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2016.02.23

Dr. Carl Brown,
Manager, Emergencies Science and Technology Section
Environment and Climate Change Canada
335 River Road
Ottawa, Ontario
K1V 1C7

Re: Request to Delay Approval of Corexit Products as Spill Treating Agents Pending Further Review

Dear Dr. Brown:

I am writing to you today at the invitation of Minister McKenna.

I asked Minister McKenna to delay approval of the specific Corexit products as dispersants and surface-washing tools, taken together as 'spill treating agents' for the purposes of Bill C-22. The reasons for my request are based on my concerns about the overall potential damage to the environment from use of Corexit, and concerns about the effectiveness of the products in the Canadian context in particular. I fully admit to not being a credentialed scientist. I have spent some time researching the effects of dispersant use since the time of the *Torrey Canyon* break up and spill in U.K. waters in 1967. I have read a lot of scientific papers in the past few years related to oil spill response tools and systems. I have spoken with scientists who indicate toxicity and longer term fate concerns. As a result, my concerns have increased, rather than be allayed, by conventional approaches to oil spills. As my original letter to Minister McKenna was specific to the two products to be approved, I will try to limit my points here to the application of dispersant on marine spills in general, and Corexit in particular.

1) Application of Corexit does not remove oil from the environment (only disperses it into the water column and to the water bottom and sediments, increasing exposure for plankton, fish and shellfish)

2) Application of Corexit does not provide a Net Environmental Benefit (ultimately, it makes the oil MORE toxic to marine life)

3) Application of Corexit hurts the living microbes that actually break down the oil

4) Application of Corexit does not work well in cold temperatures, like the waters of the Scotian Shelf and off Newfoundland

5) Application of Corexit does not work well on heavy (viscous) oils

6) Application of Corexit is not cost effective

7) Application of Corexit is only effective for a short time

8) There are better options available today for responding to marine oil spills

There are several recent scientific papers in particular which are intended to summarize the state of oil spill response, and have been embraced by the oil industry as endorsing dispersant use. Having read those papers, I believe the industry has misunderstood their content. There is no scientific certainty supporting the use of Corexit as a beneficial tool for treating oil spills in or on water in the Canadian context.

I would welcome an opportunity to meet with you to discuss this further at your convenience. I will ask my colleague, Dr. Bill Adams, to attend with me. Dr. Adams was a principal investigator in the Beaufort Sea Project, which investigated the effects of oil spills on land and in water in cold conditions. RESTCo has reprinted the summaries and technical papers from the Beaufort Sea Project on its website. (http://www.restco.ca/BSP_Reprints.shtml)

The remainder of this letter goes into some detail supporting the points made above. We have additional material to present, if you desire it.

For the reasons set out above, I respectfully request that the Government of Canada not approve Corexit products as spill treating agents under Bill C-22, and conduct targeted and focused research on the efficacy of multiple approaches to oil spill response to find options which are environmentally superior to Corexit/dispersant as oil spill treatments.

Yours sincerely,

Darryl H McMahon

Darryl McMahon

cc: The Honourable Catherine McKenna, P.C., Minister of Environment and Climate Change

Below, I present only 1 or 2 documents in support of each point. In general, there is more material to support my contention. My objective is not to vilify dispersants, but simply to indicate they are not sufficiently better than other approaches to justify them as a first-order response tool when other options which appear to be as good or superior are available. The items below are presented in the same order as shown on the first 2 pages of this letter.

1) It does not remove oil from the environment (only disperses it into the water column and to the water bottom, increasing exposure for plankton, fish and shellfish)

Oil Spill Dispersant (COREXIT ®EC9500A and EC9527A) Information for Health Professionals (http://www.cdc.gov/nceh/oil_spill/docs/Oil%20Spill%20Dispersant.pdf)

"Dispersants do not remove oil from the water, but instead break the oil slick into small droplets. These droplets disperse into the water and are further broken down by nature. Dispersants also prevent the oil droplets from coming back together and forming another surface slick."

2) It does not provide a Net Environmental Benefit (it actually makes the oil MORE toxic to marine life)

The application of dispersants, as in the case of the Deepwater Horizon event in 2010 does not make the oil less toxic to marine life. In the short term, it makes the oil more bioavailable to exposed living organisms. In the longer term, it increases negative health effects for larger organisms, as the toxic effects are bioaccumulated through the food chain.

Synergistic toxicity of Macondo crude oil and dispersant Corexit 9500A® to the *Brachionus plicatilis* species complex (Rotifera)
Roberto Rico-Martínez, Terry W. Snell, Tonya L. Shearer
Environmental Pollution, Volume 173, February 2013, Pages 5–10
(http://www.sciencedirect.com/science/article/pii/S0269749112004344)

"When Corexit 9500A® and oil are mixed, toxicity increases 52-fold to B. plicatilis"

A Review of Literature Related to Oil Spill Dispersants 1997-2008
for Prince William Sound Regional Citizens' Advisory Council (PWSRCAC), Anchorage, Alaska
by Merv Fingas, Spill Science, Edmonton Alberta

"The results of dispersant toxicity testing are similar to that found in previous years, namely that dispersants vary in their toxicity to various species, however, dispersant toxicity is less than the toxicity of dispersed oil, by whatever tests."

FIVE YEARS AND COUNTING: GULF WILDLIFE IN THE AFTERMATH OF THE DEEPWATER HORIZON DISASTER
(http://www.nwf.org/~/media/PDFs/water/2015/Gulf-Wildlife-In-the-Aftermath-of-the-Deepwater-Horizon-Disaster_Five-Years-and-Counting.pdf)

"Notably, dispersants do not reduce the amount of oil in the environment; they simply break the oil into fine droplets. Dispersants are intended to reduce the likelihood that birds and other wildlife may be oiled or that an oil slick will contaminate beaches and coastal marshes. However, the fine droplet

size of dispersed oil increases the likelihood that fish, coral, and other organisms in the water column will be exposed to the harmful compounds in oil. There are also indications that dispersants can remain in the environment for years."

Dispersed Oil Disrupts Microbial Pathways in Pelagic Food Webs
Alice C. Ortmann , Jennifer Anders, Naomi Shelton, Limin Gong, Anthony G. Moss, Robert H. Condon
Published: July 31, 2012
DOI: 10.1371/journal.pone.0042548
(http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0042548)

"While the addition of glucose or oil alone resulted in an increase in the biomass of ciliates, suggesting transfer of carbon to higher trophic levels was likely; a different effect was seen in the presence of dispersant. The addition of dispersant or dispersed oil resulted in an increase in the biomass of heterotrophic prokaryotes, but a significant inhibition of ciliates, suggesting a reduction in grazing and decrease in transfer of carbon to higher trophic levels. Similar patterns were observed in two separate experiments with different starting nutrient regimes and microbial communities suggesting that the addition of dispersant and dispersed oil to the northern Gulf of Mexico waters in 2010 may have reduced the flow of carbon to higher trophic levels, leading to a decrease in the production of zooplankton and fish on the Alabama shelf."

The behaviour and environmental impacts of crude oil released into aqueous environments,
Royal Society of Canada Expert Panel, 2015
(https://rsc-src.ca/en/expert-panels/rsc-reports/behaviour-and-environmental-impacts-crude-oil-released-into-aqueous)

"… natural recovery is an option that should always be considered when determining which response option should be implemented. It may be the best alternative especially in certain situations where human intervention could result in more harm than good. … For some spills, such as those that have contaminated highly sensitive … environments that serve as habitats for endangered species occupying several trophic levels, it is probably more cost-effective and ecologically sound to let the site recover naturally than attempt to intervene. "

Given the sub-surface effects of mixing oil and Corexit on marine life, the longer oil persistence in the water column and at the water bottom as a result of binding with dispersant, the higher toxicity due to increased bioavailability, and that natural processes for weathering and breaking up spilled oil over time, there is an argument to be made that not treating the oil has a superior net environmental benefit than use of dispersants, if life and environment beyond the water surface are considered. (Fortunately, leaving the oil to natural weathering and breakdown, while potentially less harmful than using dispersants, is not the best option available to us.)

3) It hurts the microbes which actually break down the oil

Chemical dispersants can suppress the activity of natural oil-degrading microorganisms
Sara Kleindienst, Michael Seidel, Kai Ziervogel, Sharon Grim, Kathy Loftis, Sarah Harrison, Sairah Y. Malkin, Matthew J. Perkins, Jennifer Field, Mitchell L. Sogin, Thorsten Dittmar, Uta Passow, Patricia M. Medeiros, and Samantha B. Joye (2015)
(http://www.pnas.org/content/112/48/14900.abstract)

"The presence of dispersant significantly altered the microbial community composition through selection for potential dispersant-degrading Colwellia*, which also bloomed in situ in Gulf deep waters during the discharge. In contrast, oil addition to deepwater samples in the absence of dispersant stimulated growth of natural hydrocarbon-degrading* Marinobacter*. In these deepwater microcosm experiments, dispersants did not enhance heterotrophic microbial activity or hydrocarbon oxidation rates. An experiment with surface seawater from an anthropogenically derived oil slick corroborated the deepwater microcosm results as inhibition of hydrocarbon turnover was observed in the presence of dispersants, suggesting that the microcosm findings are broadly applicable across marine habitats. Extrapolating this comprehensive dataset to real world scenarios questions whether dispersants stimulate microbial oil degradation in deep ocean waters and instead highlights that dispersants can exert a negative effect on microbial hydrocarbon degradation rates."*

4) It does not work well in cold temperatures, like the waters of the Scotian Shelf and off Newfoundland

Effects of temperature and wave conditions on chemical dispersion efficacy of heavy fuel oil in an experimental flow-through wave tank.
Li Z1, Lee K, King T, Boufadel MC, Venosa AD.
Maritime Pollution Bulletin 2010.04.012, Epub 2010 May 18

"The effectiveness of chemical dispersants (Corexit 9500 and SPC 1000) on heavy fuel oil (IFO180 as test oil) has been evaluated under different wave conditions in a flow-through wave tank. The dispersant effectiveness was determined by measuring oil concentrations and droplet size distributions. An analysis of covariance (ANCOVA) model indicated that wave type and temperature significantly ($p<0.05$) affected the dynamic dispersant effectiveness (DDE). At higher temperatures (16 degrees C), the test IFO180 was effectively dispersed under breaking waves with a DDE of 90% and 50% for Corexit 9500 and SPC 1000, respectively. The dispersion was ineffective under breaking waves at lower temperature (10 degrees C), and under regular wave conditions at all temperatures (10-17 degrees C), with DDE<15%. Effective chemical dispersion was associated with formation of smaller droplets (with volumetric mean diameters or VMD < or = 200 microm), whereas ineffective dispersion produced large oil droplets (with VMD > or = 400 microm)."

SINTEF A 16086 Report, Oil in Ice - JIP Report no.: 11
A Review of Studies of Oil Spill Dispersant Effectiveness in Arctic Conditions
(https://www.sintef.no/globalassets/project/jip_oil_in_ice/dokumenter/publications/jip-rep-no-11-dispersant-effectiveness-in-arctic-conditions-150207.pdf)

"The common feature of seasonally sub-zero air and low sea temperatures will cause the spilled oil to have a relatively high viscosity - compared to the same oil in more temperate conditions - or to be substantially below the Pour Point of the oil, and therefore effectively solid. Oil viscosity is known to influence the performance of many oil spill countermeasures, including the use of oil spill dispersants.

"The relationship between oil viscosity (or emulsified oil viscosity) and dispersant effectiveness is not linear. Dispersant effectiveness, as judged by a variety of test methods, is generally high up until a limiting viscosity value and then drops to a much lower level at higher viscosity. "

The Effectiveness of Corexit 9527 and 9500 in Dispersing Fresh, Weathered, and Emulsion of Alaska North Slope Crude Oil Under Subarctic Conditions
A Preliminary Report prepared for Prince William Sound Regional Citizen's Advisory Council, Anchorage Alaska
by Adam Moles, Larry Holland and Jeffrey Short, National Marine Fisheries Service (2001)
(http://www.pwsrcac.org/wp-content/uploads/filebase/programs/environmental_monitoring/dispersants/effectiveness_of_corexit.pdf)

"The effect of various states of weathering: no weathering, 20% evaporatively weathered, and emulsification on the effectiveness of oil dispersants Corexit 9527 and Corexit 9500 in dispersing Alaska North Slope crude oil into the water column was tested at a combination of realistic subarctic salinities and temperatures. A modified version of the swirling flask effectiveness test was conducted at temperatures of 3, 10 and 22° C with salinities of 22% and 32%. Petroleum dispersed into the water column following application of dispersant was measured by gas chromatography with FID detection. Results showed dispersants dispersed less than 40% of the fresh oil, none of the weathered oil, and were most effective when used to disperse a stable oil/water emulsion at 10° C. At the combinations of temperature and salinity most common in the estuaries and marine waters of Alaska, the dispersants were largely ineffective (<10% effective, the detection limit of the tests) at dispersing fresh or weathered Alaska North Slope crude oil in laboratory tests."

Surface water temperatures in the North Atlantic are cold (e.g., approximately 0° C in the Labrador Current, a temperature at which Corexit 9500 and Corexit 9527 are demonstrated to have extremely limited effectiveness).

A Proposed New Dispersant Monitoring Protocol
Merv Fingas, Joe Banta (June 2014)

"Areas of low salinity from the surface to the 10 m depth (< 30 o/oo salinity) and temperatures (< 15 °C) should be excluded from prospective dispersant applications (Fingas, 2004). These data are generally available because this data is the subject of frequent oceanographic studies." (page 10)

5) It does not work well on heavy (viscous)oils

Comparative Laboratory-Scale Testing of Dispersant Effectiveness of 23 Crude Oils Using Four Different Testing Protocols
Edith L. Holder, Robyn N. Conmy, Albert D. Venosa
Received 10 May 2015; accepted 27 June 2015; published 30 June 2015
"The test used in this study was the Baffled Flask Test (BFT), which is planned for adoption as EPA's official testing protocol for listing commercial dispersant products on the National Contingency Plan Product Schedule, replacing the current Swirling Flask Test (SFT). In addition, the results of 3 additional oils, the 2 used in the SFT and BFT as currently written plus another reference oil, are presented. The temperature used for the tests was 15˚C, to match the temperature used at Ohmsett. The dispersion effectiveness ranged from 3.4% to 93%. The BFT is a laboratory test with results that are inversely correlated with oil viscosity and therefore has predictive value in the decision to use a dispersant in the event of a spill."

Large Tank Effectiveness Testing of an Experimental Dispersant on Viscous Oils
SL Ross Environmental Research Ltd. , ExxonMobil Upstream Research Ltd., & MAR Inc. (April 2007)
(http://www.netl.doe.gov/kmd/cds/disk23/k-general/51503-final.pdf)

In testing reported in the paper above, Corexit 9500 was only 40% effective on Irene crude oil (viscosity 32,500) in warm (17° C), unrealistically saline (40 ppt) water. Weathered bitumen has a viscosity of 15,000+ at 15° C and 191,000+ at 0°C.
(https://docs.neb-one.gc.ca/ll-eng/llisapi.dll/fetch/2000/90464/90552/548311/956726/2392873/2451003/2812634/B417-29_-_Reply_Evidence-Appendix_25A-Investigation_of_the_Behavior_of_Diluted_Bitumen_Part1_-_A4S7H6.pdf?nodeid=2812636&vernum=-2, page 43)

6) It is not cost effective

Continuing statements by BP and news reports from the Gulf of Mexico place the cost of clean-up operations to date into the tens of billions of dollars. The cleanup is not complete, and these costs are not comprehensive in putting a value on lost productivity, wildlife and habitat loss and human health.

Corexit 9500 price is approximately US$50 / gallon (http://moneymavens.medill.northwestern.edu/2010/07/nalco-holding-set-to-report-first-earnings-impacted-by-oil-spill/) or about Cdn$20/litre. That does not include shipping, taxes or application costs, which will at least double by the time the dispersant is applied. The recommended application ratio varies from1:10 to 1:50 (http://www.epa.gov/emergency-response/corexitr-ec9500a). Assuming a ratio of 1:30, this comes to over US$3/gallon of oil treated. Crude oil is currently selling for approximately $0.70/gallon on the spot market (US$30 per 42-gallon barrel). A 4.5 million gallon spill (Arrow sinking, Chedabucto Bay, 1970) would cost approximately US$14 million in Corexit and application. This does not include any downstream costs or impacts resulting from the use of the Corexit.

7) It is only effective for a short time

A Review of Literature Related to Oil Spill Dispersants 2011-2014
for Prince William Sound Regional Citizens' Advisory Council (PWSRCAC), Anchorage, Alaska
by Merv Fingas, Spill Science, Edmonton Alberta

"Oil spill dispersions themselves are not stable and dispersed oil will de-stabilize and rise to the surface. Half-lives of dispersions may be between 4 to 24 hours."

Basics of Oil Spill Cleanup (3rd Edition) (2011)
by Merv Fingas
"Upon forming a dispersion plume, the plume spreads. Some of the surfactant in the dispersant forming the dispersion slowly leaches into the water. This slowly destabilizes the dispersion. After about 1 to 3 hours some of the heavy components of the oil may resurface. During this time there is a competition between redispersal of the droplets by wave action and the slow, continual rise of droplets. A significant portion of the slick may resurface within about a day. As the transport of the

subsurface and the surface slick often differs, the resurfacing slick may be too thin to be seen and may be in a different location than the undispersed slick." (page 137)

8) There are better options available today for responding to marine oil spills

It is not my intention here to catalogue the various spill response products available today, either off the shelf or ready for deployment. I would only make the point that I have acquired small quantities of several and observed their use. These products are effective (per other third party testing), and many have been evaluated and listed by the US EPA for use in treating oil spills. There is also an innovative, award-winning mechanical oil spill recovery skimmer developed here in Canada which has proven highly effective in government testing.

Below is a list of recent relevant scientific papers and reviews with a short commentary on each.

A Review of Literature Related to Oil Spill Dispersants 2011-2014
for Prince William Sound Regional Citizens' Advisory Council (PWSRCAC), Anchorage, Alaska
by Merv Fingas, Spill Science, Edmonton Alberta

"The prime motivation for using dispersants is to reduce the impact of oil on shorelines, but the application must be successful and effectiveness high. As some oil would come ashore, discussion remains on what effectiveness is required to significantly reduce the shoreline impact. A major issue is the actual effectiveness during spills so that these values can be used in estimates for the future. The second motivation for using dispersants is to reduce the impact on birds and mammals on the water surface. The benefits of using dispersants to reduce impacts on wildlife still remain unknown. The third motivation for using dispersants is to promote the biodegradation of oil in the water column. The effect of dispersants on biodegradation is still a matter of dispute. Some papers state that dispersants inhibit biodegradation, others indicate that dispersants have little effect on biodegradation. Recent papers, however, confirm that inhibition is a matter of the surfactant in the dispersant itself and factors of environmental conditions. It is clear, on the basis of current literature that the surfactants in some of the current dispersant formulations can inhibit biodegradation.

"Effectiveness remains a major issue with oil spill dispersants. It is important to recognize that many factors influence dispersant effectiveness, including oil composition, sea energy, state of oil weathering, the type of dispersant used and the amount applied, temperature, and salinity of the water. The most important of these is the composition of the oil, followed closely by sea energy. "

Oil Spill Dispersants: Boon or Bane?
Roger C. Prince
ExxonMobil Biomedical Sciences, Inc.
Environ. Sci. Technol., 2015, 49 (11), pp 6376–6384 (2015)

"The oil spill response community agrees that the best response to an oil spill would be to collect it from the environment before it reached a shoreline, and many response plans focus on this requirement by staging large amounts of equipment aimed at achieving this goal even in the face of a very large spill (e.g., refs 9−12)."

I agree with the statement above. However, the paper does not proceed to examine any options which would actually be effective in this regard. Such technology does exist, and could be deployed in a cost effective manner. I would add the response needs to be fast. I would also suggest that environmentally benign treatments of oil on open water before it reaches the shoreline would also be a viable response method.

The behaviour and environmental impacts of crude oil released into aqueous environments,
Royal Society of Canada Expert Panel, 2015
(https://rsc-src.ca/en/expert-panels/rsc-reports/behaviour-and-environmental-impacts-crude-oil-released-into-aqueous)

I fully endorse the High-Priority Research Needs Identified by the Expert Panel (page 25)
The authors conclude that the behaviour of crude oil is not uniform, nor is its response to dispersants, based on type and aging of oil and environmental conditions, etc. They also emphasize the importance of the speed of response.

"Indeed, the Panel found that, despite the importance of oil type, the overall impact of an oil spill, including the effectiveness of an oil spill response, depends mainly on the environmental characteristics, the conditions where the spill takes place and the speed of response" (page 28)

"Chemical dispersion of marine oil slicks reduces the amount of oil contacting shorelines and surface species such as aquatic birds. Dispersion increases the rate at which oil is removed from the surface, is diluted and is available for microbial degradation. However, the dispersants may increase the impact of oil spills by increasing the exposure of subsurface species. In the top 10 m of water, concentrations of dispersed oil may be increased to levels toxic to fish and invertebrate embryos. While the intent of oil dispersion is to dilute the oil to concentrations below toxicity threshold limits, even brief exposures can cause delayed effects that are evident in the weeks, months and years following a spill. The net environmental benefits of dispersion represent the trade-offs between protecting easily-identified surface resources and much less-obvious sub-surface resources and coastal/near shore environments." (page 127)

"At open ocean spills, cleanup efforts are viewed as mostly positive because oil is physically removed from the surface (skimming, burning, chemical dispersion) to protect surface species and sensitive shorelines." (page 168 italic font in original)

This paper effectively dismisses mechanical and bioremediation techniques out of hand, and does not explore recent innovations (post 1980) in these areas.

Chemical dispersants can suppress the activity of natural oil-degrading microorganisms
Sara Kleindienst et al (2015)
(http://www.pnas.org/content/112/48/14900.abstract)

I considered this a telling and convincing paper.

Using dispersants after oil spills: impacts on the composition and activity of microbial communities
Perspectives (www.nature.com/reviews/micro)
Sara Kleindienst, John H. Paul and Samantha B. Joye (June 2015)

"Of the 23 dispersants currently approved by the US EPA for use in oil spill response, to the best of our knowledge none has been tested thoroughly to evaluate its effect on microbial communities under

environmentally relevant conditions. Thus, based on currently available information, the utility of the environmental use of dispersants as a stimulant for microbial oil degradation through oil dispersion is questionable. The risks and potentially negative effects of dispersants must be carefully evaluated in the laboratory as well as in the field. These studies should be conducted using standardized protocols and methods to eliminate potential method-associated artefacts."

Deadly Dispersants in the Gulf: Are Public Health and Environmental Tragedies the New Norm for Oil Spill Cleanups? (U.S) Government Accountability Project) (https://www.whistleblower.org/sites/default/files/Executive_Summary_Corexit.pdf) (2013)

"The 2010 Deepwater Horizon disaster was the largest U.S. oil spill, and second largest in world history. Even worse, evidence suggests that cleanup efforts were more destructive to human health and the environment than the spill itself. BP and the federal government intend for their joint response to be the precedent for a new cleanup standard operating procedure (SOP), centered on the widespread use of the chemical dispersant Corexit. When this product is mixed with oil, a deadly synergy occurs that poses greater threats than oil alone. The only so-called advantage of Corexit is the false impression that the oil disappears – in reality, the more toxic chemical mixture spreads throughout the environment, or settles on the seafloor."

A Call for a Twenty-First-Century Solution in Oil Spill Response
Lawrence Anthony Earth Organization (2013)

"The Science & Technology Advisory Board of the Lawrence Anthony Earth Organization (LAEO) maintains that the purpose of oil/chemical spill cleanup is to remove the pollutants/toxicity from the environment as rapidly as possible so that living organisms can survive."

"… the EPA's National Contingency Plan (NCP) currently lists a ***category*** *of nontoxic first-response oil spill cleanup technology, applicable in all environments, that safely and effectively removes hydrocarbons from a spill site, resulting in full and swift restoration of the environment to pre-spill conditions with no negative environmental "trade-offs."*