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**Canadian Science Advisory Secretariat (CSAS)**

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**National Capital Region**

# Proceedings of the National Peer Review on the Status Report on the Knowledge of the Fate and Behaviour of Diluted Bitumen in the Aquatic Ecosystems

**April 19 and 20, 2017**
**Ottawa, ON**

**Chairperson: Gilles Olivier**
**Editor: Shannon Stuyt**

Fisheries and Oceans Canada
200 Kent Street
Ottawa, ON K1A 0E6

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Canada

**Foreword**

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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*MPO 2018. Compte rendu de l'examen national par les pairs du rapport de situation sur la connaissance du devenir et du comportement du bitume dilué dans les écosystèmes aquatique; 19 et 20 avril 2017. Secr. can. de consult. sci. du MPO, Compte rendu 2018/012.*

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## SUMMARY

These proceedings summarize the relevant presentations and discussions of the national science advisory meeting held on April 19-20, 2017 at the Central BizLounge in Ottawa, ON. The title of the meeting was “Status Report on the Knowledge of the Fate and Behaviour of Diluted Bitumen in the Aquatic Ecosystems”. The overarching objective of this Science Response Process was to summarize information that has been obtained to date about the fate, behaviour, biological effects, and mitigation techniques for diluted bitumen in order to inform future research work; support current and future emergency response planning/preparedness and operations; as well as to inform the public about recent findings.

The conclusions and advice resulting from this meeting will be provided in the form of a Science Response that will be made publicly available on the CSAS website. Meeting participants included experts from various sectors and regions of Fisheries and Oceans Canada (DFO), Environment and Climate Change Canada (ECCC), Natural Resources Canada (NRCan), as well as external participants from government agencies from outside Canada, industry and response organizations. Presentations formed the basis for the discussions.

Effective spill response depends on a good scientific understanding of the fate and behaviour of a specific product into the environment (e.g., changes in physical properties and chemical composition that influences its environmental persistence and potential biological effects). As part of the Government of Canada’s strategy to implement a world class prevention, preparedness and response regime, investments into DFO, ECCC, and NRCan have been made to conduct research on diluted bitumen fate, behaviour and biological effects when spilled into aquatic environments under climatic conditions relevant to a Canadian context.

These research investments are ongoing over a period of years; however, in advance of the publication of final findings, it is important that the aforementioned government agencies share and exchange new information; validate their work against industry-led initiatives; and work to make interim knowledge available in support of a robust and leading-edge emergency response regime.

## INTRODUCTION

Gilles Olivier (chair) opened the meeting by welcoming the participants, providing a brief overview of the CSAS peer-review process, and requesting that everyone consider, throughout the course of the meeting, how science advice can be extracted from the discussions of the meeting. The Terms of Reference (Appendix 2) indicate that the purpose of the meeting was to summarize what has been learnt about the fate, behaviour, biological effects, and mitigation techniques for diluted bitumen in order to inform future research work; support current and future emergency response preparedness, planning and operations; as well as to inform the public about recent findings. The Chair reviewed the agenda (Appendix 3) and discussed deadlines for the expected publications.

## DAY 1

### PRESENTATION: WHAT IS DILUTED BITUMEN AND HOW DOES IT'S COMPOSITION VARY?

Presenter: Bill Lywood, Crude Quality Inc.

Crude Quality Inc. has been involved in the characterization and quality evaluations for crude and bitumen products for over 20 years. Mr. Lywood first explained that Industry-wide, there is a lack of clear terminology associated with the term "diluted bitumen" which can be a challenge when identifying a product, trying to compare products, and identifying the product source. Fundamentally, bitumen is defined as petroleum crude that is immobile at formation temperature and pressure (physical boundaries), not specific or rigorous chemistry. Bitumen requires thermal, chemical, hydraulic or mechanical extraction; typically has a higher density; has a higher boiling point distribution; and contains a higher concentration of polycyclic aromatic hydrocarbons (PAHs) compared to conventional crudes. Diluted bitumen is a blend of bitumen and any lower density, lower viscosity hydrocarbon diluent. The composition and proportion of bitumen and diluent varies significantly and can be influenced by: geography, seasonality, availability of diluent, source of diluent, customer or infrastructure requirements, or a number of other factors. The differences and proportions of the diluent has an impact on the chemical composition of the dilbit, which then influences the fate and behaviour of the product when spilled into the aquatic environment. He presented a characterization of what is being produced and delivered within Canada, as well as an overview of the distribution network and how the product differs depending on where it is within the network. He also provided his insights as to what should be further studied, some strategies to enhance the comparability of studies and highlighted some available information sources that could be better utilized and leveraged by the response community in the future.

### PRESENTATION: CANADIAN COAST GUARD'S CURRENT RESPONSE PLANNING, ACTIONS, COUNTERMEASURES AND EFFECTIVENESS

Presenter: Larry Trigatti, Canadian Coast Guard (CCG) Central and Arctic Region

The CCG has an existing, response planning, preparedness and response regime in place to address petroleum-based spills into the aquatic environment. He provided an overview of the evolution of that response regime and the distinction between planning/preparedness and response activities, as well as the opportunities for science to support the existing regime. He discussed the general recovery strategies being employed by CCG, which consist of: mechanical containment, surface recovery, shoreline recovery, water column or sub-surface recovery and water-bed recovery. He highlighted the information that is most relevant to inform

tactical and operational decisions (the fate and behavior of the product, the potential impacts of the spilled product and the management strategies for the recovered product). He noted that environmental conditions play a critical role in determining the fate, behaviour, recovery options and possibility for consideration of response or mitigation measures. He also provided his insights about the priority knowledge gaps for CCG, the mechanisms within the existing regime to access existing information and specialists and noted potential strategies for leveraging incident information and opportunistic research.

## PRESENTATION: CURRENT RESPONSE ACTIONS FOR DILBIT AND LESSONS LEARNED

Presenter: Chantal Guénette, Eastern Canada Response Corporation Ltd. (ECRC) - Société d'Intervention Maritime de l'Est du Canada (SIMEC)

ECRC-SIMEC, one of Canada's four Transport Canada certified Response Organizations, responds to roughly 15 to 20 spills per year that enter the marine or aqueous environment. ECRC-SIMEC's vast Geographic Area of Response has meant responding to a wide range of spills under varying geographic and environmental conditions and to a broad range of hydrocarbon products including conventional and synthetic crudes, refined fuels, heavy fuel oils, and asphalt. Planning considerations for responding to sinking oils include determining the potential for the product to sink given the spill conditions, selecting appropriate detection techniques, determining feasible containment and recovery options and developing effective waste stream management. Products that are heated for transportation or with pour points close to that of the water temperature present specific response challenges related to their fate and behaviour when spilled and may limit the use of conventional spill response equipment.

Response techniques specific to dealing with sinking oils or sub-surface oils have been developed, often involving innovative use of existing technologies. Sunken oil can be located using visual observations (divers, view box, snorkel), underwater video, photo-bathymetry techniques or physical techniques such as towing bottom trawls, weighted sorbents or cages containing sorbent material. Containment of sub-surface oils can be achieved using in-water and submerged dykes, trenches or permeable barriers, depending on the location of the oil in the water column or bottom. Potential recovery methods include the use of pumps, dredges, mechanical earth-moving equipment, nets and weed harvesters. As many of these detection, containment and recovery techniques require working underwater, usually using commercial divers, specific safety considerations must be made.

Lessons learned from responding to spills of submerged oil include the need to be prepared for unexpected and changing oil behaviour and that many currently available oil spill response strategies can be effective if adapted to the conditions at hand. Improvisation is key to a successful response.

## PRESENTATION: DILBIT BEHAVIOUR AND INFLUENTIAL FACTORS OBSERVED FROM KALAMAZOO

Presenter: Faith Fitzpatrick, United States Geological Survey

Dr. Fitzpatrick presented an overview of the fate, behaviour and influential factors observed from the Kalamazoo River spill in July 2010. She summarized the incident, the type of diluted bitumen product spilled, the site-specific conditions and the response strategies and tactics used. She then discussed the fate and behaviour observed in the river from 2011 to 2014 and the multiple lines of evidence required for submerged oil assessment and evaluation of recovery, containment and cleanup endpoints. She presented a summary of the oil-particle interactions observed in the field, as well as a discussion about modelled simulations for submerged oil and batch-scale tests designed to better understand what had been observed

during the incident. She summarized how the results of recent research have translated into a new oil-particle aggregate (OPA) algorithm, integrated into the US Army Corps of Engineers Sediment Transport Model. She also summarized other ongoing studies to further examine the formation of OPAs in riverine sediments and highlighted some of the outstanding research questions for which additional work is required.

## PRESENTATION: CONTAINMENT AND RECOVERY OF DILBIT IN MARINE AND FRESH WATER

Presenter: Stanislav Stoyanov, NRCan

Dr. Stoyanov presented an overview of project FF-OS-026 Containment and Recovery of Heavy Oil Spills to the Meeting participants. This project investigates the fate of diluted bitumen products spilled in marine and fresh water. It also explores new approaches for spill containment and recovery. The fate of diluted bitumen spilled in water with sediment is investigated using analytical chemistry and surface adhesion methods. Computational modeling of the distribution of oil components in water and at interfaces is also performed. The modeling is intended to help understand the mechanisms of adhesion and emulsification of diluted bitumen. The experimental findings on the fate of spilled diluted bitumen are correlated with the modeling results. These correlations could help understand better the distinct spill behavior of diluted bitumen compared to conventional oils. Containment and recovery by solidification using small-molecule and polymeric gelators is being explored. Synergistic combinations of these two types of gelators will also be tested. The intent is to design fast-acting, green, phase-selective switchable, efficient and effective solidifiers. The project will generate knowledge for the extended federal policy development effort and the development of world-class spill response. This knowledge is important for the review and approval of diluted bitumen pipelines and loading ports.

## PRESENTATION: ENVIRONMENT AND CLIMATE CHANGE CANADA RESEARCH SUMMARY

Presenter: Patrick Lambert and Ben Fieldhouse, Environment and Climate Change Canada (ECCC)

ECCC's Environmental Science and Technology Laboratories have been undertaking scientific research and providing advice on petroleum product characterization, fate and behaviour (including diluted bitumen); alternative response measures; operational and tactical response strategies and environmental influences for decades. They presented the results of their effectiveness tests for chemical countermeasures, including: dispersants, surface washing agents, solidifiers and herders; as well as sorbents. Their findings suggest that the effectiveness of countermeasures are dependent on the product, the energy in the environment and temperature and highlighted that the appropriateness of a specific measure is based on the specific conditions at the time of an incident.

They also presented the preliminary results of recent studies on the Pacific coast that examined baseline, shoreline petroleum hydrocarbon or pesticide concentrations, as well as characterizing diluted bitumen and sediment interactions. The documents that will be produced from this program will provide current baseline scientific information to support decision-makers and preparedness activities to reduce the environmental consequence of an oil spill on shorelines.

## PRESENTATION: INDUSTRY-FUNDED DILBIT RESEARCH RESULTS

Presenter: David Cooper, SL Ross

Mr. Cooper presented an overview of the laboratory and meso-scales tests currently being designed and initiated by industry. These include studies to: test oil properties and changes

across a range of environmental conditions; spill behaviour (emulsion, submergence, and interaction with shorelines/sediments); differences between bitumen blends and the significance for spill behaviour and standard protocols for testing crude oil types for 14 oil types.

## PRESENTATION: WAVE TANK AND IN-SITU STUDIES OF THE FATE AND BEHAVIOUR OF DILUTED BITUMEN

Presenter: Alice Ortmann, Centre for Offshore Oil and Gas Energy Research (COOGER)

Dr. Ortmann presented a summary from recent research. Over the last several years, the COOGER lab has carried out a series of experiments to understand the fate and behaviour of diluted bitumen. Research has focused mainly on Access Western Blend (AWB) and Cold Lake Blend (CLB) dilbit products in seawater ranging from 7-22$^{o}$C and salinity of 25 to 30. Weathering experiments under natural conditions have quantified increases in viscosity and density as light ends are lost through evaporation, dissolution and photo-oxidation. Some products may increase in density enough to sink in freshwater, but are not likely to sink in marine waters. However, interactions with sediments may result in oil mineral aggregates (OMAs) which could sink. Dispersants may disrupt OMA formation, inhibiting sinking. Wave tank experiments found that the application of dispersants to diluted bitumen may be an effective spill countermeasure option, but there is a short window of opportunity due to rapid increases in viscosity. Biodegradation may contribute to loss of oil following a diluted bitumen spill, with Bacteria capable of degrading alkanes and some PAHs able to respond with and without the presence of dispersants. These experiments together indicate that in marine environments, diluted bitumen products are likely to remain on the surface and undergo rapid weathering, with loss of the diluent. The remaining heavier materials will not be amenable to natural or chemical dispersion and is not likely to undergo biodegradation.

## PRESENTATION: SPILL TESTS AND ANALYSES OF CRUDE OIL BEHAVIOUR IN FRESH AND SALT WATER CONDITIONS

Presenter: Heather Dettman, Natural Resources Canada (NRCan)

CanmetENERGY Devon is a leading research and technology organization in the field of clean energy and has been undertaking research and development related to oil sands production and refining, in collaboration with industry, for over 25 years. Dr. Dettman summarized that diluted bitumen is oil that consists of oil produced in northeastern Alberta blended with a diluent to meet pipeline density and viscosity specifications for transportation. Bitumen composition varies by production region, oil cleanup method, and pretreatment method. Diluent composition varies by product where light-oil condensate and synthetic crude oil are used to make dilbit and synbit, respectively for regulated pipelines out of Alberta; natural gas condensate and refinery-produced solvents are used in gathering lines within Alberta. She presented a summary of the recent research completed and underway by CanmetENERGY, which includes both laboratory and open tank tests intended to enable the comparative evaluation of diluted bitumen behaviours influenced by: product type, salinity, sediment, temperatures (both air and water) and time. She highlighted some of the design and analytical limitations associated with laboratory and meso-scale tests and provided her insights about the priority knowledge gaps to help better inform the response community.

## DAY 2

## DISCUSSION: WHAT IS DILUTED BITUMEN AND ARE THE PRODUCTS BEING TESTED A FAIR REPRESENTATION

An in-depth discussion was had regarding the definition and characterization of diluted bitumen, specifically within the context of this Science Response Process (SRP). There was an acknowledgement that the specific blends and compositions of diluted bitumen are influenced by a variety of factors, including: producer; geographic source for the bitumen; source, product and proportion of diluent; temperature; intended markets; as well as location within transmission lines (e.g., gathering lines versus regulated transmission lines).

There was reference back to the presentation from B. Lywood (2017) given on Day 1. The figure presented in the Science Response, depicting the general creation pathways for diluted bitumen from the Northern Regions of Alberta and Saskatchewan was used as a communication tool to ensure there was a common understanding amongst meeting participants.

In the end, meeting participants agreed that bitumen, for the purposes of this SRP, should be defined as oil that doesn't flow at reservoir conditions. In Canada, bitumen is oil that is extracted from the northern region of Alberta and Saskatchewan, and then blended with diluent to make diluted bitumen that meets pipeline density and viscosity specifications for transportation. Inland, bitumen and its diluted derivatives are transported by pipelines, trains and trucks. In most cases, it flows from gathering lines near the extraction sources (northern region of Alberta and Saskatchewan) towards regulated transmission lines. For the purposes of this SRP, only diluted bitumen (as presented in Figure 1 of the Science Response) was considered and the examination of synbits and synthetics was considered external to this discussion but conventional crude behaviour was included for reference.

Research completed by Fisheries and Oceans Canada (DFO), ECCC and NRCan has only focused on the standardized product that would be found in the regulated transmission lines. While the products tested cover the range of most commonly transported products in Canada, the scope of products could be further narrowed in order to facilitate comparative analysis between studies. Access Western Blend (AWB) and Cold Lake Blend (CL) have been used in a number of studies conducted to date. In general, these two diluted bitumen blends reasonably represent the "normal" chemical and physical characteristics of diluted bitumen used and transported in Canada. It is recommended that AWB and CL continue to be the primarily tested diluted bitumen blends. Should an expansion of the researched diluted bitumen blends be considered, based on the volume of product shipped and the compositional differences that result in a range of physical and chemical properties for diluted bitumen, it is suggested that the following additional blends be examined (by order of priority): Borealis Heavy Blend (BHB), Seal Heavy (SH) and Wabasca Heavy (WH).

## DISCUSSION: WHAT DO WE KNOW ABOUT DILUTED BITUMEN, WHAT ARE THE KNOWLEDGE GAPS, WHAT ARE THE ANALYTICAL GAPS?

It was decided amongst meeting participants that the most effective means of providing an update on the current status of knowledge related to diluted bitumen would be to compile summary tables: one for observations from real-world incidents and one for observations from meso-scale laboratory studies.

Subsequently, two breakout groups were formed to consolidate the information presented, discussed and recently observed. The first group populated a table summarizing information from recent spill incidents into the aquatic environment involving similar or representative oils to diluted bitumen. The table (Table 1 presented in the Science Response) provides a

consolidation of information about: incidents, products, volumes, fate and behaviour, key conditions that may have influenced the fate and behaviour, as well as clean-up methods used. The second group populated a table summarizing preliminary results from recent meso-scale lab experiments. The table (Table 2 presented in the Science Response) provides a consolidation of information about the study: methodology, parameters, products tested and overall results or outcomes. This table also includes an initial characterization of the potential implications the research findings could have on operational response options.

Unfortunately, it was acknowledged by meeting participants that a more in-depth analysis of the information was not feasible within the time allotted for this process; however, such an exercise would be beneficial in the future. It was agreed that a comprehensive examination of this information, including a comparative analysis between the fates and behaviours observed during real world events (summarized in Table 1 presented in the Science Response) and in meso-scale experiments (summarized in Table 2 presented in the Science Response) is warranted in order to better understand the variability in environmental factors that may have influenced the observed behaviours; validate lab results; and identify priority research areas for future work.

The following is a summary of the knowledge gaps and operational support tools that were noted by participants during the SRP. The majority of the identified knowledge gaps relate to environmental settings and characteristics that affect the fate and behaviour of the diluted bitumen blend. The lists are not ranked by priority and should not be considered exhaustive; instead, they highlight opportunities for future work. It was also acknowledged by all participants that additional gaps are likely to be identified following the comparative analysis of Tables 1 and 2 presented in the Science Response.

Additional research is required to better understand:

- The fate and behaviour of diluted bitumen under low temperature and ice conditions;
- Physical, chemical and environmental processes that most influence diluted bitumen fate and behaviour;
- Natural weathering processes;
- Impacts of degradation and weathering on toxicity;
- The vulnerability of species to diluted bitumen blends;
- Methods to detect, track and monitor product movement when spilled;
- Processes for the formation and breakup of oil-mineral aggregates in the environment; and
- Further analysis of hydrocarbon composition present in fresh and weathered diluted bitumen blends.

Operational tools required to enable the integration of scientific research into emergency response planning, preparation and operations:

- Countermeasure decision tree that considers the most influential factors for diluted bitumen fate and behaviour;
- Support tools for the net environmental benefit analysis (including the evaluation of natural attenuation as a shoreline clean-up strategy);
- More robust and comprehensive predictive models (including improvements to mass balance models);

- Summaries of the characteristics of the AWB and CL diluted bitumen blends; and
- Simplified, comparative categorizations of known diluted bitumen blends.

## DISCUSSION: EFFECTIVENESS OF RESPONSE OPTIONS, RISKS TO THE ENVIRONMENT, INTEGRATING KNOWLEDGE INTO RESPONSE AND OPPORTUNITY TO BENCHMARK LAB STUDIES

Prompt response actions are of upmost importance for any spill. It was agreed that conventional spill response countermeasures are as effective for diluted bitumen as they are for conventional oil products because its fate and behaviour remains within the existing range for conventional petroleum products.

Based on the behaviour observed during recent incidents (Table 1 presented in the Science Response) and laboratory experiments, the window-of-opportunity for surface-focused countermeasures can range from less than 24 hours to weeks, depending on specific products and site-specific environmental conditions. Response options will always be site-specific, as they are for any conventional oil spill and performance will vary based on the current state of the product, which will change over the course of a spill.

It was generally agreed that although new emerging technologies may improve efficiencies, no new response countermeasures are specifically required to address diluted bitumen because its fate and behaviour is within the range observed for other conventional oils, for which there exist response countermeasures. A greater understanding of fate and behaviour for diluted bitumen will help to better inform the tactical strategies for the deployment of specific countermeasures.

## SCIENCE ADVISORY REPORT AND MEETING CONCLUSION

Finally, all participants and authors outlined the summary bullets for the Science Response. As the chair explained, the Science Response should convey the essence of the meeting and needed to include sources of uncertainty, results and conclusions of the CSAS review, and additional advice to management.

Ultimately, Science Response Participants reached consensus on the summary points that captured the essence of the meeting and the fundamental responses to the nine (9) questions posed within the Terms of Reference.

# APPENDICES

## APPENDIX 1: LIST OF MEETING PARTICIPANTS AND REVIEWERS

*Table 1: List of Meeting Participants and Reviewers*

| Name | Affiliation |
|---|---|
| Gilles Olivier | Chair, DFO Science, National Headquarters |
| Shannon Stuyt | Lead Editor, DFO Science, National Headquarters |
| Sophie Foster | Editor, DFO Science, National Headquarters |
| Larry Trigatti | Reviewer, DFO Canadian Coast Guard, Central and Arctic Region |
| Kenneth Lee | Reviewer, DFO Science, National Headquarters |
| Brian Robinson | Reviewer, DFO Science, Maritimes Region |
| Alice Ortmann | Reviewer, DFO Science, Maritimes Region |
| Mike Stoneman | Reviewer, DFO Science, National Headquarters |
| Cecilia Lougheed | Reviewer, DFO Science, National Headquarters |
| Joel Chassé | Reviewer, DFO Science, Quebec Region |
| Sophie Johaneesen | Reviewer, DFO Science, Pacific Region |
| Carl Brown | Reviewer, ECCC Science and Technology Branch, Ottawa |
| Patrick Lambert | Reviewer, ECCC Science and Technology Branch, Ottawa |
| Ben Fieldhouse | Reviewer, ECCC Science and Technology Branch, Ottawa |
| Vlad Blinov | Reviewer, ECCC Science and Technology Branch, Ottawa |
| Bruce Hollebone | Reviewer, ECCC Science and Technology Branch, Ottawa |
| James Porter | Reviewer, ECCC Environmental Protection Branch, Gatineau |
| Josée Lamoureux | Reviewer, TC Marine Safety & Security, Ottawa |
| Tagenine Alladin | Reviewer, TC Transport Dangerous Goods, Ottawa |
| Julie Laurendeau | Reviewer, TC Transport Dangerous Goods, Ottawa |
| Heather Dettman | Reviewer, NRCan CanmetENERGY, Devon |
| Stanislav Stoyanov | Reviewer, NRCan CanmetENERGY, Devon |
| Nafis Karim | Reviewer, NRCan CanmetENERGY, Devon |
| Ed Owens | Reviewer, Owens Coastal Consultants, Washington, USA |
| Greg Challenger | Reviewer, Polaris Applied Sciences, Washington, USA |
| Ken Trudel | Reviewer, SL Ross Environmental Research, Ottawa |
| David Cooper | Reviewer, SL Ross Environmental Research, Ottawa |
| Chantal Guénette | Reviewer, Eastern Canada Response Corporation Ltd., Ottawa |
| Bill Lywood | Reviewer, Crude Quality Inc., Edmonton |
| Faith Fitzpatrick | Reviewer, US Geological Survey, Wisconsin, USA |
| Michel Boufadel | Reviewer, New Jersey Institute of Technology, New Jersey, USA |

## APPENDIX 2: MEETING TERMS OF REFERENCE

## STATUS REPORT ON THE KNOWLEDGE OF THE FATE AND BEHAVIOUR OF DILUTED BITUMEN IN THE AQUATIC ECOSYSTEMS

**National Peer Review – National Capital Region**

**19-20 April 2017**

**Ottawa, ON**

Chairperson: Gilles Olivier

### Context

Effective spill response depends on good scientific understanding of the fate and behaviour of the petroleum product in the environment (e.g., movement and changes in physical properties and chemical composition of the oil that influence its environmental persistence and potential biological effects). Bitumen is a heavy crude oil being produced from Alberta oil sands that is diluted with lighter oil to enable its transport by pipeline. Information about the fate, behaviour, biological effects, and mitigation techniques for diluted bitumen is crucial to effective regulatory decision making, and for emergency planning and response.

As part of the Marine Safety System, investments have been made within Fisheries and Oceans Canada, Environment and Climate Change Canada, and Natural Resources Canada to conduct research on diluted bitumen behaviour when spilled in marine environments and climate conditions found across Canada.

### Objectives

The overarching objective is to summarize what has been learnt about the the fate, behaviour, biological effects, and mitigation techniques for diluted bitumen to inform future work and direction, as well as communicate the results to the public. Areas of uncertainty and knowledge gaps will be identified in order to inform a research agenda for future work.

Specific questions to address at the meeting include:

1. What is diluted bitumen and how does its composition vary between gathering lines within Alberta, and transmission pipelines that carry diluted bitumen out of Alberta?
2. What do we know about diluted bitumen behaviour when spilled under which defined conditions? What environmental conditions or other factors influence their behaviour when spilled?
    a. Real-world spill experience (e.g. Kalamazoo, MI spill, Gogama, ON spills, North Saskatchewan River, SK spill, etc.)
    b. Results of laboratory and meso-scale studies
3. What do we know about the effectiveness of response options to treat diluted bitumen spills? What environmental conditions or other factors influence their effectiveness?
    a. Are conventional crude oil spill response countermeasures effective for diluted bitumen spills?
    b. Is the countermeasure “time window-of-opportunity” for diluted bitumen different than for conventional crudes?

4. Are the products currently being tested a fair representation of what is being transported throughout Canada?
5. What are the priority gaps in knowledge related to diluted bitumen, and what are their implications for spill response and recovery?
6. Compare the relative risks of diluted bitumen to conventional crudes if spilled into ecologically sensitive areas under which defined conditions?
7. What analytical methods need to be updated to improve their accuracy and precision for predicting crude behavior including heavy oils?
8. How do responders access GOC knowledge to obtain the information needed during a spill event?
9. How can GOC scientists obtain samples and technical information from spill events to benchmark tank- and lab-scale results?

**Expected Publications**

- Science Response
- Proceedings

**Expected Participation**

- Fisheries and Oceans Canada (DFO) (e.g., Ecosystems and Oceans Science, and Ecosystems and Fisheries Management)
- Other Federal Government experts (eg. Natural Resources Canada, Environment and Climate Change Canada)
- Academia or Academics
- Industry
- Other invited experts

## APPENDIX 3: MEETING AGENDA

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat (CSAS)
National Science Advisory Workshop

**AGENDA – Status Report on the Knowledge of the Fate and Behaviour of Diluted Bitumen in the Aquatic Environment**

Chairperson: Gilles Olivier
Location: BizLounge (140 O'Connor Street), Ottawa, ON
April 19 and 20, 2017

*Table 1: Agenda for Day 1*

| Time | Topic | Presenter |
|---|---|---|
| 9:00 – 9:15 | Introduction to CSAS advisory process<br>Review Terms of Reference | Chair |
| 9:15 – 9:45 | Presentation: What is Diluted Bitumen and How Does its Composition Vary? | Bill Lywood |
| 9:45 – 10:30 | Presentation: CCG Current Response Planning, Actions, Countermeasures and Effectiveness | Larry Trigatti |
| 10:30 | Break | All |
| 10:45 – 11:00 | Presentation: Current Response Actions for Dilbit and Lessons Learned | Chantal Guénette |
| 11:00 – 11:15 | Presentation: Dilbit Behaviour and Influential Factors Observed from Kalamazoo | Faith Fitzpatrick |
| 11:15 – 11:45 | Presentation: Containment and Recovery of Dilbit in Marine and Fresh Water | Stanislav Stoyanov |
| 11:45 – 12:00 | Discussion / Buffer | All |
| 12:00 – 1:00 | Lunch Break | All |
| 1:00 – 1:20 | Presentation: ECCC Part 1 – What Do We Know | Bruce Hollebone |
| 1:20 – 1:40 | Presentation: ECCC Part 2 – Response Actions and Examples | Ben Fieldhouse |
| 1:40 – 2:00 | Presentation: ECCC Part 3 – Penetration and Retention Studies | Patrick Lambert |
| 2:00 – 2:30 | Presentation: Industry Funded Dilbit Research Results | David Cooper |
| 2:30 – 2:45 | Break | All |
| 2:45 – 3:45 | Presentation: Wave Tank and In Situ Studies of the Fate and Behaviour of Diluted Bitumen | Alice Ortmann |
| 3:45 – 4:45 | Presentation: Spill Tests and Analyses of Crude Oil Behaviour in Fresh and Salt Water Conditions | Heather Dettman |
| 4:45 – 5:00 | Wrap-up | Chair |

*Table 2: Agenda for Day 2*

| Time | Topic | Presenter |
|---|---|---|
| 8:30 – 8:45 | Re-cap of Day 1 | Chair |
| 8:45 – 9:00 | Discussion: What is Diluted Bitumen and Are the Products Being Tested a Fair Representation | All |
| 9:00 – 10:00 | Discussion: What Do We Know about Diluted Bitumen, What Are the Knowledge Gaps, What Are the Analytical Gaps? | All |
| 10:00 | Break | All |
| 10:15 – 11:00 | Discussion: Effectiveness of Response Options, Risks to the Environment, Integrating Knowledge into Response and Opportunity to Benchmark Lab Studies | All |
| 11:00 – 12:00 | Identification of Key Themes for the Science Advisory Report and Begin Drafting Science Advisory Report | All |
| 12:00 – 1:00 | Lunch Break | All |
| 1:00 – 2:30 | Drafting Science Advisory Report | All |
| 2:30 – 2:45 | Break | All |
| 2:45 – 4:30 | Continue Drafting Science Advisory Report | All |