viscosity increase and slick volume increase is highly dependent upon environmental conditions.

## Interaction with suspended sediment and shorelines

AWB demonstrated a low-to-moderate propensity of interaction with suspended sediment in fresh water and marine water, so Oil-Mineral Agglomeration (OMA) formation is expected to be low. This oil displayed high adhesion properties, with residues persisting for extended periods of time on simulated shorelines (beach substrates) subjected to repeated wave action. This oil would have low risk for remobilization after impacting shorelines (dependent upon local conditions). Lightly weathered oil has a comparatively low tendency to penetrate into sandy or cobble shorelines. Penetration would slow substantially as the oil weathers and becomes more viscous. Impacts from weathered oil would be expected to remain at or very near the surface when dealing with shorelines of smaller sized substrates with small void spacing.

## Oil Weathering

*Results presented below are actual measurements from Flume Tank Testing.*

### Submergence Potential

**Fresh Water – Oil/Emulsion Density Range (g/mL)**

| | Sediment | Time | | | | |
|---|---|---|---|---|---|---|
| Temp | (ppm) | 0hr | 6hr | 24hr | 48hr | 120hr |
| ~0° | 0 | 0.929 | 0.993 | 0.996 | 1.004 | 1.005 |
| 20°C | 0 | 0.914 | 0.998 | 1.000 | 0.998 | 1.005 |

**Legend**
Low <0.96 g/ml
Mid 0.96 - 0.98 g/ml
High >0.98 g/ml
Fresh water density: 1.000 g/mL approx.

**Marine Water – Oil/Emulsion Density Range (g/mL)**

| | Sediment | Time | | | | |
|---|---|---|---|---|---|---|
| Temp | (ppm) | 0hr | 6hr | 24hr | 48hr | 120hr |
| ~0° | 0 | *No test conducted under this condition, expected to float* | | | | |
| 20°C | 1000 | 0.914 | 1.001 | 1.008 | 1.012 | 1.012 |

**Legend**
Low <0.99 g/mL
Mid 0.99 – 1.01 g/mL
High >1.01 g/mL
Ocean water (35% salt) density: 1.026 g/mL approximately

### Viscosity

**Fresh Water – Oil/Emulsion Viscosity Range (cP)**

| | Sediment | Time | | | | |
|---|---|---|---|---|---|---|
| Temp | (ppm) | 0hr | 6hr | 24hr | 48hr | 120hr |
| ~0° | 0 | 2,100 | 290,000 | 320,000 | 330,000 | 220,000 |
| 20°C | 0 | 280 | 61,000 | 120,000 | 280,000 | 350,000 |

# COLD LAKE BLEND (CLB): Unconventional heavy sour, 22.4°API (60°F/15.6°C)

TRANSMOUNTAIN

## What to Expect

**Freshwater:** When spilled the oil will initially float on water. As CLB weathers, its density will begin to approach that of water and the risk of submergence will be present. Weathering due to evaporation slows after the first 24 hours and the density may plateau just under the density of water for some time (days). No submergence was observed during 5-day flume tank testing.

**Marine Environment:** Similar behaviour to that experienced in the freshwater tests, with the density seemingly plateauing right around 1 g/mL, which is lower than the density of marine environment. The oil should float for long periods (tested for 6 days).

**Additional Highlights:** Oil weathers quickly for the first 24 hours and the density approaches that of fresh water which increases the risk of submergence.

In a marine environment the oil should remain floating for long periods of time (tested to 6 days with very slow changes in density past the first 24 hours).

Evaporative losses of approximately 15- 20% by volume would be expected in the first few hours of a spill, tapering off to 25-30% loss by the first few days depending upon the environmental conditions.

## Oil Properties

**Initial (fresh) Flash Point:** lower than -10°C
**Weathered (26% loss) Flash Point:** 50°C

**Initial (fresh) Pour Point:** -39°C
**Weathered (26% loss) Pour Point:** 6°C

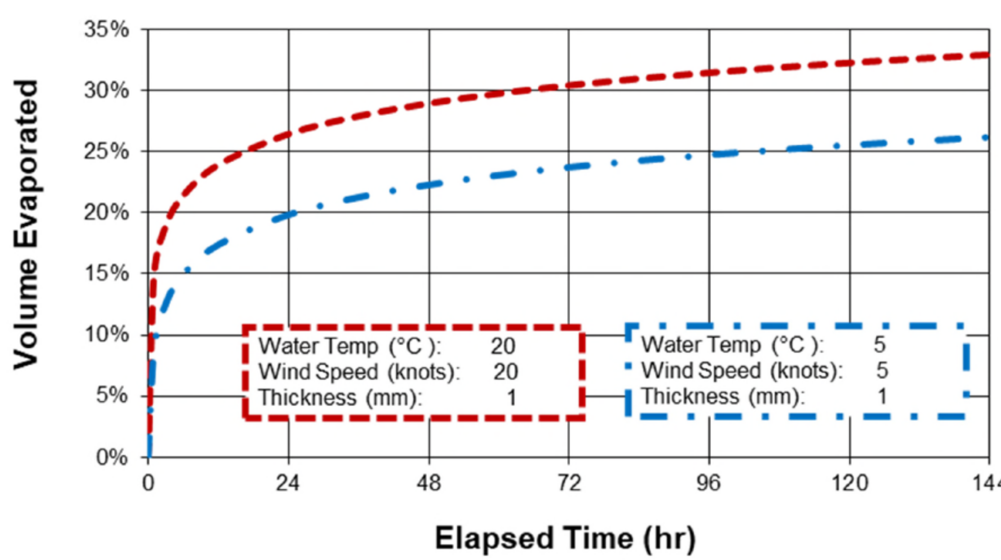
**Initial Density (g/cm3)**
**@ 0°C:** 0.930 **@15°C:** 0.920 **@20°C:** 0.916

**Initial Viscosity (cP)**
**@ 0°C:** 663 **@15°C:** 258 **@20°C:** 156

## Evaporation Potential

SLROSM (SL Ross Model) outputs of two scenarios are shown to the right:

*Actual evaporation will depend upon specific spill conditions encountered such as the volume of oil, water and air temperatures, and wind speed.*




## Emulsification Potential

Fresh CLB is likely to form entrained water emulsions under cold conditions (0°C). As it weathers under cold conditions, it quickly becomes too viscous to emulsify further to any large extent. When weathering under warm conditions (20°C) it is likely to form entrained water emulsions when fresh through light weathering (14% volumetric loss). As it weathers further, it too becomes too viscous to emulsify further to any large extent. (An entrained water emulsion looks black, with large water droplets; has water contents after 24 hours settling of 26% to 62% averaging 42%; and the emulsion viscosity is 13x greater than the parent oil on average).

## Interaction with suspended sediment and shorelines

CLB demonstrated a low to moderate propensity of interaction with certain suspended sediment in fresh water, so Oil-Mineral Aggregate (OMA) formation is expected to be up to moderate when mineral loadings are very high. This oil displayed moderate-to-high adhesion properties, with residues lightly persisting for periods of time on simulated shorelines (beach substrates) subjected to repeated wave action. This oil would have moderate to low risk for remobilization after impacting shorelines (dependent upon local conditions). Lightly weathered oil would have a low tendency to penetrate into sandy or cobble shorelines. Penetration would slow substantially as the oil weathers and becomes more viscous. Impacts from weathered oil would be expected to remain at or very near the surface.

## Oil Weathering

*Results presented below are actual measurements from Flume Tank Testing.*

### Submergence Potential

**Fresh Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 0.930 | 0.989 | 0.992 | 0.998 | 0.995 |
| 20°C | 0 | 0.920 | 0.983 | 0.994 | 0.999 | 1.000 |

**Legend**

- Low <0.96 g/ml
- Mid 0.96 - 0.98 g/ml
- High >0.98 g/ml

Fresh water density: 1.000 g/mL approx.

**Marine Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | *No test conducted under this condition, expected to float* | | | | |
| 20°C | 1000 | 0.920 | 0.978 | 1.001 | 1.004 | 1.008 |

**Legend**

- Low <0.99 g/mL
- Mid 0.99 – 1.01 g/mL
- High >1.01 g/mL

Ocean water (35% salt) density: 1.026 g/mL approximately

### Viscosity

**Fresh Water – Oil/Emulsion Viscosity Range (cP)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 660 | 190,000 | 220,000 | 273,750 | 210,000 |
| 20°C | 0 | 160 | 18,000 | 55,000 | 38,900 | 49,000 |

## What to Expect

**Freshwater:** CRW is extremely light and will spread rapidly if spilled. Because it is so light, it will also weather (evaporate) and disperse very quickly. A high evaporation rate would be expected for the initial 6 hours, slowing after that time period. No risk of sinking.

**Marine Environment:** Although no tests were conducted under marine environment conditions in the 2020 study, CRW is expected to weather (evaporate) very quickly during the initial 6 hour period, slowing after that. It will also naturally begin a dispersion process. There is no risk of sinking in a marine environment.

**Additional Highlights:** Rapid weathering (evaporation) in the first 6 hour period, slowing after that. Rapid spreading would occur due to low viscosity, no risk of sinking due to low density.

Expected to evaporate and disperse naturally in the water. Weather to 60-65% volumetric loss due to evaporation within the first few hours, and up to approximately 80- 85% loss expected in a matter of days due to evaporation plus additional losses due to natural dispersion would be expected in a spill depending upon the environmental conditions.

## Oil Properties

**Initial (fresh) Flash Point:** lower than -12°C
**Weathered (80% loss) Flash Point:** 148°C

**Initial (fresh) Pour Point:** -57°C
**Weathered (26% loss) Pour Point:** 15°C

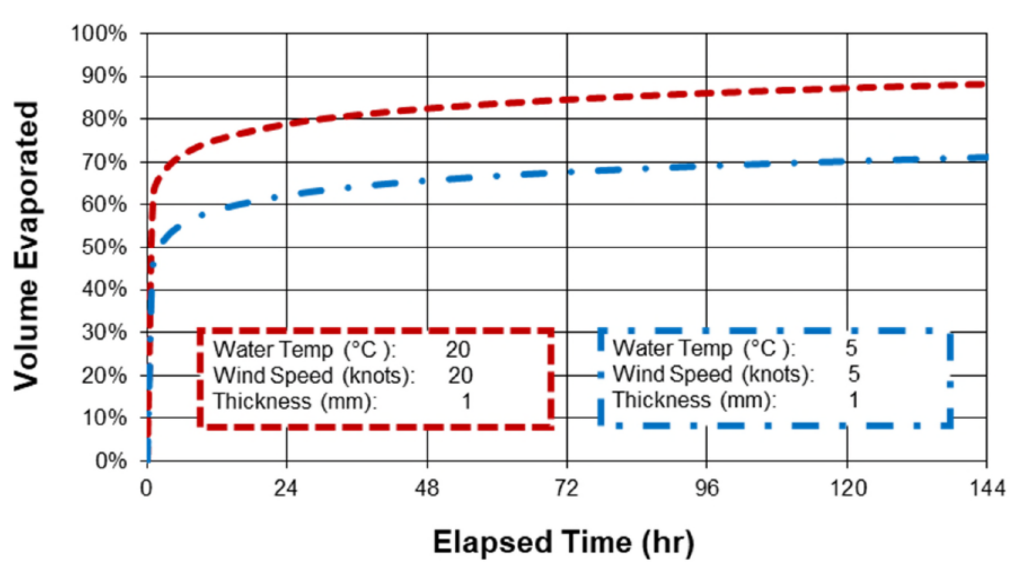
**Initial Density (g/cm3)**
**@ 0°C:** 0.760 **@15°C:** 0.748 **@20°C:** 0.744

**Initial Viscosity (cP)**
**@ 0°C:** <3 **@15°C:** <3 **@20°C:** <3

## Evaporation Potential

SLROSM (SL Ross Model) outputs of two scenarios are shown to the right:

*Actual evaporation will depend upon specific spill conditions encountered such as the volume of oil, water and air temperatures, and wind speed.*




## Emulsification Potential

CRW is unlikely to form water emulsions under cold (0°C) and warm (20°C) conditions. Any water picked up would become entrained or incorporated as an unstable emulsion. An unstable emulsion may have between 1% through 23% water content, and the viscosity would be similar to that of the parent oil.

## Interaction with suspended sediment and shorelines

CRW demonstrated a moderate to high propensity of interaction with suspended sediment (minerals) in fresh water, so Oil-Mineral Aggregate (OMA) formation is expected to be moderate if mineral loadings are high.

This oil displayed low adhesion properties, with residues not persisting on simulated shorelines (beach substrates) subjected to repeated wave action (many hundreds of wave impacts). This oil would have high risk for remobilization after impacting shorelines unless stranded (dependant upon local conditions).

Partially weathered oil would have a high tendency to penetrate deep into sandy or cobble shorelines. Penetration would continue as the oil weathers because viscosity increases are slight.

## Oil Weathering

*Results presented below are actual measurements from Flume Tank Testing.*

### Submergence Potential

**Fresh Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 0.760 | 0.829 | 0.848 | 0.854 | 0.869 |
| 20°C | 0 | 0.744 | 0.837 | 0.851 | 0.863 | 0.875 |

**Legend**
Low <0.96 g/ml
Mid 0.96 - 0.98 g/ml
High >0.98 g/ml
Fresh water density: 1.000 g/mL approx.

**Marine Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | *No test conducted under this condition, expected to float* | | | | |
| 20°C | 1000 | *No test conducted under this condition, expected to float* | | | | |

**Legend**
Low <0.99 g/mL
Mid 0.99 – 1.01 g/mL
High >1.01 g/mL
Ocean water (35% salt) density: 1.026 g/mL approximately

### Viscosity

**Fresh Water – Oil/Emulsion Viscosity Range (cP)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 1 | 36+ | 124 | 352 | 800 |
| 20°C | 0 | 1 | 11 | 26 | 42 | 136 |

# MEDIUM SOUR BLEND (MSB): Conventional medium sour pool, 35.5°API (60°F/15.6°C)

TRANSMOUNTAIN

## What to Expect

**Freshwater:** MSB will remain floating for an extended period of time. Weathering (evaporative losses) are expected to start off quickly (for the first 12 hours) then continue at a much slower rate. Density increases are slight, while viscosity impacts may be affected by emulsification.

**Marine Environment:** Not tested in a marine environment but expected to remain floating for extended periods of time allowing for a wide range of spill countermeasures.

**Additional Highlights:** Evaporative losses of approximately 30-35% by volume would be expected within the first few hours of a spill, tapering off to 45-50% volumetric loss by the first few days depending upon the environmental conditions. MSB is expected to remain light and retain a low viscosity under many conditions which may cause increased spreading.

## Emulsification Potential

MSB is unlikely to form stable emulsions when fresh, but that changes once weathering processes begin. At cool (0°C) temperatures, lightly weathered oil was found to be very likely to form stable emulsions. As the oil became more heavily weathered, it transitioned to form meso-stable emulsions. Under warm conditions (20°C), the oil is unlikely to form an emulsion until it becomes more heavily weathered. At that point, it is very likely to form an entrained (weak) emulsion. A stable emulsion is a brown gel/solid, with water content in the 65% to 93% range, and an emulsion viscosity up to 1000x greater than the parent oil. A meso-stable emulsion is a brown viscous liquid with water content in the 35% to 85% range, with an emulsion viscosity up to 45x greater than the oil on average. Finally an entrained water emulsion looks black with large water droplets, has a water content in the 26% to 62% range, and an emulsion viscosity up to 13x greater than the oil.

## Interaction with suspended sediment and shorelines

MSB demonstrated a moderate-to-high propensity of interaction with suspended sediment in water, so Oil-Mineral Aggregate (OMA) formation is expected to be moderate in high sediment loadings conditions. This oil displayed low adhesion properties, with residues not persisting on simulated shorelines (beach substrates) subjected to repeated wave action (many hundreds of wave impacts). This oil would have high risk for remobilization after impacting shorelines (dependent upon local conditions). Fresh oil would have high tendency to penetrate into sandy or cobble shorelines. Penetration would slow slightly as the oil weathers because viscosity increases are limited. Impacts from weathered oil would be expected to penetrate past the surface.

## Oil Properties

**Initial (fresh) Flash Point:** lower than -12°C
**Weathered (44% loss) Flash Point:** 144°C

**Initial (fresh) Pour Point:** -46°C
**Weathered (44% loss) Pour Point:** 9°C

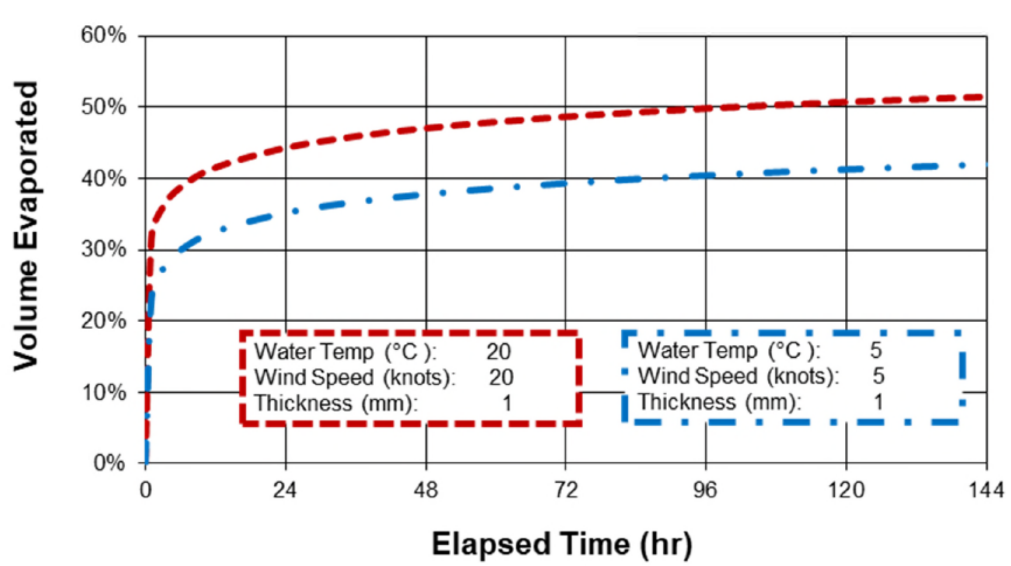
**Initial Density (g/cm3)**
**@ 0°C:** 0.859 **@15°C:** 0.848 **@20°C:** 0.844

**Initial Viscosity (cP)**
**@ 0°C:** 15 **@15°C:** 8 **@20°C:** 7

## Evaporation Potential

SLROSM (SL Ross Model) outputs of two scenarios are shown to the right:

*Actual evaporation will depend upon specific spill conditions encountered such as the volume of oil, water and air temperatures, and wind speed.*




## Oil Weathering

*Results presented below are actual measurements from Flume Tank Testing.*

### Submergence Potential

**Fresh Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 0.859 | 0.916 | 0.925 | 0.929 | 0.937 |
| 20°C | 0 | 0.844 | 0.909 | 0.918 | 0.922 | 0.928 |

**Legend**
- Low <0.96 g/ml
- Mid 0.96 - 0.98 g/ml
- High >0.98 g/ml

Fresh water density: 1.000 g/mL approx.

**Marine Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | *No test conducted under this condition, expected to float* | | | | |
| 20°C | 1000 | *No test conducted under this condition, expected to float* | | | | |

**Legend**
- Low <0.99 g/mL
- Mid 0.99 – 1.01 g/mL
- High >1.01 g/mL

Ocean water (35% salt) density: 1.026 g/mL approximately

### Viscosity

**Fresh Water – Oil/Emulsion Viscosity Range (cP)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 15 | 310 | 640 | 950 | 1,400 |
| 20°C | 0 | 7 | 84 | 160 | 200 | 350 |

## MIXED SWEET BLEND (MSW): Conventional light sweet pool, 35.5°API (60°F/15.6°C)

TRANSMOUNTAIN

### What to Expect

**Freshwater:** MSW is expected to remain floating for an extended period of time. Based on 5-day testing in a flume, evaporative losses and other weathering processes should not result in the density approaching that of fresh water under either warm (20°C) or cold (0°C) water conditions. Oil viscosity increases would likely be impacted by emulsification.

**Marine Environment:** Expected to remain floating for extended periods of time, allowing for a wide range of spill countermeasures. Evaporative losses during weathering would be high during the initial 12 hour period of a spill, slowing substantially after that.

**Additional Highlights:** This low density oil remained light, and kept a low viscosity (less than 5,000 cP) during flume testing under a range of conditions. Evaporative losses of approximately 30-35% by volume would be expected within the first few hours of a spill, tapering off to 50-55% loss by the first few days depending upon the environmental conditions.

### Oil Properties

**Initial (fresh) Flash Point:** lower than -12°C
**Weathered (49% loss) Flash Point:** 88°C

**Initial (fresh) Pour Point:** -24°C
**Weathered (49% loss) Pour Point:** 15°C

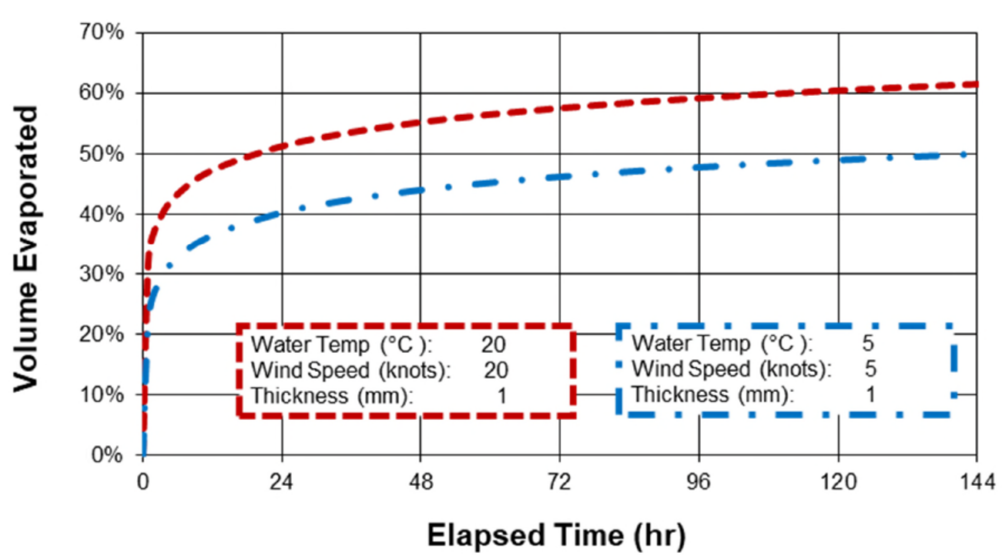
**API Gravity (60°F/15.6°C): 35.5°**
**Initial Density (g/cm3)**
**@ 0°C:** 0.832 **@15°C:** 0.820 **@20°C:** 0.816

**Initial Viscosity (cP)**
**@ 0°C:** 10 **@15°C:** 5 **@20°C:** 5

### Evaporation Potential

SLROSM (SL Ross Model) outputs of two scenarios are shown to the right:

*Actual evaporation will depend upon specific spill conditions encountered such as the volume of oil, water and air temperatures, and wind speed.*




### Emulsification Potential

At cooler temperatures (0°C) fresh MSW is very likely to form unstable emulsions, transitioning to stable emulsions as it begins to weather. Emulsification tendencies drop off as the oil weathers more heavily and the relatively low pour point increases its impact on behaviour. At warmer temperatures (20°C) the fresh oil is initially unlikely to form emulsions; however, as it weathers it has a very likely tendency to form meso-stable emulsions.

A meso-stable emulsion is a brown viscous liquid with water content in the 35% to 85% range, with an emulsion viscosity up to 45x greater than the oil on average.

### Interaction with suspended sediment and shorelines

MSW demonstrated a low-to-moderate propensity of interaction with suspended sediment in fresh water, so Oil-Mineral Aggregate (OMA) formation is expected to be low. This oil displayed low adhesion properties, with residues not persisting on simulated shorelines (beach substrates) subjected to repeated wave action. This oil would have a high risk for remobilization after impacting shorelines (dependant upon local conditions). Fresh oil would have a moderate to high tendency to penetrate into sandy and cobble shorelines. Penetration would slow and become increasingly limited as the oil weathers further and/or emulsifies.

### Oil Weathering

*Results presented below are actual measurements from Flume Tank Testing.*

#### Submergence Potential

**Fresh Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 0.832 | 0.891 | 0.901 | 0.914 | 0.918 |
| 20°C | 0 | 0.816 | 0.884 | 0.895 | 0.942 | 0.942 |

**Legend**
Low <0.96 g/ml
Mid 0.96 - 0.98 g/ml
High >0.98 g/ml
Fresh water density: 1.000 g/mL approx.

**Marine Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | *No test conducted under this condition, expected to float* | | | | |
| 20°C | 1000 | 0.816 | 0.885 | 0.894 | 0.905 | 0.928 |

**Legend**
Low <0.99 g/mL
Mid 0.99 – 1.01 g/mL
High >1.01 g/mL
Ocean water (35% salt) density: 1.026 g/mL approximately

#### Viscosity

**Fresh Water – Oil/Emulsion Viscosity Range (cP)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 10 | 390 | 1,200 | 2,600 | 3,200 |
| 20°C | 0 | 5 | 57 | 120 | 520 | 435 |

## SYNBIT BLEND (SYB): Blend of unconventional heavy and synthetic, 20.5°API (60°F/ 15.6°C)

TRANSMOUNTAIN

### What to Expect

**Freshwater:** SYB is expected to initially float if spilled in a fresh aqueous environment. Based on 5-day testing in a flume tank, oil density readings remained below the density of fresh water in both warm (20°C) and cold (0°C) water testing. Extended testing beyond 5 days showed the density slowly rising into the medium risk level. Initial rapid weathering (evaporative losses) would occur during the first 12 - 24 hours after a spill, slowing dramatically after that period.

**Marine Environment:** The oil is expected to float for an extended period of time in the marine environment, allowing for a wide range of countermeasures including containment and recovery operations.

**Additional Highlights:** Evaporative losses of approximately 10-15% by volume would be expected within the first few hours of a spill, tapering off to 20-25% loss by the first few days depending upon the environmental conditions.

### Emulsification Potential

In cold conditions (0°C) water temperature, SYB is likely to form meso-stable emulsions when fresh, reducing in stability as it weathers forming entrained emulsions at around 10% weathered (volumetric loss due to evaporation). In warm conditions (20°C), fresh and lightly weathered SYB formed meso-stable emulsions, while more extensively weathered samples generated entrained emulsions.

A meso-stable emulsion is a brown viscous liquid with water content in the 35% to 85% range, with an emulsion viscosity up to 45x greater than the oil on average. An entrained water emulsion retains the colour of the parent oil embedded with large water droplets and has a water content ranging from 26% to 42% with a viscosity near 10x that of the parent oil.

### Interaction with suspended sediment and shorelines

SYB demonstrated a moderate to high propensity of interaction with suspended sediment in water, so Oil-Mineral Aggregate (OMA) formation is expected in water with high sediment load. This oil displayed moderate adhesion properties, with residues not persisting for extended periods of time on simulated shorelines (beach substrates) subjected to repeated wave action (many hundreds of wave impacts). This oil would have high risk for remobilization after impacting shorelines (dependent upon local conditions). Fresh oil would have a ready tendency to penetrate into sandy and cobble shorelines. Penetration would slow somewhat as the oil weathers and becomes more viscous.

### Oil Properties

**Initial (fresh) Flash Point:** lower than -10°C
**Weathered (20% loss) Flash Point:** 133°C

**Initial (fresh) Pour Point:** -42°C
**Weathered (49% loss) Pour Point:** 0°C

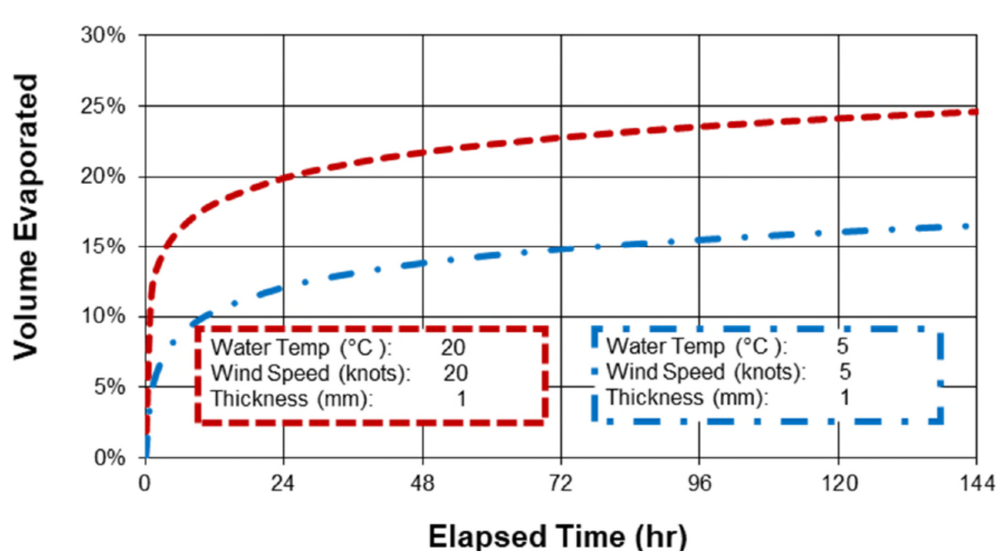
**Initial Density (g/cm3)**
**@ 0°C:** 0.941 **@15°C:** 0.931 **@20°C:** 0.928

**Initial Viscosity (cP)**
**@ 0°C:** 587 **@15°C:** 194 **@20°C:** 144

### Evaporation Potential

SLROSM (SL Ross Model) outputs of two scenarios are shown to the right:

*Actual evaporation will depend upon specific spill conditions encountered such as the volume of oil, water and air temperatures, and wind speed.*




### Oil Weathering

*Results presented below are actual measurements from Flume Tank Testing.*

#### Submergence Potential

**Fresh Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 0.941 | 0.961 | 0.974 | 0.975 | 0.978 |
| 20°C | 0 | 0.928 | 0.963 | 0.971 | 0.975 | 0.978 |

**Legend**

Low <0.96 g/ml
Mid 0.96 - 0.98 g/ml
High >0.98 g/ml

Fresh water density: 1.000 g/mL approx.

**Marine Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | *No test conducted under this condition, expected to float* | | | | |
| 20°C | 1000 | 0.928 | 0.963 | 0.981 | 0.977 | 0.976 |

**Legend**

Low <0.99 g/mL
Mid 0.99 – 1.01 g/mL
High >1.01 g/mL

Ocean water (35% salt) density: 1.026 g/mL approximately

#### Viscosity

**Fresh Water – Oil/Emulsion Viscosity Range (cP)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 587 | 3,000 | 11,500 | 12,000 | 18,000 |
| 20°C | 0 | 144 | 2,100 | 4,100 | 6,700 | 7,100 |

# SYNTHETIC (SYN): Unconventional sweet blend, 33.3°API (60°F/15.6°C)

TRANSMOUNTAIN

## What to Expect

**Freshwater:** Based upon 5-day testing in a flume tank, SYN will float for an extended period of time in the fresh aqueous environment. Weathering of the oil slick did not result in the density increasing past the low risk range except for the final reading of the cold water (0°C) run, where it moved into the mid risk range. The oil viscosity remained at a low reading (under 100 cP) over the durations of the test in 20°C and 0°C water temperatures.

**Marine Environment:** Although not tested in the marine environment, it is expected to float for an extended period of time. SYN is not likely to form a stable emulsion.

**Additional Highlights:** SYN will float for an extended period of time and is not likely to form stable emulsions. Evaporative losses of 20-25% by volume would be expected in the first few hours of a spill, increasing to 30-35% loss by the first few days depending upon the environmental conditions.

## Emulsification Potential

SYN is unlikely to form stable emulsions.

## Interaction with suspended sediment and shorelines

Fresh SYN demonstrated a low propensity of interaction with suspended sediment in fresh water during flume tests, so Oil-Mineral Aggregate (OMA) formation is expected to be low or unlikely.

This oil displayed low adhesion properties, with residues not persisting on simulated shorelines (beach substrates) which were subjected to repeated wave action (many hundreds of wave impacts). This oil would have high risk for remobilization after impacting shorelines (dependent upon local conditions).

Slightly weathered oil would have a high tendency to penetrate into sandy or cobble shorelines. Penetration would not be highly impacted as the oil weathers because its viscosity remains light. Highly weathered oil would be expected to readily penetrate the surfaces of shorelines.

## Oil Properties

**Initial (fresh) Flash Point:** lower than -12°C
**Weathered (20% loss) Flash Point:** 139°C

**Initial Density (g/cm3)**
**@ 0°C:** 0.870 **@15°C:** 0.859 **@20°C:** 0.855

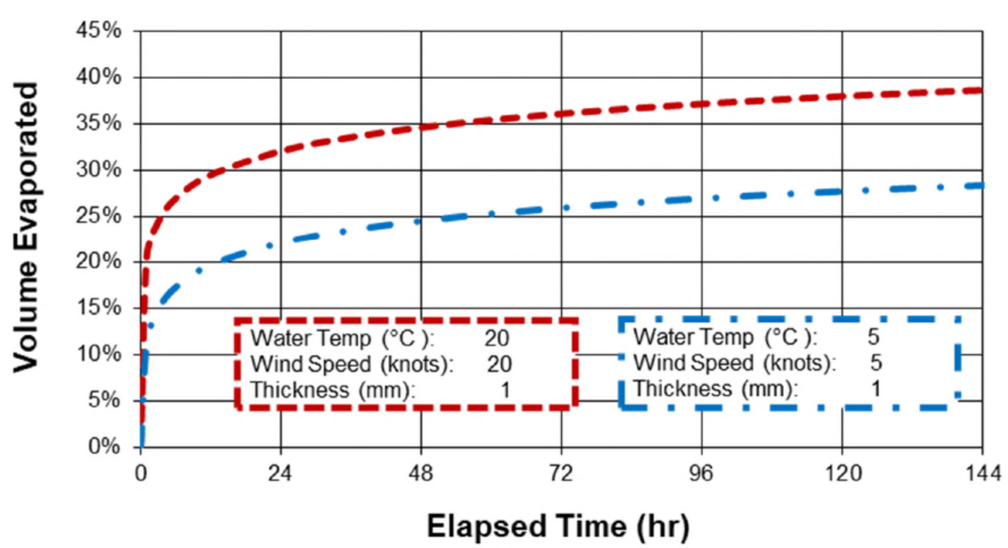
**Initial (fresh) Pour Point:** -51°C
**Weathered (49% loss) Pour Point:** -18°C

**Initial Viscosity (cP)**
**@ 0°C:** 12 **@15°C:** 7 **@20°C:** 6

## Evaporation Potential

SLROSM (SL Ross Model) outputs of two scenarios are shown to the right:

*Actual evaporation will depend upon specific spill conditions encountered such as the volume of oil, water and air temperatures, and wind speed.*




## Oil Weathering

*Results presented below are actual measurements from Flume Tank Testing.*

### Submergence Potential

**Fresh Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 0.870 | 0.897 | 0.907 | 0.936 | 0.968 |
| 20°C | 0 | 0.855 | 0.890 | 0.896 | 0.898 | 0.904 |

Legend
Low <0.96 g/ml
Mid 0.96 - 0.98 g/ml
High >0.98 g/ml
Fresh water density: 1.000 g/mL approx.

**Marine Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | *No test conducted under this condition, expected to float* | | | | |
| 20°C | 1000 | *No test conducted under this condition, expected to float* | | | | |

Legend
Low <0.99 g/mL
Mid 0.99 – 1.01 g/mL
High >1.01 g/mL
Ocean water (35% salt) density: 1.026 g/mL approximately

### Viscosity

**Fresh Water – Oil/Emulsion Viscosity Range (cP)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 12 | 38 | 62 | 70 | 92 |
| 20°C | 0 | 6 | 20 | 26 | 31 | 42 |

## SUNCOR SYNTHETIC P (OSP): Heavy synthetic oil, 21.0°API (60°F/15.6°C)

### What to Expect

**Freshwater:** OSP is expected to initially float if spilled in a fresh aqueous environment. Based on 7-day testing in a flume tank, oil density readings climbed and within the first few days reached and plateaued at around 0.98 g/mL during the warm (20°C) water testing, and just reached 0.98 g/mL at the very end of the cold (0°C) water testing. Oil may begin shedding neutrally buoyant droplets or small blobs into the water column. Oil viscosity is expected to remain low during the first few days.

**Marine Environment:** Although not tested, based upon the freshwater results the oil is expected to float for significant periods of time in the marine environment, allowing for rapid recovery operations. Some emulsification is expected to occur in the early stages of a spill (depending upon environmental conditions) but slick viscosity should initially remain relatively low.

### Oil Properties

**Initial (fresh) Flash Point:** higher than 2°C

**Initial (fresh) Pour Point:** -18°C

**Initial Density (g/cm3)**
**@ 0°C:** 0.939 **@15°C:** 0.928 **@20°C:** 0.924

**Initial Viscosity (cP)**
**@ 0°C:** 56 **@15°C:** 32 **@20°C:** 19

### Oil Weathering

*Results presented below are actual measurements from Flume Tank Testing.*

#### Submergence Potential

**Fresh Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 0.939 | 0.948 | 0.956 | 0.960 | 0.979 |
| 20°C | 0 | 0.924 | 0.937 | 0.943 | 0.952 | 0.980 |

Legend
- Low <0.96 g/ml
- Mid 0.96 - 0.98 g/ml
- High >0.98 g/ml

Fresh water density: 1.000 g/mL approx.

#### Viscosity

**Fresh Water – Oil/Emulsion Viscosity Range (cP)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | n/a | 47 | 79 | 90 | 133 | 163 |
| 20°C | n/a | 15 | 30 | 35 | 73 | 300 |

## KEARL DILBIT (KRL): Unconventional heavy sour, 20.9°API (60°F/15.6°C)

### What to Expect

**Freshwater:** KRL is expected to initially float if spilled in a fresh aqueous environment. Based on 5-day testing in a flume tank, oil density readings climbed and within the first few days reached that of water during both the warm (20°C) and cold (0°C) water testing. Oil may begin shedding neutrally buoyant droplets or small blobs into the water column.

**Marine Environment:** The oil is expected to float for significant periods of time in the marine environment, allowing for rapid recovery operations. Some emulsification is expected to occur in the early stages of a spill (depending upon environmental conditions) but rapid increases in slick viscosity due to weathering may slow the process as higher energy would be needed to drive water into the slick.

### Oil Properties

**Initial (fresh) Flash Point:** lower than -18°C

**Initial (fresh) Pour Point:** -42°C

**Initial Density (g/cm3)**
**@ 0°C:** 0.938 **@15°C:** 0.927 **@20°C:** 0.923

**Initial Viscosity (cP)**
**@ 0°C:** 1090 **@15°C:** 368 **@20°C:** 267

### Oil Weathering

*Results presented below are actual measurements from Flume Tank Testing.*

#### Submergence Potential

**Fresh Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 0.938 | 0.987 | 0.994 | 0.999 | 1.000 |
| 20°C | 0 | 0.923 | 0.977 | 0.992 | 0.996 | 1.000 |

Legend
- Low <0.96 g/ml
- Mid 0.96 - 0.98 g/ml
- High >0.98 g/ml

Fresh water density: 1.000 g/mL approx.

**Marine Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| 0° | 0 | 0.938 | 0.996 | 0.998 | 1.002 | 1.006 |
| 20°C | 0 | 0.923 | 0.993 | 0.990 | 0.998 | 1.003 |

Legend
- Low <0.99 g/mL
- Mid 0.99 – 1.01 g/mL
- High >1.01 g/mL

Ocean water (35% salt) density: 1.026 g/mL approximately

#### Viscosity

**Fresh Water – Oil/Emulsion Viscosity Range (cP)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 1,090 | 35,800 | 250,000 | 400,000 | 445,000 |
| 20°C | 0 | 267 | 19,300 | 51,400 | 59,400 | 61,700 |

# FORT HILLS DILBIT (FRB): Diluted Bitumen, 21.0°API (60°F/15.6°C)

TRANSMOUNTAIN

## What to Expect

**Freshwater:** FRB is expected to initially float if spilled in a fresh aqueous environment. Based on 5-day testing in a flume tank, oil density readings climbed and within the first 6 hours surpassed 0.98 g/mL during both the cold (0°C) water testing and the warm (20°C) water testing which demonstrates an increased risk for submergence. This product may begin shedding neutrally buoyant droplets or small blobs of oil into the water column.

**Marine Environment:** FRB is expected to initially float if spilled in a marine environment. Some initial loss of oil into the water column as small droplets in the first few hours may occur depending upon wave action. Oil density is expected to climb rapidly then taper off as the slick weathers. Portions of the slick floated low at the surface during testing, with some overwash of water which may complicate detection and recovery during a spill. There was evidence of at least portions of the slick becoming neutrally buoyant within the 5-day test – indicating an increased risk of submergence.

**Special Considerations:** Oil viscosity is expected to climb during a spill – quite dramatically in cold conditions. Portions of the slick did hang low in the water column particularly in the marine condition tests. This can be interpreted as a portion of the slick being denser than the results of the surface grab samples would indicate

## Oil Properties

**Initial (fresh) Flash Point:** lower than 0°C

**Initial (fresh) Pour Point:** -30°C

**Initial Density (g/cm3)**
**@ 0°C:** 0.937 **@15°C:** 0.927 **@20°C:** 0.923

**Initial Viscosity (cP @ 100s$^{-1}$)**
**@ 0°C:** 1107 **@15°C:** 275 **@20°C:** 204

## Oil Weathering

*Results presented below are actual measurements from Flume Tank Testing.*

### Submergence Potential

#### Fresh Water – Oil/Emulsion Density Range (g/mL)

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 96hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 0.937 | 0.987 | 0.996 | 0.997 | 0.992 |
| 20°C | 0 | 0.925 | 0.987 | 0.981 | 0.992 | 0.994 |

**Legend**

- Low <0.96 g/ml
- Mid 0.96 - 0.98 g/ml
- High >0.98 g/ml

Fresh water density: 1.000 g/mL approx.

#### Marine Water – Oil/Emulsion Density Range (g/mL)

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 96hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 0.937 | 1.00 | 0.997 | 0.992 | 1.00 |
| 20°C | 0 | 0.925 | 0.994 | 0.988 | 0.994 | 0.996 |

**Legend**

- Low <0.99 g/mL
- Mid 0.99 – 1.01 g/mL
- High >1.01 g/mL

Ocean water (35% salt) density: 1.026 g/mL approximately

### Viscosity

#### Fresh Water – Oil/Emulsion Viscosity Range (cP)

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 96hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 1100 | 54500 | 175000 | 293000 | 364000 |
| 20°C | 0 | 205 | 14200 | 26400 | 47500 | 53000 |

#### Marine Water – Oil/Emulsion Viscosity Range (cP)

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 96hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 1100 | 34600 | 164000 | 127000 | 80000 |
| 20°C | 0 | 205 | 14100 | 282000 | 31100 | 47000 |

# ALBIAN VACUUM BOTTOMS (AVB): Refinery Feedstock, 18.6°API (60°F/15.6°C)

TRANSMOUNTAIN

## What to Expect

**Freshwater:** AVB is expected to initially float if spilled in a fresh aqueous environment. Based on 7-day testing in a flume tank, oil density readings climbed and within the first 24 hours surpassed 0.98 g/mL during the cold (0°C) water testing but remained under 0.98 g/mL at the end of the extended warm (20°C) water testing. This product may begin shedding neutrally buoyant droplets or small blobs into the water column. Oil viscosity is expected to remain low (below 7,500 cP) during the first few days.

**Marine Environment:** Although not tested, based upon the freshwater results the oil is expected to float for significant periods of time in the marine environment, allowing for rapid recovery operations. Rapid emulsification is expected to occur in the early stages of a spill (depending upon environmental conditions) but slick viscosity should initially remain relatively low

## Oil Properties

**Initial Density (g/cm3)**
**@ 0°C:** 0.950 **@15°C:** 0.940 **@20°C:** 0.936

**Initial Viscosity (cP @ 100s$^{-1}$)**
**@ 0°C:** 635 **@15°C:** 203 **@20°C:** 184

## Oil Weathering

*Results presented below are actual measurements from Flume Tank Testing.*

### Submergence Potential

**Fresh Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 0.950 | 0.972 | 0.986 | 0.989 | 0.984 |
| 20°C | 0 | 0.937 | 0.973 | 0.969 | 0.968 | 0.979 |

**Legend**

- Low <0.96 g/ml
- Mid 0.96 - 0.98 g/ml
- High >0.98 g/ml

Fresh water density: 1.000 g/mL approx.

**Marine Water – Oil/Emulsion Density Range (g/mL)**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | *No test conducted under this condition.* | | | | |
| 20°C | 1000 | *No test conducted under this condition.* | | | | |

**Legend**

- Low <0.99 g/mL
- Mid 0.99 – 1.01 g/mL
- High >1.01 g/mL

Ocean water (35% salt) density: 1.026 g/mL approximately

### Viscosity

**Fresh Water – Oil/Emulsion Viscosity Range (cP)[2]**

| Temp | Sediment (ppm) | Time 0hr | 6hr | 24hr | 48hr | 120hr |
|---|---|---|---|---|---|---|
| ~0° | 0 | 635 | 3600 | 3900 | 3800 | 2500 |
| 20°C | 0 | 184 | 860 | 990 | 1390 | 2400 |