33 HUMAN HEALTH

33.1 Approach

The potential for human health effects as a result of the Project may be associated with changes in air quality, water quality, noise and vibration, electric and magnetic fields (EMF), and methylmercury levels in fish. Chemicals or contaminants of concern that human receptors may be exposed to from Project construction and operational activities, as well as the nature and magnitude of potential exposure of human receptors to potential changes in these five parameters are described in the human health assessment. Exposure and potential effects on human health are evaluated in relation to regulatory guidelines and requirements for exposure limits.

The scope of the human health assessment was guided by human health considerations for large hydroelectric generating facilities and health issues identified as potential areas of concern by Aboriginal groups, regulators, the public, and other stakeholders, and by relevant regulatory standards and guidelines. The human health effects assessment was informed by results from the following technical studies:

- Water Quality – Volume 2 Section 11 Environmental Background Section 11.5 Water Quality and Volume 2 Appendix E Water Quality Baseline Conditions in the Peace River
- Groundwater Regime – Volume 2 Section 11 Environmental Background Section 11.6 Groundwater Regime and Volume 2 Appendix F Groundwater Regime Technical Data Report
- Fluvial Geomorphology and Sediment Transport – Volume 2 Section 11 Environmental Background Section 11.8 Fluvial Geomorphology and Sediment Transport Regime and Volume 2 Appendix I Fluvial Geomorphology and Sediment Transport Technical Data Report
- Air Quality – Volume 2 Section 11 Environmental Background Section 11.11 Air Quality and Volume 2 Appendix L Air Quality Technical Data Report
- Noise and Vibration – Volume 2 Section 11 Environmental Background Section 11.12 Noise and Vibration and Volume 2 Appendix M Noise and Vibration Technical Data Report
- Electric and Magnetic Fields – Volume 2 Section 11 Environmental Background Section 11.13 Electric and Magnetic Fields and Volume 2 Appendix N Electric and Magnetic Fields Technical Data Report
- Mercury Human Health Risk Assessment – Volume 2 Appendix J Mercury Technical Reports, Part 2 Mercury Human Health Risk Assessment

Potential effects of the Project on health services are assessed in Volume 4 Section 30 Community Infrastructure and Services. Potential effects of the Project on community health and well-being of Aboriginal groups as a result of effects on traditional use and culture are assessed in Volume 5 Section 34 Asserted or Established Aboriginal Rights and Treaty Rights, Aboriginal Interests, and Information Requirements. Health, safety, and environmental management measures (including workforce health and safety) are

addressed in relevant Environmental and Safety Management Plans (Volume 5 Section 35 Summary of Environmental Management Plans).

33.1.1 Regulatory Framework

Health in B.C. is regulated by the *Public Health Act,* which delineates the powers, duties, and function of the minister and public health officials with respect to public health monitoring, environmental health hazard response, public health emergency response, and other public health issues. The *Public Health Act* also specifies responsibilities for local governments regarding public health. Relevant regulations, regulatory objectives, standards and guidelines applicable to the human health effects assessment are described below.

33.1.1.1 Drinking and Recreational Water Quality

In B.C., responsibility for drinking and recreational water quality rests with the Ministry of Health. The *Drinking Water Protection Act* covers all water systems other than single-family dwellings and systems excluded through the Drinking Water Protection Regulation. The Act outlines requirements for water suppliers in terms of ensuring that the water supplied to users is potable, and meets any additional requirements established by the Drinking Water Protection Regulation or by the water supply system's operating permit.

The Drinking Water Protection Regulation established under the *Drinking Water Protection Act* sets out requirements for drinking water quality. This includes standards for drinking water, treatment, water quality monitoring and reporting, water supply construction and operation permitting, public notification in the event water becomes undrinkable, and emergency response and contingency plans for water suppliers.

Regional health authorities in B.C. are responsible for administering and enforcing the *Drinking Water Protection Act* and Drinking Water Protection Regulation. Municipal governments are responsible for monitoring drinking water facilities and distribution systems to ensure that the water reaching residents and consumers meets provincial drinking water quality standards, and for management of water quality at public beaches and other recreational facilities within their jurisdiction.

Both federal and provincial health-based guidelines for drinking water quality are established for contaminants where exposure could lead to adverse health effects. Drinking water quality guidelines relevant for the Project include:

- Health Canada Guidelines for Canadian Drinking Water Quality, applicable in both Alberta and B.C. (Health Canada 2012)
- B.C. Water Quality Guidelines for Drinking and Recreational Uses (BCMOE 2006)

Guidelines for drinking water quality parameters are presented in Table 33.1.

1 **Table 33.1 Federal and Provincial Drinking Water Quality Guidelines**

Parameter	Units	Health Canada [a]	British Columbia Ministry of Environment [b] (Drinking Water)
Conventional Parameters			
pH	pH units	6.5 – 8.5	N/A
Total dissolved solids	mg/l	< or = 500	N/A
Total suspended solids	mg/l	N/A	N/A
Temperature	°C	15	15
Turbidity	NTU	Treated water <0.1 at all times < or = 0.3 (chemically assisted filtration) < or = 1.0 (slow sand or diatomaceous filtration	N/A
Major Ions			
Sodium	mg/l	200	N/A
Chloride	mg/l	250	250
Sulphate	mg/l	500	500
Sulphide	mg/l	0.05	N/A
Cyanide	mg/l	0.2	N/A
Fluoride	mg/l	1.5	1.0
Nutrients and Biological Indicators			
Nitrate + nitrite	mg/l	10 (as nitrate-nitrogen)	10
Nitrate + nitrite	mg/l	45 (as nitrate)	N/A
Nitrate	mg-n/l	10	N/A
Nitrite	mg-n/l	1	N/A
Total Metals			
Aluminum	µg/l	100	N/A
Antimony	µg/l	6	N/A
Arsenic	µg/l	10	25
Atrazine	µg/l	5	N/A
Barium	µg/l	1000	N/A
Benzene	µg/l	5	N/A
Beryllium	µg/l	N/A	4
Boron	µg/l	5	5000
Bromoxynil	µg/l	5	N/A
Cadmium	µg/l	5	N/A
Chromium	µg/l	5	N/A
Chromium VI	µg/l	50	N/A
Copper	µg/l	1000	500
Iron	µg/l	300	N/A
Lead	µg/l	10	50
Manganese	µg/l	50	1
Mercury	µg/l	1	N/A
Molybdenum	µg/l	N/A	250
Selenium	µg/l	10	10

Parameter	Units	Health Canada [a]	British Columbia Ministry of Environment [b] (Drinking Water)
Thallium	µg/l	N/A	2
Uranium	µg/l	2	N/A
Zinc	µg/l	5000	5000
Organics			
Benzo(a)pyrene	mg/l	0.00001	N/A
Benzene	mg/l	0.005	N/A
Ethylbenzene	mg/l	0.0024	N/A
Toluene	mg/l	0.024	N/A
Xylene	mg/l	0.3	N/A

NOTES:
[a] Health Canada (2012a)
[b] BCMOE (2006)
N/A – not applicable

33.1.1.2 Air Quality

The *Environmental Management Act* and the Waste Discharge Regulation are the main air quality legislation in B.C. The Open Burning Smoke Control Regulation (under the *Environmental Management Act*) governs burning of vegetative material associated with land clearing and forestry-related resource management, and sets out the conditions under which the open burning of vegetative debris can be authorized.

Ambient air quality objectives and standards for criteria air contaminants (CACs) are developed by environmental and health authorities to provide guidance for environmental protection and air quality decisions. Applicable air quality standards include:

- Air Quality Objectives and Standards (BCMOE 2009) – maintenance and improvement of health are identified as the primary objective of the Air Quality Objectives and Standards
- Canada-wide Standards (CWS) for Particulate Matter and Ozone: Five Year Report: 2000–2005 (CCME 2006) – the CWS encompasses standards, guidelines, objectives, and criteria for protecting human health; the CWS for particulate matter are identified as a step towards the goal of minimizing the risks that they impose on human health

The CACs for which there are either ambient air quality objectives or Canada-wide standards include particulate matter (PM), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and carbon monoxide (CO). Federal and provincial air quality objectives for these CACs are outlined in Table 33.2.

Table 33.2 British Columbia Ambient Air Quality Objectives and Canada-wide Standards

Contaminant	Averaging Period	Objectives/Standards (µg/m^3)			
		British Columbia			Canada-wide Standard
		Level A	Level B	Level C	
Total Suspended Particulate	24-hour	150	200	260	—
	Annual	60	70	75	
Particulate Matter less than 10 µm (PM_{10})	24-hour	50			—
	Annual	—			—
Particulate Matter less than 2.5 µm ($PM_{2.5}$)	24-hour	25 [a]			27 to 30 [b]
	Annual	8 [c]			8.8 to 10 [f]
Dustfall [d]	24-Hour	1.75 mg/dm^2-d residential, 2.9 mg/dm^2-d non-residential			—
Nitrogen Dioxide [e]	1-hour	—	400	1,000	—
	24-hour	—	200	300	
	Annual	60	100	—	
Sulphur Dioxide	1-hour	450	900	900-1,300	—
	24-hour	160	260	360	
	Annual	25	50	80	
Carbon Monoxide	1-hour	14,300	28,000	35,000	—
	8-hour	5,500	11,000	14,300	

NOTES:

[a] Compliance based on annual 98th percentile value

[b] Compliance based on annual 98th percentile value, averaged over three consecutive years. Current objective of 30 µg/m^3 is proposed to change to 28 µg/m^3 in 2015 and 27 µg/m^3 in 2020.

[c] B.C. also has a planning goal for annual $PM_{2.5}$ of 6 µg/m^3

[d] 24-hour average based on 30-day sample

[e] B.C. does not have ambient air quality objectives for NO_2 and therefore the federal maximum acceptable (Level A), desirable (Level B), and tolerable (Level C) objectives are presented

[f] There are currently no annual Canada-wide standards for annual $PM_{2.5}$, but there is a proposed objective of 10.0 µg/m^3 for 2015 and 8.8 µg/m^3 for 2020

— none

Sources: CCME (2006); BCMOE (2009)

33.1.1.3 Noise

There are no provincial regulations regarding noise in B.C. The British Columbia Oil and Gas Commission (BCOGC) Noise Control Best Practices Guidelines 2009 document (BCOGC 2009) outlines a process for determining the sound level criteria for an identified receptor, which includes how to define noise-sensitive receptors and study areas. Noise levels are presented as “A-weighted” decibels (dBA), which incorporates noise frequencies audible to the human ear (refer to Volume 2 Appendix M Noise and Vibration Technical Data Report for details).

The L_{eq} is a single-number representation of naturally variable sound energy measured over a time interval. The time intervals used for the noise study are as follows:

- Night: the nighttime period $L_{eq(9)}$, a 9-hour L_{eq} determined for the hours of 22:00 through 07:00

- Day: the daytime period $L_{eq(15)}$, a 15-hr L_{eq} determined for the hours of 07:00 through 22:00

The BCOGC guideline values (outlined in Table 33.3) are based on land use categories and reflect the expected variation in ambient sound level associated with the different degrees of area development. The daytime PSL includes a +10 dBA adjustment as defined in the BCOGC Guideline.

Table 33.3 British Columbia Oil and Gas Commission Guideline Table 1: Basic Permissible Sound Levels by Land Use Category

Proximity to Transportation	Dwelling Unit Density Per Quarter Section of Land		
	1 – 8 Dwellings; 22:00 – 07:00 (Nighttime) (dBA L_{eq})	9 – 160 Dwellings; 22:00 – 07:00 (Nighttime) (dBA L_{eq})	>160 Dwellings; 22:00 – 07:00 (Nighttime) (dBA L_{eq})
Category 1	40	43	46
Category 2	45	48	51
Category 3	50	53	56

NOTES:

Category 1 – dwelling units more than 500 m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers

Category 2 – dwelling units more than 30 m but less than 500 m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers

Category 3 – dwelling units less than 30 m from heavily travelled roads and/or rail lines and/or subject to frequent aircraft flyovers

Density per quarter section – refers to a quarter section with the affected dwelling at the centre (a 451 m radius). For quarter sections with various land uses or with mixed densities, the density chosen is then averaged for the area under consideration.

Source: BCOGC (2009)

Guidelines on blasting noise or airborne vibration are provided by the United States Office of Surface Mining (USOSM 1986) and the Ontario Ministry of Environment (ONMOE No date). The Ontario guidelines (used for the Noise and Vibration Technical Study) are provided in Table 33.4 below.

Table 33.4 NPC 119 Noise Pollution Control Guideline for Blasting Activity

Vibration Type	Unit	Guideline [a]
Blasting noise	Peak Pressure Level L_{peak} (dBL)	120

NOTES:

[a] Cautionary Limit as published in Noise Pollution Control Publication 119 (NPC-119) by Ontario Ministry of the Environment

dBL = linear decibel

Source: ONMOE (No date)

33.1.1.4 Electric and Magnetic Fields

In Canada, there are no federal standards for EMF at low frequencies, as there is no conclusive evidence of harm caused by EMF exposure at levels found in Canadian homes and schools, including those located just outside the boundaries of power line corridors (Health Canada 2010a). Health Canada does not consider guidelines to be necessary but recommends carrying out exposure assessments where public concern is expressed.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) and International Committee on Electromagnetic Safety (ICES) have published guidelines for limiting public exposure to EMF (ICNIRP 2010; ICES 2002) (Table 33.5). Both organizations incorporate safety factors such that the guidelines are at a level below that which effects are known to occur in order to account for any unknown variability or greater likelihood for effects on susceptible populations.

Table 33.5 Reference Levels for Whole Body Exposure to 60-Hz (Extremely Low) Frequency Fields: General Public

Organization Recommending Limit	Magnetic Fields	Electric Fields
ICNIRP screening value or restriction level	2,000 mG	4.2 kV/m
ICES maximum permissible exposure	9,040 mG	5 kV/m 10 kV/m [a]

NOTES:

[a] This exposure limit is an exception with transmission line rights-of-ways, since people do not spend a substantial amount of time in rights-of-way, and very specific conditions are needed before a response is likely to occur (i.e., a person must be well insulated from ground and must contact a grounded conductor) (ICES 2002)

Source: Exponent (2012a)

33.1.1.5 Methylmercury

Health Canada defines environmental quality standards and guidelines for acceptable concentrations of mercury in the environment (i.e., mercury concentrations in food, soil, and drinking water) and the level of methylmercury that people can be exposed to without risk of adverse effects. Provisional Tolerable Daily Intake (pTDI) is defined as the maximum amount of chemical that can be ingested on a daily basis over a lifetime without increased risk of adverse health effects (Health Canada 2007). As indicated in Table 33.6, the pTDI for methylmercury for the general population is 0.47 µg/kg body weight/day (µg/kg bw/d). Due to a higher susceptibility of potential health effects of methylmercury to~~in~~ infant and young children, and the fact that a mother's methylmercury exposure to potential health effects can be passed on to her fetus or child during lactation, Health Canada has developed more conservative pTDI of 0.2 µg/kg bw/d for methylmercury for children less than 13 years of age, and for women of childbearing age.

Table 33.6 Canadian Upper Limits for Methylmercury Ingestion

Guidelines on Tolerable Daily Intake	Value	Units
Health Canada provisional Tolerable Daily Intake (pTDI) for methylmercury for the general population	0.47	µg methylmercury/kg body weight/day
Health Canada provisional Tolerable Daily Intake (pTDI) for children less than 13 years old and women of child-bearing age	0.2	µg methylmercury/kg body weight/day

NOTE:

Source: Health Canada (2007, 2009a)

33.1.2 Key Issues and Identification of Potential Effects

Concerns have been raised about the potential for adverse effects on human health due to changes in the following as a result of the Project:

- Ambient air quality

- Potable and recreational water quality
- Noise and vibration
- EMF
- Country foods, including reduced consumption and methylmercury concentrations in fish consumed by humans (herein referred to as "changes in country foods – methylmercury in fish")
- Landscape, including access to and use of land

Issues, concerns and interests identified during consultation with the public, Aboriginal groups, and government agencies guided the scope of the human health assessment (refer to Volume 1 Section 9 Information Distribution and Consultation). The key issues identified and the approaches used to address issues are outlined in Table 33.7.

Table 33.7 Key Issues: Human Health

Key Issues	Approach to Addressing Key Issues
Air Quality	
Human receptor category of "resident" being inclusive of both permanent and temporary (seasonal) residents (e.g., First Nations hunting camps)	• Human receptors are specified in the human health assessment, including First Nations receptors of concern such as temporary habitation sites and use areas (e.g., hunting/fishing camps, elder/youth camps), residences, schools, hospitals/health care facilities, child care facilities, and senior care facilities where air quality may be affected by the Project • Included 85th Avenue Industrial Lands and Hudson's Hope in the geographical scope of air quality technical study and human health assessment • Dispersion model conducted for the dam site area and surroundings due to the extent of construction activities in the area and proximity to the City of Fort St. John • Emissions from all Project components during construction and operation estimated for the large Project area (138 km by 102 km) • Sub-areas defined around Hudson's Hope Shoreline Protection area, and construction material source areas (Wuthrich Quarry, West Pine Quarry, 85th Avenue Industrial Lands, Portage Mountain, Del Rio Pit) to further characterize Project emissions in these areas. • Addressed in the design of air quality modelling and analysis of project effects on human health (Refer to Volume 2 Appendix L Air Quality Technical Data Report)
Illustrate changes to air quality at human receptor locations	
Dust from excavation and movement of materials	
Changes to air quality from construction activities at 85th Avenue Industrial lands	
Changes to air quality in the upstream end of the Site C reservoir near Hudson's Hope	

Key Issues	Approach to Addressing Key Issues
Protection of air quality through monitoring and management plans	• Air quality monitoring and management plans will be developed for the Project. These will include management measures for observed particulate matter levels that would pose risks to human health.
Management of particulate matter and risks to human health	
BC Hydro commitment to Canada-wide standard principles for Particulate Matter (PM) and pollution prevention	
Potable and Recreational Water Quality	
Water contamination and associated health risks	• Human receptors are specified in the human health assessment, including First Nations receptors of concern such as temporary habitation site and use areas (e.g., hunting/fishing camps, elder/youth camps), residences, schools, hospitals/health care facilities, child care facilities, and senior care facilities where potable drinking water quality may be affected by the Project • Fort St. John landfill was included in the geographical scope of surface and groundwater quality technical studies, and human health assessment • Taylor's water intakes were included in the geographical scope of the groundwater quality technical studies and human health assessment • Addressed in design of water quality modelling (see Volume 2 Appendix D Surface Water Regime Technical Memos, Volume 2 Appendix E Water Quality Baseline Conditions in the Peace River, and Volume 2 Appendix F Groundwater Regime Technical Data Report) and analysis of Project effects on human health
Leaching of contaminants from Fort St. John landfill	
Clogging of Taylor's water intakes/reduction in water quality due to increased turbidity	
First Nations concerned with water quality and pollution	
Operational monitoring program for users of well water	• Mitigation measures include monitoring of groundwater quality
Follow-up monitoring for water quality	
Noise and Vibration	
Noise from construction activities including those at 85th Avenue Industrial Lands	• Issues were used to identify human receptors of concern including First Nations receptors such as temporary habitation use areas (e.g., hunting/fishing camps, elder/youth camps), municipalities, districts, and reserves in areas where noise and vibration may be affected as a result of the Project • Included 85th Avenue Industrial Lands in the geographical scope of noise and vibration technical study and human health assessment • Addressed in the design of noise modelling and analysis of project effects on human health (see Volume 2 Appendix M Noise and Vibration Technical Data Report)
Identify noise-sensitive human receptors, including permanent and temporary land use by First Nations	
First Nations concern with loss of quiet enjoyment due to increased noise	
First Nations concern with loss of quiet enjoyment due to increased noise	
Management of noise emissions to avoid nighttime weekend and evening disturbance	• Mitigation measures include management of noise emissions during off-peak hours, and noise effects from the conveyor belt
Manage noise effects from 85th Avenue conveyor belt	

Key Issues	Approach to Addressing Key Issues
Electric and Magnetic Fields	
Consider current state of scientific knowledge with respect to health effects from EMF exposure and a review of current exposure guidelines and/or position statements from health-related organizations	• Issues were used to identify human receptors of concern including First Nations receptors such as temporary habitation use areas (e.g., hunting/fishing camps, elder/youth camps), municipalities, districts, and reserves • A study was completed on current state of scientific knowledge with respect to health effects from EMF exposure (refer to Volume 2 Appendix N Electric and Magnetic Field Technical Data Report)
Consider permanent and temporary human receptors within proximity to 500 kV right-of-way	
Changes in Country Foods – Methylmercury in Fish	
Erosion and associated mercury effects	• Patterns of fishing and fish consumption by receptor type and activity (for recreation, subsistence and traditional use purposes) from water bodies where changes in methylmercury in fish could potentially occur as a result of the Project were defined • Mercury exposure ingestions and/or dermal contact was addressed in the Volume 2 Appendix J Mercury Technical Reports Part 2 Mercury Human Health Risk Assessment, and the human health assessment • Addressed in design of mercury modelling and analysis of project effects on human health (see Volume 2 Appendix J Mercury Technical Reports)
Concerns with contamination of fish and wildlife; faith in country foods (First Nations)	
Patterns of fish consumption (First Nations and non-First Nations)	
Consider age and gender characteristics of human receptors to identify subpopulations most sensitive to mercury exposures	
Concerned with mercury in fish (First Nations)	
How many fish people can safely eat out of the Peace River now, and how many fish people could safely consume from the Site C reservoir (First Nations)	
Mercury exposure from ingestion or dermal contact with surface waters and sediments while swimming or participating in other recreational activities	
Perception of health risk related to methylmercury in country foods	• Results from the Human Health Risk Assessment for Methylmercury and Fish (Volume 2 Appendix J Mercury Technical Reports, Part 2 Mercury Human Health Risk Assessment) identify safe fish consumption levels for fish from the Site C reservoir and downstream of the Site C dam, during post construction during periods (i.e., at peak methylmercury levels)
Follow-up monitoring for methylmercury	
Landscape, including Access to and Use of Land	
Concern that significant changes to the landscape are expected to have both short-term and long-term health effects, including both physical well-being and psychological and spiritual health. Saulteau members rely on the land to collect medicinal plants, and for spiritual and ceremonial purposes, and other plants for sustenance (Saulteau First Nations)	Issues associated with changes to landscape and the use of land for cultural purposes and harvesting are assessed in Volume 3 Section 19 Current Use of Land and Resources for Traditional Purposes
Concern that reduced access to preferred lands could lead to exacerbation of existing reduced social and cultural status of elders and reducing quality of life and mental health (Treaty 8 Tribal Association)	The issue of reduced access to land during the construction and operation of the Project is related to public safety and, therefore, addressed through individual management plans outlined in Section 35 Summary of Environmental Management Plans

Potential project interactions with human health are summarized in Volume 2 Appendix A Project Interaction Matrix, Table 2. As defined in Section 10 Environmental

Assessment Methodology, a rank of "2" was given where interactions may result in an adverse effect and the nature of the effect and/or the effectiveness of mitigation measures is uncertain. These interactions were taken forward through the effects assessment.

Project interactions with a ranking of "2" are set out in Table 33.8 below.

Table 33.8 Interactions of the Project with Human Health

Project Components and Activities	Key Aspects				
	Change to potable and recreational water quality	Change in Ambient Air Quality	Change in Noise and vibration	Change in Electric and Magnetic Fields	Changes in Country Foods – Methylmercury in Fish
CONSTRUCTION					
Site C Dam and Generating Station		✓	✓		
Site C Reservoir Preparation and Filling (including construction of Hudson's Hope Shoreline Protection)		✓	✓		
Transmission Line to Peace Canyon		✓	✓		
Quarried and Excavated Material Source Development		✓			
85th Avenue Till Source Conveyor Belt		✓	✓		
Highway 29 Realignment		✓	✓		
Construction Access Road Development		✓	✓		
Worker Accommodation		✓			
OPERATIONS					
Powerhouse, substation, and Site C reservoir (including Hudson's Hope Shoreline Protection maintenance)	✓				✓
500 kV lines				✓	

NOTE:
Only Project interactions ranked as "2" in Volume 2 Appendix A Project Interactions Matrix, Table 2 are carried forward to this table. A ✓ indicates that a project component or activity is likely to interact with Human Health.

33.1.3 Standard Mitigation Measures and Effects Addressed

A "1" ranking was given where an adverse effect may result from an interaction, but standard mitigation measures to avoid or minimize the potential effects are available and well understood to be effective, and any residual effect is negligible. These interactions were not carried forward through the effects assessment.

For construction, a "1" ranking was assigned for all project construction components, as they related to changes in potable and recreational water quality. Management plans for hazardous and non-hazardous waste management, and fuel handling and storage will

be developed in accordance with federal and provincial requirements (Volume 5 Section 35 Summary of Environmental Management Plans). A Contaminated Sites Management Plan will be implemented for management of contaminated or potentially contaminated sites and potential effects on groundwater quality. A Ground Water Quality Management Plan will also be implemented during construction (in accordance with Contaminated Sites Regulation and the *Environmental Management Act*) to protect groundwater sources used for potable drinking water. An Erosion Prevention and Sediment Control Plan will be implemented in accordance with the federal *Fisheries Act* and the *Provincial Water Act* to avoid or minimize adverse effects of erosion and sediment on receiving surface drinking water quality. A Surface Water Quality Management Plan will be implemented to control, manage, and treat surface runoff into surface water. In relation to worker accommodation, potable water for on-site workforce would be subject to provincial water quality guidelines and treatment.

A “1” ranking was also assigned to activities associated with construction of on-site worker accommodation for noise and vibration, as the Project will adhere to applicable noise guidelines during accommodation site preparation, installation, and operations.

During operations, a “1” ranking was assigned for all operation components as they relate to changes in air quality and noise and vibration (including powerhouse, substation, and Site C reservoir operations, and maintenance of Hudson’s Hope shoreline protection, transmission line right-of-way, overhead structures, and access roads. Potential effects will be mitigated by implementing noise and vibration air quality standards and guidelines (see Volume 5 Section 35 Summary of Environmental Management Plans).

All other project activities and works listed in a Table 2 of Volume 2 Appendix A Project Interaction Matrix were ranked as “0” either because the activities do not interact with human health.

33.1.4 Selection of Key Indicators

A screening process was implemented by the water quality, air quality, noise and vibration, EMF, mercury and human health risk, and human health assessment teams to identify specific indicators related to water quality, air quality, noise and vibration, EMF, methylmercury, and country foods that may change as a result of the Project, and that have the potential to affect human health.

These are identified as indicators against which effects on human health were assessed (with reference to changes in these indicators and any exceedances of standards, guidelines, and/or objectives as presented in Section 33.1.1). Table 33.9 summarizes the indicators, a description of health effects associated with exposure, and rationale for their selection.

1 **Table 33.9 Key Indicators for Human Health**

Key Indicators for the Effect	Potential Health Effects [a]	Rationale for Selection of the Key Indicators
Change in Potable and Recreational Water Quality [b] Temperature Turbidity Concentrations of: • Total suspended solids (TSS) • Nutrients (nitrates) • Mercury	Turbidity – particles can harbour microorganisms, protecting them from disinfection, and can entrap heavy metals and biocides TSS –- associated with higher concentrations of bacteria, nutrients, pesticides, and metals in the water Nitrates – Possible carcinogen; blue baby syndrome in infants less than 3 months old (short term). Microbial and organic contaminants – gastrointestinal upset/illness Mercury – neurological symptoms	Key drinking water and recreational water quality parameters potentially affected by Project Project could increase suspended sediments in drinking water sources; increases in organic contaminants in surface and groundwater could occur from contaminant soils being uncovered during excavation activities and flooding Concentrations of parameters in exceedance of federal and provincial water quality guidelines can adversely affect human health
Change in Ambient Air Quality Concentrations of: • Total suspended particulates • Particular Matter (PM_{10}; $PM_{2.5}$) • CO • NO_2 • SO_2	PM_{10} and $PM_{2.5}$ – coughing, shortness of breath, aggravation of existing respiratory illness such as asthma CO – headache, dizziness, nausea, impaired mental and cognitive functioning, fainting NO_2 – irritation of mucous membranes of eyes, nose, throat and respiratory tract. Continued exposure can irritate lungs and lower resistance to respiratory infection SO_2 – shortness of breath, coughing, lung irritation; aggravation of existing respiratory illness such as asthma	Key air quality parameters (criteria air contaminants) that would potentially be changed as a result of construction of the Project Combustion and fugitive dust emissions would occur through operation of construction vehicles and equipment, clearing and burning vegetation and debris and extraction of construction materials from quarries Concentrations of air quality parameters in exceedance of federal and provincial air quality objectives can adversely affect human health

Key Indicators for the Effect	Potential Health Effects [a]	Rationale for Selection of the Key Indicators
Change in Noise and Vibration Daytime and Nighttime L_{eq} (Continuous equivalent noise level) (dBA) "Just noticeable" change in ambient noise levels (defined as changes in noise levels greater than 3dBA) Vibration Peak Pressure Level L_{peak} (dBL)	Hearing loss sleep disturbance interference with speech comprehension	Noise and vibration would occur from construction equipment, vehicles, and conveyor operations Noise levels in exceedance of regulated permissible sound levels can adversely affect human health
Change in EMF Magnetic field (mG) levels electric field (kV/m) levels	No conclusive evidence of effect on human health caused by EMF exposure levels located just outside of boundaries of power line corridors	Potential public concern of health risk from EMF exposure
Change in country foods – methylmercury in fish Provisional Tolerable Daily Intake (pTDI) for methylmercury [c] The number of servings of fish that can be consumed without exceeding Health Canada's provisional Total Daily Intake (pTDI) for methylmercury	Neurological impairment Short- to long-term exposure can result in paresthesia, malaise and blurred vision, concentric constriction of the visual field, deafness, dysarthria, and ataxia Very high exposures – methylmercury poisoning, leading to coma and death Chronic exposure – negative effect on the immune system and cardiovascular effects The developing fetus most sensitive to methylmercury exposure – can affect the nervous system, fine motor function, attention, verbal learning, and memory	Inundation of the Site C reservoir would result in change in methylmercury concentrations in fish, with potential for accumulation of mercury in fish as a food source

NOTES:

[a] Health effects vary in type and intensity based upon magnitude of dose and duration of exposure.

[b] There are no federal or provincial drinking water quality standards for total suspended solids (TSS) however TSS contributes to the turbidity of water. Concerns associated with turbidity (of which there is a health based objective – see Health Canada 2012) are related to the propensity for suspended particles to contain other chemicals including metals, biocides and microorganisms (which in of themselves can affect drinking water quality).
Health Canada does not provide a health based maximum acceptable concentration for total dissolved solids (TDS), but does provide an aesthetic objective of < or = 500 mg/L (Health Canada 2012). Change in TDS during operations was not assessed through the water quality technical studies for the Project due to the very low existing TDS baseline concentrations and anticipated negligible effect of the Project on TDS (refer to Golder 2012). Changes in nutrients (including nitrates which have drinking water quality guidelines, ammonia and total phosphates which do not), TSS, and mercury are the key water quality parameters considered in the water quality studies completed for the Project. Metals (other than mercury), pesticides and organic constituents have not typically been analyzed in other reservoir studies when assessing effects of reservoir creation on water quality and were not assessed through the water quality technical studies completed for the Project.

[c] Long-term, frequent consumption of fish with mercury concentrations in excess of provisional tolerable intake levels may pose a risk to human health, although adverse health effects are difficult to definitively diagnose. Nevertheless, concern remains. Health Canada (2007) advise that fish are a nutritious food source and should be regularly consumed, but that health benefits should be weighed against health risks.

33.1.5 Spatial and Temporal Boundaries

33.1.5.1 Spatial Boundaries

The Local Assessment Area (LAA) for human health was based on the technical study area boundaries for air quality, noise, water quality, and EMF studies, and the mercury human health risk assessment, in combination with location of human receptors of concern. The LAA includes the following:

- Potable and recreational water quality – areas of the Peace River watershed in which changes to water quality from the Project would occur and where groundwater and surface water sources are used as drinking water sources and/or for recreational use (e.g., swimming). These include:
  - Peace River mainstem:
    - Below the Peace Canyon Dam but above the Site C dam location (i.e., the proposed Site C reservoir)
    - Below the proposed Site C Dam to confluence with the Alces River (for surface water quality only, as the Project is not expected to change groundwater quality downstream of the Site C dam)
  - Tributaries:
    - Below Peace Canyon Dam but above proposed Site C Dam (Maurice Creek, Lynx Creek, Farrell Creek, Halfway River, Boudreau Creek, Cache Creek, Moberly River)
    - Below proposed Site C Dam to confluence with the Alces River (Pine River, Beatton River, Kiskatinaw River)
- Ambient air quality:
  - A 5 km buffer along new roads, upgraded roads, and existing roads to be used for transport; along Highway 29 realignment, and along the 500 kV transmission lines
  - Buffers of 12 km x 12 km from the aggregate quarry sites including West Pine Quarry, the Del Rio Pit, and Portage Mountain Quarry
  - A 26 km x 27 km dispersion modelling study area (DSMA) to predict ambient air quality concentrations resulting from the Site C dam site, generation station, and spillways construction emissions (the DSMA was identified due to the Site C Dam's proximity to the City of Fort St. John and includes a large percentage of Fort St. John's municipal boundary and extends north and east to include the community of Charlie Lake and the District of Taylor)
- Noise and vibration:
  - 1.5 km buffer area (per BCOGC 2009 guidelines) around the Project activity zone (including Site C dam site, quarries, 500 kV transmission Line, Site C reservoir clearing areas and Hudson's Hope Shoreline Protection, and sections of Highway 29 realignments)

- EMF:
  - 50 m from edge of the right-of-way of the 500 kV transmission lines
- Country foods – methylmercury in fish – water bodies where methylmercury concentrations in fish may increase above background concentrations as a result of the Project, and where people catch and consume fish including:
  - Proposed Site C reservoir and major tributaries
  - Downstream of proposed Site C Dam to Many Islands, Alberta (approximately 100 km downstream of the proposed Site C dam site)

The RAA for human health is the same as the LAA. The RAA is the area within which projects, the residuals effects of which may overlap in time and space with those the Project, to be considered in the assessment of cumulative effects (where there are anticipated residual effects).

The LAAs and RAAs for Human Health are shown in Figures 33.1, 33.2, 33.4 and 33.5 (as indicated in Figure 33.1, baseline water quality information was collected for the area between the Williston Reservoir and Peace Canyon Dam, to support calibration of the water quality model. However, changes to water quality as a result of the Project were assessed downstream of Peace Canyon, as the part of the Peace River that would potentially be affected by the Project).

33.1.5.2 Temporal Boundaries

The temporal boundary for the assessment includes the construction and operations phase of the Project as described in Section 4.3 in Volume 1 Section 4 Project Description.

Specific temporal boundaries are listed below:

- Potable and recreational water quality – operations phase, with a focus on first 10 years of Site C reservoir operations (with the implementation of specified construction management plans as indicated in Section 33.13, changes to drinking water quality are not anticipated during the project construction phase)
- Ambient air quality – estimated for a conservative construction year based on predicted quantity of emissions and proximity of sources to residences (as indicated in Volume 2 Appendix L Air Quality Technical Data Report, emissions from dam and generating station operations and potential for fugitive dust emissions from shoreline exposure along the Site C reservoir will be negligible and will not interact with human health)
- Noise and vibration – construction phase, with a focus on Year 3 and Year 5, which is the period during which the greatest amount of equipment would be on-site, and the highest concentration of construction activity would occur (as indicated in Volume 2 Appendix M Noise and Vibration Technical Data Report, sound-emitting activities during operations would be negligible at the Site C dam site, Site C reservoir, Highway 29 and 500 kV transmission lines, and would not interact with human health)
- EMF – operations phase of the 500 kV transmission lines

- Country foods – methylmercury in fish – Operations phase Years 3-8~~3–5,~~ where anticipated peak methylmercury concentrations would occur before returning to baseline levels within 10 – 15 years after peak (depending on species) ~~(20-30 years later)~~

33.2 Information Sources and Methods

33.2.1 Information Sources

33.2.1.1 Reference Documents

The following information was used to formulate the baseline, and assist with assessment of potential effects:

- Section 4.3 in Volume 1 Section 4 Project Description
- Baseline and modelling results from the water quality, air quality, noise and vibration, EMF technical studies, and the mercury human health risk assessment
- Objectives, standards, and guidelines for air quality, water quality, noise and vibration, EMF, and methylmercury (as specified in Section 33.1.1)
- General Health Canada guidance documents including:
  - Hydroelectric Projects (Health Canada 2011a)
  - Useful Information for Environmental Assessments (Health Canada 2010b~~1b~~)
  - Canadian Handbook on Health Impact Assessment (Health Canada 2004a)
- Other Health Canada guidance documents including:
  - EMF and Human Health:
    - It's your Health – EMF at Extremely Low Frequencies (Health Canada 2010a)
  - Human Health Risk Assessment – Mercury and Fish:
    - Human Health Risk Assessment of Mercury in Fish and Health Benefits of Fish Consumption (Health Canada 2007)
    - Mercury: Your Health and the Environment, a Resource Tool (Health Canada 2004b)
  - Air Quality and Human Health:
    - Supplemental Guidance on Human Health Risk Assessment on Air Quality (Health Canada 2009b)
  - Potable Water Quality and Human Health:
    - Guidelines for Evaluating Human Health Impacts in Environmental Assessment: Drinking and Recreational Water Quality (Health Canada 2011b~~c~~)
- Information on recreational angler fish catch, retention, and consumption from secondary research sources (including GSGislason 2009; LGL 2010; Pattenden 2010, 2011)

Information on First Nations fish consumption was obtained from Country Food Harvest and Consumption Surveys completed by some First Nations for their Traditional Land Use Surveys, and from a Country Foods Questionnaire included as data collection for First Nations Community Baseline Reports (refer to Volume 3 Appendix B First Nations Community Baseline Reports, Part 1 to Part 7). Non-quantitative data on species of fish harvested and consumed from the Traditional Land Use Studies were also referenced. Secondary data from Chan et al. (2011) were used to supplement information on country foods.

33.2.1.2 Interviews

The following interviews (and associated communications) were held with Health Canada:

- A meeting with Health Canada on November 23, 2011 to discuss the Human Health Assessment scope and method
- BC Hydro provided a written summary of the mercury human health risk assessment scope and method to Health Canada on January 4, 2012. Written comments on the document were received from Health Canada in February 2012.
- ~~Meeting~~ Email correspondence with Health Canada January 2012 to discuss the human health risk assessment scope and method
- BC Hydro provided a written summary of the Air Quality Technical Study scope and method to Health Canada on July 18,~~6,~~ 2012
- Response received from Health Canada on September 25, 2012 on the scope and method of the Air Quality technical study and consideration of human receptors

Northern Health was interviewed to identify concerns with the Project in relation to changes to the environment and potential effects on human health. Presidents of the local rod and gun clubs were contacted to gather information on recreational fishing, fish catch, and retention, and to identify the clubs' interest in participating in the online survey to gather information from club members on fish catch, retention, and consumption.

Volume 4 Appendix D Human Health Assessment Supporting Documentation, Part 1 Human Health Assessment Interview Methodology provides details on interview methodology.

33.2.1.3 Human Receptor Mapping – Application in Ambient Air Quality and Noise and Vibration Modelling

Human receptors were mapped using data from provincial and local government documents and databases, as well as available mapping and qualitative information from First Nations Traditional Land Use Studies. Identified buildings whose receptors status was unknown were groundtruthed through on-site visual observation to confirm receptor status.

In relation to air quality, representative background concentrations for the dispersion modelling study area were calculated at representative receptors, following the Guidelines for Air Quality Dispersion Modelling in British Columbia (BCMOE 2008).

This involved defining a Cartesian nested grid of receptors within the model domain, with Receptor spacing for the Cartesian grid as follows:

- 20 m spacing along the construction boundaries for Area E, Wuthrich, 85th Avenue Industrial Lands, and the dam site area.
- 50 m spacing up to 500 m from the construction boundaries
- 250 m spacing up to 2 km from the construction boundaries
- 500 m spacing up to 4 km from the construction boundaries
- 1,000 m spacing in the remainder of the 26 km x 27 km model domain

To ensure that maximum concentrations near populated areas were captured, a fine receptor grid with 100 m spacing was defined over Fort St. John and Taylor. In addition, a number of special receptors were defined at the worker camps, schools, child care facilities, health care facilities, senior care facilities and private buildings (receptor locations are shown in Figure 2.5.1 in Volume 2 Appendix L Air Quality Technical Data Report; Appendix D of the same report lists special receptors). Several of the identified residences and non-residences are located within the proposed dam site area where construction activities are expected to occur, and therefore these receptors were identified as being located within or very close to modelled emission sources.

In relation to noise and vibration, measurement data for representative receptors were selected based on relative location and proximity of receptors to existing sound sources.

33.2.1.4 Surveys

Information on recreational fish catch and retention was supplemented through the implementation of a dock survey at Peace Island Park on September 1, 2012 and the Halfway River Boat Launch on September 3, 2012. The purpose of the survey was to obtain information on frequency of consumption of fish caught in the Peace River and its tributaries by species. An online web-based survey was carried out with the North Peace Rod and Gun Club to obtain information on fish catch and retention from members.

Volume 4 Appendix D Human Health Assessment Supporting Documentation, Part 3 Fish Consumption Survey Methodology summarizes survey methodologies.

33.2.1.5 Aboriginal and Traditional Community Knowledge

Aboriginal traditional and community knowledge related to the Human Health VC was gained through review of results from BC Hydro's consultation with Aboriginal groups and the First Nations community baseline studies prepared and submitted to BC Hydro by the following First Nations: Duncan's First Nation, Doig River First Nation, Halfway River First Nation, Prophet River First Nation, and West Moberly First Nations, through the Treaty 8 Tribal Association. While the territories of the Blueberry First Nations and Saulteau First Nations are within boundaries of the human health LAA, BC Hydro had not received community baseline information from them at the time of writing. Should information be received during the Environmental Impact Statement review period, it will be considered and integrated in an amendment to the Environmental Impact Statement.

Baseline information and data as well as First Nations concerns and interests relevant to human health are incorporated in the baseline and effects assessment sections below. The First Nations community baseline reports are provided in Volume 3 Appendix B First Nations Community Baseline Reports.

BC Hydro's approach to gathering and integrating community-based social and economic data with First Nations is described in Volume 3 Appendix B First Nations Community Baseline Reports, Part 1 Approach to Gathering First Nations Community Baseline Information.

33.2.2 Methodology

The human health assessment compared measured or predicted changes in chemical concentrations (air quality, water quality) and energy levels (noise and vibration, EMF) as a result of the Project at human receptors sites with health-based regulatory objectives or guidelines. The human health assessment focused on the most conservative provincial and/or national objectives or guidelines that are considered protective of human health. If chemical concentrations or energy levels were identified as exceeding applicable regulatory objectives or guidelines, these were identified, and discussed in relation to potential effects on human health. It is noted that exceedences of health-based objectives or guidelines do not necessarily mean that adverse effects on human health will occur; however, exceedances of these objectives or guidelines identified through modelling and/or estimations were flagged as changes that could potentially result in adverse effects to human health if mitigation measures were not put in place.

Heath Canada indicates that a human health risk assessment may not be necessary in an environmental assessment if applicable objectives, standards, or guidelines are met, as extensive human health risk assessments have been performed to establish these objectives, standards and guidelines (Health Canada 2011b~~a~~). However, Health Canada does indicate that a human health risk assessment should be carried out when there is reasonable potential for exposure to a chemical of potential concern or where a stakeholder has expressed concerns regarding potential exposure. Given the potential for increased methylation into the aquatic environment during project operations, the potential for accumulation of methylmercury in fish and a potential health hazard for those who depend on fish as a food source, a human health risk assessment was completed for methylmercury and fish (refer to Volume 2 Appendix J Mercury Technical Reports, Part 2 Mercury Human Health Risk Assessment). Results of the Mercury Human Health Risk Assessment are summarized and referenced within the human health assessment.

The human health assessment applied a process of contaminant screening, human receptor screening and identification, exposure pathway screening, and exposure assessment (and in the case of methylmercury and fish health risk analysis) to identify potential project effects on human health. These are described in detail below.

33.2.2.1 Contaminant Screening

Contaminants that could be a human health concern were identified as:

- Those where concentrations (or levels) exceed established regulatory criteria or guidelines

- Those that could cause adverse health effects with prolonged or repeated exposure

A screening process was implemented through the water quality, air quality, noise and vibration, EMF, and human health risk assessment studies to identify changes in chemical contaminant (air quality, water quality, and methylmercury) and energy levels (noise and vibration, EMF) as a result of the Project that have the potential to effect human health (e.g., concentrations or energy levels that could exceed applicable objectives or guidelines). Table 33.9 lists the key indicators, which are also contaminants of concern identified for the human health assessment.

33.2.2.2 Receptor Screening

A human receptor is defined as any individual, population group, or community residing (or visiting) the LAAs that could potentially be exposed to contaminants of potential concern (Government of Alberta 2011). The following steps were implemented to identify human receptors of concern:

- Receptors located within the air quality, water quality, noise and vibration, and EMF LAA were identified and mapped
- Sensitive receptors (those with the potential for health risk) were identified, based on the following criteria (Health Canada 2010a):
    - Physical and behaviour characteristics:
        - Individuals/populations with high levels of sensitivity based on age (e.g., the young and the elderly)
        - Individuals/populations with existing health vulnerabilities (e.g., hospitals, seniors centres)
        - Individuals/populations who may be at risk of ingesting contaminants (e.g., individuals who consume fish from potentially affected water bodies)
    - Individuals/populations as permanent residences, including the on-site workforce
    - Individuals/populations using temporary habitation sites, areas (e.g., public/private campgrounds, First Nations use areas)
    - Presence of a potential exposure pathway (i.e., ingestion, inhalation, auditory, dermal)

Categories of sensitive receptors located within the combined LAAs that were considered in the human health assessment are summarized in Table 33.10. Specific receptor types and locations for potable and recreational water quality, ambient air quality, noise and vibration, EMF, and changes to country foods – specifically methylmercury in fish – are described in Section 33.3.

Table 33.10 Human Receptors in the Human Health LAA

Receptor Category	Rationale	Change Parameter
Project On-Site Workforce		
On-site construction worker housing – north and south camp	• Permanent residence and human activity • In proximity to Site C dam site construction area	Air quality, noise and vibration [a]

Receptor Category	Rationale	Change Parameter
Residential		
Population centres [b]	• Permanent human activity • Presence of sensitive populations (elderly, young, ill) • In close proximity to Project activity zone • Obtain drinking water from potentially affect surface water/groundwater sources • Potential fish consumption from Peace River or tributaries	Air quality; noise and vibration; potable and recreational water quality; changes in country foods – methylmercury in fish
First Nations Reserves	• Evidence of fish consumption from Peace River or tributaries	Air quality; changes in country foods – methylmercury in fish
Inhabited residences outside of urban centres, within LAA	• Permanent human activity • Potential presence of sensitive populations (elderly, young, ill) • In close proximity to Project activity zone • Obtain drinking water from potentially affect surface water/groundwater sources • Potential fish consumption from Peace River or tributaries	Air quality; noise and vibration; water quality; changes in country foods – methylmercury in fish
First Nations temporary habitation use areas (e.g., cabins, hunting and fishing camps, elder/youth camps) within LAA	• Permanent human activity • Potential presence of sensitive populations (elderly, young, ill) • Known existence of temporary habitations in proximity to Project	Air quality; noise and vibration
Public Facilities Within LAA		
Schools	• Permanent human activity • Potential presence of vulnerable populations (elderly, young, ill) • In close proximity to Project activity zone (including Site C dam site) • Obtain drinking water from potentially affect surface surface/groundwater sources	Air quality, noise, water quality
Hospitals/health care facilities		
Child care facilities		
Senior care facilities		
Public indoor recreation and cultural centres; places of work	• Intermittent/short-term human presence • In close proximity to Project activity zone (Site C dam site) • Obtain drinking water from potentially affected surface water/groundwater sources	Air quality, noise, water quality
Outdoor Recreational Facilities in the LAA		
Campgrounds, parks, areas of recreational boating/water use	• Intermittent human presence • In close proximity to Project activity zone	Air quality, noise, water quality

NOTES:

[a] The Project workforce will have access to treated drinking water; therefore, ingestion of water as a potential exposure pathway was not evaluated for the construction workforce

[b] Municipalities in the vicinity of the Project and identified as population centres of concern include the City of Fort St. John (approximately 7 km northwest of the proposed Site C dam site), the District of Taylor (approximately 16 km downstream of the proposed Site C dam site), the District of Hudson's Hope (approximately 64 km upstream of the Site C dam site and adjacent to the proposed Site C reservoir)

33.2.2.3 Exposure Pathway Screening

Exposure pathways are the means through which human receptors can come into contact with contaminants in the physical environment. Exposure pathways depend on the physical-chemical properties of the substance, the environment in which the receptor lives and the likely receptor physical and behavioral characteristics. Exposure can be direct, where the receptor comes into contact with the contaminant directly from the source, or indirect, where the contaminant passes through another environmental medium (e.g., food) before reaching the receptor. Key mechanisms of exposure include inhalation, ingestion, dermal contact, and auditory.

Potential exposure pathways are presented in Table 33.11. An assessment of Project effects on human health was carried out where a receptor had a reasonable likelihood of exposure to a contaminant from a Project activity (e.g., directly from air emissions).

Table 33.11 Potential Pathways of Exposure

Exposure Pathway	Likelihood of Exposure	Carried Forward into Human Health Assessment	Contributing Project Activities
Inhalation of air (chemicals present in air emission)	Likely	Yes	Construction – ambient air emissions and dispersion from: site clearing, preparation and disposal of timber and vegetation; construction and maintenance of temporary and permanent access roads; asphalt production; excavation and transportation of sand and gravel from source pits; aggregate processing; concrete batch plant operations; transportation of construction materials, supplies and workforce; operation of diesel-fuelled vehicles and equipment
Ingestion of surface or groundwater	Likely	Yes	The creation and operations of the Site C reservoir
Audible noise and vibration	Likely	Yes	On-site construction equipment, vehicle/road usage, conveyor transport
Ingestion of fish	Likely	Yes	Site C reservoir operations a
Ingestion of birds and wild game b	Not likely	No	N/A
Ingestion of vegetation/ garden produce c	Not likely	No	N/A

NOTES:

[a] Potential methylmercury risks from consumption of fish tissues other than muscle were not considered an exposure pathway. Surveys of local First Nations did not identify that non-muscle tissue was regularly consumed. Data from other studies (Rieberger 1992; Chan et al. 2011) suggest that methylmercury concentrations on non-muscle fish tissues (e.g., liver) tend to be lower than in fish muscle tissue of some species, notwithstanding lower serving size and consumption frequency of non-muscle tissues. Therefore, potential risks from consumption of fish tissues other than muscle were deemed negligible (refer to Volume 2 Appendix J Mercury Technical Reports, Part 2 Mercury Human Health Risk Assessment).

[b] With the possible exception of piscivorous birds, fish are expected to be the only country food item that will increase in methylmercury concentration as a result of the Project. Potential risks from consumption of piscivorous wildlife are expected to be lower than from fish consumption, as available data suggest that humans rarely consume piscivorous wildlife within the LAA (refer to Volume 3 Appendix J Mercury Technical Data Reports, Part 2 Mercury Human Health Risk Assessment).

[c] Mercury levels in soils and vegetation (including vegetation as country foods) are not expected to change as a result of the Project (refer to Volume 2 Appendix J Mercury Technical Data Reports, Part 3 Mercury Human Health Risk Assessment).

33.2.2.4 Exposure and Risk Assessment

Predicted changes in air quality, noise and vibration, EMF, and water quality were compared to concentrations or energy levels that represent safe exposure limits developed by provincial and federal regulatory agencies as objectives or guidelines relevant for human health.

Where changes exceeded objectives or guidelines at receptor location(s), these were identified, and discussed in relation to potential effects to human health. In relation to changes in methylmercury in fish, exposure results (i.e., methylmercury concentrations in fish) were used to identify potential risk to human health in terms of the maximum

number of servings of fish that could be consumed without exceeding Health Canada's Provisional Tolerable Daily Intake (pTDI) for methylmercury.

With the exception of changes to air quality, and noise and vibration, exposure was not pro-rated for duration. Instead, people were assumed to be exposed 24 hours per day, 365 days a year. This is a conservative assumption, as it is unlikely that all receptors would be at the receptor site location for this duration. If maximum exposure concentrations were below the health-based objectives and/or guidelines, then it was assumed that no unacceptable exposure would occur at the modelled locations.

33.3 Baseline Conditions

33.3.1 Potable and Recreational Water Quality

33.3.1.1 Human Receptors

Human receptors for water quality are linked to individuals and/or population groups who utilize potentially affected water bodies for drinking water and for recreational use. Sources of drinking water, as well as location of water intakes, groundwater wells, water treatment facilities, and recreational swimming sites were identified. Receptors are illustrated in Figure 33.6.

33.3.1.2 Drinking Water Sources

Drinking water sources in the LAA are found in Hudson's Hope, Taylor, and Fort St. John.. The District of Hudson's Hope draws its domestic water supply from the Peace River, downstream of the Peace Canyon Dam. The water intake is located in the river above a limestone bed. At the pumphouse, the water is treated by chlorination and is subsequently transported to approximately 1,000–1,100 water users.

The City of Fort St. John's water comes from a well system adjacent to the Peace River located approximately 20 m under the Peace River in bedrock. The water is taken from an aquifer; the intake system services Fort St. John and adjacent areas of the Peace River Regional District.

The District of Taylor draws its water from three shallow wells located on a gravel bar in the Peace River at the confluence of the Pine and Peace rivers. The pumphouse for these wells is located on the north bank of the Peace River.

First Nations communities' water supply does not come from potentially affected surface or groundwater sources.

33.3.1.2.1 Ground Water Wells

There are 48 registered and seven non-registered drinking water wells within a 2 km lateral distance from the proposed Site C reservoir that are identified as wells potentially affected by the Project.

33.3.1.2.2 Recreational Water Use

A survey of recreational water use (LGL 2010) indicates that swimming does occur in the Pine River, and in the Peace River between the Site C dam site and the Alberta border.

The survey confirmed the location of three swimming sites near the confluence of the Pine River and the Peace River (refer to Figure 33.6).

33.3.1.3 Baseline Conditions – Potable and Recreational Water Quality

Table 33.12 summarizes baseline surface water quality concentrations for drinking water quality parameters (refer to Volume 2 Appendix D Surface Water Regime Technical Memos, Volume 4 Appendix D Part 2 Human Health Technical Memoranda). Note that Site Peace 01 is in close proximity to the Hudson's Hope water intake site. In general, these baseline parameters are below Guidelines for Canadian Drinking Water Quality (Health Canada 2012) at low to very low concentrations in the reservoirs, at higher concentrations in the Peace River mainstem, and at highest concentrations in the tributaries. Mean water temperature was within drinking water quality guidelines for all sites; however, maximum temperature values at the mouths of all the measured tributaries to Peace River exceeded drinking water quality guidelines.

Table 33.12 Baseline Surface Drinking Water Quality Concentrations in the Peace River and Tributaries

Parameter	Drinking Water Guidelines[a]	Statistic	Peace-01	Peace-02	Mouth of Halfway River	Mouth of Cache Creek	Peace-03	Mouth of Moberly River	Peace-04	Mouth of Pine River	Mouth of Beatton River	Peace-05
Temperature (°C)	15[b]	Min	1.6	1.7	0.5	0.0	3.5	7.1	1.9	6.6	5.1	1.4
		Mean	7.8	8.7	10.5	11.7	9.4	13.0	9.6	12.2	14.6	9.3
		Max	13.2	13.3	20.6	24.3	14.0	19.2	14.8	18.2	20.2	14.2
Total Suspended Solids (mg/L)[c]	N/A	Min	1.5	1.5	1.5	3.0	1.5	3.0	1.5	1.5	3.0	7.5
		Mean	8.7	17.5	211.9	437.1	74.8	238.4	93.0	128.8	343.8	520.9
		Max	135.0	156.0	1960.0	2760.0	954.0	1580.0	1010.0	946.0	2210.0	1640.0
Turbidity (NTU)	Treated water <0.1 at all times[d, e]	Min	0.0	0.6	3.5	3.4	0.0	3.0	0.0	2.5	8.6	7.1
		Mean	33.1	37.8	194.68	334.8	68.9	215.4	130.4	127.9	377.0	39.7
		Max	405.0	521.0	1664	2120.0	674.0	1240	1000.0	850.0	1857.0	106.0
Nitrate (mg/L)	45[f]	Min	0.025	0.025	0.003	0.003	0.023	0.025	0.022	0.003	0.001	0.033
		Mean	0.055	0.046	0.029	0.022	0.043	0.025	0.043	0.049	0.012	0.044
		Max	0.140	0.071	0.090	0.150	0.072	0.025	0.072	0.178	0.025	0.057

NOTES:

[a] Drinking water guidelines for Health Canada, or B.C. Ministry of Environment (BCMOE). The most stringent guideline is applied when more than one guideline is applicable.

[b] BCMOE (2006); Health Canada (2012)

[c] There are no drinking water quality guidelines for total suspended solids

[d] This drinking water quality guideline for turbidity is for treated drinking water. As baseline surface water quality was collected on untreated water, this drinking water quality guideline for turbidity is not applicable to the baseline surface water quality results

[e] For raw drinking water (water before it enters the distribution system), which normally requires some form of treatment to reduce natural turbidity to a level that complies with the standard for finished water, induced turbidity should not exceed 5 NTU when background turbidity is less than or equal to 50 NTU. When background is greater than 50 NTU, the induced turbidity should not be more than 10% of background (BCMOE 2001).

[f] Health Canada (2012)

Sources: Volume 2 Appendix E Water Quality Baseline Conditions in the Peace River; Volume 2 Appendix P Aquatic Productivity Reports

Baseline concentration of total mercury in the mainstem of the Peace River averaged 1 ng/l (refer to Volume 2 Appendix J Mercury Technical Reports Part 2 Mercury Human Health Risk Assessment). This is below the identified maximum acceptable concentration for total mercury (i.e., all chemical forms including methylmercury) of 1,000 ng/l (parts per trillion), as specified by Health Canada and CCME Drinking Water Quality Guidelines.

Baseline data on groundwater quality were collected for groundwater wells that would be inundated from Peace Canyon Dam to the Site C Dam, including the tributary valleys, and for groundwater wells in areas adjacent to the Site C reservoir that would experience changes to physical groundwater flow as a result of the creation of the Site C reservoir. However, baseline data on particulate matter-based water quality parameters (TSS, turbidity, and TDS) for groundwater were not obtained since the sands and gravels that comprise the aquifer are expected to filter out particulates and, as such, water quality for these parameters were not anticipated to be affected by the Project (Golder 2012). Baseline concentrations of nitrate in groundwater were not obtained due to expected low concentrations of nutrients to be found in groundwater.

The following drinking water quality parameters exceeded drinking water quality guidelines in groundwater water wells (refer to Table 4-4 in Volume 2 Appendix F Groundwater Regime Technical Data Report):

- pH (exceedance in one well)
- Total dissolved solids (exceedance in two wells)
- Barium (exceedance in one well)
- Iron (exceedance in two wells)
- Manganese (exceedance in two wells)
- Sodium (exceedance in one well)
- Detectable concentrations of total coliforms (exceedance in three wells)

33.3.2 Ambient Air Quality

33.3.2.1 Human Receptors

Human receptors within the LAA for air quality are identified in Figure 33.7. Human receptors within the LAA for air quality (and within the dispersion modelling study area) include the proposed north and south bank camps, residences, schools, child care facilities, health care facilities, and senior care facilities (refer to Figure 33.8). The location of sensitive human receptors are also illustrated in Figures 5.1.1 to 5.2.3 in Volume 2 Appendix L Air Quality Technical Data Report.

West Moberly Lake Reserve 168A and East Moberly Lake Reserve 169 are located within the LAA pertaining to changes in air quality. A number of First Nations temporary habitation sites and habitation use areas (including cabins, overnight camps, hunting and fishing camps, and spiritual gathering sites) were identified as being in proximity to the Project activity zone, and within the LAA for air quality. These sites were qualitatively referred to in a number of First Nations Traditional Land Use Studies and/or Community Baseline Reports. Saulteau First Nations and the Treaty 8 Tribal Association provided

maps illustrating the location of habitation use areas (GIS coordinates were not available). General locations of reported habitation site locations and habitation use areas by First Nations are illustrated in Figure 33.9.

Information on habitation use areas provided a general understanding of the location and number of sites that could potentially experience changes in ambient air quality (as well as noise and vibration, and EMF) as a result of the Project. These changes and potential effects on First Nations human health are discussed qualitatively in relation to these sites (i.e., predicted changes to ambient concentrations of CACs were not carried out).

The general locations of known First Nations temporary habitation sites and use areas include the following:

- Duncan's First Nation (Duncan's First Nations 2011):
  - Between the Peace River (south bank) and Boucher Lake (near Hudson's Hope)
  - At Charlie Lake
  - In the lower reaches of the Pine River watershed and at the Pine/Peace River confluence
- Saulteau First Nations – The following temporary habitation use areas are located in a "local study area" defined by the Saulteau as comprising the Project footprint (including the Site C dam site, transmission line, flooded area, safe line, Highway 29 realignment, and north bank area) and a 500 m buffer equaling 50,844 ha in size (Saulteau First Nations 2011):
  - 11 cabin sites
  - one cache site
  - 79 camps
  - six day camps
- Blueberry River First Nations (Kennedy 2011):
  - Bear Flats
  - Butler Ridge
  - Farrell Creek (i.e., north bank of the Peace River east of Farrell Creek)
  - Farrell Creek (i.e., east side of Farrell Creek, about one kilometre upstream) (near project area)
  - Halfway River (i.e., lower Halfway River)
  - Moberly Creek (i.e., south side of the Peace River – east of confluence with Moberly River)
  - Moberly River (i.e., northeast of Moberly Lake)
  - Pine River (i.e., mouth of the Pine River)

The Treaty 8 Tribal Association identified 77 sites with habitation values (defined as temporary or occasional and permanent or seasonal camps and cabins) within 5 km of the Project activity zone (Table 33.13).

Table 33.13 Treaty 8 Tribal Association Reported Habitation Values within 5 km of the Project Activity Zone by Confluence Area

Confluence Areas	Number of Reported Habitation Values
Bear Flats (Cache Creek/Peace River)	52
Farrell Creek/Peace River	8
Halfway River/Peace River	30
Lynx Creek/Peace River	19
Moberly River/Peace River	13

NOTE:
[a] There is some overlap between the 5 km areas. Values within 5 km of more than one confluence and gathering place were counted in each area.
Source: Candler and the Firelight Group Research Cooperative with the Treaty 8 Tribal Association (2012)

33.3.2.2 Ambient Air Quality Baseline Conditions

This section summarizes baseline conditions for ambient air quality. Refer to Volume 2 Appendix L Air Quality Technical Data Report for further details.

The LAA for air quality generally consists of low population densities (with the exception of Fort St. John, Taylor, and Hudson's Hope) in rural settings. Forestry, agriculture, oil and gas, mining, and power generation are the main industries and emission sources in the region. Emissions from vehicle traffic and residential wood heating are key factors affecting local air quality in main population centres of Fort St. John, Hudson's Hope, and the District of Taylor, as are emissions from vehicle traffic along major roads, in particular Highway 97.

Baseline data indicated that background concentrations of the following individual CACs were below health-based ambient air quality objectives (Table 33.14):

- Dustfall
- Total suspended particulate
- Particulate matter less than 10 µm (PM_{10})
- Particulate matter less than 2.5 µm ($PM_{2.5}$)
- CO
- NO_2
- SO_2

Table 33.14 Maximum Air Quality Concentrations: Background Value

Criteria Air Contaminant	Averaging Period	Representative Background Value (µg/m3)	Ambient Air Quality Objective (µg/m3) a	Basis for Objective
Dustfall [d]	24-hour	0.8mg/dm^2-d	1.75 mg/dm^2-d residential, 2.9 mg/dm^2-d non-residential	Nuisance
Total Suspended Particulate	24-hour	26	150	Visibility
	Annual	5.4	60	Visibility, soiling
Particulate Matter less than 10 µm (PM_{10})	24-hour	26	50	Health
Particulate Matter less than 2.5 µm ($PM_{2.5}$)	24-hour	15	25 [b]	Health
	Annual	5.0	8 [c]	Health
Carbon Monoxide (CO)	1-hour	229	14,300	Health
	8-hour	160	5,500	Health
Nitrogen Dioxide (NO_2) [e]	1-hour	0	400	Health
	24-hour	0	200	Health
	Annual	0	60	Health
Sulphur Dioxide (SO_2)	1-hour	0	450	Health
	24-hour	0	160	Health
	Annual	0	25	Health

NOTES:

[a] BCMOE 2009. This is the Level A (most stringent) Ambient Air Quality Objective, where applicable. Provincial ambient air quality objectives are divided into three categories designated as Level A, B, and C, with Level A being the most stringent. These levels correspond roughly to federal levels, as defined below:

- Level A is equivalent to the federal maximum desirable objective, which is a long-term goal for air quality and provides a basis for an anti-degradation policy for unpolluted areas, and for continuing development of control technology
- Level B is equivalent to the federal maximum acceptable objective, which is intended to provide adequate protection against effects on soil, water, vegetation, materials, visibility, personal comfort, and well-being
- Level C is equivalent to the federal maximum tolerable objective, which denotes time-based concentrations of air contaminants beyond which, due to a diminishing margin of safety, appropriate action is required without delay to protect the health of the general public

[b] Compliance based on annual 98th percentile value

[c] B.C. also has a planning goal for annual $PM_{2.5}$ of 6 µg/m^3

[d] 24-hour average based on 30-day sample

[e] B.C. does not have ambient air quality objectives for NO_2; therefore, the most stringent federal objectives are presented (Level A where available)

Source: Volume 2 Appendix L Air Quality Technical Data Report

33.3.3 Noise and Vibration

33.3.3.1 Human Receptors

The location of the sensitive human receptors for noise and vibration in the LAA are indicated in Figure 33.10 and are described in more detail in Figures 4.1.1 to 4.1.11 in Volume 2 Appendix M Noise and Vibration Technical Data Report. First Nations habitations sites as described in Section 33.3.2.1 and Figure 33.9 above were also identified as relevant human receptor sites for noise and vibration. First Nations reserves are located outside the boundary of LAA pertaining to changes in noise and vibration.

33.3.3.2 Noise and Vibration Baseline Conditions

The Noise and Vibration Technical Study (Volume 2 Appendix M Noise and Vibration Technical Data Report) compared the measured representative baseline values with the BCOGC-calculated ambient sound levels at receptors (which considered dwelling density and proximity to transportation routes) to estimate where there was evidence that existing noise sources may influence the background noise levels (refer to Section 3.3 in Volume 2 Appendix M Noise and Vibration Technical Study Report for a summary of existing noise conditions at all identified noise receptor sites).

The comparison of BCOGC-calculated ambient sound levels and representative measured baseline noise levels indicates that BCOGC-calculated ambient sound levels are within 1 to 5 dBA of representative measured values for nighttime at receptor sites. Daytime values are less by between 1 and 10 dBA. These differences are considered to be consistent with the natural variability that occurs in environmental sound.

For blasting noise, existing L_{peak} values are assumed to be zero at the proposed Site C dam site and new quarries, as the L_{peak} is event based. No existing activities near the Site C dam site were noted as being a possible source of blasting noise. At quarries where material extraction has occurred (West Pine Quarry and Wuthrich Quarry), receptors may have being exposed to blasting noise (note that baseline noise levels from previous blasting activity cannot be quantified).

33.3.4 Electric and Magnetic Fields

33.3.4.1 Human Receptors

Residences are located near the existing Hudson's Hope substation connection and are receptors used in this assessment (these residences are more than 1 km from the existing and proposed transmission line right-of-way). First Nations habitations sites as described in Section 33.3.2.1 were also identified as relevant human receptor sites.

33.3.4.2 Status of Research on Health Effects from EMF

High-voltage transmission lines produce both electric and magnetic fields. Electric fields are the result of voltages applied to electrical conductors and equipment. Most objects, including fences, shrubbery, and buildings, easily block electric fields. Magnetic fields are produced by the flow of electric currents; however, unlike electric fields, most materials do not readily block magnetic fields. The intensity of both electric and magnetic fields diminishes with increasing distance from the source (Exponent 2012b). Electric fields are measured in kilovolts per metre (kV/m) and magnetic fields in milligauss (mG) or microteslas (μT).

In compliance with the directive by the British Columbia Utilities Commission, BC Hydro retained the firm Exponent Research Inc. to conduct an independent review every two years or more of the current status of research regarding the potential for health effects from exposure to EMF. The most recent review was submitted by BC Hydro to the British Columbia Utilities Commission on August 29, 2012 and is included in Volume 2 Appendix N Electric and Magnetic Field Technical Data Report.

33.3.4.3 Electric and Magnetic Fields Baseline Conditions

Baseline electric and magnetic fields were calculated for the existing 138 kV transmission lines at average conductor height at maximum load under normal operating conditions. Normal operating conditions refer to the condition when all circuits are in service (i.e., they exclude the emergency operating conditions that may exist when one or more circuits are out of service). Higher EMF levels would be encountered when a power line is carrying its emergency- or maximum-rated load. However, such conditions are encountered only a few days or hours per year. Considering that the load varies over the 24 hours of the day and from month to month over the year, it is conservative to base the calculations on the condition associated with the maximum load that is expected to occur when all circuits are in service (Mazana and Mousa 2009).

The magnetic field levels calculated on the existing transmission line right-of-way, at the right-of-way edge, 25 m from the right-of-way edge, and 50 m from the right-of-way edge were all below the screening levels or maximum permissible exposures for magnetic field exposure in the ICNIRP and ICES guidelines (Table 33.15).

Table 33.15 Calculated Electric and Magnetic Field Levels for the Existing 138 kV Transmission Lines (1L374 and 1L360)

Field	On Right-of-Way	At Right-of-Way Edge	25 m from Right-of-Way Edge	50 m from Right-of-Way Edge
Magnetic field (mG)	23.88	16.91	3.35	1.29
Electric field (kV/m)	0.72	0.53	0.14	0.05

NOTE:
Magnetic fields were calculated at maximum load under normal operating conditions
Source: Exponent (2012a)

33.3.5 Country Foods and Methylmercury in Fish

33.3.5.1 Fish Consumption and Retention

Baseline information on recreational angler and fish consumption by Aboriginal groups was gathered to understand the potential for change in fish consumption levels with the Project (due to potential changes in methylmercury concentrations. and avoidance of exceedance of pTDI for mercury).

Information from First Nations Traditional Land Use Studies, Country Food Harvest and Consumption Surveys completed for these studies, and the completed Country Foods Questionnaire (refer to Volume 3 Appendix B First Nations Community Assessment Reports, Part 1 Approach to Gathering and Integrating Community Baseline Information) indicate that fish is a food source for most of these First Nations communities; however, it is not as dominant a food source as land-based mammals. Fish consumption information for individual First Nations communities is described below.

Results from Duncan's First Nation's Country Food Questionnaire indicate that respondents consume fish on average once a week. The results from Duncan's First Nation's Country Food Harvest and Consumption Survey indicates that trout, northern pike, and walleye were identified as the most harvested species followed by "other fish" and Arctic grayling. The survey reported an average of 4.2 meals of fish consumed per

respondent per month (range 0–16 meals of fish consumed per month). The average serving size of fish was 5.5 oz. or approximately 156 g (Table 33.16).

Table 33.16 Duncan's First Nation: Range and Average Number of Meals of Fish Consumed per Month

Consumption Parameter	Meals per Month
Highest average number of meals per month of (fish) reported	16
Lowest average number of meals per month of (fish) reported	0
Average number of meals per month per respondent	4.19

NOTE:
Source: Duncan's First Nation (2011)

Results from Horse Lake First Nation's Country Food Harvest Survey indicate that respondents consume on average 1.4 meals of fish per month (with a range of 0-16 meals consumed per month). The average serving size of fish was 3.6 oz. or approximately 102 g (Table 33.17).

Table 33.17 Horse Lake First Nation: Range and Average Number of Meals of Fish Consumed per Month

Consumption Parameter	Meals per Month
Highest average number of meals per month of (fish) reported	16
Lowest average number of meals per month of (fish) reported	0
Average number of meals per month per respondent	1.4

NOTE:
Source: Horse Lake First Nation (2011)

The most commonly consumed species of fish reported by participants in the B.C. First Nations Food, Nutrition, and Environment Study (Chan et al. 2011) from the First Nations communities in closest proximity to the Project (Tsay Keh Dene, Doig River, Saulteau, and Tl'azt'en) were rainbow trout (22–34% of participants reported consumption within the year prior to the survey, depending on community); lake trout (14–20%); northern pike (0–17%); bull trout (4–6%), Arctic grayling (2–5%), sucker (1–2%), whitefish (0–2%), and walleye (0–2%).

Other studies indicate that the most commonly consumed sport species from the Peace River by local fishers and First Nations are lake trout and rainbow trout. Arctic grayling and mountain whitefish are consumed infrequently, while burbot are rarely encountered in the river (Pattenden 2010, 2011). Sport species such as walleye, goldeye, burbot and yellow perch are more common in the Peace River downstream of the Site C dam site (Pattenden 2011).

Information on recreational angler fish retention was obtained to further inform understanding of fish consumption. Published information from a study on freshwater sports fishing in B.C. (GSGislason 2009) indicates that of 152,000 fish caught from sources in the Peace Region in 2005, over 34,000 were kept, indicating an 80% release (and 20% retention) rate. Of the approximately 34,000 fish kept, 47% were trout, 26% were walleye, and 16% were northern pike. Approximately one fish was kept for every

two days spent fishing by an angler, indicating that on average, five fish per angler were retained per year.

Data from the 2008–2009 Peace River Recreational Fishery Creel Survey (LGL 2010) were also reviewed to determine retention of fish caught in the Peace River watershed. To estimate the average number of fish kept per individual, the total annual harvest (1,192 fish) was divided by the number of active anglers interviewed for this survey. Similar to the results from the GSGislason study, the average number of fish retained during the 2008–2009 year was 5.52 fish per angler (Robichaud 2012). Arctic grayling were the most commonly retained fish, followed by mountain whitefish, rainbow trout, walleye, and northern pike.

33.3.5.2 Baseline Mercury Levels of Selected Aboriginal Groups

Information on the amount of mercury in identified human receptor groups can help identify any existing mercury toxicity and vulnerabilities to mercury exposure.

There are limited data published on identified receptors; however, Chan et al. (2011) tested mercury concentrations in the hair of First Nation individuals over the age of 19. Results for Ecozone/Cultural Area 2 or Boreal Plains/Subarctic (which includes only the Doig River and Saulteau First Nations) and Ecozone/Cultural Area 8 or Taiga Plains (which includes ~~Profit~~ Prophet River and the Fort Nelson First Nation) indicate that mercury hair concentrations were below 1.25 ppm, which is below Health Canada's normal acceptable limit for both women of child-bearing age and the general population. [Health Canada (2004b) guidelines for mercury exposure identify a normal acceptable limit for mercury in hair as being less than 6 ppm for the general population and less than 2 ppm for women of child-bearing age.]

33.3.5.3 Country Foods and Methylmercury in Fish – Baseline Conditions

Details of baseline mercury concentration in fish species are provided in Volume 2 Appendix J Mercury Technical Reports Part 1 Mercury Technical Synthesis Report. Historical studies (i.e., pre-2001) indicate that mean mercury concentrations in most fish species from the Peace River within B.C. were less than 0.10 mg/kg. Mercury concentrations in some large individuals of piscivorous species such as bull trout ranged up to 0.34 mg/kg.~~, except for bull trout, which ranged up to 0.2 mg/kg.~~ Mercury concentrations in Dinosaur Reservoir whitefish were slightly higher at 0.03–0.17 mg/kg, while rainbow trout was low (0.04 mg/kg). Mercury concentrations in Williston Reservoir mountain whitefish (0.03-0.43 mg/kg), rainbow trout (0.03–0.35 mg/kg) and bull trout (0.03–2.2 mg/kg) were higher than in Dinosaur Reservoir or the Peace River.

More recent mercury studies (2008–2011) support findings of historical studies that mercury concentrations in fish in the Peace River are lower than reported elsewhere in B.C., and are among the lowest reported for their size in Canada. Mean mercury concentrations of all fish species in the Peace River within the technical study area of the Site C Project were less than 0.08 mg/kg with nearly all fish less than 0.20 mg/kg. Mercury concentration in forage (redside shiner) and omnivorous species (rainbow trout, whitefish) were similar to bull trout, a large piscivorous (fish-eating) species. These data suggest that the Peace River downstream of Peace Canyon dam at least as far as the proposed Site C dam site is a poor methylating environment and that the rate of bioaccumulation and biomagnification of methylmercury by aquatic biota and fish is very low.

The mercury concentrations observed from historical and current studies, especially for large piscivorous species such as bull trout within the Peace River technical study area, including Dinosaur Reservoir, are low, lower even than mercury concentrations for similar size fish from other B.C. lakes and reservoirs. Measured tissue mercury concentrations (all means) from rainbow trout (0.09 mg/kg), lake trout (0.26 mg/kg), Arctic grayling (0.08 mg/kg) and mountain whitefish (0.11 mg/kg) from more than 100 B.C. lakes (Rieberger 1992) were higher than for all fish species in the Peace River technical study area.

Health Canada standards or maximum limits of mercury concentration in fish is 0.5 mg/kg in general commercial fish and 1.0 mg/kg in commercial predatory fish (Health Canada 2012b). The above specified baseline concentrations are very low concentrations in comparison to Health Canada's standards for maximum limits for mercury concentration in fish, especially for large piscivorous species such as bull trout and lake trout, and lower than the same species of a similar size in all other B.C. lakes and reservoirs. The commercial import limit of 0.5 mg/kg provides perspective for predicted fish mercury concentrations from the Site C reservoir. The commercial limit may not be applicable to fish captured domestically or during sport fishing.

A summary of baseline methylmercury concentrations is presented in Table 33.18 for key fish species within the Site C reservoir area of the Peace River, along with maximum of serving of fish from both upstream and downstream of the Site C dam site that can safely be consumed by different age groups (refer to Volume 2 Appendix J Mercury Technical Data Reports Part 2 Mercury Human Health Risk Assessment for details):

- Bull trout – Adults can consume between eight (women of child-bearing age) and 20 servings per week (all other adults) of bull trout without exceeding Health Canada's pTDI for methylmercury. Toddlers, the most sensitive age group, can consume up to four servings per week of bull trout without exceeding Health Canada's pTDI for methylmercury.
- Rainbow trout – Adults can consume between nine (women of child-bearing age) and 32 servings per week (all other adults) of rainbow trout without exceeding Health Canada's pTDI for methylmercury. Toddlers, the most sensitive age group, can consume up to seven servings per week of rainbow trout without exceeding Health Canada's pTDI for methylmercury.
- Lake trout – Lake trout are rare within the Peace River technical study area, but are more common in Dinosaur Reservoir, upstream of the Peace Canyon Dam. Non-childbearing or pregnant adults can consume up to 22 meals per week, and toddlers can consume up to 5 weekly meals.
- Mountain whitefish – Mountain whitefish are likely consumed very infrequently. Nevertheless, mercury concentrations in this species are very low (0.03 mg/kg), so weekly consumption allowance is also high for all receptor groups

Table 33.18 Pre-inundation (Baseline) Maximum Number of Servings of Fish per Week that can be Consumed without Exceeding Health Canada's Provisional Tolerable Daily Intake for Methylmercury

Species	Location	Average[2] methylmercury concentration in fish	Toddler 7 months – 4 years	Child 5 – 11 years	Female Teen 12 – 19 years	Women of Childbearing Age > 20 years	Male Teen 12 – 19 years	Other Adult > 20 years
		mg MeHg/kg ww	75 (g/serving)	125 (g/serving)	150 (g/serving)	163 (g/serving)	150 (g/serving)	163 (g/serving)
Bull trout	Peace River – Site C	0.072	4	5	8	8	18	20
	Peace River – Downstream	0.083	4	4	7	7	16	17
Rainbow trout	Peace River – Site C	0.044	7	8	13	14	30	32
Lake trout	Peace River – Site C	0.066	5	6	8	9	20	22
Mountain whitefish	Peace River – Site C	0.039	8	9	14	16	34	37
	Peace River – Downstream	0.037	8	10	15	16	35	39
Goldeye	Peace River – Downstream	0.238	1.3	2	2	3	6	6
Walleye	Peace River – Downstream	0.182	2	2	3	3	7	8

NOTES:
Results apply to all fish tissue types: muscle, eggs, internal organs, etc.
Arithmetic means of target size fish (Azimuth 2011)
Source: Volume 2 Appendix J Mercury Technical Data Reports, Part 2 Mercury Human Health Risk Assessment

33.4 Effects Assessment

The effects assessment in this section is based on the interactions presented in Table 33.8.

33.4.1 Effects Assessment – Operations – Change in Potable and Recreational Water Quality and Effect on Human Health

The potential to adversely affect human health was assessed by taking into account the potential for the Project to results in changes to potable and recreational water quality (refer to Volume 4 Appendix D Surface Water Regime Technical Memos, Part 3 Water Quality Technical Memo; Volume 2 Appendix F Groundwater Regime Technical Data Report; Volume 2 Appendix I Fluvial Geomorphology and Sediment Transport Technical Data Report; Volume 2 Appendix P Aquatic Productivity Reports for water quality modelling results, assumptions, and limitations).

33.4.1.1 Site C Reservoir

33.4.1.1.1 Surface Water Quality

Project effects on potable surface water quality were considered for two Site C reservoir operational time frames:

- The first nine years of Site C reservoir operation (early stage), or the period when shoreline erosion and nutrient loading from the flooded lands at the newly created reservoir are at their peak
- Thirty years after commencement of Site C reservoir operations (late stage)

Below is a summary of modelling results for each indicator (details are provided in Volume 4 Appendix D Human Health Assessment Part 2 Human Health Technical Memoranda). Overall changes in drinking water quality parameters would be similar for both early and late stages:

- Temperature:
  - Mean temperatures (at all modelled sites upstream and downstream of the Site C dam site) would decrease compared to baseline
  - Mean temperatures (at modelled sites both upstream and downstream of the Site C dam site) would not exceed drinking water quality guidelines
- Total suspended solids:
  - Mean TSS concentrations (at all modelled sites upstream and downstream of the Site C dam site) would decrease in concentration compared to baseline
- Turbidity:
  - Mean turbidity values (at all modelled sites upstream and downstream of the Site C dam site) would decrease compared to baseline, but would remain within the range of historical data (at all modelled sites)

- Nitrate:
  - Maximum nitrate concentrations would be greater than historical maximums during early stages of Site C reservoir operations, but no concentrations would exceed drinking water quality guidelines

The above results indicate that the Site C reservoir would be less susceptible to increases in temperature, and to suspended solids caused by external inputs due to greater volume and residence time of water in the Site C reservoir, compared to the Peace River.

The drinking water intake at Hudson's Hope (which draws drinking water directly from the Peace River) could experience higher nitrate levels in the early and late stages of Site C reservoir operations (compared to baseline conditions); however, concentrations would be within drinking water quality guidelines. The other drinking water quality parameters at Hudson's Hope water intake (i.e., temperature, TSS, and turbidity) are expected to remain within the predicted range of variation (not exceed drinking water quality guidelines) and would not affect quality of drinking water at Hudson's Hope water intake.

Methylmercury generated from inorganic mercury in flooded soils will be released to the overlying water column and the concentration of methylmercury in water is projected to approximately double from baseline concentrations (Volume 2 Appendix J Mercury Technical Data Reports, Part 3 Mercury Reservoir Modelling). This would increase methylmercury concentrations in water from baseline (the laboratory detection limit of <0.05 ng/l) to <0.1 ng/l in the proposed Site C reservoir. This post-inundation methylmercury concentration is 10,000 times lower than the Canadian Drinking Water Quality Guideline for total mercury. Therefore, contact with or consumption of water from the proposed Site C reservoir would not pose a health risk from mercury or methylmercury exposure.

The above results indicate that a number of surface drinking water quality parameters would change as a result of the Project; however, changes would not result in exceedance of drinking water quality guidelines (or of guidelines for recreational water use). Contact with (i.e., through recreational water use) or consumption of water from the Site C reservoir and from downstream tributaries would not pose a health risk, and no effects on human health are anticipated.

33.4.1.1.2 Groundwater Quality

Of the approximately 55 identified water wells along the Site C reservoir, six are expected to undergo direct submersion (i.e., the Site C reservoir will submerge the wells). The remaining wells are anticipated to experience a relative increase in the water level in the well, ranging from less than 1 m to 10 m, depending on their relative location along the Site C reservoir and distance away from the reservoir edge. The increase in water level is not anticipated to influence the quality of the groundwater within the well or influence well operation. However, groundwater quality could be affected if either a flooded septic field or contaminated site with impacted groundwater is located in close proximity to operating water wells. General regions where this could occur are wells in proximity to the proposed Site C reservoir in the Hudson's Hope area, Lynx Creek, and Farrell Creek areas. If this occurs, there is the potential for groundwater quality to exceed drinking water quality guidelines, with potential effects on human health.

33.4.2 Mitigation Measures – Change in Potable and Recreational Drinking Water Quality and Effect on Human Health

Implementation of the following mitigation measures (see Volume 5 Section 35 Summary of Environmental Management Plans) will assist in mitigating the risk of groundwater quality exceeding drinking water quality guidelines during operations:

- Implement a Spill Prevention and Emergency Response Plan
- Implement an Erosion Prevention and Sediment Control Plan

Although adverse project effects on groundwater quality are not anticipated during construction (and were not assessed), a Groundwater Protection Plan will be implemented during construction (years 2014–2022) and during the first five years of operations (2022–2027) to monitor potential groundwater contamination and, if required, identify appropriate groundwater protection measures. This will be done through private well sampling and will include monitoring of groundwater quality of Taylor and Fort St. John's drinking water sources.

With the above mitigation measures, no exceedances of potable and recreational drinking water quality guidelines and no residual effects on human health are anticipated.

33.4.3 Effects Assessment – Construction – Change in Ambient Air Quality and Effect on Human Health

The potential to adversely affect human health was assessed by taking into account the potential for the Project to results in changes to ambient air quality (refer to Volume 2 Appendix L Air Quality Technical Study for details on air quality modelling results, as well as assumptions and limitations of the modelling program).

Predicted maximum ambient concentrations of CACs and dustfall were estimated for the following Project components (which were included in the DSMA):

- Site C dam, generating station, and spillways
- Quarried and excavated construction material sites (Wuthrich Quarry, 85th Avenue Industrial Lands, Area E)
- Access roads and rail (within the DSMA)
- Worker accommodation

Changes to ambient air quality from emissions from quarried and excavated construction material sites outside the DSMA (i.e., West Pine Quarry, Portage Mountain Quarry, and Del Rio Pit) were also estimated.

Changes to ambient air quality for the following project components were assessed qualitatively (ambient air quality was not modelled), based on information obtained from total emissions estimation for these project components (refer to Volume 2 Appendix L Air Quality Technical Data Report for details of emission estimations):

- Transmission line to Peace Canyon
- Other quarried and excavated construction material sites (not included in the DSMA)
- Highway 29 realignment

- Construction access road development

33.4.3.1 Site C Dam, Generating Station, and Spillways (including Wuthrich Quarry, 85th Avenue Industrial Lands, and Area E)

Maximum concentrations of CACs were predicted for identified sensitive human receptor groups (Table 33.19) and reflected on isopleth maps in Figures 5.1.1 to 5.1.10, which are located in Volume 2 Appendix L Air Quality Technical Data Report (these figures are referenced in this section). Concentrations were compared to the B.C. Level A Air Quality Objective (the most stringent objective level).

In general, the highest predicted concentrations in exceedance of air quality objectives would occur in the vicinity of Wuthrich Quarry in an area within which there are no known sensitive receptors. Some exceedances of the objectives would also occur along the construction boundary for Area E and near the Peace River close to the construction boundary for the Site C dam site (no known receptors are located in this area).

33.4.3.1.1 Dustfall

Figure 5.1.10 in Volume 2 Appendix L Air Quality Technical Data Report delineates the maximum predicted concentration isopleths for dustfall. With background, exceedances would occur outside the Site C dam site area (in areas where there are no sensitive receptors). No exceedances would occur at sensitive receptors within or outside the Site C dam site area (Table 33.19).

33.4.3.1.2 Total Suspended Particulates (TSP)

Figure 5.1.1 delineates the maximum predicted concentration isopleths for 24-hour TSP. Figure 5.1.2 delineates the maximum predicted concentration isopleths for annual TSP (these figures located in Volume 2 Appendix L Air Quality Technical Data Report). The maximum predicted concentrations of TSP at various receptors in the DMSA are presented in Table 33.19. With background ambient concentrations, exceedances of the B.C. Level A objective would occur inside the Site C dam site area at the north camp site for the 24-hour averaging period.

33.4.3.1.3 $PM_{2.5}$ and PM_{10}

Figures 5.1.5 shows maximum predicted concentration isopleths for 24-hour PM_{10}. Figures 5.1.6 and 5.17 show maximum predicted concentration isopleths for 24-hour $PM_{2.5}$ and annual $PM_{2.5}$ respectively (figures are located in Volume 2 Appendix L Air Quality Technical Data Report). The highest PM values predicted outside the Site C dam site area would occur near Wuthrich quarry.

Ambient concentrations of PM levels would increase relative to baseline conditions. At sensitive receptors, exceedances for the 24-hour PM_{10} and both the 24-hour and annual $PM_{2.5}$ objectives would occur at the north camp site, located within the Site C dam site area (refer to Table 33.19). Exceedances of PM_{10} would also occur at one residence located within the Site C dam site area and at several non-residential buildings in the vicinity of the Site C dam site.

Exceedances of $PM_{2.5}$ would occur at the south camp site located within the Site C dam site area for the 24-hour averaging period and at several non-residential buildings in the vicinity of the Site C dam site for both the 24-hour (Figure 5.1.6) and annual averaging

periods. No PM exceedances would occur at sensitive receptors within the DMSA but outside the Site C dam site area.

The frequencies of predicted exceedance of the 24-hour TSP, PM_{10}, and $PM_{2.5}$ objectives at the north camp site are 1.4, 21.4, and 38.7%, respectively. The predicted frequency of exceedance of the annual $PM_{2.5}$ objective would be 100% simply because only one year was modelled. Exceedances of the 24-hour $PM_{2.5}$ ambient air quality objective would occur at the south camp site 1% of the time.

33.4.3.1.4 NO_2, SO_2, and CO

Figures 5.2.1, 5.3.1, and 5.4.1(located in Volume 2 Appendix L Air Quality Technical Data Report) delineate the maximum predicted concentration isopleths for NO_2, SO_2, and CO, respectively. Similar to particulate matter, the highest concentrations were predicted in the vicinity of Wuthrich Quarry where there are no known receptors.

Ambient concentrations of CO, NO_2, and SO_2 would increase relative to baseline conditions. Exceedances of ambient air quality objectives for NO_2 and CO would occur inside but not outside the Site C dam site area (exceedances for CO were predicted for the north and south camp sites). No exceedances of ambient air quality objectives for SO_2 would occur (Table 33.19).

Table 33.19 Maximum CAC Concentrations at Sensitive Receptor Sites Located within the Dispersion Modelling Study Area

CAC	Average Period	Maximum Predicted Concentrations (µg/m^3)											Ambient Air Quality Objectives[a] (µg/m^3)	Basis for Objective
		Receptor Group 1	Receptor Group 2	Receptor Group 3	Receptor Group 4	Receptor Group 5	Receptor Group 6	Receptor Group 7	Receptor Group 8	Receptor Group 9	Receptor Group 10	Receptor Group 11		
		Fort St. John	Taylor	Residences	Non-Residences	Unknown Buildings	North Camp Site	South Camp Site	Schools	Child Care Facilities	Health Care Facilities	Senior Care Facilities		
Dustfall[d]	24-hour	0.9	0.8	1.2	1.4	0.8	1.6	1.0	0.8	0.8	0.8	0.8	1.75 mg/dm^2-d residential, 2.9 mg/dm^2-d non-residential	Nuisance
Total Suspended Particulate	24-hour	45	32	109	115	32	210	74	35	35	35	33	150	Visibility
	Annual	8.5	6.4	17	37	6.3	45	16	6.7	6.8	6.1	6.3	60	Visibility
Particulate Matter less than 10 µg (PM_{10})	24-hour	32	28	51	67	28	90	47	29	29	29	29	50	Health
Particulate Matter less than 2.5 µg ($PM_{2.5}$)	24-hour	18	16	24	37	16	45	26	16	17	16	16	25[b]	Health
	Annual	5.8	5.2	7.3	11	5.3	13	7.6	5.3	5.3	5.2	5.2	8[c]	Health
CO	1-hour	325	258	422	571	274	783	421	277	278	268	261	14,300	Health
	8-hour	191	170	240	280	173	326	241	177	178	174	171	5,500	Health
NO_2[e]	1-hour	145	63	170	182	81	194	165	106	109	87	73	14,300	Health
	24-hour	27	8.0	44	49	10	54	45	12	13	10	10	200	Health
	Annual	3.3	1.1	8.2	24	1.4	26	13	1.3	1.4	0.9	1.0	60	Health

CAC	Average Period	Maximum Predicted Concentrations (µg/m³)											Ambient Air Quality Objectives[a] (µg/m³)	Basis for Objective
		Receptor Group 1	Receptor Group 2	Receptor Group 3	Receptor Group 4	Receptor Group 5	Receptor Group 6	Receptor Group 7	Receptor Group 8	Receptor Group 9	Receptor Group 10	Receptor Group 11		
		Fort St. John	Taylor	Residences	Non-Residences	Unknown Buildings	North Camp Site	South Camp Site	Schools	Child Care Facilities	Health Care Facilities	Senior Care Facilities		
SO_2	1-hour	1.6	0.2	3.3	4.5	0.5	14	1.1	0.7	0.7	0.5	0.3	450	Health
	24-hour	0.1	0.05	0.4	0.5	0.06	1.5	0.2	0.1	0.1	0.05	0.04	160	Health
	Annual	0.01	0.003	0.03	0.06	0.004	0.1	0.03	0.005	0.01	0.003	0.004	25	Health

NOTES:

BCMOE (2009). This is the Level A (most stringent) Ambient Air Quality Objective, where applicable. Provincial ambient air quality objectives are divided into three categories designated as Level A, B, and C, with Level A being the most stringent. These levels correspond roughly to federal levels as defined below:

- Level A is equivalent to the federal maximum desirable objective, which is a long-term goal for air quality and provides a basis for an anti-degradation policy for unpolluted areas, and for continuing development of control technology
- Level B is equivalent to the federal maximum acceptable objective, which is intended to provide adequate protection against effects on soil, water, vegetation, materials, visibility, personal comfort, and well-being
- Level C is equivalent to the federal maximum tolerable objective, which denotes time-based concentrations of air contaminants beyond which, due to a diminishing margin of safety, appropriate action is required without delay to protect the health of the general public

[b] Compliance based on annual 98th percentile value

[c] B.C. also has a planning goal for annual $PM_{2.5}$ of 6 µg/m³

[d] 24-hour average based on 30-day sample

[e] B.C. does not have ambient air quality objectives for NO_2; therefore, the most stringent federal objectives are presented (level A where available)

Source: Volume 2 Appendix L Air Quality Technical Data Report

Table 33.20 summarizes the receptor sites where ambient air quality objectives would be exceeded, with the potential for exceedances to affect human health at these receptor sites, if not mitigated appropriately.

Table 33.20 Receptor Sites where Ambient Air Quality Objectives would be Exceeded

CAC	Receptor Site	With Background (ug/m^3)	Ambient Air Quality Objective (ug/m^3)	Frequency of Exceedance
Total Suspended Particulates	North Camp	210	150	1.4% of the time (24 averaging hour)
PM_{10}	North Camp	90	50	21% of the time (24 averaging hour)
	1 Residence within Site C dam site	51		<1% (24 averaging hour)
$PM_{2.5}$	North Camp	45	25	39% of the time (24-hour); 100% of the time (annual)
	South Camp	26		1% of the time (24-hour)

33.4.3.2 Site C Reservoir Preparation and Filling

Generally, ambient air concentrations of particulate matter would increase relative to baseline during Site C reservoir site clearing. If vegetation debris is burned, then ambient concentrations of CO, NO_2, and SO_2 would also increase relative to baseline. Any exceedances in ambient air quality objectives that would occur with burning would potentially affect human health at the known receptor locations (i.e., residences and Aboriginal group habitation use areas within proximity to the clearing areas).

33.4.3.3 Transmission Line to Peace Canyon

Receptors potentially affected would be those located near the Hudson's Hope substation connection and in First Nations habitation use areas along the transmission corridor (See Figure 33.9). Identified residences near Hudson's Hope substation are more than 1 km from the right-of-way.

Increases in CAC emissions in the LAA due to transmission line construction would be less than 1% from baseline. Due to minimal increases, no exceedances of ambient air quality objectives would occur at identified receptor sites. Effects on human health are not anticipated.

33.4.3.4 Quarried and Excavated Material Development

Ambient concentrations of CO, NO_2, and SO_2 for the quarried and excavated construction material areas would increase relative to baseline, but remain below ambient air quality objectives.

Ambient concentrations of PM and dustfall would also increase relative to baseline. Exceedances of B.C. air quality objectives for PM would occur within approximately 1 km of site boundaries and decrease rapidly further out. PM emissions estimated for Del Rio are about one-third of those estimated for Wuthrich Quarry and about one-fifth of those

estimated for Area E. Since the closest residence is located 4.5 km from Del Rio, project emissions from Del Rio Pit would not results exceedances of the PM objectives at a sensitive receptor. Although PM emissions estimated for Portage Mountain Quarry are two to 10 times greater than those estimated for the construction material source areas located within the DMSA, the closest permanent residence is located 8 km from Portage Mountain Quarry; therefore, it is not expected that Project emissions from Portage Mountain Quarry would result in exceedances of the PM objectives at a sensitive receptor. There is a residence located 1.5 km from the West Pine Quarry boundaries, and estimated emissions for this quarry are more than double those estimated for Wuthrich. Since exceedances would occur beyond the site boundaries for Wuthrich, there is the potential for exceedance of PM objectives at the residence due to emissions from West Pine Quarry and potential for exceedances to affect human health. It is noted that the West Pine Quarry is an existing quarry site.

33.4.3.5 Construction Access Road Development and Highway 29 Realignment

Increase in emissions from road construction would be less than 10% for all CACs, with the exception of $PM_{2.5}$, which would increase by 14% due to asphalt production at mobile asphalt plants. These increases indicate the potential for road construction to result in exceedance of ambient air quality objectives at known residences and in First Nations habitation use areas in proximity to Highway 29, and potential for these exceedances to affect human health.

33.4.4 Mitigation Measures – Change in Ambient Air Quality and Effect on Human Health

Mitigation measures to reduce emissions and ensure exceedances of ambient air quality objectives do not occur include implementation of the following (as described in other sections of the EIS):

- Air Quality Management Plan (inclusive of a Dust Control Management Plan) and Blasting Management Plan, to minimize fugitive dust from vehicle activity and heavy equipment movement, and reduce total particulate matter emissions. The Air Quality Management Plan will include the following mitigation measures to reduce dustfall and particulate matter (including emissions at the West Pine Quarry):
  - Watering of unpaved roads and other surfaces
  - Washing of aggregate and spraying aggregate stockpiles
- A Dust Control Management Plan
- Vegetation Clearing and Debris Management Plan
- Smoke Management Plan. In addition to meeting the requirements of the BC Open Burning Smoke Control Regulation, a Smoke Management Plan will be implemented that will identify smoke management strategies that will be used to reduce potential smoke emissions by a) decreasing the amount of burning by reducing wood debris volumes, b) reducing smoke associated with burning through use of low-emission incineration technologies, and c) managing the timing of ignition considering defined smoke sensitivity zones and use of custom venting forecasts, daily ignition and smoke release periods. ~~minimize smoke by minimizing burning of~~

~~vegetative debris (in accordance with BCMOE Open Burning Smoke Control Regulation)~~

Screening modelling will be implemented at the West Pine Quarry to further determine potential for exceedances of air quality objectives for dustfall and particulate matter at the identified residence located 1.5 km from the quarry. Based on modelling results, appropriate air quality management plans will be implemented as specified above to ensure that exceedances do not occur.

At the Site C dam and generating station, mitigation measures to reduce total suspended particulates and particulate matter will include the following:

- Installation of baghouses at concrete batch plants and crushers
- Installation of silos for fly ash, cement, and aggregate at the concrete batch plants
- Retention of vegetation barriers where practical.

Since PM exceedances were predicted to occur up to 39% of the time at the proposed north camp site location, (and 1% of the time at the south camp site and less than 1% of the time at one residence) a monitoring plan will be developed that includes the following:

- Confirm locations of emission sources at these sites and conduct detailed air quality modelling
- Based on modelling results, identification of locations and installation of $PM_{2.5}$, PM_{10}, wind speed, and wind direction monitors on the north and south bank.

Based on monitoring results, a list of measures will be developed prior to construction, with the objective of siting the north and south camp sites outside of areas of exceedances.

The requirements of Project management plans will be included in the contract tendering process so the contractors can plan and budget for any change in operations if real-time monitoring indicates elevated levels at sensitive locations.

With the implementation of the above mitigation measures, no exceedances in ambient air quality objectives, and no residual effects on human health are anticipated.

33.4.5 Effects Assessment – Construction – Change in Noise and Vibration and Effect on Human Health

The potential to adversely affect human health was assessed by taking into account the potential for the Project to result in changes to noise and vibration (refer to Volume 2 Appendix M Noise and Vibration Technical Study for details on noise and vibration modelling results, as well as assumptions and limitations of the modelling program).

Exceedances of BCOGC guidelines for noise levels would potentially occur during construction of the following Project components:

- Site C dam site, generating, station and spillways (including 85th Avenue Industrial Lands)
- Site C reservoir preparation and filling (including Hudson's Hope Shoreline Protection)
- Transmission line to Peace Canyon
- Quarried and excavated materials source development
- Highway 29 realignment
- Access road development

33.4.5.1 Site C Dam, Generating Station, and Spillways (including 85th Avenue Industrial Lands)

Changes in noise level greater than 3 dBA and levels higher than the BCOGC guidelines would occur during both Year 3 and 5 of construction. Predicted changes in noise levels at receptor locations are shown in Table 33.21.

Table 33.21 Predicted Changes in Noise Levels at Receptor from Site C Dam Site Activities

Noise Receptor [a]	Predicted Sound Level at Receptor	Ambient Sound Level	Cumulative Sound Level [b]	Change in Sound Level	BCOGC Guidelines Sound Level	Meets BCOGC Guideline
	(dBA)	(dBA)	(dBA)	(dBA)	(dBA)	(Y/N)
Year 3 – Daytime						
DS_NR2	49.6	48	51.9	2.5	53	Y
DS_NR3	53.4	48	54.5	3.3	53	N
DS_NR4	48	48	51.0	2.2	53	Y
DS_NR5	49.5	48	51.8	2.7	53	Y
DS_NR6	40.7	48	48.7	0.9	53	Y
DS_NR8	47.4	48	50.7	1.8	53	Y
DS_NR9	46.5	48	50.3	1.8	53	Y
DS_NR10	41.5	48	48.9	0.8	53	Y
Year 3 – Nighttime						
DS_NR1	19.2	43	43	0	43	Y
DS_NR2	26.2	38	38.3	0.3	43	Y
DS_NR3	15.3	38	38	0	43	Y
DS_NR4	25.7	38	38.2	0.2	43	Y
DS_NR5	33.6	38	39.3	1.3	43	Y
DS_NR6	29.8	38	38.6	0.6	43	Y
DS_NR8	35	38	39.8	1.8	43	Y
DS_NR9	33.7	38	39.4	1.4	43	Y
DS_NR10	37	38	40.5	2.5	43	Y
Year 5 – Daytime						
DS_NR2	53.5	48	54.6	6.6	53	N
DS_NR3	50.7	48	52.6	4.6	53	Y
DS_NR4	50.7	48	52.6	4.6	53	Y
DS_NR5	51.6	48	53.2	5.2	53	N
DS_NR6	40.9	48	48.8	0.8	53	Y
DS_NR8	48.5	48	51.3	3.3	53	
DS_NR9	45.2	48	49.8	1.8	53	Y
DS_NR10	42.6	48	49.1	1.1	53	Y
Year 5 – Nighttime						
DS_NR2	43.9	38	44.9	6.9	43	N
DS_NR3	46.0	38	46.6	8.6	43	N
DS_NR4	46.2	38	46.8	8.8	43	N
DS_NR5	43.1	38	44.3	6.3	43	N
DS_NR6	32.4	38	39.1	1.1	43	Y

Noise Receptor [a]	Predicted Sound Level at Receptor	Ambient Sound Level	Cumulative Sound Level [b]	Change in Sound Level	BCOGC Guidelines Sound Level	Meets BCOGC Guideline
	(dBA)	(dBA)	(dBA)	(dBA)	(dBA)	(Y/N)
DS_NR8	41.2	38	42.9	4.9	43	Y
DS_NR9	40.5	38	42.4	4.4	43	Y
DS_NR10	38.4	38	41.2	3.2	43	Y

NOTES:

[a] Receptor locations are illustrated in Figures 4.1.1, 4.1.2, 4.1.3, and 4.1.5 of Volume 2 Appendix M Noise and Vibration Technical Data Report

[b] Cumulative sound levels are the logarithmic addition of the Overall Predicted Sound Levels and Calculated Ambient Sound Levels

Source: Volume 2 Appendix M Noise and Vibration Technical Data Report

Sound level contours for the Site C dam site scenario in Year 5 are outlined in Figures 4.1.1, 4.1.2, 4.1.3, and 4.1.5 of Volume 2 Appendix M Noise and Vibration Technical Data Report).

Noise from Site C dam and generation station construction activities would contribute to elevated residential noise levels, with the primary noise sources being excavation and material handling at the 85th Avenue Industrial Lands and materials deliveries along Old Fort Road.

Daytime noise levels in construction in Year 3 related to Site C dam site construction activities would comply with the guideline criteria at most receptors, including the nighttime deliveries on Old Fort Road. One receptor (DS_NR3) will experience some ongoing noise exceedances during daytime hours. With the exception of DS_NR3, changes in existing daytime noise levels for those receptors adjacent to the 85th Industrial Lands (representative receptors DS_NR2 and DS_NR3) and along Wiltse Drive (DS_NR4 and DS_NR5) are just under 3 dBA (changes would be noticeable, as they are above the 3 dBA range). Nighttime noise levels in construction Year 3 would comply with BCOGC guidelines.

Daytime noise levels in Year 5 related to construction activities would generally comply with the BCOGC guidelines at most receptors. Although receptors DS_ NR2 and DS_NR5 would experience cumulative noise effects from traffic on Old Fort Road and the 85th Avenue Industrial Lands, the guideline exceedances that would occur are due to increased activity at the latter site. The change in daytime noise levels would be in the noticeable range for DS_NR2, DS_NR3, DS_NR4 and DS_NR5. Nighttime noise levels at the 85th Avenue Industrial Lands and along Wiltse Drive would exceed nighttime BCOGC guidelines, with changes of up to 9 dBA occurring.

Without mitigation, exceedances of BCOGC guidelines at the identified receptor locations could potentially affect human health.

Blasting is also planned within the Site C dam site construction area. The airborne vibration calculations indicate that L_{peak} levels would be below the 120 dBL NPC-119 Cautionary Limit within 16 m of the blast, and would reduce to 82 dBL at the boundary of the LAA. No receptors would experience airborne vibration above the NPC-119 Cautionary Limit and, as a result, there would be no effects on human health.

Project clearing activities are transient, and the nature of clearing work is such that activities would occur in relatively small areas within the Project activity zone at various

points in time. Clearing activity would result in noise levels that exceed daytime guidelines when the clearing activity takes place within 500 m of residential receptors (Table 33.22).

No nighttime clearing activity is expected (receptors are identified in Figure 4.1.7 in Volume 2 Appendix M Noise and Vibration Technical Data Report. Table 4.1.11 in Volume 2 Appendix M Noise and Vibration Technical Data Report shows the receptors where BCOGC guidelines would be exceeded). Clearing activity would occur over several years, but the actual activity would be localized, moving throughout the Site C reservoir area in that time. The expected duration of clearing activity within 500 m of any residences would be only a few days in most cases.

The temporary duration of noise level exceedances from clearing activities would be such that no effects to human health are anticipated.

Table 33.22 Predicted Noise Levels for Clearing

Day (dBA)	Distance from Clearing Boundary (m)					
	50	100	200	500	1000	1500
East	56.4	54.9	52.6	48.1	43.2	39.5
North	57.8	56.1	53.7	48.8	43.7	39.9
South	67.5	63.6	59.3	52.3	46.1	41.8
West	44.0	42.6	41.1	38.1	34.9	32.2

NOTE:
Source: Volume 3 Appendix M Noise and Vibration Technical Data Report

33.4.5.2 Site C Reservoir Preparation and Filling

Hudson's Hope shoreline protection would be located along the Site C reservoir at the foot of the slope below the community of Hudson's Hope, downslope from the nearest homes.

There are a number of residences located near the proposed shoreline protection. Four receptors representative of all the homes within 1.5 km were used to evaluate noise levels (Table 33.23). Figure 4.1.11 in Volume 2 Appendix M Noise and Vibration Technical Data Report shows the noise contours for construction of Hudson's Hope shoreline protection. Results indicate that during the start of construction, the nearest residences would experience noise levels that exceed the BCOGC daytime guidelines by up to 10 dBA. Sound levels may be less towards the end of construction of the shoreline protection, due to a reduction in the intensity of activity on-site.

Table 33.23 Daytime Predicted Noise Levels at Receptors Near Hudson's Hope Shoreline Protection During Construction

Noise Receptor	Predicted Sound Level at Receptor (dBA)	Ambient Sound Level (dBA)	Cumulative Sound Level (dBA)	Changes in Sound Level (dBA)	PSL Guideline (dBA)	Meets BCOGC Guideline (Y/N)
HH_1	58.8	53	59.8	6.8	58	N
HH_2	58.9	53	59.9	6.9	58	N
HH_3	65.5	53	65.7	12.7	58	N
HH_4	67.4	53	67.6	14.6	58	N

NOTE:
Source: Volume 3 Appendix M Noise and Vibration Technical Data Report

33.4.5.3 Transmission Line to Peace Canyon

Receptors potentially affected are those located near the Hudson's Hope substation connection and First Nations habitation use areas along the length of the transmission line corridor. Identified residences near Hudson's Hope substation are more than 1 km from the right-of-way.

Change in noise levels would occur as a result of equipment usage for installing the tower foundations and helicopter use for tower erection. However, noise levels at receptors would comply with the BCOGC guidelines during tower foundation construction activity (refer to Figure 4.1.10 in Volume 2 Appendix M Noise and Vibration Technical Data Report), and no changes in noise levels greater than 3 dBA are expected. As a result, no effects on human health are anticipated.

Noise exceedances due to helicopter usage would occur if transmission line towers (location of helicopter hovering) are within 100 m of receptors, or if helicopters would be required to land within 400 m of a receptor; however, helicopter usage in these areas would be of short duration, with 20 minutes being the longest expected duration, several times a day. Due to the short duration of changes to noise levels as a result of helicopter usage, no effects on human health are anticipated.

33.4.5.4 Quarried and Excavated Material Source Development

No residences were identified within the LAA for noise and vibration for any of the quarry or borrow areas. Campgrounds are located outside but near the Wuthrich and West Pine Quarry noise and vibration LAA boundaries (refer to Figure 4.1.5 in Volume 2 Appendix M Noise and Vibration Technical Data Report).

Model results indicate that BCOGC Guidelines at 1.5 km from quarries and pits would be met, and changes to ambient sound level would be 3 dBA or less.

For quarries where blasting would be required, airborne vibration is estimated to be below the 120 dBL ONMOE criteria within 13 m of the blast and would be reduced to 76 dBL at 1.5 km LAA boundary. This indicates that, even though the blasting noise value is considered compliant, blasts are expected to be distinguishable from other background or Project-generated sounds, both within and outside the noise and vibration LAA. No effects on human health are anticipated.

33.4.5.5 Highway 29 Realignment

The Highway 29 realignment is a transient activity that will move over the various segments of highway to be constructed. This activity would occur over several time periods.

The general results for road/bridge construction and borrow pits for the Highway 29 realignment are provided in Table 33.24 and Figure 4.1.8 in Volume 2 Appendix M Noise and Vibration Technical Data Report. The results north of the general activity are representative of cut/fill and grading activity. The results south of the activity are representative of bridge construction activity. Noise levels would be compliant with BCOGC guidelines at greater than 500 m from the cut/fill and grading activity.

Table 33.24 Predicted Noise Levels at Set Distance from Highway Construction Activities

Day (dBA)	Distance from Construction Boundary (m)					
	50	100	200	500	1000	1500
East	61.4	42.9	55.6	49.4	58.7	38.5
South	56.6	53.8	50.3	44.1	38.9	35.2

NOTE:
Source: Volume 2 Appendix M Noise and Vibration Technical Data Report

For bridge construction activity, increased sound levels in exceedance of BCOGC guidelines would occur at receptor sites within 200 m from the activity. Bridge construction activity would be relatively stationary, with mobile equipment moving about a fixed area, and may occur over a period of one to two years. Any exceedances occurring at these receptors could potentially affect receptor human health.

During construction of the roads, “cut and fill” or earthwork activity to move material to and from the alignment, as well as grading and paving, are expected to result in increased noise levels. Off-road vehicles moving along the alignment would generate noise levels that would exceed BCOGC guidelines at residences up to 500 m away for a few weeks during construction. Given the short duration of elevated noise levels near any particular receptor and the intermittent nature of noise level within that time frame, the potential for annoyance or long-term exceedance of daytime noise guidelines would be negligible. No effects on human health are anticipated.

Projected changes in noise levels from Highway 29 realignment construction activities are summarized in Table 33.25 (receptors are shown in Figure 4.1.9 in Volume 2 Appendix M Noise and Vibration Technical Data Report).

Table 33.25 Daytime Predicted Noise Levels at Receptors from Highway 29 Realignment Construction Activities

Noise Receptor	Distance to Activity Boundary (m)	Predicted Sound Level at Receptor (dBA)	Ambient Sound Level (dBA)	Cumulative Sound Level [a] (dBA)	Change in Ambient Sound Level (dBA)	PSL Guideline (dBA)	Meets BCOGC Guideline (Y/N)
HWY_1	25.0	64.2	55	64.7	9.7	60	N
HWY_2	0.0	76.6	50	76.6	26.6	55	N
HWY_3	0.0	69.5	50	69.5	19.5	55	N
HWY_4	78.0	60.1	50	60.5	10.5	55	N
HWY_5	129.0	57.4	55	59.4	4.4	60	Y
HWY_6	329.0	50.7	55	56.4	1.4	60	Y
HWY_7	160.0	56.0	50	57.0	7.0	55	N
HWY_8	681.0	44.0	55	55.3	0.3	60	Y
HWY_9	495.0	47.1	55	55.7	0.7	60	Y
HWY_10	374.0	49.6	55	56.1	1.1	60	Y
HWY_11	51.0	62.0	55	62.8	7.8	60	N
HWY_12	149.0	56.5	50	57.4	7.4	55	N
HWY_13	281.0	52.0	50	54.1	4.1	55	Y
HWY_14	270.0	52.3	50	54.3	4.3	55	Y
HWY_15	6.0	66.3	50	66.4	16.4	55	N
HWY_16	17.0	65.0	50	65.1	15.1	55	N
HWY_17	6.0	66.3	50	66.4	16.4	55	N
HWY_18	33.0	63.5	50	63.7	13.7	55	N
HWY_19	151.0	56.4	50	57.3	7.3	55	N
HWY_20	99.0	58.9	50	59.4	9.4	55	N
HWY_21	1492.0	35.3	50	50.1	0.1	55	Y
HWY_22	0.0	68.6	50	68.7	18.7	55	N

NOTES:

[a] Cumulative sound levels are the logarithmic addition of the Overall Predicted Sound Levels and Calculated Ambient Sound Levels

Source: Volume 2 Appendix M Noise and Vibration Technical Data Report

Site C dam site construction data were used to evaluate potential changes in receptor noise levels due to Project-related traffic. Results (based on traffic modelling for the worst-case scenario, which was construction Year 7) indicate that a just noticeable difference in noise level (approximately 3 dBA) may occur for three receptors during daytime hours due to Project traffic volumes (refer to Table 4.1.5 in Volume 2 Appendix M Noise and Vibration Technical Data Report). As this occurs during one year of the construction phase, long-term changes in noise levels of more than 3 dBA at receptors would not occur, and human health effects are not anticipated.

33.4.5.6 Construction Access Road Development

Access road noise was considered within the assessment of construction of the Site C dam site and Hudson's Hope shoreline protection (Sections 33.5.6.1 and 33.5.6.2). The changes in highway operation noise levels during Site C dam site construction indicate that changes in noise levels near any major highway would not exceed BCOGC guidelines. Other access roads from quarries or borrow pits to the main highways would

experience changes that are noticeable (> 3 dBA) or noise levels that exceed the BCOGC Guidelines. In these instances, The Noise Management Plan for the Site C dam site access road would be applicable to any access roads where residences are present.

33.4.5.7 Summary of Receptor Sites with Exceedances

Table 33.25 summarizes the receptor sites where BCOGC noise guidelines would be exceeded, with the potential for exceedances to affect human health at these receptor sites.

Table 33.26 Summary of Receptor Sites where BCOGC Noise Guidelines would be Exceeded

Project Component and Activity	Source Description	Affected Receptor	Description of Change (dBA)		
			Cumulative Sound Level	Ambient Sound Level	Change in Sound Level
Quarry and Excavated Material Source Development					
85th Avenue Industrial Lands	Till excavation, loading and conveyor	DS_NR2, DS_NR3, homes along 100st and Wiltse Dr. (DS_NR4 and DS_NR5)	44.3 – 54.9	35–48	6.5 – 8.8
Site C Reservoir					
Clearing activity in the Site C reservoir	Site C reservoir Clearing (daytime)	Receptors within 500 m of clearing activity	52.0 – 67.5	55–58	6.0 – 24.0
Hudson's Hope Shoreline Protection	Off-road heavy equipment	Receptors along the top of the slope, above the berm	59.8 – 67.6	53	6.8-14.6
Highway 29 Realignment					
Construction of new alignment (earthwork, cut and fill)	Off-road heavy equipment	Receptors within 500 m	50.2 – 68.7	55–58	7.0 – 19.5
Construction of bridges	Heavy equipment, off-road or generators	Receptors within 200 m	50.2 – 68.7	55–58	7.0 – 19.5

NOTE:
Source: Volume 2 Appendix M Noise and Vibration Technical Data Report

33.4.6 Mitigation Measures – Change in Noise and Vibration

33.4.6.1 Site C Dam, Generating Station, and Spillways

85th Avenue Industrial Lands Noise Management Plan

While changes to noise levels in Year 3 of construction identify the need for noise controls for one receptor, the change in noise levels would occur year over year when the 85th Avenue Industrial Land site is in operation.

A Noise and Vibration Management Plan will be developed and will include the following:

- Traffic on the roadways will be scheduled to avoid "bunch up" activity. This will include spacing out material deliveries throughout the day, such that truck traffic would result in short, but noticeable, increases in sustained noise levels.
- Enact a "no engine compression brake" policy within 2 km of a residence
- Enact a "no free-swinging tailgate" policy so highway dump trucks do not use brake jerks to swing their gates into the body (commonly done to loosen stuck material inside the bed)
- All equipment will be kept in good repair and be fitted with standard silencers/mufflers
- Use of ambient adjustable and low-frequency tone backup alarms during the daytime and nighttime
- Communication plan for neighbouring residents, including:
    - Notification to residents close to the 85th Avenue Industrial Lands (resident NR2 – the home immediately northwest of the 85th Avenue Industrial Lands site, and NR3 – the 100 Street receptor) of the timing of construction of site berms and fencing, which will result in noise for several weeks to a few months. Providing nearby residents with the timelines for completion of the berm and fencing will communicate that initial noise levels will be reduced once the berms and fencing are in place. Once the noise berm is completed, noise levels at all receptors are expected to comply with the BCOGC noise guideline values.
- Mitigation of noise levels from the increased nighttime activity at the 85th Avenue Industrial Lands during Year 5 at affected receptors will include:
    - A combination of perimeter berms for the site and localized acoustic barriers to the conveyor hopper
    - Adding an enclosure to the on-site portion of the conveyor
    - Silent backup alarm systems (sensor/light combinations) in concert with fitting nighttime heavy equipment with upgraded silencers

Implementation of these mitigation measures will reduce noise levels at receptor locations to comply with the BCOGC noise guidelines. A noise monitoring program will be implemented to monitor the effectiveness of the above mitigation.

Clearing Activities

In relation to clearing, a notification plan will be developed for residents within 500 m of clearing activity to inform them of the proximity of the clearing activity, the expected schedule, and expected duration of the noise event.

For receptors at zero distance (inside the activity zones) and receptors less than 50 m from activity, a specialized management plan will be developed in collaboration with affected receptor sites (residences). This could potentially involve temporarily relocation.

33.4.6.2 Site C Reservoir Preparation and Filling

The terrain along the proposed Hudson's Hope Shoreline Protection indicates that secondary acoustic berms would not be a practical solution to address potential

exceedances in BCOGC noise guidelines at receptors located at the top of the slope. However, should extended periods (several weeks) of increased noise levels occur at these receptors, temporary vertical noise barriers would be used in residents' yard to control noise levels. A model refinement will be conducted (after the contractor has been selected, but prior to finalizing mitigation parameters) to verify the potential for exceedances and to determine which noise sources may be dominant. A noise monitoring plan will be implemented to verify the effectiveness of any selected controls, determine the effect of equipment noise, and adjust noise mitigation measures if required.

Implementation of these mitigation measures will ensure that noise levels at receptor locations comply with the BCOGC noise guidelines.

33.4.6.3 Highway 29 Realignment

For bridge construction activity, temporary barriers and/or portable enclosures or walls will be implemented to mitigate noise levels at receptors where exceedances would occur. A notification plan will be implemented, informing residences of the expected schedule and duration of construction activities and noise events.

Annoyance to receptors due to road construction noise (cut and fill activity) will be minimized through a notification plan. Further controls such as a barrier or berms are not considered practical, due to the temporary nature of elevated noise levels.

A monitoring plan will be implemented to determine the actual noise levels related to cut and fill equipment (and activities) once a contractor has been selected, and to identify appropriate mitigation measures if warranted.

Implementation of these mitigation measures will reduction noise levels at receptor locations to comply with the BCOGC noise guidelines for receptors 50 m from the Project activity zone (receptors within 50 m or zero distance are inside the Project activity zones and will be temporarily relocated).

33.4.7 Effects Assessment – Operations – Change in Electric and Magnetic Fields and Effect on Human Health

The potential to adversely affect human health was assessed by taking into account the potential for the Project to results in changes to EMF.

Changes in EMF that could potentially affect human health were identified during operations of the transmission line to Peace Canyon. EMF levels were calculated for the proposed 500 kV transmission lines at average conductor height. Magnetic fields were calculated at maximum load under normal operating conditions (Table 33.27).

Table 33.27 Comparison of Calculated Electric and Magnetic Field Levels for the 138-kV and 500-kV Transmission Lines

Line	On Right-of-Way	At Right-of-Way Edge	25 m from Right-of-Way Edge	50 m from Right-of-Way Edge
Electric Field Levels (kV/m)				
138 kV	0.72	0.53	0.14	0.05
500 kV	5.39	2.23	0.52	0.20
Magnetic Field Levels (mG)				
138 kV	22.88	16.91	3.35	1.29
500 kV	73.40	29.67	11.41	6.03

NOTE:
Source: Exponent (2012a)

The EMF levels calculated for the proposed 500 kV transmission lines would be higher than the EMF levels for the existing 138 kV transmission lines (baseline); however, electric field levels at the right-of-way edge, 25 m from the right-of-way edge and 50 m from the right-of-way edge would be below the electric field limits, per ICNIRP and ICES guidelines. The electric field levels on the right-of-way may produce small shocks to ungrounded persons who touch grounded objects and vice versa, but these would not be harmful. The maximum electric field levels at the centre and near the edge within the right-of-way would be below the 10 kV/m ICES limit, but in a portion of this area, levels would reach 5.4 kV/m, which is above the 4.2 kV/m ICNIRP limit. This level is predicted to occur in a zone less than 20 m wide, centred at 40 m from the centre line. However, a 5.4 kV/m level would still be below 9.2 kV/m, above which the ICNIRP Basic Restriction might be exceeded.

The calculated magnetic fields levels on the right-of-way, at the right-of-way edge, 25 m from the right-of-way edge and 50 m from the right-of-way edge will be below the magnetic field limits for the general public in both the ICNIRP and ICES guidelines.

The potential exposure levels of electric and magnetic fields are sufficiently low that even on the right-of-way, the exposure limits (that is the Basic Restrictions, recommended by ICNIRP and ICES) would not be exceeded. No adverse health effects associated with exposures above the Basic Restrictions would occur.

33.4.8 Mitigation Measures – Change in Electric and Magnetic Fields and Effect on Human Health

Given that predicted EMF levels are below both the ICNIRP and ICES guidelines, and that few known human receptors are located within LAA, mitigation is not required. In compliance with the British Columbia Utilities Commission, BC Hydro will continue to review current status of research regarding the potential for health effects from exposure to EMF, including changes in guidelines developed by the World Health Organization, ICNIRP, ICES, Health Canada and other relevant agencies. BC Hydro will continue to disseminate public information on EMF. BC Hydro also maintains a webpage containing current information on electric and magnetic fields and health at http://www.bchydro.com/safety/neighbourhood/electric_magnetic_fields.html.

33.4.9 Effects Assessment – Operations – Change in Country Foods and Effect on Human Health

The potential to adversely affect human health was assessed by taking into account the potential for the Project to results in change in country foods – reduced consumption and methylmercury concentrations in fish consumed by humans (refer to Volume 2 Appendix J Mercury Technical Data Reports Part 2 Mercury Human Health Risk Assessment for details on predictive modelling results, assumptions, and uncertainties).

Operations of the Site C reservoir will result in potential increase in methylmercury concentrations in all levels of the aquatic food chain, with the highest concentrations occurring in predatory fish. The Mercury Human Health Risk Assessment focused on the potential risks associated with consumption of bull trout and rainbow trout, since available data indicate that of the fish species most commonly consumed by humans, these species would be the most abundant during the first decade of project operations. In addition, bull trout have the highest baseline mercury concentrations of all trout species tested within the changes in country foods – methylmercury in fish LAA. Also, although bull trout may not be as commonly consumed as other trout species, the result for bull trout represent an upper limit on potential risks associated with consuming bull trout of any species. While the Mercury Human Health Risk Assessment includes risk estimates for consumption of goldeye and walleye, these species are not expected to be abundant or resident in the proposed Site C reservoir (upstream of the Site C dam site). Therefore, they are unlikely to experience the same degree of increase in mercury as other fish species. It is also unlikely that these species would be captured and consumed as frequently by humans as other species. Through application of an exposure and health risk methodology, the number of meals of different species of fish obtained from the Peace River and tributaries that different population groups can consume per week without exceeding Health Canada's maximum recommended level of exposure (stated as provisional tolerable daily intake or pTDI) for methylmercury were identified.

Fish serving size and body weight were standardized so that exposure estimates could be compared to Health Canada's guidelines (Table 33.28). The values applied were based on a Health Canada review of fish portion sizes among Canadian fish eaters (Health Canada 2007). The exception was for adult group, where the values applied assumed a fish serving size for adults of 163 g per serving (the maximum average fish serving size reported by recent surveys of provincial and local First Nations) was higher than the 150 g per meal recommended by Health Canada. The use of a fish serving size of 163 g for adults takes into account information about adult serving sizes applicable to local sport and subsistence fish consumers (Chan et al 2011) (see Volume 2 Appendix J2, pages 23-24 for further information).

Table 33.28 Standard Fish Meal Portion Size by Population Group

Receptor	Fish Meal Portion Size [a]			
	Toddler 7 months – 4 years	Child 5 – 11 years	Teen 12 – 19 years	Adult ≥ 20 years
Assumed fish meal portion size (grams/meal) for Project mercury health risk assessment	**75**	**125**	**150**	**163**
Reported fish meal portion size (grams/meal)				
• First Nations Food, Nutrition and Environment Study (grams/meal) [b]	N/A	N/A	N/A	163
• Health Canada (grams/meal) c	75	125	150	150
• Health Canada recommendation for First Nations fish consumption (grams/day) d	95	170	200	220

NOTES:

[a] Fish meal portion size for infants (0–6 months) were not derived, as data on average serving size of fish were not available for this life stage and it is assumed that infants are either breast-fed or formula-fed

[b] Chan et al. (2011)

[c] Health Canada (2007)

[d] Health Canada (2009b)

N/A – not applicable

Source: Volume 2 Appendix J Mercury Technical Reports Part 2 Mercury Human Health Risk Assessment

The human health risk assessment results were based on the forecast peak methylmercury concentrations in fish that would be experienced ~~5~~3–8 years after inundation. Methylmercury concentrations are expected to gradually decline from these peak levels over time, with a return to baseline condition within 10 – 15 years after the peak, ~~concentrations over a 10- to 20-year period~~depending on species. Therefore, the risk estimates as identified in the mercury human health risk assessment would also correspondingly start to diminish ~~5~~3–8 years after inundation depending on species.

The results of the human health risk assessment are also based on a predicted post-inundation peak methylmercury concentrations in fish, which will be four times higher than baseline methylmercury concentrations (refer to Section 11.9 Methylmercury in Volume 2 Section 11 Environmental Background). A value of four times the baseline was used to ensure that the risk assessment was sufficiently conservative to recognize that some larger fish may have higher mercury concentrations. Therefore, the input values for post-inundation peak methylmercury concentrations for the Site C reservoir are the average total mercury concentrations recently measured in fish samples from the LAA multiplied by four.

Methylmercury concentrations may increase in some fish downstream of the Site C dam site such as walleye and goldeye. Fish downstream could migrate upstream to preferentially feed on fish entrained out of the Site C reservoir through turbines, resulting in their exposure to fish with elevated methylmercury concentrations. Assessments results estimated that mercury concentrations in fish downstream of the Site C dam would double from baseline (refer to Section 11.9 Methylmercury in Volume 2 Section 11 Environmental Background).

Results are presented by species for post-inundation period of peak methylmercury concentration levels (with comparison to baseline or pre-inundation conditions) for the different age groups as defined by Health Canada (Table 33.29). Since it was estimated that methylmercury concentrations in fish in the Site C reservoir would, at peak levels, be four times higher than baseline concentrations, the maximum number of servings of

fish from the Site C reservoir that could be consumed without exceeding Health Canada's PTDI for methylmercury would decrease by a factor of four. The following are estimated consumption frequencies for fish species within the Site C reservoir:

- Bull trout – Adults could consume between two (women of child-bearing age) and five servings per week (all other adults) of bull trout without exceeding Health Canada's pTDI for methylmercury. Toddlers and children, the most sensitive age groups, could consume one serving per week of bull trout without exceeding Health Canada's pTDI for methylmercury.
- Rainbow trout – Adults could consume between three (women of child-bearing age) and eight servings per week (all other adults) of rainbow trout without exceeding Health Canada's pTDI for methylmercury. Toddlers and children could consume two to three servings of rainbow trout per week without exceeding Health Canada's pTDI for methylmercury.
- Mountain whitefish – Consumption frequency of mountain whitefish within the proposed reservoir would remain high, ranging between two (toddlers) and nine meals per week (adults).

In relation to consumption of fish from downstream of the Site C dam, goldeye and walleye do migrate within the Peace River below the Site C dam. With a projected doubling of mercury concentrations in these downstream species at peak (compared to baseline), women of child-bearing age could consume one serving a week, while other adults could consume three servings a week. Toddlers could consume about half a serving a week of goldeye without exceeding Health Canada's pTDI for methylmercury. Similar results were found for walleye.

Bull trout are predicted to be present downstream of the proposed Site C dam. At peak post-impoundment mercury levels, women of child-bearing age could consume four servings a week, other adults could consume nine servings a week, and toddlers could consume two serving a week of bull trout from the Peace River downstream of the Site C dam without exceeding Health Canada's pTDI for methylmercury.

There are no data on pre-impoundment concentrations of mercury in lake trout or from northern pike from the Peace River downstream of the Site C dam site. However, assuming these species may have similar pre-impoundment mercury concentrations as bull trout, at peak post-inundation mercury levels, women of child-bearing age could consume five servings a week. Other adults could consume 11 servings a week, while toddlers could consume two servings a week of lake trout or northern pike from the Peace River downstream of the Site C dam without exceeding Health Canada's pTDI for methylmercury.

The above results indicate that commonly consumed species of fish could be continued to be consumed by even the most sensitive age group at least twice a week without exceeding Health Canada's pTDI for methylmercury. Comparing these results to reported baseline consumption frequencies of fish caught in the LAA (which indicate a relatively low frequency), it is anticipated that people will not be required to change the frequency of consumption of fish that are caught from the LAA. It is noted that fish is highly nutritious, and consumption of fish has been shown to protect health and promote healthy development. Avoiding fish consumption due to a perceived heath risk could result in negative health effects (i.e., replacement of country foods with store-bought foods and reduction in health status due to alterations in an already healthy diet).

Table 33.29 Maximum Number of Servings of Fish per Week that can be Consumed without Exceeding Health Canada's Provisional Tolerable Daily Intake for Methylmercury: Comparison with Health Canada Consumption Frequencies for other Fish Sources [a]

Species	Location	Time	Average methylmercury concentration in fish (mg MeHg/kg ww) [b]	Maximum Number of Servings of Fish Per Week					
				Toddler 7 months – 4 years (based on 75 g per serving)	Child 5–11 years (based on 125 g per serving)	Female Teen 12–19 years (based on 150 g per serving)	Women of Childbearing Age ≥ 20 years (based on 163 g per serving)	Male Teen 12–19 years (based on 150 g per serving)	Other Adult ≥ 20 years (based on 163 g per serving)
Bull trout	Peace River – Site C	Pre-inundation	0.072	4	5	8	8	18	20
		Post-inundation peak	0.288	1	1	2	2	5	5
	Peace River – Downstream	Pre-inundation	0.083	4	4	7	7	16	17
		Post-inundation peak	0.166~~332~~	2	2	3	4	8	9
Rainbow trout	Peace River – Site C	Pre-inundation	0.044	7	8	13	14	30	32
		Post-inundation peak	0.176	2	2	3	3	7	8
Lake trout	Peace River – Site C	Pre-inundation	0.066	5	6	8	9	20	22
		Post-inundation peak	0.264	1	1	2	2	5	5
Mountain whitefish	Peace River – Site C	Pre-inundation	0.039	8	9	14	16	34	37
		Post-inundation peak	0.156	2	2	4	4	8	9
	Peace River – Downstream	Pre-inundation	0.037	8	10	15	16	35	39
		Post-inundation peak	0.148	4	5	8	8	18	19
Goldeye	Peace River – Downstream	Pre-inundation	0.238	1.3	2	2	3	6	6
		Post-inundation peak	0.476~~952~~	0.6	0.8	1	1	3	3
Walleye	Peace River – Downstream	Pre-inundation	0.182	2	2	3	3	7	8
		Post-inundation peak	0.364~~728~~	0.8	1	2	2	4	4

NOTES:
[a] Results apply to all fish tissue types: muscle, eggs, internal organs, etc.
[b] Arithmetic means of target size fish
Source: Volume 2 Appendix J Mercury Technical Data Reports Part 2 Mercury Human Health Risk Assessment

33.4.10 Mitigation Measures – Change in Country Food and Effects on Human Health

A monitoring program will be implemented to monitor mercury levels in commonly consumed fish species to identify any changes in mercury concentrations. Details of this program are included as supplementary information in the Methylmercury Technical Memo and specified in Section 39 of the EIS.~~The program will commence during Year 5 of operations (commencement of period of projected peak post-inundation methylmercury concentrations), and will be undertaken annually up to Year 10 of reservoir operations (the need for and frequency of monitoring after the tenth year would be determined pending earlier monitoring results). If changes in mercury concentrations are higher than predicted, a human health risk analysis may be required (depending on actual mercury concentrations) to determine if changed mercury concentrations were to the level that would necessitate a fish consumption advisory to avoid exceedance of pTDI of mercury.~~

If monitoring and human health risk analysis results indicate a potential health risk-related consumption of fish obtained from the LAA, fish consumption advisories would be implemented, which would include communications to the public and First Nations of the potential risk of methylmercury exposure at certain consumption levels of certain fish species for certain population groups. Advisories would include information about the nutritional benefits of fish consumption, and would identify the species of fish that should be avoided. Any consumption advisories would be designed and implemented in accordance with federal and provincial procedures for issuing fish consumption advisories (Environment Canada, B.C. Ministry of Forests, Lands and Natural Resource Operations, B.C. Ministry of Health) and in accordance with good practice, including:

- Communications that are culturally appropriate to Aboriginal groups (including translation into local Aboriginal languages where required)
- Supporting a collaborative methylmercury monitoring process with Aboriginal and other communities (e.g., communities providing tissue samples, participation in data collection and analysis)
- Mechanisms to solicit and respond to comments and questions from local communities on fish consumption advisory information

33.5 Summary of Effects Assessment and Mitigation Measures

A summary of potential effects on human health and mitigation measures are shown in Table 33.30. For human health, mitigation includes monitoring of air and noise emissions, groundwater quality, and methylmercury concentration in fish to identify any potential for exceedances in air quality objectives, noise guidelines, potable water quality guidelines, mercury concentrations in fish and pTDI for mercury, and implementation of adaptive management processes to ensure that objectives, guidelines, and limits are met.

Monitoring will be designed to monitor the effectiveness of the measures implemented to mitigate the adverse effects of the Project. It will be designed to incorporate baseline data, compliance, and real time where appropriate.

Table 33.30 Project Effects on Human Health and Mitigation Measures

Potential Effect	Changes to Key Aspects	Project Component	Mitigation Measures	Monitoring Frequency and Duration	Mitigation Effectiveness	Responsibility
Construction						
Effect on human health	Ambient air quality	Site C Dam, generating station, and spillways (including worker accommodation sites)	• Implementation of Air Quality Management Plan • Baghouses at concrete batch plants and crushers • Silos for fly ash cement and aggregate at concrete batch plants • Retain vegetation barriers where practical • Minimize burning of vegetative debris and follow BCMOE Open Burning Smoke Control Regulation and implement Smoke Management Plan • Detailed modelling will be conducted once the exact locations of emission sources are better defined. Modelling results will be used to determine where to place $PM_{2.5}$ and PM_{10} monitors on the north and south bank. The north bank camp and south bank camps will be located outside the area of exceedance.	Construction: 2014 – 2022 (daily, during periods of active site use)	With the north bank camp and south bank camp located outside the area of exceedance, concentrations of total suspended particulates, PM10, PM 2.5 would remain below B.C. ambient air quality objectives at receptor sites. No residual effects on human health.	BC Hydro and contractors
		Site C reservoir preparation and filling (including clearing)	• Implementation of Air Quality Management Plan • Minimize burning of vegetative debris and follow BCMOE Open Burning Smoke Control Regulation and implement Smoke Management Plan		With mitigation, no exceedances of ambient air quality objectives. No residual effects on human health.	

Potential Effect	Changes to Key Aspects	Project Component	Mitigation Measures	Monitoring Frequency and Duration	Mitigation Effectiveness	Responsibility
		Transmission line to Peace Canyon (corridor and clearing preparation; vehicle operations)	• Minimize burning of vegetative debris and follow BCMOE Open Burning Smoke Control Regulation and implement Smoke Management Plan. • Monitoring of air quality associated with construction of Hudson's Hope Shoreline Protection.	2014 – 2022 (during construction period for the Hudson's Hope Shoreline Protection)		
		Construction access road development and Highway 29 Realignment	• Implementation of Air Quality Management Plan • Minimize burning of vegetative debris and follow BCMOE Open Burning Smoke Control Regulation and implement Smoke Management Plan • Baghouses at crushers	N/A		
		Quarried and excavated material development	• Implementation of Air Quality Management Plan • Minimize burning of vegetative debris and follow BCMOE Open Burning Smoke Control Regulation and implement Smoke Management Plan • Further screening modelling at residence located 1.5 km from West Pine Quarry to identify potential exceedances at this site; implementation of air quality management plan at this site; management plans as required	Construction: 2014 – 2022 (daily during periods of active site use)	With mitigation, no exceedances of ambient air quality objectives. No residual effects on human health	

Potential Effect	Changes to Key Aspects	Project Component	Mitigation Measures	Monitoring Frequency and Duration	Mitigation Effectiveness	Responsibility
	Noise and Vibration	Site C reservoir (Hudson's Hope Shoreline Protection)	• Temporary barriers • Portable enclosures/barriers • Notification program for residents • Monitoring of noise levels associated with construction of Hudson's Hope Shoreline Protection	2014–2022 (during construction period for the Hudson's Hope Shoreline Protection)	With mitigation, no exceedances of BCOGC noise guidelines. No residual effects on human health.	BC Hydro and contractors
		Highway 29 Realignment	• Notification program for residents • Noise monitoring program	Construction: 2014 – 2022 (during periods of construction activity)		
		Quarried and excavated material development (85th Ave Industrial Lands)	• Noise and Vibration Management Plan • Communication Plan for nearby residences (85th Avenue Industrial Lands) • Mitigation of nighttime noise at 85th Industrial Lands (perimeter berms and acoustic barriers, and portable enclosures/barriers to the conveyor hopper, silent backup alarms) • Noise monitoring at 85th Industrial Lands	Construction: 2014 – 2022 (during period of active site use)		
	Potable and recreational water quality		• Spill Prevention and Emergency Response Plan • Erosion Prevention and Sediment Control Plan • Groundwater Quality Monitoring and Management Plan to identify potential for groundwater contamination and appropriate groundwater protection measures	Well sampling 2014 – 2022	With mitigation, no exceedances of drinking water quality guidelines. No residual effects on human health	BC Hydro and contractors

Potential Effect	Changes to Key Aspects	Project Component	Mitigation Measures	Monitoring Frequency and Duration	Mitigation Effectiveness	Responsibility
	Country foods – methylmercury in fish	Powerhouse, substation, and Site C reservoir	Monitoring of mercury concentrations in fish to identify changes in mercury concentrations, and to determine appropriate public communications regarding consumption.	Monitoring of mercury concentrations in fish year 0 (baseline) and year 2 (1 to 2 years before Peace River diversion), as described in the Methylmercury Technical Memo.	With mitigation, no residual effects on human health	BC Hydro
Operations						
	Potable and recreational water quality		• Groundwater Quality Monitoring and Management Plan to identify potential for groundwater contamination and appropriate groundwater quality protection measures	Well sampling from 2022 – 2027 (first five years of operations)	With mitigation, no exceedances of drinking water quality guidelines. No residual effects on human health	BC Hydro
	Country foods – methylmercury in fish	Powerhouse, substation, and Site C reservoir	• Monitoring of mercury concentrations in fish to identify changes in mercury concentrations, and to determine appropriate public communications regarding consumption	Monitoring of mercury concentrations in fish in operating year 1, year 3, year 6, year 10, and every 5 years thereafter until fish mercury concentrations have stabilised at new baseline concentrations (predicted to be approximately 25 years after full reservoir inundation), as described in the Methylmercury Technical Memo.	With mitigation, no residual effects on human health	BC Hydro

33.5.1 Other Mitigation Options Considered

There were no other mitigation measures considered by BC Hydro for effects on Human Health.

33.6 Residual Effects

No residual effects on human health are anticipated following mitigation.

33.7 Cumulative Effects

No cumulative effects on human health are anticipated, as no residual effects following mitigation are anticipated.

33.8 Monitoring and Follow-Up

No further monitoring is required for human health.

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