MEMORANDUM

July 19, 2017

Subject: Discharges to the Marine Environment

Memo Summary

Several comments about wastewater discharges to the marine environment were submitted during the Application Review consultation for the Aurora LNG Project (the Project). This memo was revised following receipt of Round two comments from the working group. The topics included wastewater infrastructure, legal requirements governing waste discharges, potential parameters of concern, treatment technology, monitoring for potential contaminants of concern, and additional assessment of effects of wastewater discharges on the biophysical and human environments. Additional information was requested and provided about potential adverse effects of desalination plants, as requested by regulators during the review stage. This Memo responds to the requests, providing additional information to support the conclusions drawn in the Application for an Environmental Assessment Certificate (the Application) for assessment of Project effects on water quality, fish, and fish habitat. Effects of effluent releases are well understood, are addressed through the permitting process, and reflect the overarching legislative requirement of the federal *Fisheries Act*, section 36, to not release deleterious substances that are acutely lethal to fish.

Summary of Comments Received

As part of the Application Review consultation for the Project, Aurora LNG received comments related to discharges from the proposed Project to the marine environment and the potential effects of these discharges on water quality and on marine fish and fish habitat during construction and operation. The purpose of this Memo is to respond to these comments and, in doing so, this Memo is responsive to the comments received as summarized in Table 1. The topics include wastewater infrastructure (waste treatment and discharges to the marine environment); legal requirements governing waste discharges (permits and authorizations); potential parameters of concern and treatment; and monitoring for potential contaminants of concern. Also, at a Working Group meeting held April 19, 2017, the British Columbia Environmental Assessment Office requested additional assessment of environmental effects of wastewater discharges on the Valued Components (VCs) identified in the five pillars of environment, economic, social, heritage, and health, and the Ministry of Environment requested additional information about effects of desalination plant effluent on the marine environment.

Table 1 Summary of Information Requests related to Wastewater Discharge to the Marine Environment

Topic	Subject	Request for Information	Comment ID
Marine Water Quality	Approval to Discharge	The waste discharges will require waste discharge permit(s). Effluent requires characterization.	929.1, 1333.1, 2053.1
Marine Water Quality	Infrastructure – Treatment Facilities	Requests for information regarding wastewater treatment facility design, effluent modeling, and treatment levels.	819.1, 1332.1, 1333.1, 1334.1, 1345.1, 1346.1, 1347.1, 1389.1, 2037.1, 2038.1, 2039.1, 2044.1, 2045.1, 2046.1, 2047.1, 2051.1, 2072.1, 2076.1, 2078.1, 2079.1, 2300.1
Marine Water Quality	Infrastructure – Outfalls	Requests for information regarding the number of outfalls, the locations, the design, and effluent modeling.	819.1, 848.1, 1332.1, 1333.1, 1337.1, 2037.1, 2038.1, 2039.1, 2043.1, 2078.1
Marine Water Quality	Effect Assessment and Mitigation	Identification of potential contaminants of concern, impact assessment, and mitigation measures.	819.1, 848.1, 929.1, 952.1, 1091.1, 1333.1, 1345.1, 1346.1, 1347.1, 1389.1, 1405.1, 1407.1, 2037.1, 2038.1, 2039.1, 2040.1, 2041.1, 2042.1, 2043.1, 2044.1, 2045.1, 2046.1, 2047.1, 2051.1, 2078.1, 2080.1, 2081.1, 2082.1, 2300.1
Marine Fish and Fish Habitat	Impact Assessment and Mitigation	Identification of potential contaminants of concern, effects assessment, and mitigation measures.	1089.1, 2040.1, 2041.1, 2042.1, 2043.1, 2045.1, 2046.1, 2047.1, 2051.1, 2072.1, 2074.1, 2076.1, 2080.1, 2081.1, 2082.1, 2083.1, 2084.1
Marine Water Quality, Fish and Fish Habitat	Monitoring	Monitoring to confirm predicted changes in marine water quality, estuarine vegetation, marine resources, and marine fish and fish habitat	1399.1, 1405.1, 2052.1

Proponent Response

Aurora LNG is committed to providing additional information where possible. This Memo provides the following information:

- Applicable federal and provincial permits and authorizations
- Available information on wastewater sources during construction and operations
- An overview of the marine outfalls including a description of discharge infrastructure required for the construction and operation phases, parameters of potential concern, and mitigation and treatment options
- Monitoring commitments
- A further assessment of effects of effluent discharges on relevant VCs

Information on wastewater sources, collection, and treatment, and discharge infrastructure is described in the Application under Project Components (Section 1.2.5) and in the Water Quality VC (Section 4.5). Wastewater sources, and respective potential contaminants of concern associated with wastewater discharges, are listed as Measurable Parameters in Section 4.5.12 (Table 4.5-19) of the Application and summarized below in Table 2. Potential parameters of concern include, but may not be limited to, temperature, suspended sediments, salinity and associated increased metal concentrations, organic content, and hydrocarbons. Detailed treatment and discharge plans will be developed during Front End Engineering Design (FEED) and detailed design through an in-depth assessment of wastewater sources, discharge volumes, potential contaminants of concern, treatment options, the receiving environment, and modeling, which will confirm that the discharge streams will meet regulatory requirements and be protective of water quality, fish, and fish habitat. Receiving water quality at and beyond the initial dilution zone (IDZ) boundary will meet British Columbia (BC) and Canadian Council of Ministers of the Environment (CCME) water quality guidelines (WQG) for the protection of marine life. If there is a discrepancy between the BC and CCME WQG, then Aurora LNG will meet the more stringent guideline.

It is typical for engineering information to be preliminary at the time an Application for an Environmental Assessment Certificate is submitted, with more detail provided during the permitting phase. The commitment and legal requirement to meet water quality criteria prior to discharge provides sufficient information for potential effects of wastewater discharge on the marine environment to be predicted in the Application. For example, the exact composition of wastewater to be discharged from the sewage treatment plant has not been established. However, under the federal *Fisheries Act*, waste discharged to fish habitat must not be acutely toxic to fish at the “end of pipe”, and the Province will issue a wastewater discharge permit that specifies limits on wastewater characteristics (e.g., total suspended solids [TSS], biological oxygen demand [BOD_5]), volume of waste discharged, and size of the IDZ). Wastewater from the sewage treatment plant is therefore not predicted to result in significant adverse effects to the marine environment. Similar considerations apply to the other wastewater sources. The water quality parameters required by regulations are included in the Project basis of design that drives the work through FEED and detailed design. The question becomes what treatment technology is the most appropriate, not whether it is possible to meet the regulatory requirements. A description of planned wastewater sources is provided in Table 2.

Table 2 Planned Discharges to the Marine Environment

Wastewater Source	Project Phase	Estimated Volumes and Assumptions[1]	Measurable Parameters of Concern[2]	Discharge Location
Stormwater Runoff	Construction Operation	166 mm/day (1:100 year, 24 hr storm event size)	TSS, turbidity	Discharge to natural vegetation, freshwater or marine environment
Soil Storage Area Stormwater Runoff	Construction	Volume to be determined following additional field investigations	TSS, turbidity, pH, metals	Discharge to either freshwater or marine environment
Hydrostatic Testing Water	Construction	210,000 m^3 (total volume)	May include: temperature, pH and TSS	Deep water outfall
Sanitary Wastewater	Construction Operation	65 m^3/day (operations) 225 m^3/day (turn around) 900 m^3/day (peak during construction)	BOD_5, pH, TSS, Ammonium-N, Phosphate-P, Total phosphorus, fecal coliforms, residual chlorine (disinfection)	Deep water outfall
Desalination Plant	Construction Operation	10,000 m^3/day (50% of the feed water volume)	Salinity, temperature, metals naturally present	Deep water outfall
Ultra-pure water demineralization waste	Operation	890 m^3/day (20% of the feed water volume)	Salinity, temperature, metals naturally present	Deep water outfall
Power Plant Cooling Tower Blowdown	Operation	500 m^3/day (15% of the cooling tower makeup water)	Temperature, TDS, residual chlorine (biocide),	Deep water outfall
Contact Water from Process Areas	Operation	20 m^3/day	TSS, hydrocarbons	Shallow outfall

NOTES:

1 Preliminary estimated volumes and assumptions; note that the quantities of wastewater discharge streams may vary.

2 See Table 4 for information on federal, provincial and municipal guidance on wastewater discharges to marine waters.

BOD_5 Biological oxygen demand during a five-day test period

TSS Total suspended solids

TDS Total dissolved solids

Applicable Permits and Authorizations

Wastewater collection, treatment, characteristics, and outfall designs and locations will comply with federal and provincial legislation designed to protect water quality, fish, and fish habitat. The following is an overview of regulatory and permitting requirements for the discharge of liquid wastes from the proposed Project to the marine environment. Key regulatory statutes related to waste discharge to the marine environment are listed in Table 3 and discussed below.

Table 3 Legislation Applicable to Wastewater Discharges

Discharge Source	Project Phase	Applicable Legislation
Construction Areas (stormwater runoff)	Construction Operation	*Fisheries Act* (Land Development Guidelines, DFO and MOE 1996[1]) *Oil and Gas Activities Act* (*Environmental Management Act* – Waste Discharge Regulation) *Canada Marine Act* (Port of Prince Rupert Liquefied Natural Gas Regulations) MOE best management practices for construction (http://www.env.gov.bc.ca/wld/instreamworks/generalBMPs.htm#
Soils Storage Area (stormwater runoff)	Construction Operation	*Fisheries Act* (Land Development Guidelines, DFO and MOE 1996) *Fisheries Act* section 36 (related to potential metal leaching - acid rock drainage concerns)
Hydrostatic Test Water	Construction	*Fisheries Act* section 36 *Canada Marine Act* (Port of Prince Rupert Liquefied Natural Gas Facilities Regulations)
Desalination Plant	Construction Operation	*Fisheries Act* section 36 *Canada Marine Act* (Port of Prince Rupert Liquefied Natural Gas Facilities Regulations)
Power Plant Cooling Water	Operation	*Fisheries Act* section 36 *Canada Marine Act* (Port of Prince Rupert Liquefied Natural Gas Facilities Regulations)
Sanitary Wastewater	Construction Operation	*Oil and Gas Activities Act (Environmental Management Act* – Municipal Wastewater Regulation) *Fisheries Act* – Wastewater Systems Effluent Regulation (if $\geq$ 100 m^3 of influent discharged per day) *Canada Marine Act* (Port of Prince Rupert Liquefied Natural Gas Facilities Regulations)
Process Area Contact Water	Operation	*Oil and Gas Activities Act (Environmental Management Act* – Petroleum Storage and Distribution Facilities Storm Water Regulation) *Fisheries Act* section 36

NOTE:

1 Land Development Guidelines (DFO and MOE 1996) provides guidance on erosion and sediment control stormwater treatment, volume of discharge, TSS loading, discharge method.

Fisheries Act, 2012

The *Fisheries Act* contains two key provisions that are aimed at conserving and protecting fish and fish habitat essential to commercial, recreational and Aboriginal (CRA) fisheries:

1. Section 35(1) of the *Fisheries Act* focuses on protecting the productivity and sustainability of CRA fisheries by requiring projects to avoid causing "serious harm to fish" unless authorized by Fisheries and Oceans Canada (DFO). This applies to work being conducted in or near water that support CRA fisheries, such as the Pacific Ocean. "Serious harm to fish" is defined as "the death of fish or any permanent alteration to, or destruction of fish habitat"*.* Section 35 (1) of the *Fisheries Act* prohibits work from causing serious harm to fish that are part of a CRA fishery, or to fish that support such a fishery. When work cannot avoid or mitigate "serious harm to fish", projects require an authorization under Section 35(2) of the *Fisheries Act* in order for the Project to proceed without contravening the *Act*.

2. Section 36 (3) of the *Fisheries Act* is an important pollution prevention provision, which prohibits the deposition of deleterious substances into waters frequented by fish. The *Fisheries Act* defines a deleterious substance as, "any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water."

Wastewater discharged to marine waters must not be acutely toxic to fish. Project-related discharges to the marine environment must comply with subsection 36 of the federal *Fisheries Act*, which is administered by Environment and Climate Change Canada (ECCC). Construction of the footprint of the pipe and outfall in the marine environment may require a section 35(2) Authorization for the alteration of habitat.

Wastewater Systems Effluent Regulation SOR/2012-139

The Wastewater Systems Effluent Regulation, under the *Fisheries Act*, applies to owners and operators of wastewater systems designed to collect an average daily volume ≥100 m^3 of influent per day and discharge to surface water. The regulations set national effluent quality standards to decrease levels of deleterious substances deposited into waters frequented by fish and to reduce threats to fish, fish habitat, and human health. Parameters include, but may not be limited to: carbonaceous biochemical oxygen demand (CBOD), un-ionized ammonia, and total ammonia, acute lethality.

Canadian Environmental Protection Act, 2012

The *Canadian Environmental Protection Act* (CEPA) governs pollution prevention and protection of the environment and human health in Canada and is administered by ECCC. The CEPA takes an ecosystem approach and the environmental protection management process includes risk assessment, risk management, and compliance and enforcement. Part 7 of CEPA covers pollution control and waste management, including release of nutrients into aquatic environments, protection of the marine environment from land-based pollution, and disposal of substances at sea. To prevent marine pollution, Section 93 of the CEPA provides the authority to issue non-regulatory objectives, guidelines, and codes of practice. Projects need to abide by the requirements of CEPA; however, wastewater discharges for the Project will not require a permit or approval under CEPA.

Navigation Protection Act, 2012

The federal *Navigation Protection Act* (NPA) is designed to protect the right to navigation and marine safety in Canada. The Act requires approval for any works that may affect navigation on navigable waters (as defined in Schedule Parts 1 and 2 of the Act) in Canada. Outfall design is subject to approval under the NPA.

BC Environmental Management Act, [SBC 2003] Chapter 53

The BC *Environmental Management Act* (EMA) governs waste discharge to atmospheric, aquatic and terrestrial environments. Effluent discharges to the marine environment are managed under permits issued through the EMA or the associated Waste Discharge Regulation codes of practice, which establish limits on the quality and quantity of discharges. The Project will require authorization under the EMA to discharge waste to the marine environment. Unless authorized, the EMA prohibits discharge of waste from prescribed industries, operations, or activities.

Permit(s) are required to authorize discharges and a detailed technical assessment is part of the permit application process. British Columbia Ministry of Environment (BC MOE) determines the requirements of the technical assessment and resulting Technical Assessment Report and Consultation Report. Technical Assessment Reports generally include plans and specifications for works specified in the permit, studies and modeling of the effluent and effluent discharge, a cumulative effects assessment, and both discharge and receiving environment monitoring programs. A Best Available Technology evaluation is generally required when new discharges are proposed. BC MOE staff use the Technical Assessment Report and Consultation Report to inform permitting decisions that are protective of the environment.

The resulting permit(s) details the terms under which the discharge may occur (e.g., discharge volumes, levels for parameters of concern, operation and maintenance requirements, emergency procedures, and monitoring and reporting requirements).

Codes of Practice, such as that for the Concrete and Concrete Products Industry, cover specific activities under the Waste Discharge Regulation, and may be relevant to the construction phase of the Project.

Municipal Wastewater Regulation B.C. Reg. 87/2012

The Municipal Wastewater Regulation (MWR), under the EMA, provides authorization to discharge sanitary effluent in BC. Authorization to discharge requires information on facility design, plans, and an environmental impact study (EIS). Facility design must be certified by qualified professionals and both the design and proposed discharge must meet the MWR. The EIS must be conducted in accordance with the MWR. The EIS must consider cumulative effects on the receiving environment; establish effluent quality requirements necessary to protect the receiving environment and public health; demonstrate that the nature of the discharge will not adversely affect public health or the receiving environment; and establish a pre- and post-discharge receiving environment monitoring program. The receiving environment monitoring program must document pre-discharge conditions.

General operating requirements stipulate that prior to discharge, a discharger must ensure that the design of the wastewater facility is capable of consistently meeting MWR requirements. The facility must be appropriately designed, and effluent must not be discharged unless WQGs can be met at the edge of the IDZ. During construction and operation of the LNG facility, effluent quality and quantity must be monitored, as must receiving environment water quality.

Petroleum Storage and Distribution Facilities Storm Water Regulation B.C. Reg. 321/2004

The Petroleum Storage and Distribution Facilities Storm Water Regulation applies to petroleum storage and distribution facilities in BC, and may apply to liquefied natural gas (LNG) facilities. The regulation specifies how stormwater is sampled for total extractable hydrocarbons (TEH), how oily water is separated from stormwater, and the maximum TEH concentration in effluent that can be discharged (15 mg/L).

Oil and Gas Commission

The BC Oil and Gas Commission (OGC), under the Liquefied Natural Gas Facility Regulation pursuant to section 111(2) of the *Oil and Gas Activities Act*, is responsible for regulating LNG facilities in BC including administering provincial permits, and ensuring compliance with permit conditions and applicable regulations. The OGC, with support of other responsible authorities and the PRPA, coordinates permitting of process water discharges into the marine environment.

Prince Rupert Port Authority (PRPA)

The Prince Rupert Port Authority (PRPA), under a federal regulatory framework (the Letters Patent), has the authority to operate the Port in Prince Rupert Harbour. PRPA is responsible for the management of all activities related to Port development and operation and, under the Port of Prince Rupert Liquefied Gas Regulation, is responsible for management of non-process water discharges into the marine environment. The proposed Project falls within the administrative boundaries of the Port (*PRPA 2020 Land Use Management Plan*) and will require PRPA review and approval. The PRPA recognizes that projects subject to an EA have evaluated options that are environmentally sustainable (*PRPA 2020 Land Use Management Plan*).

Discharge Infrastructure, Parameters of Concern, Mitigation Measures, and Treatment Options

Preliminary outfall design includes two proposed locations where wastewater will be discharged to the marine environment:

- A deep outfall (minimum 30 m water depth at low-low tide periods) located off of Charles Point, for combined discharge from the sanitary wastewater treatment system, desalination plant, and power station during operations and the sanitary wastewater treatment system, temporary potable water treatment system, and hydrostatic test water during construction. Preliminary design of the discharge pipe indicates it would terminate in an upward oriented diffuser port(s) at a water depth of approximately 30 m (not on the seabed), and with an effluent discharge velocity of approximately 3 m/s.
- A shallow marine outfall located between Frederick Point and Miller Point for water that has had the potential to come into contact with hydrocarbons (i.e., contact water) in the processing plant.

A description of the wastewater being discharged is provided in Table 2. The location and design of the marine outfalls will be refined during FEED and finalized during detailed design. Final outfall design and locations will comply with federal and provincial legislation designed to protect water quality, fish, fish habitat, and navigation. Outfall design and location will be conservative when considering water depth, substrates, and currents available for mixing, and modeled wastewater quality and quantity. For desalination plants, the State Resources Control Board (2012) in California recommends assuming “that ocean currents do not increase dilution, and the seabed is flat and horizontal”, and that overall flushing of the discharge site be considered when designing the outfall. This refers to near field mixing, which is the area of rapid mixing at the outfall. The State Resources Control Board (2012) goes on to state “The rate of mixing in the near field is generally much greater than in the far field." and "Near field processes typically operate on time scales of minutes and over length scales of tens of meters". Further from the outfall, in the far-field zone, ocean currents exert a strong influence on mixing.

This memo assumes that an IDZ of 100 m from the discharge point, varying in direction of tidal currents (based on previously issued waste discharge permits and statements made by MOE during the April 2017 working group meeting) will apply. This is the regulatory definition of the IDZ is provided by MOE, with WQGs (or ambient conditions) being met at the IDZ boundary. The exact size of the site specific mixing area will be confirmed using an effluent mixing model during the permitting phase. The mixing model will show predicted dilution and concentrations away from the discharge point, both within the IDZ and at that boundary. It is common for some parameters to meet WQGs well within the IDZ and for others to require the full extent of the IDZ to reach WQGs.

Preliminary deep water outfall design includes: air release facilities, a shoreline access point, main transmission pipe, and a diffuser to maximize mixing of wastewater with the receiving environment. Outfall design such as the addition of diffusers and an angle on the discharge pipe can enhance mixing and dilution. Final outfall design will meet or exceed requirements for within an IDZ. At the boundary of the IDZ, CCME and BC WQGs will be met. A description of the IDZ will be provided during permitting. Typical effluent permits under the *Environmental Management Act* define an IDZ of 100 m from the discharge point.

Information about the Charles Point deep outfall and the shallow marine outfall was provided in the Application. Section 4.9 and Appendix L (Marine Fish and Fish Habitat Technical Data Report) provide biological information collected at the proposed outfall locations. For Charles Point, there were three remotely operated vehicle (ROV) transects in the vicinity, an intertidal survey, beach seine, and various fish trawls in the area. Subtidal habitat is rocky (cobble, gravel) on the slope down to the outfall and supports a diverse community of algae and sessile invertebrates. The intertidal habitat does not contain areas of eelgrass. For south Digby Island, between Miller Point and Frederick Point, there were six intertidal transects, four ROV transects, aneelgrass survey and several beach seines completed in the area. Habitat is bedrock, boulder and cobblein the high intertidal zone; and sand-mud in the mid and low intertidal zones and the shallow subtidal area. A diverse community of algae and sessile invertebrates are present and there is an eelgrass bed and several small patches of eelgrass in the general area. The location of the marine outfalls will be finalized during FEED but may include a deep water marine outfall off Charles Point and a shallow marine outfall to the west of the marine terminal (between Fredrick and Miller Point) (see Figure 1-2 in the Application) The quarterly water quality monitoring program conducted for PRPA describes water quality at several monitoring locations near the two proposed outfall locations.

Wastewater Discharges during Construction

The following wastewater discharges are identified for construction:

- Stormwater runoff from the Project Development Area (PDA)
- Sanitary wastewater (black and grey water)
- Hydrostatic testing water
- Saline wastewater from the temporary potable water treatment system

Measurable parameters of concern, water quality guidelines, and effluent criteria are listed in Table 4.

Table 4 Parameters of Concern, Water Quality Guidelines, and Effluent Criteria

Parameter	CCME[1] WQGs for Marine Waters	BC[2] WQGs for Marine Waters	MWR Effluent Criteria[3]
Temperature	Maximum change of ±1⁰C from ambient at any time, location, or depth. Maximum rate of change <0.5⁰C /hour	±1⁰C change from ambient	—
pH	pH 7.0 to 8.7; where pH is naturally outside this range, pH should not change more than 0.2 pH units from ambient	Unrestricted change when pH is 7.0 to 8.7	—
Total suspended sediments (TSS)	In clear water: maximum increase of 25 mg/L for up to 24 hr; maximum average increase up to 5 mg/L for longer periods. In turbid water: maximum increase of 25 mg/L when background levels are 25 - 2500 mg/L; increase of < 10% when background is ≥250 mg/L.	In clear water: change from background of 25 mg/L for up to 24 hr; or up to 5 mg/L for a duration of 30 days. In turbid water: change from background of 10 mg/L when background is 25 - 100 mg/L; or 10% when background is >100 mg/L	flow dependent: ≤45 or interim ≤130 mg/L
Salinity	Maximum change of <10% of natural level for given time and depth	—	—
BOD_5	—	—	flow dependent: ≤45 or interim ≤130 mg/L
Ammonium-N	—	Criteria for maximum and continuous exposure are pH, temperature and salinity dependent	—
Phosphate-P	Guidance framework	—	—
Total phosphorus	Guidance framework	—	—
Fecal coliform[4]	—	Not to exceed median MPN of 14/100 mL over 30 days, and at least 90% of samples in a 30 day period should not exceed 43 MPN/100 mL	—
Metals	Cd, Cr, Hg, Ag	Approved (As, B, Cu, Pb, Hg, Ag, Zn) Working (Sb, Be, Cd, Cr, Mn, Ni, V)	
Residual chlorine	Sum of all reactive chlorine species: 0.5 µg/L	Average continuous exposure: 3 µg/L. Maximum exposure 40 µg/L	—
Hydrocarbons	Hydrocarbon dependent, no visible oil/grease	Hydrocarbon dependent	—

NOTES:

1 CCME WQG for the protection of marine aquatic life.

2 British Columbia Ministry of Environment (BC MOE) approved WQGs for the protection of marine aquatic life.

3 MWR effluent parameters (dependent on daily flow, dilution ratio, and receiving water quality).

4 Fecal coliform limits are for marine waters used for shellfish harvesting for human consumption.

5 BOD_5: Biological oxygen demand during a 5 day test period

Stormwater Runoff

Stormwater runoff to freshwater habitat during the construction phase is expected to have elevated TSS levels (Table 1). Mitigation strategies will be detailed in the Marine and Freshwater Resources Management Plan, and will include best management practices for soil erosion and sediment control. During the construction phase, a temporary drainage and stormwater management system will be established to collect and control stormwater flows and runoff from the PDA. Stormwater will be directed through internal and perimeter ditches, and erosion and sediment control measures (e.g., silt fences) that are appropriately designed for local site conditions. Water from construction areas will be collected in ditches and allowed to settle in smaller sediment traps or larger sediment ponds, as required, to manage basic water quality parameters (e.g., turbidity to meet DFO Land Development Guidelines criteria (DFO and MOE 1996) in discharges). Use of flocculents to promote settling has not been proposed. WQGs applicable to the freshwater or marine environment are as follows: in clear water conditions, BC and CCME WQGs are for a maximum increase of 25 mg/L TSS for up to 24 hours or 5 mg/L over longer periods (Table 4).

The DFO Land Development Guidelines provide a suitable best management practice and are still cited by DFO and MOE, given that more recent guidance applicable to construction sites and construction activities has not been issued. MOE's best management practices for construction (http://www.env.gov.bc.ca/wld/instreamworks/generalBMPs.htm#) supplement the protocols in the Land Development Guidelines.

Excess soils from PDA site preparation activities will be placed in a soils storage area. Stormwater runoff from the soils storage area is expected to have elevated TSS, and may have low pH or elevated metals if potentially acid generating (PAG) material is confirmed to be on site. The soils storage area will be sited and designed to manage surface water runoff for sediment and acidity prior to discharge. Runoff will be directed to a sedimentation pond to allow sediments to settle out. A PAG management plan will be developed to address potential acidity and metal leaching concerns, if acid generating rock is confirmed to be on site. This water will be tested and treated as required prior to discharging to freshwater and/or marine environments and will meet applicable discharge permit conditions.

Sanitary Wastewater

A sanitary wastewater treatment plant (WWTP) will be established for the construction camp. The type of treatment will be determined during FEED and finalized during detailed design. Wastewater effluent will meet Municipal Wastewater Regulation (MWR; *Environmental Management Act*) discharge quality criteria based on daily flow volume, dilution ratio, and receiving environment characteristics. Treated wastewater will be discharged through the deep water marine outfall proposed off Charles Point. As per the MWR, the CCME and BC WQG for protection of marine life (or background concentrations) will be met at the boundary of a defined IDZ. Prior to the sewage treatment facility being functional, portable toilets will be available onsite; waste will be transported offsite for disposal at a licensed facility.

Hydrostatic Testing Wastewater

Hydrostatic testing is expected to be conducted on the LNG storage tanks. The water source is expected to be desalinated water and the determination of biocide usage has not been finalized. Wastewater quality following hydrostatic testing can vary depending on the raw water source, contaminants in the tanks, condition of the tanks, and use of a biocide. The Canadian Association of Petroleum Producers Hydrostatic Test Water Management Guidelines (CAPP 1996) provides guidance on parameters of concern to be monitored. The parameters may include temperature, pH, TSS, chlorine, metals, and organics (Table 2 and Table 4). Mitigation strategies in CAPP (1996) will be implemented. Water used for hydrostatic testing will be collected and treated as required to meet regulatory and permit requirements prior to discharge to marine waters at the deep water outfall off Charles Point.

Desalination Wastewater

Wastewater (brine with elevated salinity) from the temporary desalination plant will be discharged, after being tested and treated (if required), to the marine environment through the deep water marine outfall proposed off Charles Point. Salinity, temperature, metals, treatment chemicals, and particulate levels in the wastewater will be assessed during FEED to determine an appropriate treatment and outfall design. Wastewater will be treated to meet regulatory and permit requirements in the discharge and WQGs in marine waters at the boundary of the IDZ.

Wastewater Discharges during Operations

The following wastewater discharges are identified for operations:

- Contact water from the process area
- Stormwater runoff (non-contact water)
- Sanitary wastewater (black and grey water)
- Saline wastewater from the desalination plant
- Blowdown from the power plant cooling tower

Contact Water from the Process Area

Contact water from the LNG process areas (areas within the plant where small amounts of hydrocarbons may be present) will be collected in a stormwater management system (closed drainage network), treated using a wastewater treatment module (oil and water separation), then released through the shallow water marine outfall between Frederick Point and Miller Point. Potential treatment recommendations for the contact water include a Corrugated Plate Interceptor for separating oil and water, followed by Dissolved Air Floatation as secondary treatment to remove remaining oil, grease, and TSS. Treated contact water will meet the Petroleum Storage and Distribution Facilities Storm Water Regulation criterion for hydrocarbons in the discharge water (total extractable hydrocarbons less than 15 mg/L) and the BC and CCME WQGs for TSS (Table 4) prior to being released to the marine environment.

Stormwater Runoff (Non-contact Water)

Stormwater runoff from roads and non-process areas will be collected in ditches and allowed to settle in smaller sediment traps or larger sediment ponds, as required, to enable basic water quality parameters (e.g., turbidity) to meet the DFO and MOE (1996) criteria prior to being discharged to the freshwater or marine environment and BC and CCME WQGs (maximum increase of 25 mg/L TSS for up to 24 hours or 5 mg/L over longer periods; Table 4) to be met at the edge of the IDZ in receiving waters.

Potential runoff and seepage from the soils storage area may have elevated TSS and low pH and will be monitored for water quality prior to discharge. The soils storage area will be re-vegetated, where possible, following completion of the major earthworks portion of construction. Drainage patterns will be established to manage runoff and appropriate erosion control measures will be put in place. If acid generating rock is confirmed to be on site, the PAG management plan developed during construction will be implemented during operations, as required.

Sanitary Wastewater

Parameters of concern in sanitary wastewater are BOD_5, TSS, nutrients, and fecal coliform bacteria (Table 2 and Table 4). The wastewater treatment facility and outfall will be appropriately designed to meet MWR effluent quality requirements based on daily flow volume, dilution ratio, and receiving environment characteristics. Typical treatment recommendations for sanitary wastewater treatment could include an equalization tank, coarse screen, fine screen, membrane bioreactor (MBR), and disinfection system. The equalization tank is used to collect wastewater and facilitates consistent flows to the biological treatment process. Coarse and fine screens remove particles, protecting the MBR and disinfection processes. MBRs use biological treatment and removes ammonia, BOD oxidation, and TSS. MBRs are often used for remote facilities across North America. If chlorine is used for disinfection (to control fecal coliform levels), the wastewater will be dechlorinated prior to release using one of many treatment options available (e.g., sodium bisulphite, sodium thiosulphate, sulphur dioxide). Selection of the final treatment process will be determined during detailed design, designed by qualified professionals, and suitable for a north coast location. Treated sanitary wastewater will be discharged through the deep water marine outfall currently planned to be located off Charles Point. As per the MWR, the CCME and BC WQGs will be met at the boundary of the IDZ.

Desalination Wastewater, Reject Water, and Power Plant Cooling Tower Blowdown

The desalination plant will provide freshwater for potable use and a small amount of process plant use (ultra-pure water from the demineralized water unit). The water-cooled power plant will also use desalinized water. Wastewater from the desalination plant and reject water from the demineralized water unit will be combined with the power plant cooling tower blowdown and treated WWTP effluent for discharge through the deep water marine outfall. Elevated temperature, salinity, residual chlorine, and particulates (Table 2 and Table 4) are the parameters of concern in this wastewater stream, which have the potential to affect marine water quality, fish, and fish habitat. Quality of the combined wastewater streams will be evaluated during FEED and detailed design to finalize outfall design and determine what treatment will be required to meet permit requirements for temperature and salinity and to meet WQGs at the boundary of the IDZ. The BC and CCME WQG for temperature change is ±1^{0}C from the natural background temperature outside the IDZ. The CCME interim WQG for salinity limits the change of salinity to 10% from background conditions for a given time and depth. The residual chlorine concentration at the edge of the IDZ will be below the CCME WQG of 0.5 µg/L (Table 4), which is lower that the BC WQG for average continuous exposure (3 µg/L).

Mitigation Measures and Monitoring

Mitigation measures are intended to avoid or limit potential adverse effects on marine water quality, fish, and fish habitat. Aurora LNG will follow a hierarchical approach to mitigation by first implementing avoidance measures that remove the potential for changes in water quality, followed by measures to reduce remaining changes. Mitigation measures are listed in Section 4.5.15 of the Application, with additional mitigation measures discussed in the following environmental assessment section. Effects of waste discharges to the marine environment will be mitigated through collection and treatment of wastewater streams to comply with legal requirements described in the preceding section.

Modelling of effluent mixing within and outside of the IDZ will be used to assess the ability to meet WQGs at the IDZ boundary, evaluate whether additional mitigation measures are required, and arrive at a final design for the treatment facilities and discharge. For example, if the initial model run indicates that WQGs cannot be met at the IDZ boundary, the discharge design will be modified; modifications may include using a different array of diffusers or angle of discharge pipe to better promote mixing, and/or different treatment methods for the effluent streams if necessary. The model will be run again to confirm that the revised design elements address the requirement to meet WQGs (or ambient conditions) at the IDZ boundary.

Wastewater, stormwater runoff, receiving water quality, and biological effects in the marine environment will be monitored to verify compliance with EMA permitting requirements, to confirm effectiveness of mitigation measures, and inform if corrective action is required. Both wastewater and receiving water quality will be monitored for compliance with the applicable permits (e.g., for frequency, discharge volumes, levels for constituents of concern in wastewater, and reporting requirements) and to assess whether WQGs are met at the IDZ boundary. Baseline data on marine water quality and organisms in the region of the proposed outfall will be collected prior to submission of the permit application. These baseline data will be used to monitor and evaluate subsequent changes in the ecosystem. Corrective action will be taken as required based on the specific issue or concern and to mitigate for Project effects.

Potential Interactions of Wastewater Discharges with Valued Components

The environmental effects of wastewater discharges are assessed for VCs within the five pillars defined in the British Columbia *Environmental Assessment Act*: environment, economic, social, heritage, and health. Of the five pillars, there is potential for wastewater discharge to interact with the environment (marine and freshwater) and heritage pillars during construction, operation and decommissioning of the Project. Potential interactions with freshwater fish and fish habitat are addressed in Section 4.7, Freshwater Fish and Fish Habitat.

No interactions of wastewater discharge with VCs within the economic, social, and health pillars are identified. For example, there are no specific concerns for human health from wastewater discharges at the Charles Point marine outfall. Direct exposure is not a concern because people do not drink seawater. The area around the proposed discharge location, including the IDZ, is known for its marine resources, including CRA fisheries, and there may be perceived concerns about consumption of seafood harvested from that area. However, indirect exposure from seafood consumption is not a concern because the types of substances in the wastewater discharges do not affect seafood quality. For example, ammonia, phosphate, chlorine and trace metals naturally present in seawater do not bioaccumulate in the tissues, so people would not be eating seafood with higher amounts of these constituents. Trace amounts of hydrocarbons that could be present in contact water would not accumulate in seafood, since these substances would be simple alkane hydrocarbon (e.g., methane, ethane, propane) residues that are readily broken down from both environmental and biological degradation. Trace metals from the desalination plant brine or power station cooling process are also not a concern from a human health perspective for the same reasons as discussed above. The WWTP discharges will be similar to, or better in quality than, those sanitary wastes currently released into Prince Rupert harbour from existing facilities, and will not affect human health.

Interactions between wastewater discharges and the environment and heritage VCs are discussed in the following sections.

Environment Valued Components

Wastewater discharges have the potential to interact with marine water quality, marine fish and fish habitat, and marine mammal VCs during the construction, operation, and decommissioning phases of the Project, through release of potential contaminants (nutrients, TSS, salinity, chlorine, BOD_5, metals, ammonia) and elevated temperatures. No interaction with marine birds is expected, given the depth of the discharge outfalls and absence of predicted effects on potential marine food sources for marine birds (meeting WQGs for protection of marine life will protect marine food sources). Additional information on baseline water quality is provided in this section to set the context for the assessment of potential effects.

Baseline Water Quality

Baseline marine water quality is summarized in Section 4.5.11 of the Application and described in the Marine Sediment and Water Quality Technical Data Report (Appendix F of the Application). Baseline water quality was characterized using water quality samples collected from the proposed Berth 1, Berth 2, and Materials Offloading Facility (MOF) areas and supplemented with PRPA water quality data from 2013–2015.

Baseline water quality samples were collected in December 2014 at the proposed Berth 1, Berth 2, and MOF areas (Appendix F: Figure 5). At each location, shallow (1 m from surface) and deep (1-2 m from bottom) water quality samples were collected during flood and ebb tides (12 samples total). *In situ* water quality data indicated no thermal or salinity stratification at the time of winter sampling. Table 5 provides a summary of the parameters measured, WQG's and average and maximum values measured. Of the 41 metals analyzed, 23 were below detection limits. All metals were below CCME WQGs and they were also below BC MOE WQGs, with the exception of boron and copper. Boron exceeded the BC MOE guideline of 1.2 mg/L in all 12 samples, and ranged from 3.36 to 4.19 mg/L; this is within the range collected by the PRPA at nearby sites (2.10 to 4.52 mg/L). Boron concentrations in Canadian coastal waters typically range from 3.7 to 4.3 mg/L and exceed the BC WQG (Health Canada 1990; Moss and Nagpal 2003). Copper exceeded the BC MOE maximum guideline of 0.003 mg/L in the deep and shallow samples taken at Berth 1 during the flood tide (0.00339 and 0.00509 mg/L). Only total copper was measured, and the proportion of dissolved copper (the more bioavailable and toxic form) is not known. In these samples, the elevated copper concentrations in water may be related to resuspension of sediment on a flooding tide, given the naturally elevated levels of copper measured in sediment in the proposed berth areas (Appendix F). As noted below, the PRPA marine water quality studies of Prince Rupert Harbour reported copper concentrations higher than the WQG at some sites sampled in Q2 2013 (SNC Lavalin 2013); however, subsequent sampling in 2013 through 2015 did not indicate elevated copper concentrations, and the Q2 2013 results may be outliers related to laboratory conditions.

Baseline water quality data for the Project were supplemented with data collected for the PRPA Marine Environmental Water Quality (MEWQ) program. The PRPA MEWQ program monitors and documents marine water quality from multiple areas within PRPA jurisdiction. This includes the inner harbour, outer harbour, Porpoise Harbour, Ridley Island Harbour, and sites around Digby Island. To date, PRPA MEWQ has collected water quality information quarterly from 2013 through 2016. Water chemistry samples from 1 m depth are analyzed and *in situ* parameters (water temperature, salinity, total dissolved solids, pH, and dissolved oxygen) are measured at 1 m intervals (SNC Lavalin 2013, 2014, 2015). Samples are also collected at 9 m depths during the spring freshet and summer programs, when water column stratification is evident.

Table 5 Marine Water Quality Summary for Samples Collected in 2014 From the Proposed Berth 1, Berth 2 and MOF Areas during Flood and Ebb Tides (n = 12). Maximum Concentration Values Were Multiplied by a Factor of 2 to Represent Potential Desalination Plant Discharge Quality.

Parameter	BC MOE Guidelines		CCME Guidelines		Concentration		
	30-day Average	Maximum	Long-term	Short-term	Mean	Maximum	Maximum times 2[f]
Physical Tests							
Conductivity (µS/cm)	NA	NA	NA	NA	43775	46300	92,600
Hardness (as CaCO3)	NA	NA	NA	NA	5,190	5,590	11,180
pH (pH)	NA	7.0-8.7	NA	NA	8	8	8
Salinity (ppt)	NA	NA	<10% fluctuation[e*]	NA	28	30	60
Total Suspended Solids (mg/L)	NA	NA	5 mg/L max average increase or <10% from background	5 - 25 mg/L max increase from background	<2	<2	2
Anions and Nutrients (mg/L)							
Alkalinity, Bicarbonate (as CaCO3)	NA	NA	NA	NA	119	125	250
Alkalinity, Carbonate (as CaCO3)	NA	NA	NA	NA			2
Alkalinity, Hydroxide (as CaCO3)	NA	NA	NA	NA	<2	<2	2
Alkalinity, Total (as CaCO3)	NA	NA	NA	NA	119	125	250
Ammonia, Total (as N)	0.10-47[a] (2.2)	0.67-312[a] (15)	NA	NA	<0.005	<0.005	0.005
Bromide (Br)	NA	NA	NA	NA	57	62	124
Chloride (Cl)	NA	NA	NA	NA	16,633	17,800	35,600
Fluoride (F)	NA	1.5	NA	NA	1.11	1.27	2.54
Nitrate (as N)	3.7*	NA	200	1500	0.54	0.95	2
Nitrite (as N)	NA	NA	NA	NA	0.05	0.1	0.2

Table 5 Marine Water Quality Summary for Samples Collected in 2014 From the Proposed Berth 1, Berth 2 and MOF Areas during Flood and Ebb Tides (n = 12). Maximum Concentration Values Were Multiplied by a Factor of 2 to Represent Potential Desalination Plant Discharge Quality.

Parameter	BC MOE Guidelines		CCME Guidelines		Concentration		
	30-day Average	Maximum	Long-term	Short-term	Mean	Maximum	Maximum times 2[f]
Total Nitrogen	NA	NA	NA	NA	0.29	0.42	1
Phosphorus (P)-Total	NA	NA	NA	NA	0.05	0.052	0.104
Sulfate (SO4)	NA	NA	NA	NA	2323	2480	4960
Total Metals (mg/L)							
Aluminum (Al)	NA	NA	NA	NA	0.0191	0.0259	0.052
Antimony (Sb)	NA	0.270[d]	NA	NA	<0.0005	<0.0005	0.0005
Arsenic (As)	NA	0.0125[b]	0.0125	NA	<0.002	<0.002	0.002
Barium (Ba)	NA	NA	NA	NA	0.0079	0.0088	0.0176
Beryllium (Be)	0.1[d]	NA	NA	NA	<0.0005	<0.0005	0.0005
Bismuth (Bi)	NA	NA	NA	NA	<0.0005	<0.0005	0.0005
Boron (B)	NA	1.2	NA	NA	3.87	4.19	8.38
Cadmium (Cd)	NA	0.00012[d]	0.00012	NA	<0.00005	<0.00005	0.00005
Calcium (Ca)	NA	NA	NA	NA	339	364	728
Cesium (Cs)	NA	NA	NA	NA	<0.0005	<0.0005	0.0005
Chromium (Cr)	NA	0.056[d]	0.056	NA	<0.0005	<0.0005	0.0005
Cobalt (Co)	NA	NA	NA	NA	<0.00005	<0.00005	0.00005
Copper (Cu)	0.002[b]	0.003[b]	NA	NA	0.00156	0.00509	0.01
Gallium (Ga)	NA	NA	NA	NA	<0.0005	<0.0005	0.0005
Iron (Fe)	NA	NA	NA	NA	0.04	0.046	0.092
Lead (Pb)	0.002[c]	0.14	NA	NA	<0.0003	<0.0003	0.0003
Lithium (Li)	NA	NA	NA	NA	0.14	0.166	0.332

Table 5 Marine Water Quality Summary for Samples Collected in 2014 From the Proposed Berth 1, Berth 2 and MOF Areas during Flood and Ebb Tides (n = 12). Maximum Concentration Values Were Multiplied by a Factor of 2 to Represent Potential Desalination Plant Discharge Quality.

Parameter	BC MOE Guidelines		CCME Guidelines		Concentration		
	30-day Average	Maximum	Long-term	Short-term	Mean	Maximum	Maximum times 2[f]
Magnesium (Mg)	NA	NA	NA	NA	1055	1140	2280
Manganese (Mn)	NA	0.1[d]	NA	NA	0.00318	0.00391	0.0078
Molybdenum (Mo)	NA	NA	NA	NA	0.0087	0.0093	0.0186
Nickel (Ni)	NA	0.0083[d]	NA	NA	<0.0005	<0.0005	0.0005
Phosphorus (P)	NA	NA	NA	NA	0.5	0.5	1
Potassium (K)	NA	NA	NA	NA	317	342	684
Rhenium (Re)	NA	NA	NA	NA	<0.00005	<0.00005	0.00005
Rubidium (Rb)	NA	NA	NA	NA	0.115	0.124	0.248
Selenium (Se)	NA	NA	NA	NA	<0.002	<0.002	0.002
Silicon (Si)	NA	NA	NA	NA	0.96	1.04	2.08
Silver (Ag)	0.0015[b]	0.003[b]	NA	0.0075	<0.0001	<0.0001	0.0001
Sodium (Na)	NA	NA	NA	NA	8824	9290	18580
Strontium (Sr)	NA	NA	NA	NA	6	7	13
Tellurium (Te)	NA	NA	NA	NA	<0.0005	<0.0005	0.0005
Thallium (Tl)	NA	NA	NA	NA	<0.00005	<0.00005	0.00005
Thorium (Th)	NA	NA	NA	NA	<0.0005	<0.0005	0.0005
Tin (Sn)	NA	NA	NA	NA	<0.001	<0.001	0.001
Titanium (Ti)	NA	NA	NA	NA	<0.005	<0.005	0.005
Tungsten (W)	NA	NA	NA	NA	<0.001	<0.001	0.001
Uranium (U)	NA	NA	NA	NA	0.00248	0.00275	0.0055
Vanadium (V)	NA	0.05[d]	NA	NA	0.00144	0.0016	0.0032

Table 5 Marine Water Quality Summary for Samples Collected in 2014 From the Proposed Berth 1, Berth 2 and MOF Areas during Flood and Ebb Tides (n = 12). Maximum Concentration Values Were Multiplied by a Factor of 2 to Represent Potential Desalination Plant Discharge Quality.

Parameter	BC MOE Guidelines		CCME Guidelines		Concentration		
	30-day Average	Maximum	Long-term	Short-term	Mean	Maximum	Maximum times 2[f]
Yttrium (Y)	NA	NA	NA	NA	<0.0005	<0.0005	0.0005
Zinc (Zn)	Chronic: 0.01[b]	Acute: 0.055[b]	NA	NA	<0.003	<0.003	0.003
Zirconium (Zr)	NA	NA	NA	NA	<0.0005	<0.0005	0.0005

NOTES:

NA = not available

Shaded cells indicate guideline exceedance

[a] The ammonia nitrogen guidelines are dependent upon salinity, temperature, and pH. For saltwater with salinity of 30 ppt, temperature of 10 C, and pH 8.0 (conditions which most conservatively represent the observations made during the December sampling program, for all sites), the maximum concentration of total ammonia nitrogen for protection of saltwater aquatic life is 15 mg/L, while the average 5-30 d concentration guideline is 2.2 mg/L.

[b] Approved Water Quality Guidelines (BC MOE 2016)

[c] 80% of the values less than or equal to 0.002 mg/L Pb

[d] Working Water Quality Guidelines (BC MOE 2015)

[e] Human activities should not cause the salinity to fluctuate by more than 10%

[f] Maximum times 2 represents an estimated concentration in desalination brine, comprising the bulk of the effluent to be discharged

* Interim guideline

The six PRPA MEWQ sampling sites closest to the Project are Fairview Terminal (Site 7; north east of the MOF), Philips Point (Site 29; north east of Berth 1), Harbour Entrance (Site 8; south of Berths 1 and 2), North Ridley (Site 9; south of the Berths 1 and 2), Tuck Island (Site 31; within the Berth 2 dredge footprint), and Casey Cove (Site 32, within the MOF dredge footprint). Appendix F of the Application provides a summary of 2013–2015 PRPA MEWQ data from the six sites for TSS, turbidity and boron. Boron concentrations exceeded BC WQGs at all PRPA MEWQ sampling sites in 2013, 2014, and 2015. This is consistent with typical boron concentrations in Canadian coastal waters and with samples collected from the MOF and berth areas. Among the six PRPA MEWQ sampling sites close to Digby Island, copper exceeded BC WQGs in May 2013 at sites 8 and 9 (Table 6). These copper concentrations were many times higher than measured in all other water quality samples. The reason for the elevated copper concentrations on this one out of 12 sampling dates is not clear. The PRPA MEWQ report for May 2013 did not discuss potential data quality concerns, but analytical interference or laboratory error may have affected results for copper and perhaps for other metals. The only other metal that exceeded BC WQGs was total selenium (0.0021 mg/L) in one sample taken at Fairview Terminal (Site 7). The BC average WQG is 0.002 mg/L. There is no CCME WQG for selenium in marine water. There were no WQG exceedances for copper in 2014 or 2015.

The PRPA MEWQ program rated water quality at the sampling sites according to the CCME Water Quality Index (WQI) (CCME 2001). The CCME WQI is used to rate water quality based on the number of parameters not meeting provincial or federal guidelines, the frequency WQGs are not met, and the amount by which WQGs are exceeded. Water quality at sampling sites close to Digby Island were rated fair to excellent from 2013 to 2015 due to WQG exceedances (SNC Lavalin 2015). In 2013 sites 7, 8, and 9 were rated fair, good, and good respectively due to exceedances for one or more of copper, *Enterococcus* bacteria, fecal coliforms, and naphthalene. In 2014, sites 7, 8 and 9 were rated good, excellent, and excellent respectively due to WQG exceedances for one or more of dissolved oxygen, selenium, and *Enterococcus* bacteria. In 2015, sites 7, 8 and 9 were all rated good due to WQG exceedances for one or more of dissolved oxygen, TSS, and *Enterococcus* bacteria. In 2015, sites 7, 8, 9, 31, and 32 were all rated good due to WQG exceedances for one or more of dissolved oxygen, TSS, and Enterococcus bacteria.

Bodies of water can become stratified due to differences in temperature or salinity that prevent mixing of the water column. Stratification of the water column around Digby Island has been studied by Stucchi and Orr (1993) and as a component of the PRPA MEWQ program. Stucchi and Orr (1993) concluded that there is active mixing in the narrow entrance to the inner harbour, but that water is not as well mixed outside the harbour near Digby Island. SNC Lavalin 2013 analyzed Stucchi and Orr (1993) results in conjunction with PRPA MEWQ program results, and concluded that "…active mixing regularly takes place inside the harbour during summer" and that waters in the Outer Harbour are not as well mixed, most likely due to a freshwater surface layer from the Skeena River. SNC Lavalin (2015) confirmed that at sites 7, 8 and 9 the depth of the mixed layer decreases from May to August due to freshwater discharge and solar heating. For the remainder of the year the water column mixed layer extends to 20 m or to the ocean floor.

Table 6 Copper Data, Prince Rupert Port Authority Marine Environmental Monitoring Program Water Quality Program

Year	Sampling Site		Q1 (April)		Q2 (May)		Q3 (July)		Q4 (November)	
			Surface	Depth	Surface	Depth	Surface	Depth	Surface	Depth
2013	7	Fairview Terminal	<0.0005	<0.0005	<0.0005	<0.0005	0.00	<0.0005	0.00	<0.0005
	8	Harbour Entrance	<0.0005	<0.0005	0.0419	0.0378	<0.0005	<0.0005	<0.0005	<0.0005
	9	North Ridley	<0.0005	<0.0005	0.0210	0.0162	<0.0005	0.00215	0.00062	<0.0005
	29	Philips Point	ND	ND	ND	ND	ND	ND	ND	ND
	31	Tuck Island	ND	ND	ND	ND	ND	ND	ND	ND
	32	Casey Cove	ND	ND	ND	ND	ND	ND	ND	ND
2014	7	Fairview Terminal	<0.0005	ND	0.00053	<0.0005	<0.0005	<0.0005	<0.0005	ND
	8	Harbour Entrance	<0.0005	ND	<0.002[a]	<0.005	<0.0005	<0.0005	<0.0005	ND
	9	North Ridley	<0.0005	ND	<0.0005	<0.0005	<0.0005	0.0014	0.00092	ND
	29	Philips Point	ND	ND	<0.0005	<0.0005	ND	ND	ND	ND
	31	Tuck Island	ND	ND	ND	ND	ND	ND	ND	ND
	32	Casey Cove	ND	ND	ND	ND	ND	ND	ND	ND
2015	7	Fairview Terminal	<0.0005	ND	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	ND
	8	Harbour Entrance	<0.0005	ND	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	ND
	9	North Ridley	<0.0005	ND	0.00059	<0.0005	<0.0005	<0.0005	<0.0005	ND
	29	Philips Point	ND	ND	ND	ND	ND	ND	ND	ND
	31	Tuck Island	<0.0005	ND	<0.0005	0.00071	<0.0005	<0.0005	<0.0005	ND
	32	Casey Cove	<0.0005	ND	0.00065	<0.0005	<0.0005	<0.0005	<0.0005	ND

NOTES:

Surface samples collected at 1 m and depth samples collected at 9 m.

Site 29 was added to the monitoring program in May 2014 but was not sampled on subsequent dates.

a) Indicates realized detection limit was above water quality guideline

Shaded cells indicate water quality guideline exceedance

ND = no data

Project Mechanisms

Planned discharges from the proposed Project to the marine environment have the potential to affect marine water quality, marine fish, and marine mammals. A review of potential effects is provided here. An assessment of potential effects of the discharge pipe on marine fish and fish habitat can be found in Section 4.9, Marine Fish and Fish Habitat.

Desalination Brine

During operations, desalination brine will comprise almost 95% of the wastewater discharges, and will provide dilution of the other wastewater streams. Table 2 indicates discharge volumes of 10,000 m^3/day for desalination brine, 500 m^3/day for the power plant cooling tower blowdown, and 65 m^3/day (typical) or 225 m^3/day (during turnaround) for WWTP discharges. During construction, when peak WWTP output of up to 900 m^3/day is estimated, desalination brine will comprise about 91% of the wastewater discharges. Given that desalination brine will comprise about 91 to 95% of the wastewater discharged during construction and operations, effects of parameters associated with power plant cooling water (elevated temperature, potential use of chlorine as a biocide) or treated sanitary wastes (e.g., TSS, BOD_5) will be reduced through mixing with desalination plant wastewater, and these parameters are not expected to exceed permit limits for the discharge itself or WQGs at the IDZ boundary. The desalination process and discharge is continuous, while other waste streams are variable to intermittent. Given the small contributions of the other wastewater streams, this assessment focuses mainly on effects of desalination plant wastewater into the marine environment.

The information provided in this section is based on a literature review of marine assessments, reviews, and recommendations associated with desalination plants. A reverse osmosis process is the preferred option for desalination, given the lesser environmental effects compared to plants that use a distillation process (Lattermann and Hopner 2008, State Resources Control Board 2012, Cooley et al. 2013); however, final selection of the desalination process will occur during FEED. Desalination plants are in use in the Mediterranean and the Middle East, and more recently in the United States, Europe, and Australia, often to process drinking water. These desalination plants use either a distillation or reverse osmosis process, with the older plants often using distillation and the more modern plants typically using reverse osmosis.

The literature review indicates adverse effects on the marine environment are more likely to be associated with desalination plants that use a distillation process (related to elevated temperature and treatment chemicals), discharge to areas of poor mixing capability, or discharge to shallow water (Lattermann and Hopner 2008, State Resources Control Board 2012, Cooley et al. 2013, Roberts et al. 2010). For example, sublethal effects of elevated temperature can include reduced growth, stress on fish, susceptibility to disease, change in community composition, change in migration patterns of salmon, and avoidance of areas of altered water quality (CCME 1999, Peterson and Anderson 1969, BC MOE 2017, Cooke and Schreer 2001, Carter 2005).

The desalination process results in a brine concentrate, typically about twice the concentration of ambient seawater (Table 2; State Resources Control Board 2012). Other brine characteristics include: concentration of naturally occurring seawater constituents such as metals; metals from equipment corrosion; presence of potentially toxic chemicals added during the desalination process; and elevated temperature. However, temperature increases associated with reverse osmosis plants are small (about 1ºC) compared to those associated with distillation plants (Cooley et al. 2013). Effects on water quality can include increased salinity and turbidity, and potential toxicity.

The main concerns with desalination plant discharges are the elevated salinity and the residues of pretreatment and cleaning chemicals (Lattermann and Hopner 2008, State Resources Control Board 2012, Cooley et al. 2013). The high salinity brine is denser than seawater and, if not diluted, can sink to the seabed, where the low water currents do not promote rapid mixing, and can affect benthic communities. The CCME WQG for salinity is an increase of no more than 10% over ambient concentrations (CCME 1999), which in Prince Rupert waters at depth would be 2.5 to 3 parts per thousand (ppt) above ambient (28 ppt). There have been few, well-designed, statistically verifiable studies on the effects of desalination effluent on marine life, and results vary with conditions at specific desalination plants and receiving environments (RPS 2009, Cooley et al. 2013, Roberts et al. 2010). However, some studies showed effects on diatoms, seagrass, polychaetes, and meiofauna associated with a 2 ppt increase in salinity of bottom waters (State Resources Control Board 2012, Talavera and Ruize 2001, Jenkins et al. 2012). Echinoderms appear to be sensitive to small salinity changes (Fernandez-Torquemada et al. 2005, Del-Pilar-Ruso et al. 2008), as do tropical and temperate sea grasses (Sanchez-Lizaso et al. 2008, Fernandez-Torquemada et al. 2005, Hopner and Windelberg 1996). A before-after-control-impact study of effects of a Spanish desalination plant discharge indicated no significant variation in benthic communities inhabiting sandy substrates that could be attributable to brine discharges, although the high natural variability at the sites may have influenced the results (Raventos et al. 2006).

Pretreatment chemicals for reverse osmosis plants typically include a biocide, such as chlorine, to reduce biofouling of the intake infrastructure; however, the chlorine needs to be removed (using, for example, sodium bisulphite, sodium thiosulphate, or sulphur dioxide) to avoid damage to the reverse osmosis membranes, so chlorine concentrations in wastewater are typically low and not a concern in the receiving waters (Lattermann and Hopner 2008). Anti-scalants (strong acids or bases) are often used to remove calcium carbonate build-up, but are neutralized in the process (Lattermann and Hopner 2008). Metals may be present due to leaching from pipes in the desalination plant (iron, chromium, nickel or molybdenum if low quality stainless steel pipes are used in a reverse osmosis plant). There is also periodic use of cleaning chemicals (e.g., detergents, EDTA, oxidants, biocides) that may be released in the discharge, although these can be removed and disposed of separately (Lattermann and Hopner 2008). The potential for halogenated organic by-products (reactions of hypochlorite and hypobromite with organic compounds) can lead to formation of compounds such as trihalomethanes; however, concentrations and toxicity risks are expected to be relatively low (Lattermann and Hopner 2008).

Nutrient Load

Wastewater from the proposed desalination plant and WWTP will contain nutrient levels higher than the receiving environment. To evaluate the potential for eutrophication, ambient concentrations of total nitrogen (N) and total phosphorus (P) (Table 5) were compared with the Trophic Index for Marine Systems (TRIX) shown in Table 7 (CCME 2007).

Table 7 Trophic Status of Marine Systems (Vollenweider 1998)

Trophic Status	Total Nitrogen (mg N/L)	Total Phosphorus (mg P/L)	Chlorophyll *a* (µg/L)	Secchi Depth (m)
Oligotrophic	<0.26	<0.01	<1	>6
Mesotrophic	≥0.26 - 0.35	≥0.01 - 0.03	≥1-3	3 - ≤6
Eutrophic	≥0.35 - 0.4	≥0.03 - 0.43	≥3-5	1.5 - ≤3
Hypereutrophic	>0.4	>0.04	>5	<1.5

In samples collected in December 2014 from the proposed dredge areas, concentrations of total nitrogen (maximum of 0.95 mg N/L) and total phosphorus (maximum 0.052 mg P/L) fell within the hypereutrophic category. Nutrient levels vary seasonally and the total nitrogen measured at PRPA MEWQ sites 7, 8 and 9 from 2013 to 2015 ranged from below the detection limit (<0.2, oligotropohic) to 0.3 mg N/L (mesotrophic). Total phosphorus at MEWQ sites 7, 8 and 9 from 2013 to 2015 ranged from 0.01 (mesotrophic) to 0.054 mg P/L (hypereutrophic), with most samples notably lower than the December 2014 values. Depending on the season and ambient nutrient levels, the addition of nutrients could change the trophic level within the IDZ, resulting in greater plant growth (primarily plankton forms, as a 100 m IDZ would not impinge on habitats that support benthic algae).

Wastewater Discharges and Mitigation

Mitigation measures will be implemented to avoid or limit potential adverse effects on marine water quality. Mitigation measures will include the collection and treatment of wastewater streams, to comply with legal requirements described in the preceding sections, prior to discharge to the marine environment. The outfall design will consider water depth, substrates, and currents available for mixing, modeled wastewater quality and quantity, environmental conditions in the receiving environment, and proximity to sensitive marine habitats. Final outfall design will comply with federal and provincial legislation designed to protect water quality, fish, fish habitat, and navigation. Wastewater and receiving water quality will be monitored to verify compliance with permitting requirements, to confirm effectiveness of mitigation measures, and inform if corrective action is required.

Specific mitigation measures applicable to the desalination plant, power plant blowdown water and WWTP discharges are:

- A dechlorination step would be added, should chlorine be used in any of the wastewater streams (for proper functioning of the reverse osmosis plant, chlorine added as an anti-fouling agent needs to be removed before the source water reaches the membranes, to avoid damaging the membranes); common dechlorination agents include sodium bisulphite, sodium thiosulphate, sulphur dioxide, and ascorbic acid.
- Discharge of wastewater through a diffuser into a well-mixed marine area away from environmentally sensitive habitats, with the diffuser directing wastewater upward in the water column to promote mixing in the water column and avoid settling on the sea bottom.

Research groups in the United States and Australia (e.g., State Resources Control Board 2012, Cooley et al. 2013, Roberts et al. 2010) have reviewed the existing impact assessment data and made recommendations for managing discharge from desalination plants and monitoring ecological effects. The State Resources Control Board (2012) concluded that brine concentrate can be discharged to the marine environment "with minimal environmental effects" if done properly (i.e., using a diffuser and releasing into well mixed areas away from environmentally sensitive habitat).

Characterization of Residual Effects on Marine Water Quality, Marine Fish, and Marine Mammals

Effects of wastewater discharge on marine water quality are assessed in the Application in Section 4.5 Water Quality. Effects of changes in water quality (through wastewater discharge) on marine biota are assessed for fish and fish habitat (Section 4.9), and marine mammals (Section 4.10) in the Application. Additional information is provided below.

Discharge Effects on Marine Water Quality

With the implementation of mitigation measures, the discharge of effluent may still result in an increase in TSS, salinity, and nutrient levels. The TSS and turbidity levels in the outer harbour are influenced by seasonal discharges and sediments from the Skeena River. From 2013 to 2015, TSS at PRPA MEWQ sites 7 and 9 ranged from below the detection limit (<2 mg/L) to 29.5 and 34.2 mg/L respectively. At some times of year, TSS will need to be managed in the source water used for desalination and in wastewater streams being discharged to the marine environment.

In coastal BC waters, salinity ranges annually from 28 ppt (summer) to 32 ppt (winter). The interim CCME WQG for aquatic life for salinity states that human activities should not cause salinity to fluctuate by more than 10% of the natural level expected at a time and depth. Doubling the maximum salinity concentration measured in December 2014 increases it from 30 ppt to 60 ppt, exceeding the CCME interim WQG. The outfall will need to be designed to incorporate rapid initial dilution and flushing so that effects are limited to the IDZ. Monitoring of operating desalination plants indicates the brine is rapidly diluted to ambient salinity levels (within tens of metres of the discharge point), particularly when a diffuser is used (Talavera and Ruize 2001, Reventos et al., 2006, Fernandez-Torquemada et al. 2005, Del-Pilar-Ruso et al. 2008, Roberts et al. 2010). If additional dilution is required, non-contact runoff may be combined with the discharge wastewater prior to release.

The volume and composition of the brine depends on the source water, the desalination method, and the recovery rate. To provide a conservative estimate of brine composition and potential effects of the Aurora LNG Project, the maximum concentrations of salinity, TSS, nutrients, and metals measured in December 2014 water samples were doubled (Table 6) based on the knowledge that the expected desalination plant output is 50% of the input. When a value was below the detection limit, the detection limit was used. With the doubling of water chemistry concentrations to approximate levels in brine, boron and copper remain the only metals with WQG exceedances. Of the 41 metals analyzed, 23 had concentrations below detection limits and doubling their respective concentrations resulted in values remaining below WQGs. The remaining metals, anions, and nutrients with concentrations above detection limits but with no WQGs, such as calcium, iron, phosphorus, potassium, and silicon, are biologically required and organisms have the ability to regulate internal concentrations. Hence, toxicity effects related to elevated concentrations of these elements within the IDZ are not expected. To be protective of the environment, treatment of effluent to reduce copper concentrations prior to discharge will need to be further evaluated during the FEED and final design phases. The predicted copper concentrations, while higher than the WQG, are still within the safety margin incorporated in the guideline. Also, these copper concentrations reflect both particulate and the more biologically available and toxic dissolved fractions upon which the WQG was developed, and would be diluted to background levels at the boundary of the IDZ. Taken together, these factors would reduce the potential for toxicity to marine organisms.

Depending on the season and ambient nutrient levels, the addition of nutrients could change the trophic level within the IDZ, however, no changes are anticipated outside of the IDZ. Wastewater from the proposed desalination plant and WWTP will contain nutrient levels higher than the receiving environment. To evaluate the potential for eutrophication, ambient concentrations of total N and total P were doubled (Table 5) and these values were compared with the Trophic Index for Marine Systems (TRIX) shown in Table 7 (CCME 2007). The baseline conditions measured in December 2014 indicated total nitrogen (maximum of 0.95 mg N/L) and total phosphorus (maximum 0.052 mg P/L) concentrations fell within the hypereutrophic category. As a result, doubling these nutrient concentrations would not change the trophic status or indicate eutrophication. The December 2014 nutrient concentrations were notably higher than levels measured at the PRPA MEWQ sites 7, 8, and 9 in 2013 through 2015. Total nitrogen measured at PRPA MEWQ sites ranged from below the detection limit (<0.2) to 0.3 mg N/L (mesotrophic) and total phosphorus ranged from 0.01 to 0.054 mg P/L (mesotrophic to hypereutrophic). Depending on the season and ambient nutrient levels, the addition of nutrients could change the trophic level within the IDZ.

Wastewater from the desalination plant has the potential to affect marine water quality within the IDZ. However, implementation of mitigation measures such as treating the wastewater for copper and TSS, careful selection and use of anti-fouling and anti-scaling agents and entraining oxygen in the waste stream will reduce the potential for effects on water quality. There is a high likelihood of success of mitigation measures to limit or avoid adverse effects on marine water quality.

The additional effects assessment for potential effects of wastewater discharges on water quality is unchanged from that provided in Section 4.5 of the Application. For the discharges, the Project is expected to result in low magnitude residual effects within the local assessment area (LAA), limited mainly to the IDZ, continuous over the long-term, and reversible when discharges cease. The residual effect is characterized as not significant.

Discharge Effects on Fish and Fish Habitat

The discharge of wastewater into the marine environment has the potential to affect the quality of the receiving environment, and in turn, affect marine fish health (as assessed in Section 4.9.5.5 of the Marine Fish and Fish Habitat VC). The assessment below focuses on effects to marine fish health associated with the discharge of desalination brine, which is expected to comprise 91 to 95% of the wastewater discharged during operations. Other potential changes to marine water quality from power plant blowdown or WWTP sources (e.g., changes in temperature or BOD) are not expected to affect marine fish health because of the large dilution provided by the desalination wastewater, which will allow potential parameters of concern to meet WQGs.

Potential changes in fish health are expected to be limited to marine fish located within the IDZ. Because of the direction of the prevailing tide, it is assumed that the IDZ could extend up to 100 m to the north and south of the end of the outfall pipe. Within the IDZ, species with limited motility, such as sessile or slow moving benthic invertebrates and epifauna, as well as larval fish, will be especially vulnerable to exposure to elevated salinity. Based on results of the ROV survey, marine invertebrates observed near Charles Point include shrimp, prawn, crabs, Giant California sea cucumber, urchins, and scallops (Figure 20 and Figure 21 of Appendix L). It is expected that motile fish species traveling between Kaien and Digby Island will be able to perceive changes in water quality and select more favourable habitats in adjacent areas to avoid potential or perceived risk from exposure. Based on observations of marine fish in this area, these species could include flounders, soles, and greenlings (based on ROV observations, Figure 19 of Appendix L), as well as unidentified smelts and eulachon (based on catch from mid-water trawls, Appendix L). Other CRA fish species, such as Pacific salmon and Pacific herring, are also likely to use the channel and avoid the IDZ where salinity is elevated.

Based on use of mitigation measures (including locating the outfall pipe in a well flushed, tidally influenced and dynamic environment with diffuser(s) to disperse effluent upwards to reduce effects on benthic habitats) and Aurora LNG's commitment to model effluent discharges as part of permitting, Project-related discharges are not expected to result in residual adverse effects to marine fish health. Aurora LNG is committed to conducting a Marine Water Quality Monitoring Program, which will include monitoring effluent discharges as per permitting requirements (see Section 15.3.6 of the Application). Details of this monitoring program will be refined through consultation with appropriate regulators during permitting.

The additional effects assessment for potential effects of wastewater discharges on marine fish health is unchanged from that provided in Section 4.9.5.5 of the Application, which states that, with compliance to regulations and permitting, effects on fish health from effluent discharges are anticipated to be low magnitude and confined to the immediate vicinity of the outfall (see Section 4.5 for further details). Residual effects are considered to be confined to the LAA, occur continuously over the long-term, be reversible following the completion of the Project, and to occur in a previously undisturbed environment.

Discharge Effects on Marine Mammals

Given the localized area within the IDZ (within 100 m of the diffuser) where salinity would be elevated, it is assumed that marine mammals would avoid the area or, if they do travel through the IDZ, they would experience no obvious health effects due to exposure to elevated salinity in this small area. As a result, and with the implementation of mitigation measures, the effect of wastewater discharge on marine mammals should be constrained to the IDZ and be low in magnitude. The effect will occur continuously throughout the construction and operation of the Project and be reversible following Project decommissioning.

Discharge Effects on Heritage Valued Components

As documented in the Application (Section 7 Heritage Effects) archaeological studies conducted within Prince Rupert Harbour have identified hundreds of archaeological sites. There are 110 sites currently recorded on Digby Island, of which 62 are within the PDA. The currently proposed outfall pipe path crosses through a recorded archaeological site (GbTo-175), which is in the inter-tidal region (Section 7 of the Application, Figure 7.1). The site GbTo-175 includes seven canoe skids and two HCA protected petroforms along the beach within the intertidal zone. A *Heritage Conservation Act* Section 12 permit will be required for construction/placement of the pipe. Mitigation strategies will include avoidance, and data recovery. There is also a nearby archaeological shell midden site along the shoreline (closest is approximately 250 m from the proposed outfall). Elevated salinity in the discharge would not be expected to affect shell and bone at these sites. If the effluent was to have a lower pH, this could affect the preservation of shell and bone at these sites; however, decreased pH in marine water is not predicted.

Effects of wastewater discharge from the Project on heritage sites will be limited to construction of the outfall. The magnitude of residual effects of wastewater discharge due to construction on heritage sites will be moderate. Mitigation strategies, including avoidance, a *Heritage Conservation Act* Section 12 permit, and data recovery, will be used to limit effects during construction. Direct impact of heritage sites is not reversible. Meeting WQGs by the edge of the IDZ will mitigate for potential water quality effects on shell middens along the shoreline.

Summary

The regulations and permits described in this memo are legally binding requirements. Although the exact quality and quantity of discharges are not yet known, discharge volumes, rates, and concentrations will need to meet permit requirements, which are designed to protect aquatic life. Permits also mandate monitoring to detect degradation of the marine environment which, if detected, must be mitigated. In addition to permitting, all discharges to the aquatic environment must comply with the *Fisheries Act*, and its overriding principle of fish and fish habitat protection. The effects assessment on VCs that could interact with the wastewater discharges concluded that the findings do not change the effect characterization or conclusions provided in the Application.

The Aurora LNG facility will be designed, built, and operated by appropriately qualified and experienced personnel, who are committed to abiding by environmental legislation and best management practices.

The additional assessment of effects of Project discharges on marine water quality, marine fish, marine mammals and heritage VCs provided in this memo indicates that, with mitigation, residual effects will be not significant, consistent with the effect characterizations and conclusions stated in the Application. There is a high likelihood of success of mitigation measures to limit or avoid adverse effects on these VCs. Residual effects on water quality (mainly elevated salinity), marine fish health, and marine mammals are predicted to be low in magnitude, within the LAA (limited to the IDZ), occur continuously over the long-term, be reversible following cessation of discharges, and to occur in a previously undisturbed environment. Residual effects on the heritage VC will be mitigated through avoidance and data recovery and are considered moderate in magnitude, occur one time, during construction, and irreversible.

Aurora LNG is committed to conducting a Marine Water Quality Monitoring Program, which will include monitoring effluent discharges as per permitting requirements (see Section 15.3.6 of the Application). Details of this monitoring program will be refined through consultation with appropriate regulators.

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