22.0 ACCIDENTS AND MALFUNCTIONS

The assessment of potential accidents or malfunctions for the Project was provided in Section 22 of the EIS. This section of the EIS Addendum provides:

- An update to the Accidents or Malfunctions VC as a result of the project changes
- Responses to requests for additional information from the federal government (August 14, 2014)
- Updated conclusions on the assessment of Accidents or Malfunctions, taking into account project changes and the requested additional information.

Table 22-1 lists the documents applicable to Accidents and Malfunctions submitted by PNW LNG as part of the environmental assessment process to date and identifies if information is either *updated by EIS Addendum, superseded*, *not relevant*, or *not affected* by information in the EIS Addendum. The following sections of the EIS Addendum contain information that updates the documents classified as *updated by EIS Addendum* in Table 22-1. Figure 12-1 has been updated from that provided in the EIS to reflect the project changes and any other applicable updates.

Table 22-1 Status of Previously Submitted Documents

Document Name	Status
Section 22 of the EIS (February 2014)	Updated by EIS Addendum
Technical Memorandum: LNG Carrier Explosion (June 23, 2014)	Updated by EIS Addendum
Technical Memorandum: Vessel Collisions with Marine Mammals (June 23, 2014)	Not affected
Technical Memorandum: Marine LNG Spill (June 23, 2014)	Updated by EIS Addendum
Technical Memorandum: Cumulative Effects Assessment and Significance Determination for Effects of Accidents and Malfunctions (June 23, 2014)	Updated by EIS Addendum
Responses to the Working Group (June 2014)	Updated by EIS Addendum

22.1 PROJECT EFFECTS ASSESSMENT UPDATE

22.1.1 Approach

The following five accident or malfunction scenarios were considered in the EIS:

- Scenario #1: Emergency Flaring and liquefied natural gas (LNG) Facility Shutdown
- Scenario #2: Explosion or Fire
- Scenario #3: Fuel or Hazardous Materials Spills
- Scenario #4: LNG Spills
- Scenario #5: Marine Vessel Grounding, Collision or Allision.

The marine terminal design mitigation does not affect the assessment of the accidents or malfunctions scenarios listed above and they remain valid for the purpose of effects assessment. An additional accident or malfunction scenario was identified in consideration of the marine terminal design mitigation and during review of the EIS:

- Scenario #6: Aircraft collision with the flare stack or the bridge towers.

22.1.2 Baseline Conditions

The baseline conditions described in the EIS have not changed for VCs potentially affected by project related accidents or malfunctions compared with the baseline information presented in the EIS and subsequent technical memorandums. The marine terminal design mitigation results in the relocation of the marine terminal berth by about 510 m from the location described in the EIS, as well as a 1.6 km suspension bridge supported by two 128 m tall towers. This change does not affect the baseline conditions.

22.1.3 Scenarios #1 to #5

The effects of the **emergency flaring and LNG facility shutdown** scenario, **explosion or fire** scenario, **fuel or hazardous material spill** scenario, **LNG spill** scenario and **marine vessel grounding, allision, or collision** scenario are the same as described in the EIS. Potential effects from this scenario on most VCs are expected to be not significant, and characterizations of effects (i.e., context, magnitude, extent, duration, frequency, reversibility) remain the same as described in the EIS (see Technical Memorandum: *Cumulative Effects Assessment and Significance Determination for Effects of Accidents and Malfunctions* submitted in June 2014).

In the unlikely event that a listed species were killed during **flaring**, by an **explosion or fire**, by a **fuel, hazardous material** or **LNG spill**, residual effects on terrestrial wildlife and marine birds could be significant.

If an **explosion or fire** or a **fuel or hazardous materials spill** were to disturb the red-listed ecological community on the northwestern perimeter of Lelu Island (see Figure 10-4 of the EIS Addendum), effects on vegetation could be significant. In such an event, the ecological functions provided by that wetland could be offset through additional habitat compensation.

Marine resources, including marine mammals, could be affected by a rapid phase transition-type **explosion**.
If a listed species were killed by a rapid phase transition, effects on marine resources could be significant. If a **fuel, hazardous material** or **LNG spill** were to occur over Flora Bank, at a low tide, during a period of high juvenile salmon abundance, there could be effects on local salmon populations, which could be significant. However, this circumstance is considered to be very unlikely given species utilization of the area (see response to Accidents or Malfunctions Information Request #1 in Section 23.2.1). If concerns with a fishery prompted fishery closures, effects on marine resource use, the economic environment, and current use of lands and resources for traditional purposes could also be significant.

Ship strikes to marine mammals may also cause injury and potential mortality (See the Technical Memorandum: *Vessel Collisions with Marine Mammals* submitted in June 2014 for further details). Overall, the project mitigation measures are anticipated to greatly reduce the likelihood of serious injury to marine mammals associated with vessel collisions. While there is some potential for a lethal vessel strike to occur, the probabilities are considered to be very low; for the majority of marine mammal species present, population level effects are not expected and effects are not expected to be significant. However, if a listed species were killed, effects could be significant.

For the assessment of project effects on mortality of listed species (See Appendix A of the EIS Addendum) a component of the significance threshold is "any residual effect with a high likelihood of causing mortality to species at risk". By definition, an accident or malfunction is an unlikely event that is not anticipated as a routine aspect of project construction, operations, or decommissioning. The EIS assumes that any accident or malfunction, should it occur, has the potential to cause significant adverse effects, including the mechanism above (i.e., through accidental mortality of a species at risk). The assessment of effects of accidents and mulfunctions therefore focusses on (1) the qualitative likelihood of such an event occurring, and (2) mitigation measures and best practices that will be applied to reduce the likelihood of an accident or malfunction occurring. While vessel strikes with marine mammals can and do occur, these occurrences are extremely infrequent relative to the volume of vessel traffic. The likelihood of any individual vessel fatally striking a whale is also quite low, particularly at the speeds travelled [weighted average of ~ 7 knots across the regional assessment area (RAA)].

The probability of injury or direct mortality to human and ecological receptors outside the facility from an **explosion or fire** outside the facility are less than one in ten million (for a receptor in place 24 hours per day, 365 days per year) However, any death that resulted from an explosion or fire would be a significant effect on human and ecological health; as noted, such a death is highly unlikely.

If effects of an **explosion or fire** were to spread beyond the "sterile zone" around the flare stack (the size of which is based on modelled thermal radiation levels from the flare) into the vegetative 30 m buffer zone around the facility, irreversible damage could occur to culturally modified trees in the zone. If these heritage resources were not fully documented, effects on archaeological and heritage resources could be significant. However, this is considered to be unlikely given that the local assessment area (LAA) has been subject to an archaeological inventory study.

22.1.4 Scenario #6: Aircraft collision with the flare stack or the bridge towers

22.1.4.1 Description of the Possible Scenario

The flare stack extends up to 181 m above ground level, and has potential for thermal effects during flaring events that extend up to 641 m above ground level. The two suspension bridge towers associated with the marine terminal design mitigation extend 140 m (460 feet) above sea level. Aircraft operate in the vicinity of the Project, associated with three bases:

- Prince Rupert Airport:
  - approximately 7 nm (13 km) northwest of the bridge
  - approximately 8 nm (15 km) northwest of the flare stack
- Digby Island Seaplane Base:
  - approximately 8 nm (15 km) north of the bridge
  - approximately 8.4 nm (16 km) north of the flare stack
- Seal Cove Seaplane Base:

- approximately 9 nm (17 km) north of the bridge
- approximately 8 nm (15 km) north of the flare stack.

The credible worst-case scenario is that an aircraft collides with one of the three structures. The single runway at Prince Rupert Airport is aligned such that aircraft approaching from or departing to the southeast could fly over the marine terminal (see Figure 22-3). However, the obstacle limitation surface for the airport extends 3,000 m from the end of the runway, has a 2.5 degree angle of inclination, and widens at a 15 degree angle laterally from either side of the runway (pers. comm. Richard Reed, Prince Rupert Airport Manager). Because the flare stack and bridge are more than 10 km from the end of the runway, they are well outside the obstacle limitation surface for the airport and vertical separation distances will be sufficient. Because the flare stack is over 10 km from the runway and has sufficient separation distance, thermal radiation during emergency flaring events is also not expected to adversely affect civil aviation associated with Prince Rupert Airport.

Seaplanes using these bases reach cruising altitudes (typically 200 to 500 feet above sea level (asl) [60 to 150 m]) shortly after take-off and well before reaching the marine terminal. Discussions with local seaplane operators (Inland Air Charters Ltd.; Ocean Pacific Air) indicate that aircraft flying under visual flight rules (VFR) currently use the airspace in the vicinity of Lelu Island (e.g., to and from Porcher Island and along Inverness Passage; South Corridor VFR Route), including over the marine terminal (Figure 22-3). Both operators indicated that with updated navigational charts, proper marking and lighting, and distribution of NOTAMs (notices to airmen), the bridge and flare stack would not adversely affect their operations. Pilots would avoid the bridge and flare stack as they would any other obstacle. NOTAMs are not expected to mitigate specific emergency flaring events (unless they are scheduled). Map updates and NOTAMs are intended to encourage pilots to avoid the potential thermal effect radius of the flare at all times (not just during emergency flaring events).

Effects of thermal radiation are not expected to have an effect on seaplane operations since effects of thermal radiation would only interact with seaplanes during flaring. Since current VFR routes do not cross the thermal effect radius of the flare, and because updated navigation maps and NOTAMs will make operators aware of the flare location no effects on seaplane operations are expected.

A preliminary search of online sources did not reveal any publications or incidents concerning the interactions between small aircraft and flare towers.

22.1.4.2 Project Design Measures to Reduce Risk

Transport Canada is responsible for developing safety standards, policies, and criteria for obstacle limitation surfaces in the vicinity of airports. Transport Canada also issues marking guidelines, the Standards Obstruction Markings Manual (Standard 621.19), for structures that are considered obstructions under the *Canadian Aviation Requirements* (CARs). Although compliance to the Standards Obstruction Markings is generally voluntary, a proponent may be ordered by the minister to mark a structure deemed to be hazardous to aviation safety because of its height and location. During the detailed design phase of the Project, the “Aeronautical Assessment Form for Obstruction Marking and Lighting” will be submitted to Transport Canada for an Aeronautical Obstruction Clearance assessment of the bridge and flare stack.

The bridge and flare stack will require marking or lighting as per Standard 621.19 of the CAR. PNW LNG will ensure that all regulatory requirements with respect to aviation safety are met. This will include revisions to aeronautical charts to identify the location and height of the bridge towers and the flare stack, and the use of marking or lighting on the bridge, towers and flare stack as prescribed in Standard 621.19 of the CAR.

22.1.4.3 Emergency Response Approach

In the event of an aircraft collision with facility infrastructure, the primary goal would be to protect human safety. Measures would be taken to limit the potential effects of additional hazards caused by damage to facility infrastructure. Appropriate actions would be outlined in greater detail in the Emergency Response Plan for the Project, but would follow the general steps outlined in Section 22.5.3 of the EIS. Depending on the severity of the collision, emergency response could be similar to the response for the Emergency flaring and LNG facility shutdown scenario, the explosion or fire scenario, the fuel or hazardous material spill scenario or the LNG spill scenario.

22.1.4.4 Clean-up and Restoration Methods

Clean-up and restoration methods would vary depending on the severity of the collision, and the degree and type of damage to the facility. Methods could be similar to those for the emergency flaring and LNG facility shutdown scenario, the explosion or fire scenario, the fuel or hazardous material spill scenario or the LNG spill scenario.

22.1.4.5 Potential Environmental Effects

No direct effects of an aircraft collision with facility infrastructure are expected to occur. If damage to the facility is sufficiently severe, effects arising from that damage are expected to be the same as those identified by the other five accident or malfunction scenarios. Characterization of these effects (i.e., context, magnitude, extent, duration, frequency, reversibility) will vary according to the types of secondary effects arising from an aircraft collision; these effects are characterized the same as for the other five scenarios (see Technical Memorandum: *Cumulative Effects Assessment and Significance Determination for Effects of Accidents and Malfunctions* submitted in June 2014). Thus, under most circumstances, effects are expected to be not significant (see Section 22.1.3 of the EIS Addendum). Effects could be significant if a listed species were killed as a result of a collision. However, with the project changes and mitigation measures, the likelihood of any collision occurring is considered to be very low and significant effects are unlikely.

22.2 CUMULATIVE EFFECTS ASSESSMENT UPDATE

The project changes are not expected to result in a material change to the assessment of residual cumulative effects from project related accidents and malfunctions. Most scenarios are not expected to have cumulative effects. Cumulative effects on marine resources from marine mammal strikes are expected to be not significant. However, if a listed species (such as a fin whale) died as a result of a vessel collision, cumulative effects on marine resources could be significant (the same significance rational as presented in Section 22.1.3 with respect to marine mammals applies in the cumulative case). Small hazardous material spills could result in cumulative effects, but these are expected to be not significant.

Potential effects arising from aircraft collisions with the flare stack or bridge towers could act cumulatively with navigation hazards associated with other proposed projects, such as the flare stack for the proposed Prince Rupert LNG Project. However, the same mitigations presented for this Project would be expected to be in place for other navigational hazards; therefore, cumulative effects are also expected to be not significant, unless a human fatality occurs or a listed species is killed.

22.3 RESPONSES TO THE OUTSTANDING INFORMATION REQUESTS

This section is prepared in response to the request for Outstanding Information received from the CEA Agency on August 14, 2014.

22.3.1 Accidents or Malfunctions Information Request #1

22.3.1.1 Government of Canada – Outstanding Information

DFO: *The proponent has not provided sufficient information to determine potential effects to local salmon population resulting from an accident or malfunction. To understand impacts to local salmon populations the proponent first needs to understand salmon utilization and dependency on the habitats that could be potentially impacted, and update the assessment of effects from accidents and malfunctions accordingly.*

22.3.1.2 Response

LNG spills originating from a full rupture or failure at the marine terminal (including bridge, trestle, berth, LNG cryogenic lines and LNG loading lines/arms connected to berthed LNG vessels) have a probability of recurrence of 7.6 in 10,000,000 years (Section 22.7.1 of the EIS). A LNG loading line rupture over marine waters would involve a shutdown of flow in the line in 30 seconds through operation of the system of emergency shut-down valves. A full catastrophic failure of all systems from a leak or failure in the LNG loading lines would include a maximum of four minutes release before manual shut-down, in the event that the automatic emergency shut-down system failed. This would result in a potential release of 800 m^3 of LNG, given maximum flows of 12,000 m^3/h in the cryogenic line.

The cryogenic line includes additional protection from leak and failure by a fully insulated outer layer around the entire length of line, and is on top of a fully sealed deck surface across the entire width and length of the marine terminal (bridge, trestle and berth). It will be approximately 3 m adjacent to the marine berth to 11 m adjacent to the southwest tower, above the water surface at high tide (underside of the deck), and approximately 10 to 18 m at low tide (7 m tide range). The lines are positioned approximately 1 to 2 m above the marine terminal underside deck. A spill from the line is designed to flow down the length of the marine terminal from the leak point toward the marine terminal berth area, prior to any potential spill onto the water surface.

If the spill reaches the water, the extent of the LNG pool formation on the water surface depends on the drop height, LNG flow rate and size of leak, and marine water temperature. The potential drop height from the deck surface of the marine terminal (trestle and bridge) to the water surface ranges from 3 m (lowest underside deck above the water) at high tide to 18 m at low tide. No exposed sediments are expected under the presented alignment for the marine terminal. Water has greater heat capacity when compared with terrestrial environments. Spills over water, relative to land, will readily vaporize over a potential drop height ranging from 11 to 18 m.

Large sized spills that reach the water surface may form a pool on the water surface until the LNG vaporizes. Because of the drop heights, pool formation is not expected to occur unless a spill takes place during high tide. Should an LNG pool form, it is not expected to penetrate the water surface (Wellman et al. 2004, Luketa et al. 2008). Based on predictions from a maximum leak hole size of the entire diameter of the LNG cryogenic line (up to 36 inches [approximately 900 mm]), pool formation on the water is not expected be greater than approximately 85 m in diameter (Luketa et al. 2008).

Both project specific survey observations and results of past study of habitat characteristics and invertebrate and fish species habitat use, suggest there will be limited or no overlap and potential effect on marine resources from a LNG loading line rupture and spill from the marine terminal deck. Habitat surveys along the marine terminal alignment indicate the presence of soft sediment (silty sand) habitats (see Appendix M, Figure 16 of the EIS). Flora Bank eelgrass distribution mapped for the Project show eelgrass patches at distances greater than 85 m from the edge of marine terminal deck surface (see Appendix M, Figure 27 of the EIS). Polycheate invertebrates and low densities (often < $1/m^2$) of juvenile Dungeness crab (*Metacarinus magister*) were observed in subtidal soft sediment areas (see Appendix M, Figures 18 and 19 of the EIS). Pricklebacks (Stichaeidae), eelpouts (Lycodes spp.), and flatfish species (Pleuronectidae) were observed during habitat surveys in soft sediment habitats around and adjacent to the marine terminal alignment area at low densities (<1 fish/m^2) (see Appendix M, Figure 20 of the EIS).

Project specific surveys observations (see Appendix M of the EIS) of habitat types and fish distribution are consistent with past studies results conducted at Flora Bank and Lelu Island (Higgins and Schouwenburg 1973, Anderson 1986, Gottesfeld et al. 2008, Carr-Harris and Moore 2013). Past studies observed small benthic fish species (sculpins, flatfish) and low numbers of juvenile crab in soft sediment habitats outside areas of eelgrass on the northern edge of Flora Bank (Anderson 1986). Juvenile salmonids were observed during May to June, with smolt migrations at sites on the southern portions of Flora Bank (Horsey Bank) and in low-water channels with strong tidal currents, immediately adjacent to Lelu Island and outer Kitson Island (Higgins and Schouwenburg 1973, Anderson 1986, Gottesfeld et al. 2008, Carr-Harris and Moore 2013). Salmonids were observed in greater numbers in more complex nearshore habitats of Chatham Sound islands, particularly in habitats with pronounced channels and tidal current (Higgins and Schouwenburg 1973, Anderson 1986, Carr-Harris and Moore 2013). Plankton feeding sockeye (*Oncorhynchus nerka*) and pink (*O. gorbuscha*) salmon were observed in large schools outside Lelu Island and Flora Bank in areas of pronounced current following migratory pathways (Manzer 1969, Gottesfeld et al. 2008). Salmonids were not observed in soft sediment shallow depth areas of Agnew Bank and along the northern edge of Flora Bank (Anderson 1987). Based on project specific and past studies, there is little expectation of effects or overlap from a LNG spill (and pool) with existing eelgrass habitats and populations of salmonids, crab, shrimp, flatfish and forage fish species.

Past survey observations of salmonids and juvenile crab along Lelu Island and outside the immediate area of the marine terminal ranged in density from 0 to 2 individuals/m^2 (Higgins and Schouwenburg 1973, Anderson 1986, Carr-Harris and Moore 2013). In the event of a leak and spill from the LNG cryogenic line, the maximum size of an LNG pool on the water surface is 85 m in diameter (Luketa et al. 2008). If this spill overlapped with a school of salmon or herring, the expected exposure of fish will cover less than 50 m^2 of water surface area, not penetrate the water surface, and vaporize within less than 30 seconds. Based on observed fish densities and highest reported catches (~400 smelt) for smelt, herring and salmon densities (caught outside the alignment adjacent to Lelu Island), a leak or spill may overlap with a local school of fish, but is not expected to result in population level effects on fish.

22.3.2 Accidents or Malfunctions Information Request #4

22.3.2.1 Government of Canada – Outstanding Information

Transport Canada: *The flare tower is on or right beside a regularly used flight path for floatplanes and helicopters. The same radius used for effects on the ground by the flare would have to be considered as a "bubble" (i.e., in three dimensions surrounding the flare). The "Flammable Hazard Zone" depicted in Fig 22-1 of the EIS shows this zone intersects the route of small aircraft flying to and from the south from Porcher Island and along Inverness Passage. Update your assessment of effects to air navigation from emergency flaring based on this information. In your assessment, consider including references to any studies published in regards to interactions between small aircraft and flare towers, as well as communications with the airport and seaplane base operators to date.*

22.3.2.2 Response

Flare stacks are a key safety measure at LNG facilities to prevent the accumulation of gases that could pose a hazard to humans or the environment. While pilot lights will be ignited continuously, emergency flaring is a short term event and generally lasts for less than one hour.

Heat radiation characteristics of ignited gas releases during emergency flaring events were analysed during the front end engineering design (FEED) phase of the Project. Results of these studies were used to determine the flare stack height required to meet heat radiation limits at the sterile area boundary (60 m from base of stack) and then the distance from the base of the stack to the Public Short Term Exposure Limit of 2.37 kW/m^2 (CSA Z276-11, Liquefied Natural Gas – Production, Storage, and Handling; Petronas Technical Standard 80.45.10.10, Design of Pressure Relief, Flare and Vent Systems). The most conservative estimates from the engineering studies under emergency flaring conditions are used in these calculations including a stack height of 181 m above ground level (agl), flame height of 30 m, and radius from the base of the flare stack to the Public Short Term Exposure Limit of 350 m. The base of the stack is at 32 m agl.

Based on these results, the Public Short Term Exposure Limit (2.37 kW/m^2) will appear as a sphere with a radius of 413 m from the centre of the flame (Figure 22-2). Under emergency flaring events, the effective height of the flare stack will be the sum of ground level at the base of the stack, stack height, half of the flame height, and the radius of the sphere [total height 641 metres above sea level (m asl)].

Potential interference of the flare stack with civil aviation could occur in two ways. The stack could project vertically into the obstacle limitation surface for the Prince Rupert Airport, interfering with take-off and landings of aircraft navigating under both VFR and instrument flight rules, and it could project laterally into VFR routes of small aircraft, including seaplanes and helicopters. The location of the flare stack relative to nearby airports, seaplane bases, and heliports is shown on Figure 22-3.

Prince Rupert Airport, the closest airport to the potential bridge, is located approximately 8.0 nm (14.8 km) northwest of the flare stack. The single runway at Prince Rupert Airport is aligned such that aircraft approaching from or departing to the southeast would pass to the west of Lelu Island approximately 4.2 km from the flare stack (Figure 22-3). The obstacle limitation surface for the airport extends 3,000 m from the end of the runway, has a 2.5 degree angle of inclination, and widens at a 15 degree angle laterally from either side of the runway (pers. comm. Richard Reed, Prince Rupert Airport Manager). As a result, the flare stack is well outside the obstacle limitation surface for the airport, and thermal radiation during emergency flaring events is not expected to adversely affect civil aviation on approach or take/off from Prince Rupert Airport.

Digby Island Seaplane Base and Seal Cove Seaplane Base are located approximately 8.4 nm (15.6 km) and 8.3 nm (15.3 km) north of the flare stack, respectively. Seaplanes using these bases reach cruising altitudes (typically 200 to 500 feet [or 60 to 150 m] asl) shortly after take-off and well before reaching the marine terminal. Discussions with local seaplane operators (Inland Air Charters Ltd.; Ocean Pacific Air) indicate that aircraft flying under VFR currently use the airspace in the vicinity of Lelu Island (e.g., to and from Porcher Island and along Inverness Passage; South Corridor VFR Route). Both operators indicated that with updated navigational charts, proper marking and lighting, and distribution of NOTAMs (notices to airmen), the flare stack would not adversely affect their operations. Pilots would avoid the flare stack as they would any other obstacle. NOTAMs are not expected to mitigate specific emergency flaring events (unless they are scheduled). Map updates and NOTAMs are intended to encourage pilots to avoid the potential thermal effect radius of the flare at all times (not just during emergency flaring events).

Effects of thermal radiation are not expected to have an effect on seaplane operations since effects of thermal radiation would only interact with seaplanes during flaring. Since current VFR routes do not cross the thermal effect radius of the flare, and because updated navigation maps and NOTAMs will make operators aware of the flare location no effects on seaplane operations are expected.

During the detailed design phase of the Project, the "Aeronautical Assessment Form for Obstruction Marking and Lighting" will be submitted to Transport Canada for an Aeronautical Obstruction Clearance Assessment of the flare stack. The flare stack will require marking and/or lighting as per Standard 621.19 of the CAR. A preliminary search of online sources did not reveal any publications or incidents concerning the interactions between small aircraft and flare towers.

PNW LNG will ensure that all regulatory requirements with respect to aviation safety are met. This will include revisions to aeronautical charts to identify the location and height of the flare stack and the use of marking and/or lighting as prescribed in Standard 621.19 of the CAR. In addition, PNW LNG will schedule educational meetings with the Canadian Owners and Pilots Association and the Canadian Air Line Pilots Association to discuss the aviation risks associated with the flare stack.

22.3.3 Accidents or Malfunctions Information Request #7

22.3.3.1 Government of Canada – Outstanding Information

DFO: *The proponent has stated that "Fish are more likely to be present should RPT take place, and shockwaves could result in high fish mortalities, but it is unlikely that this would result in population-level effects on fish species." The proponent has not provided data to support the claim that population level effects on fish are unlikely to occur in the event of on RPT. The proponent needs to understand fish utilization and dependency on habitat in the area before concluding on population level impacts, and update the assessment of effects from accidents and malfunctions accordingly.*

22.3.3.2 Response

As noted in Section 22.5.5.7 of the EIS and the Technical Memorandum: *LNG Carrier Explosion* submitted in June 2014, a marine LNG spill could result in a Rapid Phase Transition (RPT) event. An RPT event could occur because of a spill from facility infrastructure (LNG cryogenic line or loading line spill), a spill from an LNG carrier while at berth (collision by another vessel), or a spill from an LNG carrier while under way through Chatham Sound (e.g., collision, allision or grounding). Should an LNG spill undergo RPT, there could be injury or mortality to marine mammals, fish, or marine birds located in the immediate vicinity of the spill due to either freezing or shock waves from the RPT. As described below, RPT would be highly localized (to a surface water and near-surface event) and of short duration.

22.3.3.2.1 RPT event associated with an LNG carrier under way in Chatham Sound

Given the very low probability of an RPT event occurring and the localized nature of potential effects, even if a spill were to occur (unlikely of itself), coupled with the unlikely occurrence of marine mammals or large concentrations of fish in close vicinity of an LNG carrier under way through Chatham Sound, it is extremely unlikely that an RPT event involving an LNG carrier underway would result in population level effects on either marine mammals or fish.

LNG vessels have an excellent safety record, with only two serious groundings in the last 30 years, neither of which resulted in the loss of any LNG cargo. While RPT events have occurred under controlled conditions and in tests, no RPT event is known to have occurred as a result of an accidental LNG spill involving LNG transport (ABSG Consulting Inc. 2004). Spontaneous RPT does not occur for LNG containing more than 90% methane (Cleaver *et al*. 1998); the LNG facility of the Project will contain between 91.96% and 97.2% methane. As methane boils off after a spill, however, the reduction in methane concentration can lead to eventual RPT.

22.3.3.2.2 RPT event associated with an LNG carrier at berth

Given the very low probability of an RPT event occurring and the localized nature of potential effects, high concentrations of fish would be needed for an LNG spill and RPT event at the berth to lead to population-threatening levels of harm. The marine terminal berth area is not known to support sensitive marine habitat with life process dependent habitats, where large numbers of fish may congregate (e.g., spawning area). Habitat surveys along the marine terminal alignment indicate the presence of soft sediment (silty -clay) habitats (see Appendix M, Figure 16 of the EIS). Polycheate invertebrates, shrimp and low densities (< $1/m^2$) of juvenile Dungeness crab (*Metacarinus magister*) were observed in subtidal soft sediment areas (see Appendix M, Figures

18 and 19 of the EIS). Pricklebacks (Stichaeidae), eelpouts (Lycodes spp.), and flatfish species (Pleuronectidae) were observed in soft sediment habitats in the area around and adjacent to the marine terminal at low densities (see Appendix M, Figure 20 of the EIS). Given the localized nature of the potential impact and knowledge of the berth area, and widespread distribution of most fish species and populations, it is extremely unlikely that an RPT event at the berth area would create any population-level effects on marine fish. No life process dependent habitats have been observed near or adjacent to the marine terminal.

22.3.3.2.3 RPT event associated with an LNG cryogenic line or loading line spill

Project specific surveys observations (see Appendix M of the EIS) of habitat types and fish distribution are consistent with past studies results conducted at Flora Bank and Lelu Island (Higgins and Schouwenburg 1973, Anderson 1986, Community Fisheries Development Centre 2001, Gottesfeld et al. 2008, Carr-Harris and Moore 2013). Past studies observed small benthic fish species (sculpins, flatfish) and low numbers of juvenile crab in soft sediment habitats outside areas of eelgrass on the northern edge of Flora Bank (Anderson 1986). Juvenile salmonids were observed during May to June, with smolt migrations at sites on the southern portions of Flora Bank (Horsey Bank) and in low-water channels with strong tidal currents, immediately adjacent to Lelu Island and outer Kitson Island (Higgins and Schouwenburg 1973, Anderson 1986, Community Fisheries Development Centre 2001, Gottesfeld et al. 2008, Carr-Harris and Moore 2013). Salmonids were observed in greater numbers in more complex nearshore habitats of Chatham Sound islands, particularly in nearshore habitats with complex habitats, channels and tidal current (Higgins and Schouwenburg 1973, Anderson 1986, Community Fisheries Development Centre 2001, Carr-Harris and Moore 2013). Plankton feeding sockeye (*Oncorhynchus nerka*) and pink (*O. gorbuscha*) salmon were observed in schools outside Lelu Island and Flora Bank in areas of stronger tidal current following offshore migratory pathways (Manzer 1969, Gottesfeld et al. 2008). Salmonids were not observed in soft sediment shallow depth areas of Agnew Bank and along the northern edge of Flora Bank (Anderson 1987). Based on project specific and past studies, there is little expectation of effects or overlap from an RPT event from an LNG spill with existing eelgrass habitats and populations of salmonids, crab, shrimp, flatfish and forage fish species.

Past survey observations of salmonids and juvenile crab along Lelu Island and outside the immediate area of the marine terminal ranged in low densities (Higgins and Schouwenburg 1973, Anderson 1986, Carr-Harris and Moore 2013). In the event of a leak and spill from the LNG cryogenic line, the maximum size of an LNG pool on the water surface is 85 m in diameter (Luketa et al. 2008). Based on observed fish densities and highest reported catches (~400 smelt) for smelt, herring and salmon densities (caught outside the alignment adjacent to Lelu Island), if this an RPT event resulted from a spill it might overlap with a local school of fish, but is not expected to result in population level effects on fish.

RPT is only likely to occur when there is significant mixing of the spilled LNG with the receiving water (Cleaver *et al*. 1998; United States Department of Energy 2012). This mixing is generally only observed with high velocity or high flow rate spills (Cleaver *et al*. 1998; United States Department of Energy 2012). The level of mixing correlates strongly with the severity of an RPT event (Cleaver et al. 1998; Sauter et al. 2004). Because of the high flow rates in loading arms (4,000 m^3/h), mixing could be sufficient to result in RPT. However, the relative low volumes that could be released from a loading arm (less than 100 m^3) would limit the severity of an overpressure event from RPT. Controlled experiment with LNG RPT indicates releases of up to 5.6 kJ/L of LNG; however this energy is only released by the portion of LNG that undergoes significant mixing and subsequent RPT (Sauter et al. 2004).

Should an RPT event take place, overpressure can result in both the water and air at the spill site. Overpressures of tens of bar have been recorded close to a spill site, but have very short duration (less than 10 milliseconds). Water overpressure also decreases rapidly with distance, so any potential damage from the overpressure is likely to be extremely localized (Cleaver et al. 1998).

22.3.3.2.4 Summary

Potential environmental effects of an RPT event at the marine terminal would be similar to those should an RPT event occur anywhere in the marine environment. This includes the potential for acoustic effects on marine organisms, particularly marine mammals, as a result of the event. Shockwaves could result in high fish mortalities adjacent to and in the immediate vicinity of the RPT event. However, the very low probability of an RPT event occurring and the localized nature of potential effects, combined with a lack overlap with marine mammal presence, or likely high concentrations of fish, means that effects on marine mammals, and population level effects on fish are not expected. Therefore, potential effects are expected to be not significant.

The focus of mitigation measures for an LNG spill (and potential risk from RPT) is on prevention. This includes emergency shutdown systems to prevent or limit the size of spills from LNG handling infrastructure at the facility, as well as collisions prevention and spill-preventing design mitigations for LNG carriers.

22.3.4 Accidents or Malfunctions Information Request #8

22.3.4.1 Government of Canada – Outstanding Information

Transport Canada: *The scenario presented by the proponent would be a vessel or barge hitting the trestle at right angles to the pipe with a full or partial breech. It is unclear from the proponent's response whether the valves in question can shut off the flow at the pipe junction where the pipe goes from land to trestle. Do the volumes and times indicated in the memo apply to this scenario? If not, please indicate what they are. Also indicate where the likely location of the valves is including valves to the land on the trestle at the loading platforms.*

22.3.4.2 Response

The volumes and times indicated in the EIS do apply to a scenario where a vessel strike to the trestle results in full breach. Volumes would be less for a partial breach. A number of emergency shutdown valves for the cryogenic line will be installed off-shore on the marine terminal, and on-shore near the LNG storage tanks (see Figure 22-4).

As noted in the EIS (Section 22.7.1), the emergency shutdown valves typically shut down within 30 seconds, and the emergency release valves located at the coupling for each loading arm typically shut down in 5 seconds. Under a worst-case scenario where some aspects of the emergency shutdown system were rendered inoperable, a conservative estimate for shut down time of four minutes was used to calculate spill volumes. This scenario would result in an 800 m^3 spill of LNG based on a flow rate of 12,000 m^3/h.

22.4 CONCLUSION

Based on the assessment of project changes and the environmental effects of accidents and malfunctions, there are no changes to the residual effects characterization (i.e., context, magnitude, extent, duration, frequency, likelihood) or to the determination of significance presented in the Technical Memorandum: *Cumulative Effects Assessment and Significance Determination for Effects of Accidents and Malfunctions* submitted in June 2014. While an additional accident or malfunction scenario (Scenario #6: Aircraft collision with the flare stack or the bridge towers) has been added to the assessment, characterization of the effects arising from this scenario are the same as those for the previous five scenarios. Similarly, effects of the **aircraft collision with the flare stack or the bridge towers** scenario are expected to be not significant, unless a listed species were killed as a result of a collision. The likelihood of any collision occurring is considered to be very low, and significant effects are not likely.

The outstanding information provided in response to the information requests does not change the results of the assessment.

Cumulative effects are not expected to occur for most accident or malfunction scenarios. Cumulative effects are expected for marine vessel collisions with marine mammals and for small hazardous material spills. Cumulative effects on marine mammals from vessel collisions are expected to be not significant, unless a listed species dies as a result of a vessel collision. Cumulative effects from small hazardous material spills are expected to be not significant. In all cases, significant residual effects from project specific or cumulative effects are not likely to occur.

22.5 REFERENCES

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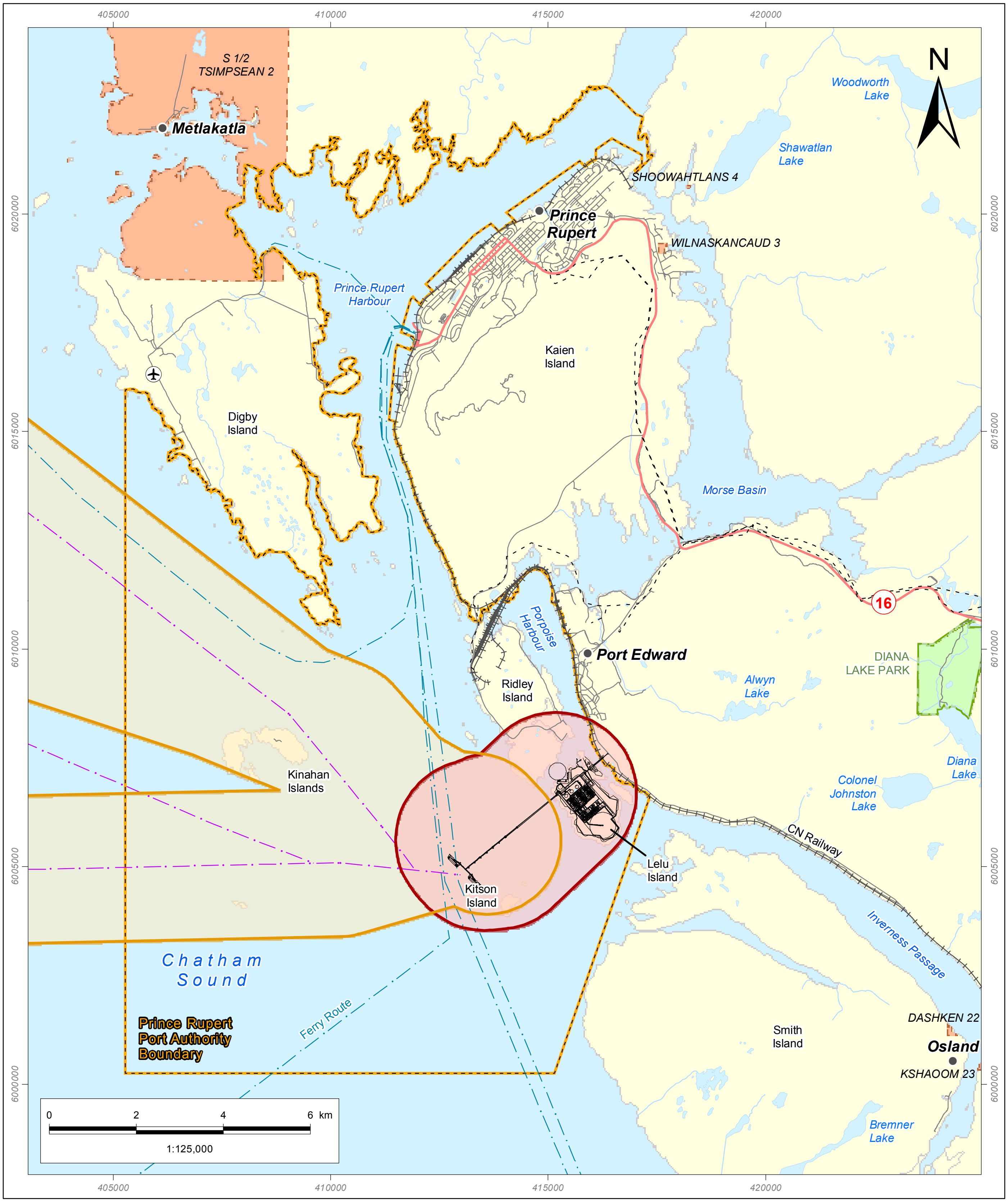
22.6 FIGURES

Please see the following pages



Flammable Hazard Zone due to Release of LNG from the Following Sources:*

- Marine Terminal Trestle Pipe or Loading Arm
- LNG Vessel
- Potential Shipping Route
- Project Component
- Airport
- City or Town
- Electrical Power Transmission Line
- Ferry Route
- Highway
- Railway
- Secondary Road
- Watercourse
- Indian Reserve
- Prince Rupert Port Authority Boundary
- Protected Area
- Waterbody

* Maximum estimated flammable hazard zone associated with a credible release of LNG from the trestle pipeline or loading arm infrastructure at the marine terminal (1,850 m radius), or an LNG vessel along the shipping routes (1,700 m radius).
Source: Det Norske Veritas 2013a.

Pacific NorthWest LNG

Flammable Hazard Zone: Release of LNG from the Marine Terminal during Loading Operations or an LNG Vessel along the Chatham Sound Sailing Routes

EIS ADDENDUM

Sources: Government of British Columbia; Prince Rupert Port Authority; Government of Canada, Natural Resources Canada, Centre for Topographic Information; Progress Energy Canada Ltd.; Det Norske Veritas, 2013a.

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

DATE: 20-NOV-14	PROJECTION: UTM - ZONE 9
FIGURE ID: 123110537-471	DATUM: NAD 83
DRAWN BY: K. POLL	CHECKED BY: M. BREWIS

PREPARED BY: Stantec

PREPARED FOR: Pacific NorthWest LNG

FIGURE NO:

22-1

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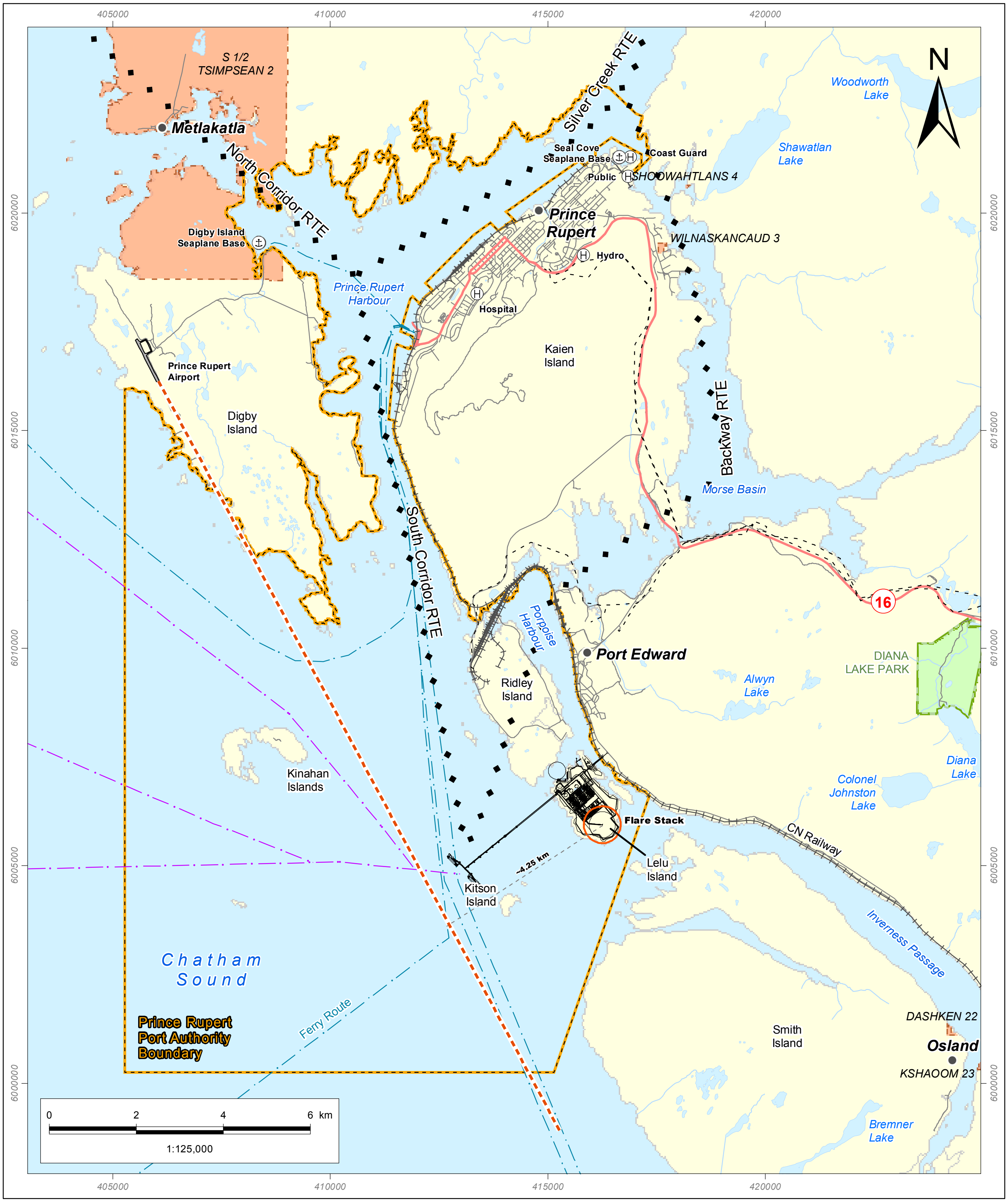
Figure 22-2 Public Short Term Exposure Limit (2.37 kW/m2) under an Emergency Flaring Event



- City or Town
- Seaplane
- Helicopter
- Electrical Power Transmission Line
- Ferry Route
- Flight Path to/from Prince Rupert Airport
- Project Component
- Project Shipping Route
- Highway
- Railway
- Secondary Road
- VFR Routes
- Watercourse
- Airport Runway
- Emergency Flaring Heat Flux Bubble
- Indian Reserve
- Prince Rupert Port Authority Boundary
- Protected Area
- Waterbody

* Maximum estimated flammable hazard zone associated with a credible release of LNG from the trestle pipeline or loading arm infrastructure at the marine terminal (1,850 m radius), or an LNG vessel along the shipping routes (1,700 m radius). Source: Det Norske Veritas 2013a.

Pacific NorthWest LNG

Airports, Seaplane Bases, Heliports, and VFR Routes near the Project and Emergency Flaring Heat Flux Bubble

EIS ADDENDUM

Sources: Government of British Columbia; Prince Rupert Port Authority; Government of Canada, Natural Resources Canada, Centre for Topographic Information; Progress Energy Canada Ltd.; Det Norske Veritas, 2013a.

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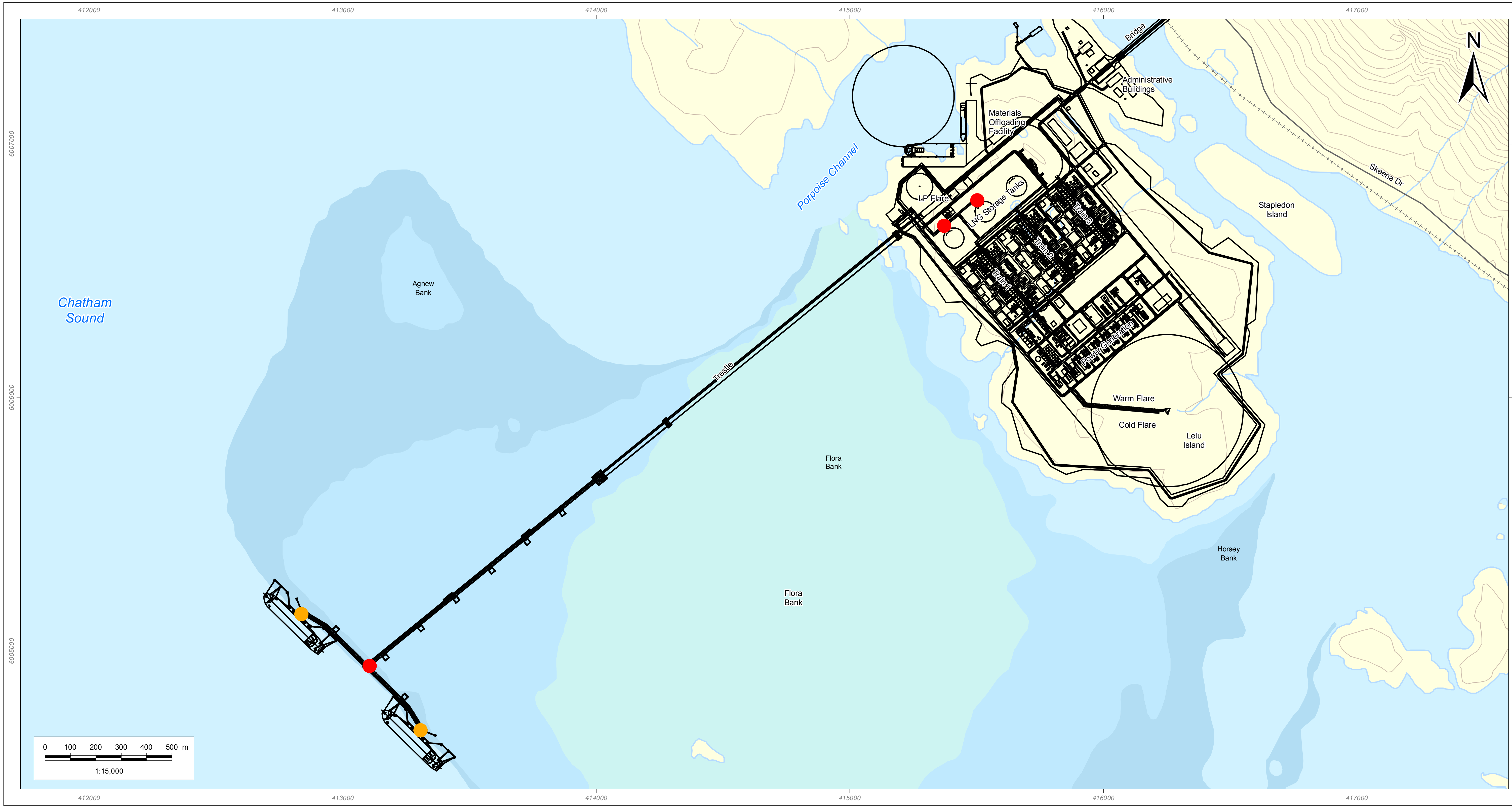
PREPARED BY: Stantec

PREPARED FOR: Pacific NorthWest LNG

DATE: 20-NOV-14	PROJECTION: UTM - ZONE 9
FIGURE ID: 123110537-825	DATUM: NAD 83
DRAWN BY: T. CARDINAL	CHECKED BY: N. MACLEOD

FIGURE NO: **22-3**



Emergency Release Valve
Emergency Shutdown Valve

Road
Secondary Road
Railway
Watercourse
Contour (m)
Waterbody

Agnew Bank
Flora Bank
Horsey Bank

Pacific NorthWest LNG

Emergency Shutdown Valve Locations

EIS ADDENDUM

Sources: Government of British Columbia; Government of Canada, Natural Resources Canada, Centre for Topographic Information; Progress Energy Canada Ltd; WorldView-2 Imagery. Imagery date: 2011.

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DATE: 20-NOV-14
FIGURE ID: 123110537-307
PROJECTION: UTM - ZONE 9
DATUM: NAD 83
DRAWN BY: A. BOONE
CHECKED BY: B. BYRD

PREPARED BY: Stantec
PREPARED FOR: Pacific NorthWest LNG
FIGURE NO: 22-4

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