F Special Projects

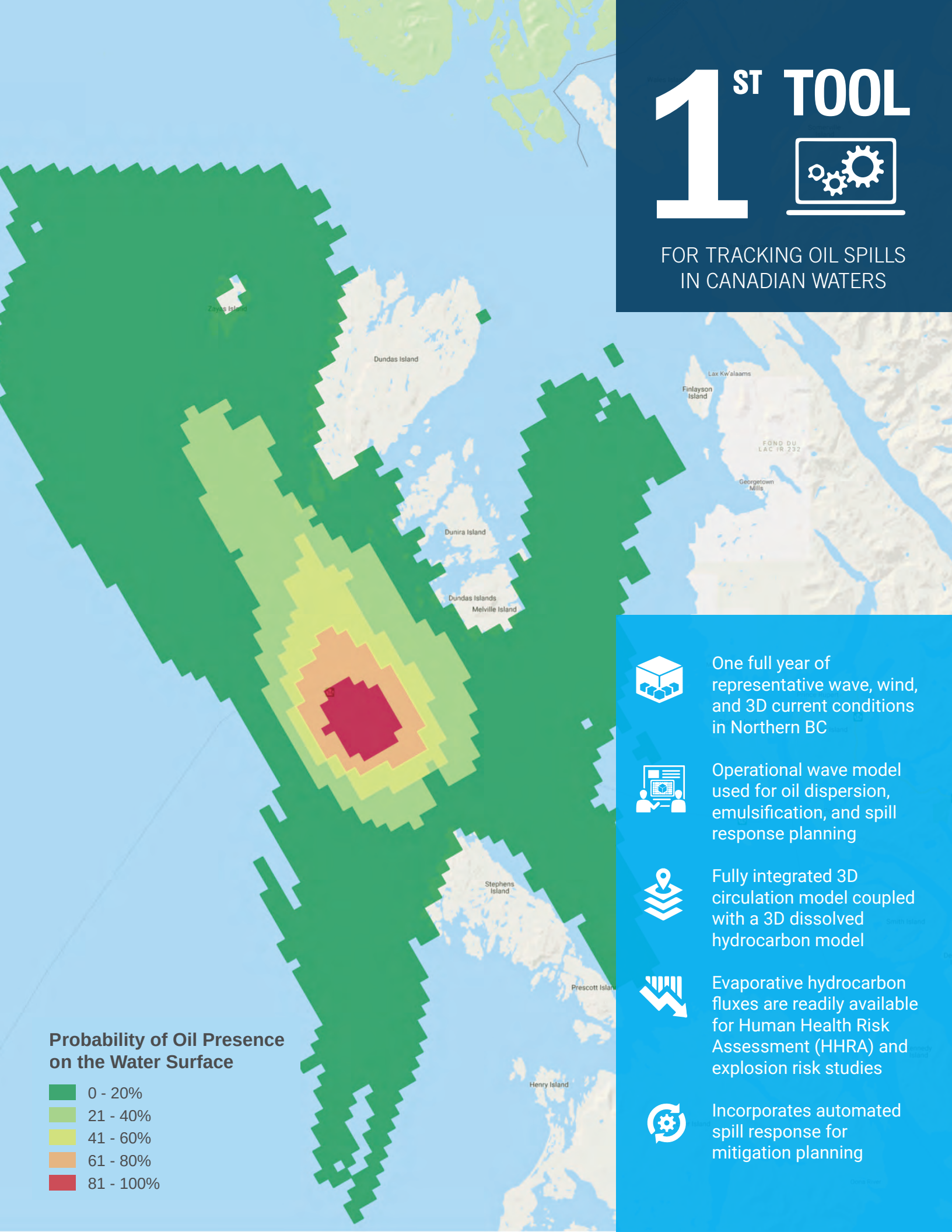
CANADIAN CONSULTING engineer

ASSOCIATION OF CONSULTING ENGINEERING COMPANIES | CANADA
ASSOCIATION DES FIRMES D'INGÉNIEURS-CONSEILS | CANADA

2020 CANADIAN CONSULTING ENGINEERING AWARDS

Oil Spill Software for Canadian Waters

TETRA TECH



1ST TOOL

FOR TRACKING OIL SPILLS IN CANADIAN WATERS

- One full year of representative wave, wind, and 3D current conditions in Northern BC
- Operational wave model used for oil dispersion, emulsification, and spill response planning
- Fully integrated 3D circulation model coupled with a 3D dissolved hydrocarbon model
- Evaporative hydrocarbon fluxes are readily available for Human Health Risk Assessment (HHRA) and explosion risk studies
- Incorporates automated spill response for mitigation planning

CANADIAN CONSULTING engineer

ASSOCIATION OF CONSULTING ENGINEERING COMPANIES | CANADA
ASSOCIATION DES FIRMES D'INGÉNIEURS-CONSEILS | CANADA

2020 CANADIAN CONSULTING ENGINEERING AWARDS

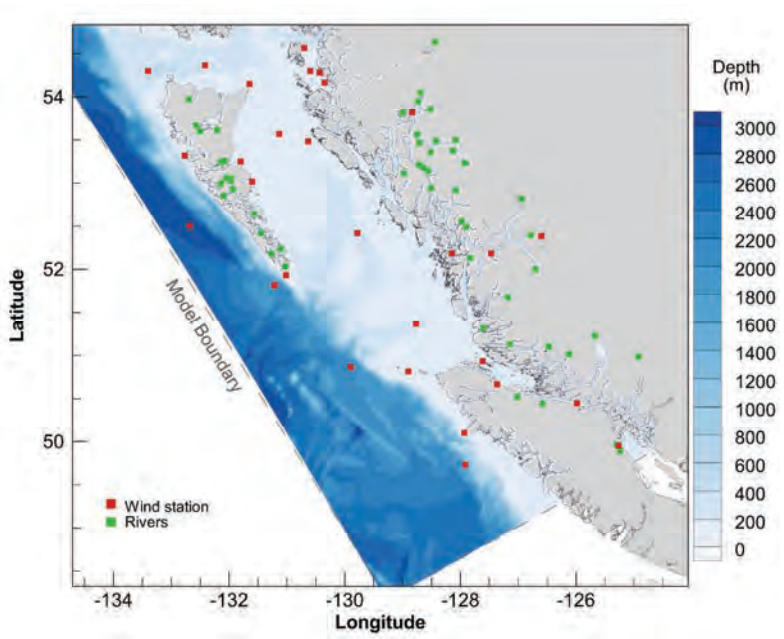
Oil Spill Software for Canadian Waters

Introduction

As part of Canada's Ocean Protection Plan, Transport Canada selected Tetra Tech and Dillon to conduct a Regional Risk Assessment of Ship-source Oil Spills for the entire Northern Shelf Bioregion of BC. Tetra Tech developed a tailored, leading-edge modelling framework, considered existing spill preparedness and local representative environmental conditions, conducted over 5,000 simulations to quantify the realistic behaviour of different oil spills, and supplied the software, SPILLCALC, to Transport Canada for use in Canadian Waters.

Intertidal areas along the coast of northern British Columbia

Source: Pacific North Coast Integrated Management Area



Key local environmental conditions captured through over 80 river gauges, buoys and meteorological stations

Innovation

As part of Canada's Ocean Protection Plan, Transport Canada selected Tetra Tech and Dillon to conduct a Regional Risk Assessment of Ship-source Oil Spills for the Northern Shelf Bioregion of BC (Vancouver Island up to Alaska).

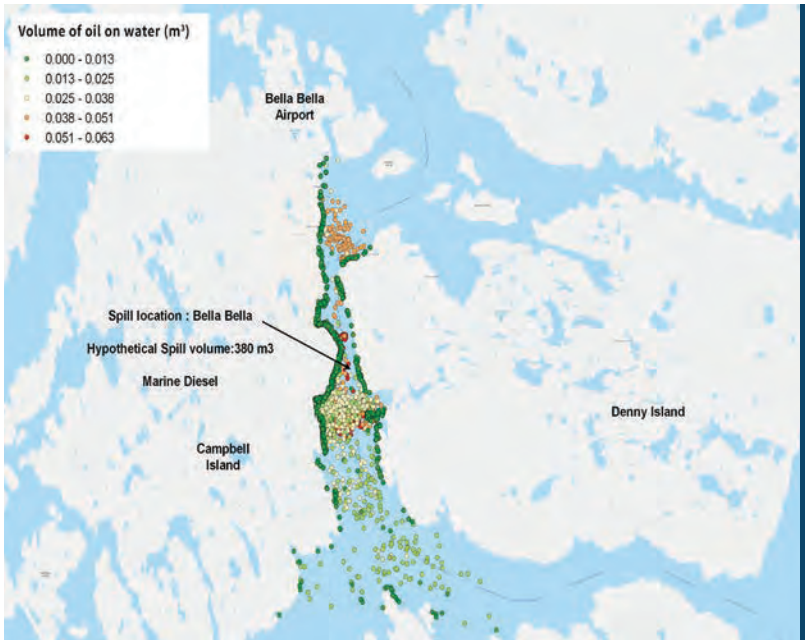
Tetra Tech completed the entire oceanographic and oil spill modelling component, using the following framework:

- 3D circulation model, H3D
- Wave model, SWAN
- Trajectory and weathering oil spill model, SPILLCALC

Since very specific local environmental conditions needed to be addressed for a particular spill and for any given area of the Northern Shelf Bioregion, the team focused on technical excellence, best practice, and innovation throughout the project, particularly with the following:

i. Most oil spill models consider a fetch-based equation to describe wave conditions, which do not represent transient phenomena. SPILLCALC incorporates an operational wave model (SWAN), providing hourly wave conditions. A year-long simulation was conducted at a nominal spatial resolution of 850 m over the entire study area: the southern tip of Haida Gwaii may experience a storm on a certain day leading to oil entrainment, but in the sheltered areas east of Queen Charlotte, a migrating oil slick may experience much calmer conditions and stay on the surface.

ii. By using data from more than 80 river gauges/buoys/meteorological stations, Tetra Tech could provide a realistic amount of freshwater to the system as well as representative wind stress on the ocean surface and oil slicks. Key local environmental conditions, such as river plumes and estuarine conditions, were properly incorporated into the model, addressing the local environmental variability that can be observed over the entire domain.



Output from SPILLCALC software: Oil trajectory representing surface oil volume (m^3) for a deterministic spill scenario at Bella Bella

iii. The innovation of combining a fully integrated 3D circulation model with the spill model allowed a realistic assessment (used for the impact study) of the distribution of dissolved hydrocarbons over the water column, based on realistic local ocean conditions.

iv. Tetra Tech provided additional technical excellence by developing an automated spill response module. Project partners, such as the Coast Guard, gathered specific spill response information (vessel travel time, arrival time, capacity, etc.) and provided it to Tetra Tech. The automated spill response module then simulated oil recovery hourly. Using this approach, recovery rates could be quantified seasonally for specific areas (e.g., the Prince Rupert area), with outcomes that were sometimes different from the expected recovery rates. For instance, due to unforeseen entrainment of oil into the water column, the oil recovery was reduced in some simulations.

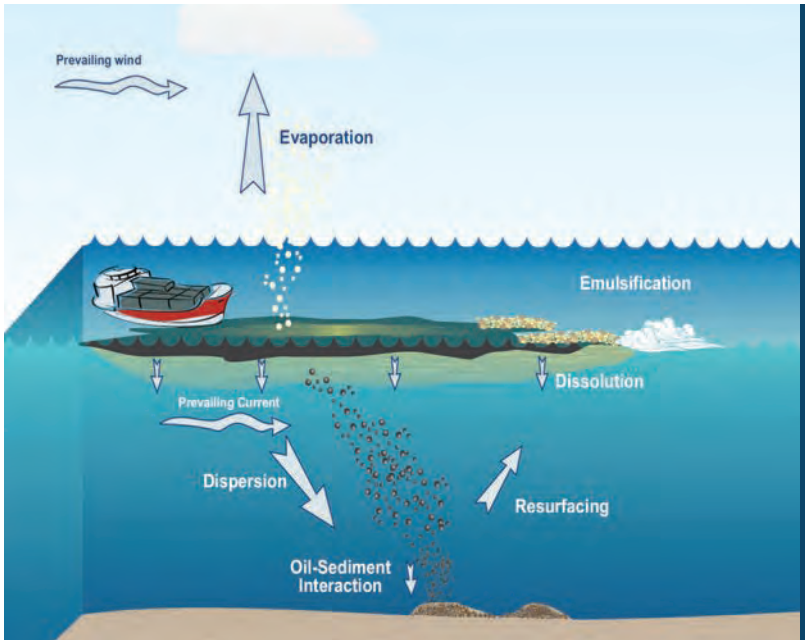
v. Finally, innovation was also brought with regards to the evaporative fluxes of hydrocarbons. While such flux is part of the mass balance, SPILLCALC, in combination with the air quality model CALPUFF, provides detailed geographical information on the quantity and composition of this evaporative hydrocarbon flux, and is readily available for future Human Health Risk Assessment and explosion risk studies. For example, the evaporated cloud will present more benzene and light hydrocarbons at the beginning of the spill, while over time this evaporative flux will be reduced and shift towards hydrocarbons with 10 carbon atoms or more.

5,000+ SPILLCALC simulations characterizing oil extent, concentration and travel time corresponding to 30 different scenarios

56 River inputs

30 Buoys and meteorological station inputs

Simulation of all oil types regularly transported in Canadian waters



Weathering process during oil spill used in SPILLCALC software

Complexity

Two main complexities needed to be overcome during this project:

i. Realistically simulating local conditions over a large domain from Vancouver Island to Alaska and linking the deep offshore (west of Haida Gwaii) to narrow coastal fjords along BC's coast (Douglas Channel)

i. Incorporating detailed spill response inputs, with a time-varying recovery rate based on vessels at-site, vessel capacity, and local wave conditions, among others

Tetra Tech addressed these two complexities using SPILLCALC—a tailored, cutting-edge numerical oil spill model. SPILLCALC has been used to great success in several high-profile projects across Canada. It can simulate different oil types (from heavy crude to diesel) while considering realistic and local environmental conditions to supply well-informed results on the trajectory and weathering of oil spills.

Using data from over 80 river gauges/buoys/meteorological stations in the model combined with a high-resolution mesh over the entire domain (about 850 m), Tetra Tech realistically simulated key natural processes such as river plumes, wind forcing, and wave conditions, capturing spatially and temporally varying storms and calm periods.

Additionally, SPILLCALC's mitigation programming was fine tuned to include a variety of additional details in the simulations (e.g., current and wave thresholds of booms, time to deploy different assets, considerations on limitations of primary storage of recovery vessels, and the time required to discharge to secondary storages). This enhanced automated spill response module strengthened the study because it identified gaps in current mitigation strategies and supported the assessment of their efficiency.

Prince Rupert Stakeholder Engagement in January 2019

Social and Economic Benefits

Through this study, we obtained a better understanding of potential spill impacts by characterizing areas most at risk. We assessed spill response preparedness, so mitigation efficiency could be better quantified and potential gaps in existing response systems could be highlighted. This knowledge has the economic benefit of reducing the clean-up cost of oil spills and helping with mitigating damages to areas tied to industry.

The study area contains many coastal communities and ports, and several key industries are tied to these townships, for example, commercial fishing. Four of the top ten fishing areas along the coast of BC are found in the study area, including a variety of species (e.g., halibut, salmon, herring, crab, and smelt). In addition, the aquaculture industry in BC produces more than half of total aquaculture in Canada. Tourism is a strong economic driver in this area, including activities from fishing lodges to whale watching to cruise ships.

For this project, we needed to consult with local communities, through stakeholder engagements and discussions. The study area is home to several groups of Indigenous peoples, who use the environment in culturally meaningful ways, such as sites for ceremonies and burials or for sustenance harvesting.

With SPILLCALC now licensed to Transport Canada, additional studies and additional stakeholder engagement will be undertaken by Transport Canada in Canadian Waters, starting along the BC coast.

Tetra Tech supplied SPILLCALC to Transport Canada for in-house use including stakeholder engagement.

Waves approaching the coastal landscape in Haida Gwaii, British Columbia, Canada

Environmental Benefits

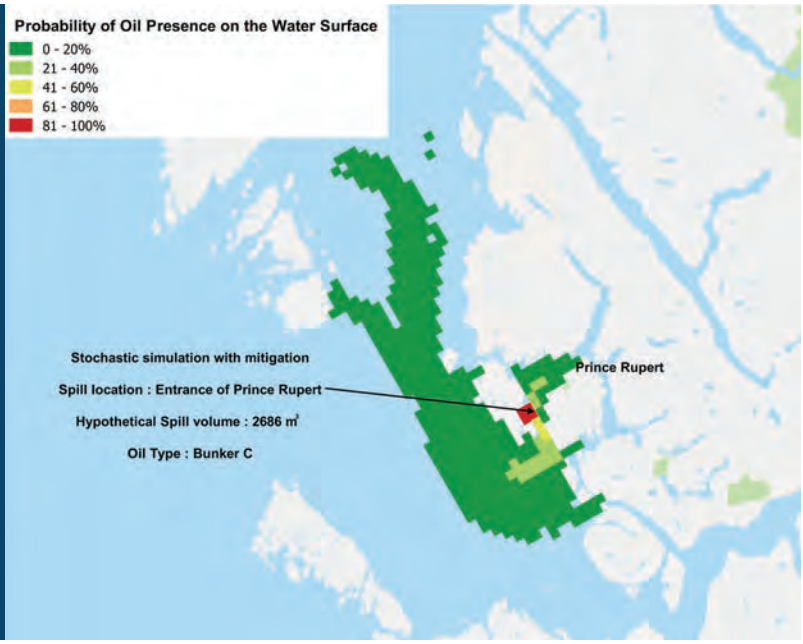
The BC coast is one of the most biologically diverse areas in Canada, containing several migratory routes for birds, fish, and other species on land, air, and water. The Northern Shelf Bioregion of BC also contains the Great Bear Rainforest (home to the Kermode Bear and coastal wolves), among numerous other biologically sensitive sites.

This area also includes about 28,000 km of shoreline. Approximately 25% of this shoreline consists of rocky cliff, 20% is rock with gravel beaches, and 20% rock, sand, and gravel beaches. The seafloor is over 100,000 km^2 and predominantly a mixture of sand, mud, or hard rock. A surface oil slick with a thickness of 1 µm of oil is all that is needed to submit sub-lethal effects to marine mammals, birds, and reptiles.

Although the risk is very low, transporting dangerous goods such as crude oil within these Canadian Waters exposes these environments to a risk. The leading-edge oil spill model SPILLCALC would allow decision-makers to consider, assess, and re-evaluate existing and future spill preparedness and response activities, improving impact mitigation when a spill occurs.

For example, SPILLCALC provided a detailed mapping of oiled shoreline based on the season, as well as the minimum time for oil to reach a shoreline segment. This important result would allow first responders to understand which shoreline is most at risk depending on the season, and which shoreline (and associated wildlife and environment) can be protected (deflective booms) in a hypothetical spill.

Winter season probability of oil presence during a spill



Meeting Client's Needs

The increased transportation of dangerous goods (such as crude oil) presents inherent risks. Through the Regional Risk Assessment methodology, Transport Canada aimed to identify risks associated with ship-source oil spills in Northern BC, engaging stakeholders and using the developed modelling tool in Canadian Waters after the study was complete.

To achieve this goal, Tetra Tech accomplished the following:

i. Simulated the movement of a wide range of oil spills using a tailored, cutting-edge numerical modelling structure that considers existing and future spill preparedness and response activities (automated spill response module), and local geography and environmental conditions (using numerous river gauges, buoys, and coastal meteorological stations). This framework responded to one main goal of this project: the realistic simulation of oil spills in the study area.

ii. Identified and analyzed the impact of spills to existing biological sensitivities, physical environments, socio-economic factors, and valued Indigenous and local resources. The fully integrated 3D circulation model coupled with the oil spill model allowed for a full assessment of the concentration of dissolved hydrocarbons through the water column, supporting the assessment of the impact of a spill on existing valued ecological components.

iii. Conducted over 5,000 simulations to quantify the fate and behaviour of an oil spill in the study area to cover the wide range of possible environmental conditions.

iv. Provided the software to Transport Canada for present and future studies in Canadian Waters.

v. Engaged with First Nations, municipalities, first responders, pilots, and Coast Guard stakeholders, along with Transport Canada and Dillon.

The BC coast is one of the most biologically diverse areas in Canada.

The leading-edge oil spill model SPILLCALC allows decision-makers to estimate risks in a specific area and consider, assess, and re-evaluate existing and future spill preparedness and response activities, improving impact mitigation when a spill occurs.

TETRA TECH