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Comment on the Nexen Aurora LNG Export Terminal Digby Island

Application and Appendices for an Environmental Assessment Certificate

British Columbia Environmental Assessment Office

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The bottom line: **The Digby Island Aurora LNG Application ["Application"] cannot be viewed as a serious effort.**

It systematically:

- **Ignores the history of LNG and similar hydrocarbon facility accidents, including recent escalations of these and expert assessments of likely future escalations [1]**
- **Declines to take seriously safety issues regarding potential catastrophic LNG facility or vessel releases [accidental or intentional], even declining to present vividly any hypothetical potential releases or their impacts on nearby populations [2]**
- **Asserts complacently without evidence that the existing regulatory system and industry codes are sufficient to prevent major LNG releases [accidental or intentional] [3]**
- **Is non-transparent, withholding information on key assumptions and technical models, declining to describe major and significant potential public safety impacts, and keeping the most critical risk studies and management plans secret for now, to be provided sometime in the future**

Application is therefore an obfuscation of issues the workforce, the community at risk, public officials and investors need to discuss in this proceeding. Those seeking more useful LNG public safety risk information may find some citations herein helpful.

A. **The Application cavalierly touts the safety record of the relatively new worldwide LNG** industry, and the practically Born Yesterday North American LNG export industry, as **"exceptional"** --

as if this were a **non-controversial and reassuring** reality that can be expected to continue. It is true that "pure" LNG under most conditions is less risky than other hydrocarbons in its potential for causing major accidents. It is also true, however, that current existing and proposed North American export terminals contain **simultaneously huge quantities of LNG and heavier hydrocarbons that introduce much higher risks**, some of which are not fully understood, as top experts admit.

And apart from the experienced LNG accidents in North America, the rising rate of huge and unexpectedly damaging Unconfined Vapor Cloud Explosions [UVCEs] at major hydrocarbon facilities worldwide suggests that even in much more established petrochemical industry sectors [refineries and storage] the long-standing disaster risk assumptions and prevention regulations are seriously insufficient. Both US and UK regulatory bodies have engaged in **recent significant research of historical UCVE accidents worldwide specifically in the context of trying to understand "the potential for Vapor Cloud Explosions at LNG sites"** [p. 1 -Table of Contents, HSL 2016] and specifically recognizing the increased risk of LNG facilities such as the burgeoning new LNG export facilities who have huge quantities of heavy hydrocarbons as well as methane on site.

In part because major LNG facilities have been built in large North American cities with significant disaster potential, lessons are being studied from the huge 2004 LNG disaster in Algeria as well as from the recent serious 2014 LNG accident in Plymouth WA – but neither of these are mentioned by Application.

Leading LNG expert Dr. Jerry Havens, Distinguished Professor of Chemical Engineering, University of Arkansas, attended the [US federal agency] LNG 200-person workshop at [US Department of Transportation] DOT Headquarters in Washington on May 18 and 19, 2016, that illustrates the momentum to revise current US LNG safety regulations. He later outlined in a July 28 2016 Comment to federal regulators regarding the Jordan Cove Energy Project LNG Export Facility [Oregon] how and why **outstanding and basic LNG safety design and regulatory issues are currently hotly debated in North America, and indeed internationally, and why these issued demand urgent regulatory revisions.**

Given the substantial worldwide integration of the energy industry, perhaps it is fair to assume that the currently perceived basic inadequacies of the main features of US regulation of LNG facilities likely apply generally in

current Canadian regulations as well. Although it may be said that the current Application hardly features any Canadian regulations as weighty considerations, instead highlighting generally what the company will do as part of its due diligence.

Relevant to the current Nexen Application's studied averting of its eyes from describing, much less analyzing, any actual historical LNG industry accidents or other petrochemical Unconfined Vapor Cloud Explosion events that are important to consider in assessing the safety of the new and fast-growing North American industry of LNG export facilities**,** Dr. Havens pointed out**:**

"This is more than a debate about scientific theories of the hazards of [potential LNG explosions]… My comments provided verified information that ***at least four catastrophic UVCE events, all occurring under conditions that clearly justify their description as worst-case accidents (therefore normally considered highly improbable), have occurred in the past decade.*** *… Those incidents, and additional ones, were also described by Dr. Atkinson at the workshop". [p 7]* http://www.hse.gov.uk/research/rrpdf/rr789.pdf Dr. Havens briefly described these recent major accidents in his January 14 and February 8 2016 comments on the Jordan Cove Project. **[3]**

Regarding the need to take seriously the technical inadequacies of current LNG safety regulations, Dr. Havens in his 7 28 16 comment elaborated:

"*…My comments are directed to the plans previewed by [US Pipeline and Hazardous Materials Safety Administration] PHMSA at the workshop for updating the federal regulatory requirements for safe siting of LNG facilities; especially relating to the workshop presentations made by Drs. Graham Atkinson and Simon Gant of the British Health and Safety Laboratories (HSL) regarding predictive modeling of flammable vapor cloud formation, dispersion, and explosion hazards.*

I understand that HSL is under contract to PHMSA to provide an assessment of specific needs that should be addressed by PHMSA for its planned updating of LNG Regulation 49 CFR 193. I do not know the specific requirements of the contract with HSL, but it seemed strongly suggested at the workshop that HSL is considering at least two critical needs for LNG facility siting regulation evaluation and updating:

• Unresolved questions about the potential at LNG storage terminals for unconfined vapor cloud explosion (UVCE), with emphasis on the increased potential for severe explosions involving heavier-than-methane hydrocarbons used and stored in large amounts in LNG export terminals. (Workshop presentation by Dr. Atkinson)

• Protocols for approval of mathematical models for LNG vapor cloud formation, dispersion, and explosion potential, particularly for heavier-than-methane hydrocarbons. (Workshop presentation by Dr. Gant)" Comments, 7 28 16 p. 1

Dr. Havens is concerned to highlight the flaws in current US LNG safety-siting regulations [which one can assume applies also to the current Canadian national and provincial regulations] that **allow Applicant use of proprietary and this virtually secret gas models** that systematically lead to under-estimation of safety risks of LNG facilities:

*"The main purpose of my comments is to request PHMSA to address concerns that have been raised that **some of the mathematical modeling methods currently in use can produce results that severely underestimate vapor cloud explosion hazards (consequences) to the public**. I am very concerned that PHMSA's current procedure for determining the hazards attending large-scale LNG Export Terminals, including the present protocol for approval of vapor dispersion models for such use, is seriously flawed, particularly regarding [Unconfined Vapor Cloud Explosion] UVCE hazards."[p. 1]*

*The most serious flaw in the current procedure, in my opinion, is that because **the protocol allows approval of modeling methods that are proprietary, and thus not subject to independent scientific-peer review**, neither PHMSA nor the public can confidently determine whether the models are suitable for purpose. The result is that the public is not provided the following information about the hazard-modeling process, all of which is necessary to make a science-based evaluation of the model predictions that form the basis for FERC's approval or disapproval of proposed LNG terminals:*

• Details of data input to the model(s),

• Detailed results produced by the model(s), and,

• most importantly, a transparent description of the methods used in the models that is suitable for examination and scientific review to ensure that the methods are not used improperly.

The use of proprietary models denies the public an effective means of ensuring that errors in model application are not committed accidentally or intentionally*. Such a process portends danger to the public. There is no question that the hazards attending the handling and storage of extremely large quantities of potentially flammable/explosive materials in LNG facilities, if the hazard determinations are not accurate, could result in catastrophic damages extending beyond facility boundaries.*

PHMSA has a single means of ensuring that the decisions for approval of the safety provisions claimed are not subject to error – a scientific peer review process*. There must be a means developed to insure that the public is provided information sufficient to independently verify the accuracy and applicability of the model predictions that determine [US Federal Regulatory Commission] FERC's decision for or against LNG facility approval." [p. 2]*

Dr. Havens' Comment also raises the specific safety issues regarding proposed LNG facilities' use of gas-impervious **vapor fences:**

"The use of gas-impervious vapor fences is relatively new to the industry; it appears to be resulting more frequently associated with requests for approval for siting of very large facilities which cannot economically provide satisfactory exclusion distances to the facility property line without resort to such "vapor cloud mitigation practices". The majority of LNG Export Terminals now being considered have requested approval by FERC of vapor-impervious fences placed strategically to limit flammable vapor cloud travel beyond the applicant's property line. Such practices raise important (unanswered) questions about the increase in the severity of vapor cloud explosions that can result from such partial confinement. Based on my review of the Jordan Cove project DEIS, it appears that FERC has not considered the potential of such fences, some of which are 40 feet tall and constructed with reinforced concrete, to increase explosion overpressure damage. In my opinion this neglect of explosion science knowledge is wrong."

The current Nexen Application is entirely vague on whether such a mitigation measure has been or will be proposed for the Digby Island facility [perhaps this is what is being suggested as the "secondary containment" mentioned on p. 9-25].

Other aspects of the Application which show a carelessness about safety:

"Worker safety is beyond the scope of this assessment [p. 9-47 and throughout]. Even though as shown in the Plymouth WA accident workers will be the most likely to suffer harm.

[Among the Application's categories of "Valued Components", neither "Human Health" nor "Community Health" – nor any other category -- clearly expresses major LNG release-related chemical hazards to **public safety** such as fire, explosion or toxic gas clouds.]

B. Application is complacent in describing release risks: Chapter 9 on "Accidents or Malfunctions" immediately sets the complacent tone which prevails throughout the document**: "The LNG industry has an exceptional safety record." [p. 9-1]**

Application [p. 9-1] then promptly suggests that the chemical/physical properties of LNG make it nearly [not completely] impossible for a serious accident to occur.

"The LNG industry has an exceptional safety record. This is partially attributable to the relatively low risk associated with the production, handling and transportation of LNG. Liquefied natural gas as a liquid is not flammable or explosive, and it is stored in non-pressurized conditions at sub-zero temperatures. The production of LNG for transport requires that impurities be removed. Therefore, LNG that is released into the environment will rapidly vaporize into natural gas, leaving no residue or contamination to the surrounding land, water or biota. When LNG vapourizes into natural gas (i.e., methane), the gas has a narrow flammable range of 5% to 15% by volume in air. However, natural gas has a lower density than air and rapidly dissipates in the air to concentrations that are below the lower flammable limit. Nonetheless, there is potential for accidents or malfunctions to occur during the course of Project activities."

C. Application **almost never vividly describes the scale** [see an exception regarding the potential amount released, but not dimensions of area covered, on p. 9-34 regarding vessel grounding or collision-caused release] **nor the impacts of a single historical LNG release accident in North America or elsewhere**, onshore or offshore. It suggests that there has never been a significant historical facility release by mentioning only the alleged perfect "fires or explosions" record of commercial LNG shipping [p. 9-34]

This industry silence about historical accidents has also noted to extend into industry and government silence about a recent quite serious LNG facility release, as one remarkable report by the Washington State public interest group Sightline has charged: **"the LNG industry is creating a false safety record, and current regulations allow the industry to do so."**

One recent serious LNG facility accident in a rural community nearby in the Pacific Coast region which injured workers is surprisingly ignored by Application. The LNG release, which also usefully illustrates the severe damages that can be caused by accident knock-on effects, was on March 31 2014 just a few hundred miles south of the Digby Island community, in **Plymouth WA** on the Columbia River. The Williams Brothers/Plymouth LNG peak shaving liquefaction facility suffered a "catastrophic failure and a resulting explosion", reportedly caused by operator error. The resulting detonation accident caused 5 injuries and $47 million in damages, with hundreds evacuated, and the LNG release continued for 25 hours.

See:
http://www.phmsa.dot.gov/staticfiles/PHMSA/PipelineFailureReports/FIR_and_APPENDICES_PHMSA_WUTC_Williams_Plymouth_2016_04_28_REDACTED.pdf

http://www.sightline.org/2016/02/08/how-industry-and-regulators-kept-public-in-the-dark-after-2014-lng-explosion-in-washington/ HOW INDUSTRY AND REGULATORS KEPT PUBLIC IN THE DARK AFTER 2014 LNG EXPLOSION IN WASHINGTON 2 8 16 Lax industry oversight and incomplete reporting leave us with questions still today.

D. Application [p. 9-25] only briefly mentions the potential for a Worst Case Scenario LNG release at Digby Island, and follows with typically dismissive conclusions. In the section on On-shore Hazardous Spills:

"A likely [ed. note: meaning what Application authors would have likely chosen as] worst case scenario would include loss of on-shore containment of materials in storage tanks (e.g., LNG, gasoline, diesel or propane), or a natural gas pipeline rupture onsite upstream of the liquefaction process. This scenario may result in a large-scale release of hazardous materials in amounts or volumes greater than those described in the Spill Reporting Regulation (BC 2008).

***The probability of a large-scale spill is very low due to the design of the Project**, which includes spill prevention measures and controls specifically intended to reduce the probability of such an event (e.g.,*

***secondary containment**). The implementation of spill response plans further mitigates the potential residual effects that could occur in the event of a large-scale hazardous spill. Fires or explosions that may result from a hazardous spill of flammable or explosive substances are addressed in Section 9.6.*

*On-shore hazardous spills have the potential to interact with the following [Valued Components] VCs: Air Quality, GHGs, Water Quality, Vegetation and Wetland Resources, Wildlife Resources (Terrestrial), Freshwater Fish and Fish Habitat, Marine Fish and Fish Habitat, Marine Mammals, Marine Birds, Infrastructure and Services, Land and Resource Use, Archaeological and Heritage Resources, and **Human Health** (see Table 9.3-1).*

Preventative and Response Measures

The Project will be designed, operated, and managed to reduce the potential for hazardous spills of any size. Hazardous materials will be transported, handled, and stored in accordance with the Transportation of Dangerous Goods Act, WHMIS, and other applicable regulations.

The proposed facility will meet strict design codes and standards and will be designed to avoid confined spaces where spills of LNG could vaporize into natural gas and accumulate. Canadian Standards Association code Z276-2011 requires that LNG storage systems be located far enough from the facility boundary to mitigate the levels of radiant heat flux from fires and to mitigate the potential for spills to generate vapour concentrations beyond acceptable limits at the facility boundary. While these events could still have effects to staff onsite, these personnel will be appropriately trained to react and respond to any such event.

The Project will implement a series of preventative measures to reduce the probability of hazardous material spills of any size during all phases of the Project." [p. 9-25]

Similarly for Vessel Grounding or Collision [pp. 9-34ff], Application does for once suggest a figure of how much LNG might be released. A large disaster with an LNG ship, whose dynamics are poorly understood, has been the subject of many years of federal research in North America. But Application only briefly mentions the potential for significant LNG releases with possibly serious damages, only to dismiss the potential based on the safety record of the industry and the existing preventative and response measures. While such a release might impact marine birds or mammals, Applications states, the impacts on human health and community health are **"not significant". [**p. 9-42]

“In the event of a vessel grounding or collision resulting in a hull breach and containment failure of an LNG membrane tank, up to 48,000m3 of LNG may be released into the marine environment. Released LNG would vaporize quickly by absorbing heat from contact with warm water surfaces and the atmosphere. The resulting natural gas is only flammable if it occupies a relatively small range of 5 to 15% by volume of air. Water and other surfaces in the immediate vicinity of the spill would freeze. Upon cessation of the spill, the ice created by the spill would warm and melt rapidly back to ambient conditions.

If the LNG is released into the water and vaporizes quickly (i.e., rapid phase transition), a large amount of energy is released from the LNG transition from a liquid to gas. An explosion from pressurized gas in the immediate vicinity where LNG contacts water may occur. This explosion does not involve fire, but it can cause underwater blasts of pressure that could damage structures or injure marine life. Over the history of commercial LNG shipping, there have been no fires or explosions concerning an LNG ship's containment system in port or at sea (GIIGNL 2012).”

Applications describes in technically very over-simplistic terms potential LNG releases at the Loading Facility [p. 9-44 ff], mentioning briefly a worst case scenario dense “fog” that if ignited could possibly damage structures:

[p. 9-44] *“This accident or malfunction scenario includes the potential for cryogenic releases of LNG at the loading facility. The likely worst case scenario for an LNG carrier while loading would be a separation of the LNG loading arm or loading line from the carrier resulting in the release of non-pressurized LNG and liquid pool formation on water with a subsequent vapour cloud of natural gas. Released LNG is expected to spread across the water surface, possibly freezing the water in the immediate vicinity. If spilled on a metal surface, contact with LNG may make the metal brittle. The vaporization of LNG to natural gas would create a dense fog in the immediate vicinity and reduce visibility of the affected area.*

The natural gas vapour cloud will disperse into the atmosphere as natural gas is lighter than air, and the vapour cloud is only flammable if it occupies a range of 5 to 15% by volume of air. The probability of ignition of the vapour cloud is low. Ignition of the vapour cloud would result in a fire that would burn back to the source or to the LNG pool and continue as a pool fire over water. Natural gas vapours generated from the LNG pool will continue to burn until the LNG has evaporated. An explosion is not a likely scenario because LNG is not pressurized.

If the LNG is released into the water and vaporizes quickly (i.e., rapid phase transition), a large amount of energy may be released from the rapid transition of LNG from a liquid to gas. An explosion from pressurized gas in the immediate vicinity where LNG contacts water may occur. This explosion does not involve fire, but it can cause underwater blasts of pressure that could damage structures or injure marine life.

Although the probability of cryogenic releases of LNG at the loading facility is very low, there is potential interaction with Air Quality, GHGs, Water Quality, Marine Fish and Fish Habitat, Marine Mammals, Marine Birds, Marine Use and Navigable Waters, Community Health, and Human Health VCs (see Table 9.3-1).”

This seems to be the only case of a possible release, presented very briefly and very late in the document [p. 9-48] with an assessment by Application that a potential LNG release could be “significant” [but with no potential impact scale indicated, as Application did indicate regarding the possible shipping release event on p. 9-34]

E. Application suggests [pp. 9-2, 9-3] that proponent not only evaluates <u>subjectively</u> the factors involved in potential LNG releases but also is responsible for assessing what level of safety measures can “manage the risks to tolerable levels”. Presumably these levels are also set by proponent management, since there is nowhere in Application any indication of objective or third-party risk levels or risk tolerance levels. Nor does Application provide any details of the selected “scenarios.”

“Accident or malfunction scenarios were identified based on experience with similar projects, input from regulators and the Working Group, and professional judgment. This assessment considers the following accident or malfunction scenarios, consistent with the scenarios described in the AIR:

- *Motor vehicle collision*
- *Facility impact from aircraft*
- *On-shore fires or explosions*

♣ LNG Plant malfunctions (emergency LNG facility shutdown including emergency flaring)

♣ On-shore hazardous spills

• Stationary and mobile equipment (fuelling, fluid leaks)

• On-shore hazardous material storage (fuels, waste, reagents)

• On-shore releases of LNG (loss of containment of LNG or other hydrocarbons in the plant process area or storage tanks) • Process water and surface/storm water containment areas.

♣ Vessel grounding or collision Aurora LNG Environmental Assessment Certificate Application Section 9: Accidents or Malfunctions 9-3

♣ Releases from LNG carriers (cryogenic releases at loading facility)

♣ Outflow of non-pressurized LNG (above and below waterline)

• Liquid pool formation resulting in a pool fire.

The AIR lists fires, explosions and hazardous spills as "onsite" scenarios within the Project development area (PDA). For clarification, this chapter describes fire, explosion and hazardous spill events as originating "on-shore" with the potential to spread off-shore within the PDA. The AIR also listed power generation malfunction as a scenario requiring consideration. Power generation is the most likely cause of an LNG plant malfunction and therefore is being assessed as part of this scenario. Hypothetical events or interactions were identified for each scenario and ***were selected if they were recognized as a likely accident and had a potential consequence of concern."*** **Application gives no indication of the criteria used in these selection decisions.**

F. Application provides no clear presentations on <u>the extent</u> of potential offsite release risks. [4]

Application provides no vivid description nor analysis of the scope [distances and intensity] of the potential releases and their associated effects on people and buildings, etc., for example:

- blast zones and damages
- fire radiation zones
- likely casualties

Application does not provide graphics to indicate the scale, distance nor impacts of worst case LNG release scenarios nor even alternative less-serious releases. Application suggests that these scenarios "will" be described in the future in the Environmental Management Plan and the Emergency Response Plan. Without these scenarios, presented in detail and vividly with site-specific effects considered, it is impossible to evaluate the Application.

G. Application provides almost no information on release <u>prevention measures</u> at the facility

There is very little discussion of adoption [or not] of significant prevention measures – only a brief suggestion of buffer zone in siting. The proposed facility would be very close to the nearby community and airport. Application suggests some buffer zones [of unstated dimensions] will be arranged, but without any mapping of potential offsite consequences, makes it impossible to gauge the efficacy of such buffer zones. Application mainly suggests that existing regulations on prevention, emergency response, etc. will be sufficient.

H. Application pays scant attention to risks to human health and safety

Application's format implies that Canadian law requires company and Responsible Authority attention to impacts on human health and community health.

Application in general systematically and substantially lowballs risks to human health and safety, and in only a few sections admits that significant hazardous releases [accidents or terrorism] causing death or injury could occur.

Application thus seems to adopt the implicit stance that any serious potential impacts for human health and safety can be asserted to be **so improbable** that any serious consideration or vivid presentation of possible serious scenarios to the reader is unnecessary.

I. Application does not provide nor summarize any of the essential Proposed Environmental and Operational Management Plans [e.g., the Emergency Response Plan] which Application asserts "will" cover critical measures on which safety depends: [p. 14-8]

- “Spill response
- Site security
- Emergency support services and corresponding support staff
- Fire safety, including fire code compliance and fire response.”

Without the Application’s providing the specifications for these, the adequacy of the plans [and of the industry-generated “guidance” CAN/CSA-Z246.2-14 on which they “will” be based] cannot be assessed.

Furthermore, Application is unclear about the status of emergency response capabilities and responsibilities in case of a release. It says Aurora LNG will be the primary responder [p. 14-8] and use the Incident Command System method of on-scene management, but does not indicate the relationship with nor capabilities of the nearby volunteer fire departments and community/provincial agencies, nor exactly how the facility will reliably provide notifications in any serious emergency:

“Nexen will initiate a proactive response when early signs indicate a potential emergency condition may be developing. Nexen’s Health Safety and Environment (HSE) Emergency Response Plan philosophy is to initiate an early and rapid response to a safety issue and to scale down resources and response efforts as needed, rather than attempting to scale up response efforts when faced with an actively changing, deteriorating or misunderstood situation. Nexen’s North American Gas and Tight Oil emergency management plan defines the framework and the tools that will facilitate the ability of Nexen to respond to emergency incidents in order to protect human life and mitigate adverse effects to the environment. In the event of an accident or malfunction scenario, Nexen will give prompt and appropriate notification of an emergency condition to government agencies, local Aboriginal Groups, area residents, stakeholders and authorities. Nexen will maintain lines of communication that provides accurate, consistent and timely information to employees, regulators, local Aboriginal Groups, governments, local stakeholders, the general public and the mass media.”

Application manifests an over-reliance on flawless implementation of existing [but not provided] management plans:

Application assumes emergency plans will be successful, and shows little indication of concern for release consequences if mitigation measures prove ineffective, e.g., if they are overwhelmed by the scale of the release. There is no discussion of potential human error, as has been alleged to be at the root of the recent serious Plymouth LNG release in Washington State.

And Application tends mainly to assume that **mitigations** will:

- be available as planned
- work as planned
- prevent unmitigated accidents

Application briefly asserts that Nexen has a “Safety First” culture and a proactive stance to emergency response [p. 9-2], but with no details on the capabilities available nor on any third party review of the corporate safety culture, plans and systems.

J. **Application has too-sketchily outlined its <u>methodology</u> for ranking the effects and significance of various release risks --** in what amounts to a “trust us” message [pp. 9-2 to 9-6]. Application early on describes how it has developed a “qualitative” methodology for determining and ranking the significance of various hypothetical impacts of the facility, with no explanation of the weighting of various factors nor any way to avoid the appearance of narrow and pervasive subjectivity. There was seemingly no effort to get inputs from the at-risk workforce or community as to how to weight these factors, for example.

The brief description of the “risk matrix” methodology [pp. 9-2 through 9-6] suggests it was **developed largely in-house** by the proponent.

“Accident or malfunction scenarios were identified based on experience with similar projects, input from regulators and the Working Group, and professional judgment.” It mentions no evaluation of this methodology nor of its validity or success in previous applications as assessed by government agencies, third party reviewers, or any other entity. It mentions no peer-reviewed publication on the methodology by any source. It fails to admit that the methodology could be only valuable in evaluating risks in a relative sense.

Most important it fails to outline the <u>limitations</u> of any risk assessment methodology that relies on in-house engineering judgment and the scores of non-transparent assumptions that go into such of course evidently biased judgments.

The brief outline [p. 9-3] of its methodology, **accompanied by no detailed Appendix detailing specific methodological procedures, assumptions and decisions** for the LNG release-related scenarios considered, only shows that the **Applicant made numerous subjective judgments** in selecting potential LNG release scenarios and evaluating their effects, and then assigning levels of significance to each. Apart from a few exceptions [e.g., p. 9-34] no indications are given of the scale or effects of the scenarios that might allow stakeholders or regulators independently to evaluate whether

the assessed size, impacts, frequency of the proponent-selected scenarios are appropriate, complete or significant.

The Application's **avoidance**, for the most part, of the normally-used term **"consequences"** of a potential major hazard chemical release is useful to note: instead [p. 9-3] Application uses the bloodless terms "potential residual effects" or "potential interactions between the potential event and the Project VCs [Valued Components]." There is no vivid discussion or presentation of blast zones or burn damage zones, etc. on shore or offshore.

[p. 9-5] *"As noted in Section 3.6.6, threshold criteria were developed for each potential effect, beyond which a residual effect would be assessed as significant. The thresholds present the limits of an acceptable change in a measurable parameter or state of the VC or CEAA 5(1)(c), based on resource management objectives, community standards, scientific literature or ecological processes (e.g., desired states for fish or wildlife habitats or populations). Residual effects significance thresholds have been developed for each VC (see Sections 4.0 through 8.0) and have been used to determine the significance of residual effects resulting from key accident or malfunction events. 9.3 Identification of Potential Interactions with VCs For each accidents or malfunctions scenario, consideration was given to whether the scenario could have an interaction of concern with each VC. Potential interactions between each accident and malfunction event and the VCs are indicated in Table 9.3-1. A check mark indicates that an interaction of concern could occur. Subsequent sections discuss the associated probability of the event occurring and the likelihood and consequence of post-mitigation residual effects following such an event."*

Application suggests its methodology entails a reliance on unspecified historical data of dubious validity, perhaps LNG accident data, and makes sweeping generalizations presumably based on some available and valid data about the safety record of the LNG industry:

"The likelihood of events is discussed quantitatively where data are available (e.g., historic statistics); otherwise, a qualitative approach is taken based on professional judgment." [p. 9-4]

But Application provides no indication of what databases have been relied upon or will be relied upon in future as-yet-unavailable risk studies, with what levels of tested reliability, from what historical periods, collected by what methods, what data might have been discarded as unreliable, etc.

Application never expresses any uncertainties about the validity of databases to be relied upon, and shows no appreciation of the doubts experts often express of such databases, as seen in US DOT/PHMSA's 2009 authoritative and scathing critique of all of its own hazmat transportation modal accident databases, for example, as inadequate for even its own policy-making decisions.
http://www.phmsa.dot.gov/staticfiles/PHMSA/DownloadableFiles/Files/DQA%20Report.pdf

Application's entire methodology indicates a substantial reliance on subjective "professional/engineering judgment" to make decisions for example: "**Hypothetical, credible, high consequence events for each type of accident or malfunction were identified based on professional judgment, experience with similar projects, and input from regulators and the Working Group." [page number??]**

But Application provides no substantial transparency, e.g., not indicating what are the major physical models and engineering assumptions [potentially scores of these] even in the key judgment decisions made. The result of such non-transparency is the inability of any third-party independent reviewer to assess the validity of the methodology.

K. Application indicates that the most important release risk studies are not available.

Application's descriptions of accident potentials in "Section 9.6 On-shore Fires or Explosions" [pp. 9-11ff] continues the pattern of only briefly describing what it suggests are quite serious releases of flammable liquids and gases reaching even off-site onto the Digby Island community, then promptly asserting the adequacy of existing codes and standards, and concluding that the risks are low.

But this section provides evidence that **actually highlights the inadequacy** of the Application in that it states that **key risk studies** related to serious potential LNG releases at the Project have yet to be produced:

- "fire and explosion analyses as per company requirements"
- "a quantitative risk analysis" for the facility [p. 9-12] [which will no doubt have its own technically problematic aspects]
- "vapour dispersion modelling" [p. 9-13]
- experimental test data [p. 9-13]

Applications states **the results of these studies will determine [pp. 9-12 through 9-13] such key Project safety-related features** as:

- "setbacks from occupied areas", and
- "design mitigations"

With the Application's pervading lack of transparency and specificity and its withholding of key studies, it is difficult to take seriously its Conclusions [p. 9-18] that purport to distinguish between some predicted LNG fire or explosion release impacts from the facility that are "significant" or "not significant". In fact, **the distinct impression is that the results of these risk studies are pre-determined**, and are very unlikely to challenge any of Application's premature and peremptory conclusions that the facility risks will be "low."

L. Application declines to consider LNG industry accident risk-related <u>cumulative</u> impacts:

Application should have considered seriously the cumulative impacts of the proposed Digby Island facility along with the six or so other LNG facilities proposed for its Northwest neighborhood. For example, would a surge of LNG shipping in nearby waters raise the chances of serious collisions and potential LNG releases?

It is unfortunate if, as reported by Application, Government of Canada decisions on scope reportedly eliminated the consideration of transportation of natural gas to the proposed facility from mandatory inclusion in the Application, but the Applicant might voluntarily include some such consideration as entirely sensible [as proponents of new crude by rail unloading facilities in California and Washington State have done, in view of significant impacts on residents along the likely major transportation routes to the facilities], given the likely new impacts on transportation infrastructure and new levels of transportation release risk entailed. Application should describe whether the proposed Digby Island facility would entail transportation, by whatever modes, over very long distances and would put at risk many communities.

M. Application ignores potential LNG <u>terrorism</u>-related release potentials and risks: [5]

Application [p. 9-1] does claim to evaluate the effects of "a Project-related **accident**" ["as required in Section 19(1)(a) of the CEAA 2012"], and defines

this as “unexpected occurrence or unintended action”-- which would arguably seem to include sabotage- or terrorism-related LNG releases.

Proximity of the proposed facility to the local airport flight path raises to a higher concern the question of potential terrorism. Especially since the 9/11 attacks with hijacked airliners – US regulators now have mandated locked major airliner cabin doors, but that is not a silver bullet solution to the potential of terrorism by planes of various sizes, as indicated by the No-Fly zones around sensitive terrorist target areas.

Application recognizes the potential at the Digby Island site of “facility impact from aircraft” [p. 9-8], but focuses on the **probability** of the accident potential being “very low” [as if anyone can pretend to be able to ascertain the probability of terrorists’ actions], and does not describe the scope or extent of the potential consequences [“potential interaction with Community Health VCs” – that is Valued Components, possibly meaning people].

[p. 9-8] *“**Facility Impact from Aircraft***

Description of Event or Interactions

There is a potential for an aircraft to directly impact the LNG facility considering that the Project is located within an existing aerodrome, namely the Prince Rupert airport on Digby Island. The types of aircrafts that could be involved in a direct impact to the LNG facility includes airplanes, float planes and helicopters from Project-related, commercial, private and personal/recreational applications.

Safety data are tracked, investigated and documented by the Transportation Safety Board of Canada to analyze safety deficiencies and identify safety risks in the Canadian transportation system. From 2005 to 2014, the number of aircraft accidents per year ranged from 30 to 70 in British Columbia (BC) (TSBC 2014). In 2014, 12% (30) of Canadian-registered aircraft accidents occurred in BC, two of which resulted in a total of three fatalities. That compares with a ten-year annual average of 51 accidents and 17 fatalities. This decreasing trend is attributed to an increase in professionalism (particularly in small and mid-sized commercial operations), high fuel prices resulting in less flying by private enthusiasts, and implementation of safety management systems for larger management systems for larger operations.

Although the probability of facility impact from aircraft is very low, there is potential interaction with the Infrastructure and Services, and Community Health VCs (see Table 9.3-1). The potential consequences of concern from an aircraft directly impacting the LNG facility includes serious injury to people, loss of human life and damage to property and infrastructure. Events that could occur subsequent to an aircraft directly impacting the LNG facility

include on-shore fires or explosions, which are assessed in Section 9.6; and on-shore hazardous spills, which are assessed in Section 9.8."

Application does not describe these impacts with much more detail in that section, however.

Application in this section briefly mentions the "loss of human life", but again without indicating exactly how this could happen or how extensive a loss of life might be experienced. Nor does Application indicate whether the risk of such a facility impact is a significant risk to be mitigated. **Application avoids this risk significance question by trying to have it both ways,** in suggesting inappropriately that it depends [post facto] on whether a life is lost.

[p. 9-10] ***" If a facility impact from an aircraft*** *resulted in the loss of human life, the magnitude of residual effects to community health would be high and within the geographical extent of the LAA. The residual effects would be characterized as a continuous effect that is irreversible with a long-term duration potentially lasting through the life of the Project. The context of residual effects to community health is resilient (moderate) because community health is moderate and slightly vulnerable to social, economic and environmental change.*

The likelihood and consequence of residual effects to community health from a facility impact from an aircraft without the loss of human life are low. In this scenario, the risk matrix ranking would be low and the potential residual effects to community health are ***predicted to be not significant****. The likelihood and consequence to community health from a facility impact from an aircraft resulting in the loss of human life are very high. In this scenario, the risk matrix ranking would be very high and the potential residual effects to community health* ***would be significant."***

The terrorism release question in regard to chemical transportation arises often in the US since 9/11, even in regard to the months-long security training and multi-jurisdictional pre-planning for Special National Security Events or even big crowd events in major NFL stadiums -- see attached. And has also arisen in connection with chemical transportation release risks, e.g., possible use of a hazmat train for terrorist attack on the Denver Democratic National Convention in 2008 forced a daily re-routing of most trains around Denver.

https://www.bnsf.com/employees/communications/railway/pdf/200810.pdf

http://www.huffingtonpost.com/gregory-daurer/denver-officials-ban-buck_b_120061.html

Given that the proposed Aurora facility will be touted as an important new addition to North America's energy infrastructure, it could be an attractive target for the kind of “homegrown” more modest type of terrorism whose potentials are newly appreciated. Application does not deal seriously with terrorism, however. While mentioning various potential mitigations of the aircraft-caused LNG release risk, e.g., whether the flight path could be changed, etc., it does not discuss these in any detail nor indicate whether the Project will adjust its potential flight-path-impacting “gas plumes” accordingly.

Potential LNG terrorism was a major focus of concern regarding a proposed Rhode Island LNG facility. [attached Clarke report commissioned by the Rhode Island AG] Richard A. Clarke Study LNG Facilities in Urban Areas: A Security Risk Management Analysis 2005 for
Attorney General Patrick Lynch Rhode Island **[5]**

As LNG risk expert Dr. Havens also has noted in his 7 28 16 Comment regarding “Intentional events” [p. 7] :

“A Closing Comment on Accidental vs. Intentional Events

…I believe it is just as important that the regulations begin to address the burgeoning problem of the potential for intentional acts against LNG facilities to cause extremely serious fire and explosion cascading events. It is clear that reliance on design of LNG facilities to minimize the probability (measure of likelihood) of accidental occurrences is turned on its head when intentional acts are considered. A simple fact plagues all of the energy industry, including the nuclear power and weapons sectors; it is relatively easy to assemble an explosive device that can be made to explode. ***Designing the same device to ensure that it doesn’t explode is another matter entirely.*** *We can start by doing a better job in applying our scientific knowledge to minimize the extent to which we provide opportunities to those inclined to take advantage. The incorrect use of our scientific tools, so as to mistakenly conclude that the design under consideration is a benign one, leads us in the wrong direction.”*

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--- Fred Millar, Ph.D. is an expert on energy transportation risks, based in Washington DC, and has testified by invitation in local and national legal

and legislative proceedings involving nuclear, chemical and crude oil transportation.

--------- END NOTES -------

[1] ***Algerian Explosion Stirs Foes of U.S. Gas Projects*** **By** SIMON ROMEROFEB. 12, 2004

http://www.nytimes.com/2004/02/12/business/algerian-explosion-stirs-foes-of-us-gas-projects.html?_r=0

Blast at U.S. LNG site casts spotlight on natural gas safety Reuters 4 6 14 [Plymouth WA] http://www.reuters.com/article/us-lng-blast-analysis-idUSBREA3506Y20140406

Review of Vapor Cloud Explosion Incidents MH/15/80 Lead Authors: Graham Atkinson and Jonathan Hall Contributing Authors: Alison McGillivray Technical Reviewer: Jill Wilday Editorial Reviewer: Mike Wardman April 11th 2016

See link at: PHMSA Workshop on LNG regs YouTube 4 sessions taped includes references to historical LNG accidents.

http://phmsa.dot.gov/pipeline/public-workshop-on-liquefied-natural-gas-lng-regulations

Several online sources list the history of worldwide LNG “incidents”.

[2] Governments and experts in the US and elsewhere have taken the risk of potential LNG catastrophic releases seriously for decades, e.g.:

Lessons learned from LNG safety research Ronald P. Koopman, Hazard Analysis Consulting, 4673 Almond Circle, Livermore, CA 94550, Donald L. Ermak Lawrence Livermore National Laboratory

Available online 20 October 2006 Abstract

During the period from 1977 to 1989, the Lawrence Livermore National Laboratory (LLNL) conducted a liquefied gaseous fuels spill effects program under the sponsorship of the US Department of Energy, Department of Transportation, Gas Research Institute and others. The goal of this program was to develop and validate tools that could be used to predict the effects of a large liquefied gas spill through the execution of large scale field experiments and the development of computer models to make predictions for conditions under which tests could not be performed. Over the course of the program, three series of LNG spill experiments were performed to study cloud formation, dispersion, combustion and rapid phase transition (RPT) explosions.

[3] The most recent compelling evidence of US and UK government interest in revising inadequate LNG safety regulations was the May 2016 PHMSA Workshop on LNG regulations attended by 200 experts – see video on YouTube 4 sessions taped includes references to historical LNG accidents: "This public meeting is to solicit input and obtain background information for the formulation of a future regulatory change to CFR 49 Part 193, Liquefied Natural Gas Facilities. Invited speakers include the National Fire Protection Association (NFPA), the Pipeline Safety Trust (PST), the American Gas Association (AGA), and the LNG industry."
http://phmsa.dot.gov/pipeline/public-workshop-on-liquefied-natural-gas-lng-regulations

In a specific LNG siting proceeding context, Professors Jerry Havens and James Venart also have made a compelling case in their comment on the Jordan Cove Export Terminal [FERC Docket No CP13-483] January 14, 2015 that the US LNG terminal safe-siting policy is faulty, in that the existing federal safety standards "have not been subject to adequate science based review and appear to provide inadequate fire and explosion exclusion zones to protect the public."

Application must address the serious Havens-Venart safety questions raised at the national level in a Washington DC stakeholder meeting called to address them, and the subsequent report from UK HSE experts that confirm their validity.

1-14-2015 filing submitted to FERC by Jerry Havens and James Venart under CP13-483. http://elibrary.FERC.gov/idmws/file_list.asp?accession_num=20150114-5038

2-6-2015 filing submitted to FERC 2-6-2015 - Supplementary Comment with Questions by Jerry Havens and James Venart under CP13-483.
http://elibrary.FERC.gov/idmws/file_list.asp?accession_num=20150206-5040

Submitted by Jerry Havens Distinguished Professor of Chemical Engineering University of Arkansas James Venart Professor Emeritus of Mechanical Engineering University of New Brunswick Regarding the Jordan Cove Export Terminal Draft Environmental Impact Statement Docket No. CP13-483 January 14, 2015 UNITED STATES LNG TERMINAL SAFE-SITING POLICY IS FAULTY

https://elibrary.ferc.gov/idmws/file_list.asp?accession_num=20150114-5038

NATURAL GAS: Explosive LNG issues grab PHMSA's attention -- Tuesday, June 7, 2016 -- www.eenews.net

http://citizensagainstlng.com/wp/2015/01/20/scientist-say-united-states-lng-terminal-safe-siting-policy-is-faulty/

https://valleygreenspace.files.wordpress.com/2015/10/havens-and-venart-ferc-jce-deis-comment.pdf

*"**Catastrophic UVCEs are Becoming More Frequent** [comment on Jordan Cove Energy JCE DEIS proceeding docket]*

Confirmed scientific knowledge of the causes of UVCEs ***indicates that their frequency would increase with the potential for release of large quantities of hydrocarbons, especially highly volatile ones****. As we have stated earlier, the sizes of flammable hydrocarbon vapor clouds described in the JCE DEIS have lateral dimensions of up to 720 meters (~2,400 feet).*

To our knowledge, there have been no UVCEs in the continental United States involving flammable clouds that large. The largest vapor cloud considered at JCE, which would follow a spill of ~3/4 million gallons of LNG, involves the most volatile of the hydrocarbons, methane (CH4), which is lowest on the explosion sensitivity scale; but the mixed refrigerant liquid (MRL) spills are very large, and they approach the range of maximum sensitivity to explosion.

It appears that the ***relative rarity of large UVCEs (until recently)*** *is very likely due to the fact that most of the very large spills that have occurred did not evaporate rapidly enough, and/or were dispersed readily by the action of wind, to allow formation of a large flammable cloud . But,* ***now there have been at least four instances within the last ten years of devastating UVCEs following very large releases of gasoline class hydrocarbons*** *where the evaporation of the fuels was rapid enough, and the wind speed essentially non-existent, to allow the formation of flammable vapor clouds with lateral dimensions of several hundred meters. In all four cases these clouds were ignited (presumably accidentally) and the explosions resulted in cascading events leading to catastrophic damages to the facilities (refineries/tank-farms) and injury/and/or deaths in the public sector.*

The first occurred in December, 2005, at Buncefield in the United Kingdom. There followed three more: Jaipur, India, 2009; San Juan, Puerto Rico, 2009; and Amuay, Venezuela, 2012. The following facts are a matter of record for all four:

• The events occurred in very low wind (near calm or calm) weather conditions.

• The maximum linear extents of the flammable clouds were at least 250 meters, ranging to at least 650 meters at Amuay.

• UCVEs occurred in every case that registered above 2.0 on the Richter Scale.

• The initiating explosions resulted in cascading events leading to total loss of the facilities.

We provide below photographs of these accidents (depicting the cascading fire and explosion effects) indicating the catastrophic damages that resulted. In our view, these four events, which have similar descriptions of the weather conditions and physical factors that could cause extremely 18 large flammable vapor clouds to form, and with which the vapor cloud scenarios considered in the JCE DEIS are clearly similar, ***should be a clear warning to parties planning facilities with similar potential for catastrophe. Buncefield, United Kingdom Jaipur, India Amuay, Venezuela San Juan, Puerto Rico Scientific Conclusions re the Buncefield Event are Directly Relevant to the JCE DEIS.***

To our knowledge, detailed reports of the explosions in India, Venezuela, and Puerto Rico have not been completed. However, during the decade 2005-2015 since the Buncefield explosion occurred there have been published extensive reports of analyses thereof. ***The Buncefield explosion, which has been definitely established to be a UVCE, is thought to be the largest explosion that has occurred in peacetime Europe; damages now exceed two billion dollars.*** *In 2012, there appeared a paper in the Philosophical Transactions of The Royal Society (Great Britain) by D. Bradley, G.A. Chamberlain and D.D. Drysdale5 entitled "Large vapour cloud explosions, with particular reference to that at Buncefield". As this paper appears to be the most 5 Phil. Trans. R. Soc, A 2012 370, doi: 10 1098/rsta.2011.0419, published 2 January 2012 19 recent to summarize the present understanding of the increasing potential hazards of unconfined vapor cloud explosions (UVCE) of hydrocarbon-air mixtures, we quote directly from the Conclusions section thereof: A number of mechanisms for the propagation of combustion have been discussed, without reaching any definite conclusions as to what precisely happened at Buncefield. [pp. 18-20 in Jordan Cove submission]*

[4] Vivid graphical depictions of potential accidents and their potential impact on at-risk populations, buildings, and environmental features are standard in any serious assessments of the risks of an existing or proposed facility. Such documents have been important in debates on siting LNG facilities in urban areas. See http://www.ecori.org/social-justice-archive/2015/8/3/national-grid-wants-to-bring-new-lng-project-to-providence-waterfront

https://books.google.com/books/about/LNG_Facilities_in_Urban_Areas.html?id=ZRuhNwAACAAJ

www.acushnet.ma.us/lng-advisory-committee/files/scnu-presentation

More generically for all high-risk chemical facilities, see the longstanding 1990's era US EPA guidance documents on graphic "plume mapping" and blast-zone depictions of high-risk chemical facilities, used by Local Emergency Planning Committees and similar depictions in many industry reports, available online at the EPA websites for the 1986 Emergency Planning and Community Right to Know Act [cf. both NRT-1 and Technical Guidance for Hazard Analysis] and for the EPA's Risk Management Plan Program under the Clean Air Act Amendments of 1990 Section 112 r, especially Guidance for Offsite Consequence Analysis, both generic and for specific industry groupings:

https://www.epa.gov/epcra

https://www.epa.gov/rmp/risk-management-plan-rmp-rule-overview

Multiple US agencies regulate different aspects of safety of LNG facilities:

http://www.phmsa.dot.gov/pipeline/technical-resources/liquefied-natural-gas/regulatory-information

[5] http://www.lbreport.com/news/may05/lngri.htm LBR summary of Richard Clarke 2005 report LNG facilities in urban areas: security aspects

http://www.worldcat.org/title/lng-facilities-in-urban-areas-a-security-risk-management-analysis-for-attorney-general-patrick-lynch-rhode-island/oclc/60341827?referer=di&ht=edition

LNG facilities in urban areas : a security risk management analysis for Attorney General Patrick Lynch, Rhode Island

Author: Richard A Clarke; Patrick Lynch; Pro Bono Publico.