The Dilbit (Diluted Bitumen) Debate: Going Down the Rabbit Hole

A DISCUSSION PAPER

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ABOUT BITUMEN CRUDE OIL

Bitumen is a crude oil that has been subjected to biodegradation and evaporation processes *in-situ* (in place) over millions of years. Bitumen comes from oil sands in Alberta. Bitumen crudes are referred to as "unconventional" oils when extracted from sand and shale, rather than "conventional" oil obtained from drilled wells

Bitumen is too viscous to pump through a pipeline - about the consistency of peanut butter. To transport by pipeline, it is typically thinned with a diluent or up-graded as a syncrude. There are basically four-types modified to enable its transport: 1) bitumen diluted with raw condensate or processed naphtha (dilbit): 2) bitumen up-graded as a synthetic oil (syncrude); 3) bitumen diluted with syncrude (synbit), and 4) diluted bitumen with synthetic crude and another diluent – usually condensate (dilsynbit). There are many variations within these categories. For more details about each type, visit Crude Monitor at: http://www.crudemonitor.ca.

Bitumen crudes for transport are fully blended chemically like any other conventional crude oil. All modified bitumen crudes share the same weathering processes as any other spilled oil (*e.g.,* evaporation, dissolution, oxidation, and biodegradation). As well, it will float in both fresh and marine water in most situations, even when weathered and has reverted to its parent-material - bitumen. Dilbit with its blended condensate or naptha has significantly higher amounts of volatile components than conventional crude oils. The condensate is raw product from gas wells; naphtha is a refined solvent.

INTRODUCTION

This discussion paper's focus is on the scientific debate pertaining to the fate and behaviour, as well as associated response challenges of a modified bitumen crude with a condensate or naptha if spilled into marine waters. This is a "dilbit", as often referred to as a "diluted bitumen". Names of dilbit include, but not limited to: *Access Western Blend, Cold Lake, Western Canada Dilbit, Western Canadian Select*. At this point of conversation, the term "dilbit" is used.

Debates about the scientific findings of dilbit are noisy and fragmented. The premise of this opinion paper is that concerned parties - industries, governments, non-government organizations - are mostly correct in their scientific findings and interpretations. The difficulty is that each approaches the topic from different starting point, and do not necessarily continue their analysis to completion. That is, they don't go down the rabbit hole deep enough and together.

There are also many institutional obstacles to achieving meaningfully and respectfully discussion on the efficacy of on-water and on-shore mitigation measures of a dilbit spill.

The first part of this opinion paper examines social, economic, and political impediments to effective dialogue on this topic. The second part addresses topics to cast the "dialogue-net" a bit further from scientific and response standpoints. Part 2 goes into aspects of fate, behavour and challenges of a dilbit if spilled in marine waters from a tanker casualty. These aspects are referred to as "touchstones" in that they strive to examination of the debate from just a scientific/technical standpoint at a "Readers Digest" level.

PART 1: Institutional Obstacles to Effective Dialogue

The obstacles for effective dialogue amongst concerned parties (*i.e.,* industry, government, public, non-government organizations) can be framed around:

- Ambiguity on defining what is Canada's National Interest;
- Harmonizing probability of a spill with its consequences as a function of risk;
- Risk acceptance, tolerance, and normalization;
- Polarized passions between risk-makers and risk-receivers;
- Science doesn't care about opinions, but application of scientific findings does;
- Communication gap created by offering a scientific discourse *versus* social dialogue;
- Who is best to collate and interpret scientific findings with spill operations; and
- Who inherits scientific and operational uncertainty.

1.1 Ambiguity on Defining What is Canada's National Interest

The "National Interest" pertaining to the development and export of Canada's oil sands is ambiguous? National Interest could be viewed as having three components regarding the need to:

1. Address climate change as part of Canada's contribution to global well-being;
2. Promote regional economic development as part of Canada's economy; and
3. Protect inland rivers and coastal marine resources as Canada's environmental protection responsibilities.

The three requisites are very inter-connected. Often one party - whether a person from industry, government, or a NGOs (environmental, industry, academic) - adopts one or two of these components, and vehemently rejects or dispels the other. In doing so, each party with their own interests, values, and perspectives play each one off as been self-serving; that is not embracing the elusive National Interest. This dynamics makes it difficult to carry on a conversation on any of these subjects.

If one adopts just National Interest as only #2, whereby pipeline and tanker export of products from oil sands contribute to Canada's economy, then government and industry needs to tinker with items 1 and 2. For climate change, it would be an up-hill struggle to meet national and global objectives. For protection of Canada's water-ways, it would be an up-hill struggle to meet performance standards in spill mitigation for dilbit (See: Part 2). If item #2 is not part of the National Interest and new or additional export does not transpire, then the other two challenges are no longer relevant to the conversation.

1.2 Harmonizing the Probability of a Spill with its Consequences as Function of Risk

The risk of a major spill from an oil tanker is a function of probability (likelihood) and consequences (impacts). There is a tendency during a major project review for new or expanded pipeline proposal that if the probability of an environmental incident (*e.g.,* tanker casualty) is deemed extremely low - though there are some notable consequences (*e.g.,* oil spill) - then impact mitigation (*i.e.,* consequence management) becomes somewhat of an after thought. That is "probability" outmaneuvers "consequences" in tipping towards a project's approval. An outcome is that the management of consequence then becomes a process of "catch-up"- often written as a list of conditions for a project's permitting and/or as directives for further study. This is the case for calling for more scientific studies on the fate, behaviour and operational challenges of spilled dilbit based on various Canadian pipeline proposals that includes tanker exports.

One needs to recognize that probability is statistical analysis. The underlying issue isn't necessarily about the accuracy of statistics for risk calculation, but that there is a lack of trust by risk-receivers (*e.g.,* coastal communities, First Nations). Risk's probability determination is "theoretical", but the consequence side of risk is "reality". Coastal communities and First Nations are pragmatic; they don't base their social, cultural, and commercial well-being on just theoretical calculations.

Risk statistics is essentially the art of never having to say you're wrong. However, there are many examples of "Black Swan" events that demonstrate major events can happen anytime and anywhere. Black Swan events are impossible to predict, yet have catastrophic ramifications (Nassim Nicholas Taleb). The list is long, and includes: financial market crashes, 9/11 trade-tower incident, and Chernobyl and Fukushima nuclear disasters. Therefore, it is important for government and corporations to always assume a Black Swan event is a possibility, whatever it may be, and to plan accordingly. This includes a catastrophic (worst-case) spill of dilbit from a tanker casualty related to a grounding, collision, fire, or sinking. It is difficult to have a conversation about a catastrophic episode, when reminded that statistical findings show very low probability.

It is problematic having a scientific debate around the fate and behaviour, as well as associated response challenges of a dilbit spill once a pipeline project has been approved. There is an attitude by project supporters of "get over it". This is in contrast to the angst by those still concerned about the efficacy of spill response measures and want to continue to study the situation. "Move on" *versus* "hang on" are barriers to effective dialogue amongst affected parties.

1.3 Risk Acceptance, Tolerance, and Normalization

There is a gap between how the oil transportation industry views and manages their risk acceptance, tolerance, and normalization, compared to coastal communities - particularly those of a First Nation. This further impedes the conversation around the risk of a dilbit spill related to increased tanker traffic volumes in British Columbia.

Risk acceptance is when the risk involved is not high enough to warrant investments to mitigate or prevent the risk-making factors. A shipping industry example pertains to the probability a major vessel losing power and drifting aground. The probability is both calculated and perceived to be so low, that the shipping industry sees no business case for large capital investment such as funding a dedicated ocean rescue tug or creating regionally-staged salvage operations. As such, coastal protection relies solely on commercial tugs-of-opportunity for ocean rescue, If the tanker grounds and requires off-loading of its cargo, hull patching, and/or wreckage remove, then coastal protection also relies the arrival of an internationally-sourced salvage company. However, the oil shipping industry does make a business case for use of escort tugs for its oil tankers transiting in narrow, current dominated locations. The tanker owner/operator pays for this service for each out-bound transit when loaded with a persistent crude, such as dilbit.

The major shipping and oil handling companies do collectively contribute in the funding of oil spill preparedness under Canada's oil spill response organization regime. This is a legislated requirement since 1995 as an outcome of the *Exxon Valdez* tanker *(1989) /Nestucca* barge (1988) oil spill incidents. The funds are for oil spill preparedness, not for response. The latter is paid by the ship owner (Responsible Party) at the time of an incident.

Coastal communities cannot afford such capital costs of dedicated tugs and salvage resources. There is interest in establishing local (Tier 1) response capability and capacity as being a good business case for vessel casualty risk for all types of vessels frequenting within their region. Today, such investments are just being considered now in British

Columbia. This local response preparedness is a key message from coastal communities to the federal government as it delivers on its Ocean Protection Plan initiative.

Risk acceptance is essentially a matter of choice and capacity. The shipping industry (risk makers) can choose to invest in risk mitigation and collectively afford it as they do for oil spills and its Response Organization. In contrast, coastal communities (risk receivers) cannot - and do not - have such funding mechanisms. There is little opportunity for "self-determination"; instead relying on a third-party for coastal protection services (*e.g.,* industry and/or government)

Risk tolerance is the willingness of a person or group to take on risk as part of their daily lives or work requirements. An example is commuting to work. From an oil spill standpoint, the oil transportation industry has high tolerance. This is because a tanker owner is well insured for damages and compensation through its *Protection and Indemnity Club* insurer, as well as other international response/compensation funding regimes. A pipeline that supplies its tankers has no liability from a ship-source oil spill. A company's concern (*e.g.,* tanker and pipeline) about a tanker/spill incident is more related to avoiding tarnished corporate image and additional regulatory burden.

In contrast, coastal communities risk tolerance is low. There is no benefit from being at the receiving end of a major oil spill. Damage compensation is never complete. Spill response and compensation does not redress social/cultural impacts, loss of goods and services provided by a coastal ecosystem (*e.g.,* natural resource damages), and reduced confidence in the health of subsistence/commercial marine food resources. To drive this message home, the following analogy is provided. Say a visitor used your hot tub, but informs you they had an unfortunate bodily malfunction. To mitigate the situation, they removed the foul stuff and added more disinfectant. They then gave you a dissertation on the *pros* and *cons* of using chlorine *versus* bromine as disinfectants. Would you go back into your hot tub and still be at ease? When oil of any type contaminates the waters and shores of a First Nation, there is lingering distrust on the quality of their food. Spill clean up doesn't necessarily remedy lost confidence of regaining safe, clean, coastal food sources (*e.g.,* fish, seaweed, shellfish), despite what science says (*e.g.,* post-impact evaluations). An urbanite goes to a store for food, on the other hand, First Nations relies on what the ocean provides. There is a saying on the West coast: "when the tide goes out; dinner is served". Coastal community's risk tolerance is eroded by social, ecological, and commercial worry both *pre* and *post* spill. The value differential between those residing and dependent on land-based urban areas and those living in rural coastal areas makes it difficult to find common-ground on environmental issues and economic development.

The legacy of a major oil spill is not necessarily oil damage to the affected ecology, but the "torn social-fabric" of coastal communities. Coastal ecology is more resiliency and repairable than coastal people, such as First Nations. The wide-range of social and cultural impacts from a major oil spill - and how to mitigate such impacts - has not been a substantive part of the conversation regarding the consequences of a major oil spill. There has been little or no discussion amongst industry, government, and coastal communities on how to mitigate these consequences, other than to clean up the oil quickly/thoroughly, and then pay compensation for private/marketable damages. There are several opportunities to assuage social harm, such as establishment of community/industry oversight and application of Unified Command during an incident. This conversation needs to begin.

Risk normalization is the slow creep to accepting risks that were not originally acceptable, but now becomes just a matter-of-course. Essentially, risk normalization relates to institutionalized culture of complacency. It comes to the forefront during an accident investigation - why did you let this happen when fully knowing the danger! For increased risk from additional oil tanker traffic, normalization pertains to stakeholder comfort-level. The marine shipping industry is quite comfortable with increased shipping owing to vessel safety records, as well as its international and national marine shipping safety regimes. The shipping industry often cites the low volume of shipping from West Coast ports and routes compared to other parts of the world. These citations include: straits of Dover (UK) or Malacca (Malaysian), as well as ports of Singapore, Amsterdam, Rotterdam, and Antwerp. The intent of shipping industry is to show that there are lots of ways and opportunities to handle much higher vessel traffic. However, coastal communities do not view the message this way. Coastal communities see their region changing from a rural road with a few cars to a highway with lots of trucks, and that, the shipping industry is okay with this. To compare shipping in one part of the world to a region in BC side-tracks the dialogue.

There is a general acceptance (*i.e.,* normalization) of current vessel traffic by coastal communities for those passenger, general cargo, and container vessels that transit: along the Great Circle Route; within the inside passage; or access/egress to BC ports. However, for the shipping industry to expect such communities will "normalize" over time to accept a significant increase in oil tankers is somewhat unrealistic given the current passion and polarization.

Normalization by coastal communities on vessel traffic in their region does not mean they are "passiveness". Over the last 5 years, coastal First Nations recognize that vessels are essentially "industrial facilities" on water, though transitory in nature. Under First Nation right and titles, they are now more engaged on matters of vessel operations (*e.g.,* speed, anchoring, routes), cumulative impacts (*e.g.,* wave erosion, invasive species, anchor drag, air quality, acoustical noise, *etc*.), and casualty risks (*e.g.,* grounding, collisions, wreckages, spills, *etc*.). This has led to some positive government (federal) -to - government (provincial) - to government (First Nations) conversations on vessel management that harmonize with coastal community interests and activities.

In summary, clashes of values and perspectives between industry and coastal communities impedes the conversation on risk tolerance, acceptance, and normalization. The current, tripartite government initiative in BC have demonstrated that jurisdictions can sit-at-the-table and respectively and meaningful address complex and contentious shipping issues.

1.4 Polarized Passions between Risk-makers and Risk-Receivers

The shipping industry can be viewed as the risk-makers. However, this sector's low number of vessel casualties is an outcome of International and Canadian marine vessel safety systems. This is a good thing. The shipping industry is proud and passionate about its role in Canada's economy, as well as its robust safety measures and good record - and should be.

The risk-receivers can be viewed as the people and communities that reside, depend, and/or enjoy the goods and services offered by our marine environment. They are also proud and passionate regarding coastal natural diversity, health, spirituality, beauty, and services it offers (*e.g.,* food, recreation, commercial). This is also a good thing. Unfortunately, neither group acknowledges each other's passion before beginning a conversation. They immediately view each other as a threat to their respective interests, rather than acknowledging common interests and striving for common ground.

The quasi-legal process used by the National Energy Board for pipeline projects just adds fuel to this "polarized passion". Lawyers are often intermediaries in preparing submissions and interventions. The process is an adversarial environment that does not promote respectful dialogue.

A major project's assessment process can be contested if perceived adversarial and narrow in scope. A Canadian trait is that we will strive for consensus, will compromise and will accept a difficult position in-so-far-as the process is fair, thorough and transparent. This is a reflection of our Commonwealth roots of "peace, order, and good government". These attributes are entrenched in Canada's constitution. However, if a government agency's decision on a project's approval and conditions is challenged in courts and/or need to be re-enforced by a political edict, these interventions can be viewed as signs of a failed process. One doesn't get far in discussing fate, behaviour and challenges of a dilbit spill if overshadowed by a contentious process.

To further exasperate the situation, socio-economic benefits and costs stemming from a major project sometimes cannot be equitably distributed. The benefits and costs maybe too geographically wide-apart (*e.g.,* one province to another) and/or too diverse in nature (*e.g.,* economy *versus* ecology) so as to be easily remedied.

Rhetoric around NIMBY - Not In My Back Yard - doesn't foster an platform for conversation. To mitigate not wanting spill risk nearby, Impact/Benefit Packages (IBPs) are offered to affected communities - particular First Nations - the a major project proponent. These often include revenue sharing and job opportunities. However, not every First Nation is receptive to IBPs - depends on each band's location and income opportunities. Small First Nation bands with little management land-base and/or income revenue generation are often receptive to an IBP. These bands tend to be those locate inland alongside a pipeline's right-of-way. In contrast, larger coastal First Nation communities are zealous in protecting the commercial value of their resources, and in particularly those that offer subsistence and cultural food sources (non-market value). They don't need an IBP - they have the ways and means to be viable and vibrant. An unintentional result is that IBPs can divide First Nations for those that accepted one and those that refused. This social-economic cost can become a legacy that can persist for the duration of tanker/pipeline operations, and longer.

1.5 Science Doesn't Care About Opinions, but its Application Does

If science says sea-levels will rise, then it will. For this topic, the debatable issue pertains to application of scientific findings regarding when and how society will meaningfully counter sea-level inundation to vulnerable coastal populations. Are we responsive and resilient enough to meet this challenge?

If science says dilbit floats when fresh or weathered, then it will. The debatable issue pertains to application of scientific findings to effectively recover this oil as a function of its rate and extent of weathering, as well as in difficult environmental conditions (*e.g.,* waves, currents, water temperatures). What is the efficacy of our oil recovery technology for weathered dilbit? Will response efforts meet public, government, and industry performance expectations? Are there response gaps in coastal areas where effective response is not practical or safe due to adverse waves, winds, fogs, and/or currents? (See: Part 2 on "touchstones")

If science says, dilbit can submerge or sink under specific environmental conditions common in coastal waters (*e.g.,* sediment-laden waters), then it will. The debatable issue pertains to what geographical extent do these adverse conditions reside. When oil submerges or sinks, what is the efficacy of its recovery? Will response efforts meet public, government, and industry performance expectations? (See: Part 2 on "touchstones")

The key metric that opinions proliferate around is "performance expectations". An inference is that spill performance for dilbit should be as good as with any other conventional crude oil. If the dialogue on scientific findings and their application are restricted to a conversation around only "fresh" oil, then response performance can be expected to be similar - regardless of the type of crude. However, if the dialogue on scientific findings pertaining to the rate and extent of weathering of dilbit, then response performance (mitigation) can be different. Why different, because dilbit has much higher concentrations of condensate or naptha as its diluent than conventional crude oils. Once the diluent has evaporated, one is left with an heavy oil - the bitumen. (See: Part 2 on "touchstones")

What if the rate and extent of weathered dilbit significantly erodes the efficacy of spill mitigation measures compared to a conventional crude whether undertaken on on-water and on-shore? Who gets to draw-the-line-in-sand whereby response (mitigation) performance is too low and becomes unacceptable: government or industry? Where is this line? To date, the conversation offered by industry is that a dilbit when spilled behaves like any other crude oil and it will mainly be recovered in a "fresh state". That is industry's start and end-point for its dialogue. Their conversation is framed around experience-based response equipment and practices where there is industry/public confidence in mitigation performance. On-the-other-hand, the risk-receivers want to carry the conversation to the end-point of fully weathered product (*e.g.,* emulsified oil) as a floating "heavy oil" that will test our current oil-recovery systems. Their conversation also wants to extend to when the oil sinks or submerges under those environmental conditions identified in scientific literature and by past events. This conversation challenges the *status quo*. The conversations around fresh, weathered, floating, sinking, submerging dilbit has yet to meet-in-the-middle and join-up.

1.6 Communication Gap Created by Offering a Scientific Discourse versus Social Dialogue

When having a conversation - whether in written as submissions or conducted across-the-table - there is a disconnect when industry provides a "scientific discourse", whereas the layperson seeks a "social dialogue". This creates a communications gap. This issue is best described by an example. Viscosity is an important physical property of oil when fresh and weathered. Its state has a marked influence on the effectiveness of on-water response and on-shore treatments. If one described heavy oil viscosity in a manner of a scientific discourse, the oil viscosity is typically provided in terms of centiposie (cP). For example, a heavy crude in a fresh state can be described as having a viscosity approaching 10,000 cP or more - about the viscosity of molasses. For highly emulsified oil, its viscosity can reach 50,000 to 300,000 cP: about the viscosity of thick peanut butter. For a social dialogue to be attained then these technical parameter needs to be translated as having the viscosity of "molasses" or "peanut butter" - something a layperson can relate too. Rarely are these comparisons made in the conversation around spilled dilbit when fresh or weathered.

Products of a scientific discourse also appear as complex charts, graphs, and tables. In technical submissions for project assessments, there is a paucity of images and videos showing the various states of oil and its recovery from actual spills world-wide. Furthermore, there has been little effort made to compare the fate, behaviour, and operational difficulties stemming from actual large spills of intermediate to heavy grade oils - either as crude or residue cargos/fuels. Examining incidents of actual marine oil spills is of critical importance for having a dialogue about fate, behaviour and operational challenges of a dilbit spill. This is because there hasn't been marine incidents world-wide of dilbit to draw on for comparisons in B.C's coastal environments.

Incidents that could be considered to foster both a scientific discourse and social dialogue include: *Prestige* (2002) and *Erika* (1999) tanker incidents off of Spain; *Volgkoneft 248* (1999) in Turkey; *Baltic Carrier* (2001) within the German and Danish territorial waters of the Baltic Sea; *Boehlen* (1976) in Germany; *Evoikos* and *Orapin Global* (1997) incident in Singapore; and *Nestucca* (1988) of Vancouver Island, British Columbia. Comparing scientific finding to real events fosters a much better understanding and picture of dilbit's fate, behaviour and operational challenges that can be communicated. Comparative studies have not been pursued as part of the dialogue. The result is marginal effort to translate scientific findings into meaningful and relatable spill operations. Essentially, the more one obfuscates science and its interpretation, the poorer the conversation.

1.7 Who is Best to Collate and Interpret Scientific Findings with Spill Operations

As discussed above, science doesn't care about opinions, but opinions abound on how scientific findings are interpreted and used for approvals, decisions, policies, plans, strategies and tactics. Application of scientific findings on these matters engages a wide-range of researchers, scientists, and spill practitioners. Within this group, the question of who is best to collate and interpret scientific findings for a major project's approval and impact mitigation. Unfortunately, the institutional nature of major project reviews is an obstacle for collaborative and trustworthy dialogue. Panel reviews often entail interrogation of interveners on their expertise credentials, as well as whether their inputs have relevance to the project's scope. The tendency is to seek the most "scientist-of-science" and the most "responder-of-response".

Where scientific papers tend to tackle one discrete topic at a time, major project's assessment submissions create a lot of scientific information mingled with superfluous materials (*e.g.,* generic descriptions about ecology, response, legislation, *etc).* In Canada's exploratory review process for major pipeline projects, its difficult to tease-out salient issues. The intervener game is to keep expertise in a "box", such as not allowing for cross-examinations amongst scientific disciplines and spill practitioners. This is an effort to ensure experts stay to the script of their masters. This does not foster collation and integration of scientific data to the end-point of determining operational requirements, as well as mitigation limitations (*i.e.,* what can't be accomplished).

As reference above, it is not a good mix to have expertise and experience at two opposite ends of the conversation when integrating scientific findings with operational requirements, as well as addressing mitigation (performance) limitations. Opinions are formulated within their own "bubble" of experience. An example is meso-scale (small, simulated) laboratory analysis on fate and behaviour of a spilled oil. The technical design and procedures of meso-scale experiments may pass scientific peer scrutiny, but to translate its data from a tank/pond-size system to ocean environments is problematic. A case-in-point pertains to bunker fuels used for vessel's engine boilers *(i.e.,* Referred to in shipping as: Intermediate Fuel Oils). This product as a heavy oil that will still float in a tank or pond. Logic would be that it would always float in the marine environment. This is not necessarily the case under certain ocean and coastal conditions. The bunker oil spilled from 1988 *Nestucca* barge incident that occurred off the coast of Vancouver Island submerged (overwashed) under ocean waves to then reappear unexpectedly on the island's shores. The slick could not be observed from aircraft. The message here is that for fate and behaviour analysis, it is important to study past spill incidents in order to collate/interpret scientific findings from small-scale experiments to that of large environmental systems. This is not the realm of expertise of a laboratory-bound scientist.

This conversation isn't over yet...one needs to go down the rabbit hole deeper. Predicting the rate and weathering of spilled oil from laboratory to ocean now requires assessing the operational requirements and challenges for both on-water recovery (*e.g.,* booms, skimmers, pumps, hoses, storage) as well as on-shore treatments (*e.g.,* water flushing, deluge, shore agents, sediment relocation, *etc*.). This is the purview of experience oil spill practitioners. As described above, a *proviso* is that the interpreter has a complete picture of the fate and behaviour of the oil product and what operating environments are being considered (*e.g.,* open oceans, sheltered coast, current dominated passages).

Generally, data integration by scientists and spill practitioners occur at workshops, such as Canada's, *Arctic and Marine Oilspill Program* (AMOP) sessions sponsored by *Environment Canada and Climate Change*. (Note: Now referred to as: *AMOP Technical Seminar on Environmental Contamination and Response*). This workshop is an international forum on preventing, assessing, containing, and cleaning up spills of oil and hazardous materials in all types of environments. Once all the scientific papers have been written, the task is to seek consensus on operational (tactical) needs and mitigation (performance) limitations of managing a dilbit spill in marine waters. That is to foster a "common operational picture" of what can and cannot be accomplished. Once reached, one can then have a meaningful and trustworthy conversation regarding project approvals, policies, plans, response strategies *etc*. This milestone has yet to be accomplished for dilbit, but inching slowly forward. Taking science to field application is a slow process.

A deficiency is that peer-reviewed scientific papers tend not to link the fate and behaviour of dilbit very well to operational challenge in various water and shore environments (*e.g.,* winds, currents, shore types, actual sediment loading, *etc*.). It is important to building on the following three factors:

1. *Science* on fate and effect of dilbit in marine temperate waters;
2. *Evaluation* of operational challenges faced by on-water and on-shore response in logistics (transportation, people), resources (booms, skimmers, pumps, storage) and treatments (shore deluge/flushing, manual removal);
3. *Determination* of acceptable performance measures on how fast and thorough mitigation is achieved, as well as what would be deemed not acceptable.

So who should offer the best scientific/technical/operational balance regarding the nature of a dilbit spill? Essentially, it a collaborative effort of scientists and response practitioner, or experts that have both attributes. Based on these criteria, two recent papers from AMOP 40 Session (2017) provides an example of a balance of scientific findings with that of expected field results.

> *Scientific Support Information and Response Guidance for Dilbit Spills Impacting Marine Shorelines*, by Gary Sergy S3 Environmental Inc., Edmonton, AB, Canada, John Harper Coastal and Ocean Resources, Sydney BC, Sonia Laforest and P. G. Lambert Environment and Climate Change Canada, Ottawa, ON
>
> *Potential Dilbit Residence on Coarse-Sediment Shorelines* by Elliott Taylor, Polaris Applied Sciences, Inc., Bainbridge Island, WA, USA, Sonia Laforest, Environment and Climate Change Canada, Quebec, Canada, Edward Owens, OCC Ltd., Bainbridge Island, WA, USA.

The authors - both individually and collectively - have strong scientific as well as extensive field experience to apply scientific research and meso-level laboratory experiments, to speak to operational needs stemming from dilbit spill that contaminates shores.

The first scientific paper move the conversation forward in two ways, in that they address weathered and stranded dilbit, rather than just fresh oil floating on water. The paper carries the conversation from science to operations, then to response limitations. The paper paints a common operational picture that response practitioners can relate to. However, the paper could have carried the dialogue further in address several questions that arise from their findings such as:

- Once dilbit weathers on shores, will large applications of shore treatment agents such as *Corexit® EC9580A* used to augment ambient water deluge/flushing garner a net environmental benefit (NEB)?
- What are options for removal of weathered dilbit once a shore treatment agent is no longer effective?
- How does one monitor for negatively buoyant (submerging/sinking) dilbit that has entrained sediments (*e.g.,* silts, clays, sand) from water flushing/deluge treatments?
- How does one recovery negatively buoyant dilbit if found nearshore?
- How can the SCAT processes embrace shoreline treatment for dilbit to achieve NEB, monitor for negative buoyancies, and implement nearshore oil recovery?

A second paper helps one to understand how prevalent a coastal location in B.C. is subject to where a dilbit will penetrate sediment shores (*e.g.,* cobble, pebble, sand). In this case, Douglas Channel in Northern B.C was the subject area of this paper. Using coastal shore mapping and combining the findings of the above reports, the vulnerability and sensitivity of shores was mapped. This provides some understanding of the "scale" of potential shoreline impact.

Science (meso-lab studies) combined with other spill tools (coastal resource mapping) and spill field assessment process (SCAT) carries the conversation to more clearly assess impacts and challenges with a dilbit spill. These two papers embrace: consequences, consequence management, and scale of consequence.

1.8 Who Inherits Scientific and Operational Uncertainty

There always will be unmitigated (residual) environmental and social impacts from a major oil spill whenever incident management strives for response objectives that embrace "reasonable cost" and/or a "net environmental benefit". The first relates to economics of spill response (*e.g.,* don't spend $1000 for only $100 of returned value); the second relates to ecological constraints (*e.g.,* don't do more environmental harm than the oil itself). But what if there are unmitigated damages from a dilbit spill are greater and more extensive than that compared to a conventional crude oil incident? Who wears this uncertainty - the "risk receivers" or the "risk makers"? Actually, it is neither. If abiding to federal law and policy about ocean protection, the risk receiver is the marine environment. This is because of an important principle within Canada's *Ocean's Act* called "The Precautionary Principle". The precautionary principle is defined under this Act as *"erring on the side of caution."* It is a key principle that must be applied in the management of ocean activities, including shipping and spill response. The Federal 2002 Oceans Strategy provides the framework for ensuring the precautionary principle is implemented.

An example where the precautionary principle could be applicable in this conversation about a dilbit spill is whether current spill trajectory tracking and recovery technologies designed for conventional crudes can handle fresh and highly weathered dilbit to the same level of performance. In particular, this question is relevant if the dilbit submerges (overwashes) or sinks over a geographically-wide region. Can a net environmental benefit be achieved with large applications of shore agents to augment ambient water flushing/deluge operations? Will highly emulsified/viscous dilbit render heavy oil recovery systems useless? Thee questions raise uncertainty, and needs to be evaluated with caution.

It is the precautionary approach that essentially prescribes further study and technical analysis to address uncertainties around a dilbit spill. The *Ocean Act*, its precautionary principle and federal oceans strategy have never really be used to frame the conversation about the increase risk of marine export of more dilbit by tankers.

PART 2: Touchstones on Fate, Behaviour and Challenges of a Dilbit Spill

The following provides technical considerations (touchstones) to offer a dialogue as scientific studies unfold. To begin this conversation, the following teases out some of the assumptions embedded in the common message offered by industry, that goes somewhat like the following:

> Dilbit is like any other intermediate crude oil in its: density, weathering processes, as well as on-water/on-shore operations. Responders will primarily recover the product in its fresh state, in most locales and under most operational conditions. The response performance (impact mitigation) will be high because the product always floats - except under some very limited and specific circumstances. As well, the shipping industry will have established fast, robust and strategically located on-water and on-shore recovery capabilities in people, equipment and technologies provided by its Response Organization.

This is a good enough starting point for a conversation, but still just looking into the rabbit hole and not climbing down it. The following listed touchstone (in bold) moves the conversation along. Each one is structured to reflect a core message being provided by the oil industry, but then elucidates science and operational ramifications.

1. **Dilbit is like conventional crude oils sourced from drilled wells in so far as both blended petroleum chemicals, BUT its diluents (*e.g.,* raw condensate and refined naptha) vary in chemical properties and percent composition for almost every batch transported - only the "parent" bitumen is predictable in chemical properties.** A dilbit's type of diluent, high concentrations (> 25%) and its chemical variability fosters unpredictability and uncertainty on safety, fate, and behaviour when spilled.

2. **Dilbit's weathering processes (*e.g.,* evaporation, photo-oxidation, bio-degradation) are the same chemical/physical processes as all crude oils, BUT for dilbit the rate and magnitude of evaporation at the on-set a spill is much more rapid and extensive due to the larger diluent component.** Rapidly changing properties of spilled dilbit create greater operationally challenges for on-water

response oil containment and recovery, as well as on-shore treatment than compared to a conventional crude oil.

3. **Dilbit has similar oil properties and classification as an intermediate crude oil while it is contained in a tanker or pipeline, BUT this is not the case within a few hours of a dilbit being spilled due to rapid evaporation of its diluent and reverting back to its parent material of bitumen.** The window-of-opportunity for on-water recover and for shore treatment of dilbit while it in a fresh (non-weathered) state is much shorter than conventional crude oils. This creates significant challenges of getting responders on-scene and actually undertaking oil containment and recovery while it is still fresh and fluid. After a few hours, the oil is essentially a different type of product needing different response equipment. This can result in time-consuming re-tooling of oil recovery systems.

4. **Dilbit has volatile components similar to conventional crudes oils that pose unsafe air quality for initial responders related to the oil's flashpoint, flammability, and toxicity, BUT the higher amount of condensate or naptha in dilbit creates more intensive and extensive hazards at the on-set and source of the spill.** One can expect longer delay in actually oil containment and recovery of freshly released dilbit compared to a conventional crude. Waiting on stand-by for safe air quality to be reached reduces the window-of-opportunity to minimize oil spread, as well as to recover it before weathering - such as emulsification. Responder's Personnel Protective Equipment, such as cartridge respirators, is effective only for air toxicity exposures, not for fire hazard related to an oil's flashpoint and flammability of its volatile components - such as condensate or naptha component of a dilbit.

5. **Dilbit float and will continue to do so like other conventional crudes, BUT dilbit can submerge or sink if interfaces with specific environmental condition in sufficient extent and duration relate to sediments (silts, clays, sands) associated with either fresh or brackish waters, as well as if in proximity to wave exposed sediment beaches - including during shore treatments with water flushing/deluge operations.** The geographic extent of where dilbit can be negatively buoyant (sink or submerge) is a function of extent of sediment shores at risk, and seasonal extent of the Fraser River estuary freshest into the Strait of Georgia. The latter is a sediment/brackish water region conducive for a dilbit to submerge to then reappear on shores, or sink to more saline boundary-interface. Within large-ecosystems, sunken or submerged heavy oil is cannot be satisfactorily tracked nor recovered.

6. **Dilbit behaves like an intermediate crude oil on initial release and floats, BUT - as dilbit weathers and reverts back to its parent material of bitumen - it behaves as a heavy "residue" oil which has a tendency to submerge (overwash) under waves in open-ocean or estuarine conditions.** Heavy oils that submerge under waves are difficult to track and recovery until it washes and strands on shores. An example is the 1988 *Nestucca* barge incident that released Bunker C fuel that contaminated the shores of West coast of Vancouver Island. Based on experience, one can anticipate submerge oil in large systems, such as the Strait of Georgia, Juan de

Fuca Strait, and Pacific Ocean. Submerge oil may also occur in current dominated regions, such as Haro Strait, or as stated, in the estuarine waters of the Fraser River.

7. **Dilbit will emulsify (incorporate water) with wave/current energy such as other heavy (crude and residue) oils, BUT for dilbit the rate and magnitude is initially higher than conventional crude oils while its condensate/naptha evaporates.** Emulsified and highly viscous floating oil poses significant challenge to contain, recover, pump, store, and off-load. If management of weathered dilbit requires use of water annulus for transfer hoses (reduces internal fiction) and/or heating (reduces viscosity) of stored product, then the operational skills, equipment, and challenges are daunting. Any weakness in the system (*e.g.*. equipment failure) greatly reduces response performance. For dilbit, the window-of-opportunity to capture it in its fresh (non-weathered) state is measured in a few days; much shorter duration than an intermediate, conventional crude oil. To switch from fresh to weathered oil can require responders to "re-tool" most of their on-water recovery system - a difficult and time-consuming process.

8. **The practical and common method of removing stranded heavy oil (conventional, residue) from shores is to use an ambient-temperature water deluge/flushing systems to float the product off rocks and sediments, and then recover it seaward with booms and skimmers, BUT for weathered dilbit this shore treatment has limited effectiveness.** Ambient-temperature water flushing/deluge offers high confidence that a "net environmental benefit" will be achieved - *i.e.,* cause no additional ecological harm than if the oil was left alone. Owing to rapid weathering of dilbit - compared to conventional crude oils and some residue oils (Bunkers) - precludes effectiveness of this treatment. Solutions to augment and extend water deluge/flushing effectiveness are to either heat the flushing/deluging water or add a chemical shore agent to the stranded oil, such as Corexit® EC9580A. Both soften the stranded oil. For large-area applications, neither treatment methods fosters high confidence in achieving a net environmental benefit**.** Furthermore**,** Corexit quickly loses its effectiveness after about ten days for stranded, dilbit - well before shore cleanup would be completed for a large incident. These limitations could leave the only option for shore cleanup being manual recovery by workers with rakes, shovels, graders, and tractors. Manual removal is very time-consuming and necessitates a large workforce.

9. **All heavy oil spills create large volumes of oily wastes that must have final disposal solutions formulated and approved by provincial and local governments, BUT the challenges for dilbit could be much higher for these governments.** Under Canada's planning standards for certified Response Organizations, there only requires temporary storage of oil at the beach-head. It is then left to the provincial and local governments working with the shipowner to develop waste transportation and final disposal solutions. The lack of a plans, processes, and places can curtail on-water and shore operations. A major spill of dilbit will challenge oily waste management owing to it propensity to emulsify (increases volume), as well as potentially require special heating system to facilitate

transfers from various storage tanks/bladders. To date, the province has no oily waste management strategy or plan for a major marine oil spill. To establish a meaningful capability and capacity could cost local and provincial government multi-millions of dollars.

10. **All oil spills challenge the logistics of sourcing and getting equipment and people actually on-site and mitigating impacts (*i.e.,* hands-on-tools), BUT a dilbit spill could be an extreme case.**

    There are several reasons for logistical challenges for both fresh and weathered dilbit**:**

    - For fresh dilbit, the window-of-opportunity to recovery product on-water and on-shore is short (within 24 hours) before extensive weathering that creates an heavy, viscous, emulsified oil. This necessitates logistics to ensure fast personnel and equipment deployments that is typical of a fultime fire-hall approach with fultime employees.
    - Sourcing of responders skilled and experienced in on-water oil recovery with equipment designed for heavy, weathered oil (*e.g.,* skimmers, pumps, hoses, storage) will be problematic as these qualifications are not those of a spill workforce sourced from communities, First Nations, or general public**.**
    - The shipping industry's Response Organization's intention is to off-load recovered oil from its skimming vessels and then transport the oil with a fleet of mini-barges to temporary storage at the beach-head, or to a nearby "mother barge". There is the potential for heavily weathered dilbit to require powerful pumps, and may even oil heating-systems, to facilitate off-loading to temporary storage, and then to final disposal locations. The land-based operations are both labour and equipment intensive.
    - Shore treatment for fresh dilbit by ambient water deluge and flushing systems is labour intensive. It requires people with the skill and experience to handle water pumps, hoses, skimmers, booms, *etc*,. Once the dilbit weathers on shore within a matter of a week or two - even with the addition of shore washing agent - a much larger workforce will be required for manual removal of the remaining residue oil.
    - The more remote the incident and associate seasonal impediments (*e.g*., wind, fog, rain, cold), the greater logistical challenges. For remote locations, the duration in which actual shoreline cleanup is being undertaken (*i.e.,* hands-on-tools) can be only a few hours *per* day. Effective logistics extends this work.
    - A workforce will be required for final transport and disposal of oil wastes that needs to be sourced and managed by the provincial and local government.
    - Based on the above workforce demands for on-water recovery, transfer of recovered oil, shoreline cleanup and oily waste management, the number of workforce can readily exceed 3000 people for a spill approaching or exceeding 10,000 metric tonnes.
    - There may not be a willingness - nor appetite - for a community or public to be part of an oil spill workforce (*e.g.,* registered, trained, equipped, supervised, and paid), particularly for a dilbit spill. Large workforce

establishment of a thousand or more participants has never been evaluated in British Columbia.