

Behaviour of Heavy Oil in a River: North Saskatchewan River Oil Spill

Matrix Solutions Inc.
Integrated Services • Innovative Solutions

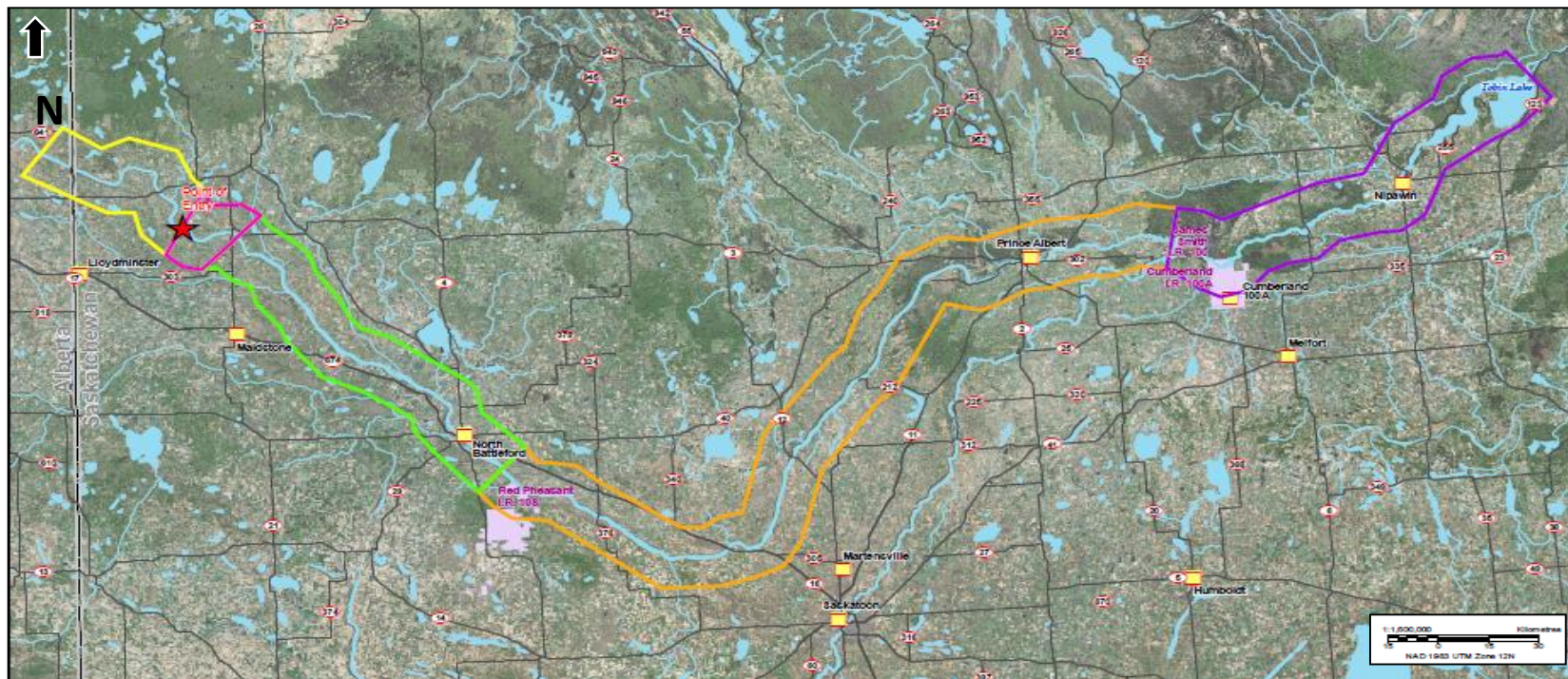
North Saskatchewan River 2016 Oil Release



- July 21, 2016: Oil leak near the North Saskatchewan River
- Break occurred on land, ~160 m from the south bank
- 225 m³ (+/- 10%) crude oil blended with condensate
- ~60% of the product contained on land



Study Area



Knowledge Gap

- Fate and behaviour of spills in freshwater environment
- Fate of unrecovered oil in:
 - sediment
 - woody debris



Initial Uncertainty

How do you find $<100\text{m}^3$
in $>600\text{Km}$ of river?

Did the released oil
deposit along the
shoreline and within
shoreline sediment?

What properties can be
used to identify the oil
from other hydrocarbon
sources?

Does the oil become
buried in sediment? If
so, how deep and at
what rate?

Would leaving
unrecoverable oil in
place result in an
acceptable risk to
receptors?



Steps to Resolve Uncertainties

Oil Characterization & Delineation

- weathering chemical mixture
- changing hydrological conditions
- soil, water, sediment, vegetation, woody debris, foam and sheen

Developing an Understanding of Fate and Transport

- assessing river hydraulics (2D modeling)
- sediment transport mechanisms
- continued weathering and entrainment

Data Acquisition and Management

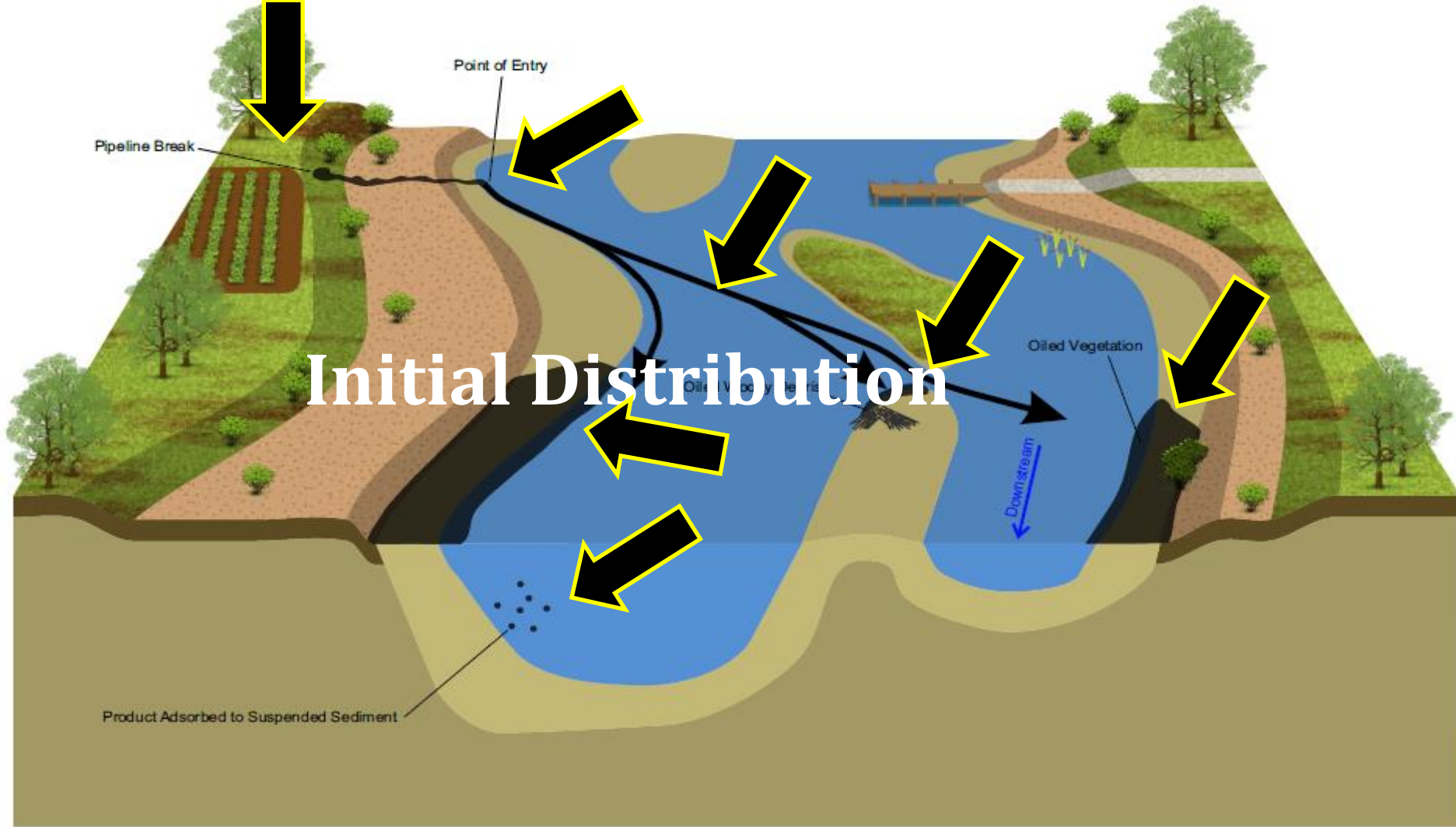
- sampling consistency
- QA/QC
- timely data storage and retrieval

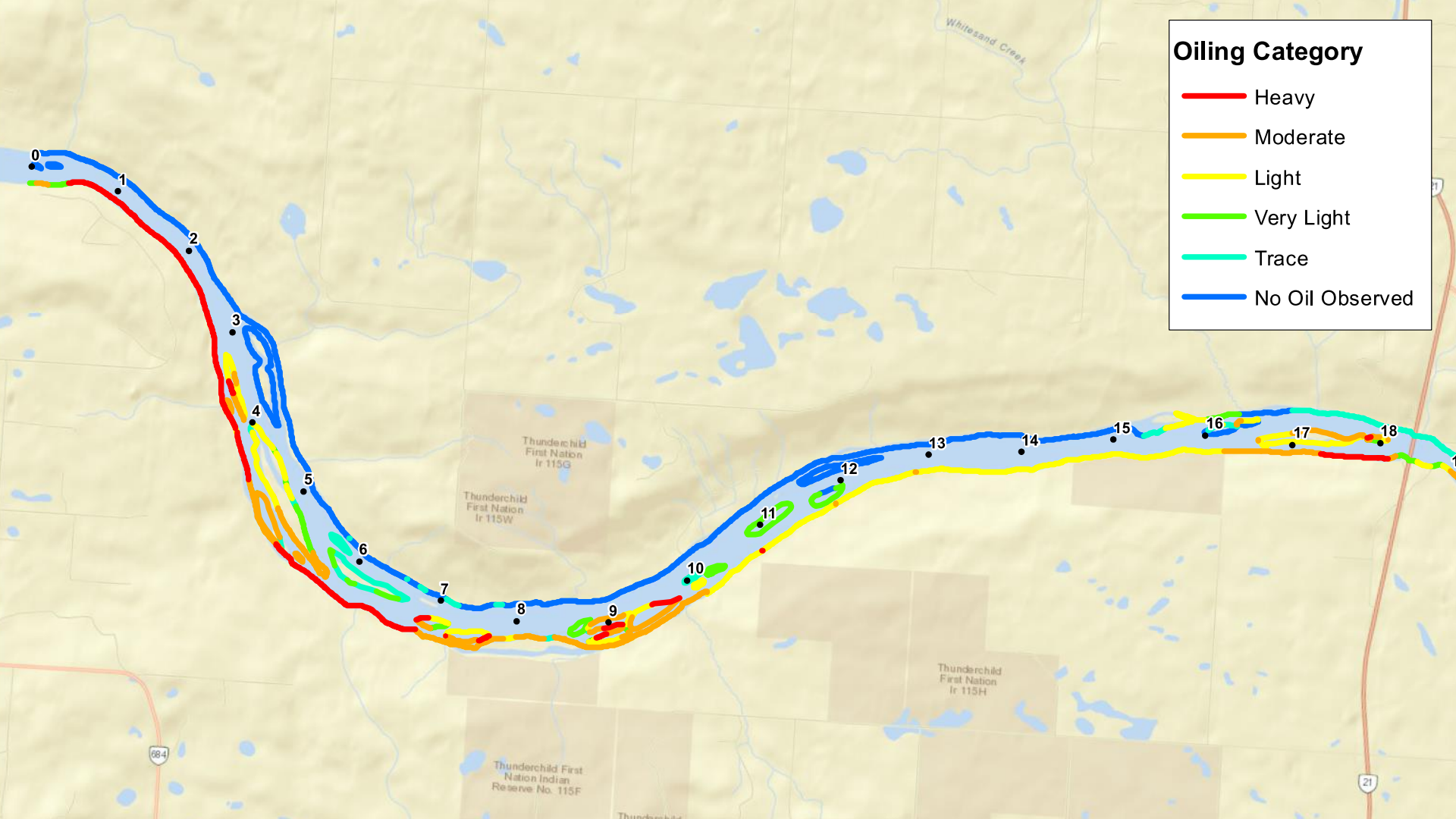
Quantifying Risk

- human health (drinking, exposure)
- ecological receptors (aquatic and terrestrial organisms)



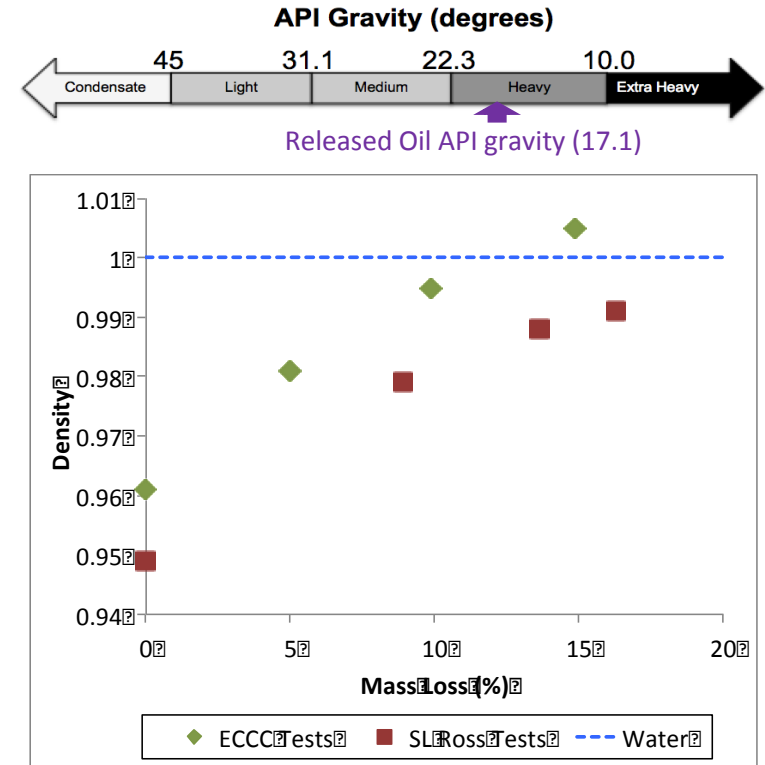




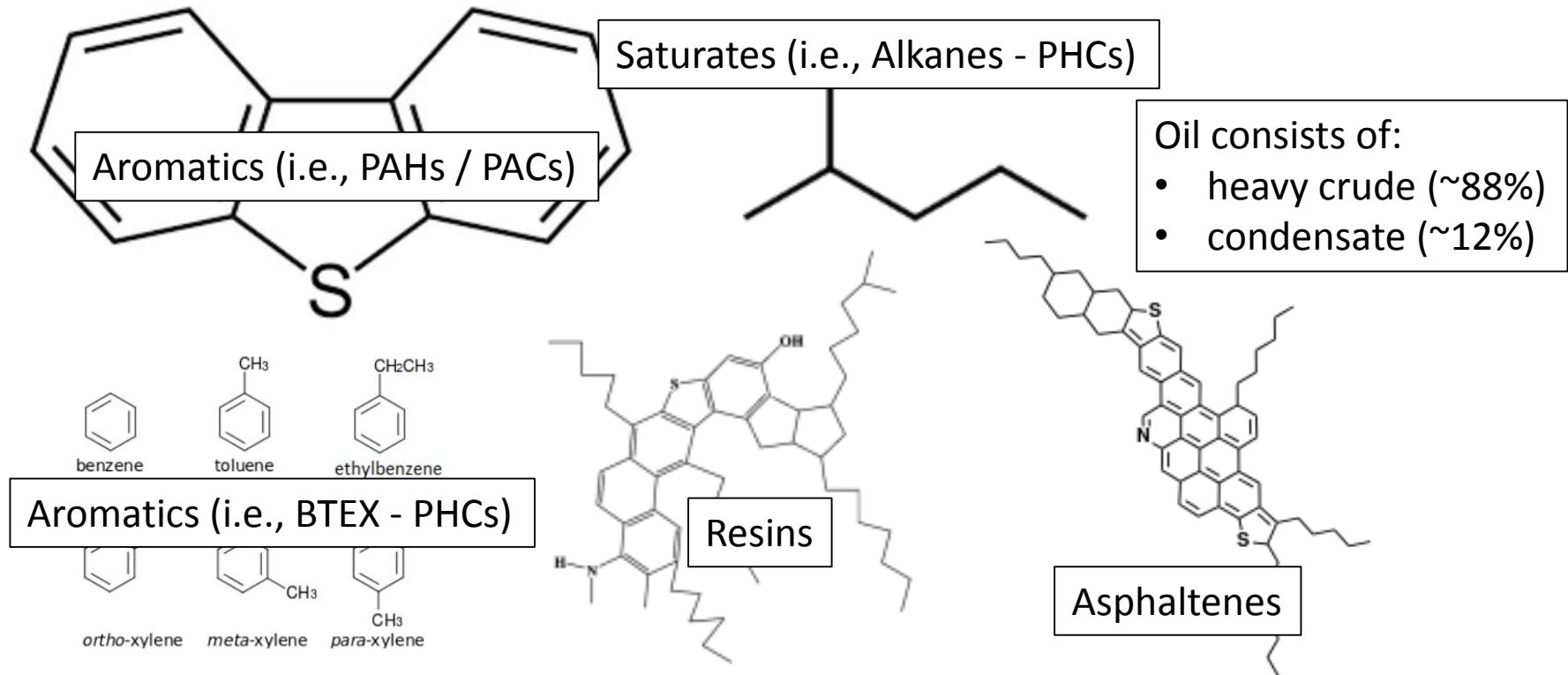


Physical Properties of the Released Oil

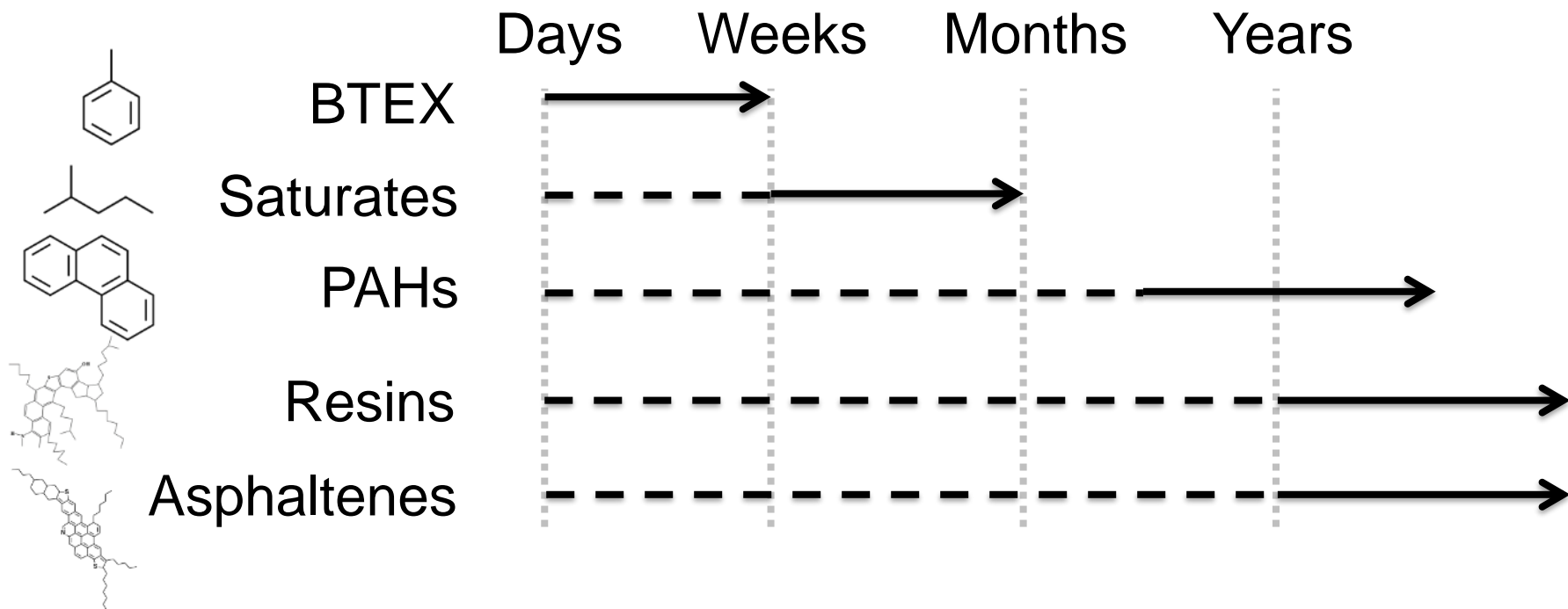
- Source and weathered samples were analyzed.
- Oil consists of:
 - heavy crude, inert to short-term weathering
 - condensate, rapidly affected by weathering
 - Hydrophobic / affinity to soils / sediment
- 15% by weight weathered after 15-18 days.
- Surface water remained over 10°C to end of September, so oil remained less dense than water



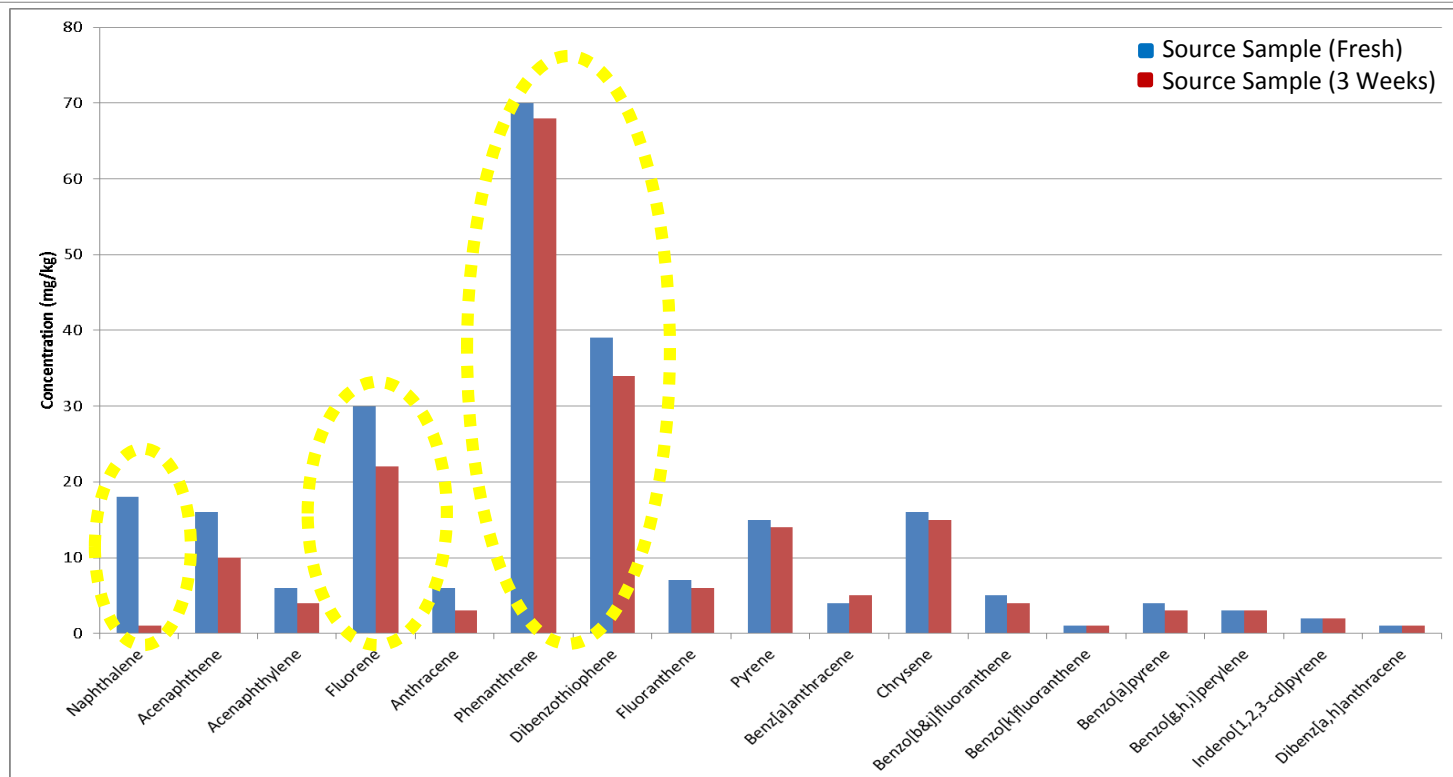
What is the Product?



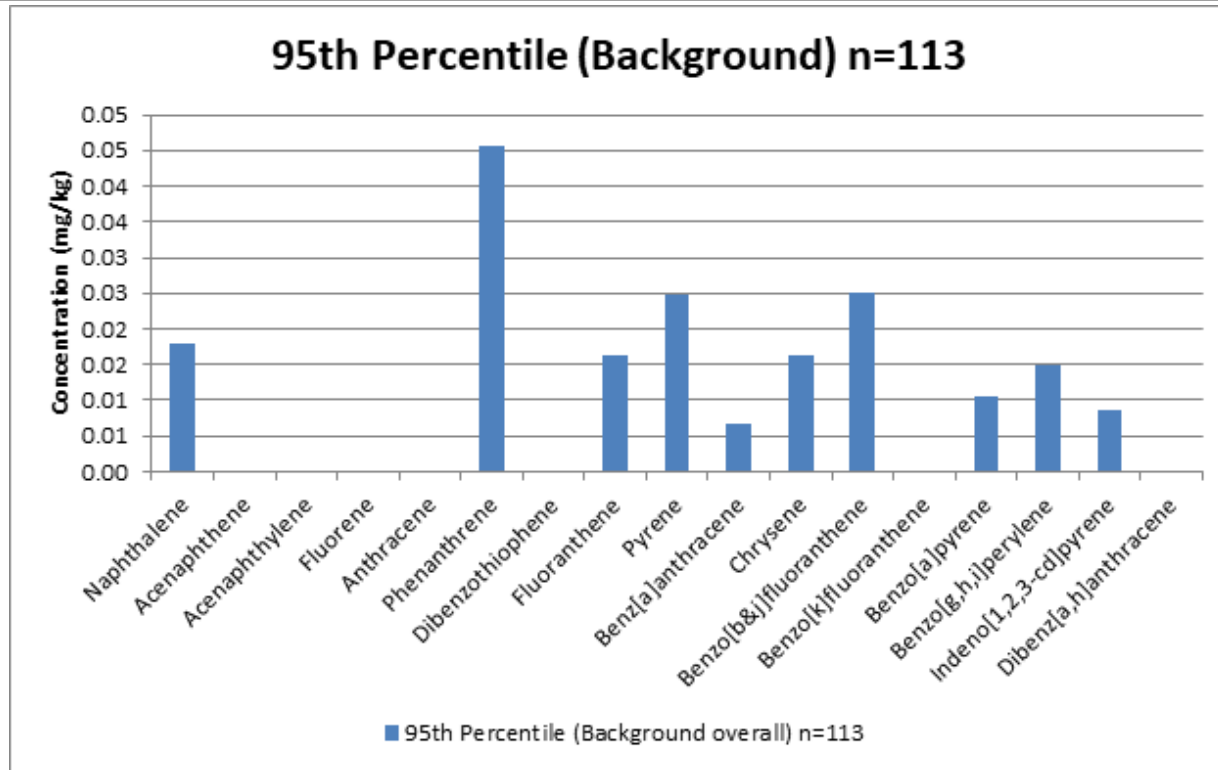
Weathering



Contaminants of Concern



Background Characterization



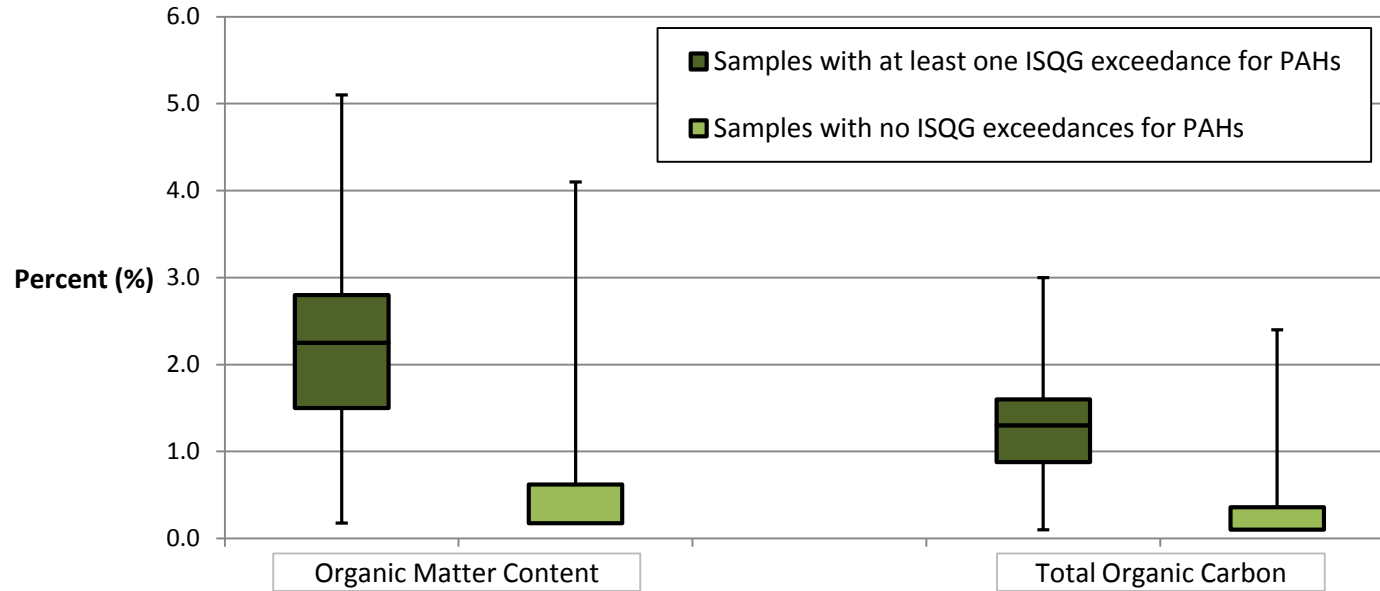
Sediment Characteristics

Sediment Type	Total # Samples Taken	% of Total Samples	# of Samples with PAH Guideline Exceedances (ISQG)	% Exceedances
Unclassified	25	2%	3	12%
Coarse	1103	85%	44	4%
Fine	175	13%	99	57%
Total	1303	100%	146	11%

- Relationship between sediment type and guideline exceedances
- More exceedances found in fine vs. coarse (i.e., sandy) sediment



Sediment Characteristics



- Relationship between organic matter and guideline exceedances
- More exceedances found in samples with higher TOC >0.5%



Hydraulic Modelling Analysis / Results

Understand the detailed hydraulics in the area immediately downstream of the spill

Prediction and verification tool

- prediction where and when do deposition conditions occur
- verification of where exceedances were found

Gain insight on mobilization and sediment transport



Hydraulic Modelling Analysis / Results

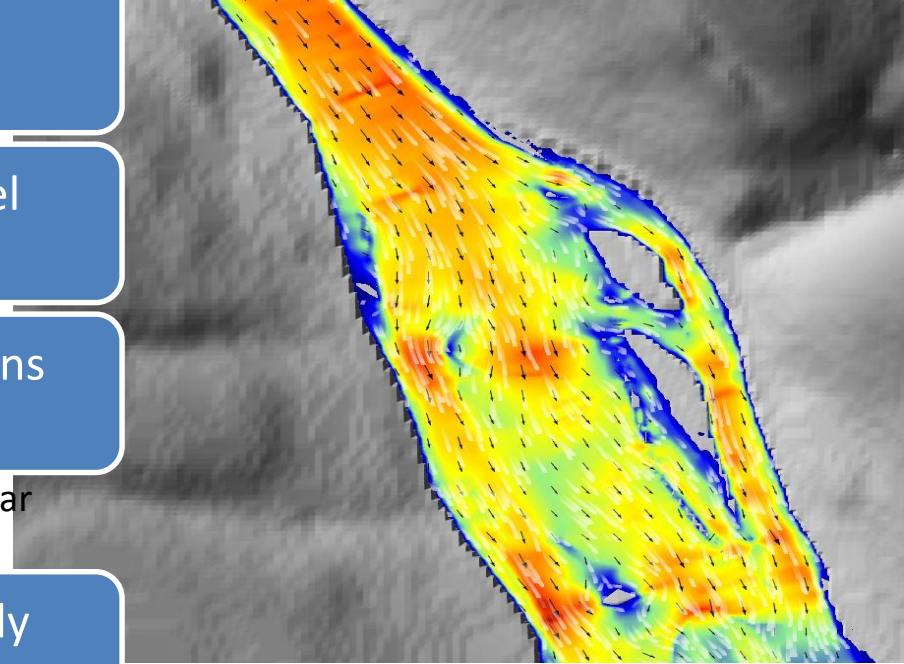
Majority of the river bed is sand

Fine sediment more likely to erode and will travel further than coarse material

Fine sediment accumulates in the channel margins and around bars and islands

- hydraulics support slow moving shallow areas with low shear stress

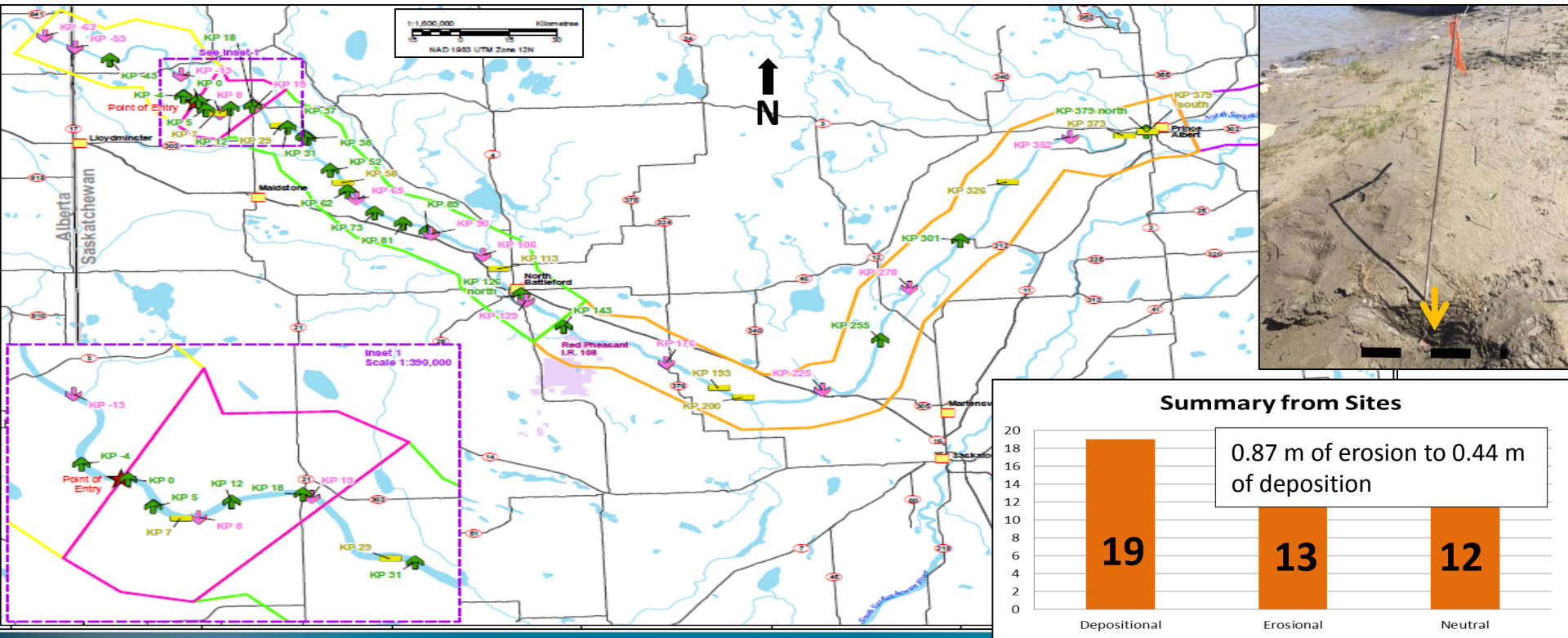
Fine sediment can travel up to 125km, more likely that particles will travel <1KM



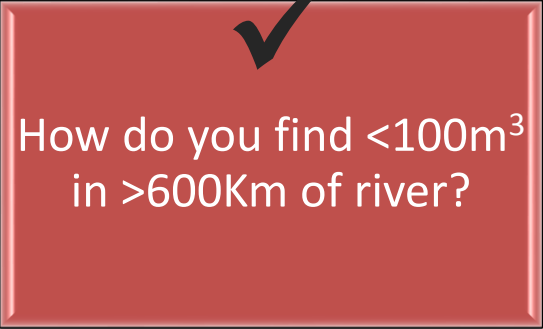


CONSIDERATIONS	IMPLICATIONS
PAHs and DBT have low volatility.	They are not a concern for breathing-zone air.
They are not water-soluble to any appreciable degree.	Analysis of NSR river water confirms that the water itself is fine.
They have an affinity for organic matter and soil particles.	Adherence to soil, sediment, woody debris.
Sediment/soil particles sink in water.	Release constituents persist chiefly in river-bottom sediment.
River turbulence causes redistribution.	High flows scour and remobilize sediment; falling water levels can leave traces of PAHs and DBT on exposed shoreline.

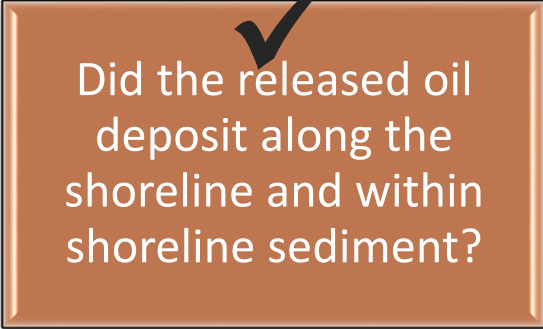
Verifying Hydraulic Model



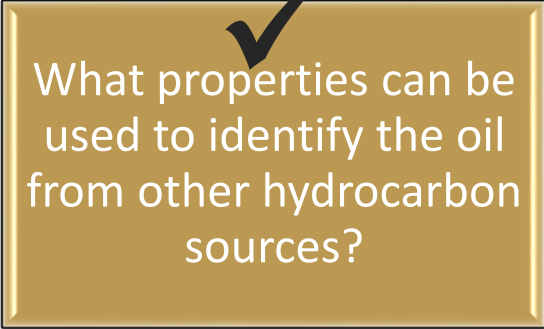
Initial Uncertainty - Revisited



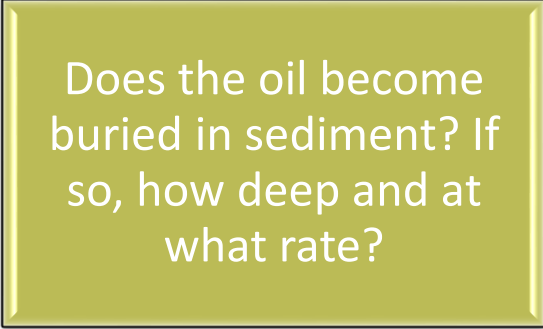
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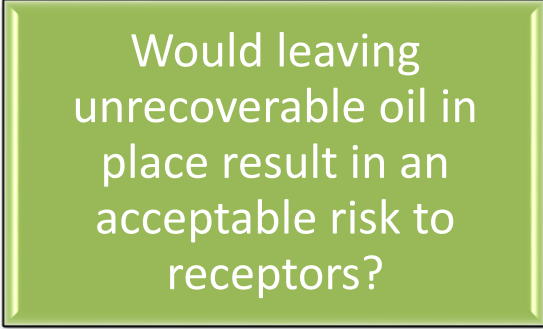
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Knowledge Gap

✓ Fate and Behaviour of Spills in Freshwater Environment

Ongoing

• Fate of unrecor in:

—sp

—v debris

Questions

