Disturbance-Sensitivity Based Approach to Prioritizing Water Monitoring in Northeast B.C.

7/22/2015

PART 2: DATA PACKAGE

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DATA PACKAGE

Table of Contents

INTRODUCTION

This report documents the data sources and geoprocessing methods applied to the indicator layers to generate the disturbance-sensitivity based assessment. The goal is to record the data used and the manipulations applied so that the results are reproducible. The rationale for the selection of data comprising an indicator layer is not the focus of this paper. Data choices were made by two technical committees (surface water and groundwater) of government experts and presented to public focus groups multiple times for review and modification. The goal for indicator layers was that they be representative without being duplicative of each other. The criterion for data was that it be publically available and universally available at the same standard across northeast British Columbia. Preference was given to data available from the British Columbia Geographic Warehouse (BCGW) which is primarily supplied by the Ministry of Forests, Lands and Natural Resource Operations (FLNRO), Ministry of Environment (MOE) or the British Columbia Oil and Gas Commission (OGC).

Surface Water Technical Committee Contributors

Name	Ministry	Position
Elizabeth Johnson	FLNRO - Regional Operations Division - North Area	Project Manager, Northeast Water Strategy
Kristy Ciruna	FLNRO - Regional Operations Division - North Area	Director, Strategic Projects
Tarik Dessouki	ENV - Environmental Sustainability and Strategic Policy	Section Head - Surface Water, Groundwater and Snow Networks
Luann Chew	ENV - Environmental Sustainability and Strategic Policy	Hydrometric Specialist
Heather Johnstone	ENV - Environmental Sustainability and Strategic Policy	Unit Head, Hydrometric & Hydrology Programs
Deb Epps	ENV - Environmental Protection Division	Environmental Impact Assessment Biologist
Jonathon Boyd	OGC	Hydrology Technician
Allan Chapman	OGC	Hydrologist
Malcolm Gray	FLNRO-Integrated Resource Operations Division	Lead, Special Projects
Brad Sparks	ENV - Environmental Sustainability and Strategic Policy Division	Water Information Technician
Kevin Rieberger	ENV - Environmental Sustainability and Strategic Policy Division	Water Quality Science Specialist

Groundwater Technical Committee Contributors

Name	Ministry	Position
Elizabeth Johnson	FLNRO - Regional Operations Division - North Area	Project Manager, Northeast Water Strategy
Andarge Baye (Technical Lead)	ENV - Water Protection & Sustainability Branch	Hydrogeologist
Jun Yin	FLNRO - Regional Operations Division - North Area	Regional Hydrogeologist
Jillian Kelly	ENV - Environmental Sustainability and Strategic Policy Division	Groundwater Monitoring Specialist
Klaus Rathfelder	ENV - Environmental Sustainability and Strategic Policy	Aquifer Water Quality Scientist
Mike Wei	ENV - Environmental Sustainability and Strategic Policy	Section Head, Groundwater & Aquifer Science
Laurie Welch	OGC	Hydrogeologist
Dave Wilford	FLNRO - Regional Operations Division - North Area	TL Hydrologist
Chelton Van Geloven	FLNRO - Regional Operations Division - North Area	Source Water Protection Hydrologist
Brad Sparks	ENV - Environmental Sustainability and Strategic Policy Division	Water Information Technician

Public Focus Group Contributors

Group	Organization(s)	Representative(s)
Academia	Simon Fraser University	Shannon Holding
Agriculture Industry	B.C. Grain Producers	Sharla Pearce
First Nations	Treaty 8 Tribal Association, West Moberly, Halfway River, McLeod Lake, Fort Nelson, Blueberry River	Susi Roy, Teresa Thielen, Sharon Tsakoza, Jason Xiao, Reg Whiten, Cec Heron, Jim Webb, Kelsey McLeod, Clayton Davis, Lana Lowe, Norma Pyle, Wayne Yahey
Local Government	Hudson's Hope, City of Dawson Creek	Gwen Johansson, Reg Whiten, Chelsea Mottishaw
Mining Industry	Mining Association of B.C., Walter Energy	Angela Waterman, Alex Brissard
Non-Governmental Organizations	Geoscience B.C., West Fraser, Fraser Basin Council	Carlos Salas, Janelle Dale, Steve Litke
Oil and Gas Industry	Canadian Association of Petroleum Producers, Shell Canada	Zöe Thomas, Tara Payment, Deanna Cottrell

Regional Government	Peace River Regional District, Northern Rockies Regional Municipality	Shannon Anderson, Harold DeJong, Fran Haughian
Regulatory Bodies	Oil and Gas Commission, Northern Health Authority	Howard Madill, Allan Chapman, Ben Rauscher, Sheila Withrow
Water Consultants	GW solutions, Peace Country Technical Services	Gilles Wendling, Antonio Barosso, Barry Ortman

This paper presents the indicator layers included in each of the four disturbance-sensitivity based approaches: surface water quantity, surface water quality, groundwater quantity and groundwater quality. Some indicator layers are used in more than one approach and the metadata is presented for each occurrence.

Polygonal Coverage

Surface Water Polygons - OGC Basins

REPRESENTATION

For the surface water analysis, northeast British Columbia was assessed using watershed subdivisions. There are several watershed definitions in B.C. including the older B.C. Watershed Atlas at 1:50,000, the Freshwater Atlas at 1:20 000, the TRIM Watershed Atlas (not publically available) and Water Management Basins as defined by the B.C. Oil and Gas Commission (OGC). For this analysis, the 69 watersheds from the OGC's water management basins were used.

Hay River Drainage (4 Watersheds): Hay River, Kyklo River, Lower Kotcho River, Shekilie River

Liard River Drainage (36 Watersheds): Beaver River, Capot-Blanc River, Chinchaga River, Dunedin River, Fontas River, Grayling River, Kahntah River, Kiwigana River, Klua River, Lower Fort Nelson River, Lower Liard River, Lower Muskwa River, Lower Petitot River, Lower Prophet River, Lower Sikanni Chief River, Lower Toad River, Middle Fort Nelson River, Middle Liard River, Middle Muskwa River, Middle Petitot River, Middle Prophet River, Middle Sikanni Chief River, Muncho River, Racing River, Sahdoanah River, Sahtaneh River, Snake River, Tsea River, Upper Fort Nelson River, Upper Kotcho River, Upper Liard River, Upper Muskwa River, Upper Petitot River, Upper Prophet River, Upper Sikanni Chief River, Upper Toad River

Peace River Drainage (29 Watersheds): Blueberry River, Burnt River, Cache Creek, Cameron River, Chowade River, Doig River, East Kiskatinaw River, Farrell Creek, Graham River, Lower Beatton River, Lower Halfway River, Lower Kiskatinaw River, Lower Peace River, Lower Pine River, Lynx Creek, Middle Beatton River, Middle Kiskatinaw River, Milligan Creek, Moberly River, Murray River, Peace Arm, Pouce Coupe River, Smoky River, Sukunka River, Upper Beatton River, Upper Halfway, Upper Peace River, Upper Pine River, West Kiskatinaw River

Groundwater Polygons - NTS Map Sheets

REPRESENTATION

For the groundwater analysis, northeast British Columbia was assessed using NTS map sheet subdivisions. Alternate methods included using the 69 OGC water management basins (above) or defined aquifer units. Watersheds were not used because aquifers are not confined by those boundaries and there was some concern that the natural extent of groundwater aquifers might be confused with the overlying arbitrary surficial boundaries. There are insufficient aquifers mapped at this time for aquifer boundaries to provide a feasible option. The map sheets at 1:50,000 scale provide a more uniform grid-like approach to the assessment and there was no concern that grid boundaries would be confused with natural groundwater boundaries.

NTS Map Sheets (219 map sheets): 093H(16), 093I(1-2, 6-16), 093O(1, 6-11, 13-16), 093P(1-16), 094A(1-16), 094B(1-16), 094F(1, 8-10, 15-16), 094G(1-16), 094H(1-16), 094I(1-16), 094J(1-16), 094K(13, 5-16), 094L(8-9, 16), 094M(1-2, 6-11, 15-16), 094N(1-16), 094O(1-16), 094P(1-16)

DATA SOURCES

Table 1: Data Sources for Polygon-Based Subdivisions

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
OGC Basins	WHSE_MINERAL_TENURE.OG_WATER_MANAGEMENT_BASINS_SP	Y	OGC	Y	2012-04-10
NTS Map Sheets	WHSE_BASEMAPPING.NTS_50K_GRID	Y	OGC	Y	2003-04-23

GEOPROCESSING METHOD

Data for each indicator layer is processed and presented as a categorized value per watershed or NTS map sheet. Each individual watershed or map sheet represents an "Area of Interest" (AOI) polygon. There are four pathways to a final result for any indicator layer where the method used is dependent upon the nature of the data available. These four methods are listed below and referred to through the remainder of the document as each indicator layer is described.

Table 2: Geoprocessing of Polygon-Based Subdivisions to Create Indicator Layers

Source Data	Modification	Result Format
Polygonal Area	Create an intersection between the polygon layer (watersheds or NTS map sheets) and the indicator layer. Use watershed polygons to summarize indicator layer polygons within each unit. Save data as a table. Join the new summary table data to watershed (or NTS map sheet) polygons in a new layer. Complete conversion calculations to express indicator data as hectare per square kilometer.	Hectare per square kilometre (ha/km^2)
Polygonal Data	Create an intersection between the polygon layer (watersheds or NTS map sheets) and the indicator layer. Use watershed polygons to summarize data from indicator layer polygons within each watershed by summing (or averaging) the field of interest (e.g. stimulation volume, population) and summing the area of the	Data unit per square kilometer (e.g. m^3/km^2,

Source Data	Modification	Result Format
	polygons. Save as a table. Join the newly created summary table to watershed polygons in a new layer. Calculate a weighting factor from the sum of the area of indicator polygon(s) within each watershed relative to the total area of that watershed. Multiply the field of interest by the newly created area-based weighting factor. Divide the resultant weighted field of interest by the watershed polygon area. Complete conversion calculations to express indicator data per square kilometer.	count/km^2)
Point Count	Create an intersection between the polygon layer (watersheds or NTS map sheets) and the indicator layer. Use watershed polygons to summarize indicator points for each watershed by counting the points within the watershed. Save as a table. Join summary table data to watershed polygons in a new layer. Complete conversion calculations to express indicator data as count per square kilometer.	Count per square kilometre
Point Data	Create an intersection between the polygon layer (watersheds or NTS map sheets) and the indicator layer. Use watershed polygons to summarize indicator points for each watershed by summing or averaging the field of interest for the points within the watershed. Save as a table. Join the newly created summary table to watershed (or NTS map sheet) polygons in a new layer. Normalize the data (e.g. by dividing the contaminant discharge volume by the total flow in the basin). Complete conversion calculations to express normalized volume relative to area in square kilometers for the watershed.	Percent total flow

SURFACE WATER QUANTITY

The disturbance-sensitivity based approach to enhanced monitoring of surface water quantity focuses on areas of higher current industrial demand and future potential industrial demand. It also emphasizes areas of importance for monitoring the trend and condition of surface water supply for human and ecosystem needs. The indicator layers used to determine enhanced monitoring needs for surface water quantity are listed below.

Table 3: Indicator Layers for Surface Water Quantity Monitoring

Topic	Indicator Layer
Current Disturbance	Allocated Water Versus Runoff
Current Disturbance	Surface Water Restrictions
Future Disturbance	Possible Future Water Demand for Hydraulic Fracturing
Future Disturbance	Possible Water Demand by Mining
Future Disturbance	Possible Water Demand by Agriculture
Sensitivity	Population
Sensitivity	Wetland Density
Sensitivity	Headwater Density
Sensitivity	Lake Density

Current Disturbance Indicator Layers

Current water demand would ideally be represented by the actual water usage relative to the total runoff in a basin. However actual water use data is not currently captured by water licenses issued through the Ministry of Forests, Lands and Natural Resource Operations (FLNRO). There is an intention to modify this practice as the new Water Sustainability Act is implemented. At present, the closest metric for current water usage is volume of water allocated under a license relative to the runoff in a basin.

In some locations, requests for water exceed available supplies and a water source is closed to further licensing. Such restrictions can be temporary, set certain limitations or permanent. This data indicates locations where water demand outpaces supply.

Water licenses are issued for long periods, but both current demand and available water can fluctuate. In future, a proviso will be built into licenses under the Water Sustainability Act which will ensure environmentally sustainable flows in basins. This is a future data source that may provide a useful indicator layer for the disturbance-sensitivity based approach. Additionally, while environmental flow needs may be met on a basin-wide level when evaluated annually, they may be exceeded locally over short time frames. Drought reporting may provide useful information in the next year or two.

Allocated Water Versus Runoff (AllocVRunoff)

REPRESENTATION

The diversion and use of all surface water in British Columbia must be authorized. The vast majority of water licenses are for domestic and irrigation purposes. Other purposes include industrial, power, conservation, mining, stock watering and land improvement. Only water uses which are consumptive in nature are included for this indicator layer. The overall volume licensed relative to runoff indicates the level of demand per basin on an annual basis.

Consumptive Water Uses

Purpose	Detail
Agriculture	IRRIGATION
	PONDS
	STOCKWATERING
	WATERING
Domestic, Water works, etc.	BOTTLE SALES
	DOMESTIC
	ENTERPRISE
	INSTITUTIONS
	SNOW MAKING
	TRUCK WASHING
	WATER DELIVERY
	WATERWORKS (OTHER)
	WATERWORKS LOCAL AUTH
Mining	Dust Control - Mining
	MINING EQUIPMENT
	MINING-WASHING COAL
	ROAD MAINTENANCE - Mining
	SEDIMENT CONTROL
Oil and Gas	MINING EQUIPMENT - O&G
	OIL FIELD INJECTION
	PROCESSING - O&G
	ROAD MAINTENANCE - O&G
Pulp Mills, Forestry	PULPMILLS
Road Maintenance	DUST CONTROL
	ROAD MAINTENANCE
	PROCESSING - Road Maintenance

Non-consumptive Water Uses

Purpose	Detail

Conservation	CONSERV.-STORED WATER
	LAND IMPROVE
	LAND IMPROVE - Mining
Cooling	COOLING
Fire Protection	FIRE PROTECTION
Power	POWER-GENERAL
	POWER-RESIDENTIAL
Storage	STORAGE-NON POWER
	STORAGE-POWER

DATA SOURCES

Table 4: Data Source for Water Allocation

Topic	Source Location	LDRW /BCGW	Data Provider	Public Data	Data Last Modified
Water Allocation relative to OGC Basin Runoff	BC OGC 2013 Annual report Appendix 2 http://www.bcogc.ca/node/11263/download	N	OGC	Y	

GEOPROCESSING METHOD

Table 5: Geoprocessing of Water Allocation Source Data

Topic	Query or Process
Water Allocation relative to OGC Basin Runoff	(OGC volume approved (2013) + OGC permitted + FLNRO permitted)/ Mean annual runoff (2013) Peace Arm = 0 because the OGC approved volumes are managed in conjunction with BC Hydro who has a large reserve in that basin.

Table 6: Geoprocessing to Create a Water Allocation Indicator Layer

Result	Source Layer	Target Layer	Action
Water allocation relative to runoff per AOI polygon (percent of total flow)	Water Allocation relative to OGC Basin Runoff	AOI polygon layer	Join

Surface Water Restrictions (SWRestrictions)

REPRESENTATION

Occasionally a restriction notification is placed on water bodies to limit future water allocation decisions. A water allocation restriction is an indication that water demand has, at least temporarily, outpaced availability. A restriction may range from including minimum fish flow clauses in a water license, to suspending the issuance of any further licenses on a water body. Basins with more restrictions indicate stress or limitation on water resources.

Types of Allocation Restrictions

Restriction Type	Description
Refused No Water	A previous application for a water license was refused because there was insufficient water in the stream to grant the application.
Possible Water Shortage	This stream is nearing the Fully Recorded stage and there is the potential for periods of insufficient water.
Fully Recorded	No further licenses should be considered on this stream.
Fully Recorded except for ….	No further licenses should be considered on this stream except for licenses for the specified purposes and/or quantities.
Office Reserve	A specialized comment should be taken into consideration before making any water allocation decisions regarding this stream.

DATA SOURCES

Table 7: Data Source for Surface Water Restrictions

Topic	Source Location	LDRW /BCGW	Data Provider	Public Data	Data Last Modified
Surface water restrictions	WHSE_WATER_MANAGEMENT.WLS_WATER_RESTRICTION_LOC_SVW	Y	FLNRO	Y	2015-03-31

GEOPROCESSING METHOD

Table 8: Geoprocessing of Surface Water Restriction Source Data

Topic	Query or Process
Surface water restrictions	All restriction types included

Table 9: Geoprocessing to Create a Surface Water Restrictions Indicator Layer

Result	Source Layer	Target Layer	Action
Surface water restrictions count per AOI polygon (count/km^2)	Surface water restrictions	AOI polygon layer	Point Count as per Table 2

Future Disturbance Indicator Layers

Future water demand is expected to be highest for the petroleum and mining industries. For petroleum development, the highest water demand is associated with unconventional gas development through hydraulic fracturing. Water demand for water flood and other petroleum development operations is not expected to be a major source of water demand in

the future. Future water demand related to mining is primarily associated with coal mining where water may be required for washing coal, slurries, dust maintenance and more. The agricultural sector may also experience increased demand for water owing to increased irrigation. Irrigation practices are minimal at present, but are expected to increase. Climate change predictions for northeast B.C. are for warmer temperatures and decreased snow in winter. The forest sector is not expected to place any significant demands on water quantity in the future.

Possible Future Water Demand for Hydraulic Fracturing (PotOGWater)

REPRESENTATION

Water demand for unconventional gas development is not uniform across northeast B.C. but varies according to geology. Water demand is a function of the hydraulic fracturing style necessary for development of a specific formation in specific area. This indicator layer, Potential Water Demand for Hydraulic Fracturing, addresses water demand by area as a function of geology and development style. It presents the average stimulation volume needed per well in a given pool where a pool represents both the region and the horizon at depth specifically being targeted.

The relative stimulation volumes currently needed across pools in northeastern B.C. is considered a proxy for future development needs. There has been rapid technological advancement in hydraulic fracturing. The style of hydraulic fracturing (e.g. high volume slickwater or energized foams) in a given pool is not expected to change very quickly. The water volume required by a select style of fracturing can be highly dynamic. For example, the stimulation volume of water per well for high volume slickwater fracturing has increased by ten-fold in the past seven years.

DATA SOURCES

Table 10: Data Sources for Potential Water Demand for Hydraulic Fracturing

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Oil and Gas Pools	WHSE_MINERAL_TENURE.OG_POOL_DESGNTN_AREA_PUB_SP	Y	OGC	Y	2015-03-31
Well completion data with water volumes	Well completion data File = compl_wo.csv	N	OGC	Y	2015-03-31
Well location by Unique Well identifier (UWI)	WHSE_MINERAL_TENURE.OG_BOTTOM_HOLE_EVENT_SP	Y	OGC	Y	2015-03-31

GEOPROCESSING METHOD

Table 11: Geoprocessing of Potential Water Demand for Hydraulic Fracturing Source Data

Topic	Query or Process
Well completion data with water volumes	Only well events (UWI) where stimulation fluid was used (i.e. Stimultn_vol>0). A pool identifier was created by concatenating Field Area, Formation and Pool

Topic	Query or Process
	Sequence. Stimulation volume was summed by UWI for each pool.
Oil and Gas Pools	A pool identifier was created by concatenating Field Area, Formation and Pool Sequence.
Well location by unique Well identifier	Well completion data table Joined to Location data by UWI.

Table 12: Geoprocessing to Create a Potential Water Demand for Hydraulic Fracturing Indicator Layer

Result	Source Layer	Target Layer	Action
Average stimulation volume per pool	Well completion data with water volumes	Oil and Gas Pools	Joined well point data to pool polygons. Pools assigned the average UWI stimulation volume per well.
Average stimulation volume per AOI polygon (m^3/km^2)	Average stimulation volume per pool	AOI polygon layer	Polygon Data as per Table 2

Possible Water Demand by Mining (Mine)

REPRESENTATION

Mining is primarily limited to coal operations in northeast B.C. The land area for active mines is represented by lease areas. Areas of future expansion are held by license. Mineral and placer-based mines are represented by licensed areas, but they are almost nonexistent in northeast B.C. Potential future mining areas are not well captured under the current system. Claims represent a potential area much larger than that which may potentially be mined. Possible Water Demand by Mining therefore is limited mainly to coal leases and licenses.

DATA SOURCES

Table 13: Data Source for Possible Water Demand by Mining

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Mining Tenure	WHSE_MINERAL_TENURE.MTA_ACQUIRED_TENURE_SVW	Y	MEM	Y	2015-03-31

GEOPROCESSING METHOD

Table 14: Geoprocessing of Possible Water Demand by Mining Source Data

Topic	Query or Process
Mining Tenure	TENURE_SUB_TYPE_DESCRIPTION = lease or License

Table 15: Geoprocessing to Create a Possible Water Demand by Mining Indicator Layer

Result	Source Layer	Target Layer	Action
Mining Tenure per AOI polygon (ha/km^2)	Mining Tenure	AOI polygon layer	Polygonal Area as per Table 2

Possible Water Demand by Agriculture (Ag)

REPRESENTATION

Currently there is little excess water demand by agriculture. It is anticipated that there may soon be a switch to irrigation. Changes to the land area are unknown so the current agricultural coverage is used to represent future areas of potential irrigation.

DATA SOURCES

Table 16: Data Source for Possible Water Demand by Agriculture

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Agriculture	WHSE_BASEMAPPING.BTM_PRESENT_LAND_USE_V1_SVW	Y	FLNRO	Y	1997-07-01

GEOPROCESSING METHOD

Table 17: Geoprocessing of Possible Water Demand by Agriculture Source Data

Topic	Query or Process
Agriculture	PRESENT_LAND_USE_LABEL = Agriculture (Land based agricultural activities undifferentiated as to crop (i.e. land is used as the producing medium) and Residential Agriculture Mixtures (Areas where agriculture activities are intermixed with residential and other buildings with a density of between 2 and 0.2 hectares).

Table 18: Geoprocessing to Create a Possible Water Demand by Agriculture Indicator Layer

Result	Source Layer	Target Layer	Action
Agriculture per AOI polygon (ha/km^2)	Agriculture	AOI polygon layer	Polygonal Area as per Table 2

Layers Indicative of Human or Ecosystem Sensitivity

The stewardship of water resources for people and the environment is considered an important duty. Population and ecosystem indicator layers prioritize areas where it is most important that water condition and trend be tracked.

Population (Pop)

REPRESENTATION

Water of sufficient quantity and quality are a necessity of life and a requirement for regions of human habitation. There are two ways to capture domestic water needs: 1) by licensed volume and 2) by population concentration. Since volume data from government issued water licenses does not capture First Nations water needs, the population data is used for this assessment.

DATA SOURCES

Table 19: Data Sources for Population

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Population Boundary	Population Boundary data	N	Statistics Canada	Y	
Population	Population data	N	Statistics Canada	Y	

GEOPROCESSING METHOD

Table 20: Geoprocessing of Population Source Data

Topic	Query or Process
Population by dissemination block area	Population boundary and population were joined BC dissemination blocks were selected and exported to a new feature class which was then reprojected from geographic to BC Albers. A new field was added "DisseminationBlock_AREA" and calculated to equal the SHAPE_AREA (using area-weighting, the new field can subsequently be used for estimating population in a dissemination block which has been split by intersection with a watershed/basin).

Table 21: Geoprocessing to Create a Population Indicator Layer

Result	Source Layer	Target Layer	Action
Population per AOI polygon (count/km^2)	Population by dissemination block area	AOI polygon layer	Polygonal Data as per Table 2

Wetland Density (Wetland)

REPRESENTATION

Wetlands affect water quality and quantity by serving to improve water quality and buffer flow volumes. They also serve as habitat for terrestrial and aquatic species. Wetland has been mapped in a variety of forms, the newest and most comprehensive mapping of wetland being by Ducks Unlimited. However that data set is not in the public realm. Sections of northeast B.C. are mapped in great detail, but universal coverage was sought for the entire northeast region. Options include the freshwater atlas (FWA), the enhanced base map (EBM), and baseline thematic map (BTM). The BTM was chosen because it is accurate to 250m across the entire region and provides polygonal data for several indicator layers

including wetland, freshwater, agriculture, and urban areas so it provides more congruence across indicator layers in the project.

DATA SOURCES

Table 22: Data Source for Wetland

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Wetland	WHSE_BASEMAPPING.BTM_PRESENT_LAND_USE_V1_SVW	Y	FLNRO	Y	1997-07-01

GEOPROCESSING METHOD

Table 23: Geoprocessing of Wetland Source Data

Topic	Query or Process
Wetland	PRESENT_LAND_USE_LABEL = Wetland (Wetlands including swamps, marshes, bogs or fens. This class excluded lands with evidence of knowledge of haying or grazing in drier years)

Table 24: Geoprocessing to Create a Wetland Density Indicator Layer

Result	Source Layer	Target Layer	Action
Wetland per AOI polygon (ha/km^2)	Wetland	AOI polygon layer	Polygonal Area as per Table 2

Headwater Density (Headwater) and Lake Density (LakeDensity)

REPRESENTATION

It was challenging to find a good indicator layer for aquatic species sensitivity. Species surveys are spotty and inconsistent in the northeast. Absence of species does not necessarily indicate a change in population. The environments that most support aquatic species diversity and population were used as indicator layers instead: riverine headwaters and lakes. Mapping comes from the Ecological Aquatic Units of British Columbia (EAU BC), a hierarchical classification of freshwater ecosystems that integrates many factors including zoogeography, physiography and climatic patterns as well as more localized physical habitat and dominant environmental processes.

DATA SOURCES

Table 25: Data Source for Headwaters

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Headwaters	WHSE_LAND_AND_NATURAL_RESOURCE.EAUBC_RIVERS_SP	Y	ENV	Y	2007-11-30

GEOPROCESSING METHOD

Table 26: Geoprocessing of Headwater Source Data

Topic	Query or Process
Headwaters	RIVER_ECOSYSTEM_CLASS = H

Table 27: Geoprocessing to Create a Headwater Density Indicator Layer

Result	Source Layer	Target Layer	Action
Headwaters per AOI polygon (ha/km^2)	Headwaters	AOI polygon layer	Polygonal Area as per Table 2

DATA SOURCES

Table 28: Data Source for Lakes

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Lakes	WHSE_LAND_AND_NATURAL_RESOURCE.EAUBC_LAKES_SP	Y	ENV	Y	2007-11-30

GEOPROCESSING METHOD

Table 29: Geoprocessing of Lake Source Data

Topic	Query or Process
Lakes	All lakes

Table 30: Geoprocessing to Create a Lake Density Indicator Layer

Result	Source Layer	Target Layer	Action
Lakes per AOI polygon (ha/km^2)	Lakes	AOI polygon layer	Polygonal Area as per Table 2

SURFACE WATER QUALITY

The disturbance-sensitivity based approach to enhanced monitoring of surface water quality focuses on areas of current industrially related disturbance and future areas of potential industrial disturbance. It also emphasizes areas of importance for monitoring the trend and condition of surface water quality for human and ecosystem needs. The indicator layers used to determine enhanced monitoring needs for surface water quality are listed below.

Table 31: Indicator Layers for Surface Water Quality Monitoring

Topic	Indicator Layer
Current Disturbance	Disturbance from Agriculture
Current Disturbance	Disturbance from Forest Clear Cutting
Current Disturbance	Disturbance from Forest Burn Scars
Current Disturbance	Disturbance from Urban
Current Disturbance	Disturbance from Oil and Gas Industry Related Infrastructure
Current Disturbance	Disturbance from Linear Features (Roads, Railway Lines and Transmission Lines)
Current Disturbance	Disturbance from Mining
Current Disturbance	Contamination from Effluent
Future Disturbance	Potential Disturbance from Unconventional Gas Development
Future Disturbance	Potential Disturbance from Mining
Future Disturbance	Potential Disturbance from Forestry
Sensitivity	Population
Sensitivity	Wetland Density
Sensitivity	Headwater Density
Sensitivity	Lake Density

Current Disturbance Indicator Layers

There are two main categories considered in this analysis where the quality of water may be impaired: impact from surface disturbance; and point source impact from the authorized release of effluent into streams.

Disturbance from Agriculture (Ag)

REPRESENTATION

Disturbance from agriculture can affect water quality through drainage of pesticides, herbicides and nutrients into nearby freshwater.

DATA SOURCES

Table 32: Data Source for Agricultural Disturbance

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Agriculture	WHSE_BASEMAPPING.BTM_PRESENT_LAND_USE_V1_SVW	Y	FLNRO	Y	1997-07-01

GEOPROCESSING METHOD

Table 33: Geoprocessing of Agricultural Disturbance Source Data

Topic	Query or Process
Agriculture	PRESENT_LAND_USE_LABEL = Agriculture (Land based agricultural activities undifferentiated as to crop (i.e. land is used as the producing medium) and Residential Agriculture Mixtures (Areas where agriculture activities are intermixed with residential and other buildings with a density of between 2 and 0.2 hectares).

Table 34: Geoprocessing to Create an Agricultural Disturbance Indicator Layer

Result	Source Layer	Target Layer	Action
Agriculture per AOI polygon (ha/km^2)	Agriculture	AOI polygon layer	Polygonal Area as per Table 2

Disturbance from Forest Clear Cutting (ForCuts)

REPRESENTATION

Areas denuded of forest cover can shed sediment via overland flow into nearby freshwater. Disturbance from agriculture can affect water quality through drainage of pesticides, herbicides and nutrients into nearby freshwater.

DATA SOURCES

Table 35: Data Sources for Disturbance from Forest Clear Cutting

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Consolidated cut blocks	Consolidated_Cutblocks_2013.gdb	N	FLNRO	Y	
Consolidated cut blocks	Consolidated_Cutblocks_2012.gdb	N	FLNRO	Y	
Harvest Authority	WHSE_FOREST_TENURE.FTEN_HARVEST_AUTH_POLY_SVW	Y	FLNRO	Y	2015-03-31

The process for capturing Consolidated Cut blocks changed for the 2013 model. It is speculated that wildfire data may have been dropped from the 2013 data.

Comparison of Consolidated Cut blocks for 2012 and 2013

Consolidated Cut block data set	Area
Common polygons (2012 and 2013)	242,055
2013 only	23,598 (includes some new 2013 cut blocks)
2012 only	43,584
Total	309,237

GEOPROCESSING METHOD

Table 36: Geoprocessing of Disturbance from Forest Clear Cutting Source Data

Topic	Query or Process
Consolidated cut blocks	None
Harvest Authority	Not used FTEN Harvest Authority contains information from occupant license to cut authorizations from tenures such as wind power; coal tenures; that are not documented in the consolidated cut blocks. Although geometry exists for these tenures, the current status of the tenures is unknown.

Table 37: Geoprocessing to Create a Disturbance from Forest Clear Cutting Indicator Layer

Result	Source Layer	Target Layer	Action
Union of Consolidated Cut blocks	Consolidated cut blocks 2012	Consolidated cut blocks 2013	Union
If one wanted to use Harvest Authority data	Harvest Authority	Union of Consolidated Cut blocks	Intersection
If one wanted to use Harvest Authority data (continued)	Intersection of Harvest Authority and Union of Consolidated cut blocks	Union of Consolidated Cut blocks	Union
Forestry Cut blocks per AOI polygon (ha/km^2)	Union of Consolidated Cut blocks	AOI polygon layer	Polygonal Area as per Table 2

Disturbance from Forest Burn Scars (ForBurn)

REPRESENTATION

Areas denuded of forest cover through fire can shed substantial sediment loads into nearby freshwater resources. Burned forested areas can be slower to regrow than recently logged areas.

DATA SOURCES

Table 38: Data Source for Disturbance from Forest Burn Scars

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Forest Burn Scars	WHSE_BASEMAPPING.BTM_PRESENT_LAND_USE_V1_SVW	Y		Y	1997-07-01

GEOPROCESSING METHOD

Table 39: Geoprocessing of Disturbance from Forest Burn Scars Source Data

Topic	Query or Process
Forest Burn Scars	PRESENT_LAND_USE_LABEL = Recently Burned (Area virtually devoid of trees due to fire within the past 20 years. Forest less than or equal to 15% cover).

Table 40: Geoprocessing to Create a Disturbance from Forest Burn Scars Indicator Layer

Result	Source Layer	Target Layer	Action
Forest Burn Scars per AOI polygon (ha/km^2)	Forest Burn Scars	AOI polygon layer	Polygonal Area as per Table 2

Disturbance from Urban (Urban)

REPRESENTATION

Urban data is taken from a land use analysis of mostly Landsat 5 image mosaics. It is spatially accurate to 250m.

DATA SOURCES

Table 41: Data Source for Urban Disturbance

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Urban	WHSE_BASEMAPPING.BTM_PRESENT_LAND_USE_V1_SVW	Y	FLNRO	Y	1997-07-01

GEOPROCESSING METHOD

Table 42: Geoprocessing of Urban Disturbance Source Data

Topic	Query or Process
Urban	PRESENT_LAND_USE_LABEL = Urban (all compact settlements including built up areas of cities, towns and villages as well as units away from settlements such as manufacturing plants, rail yards and military camps. In most cases residential use will predominate in these areas. Open space which forms an integral part of the urban agglomeration, e.g. parks, golf courses, etc. are included as urban)

Table 43: Geoprocessing to Create an Urban Disturbance Indicator Layer

Result	Source Layer	Target Layer	Action

Result	Source Layer	Target Layer	Action
Urban per AOI polygon (ha/km^2)	Urban	AOI polygon layer	Polygonal Area as per Table 2

Disturbance from Oil and Gas Industry Related Infrastructure (OGinfr)

REPRESENTATION

Oil and Gas infrastructure data is a combination of pipelines, well pads, facilities and other ancillary activity such as borrow pits, decking sites and temporary disturbances. Data comes from a variety of sources in a variety of forms. If line data is provided, the line is buffered along its length to provide a representative area value.

DATA SOURCES

Table 44: Data Sources for Oil and Gas Infrastructure Related Disturbance

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
CROWN TENURES	WHSE_TANTALIS.TA_CROWN_TENURES_SVW	Y	FLNRO	Y	2015-03-31
TANTALIS – SURVEY PARCELS	WHSE_TANTALIS.TA_SURVEYED_ROW_PARCELS_SVW	Y	FLNRO	Y	2015-03-31
OG Pipeline RW	WHSE_MINERAL_TENURE_OG_PIPELINE_RW_PUB_SP	Y	OGC	Y	2015-03-31
OG Well Sites	WHSE_MINERAL_TENURE_OG_WELL_SITES_PUB_SP	Y	OGC	Y	2015-03-31
OG Facilities	WHSE_MINERAL_TENURE_OG_FACILITY_SITES_PUB_SP	Y	OGC	Y	2015-03-31
OG Ancillary	WHSE_MINERAL_TENURE_OG_ANCILLARY_OTHER_APPS_PUB_SP	Y	OGC	Y	2015-03-31
OG Surface Hole	WHSE_MINERAL_TENURE.OG_SURFACE_HOLE_STATUS_SP	Y	OGC	Y	2015-03-31
TRIM Pipelines	WHSE_BASEMAPPING.TRIM_CULTURAL_LINES	Y	FLNRO	N	

GEOPROCESSING METHOD

Table 45: Geoprocessing of Oil and Gas Infrastructure Related Disturbance Source Data

Topic	Query or Process
CROWN TENURES	TENURE_PURPOSE = UTILITY AND TENURE_SUBPURPOSE = GAS AND OIL PIPELINE OR TENURE_PURPOSE = ENERGY PRODUCTION And proposed tenures were removed from the analysis by two additional query conditions: TENURE_TYPE <> 'RESERVE/NOTATION' and TENURE_STAGE <> 'APPLICATION'

Topic	Query or Process
TANTALIS – SURVEY PARCELS	FCODE = FA91300120 or FCODE = FA91400120
OG Pipeline RW	Pipelines under application (not constructed) were removed from the analysis by a query: APPLICATION_STATUS <> 'APPROV'
OG Well Sites	All well site polygons
OG Facilities	Facilities under application (not constructed) were removed from the analysis by a query: APPLICATION_STATUS <> 'APPROV'
OG Ancillary	ANCILLARY_OTHER_APP_TYPE not equal to “ROAD” or “INV”
OG Surface Hole	Wells never constructed were removed from the analysis using the WELL_ACTIVITY field to query out wells cancelled before being constructed ('CANC') and wells authorized but not constructed ('WAG') Point data. Data may be duplicated in Tantalis and OGC datasets; buffer 1.44 hectares (60 metres buffer radius); In ArcGIS, use the Feature Envelope To Polygon tool to convert the circle buffer to a square buffer.
Trim Pipelines	FCODE = EA21400000; buffer 10 metres

Table 46: Geoprocessing to Create an Oil and Gas Infrastructure Related Disturbance Indicator Layer

Result	Source Layer	Target Layer	Action
Oil and Gas infrastructure	CROWN TENURES TANTALIS – SURVEY PARCELS OG Pipeline RW OG Well Sites OG Facilities OG Ancillary OG Surface Hole TRIM Pipelines	New layer (Oil and Gas Infrastructure)	Merge; dissolve created on outer boundaries
Oil and Gas infrastructure per AOI polygon (ha/km^2)	Oil and Gas infrastructure	AOI polygon layer	Polygonal Area as per Table 2

Disturbance from Linear Features (Linear)

Disturbance associated with linear features is calculated as an amalgamation of disturbance from roads, railway lines and transmission lines. Data comes from a variety of sources in a variety of forms. If line data is provided, the line is buffered along its length to provide a representative area value.

Disturbance from Linear Features - Roads

DATA SOURCES

Table 47: Data Sources for Road Disturbance

Topic	Source Location (with hyperlink where possible)	BCGW	Data Provider	Public Data	Data Last Modified
Digital Road Atlas (DRA)	WHSE_BASEMAPPING.DRA_DGTL_ROAD_ATLAS_MPAR_SP	Y	FLNRO	Y	2014-12-10
Forest Service Roads (FTEN)	WHSE_FOREST_TENURE.FTEN_ROAD_SECTION_LINES_SVW	Y	FLNRO	Y	2015-03-31
Petroleum Development Roads (PDR)	WHSE_MINERAL_TENURE.OG_PETRLM_DEV_ROADS_PUB_SP	Y	OGC	Y	2015-03-31
Petroleum Development Roads Pre06 (PDR)	WHSE_MINERAL_TENURE_OG_PETRLM_DEV_RDS_PRE06_PUB_SP	Y	OGC	Y	2010-03-25
Petroleum Access Roads (PDR)	WHSE_MINERAL_TENURE_OG_PETRLM_ACCESS_ROADS_PUB_SP	Y	OGC	Y	2015-03-31
Trails (TR)	WHSE_FOREST_TENURE.FTEN_RECREATION_LINES_SVW	Y	FLNRO	Y	2015-03-31

Note: Currently there is a provincial project to produce a consolidated road network product, the Integrated Transportation Network (ITN), which would replace the multiple sources used in this initial analysis.

GEOPROCESSING METHOD

Table 48: Geoprocessing of Road Disturbance Source Data

Topic	Query or Process
Digital Road Atlas (DRA)	Road Class = Highway; buffer 15 metres Road Surface = Paved; buffer 15 metres Road Surface = Loose; buffer 10 metres Road Surface = Rough; buffer 7.5 metres Road Surface = Overgrown; buffer 7.5 metres Road Surface = Decomissioned; buffer 7.5 metres Road Surface = Unknown; buffer 7.5 metres
Forest Service Roads (FTEN)	FILE_TYPE_DESCRIPTION = FSR; buffer 10 metres FILE_TYPE_DESCRIPTION = RP; buffer 7.5 metres
Petroleum Development Roads	PETRLM_DEVELOPMENT_ROAD_TYPE = High Grade; buffer 10 metres PETRLM_DEVELOPMENT_ROAD_TYPE = Low Grade; buffer 10 metres PETRLM_DEVELOPMENT_ROAD_TYPE = Winter; buffer 3.5 metres PETRLM_DEVELOPMENT_ROAD_TYPE = blank; buffer 3.5 metres
Petroleum Development Roads Pre06	PETRLM_DEVELOPMENT_ROAD_TYPE = High Grade; buffer 10 metres PETRLM_DEVELOPMENT_ROAD_TYPE = Low Grade; buffer 10 metres PETRLM_DEVELOPMENT_ROAD_TYPE = Winter; buffer 3.5 metres PETRLM_DEVELOPMENT_ROAD_TYPE = blank; buffer 3.5 metres
Petroleum Access Roads	PETRLM_ACCESS_ROAD_TYPE = High Grade; buffer 10 metres PETRLM_ACCESS_ROAD_TYPE = Low Grade; buffer 10 metres PETRLM_ACCESS_ROAD_TYPE = Winter; buffer 3.5 metres PETRLM_ACCESS_ROAD_TYPE = blank; buffer 3.5 metres
Trails (TR)	Right of Way not null; buffer ½ of RIGHT_OF_WAY attribute value Right of Way null; buffer 2.5 metres

Table 49: Geoprocessing to Create a Road Disturbance Indicator Layer

Result	Source Layer	Target Layer	Action

Result	Source Layer	Target Layer	Action
Consolidated Roads	Digital Road Atlas (DRA) Forest Service Roads (FTEN) Petroleum Development Roads Petroleum Development Roads Pre06 Petroleum Access Roads Trails (TR	New layer (Consolidated Roads)	Merge; dissolve created on outer boundaries
Consolidated Roads per AOI polygon (ha/km^2)	Consolidated Roads	AOI polygon layer	Polygonal Area as per Table 2

Disturbance from Linear Features – Railway Lines

DATA SOURCES

Table 50: Data Sources for Railway Line Disturbance

Topic	Source Location (with hyperlink where possible)	BCGW	Data Provider	Public Data	Data Last Modified
Trim Railways	WHSE_BASEMAPPING.TRIM_TRANSPORTATION_LINES	Y	FLNRO	N	2015-03-31
Federal Railways	National Railway Network (NRWN) - BC, British Columbia	N	NRCan	Y	2013-11-03
Tantalis Survey Parcels	WHSE_TANTALIS.TA_SURVEY_PARCELS_SVW	Y	FLNRO	Y	2015-03-31
Tantalis Transportation	WHSE_TANTALIS_TA_TRANSPORTATION_SVW	Y	FLNRO	Y	2014-12-11

Trim railway features are not available to the Public. This data was added to ensure as complete dataset as possible.

GEOPROCESSING METHOD

Table 51: Geoprocessing of Railway Line Disturbance Source Data

Topic	Query or Process
Trim Railways	DE22850000, DE22850110, DE22850120, DE22900000, DE22950000, DE22950001, DE22950120, DF28850000, F28850000; buffer 17.5 metres
Federal Railways	buffer 17.5 metres
Tantalis Survey Parcels	Feature Code = FA91200130
Tantalis Transportation	Feature Code = FA91200120

Table 52: Geoprocessing to Create a Railway Line Disturbance Indicator Layer

Result	Source Layer	Target Layer	Action

Result	Source Layer	Target Layer	Action
Merged Transportation and Survey Parcels	Tantalis Survey Parcels Tantalis Transportation	New layer Transportation and Survey Parcels	Merge
Consolidated Railway lines	Merged Transportation and Survey Parcels TRIM Railways Federal Railways	New layer (Consolidated Railways)	In areas where the merged Transportation and Survey Parcels layer does not have any polygons, TRIM Railways and National Railway Network were buffered and added. Then a dissolve to create the outer boundaries of railways.
Railway Lines per AOI polygon (ha/km^2)	Consolidated Railway lines	AOI polygon layer	Polygonal Area as per Table 2

Disturbance from Linear Features – Transmission Lines

DATA SOURCES

Table 53: Data Sources for Transmission Line Disturbance

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
CROWN TENURES	WHSE_TANTALIS.TA_CROWN_TENURES_SVW	Y	FLNRO	Y	2015-03-31
TANTALIS- SURVEY PARCELS	WHSE_TANTALIS.TA_SURVEYED_ROW_PARCELS_SVW	Y	FLNRO	Y	2015-03-31
BC Hydro Transmission	Circuit.shp	N	BC Hydro	Y	

GEOPROCESSING METHOD

Table 54: Geoprocessing of Transmission Line Disturbance Source Data

Topic	Query or Process
CROWN TENURES	Subpurpose = ELECTRIC POWER LINE
TANTALIS- SURVEY PARCELS	FEATURE_CODE = FA91400110
BC Hydro Transmission	Buffer 9.15 metres

Table 55: Geoprocessing to Create a Transmission Line Disturbance Indicator Layer

Result	Source Layer	Target Layer	Action
Merged Survey Parcels and Crown Tenure	Tantalis Survey parcels Crown Tenures	Merged Survey Parcels and Crown Tenure layer	Merge
Consolidated Transmission lines	Merged Survey Parcels and Crown Tenure BC Hydro Transmission	New layer (Consolidated transmission lines)	In areas where the Merged Survey Parcels and Crown Tenure layer does not have any

Result	Source Layer	Target Layer	Action
			polygons, BC Hydro Transmission lines were buffered and added. Then a dissolve to create the outer boundaries of transmission lines.
Transmission Lines per AOI polygon (ha/km^2)	Consolidated Transmission Lines	AOI polygon layer	Polygonal Area as per Table 2

Disturbance from Mining (Mining)

REPRESENTATION

Mining is primarily limited to coal operations in northeast B.C. The land area for active mines is represented by lease areas.

DATA SOURCES

Table 56: Data Source for Mining Disturbance

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Mining Tenure	WHSE_MINERAL_TENURE.MTA_ACQUIRED_TENURE_SVW	Y	MEM	Y	2015-03-31

GEOPROCESSING METHOD

Table 57: Geoprocessing of Mining Disturbance Source Data

Topic	Query or Process
Mining Tenure	TENURE_SUB_TYPE_DESCRIPTION = Lease

Table 58: Geoprocessing to Create a Mining Disturbance Indicator Layer

Result	Source Layer	Target Layer	Action
Mining Tenure per AOI polygon (ha/km^2)	Mining Tenure	AOI polygon layer	Polygonal Area as per Table 2

Contamination from Effluent (Industrial Waste and Sewage)

REPRESENTATION

Permits are granted to dispose of liquid waste into freshwater resources. The data can be analyzed by the type of contaminant, the over tonnage of disposal, tonnage by contaminant type or the number of sites where disposal occurs. For this analysis, the number of sites for disposal was used.

DATA SOURCES

Table 59: Data Sources for Effluent Contamination

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Waste Discharge	Waste Discharge Authorizations- All Discharges Information limited to location of discharge points as they relate to authorizations. Data sporadic and requires QA/QC	N	ENV	Y	2015-03-31
Environmental Monitoring System Locations	WHSE_ENVIRONMENTAL_MONITORING.EMS_MONITORING_LOCN_TYPES_SVW	Y	ENV	Y	2015-03-31
Waste Discharge Codes	EMS Codes	N	ENV	Y	

GEOPROCESSING METHOD

Table 60: Geoprocessing of Effluent Contamination Source Data

Topic	Query or Process
Waste Discharge	Combine the Waste Discharge authorizations table with Environmental Monitoring System Locations by joining the EMS Site attribute field to MONITORING_LOCATION_ID attribute field. Then select points with DischargeType = effluent; EMSPurposeCode = 3; EMSDischargeCode = 1 or 5;

Table 61: Geoprocessing to Create an Effluent Contamination Indicator Layer

Result	Source Layer	Target Layer	Action
Waste Discharge Sites per AOI polygon (Count/km^2)	Waste Discharge	AOI polygon layer	Point Count as per Table 2

Future Disturbance Indicator Layers

Future water quality expected to be most impacted by industrial-related disturbance in the following industries: unconventional gas development, forestry and mining.

Potential Disturbance from Unconventional Gas Development (OGPlays)

REPRESENTATION

In this analysis, potential future oil and gas development is limited to unconventional gas plays because since 2005 a strongly increasing to dominant number of new well licenses is related to unconventional development. There are four large areas considered prospective for unconventional gas development on the basis of geology: the Montney Play Trend, the Horn River Basin, the Cordova Embayment and the Liard Basin. For future petroleum-related disturbance, any land surface physically above a potential unconventional play is possibly subject to water quality impact from development activities.

DATA SOURCES

Table 62: Data Source for Disturbance from Unconventional Gas Development

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Unconventional Gas Plays	WHSE_MINERAL_TENURE.OG_UNCONVENTNL_PLAY_TRENDS_SP	Y	OGC	Y	2010-03-25

GEOPROCESSING METHOD

Table 63: Geoprocessing of Disturbance from Unconventional Gas Development Source Data

Topic	Query or Process
Unconventional Gas Plays	All four play trends (Montney, Horn River, Cordova, Liard)

Table 64: Geoprocessing to Create a Disturbance from Unconventional Gas Development Indicator Layer

Result	Source Layer	Target Layer	Action
Unconventional Gas Development per AOI polygon (ha/km^2)	Unconventional Gas Plays	AOI polygon layer	Polygonal Area as per Table 2

Potential Disturbance from Mining (Mine)

REPRESENTATION

Mining is primarily limited to coal operations in northeast B.C. The land area for active mines is represented by lease areas. Areas of future expansion are held by license. Mineral and placer-based mines are represented by licensed areas, if they exist. Potential future mining areas are not well captured under the current system. Claims represent a potential area much larger than that which may potentially be mined. Possible impact to water quality by mining therefore is limited mainly to coal leases and licenses.

DATA SOURCES

Table 65: Data Source for Potential Disturbance from Mining

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Mining Tenure	WHSE_MINERAL_TENURE.MTA_ACQUIRED_TENURE_SVW	Y	MEM	Y	2015-03-31

GEOPROCESSING METHOD

Table 66: Geoprocessing of Potential Disturbance from Mining Source Data

Topic	Query or Process
Mining Tenure	TENURE_SUB_TYPE_DESCRIPTION = lease or License

Table 67: Geoprocessing to Create a Potential Disturbance from Mining Indicator Layer

Result	Source Layer	Target Layer	Action
Mining Tenure per AOI polygon (ha/km^2)	Mining Tenure	AOI polygon layer	Polygonal Area as per Table 2

Potential Disturbance from Forestry (ForestCrwn)

REPRESENTATION

The largest impact from forestry activity to water quality is in areas of cut blocks. Future forest industry activity will predominantly occur in the cutting of crown forested areas. For this analysis, all crown forest areas are considered potential for clear cutting activities.

DATA SOURCES

Table 68: Data Source for Potential Disturbance from Forestry

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Crown forest areas	WHSE_FOREST_VEGETATION.VEG_COMP_LYR_R1_POLY	Y	FLNRO	Y	2014-12-16

GEOPROCESSING METHOD

Table 69: Geoprocessing of Potential Disturbance from Forestry Source Data

Topic	Query or Process
Crown forest areas	FOR_MGMT_LAND_BASE_IND = Y

Table 70: Geoprocessing to Create a Potential Disturbance from Forestry Indicator Layer

Result	Source Layer	Target Layer	Action
Crown Forest area per AOI polygon (ha/km^2)	Crown forest areas	AOI polygon layer	Polygonal Area as per Table 2

Layers Indicative of Human or Ecosystem Sensitivity

The stewardship of water resources for people and the environment is considered an important duty. This section is designed to flag basins where monitoring should be prioritized as a safeguarding feature. The indicator layers prioritize represent areas where it is most important that water condition and trend be tracked.

Population (Pop)

REPRESENTATION

Water of sufficient quantity and quality are a necessity of life and a requirement for regions of human habitation. There are two ways to capture domestic water needs: 1) by licensed volume and 2) by population concentration. Since volume data from government issued water licenses does not capture First Nations water needs, the population data is used for this assessment.

DATA SOURCES

Table 71: Data Sources for Population

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Population Boundary	Population Boundary data	N	Statistics Canada	Y	
Population	Population data	N	Statistics Canada	Y	

GEOPROCESSING METHOD

Table 72: Geoprocessing of Population Source Data

Topic	Query or Process
Population by dissemination block area	Population boundary and population were joined BC dissemination blocks were selected and exported to a new feature class which was then reprojected from geographic to BC Albers. A new field was added "DisseminationBlock_AREA" and calculated to equal the SHAPE_AREA (using area-weighting, the new field can subsequently be used for estimating population in a dissemination block which has been split by intersection with a watershed/basin).

Table 73: Geoprocessing to Create a Population Indicator Layer

Result	Source Layer	Target Layer	Action
Population per AOI polygon (count/km^2)	Population by dissemination block area	AOI polygon layer	Polygonal Data as per Table 2

Wetland Density (Wetland)

REPRESENTATION

Wetlands affect water quality and quantity by serving to improve water quality and buffer flow volumes. They also serve as habitat for terrestrial and aquatic species. Wetland has been mapped in a variety of forms, the newest and most comprehensive mapping of wetland being by Ducks Unlimited. However that data set is not in the public realm. Sections of northeast B.C. are mapped in great detail, but universal coverage was sought for the entire northeast region. Options include the freshwater atlas (FWA), the enhanced base map (EBM), and baseline thematic map (BTM). The BTM was chosen because it is accurate to 250m across the entire region and provides polygonal data for several indicator layers

including wetland, freshwater, agriculture, and urban areas so it provides more congruence across indicator layers in the project.

DATA SOURCES

Table 74: Data Source for Wetland

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Wetland	WHSE_BASEMAPPING.BTM_PRESENT_LAND_USE_V1_SVW	Y	FLNRO	Y	1997-07-01

GEOPROCESSING METHOD

Table 75: Geoprocessing of Wetland Source Data

Topic	Query or Process
Wetland	PRESENT_LAND_USE_LABEL = Wetland (Wetlands including swamps, marshes, bogs or fens. This class excluded lands with evidence of knowledge of haying or grazing in drier years)

Table 76: Geoprocessing to Create a Wetland Density Indicator Layer

Result	Source Layer	Target Layer	Action
Wetland per AOI polygon (ha/km^2)	Wetland	AOI polygon layer	Polygonal Area as per Table 2

Headwater Density (Headwater) and Lake Density (LakeDensity)

REPRESENTATION

It was challenging to find a good indicator layer for aquatic species sensitivity. Species surveys are spotty and inconsistent in the northeast. Absence of species is does not necessarily indicate a change in population. The environments that most support aquatic species diversity and population were used as indicator layers instead: riverine headwaters and lakes. Mapping comes from the Ecological Aquatic Units of British Columbia (EAU BC), a hierarchical classification of freshwater ecosystems that integrates many factors including zoogeography, physiography and climatic patterns as well as more localized physical habitat and dominant environmental processes.

DATA SOURCES

Table 77: Data Source for Headwaters

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Headwaters	WHSE_LAND_AND_NATURAL_RESOURCE.EAUBC_RIVERS_SP	Y	ENV	Y	2007-11-30

GEOPROCESSING METHOD

Table 78: Geoprocessing of Headwater Source Data

Topic	Query or Process
Headwaters	RIVER_ECOSYSTEM_CLASS = H

Table 79: Geoprocessing to Create a Headwater Density Indicator Layer

Result	Source Layer	Target Layer	Action
Headwaters per AOI polygon (ha/km^2)	Headwaters	AOI polygon layer	Polygonal Area as per Table 2

DATA SOURCES

Table 80: Data Source for Lakes

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Lakes	WHSE_LAND_AND_NATURAL_RESOURCE.EAUBC_LAKES_SP	Y	ENV	Y	2007-11-30

GEOPROCESSING METHOD

Table 81: Geoprocessing of Lake Source Data

Topic	Query or Process
Lakes	All lakes

Table 82: Geoprocessing to Create a Lake Density Indicator Layer

Result	Source Layer	Target Layer	Action
Lakes per AOI polygon (ha/km^2)	Lakes	AOI polygon layer	Polygonal Area as per Table 2

GROUNDWATER QUANTITY

A disturbance-sensitivity based approach to enhanced groundwater monitoring is challenging. Groundwater occurs almost everywhere beneath the land surface but there is very limited information on whether the groundwater is part of an aquifer and the water quality within that aquifer. Substantially more groundwater mapping is required. In this section, groundwater quantity monitoring is directed toward current industrial groundwater demand, potential future industrial demand and monitoring the trend and condition of groundwater supply for human and ecosystem needs. The indicator layers used to determine enhanced monitoring needs for groundwater quantity are listed below.

Table 83: Indicator Layers for Groundwater Quantity Monitoring

Topic	Indicator Layer
Current Disturbance	Well Density
Current Disturbance	Current Water Demand for Hydraulic Fracturing
Future Disturbance	Possible Future Water Demand for Hydraulic Fracturing
Future Disturbance	Possible Water Demand by Mining
Future Disturbance	Surface Water Restrictions
Sensitivity	Population

Current Disturbance Indicator Layers

Current water demand is difficult to accurately represent at this time because the only information available comes from the Wells Database. This database is largely populated by information collected by drillers at the time of well installation. It is error-prone and lacking in reproducible information about well yield.

Well Density (WellDensity)

REPRESENTATION

Domestic and industrial wells (with the exception of some oil and gas industry source wells) are listed in the wells database. The density of wells in a region is a general indication of relative demand on the groundwater resources.

DATA SOURCES

Table 84: Data Source for Well Density

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Well Density	WHSE_WATER_MANAGEMENT.GW_WATER_WELLS_WRBC_SVW	Y	ENV	Y	2015-03-31

GEOPROCESSING METHOD

Table 85: Geoprocessing of Well Density Source Data

Topic	Query or Process
Well Density	All wells

Table 86: Geoprocessing to Create a Well Density Indicator Layer

Result	Source Layer	Target Layer	Action
Well Density per AOI polygon (ha/km^2)	Well Density	AOI polygon layer	Point Count as per Table 2

Current Water Demand for Hydraulic Fracturing (OGFracWater)

REPRESENTATION

Water demand for unconventional gas development is not uniform across northeast B.C. but varies according to geology. Water demand is a function of the hydraulic fracturing style necessary for development of a specific formation in specific area. This indicator layer addresses water demand by area as a function of geology and development style. It presents the average stimulation volume needed per well. Water sources for hydraulic fracturing include surface water, fresh groundwater, saline groundwater and recycled water. The source of water for hydraulic fracturing is not broken out on this layer.

DATA SOURCES

Table 87: Data Sources for Current Water Demand for Hydraulic Fracturing

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Well Completions	https://iris.bcogc.ca/download/drill_csv.zip File = compl_wo.csv	N	OGC	Y	2015-03-31
Well locations	WHSE_MINERAL_TENURE.OG_BOTTOM_HOLE_EVENT_SP	Y	OGC	Y	2015-03-31

GEOPROCESSING METHOD

Table 88: Geoprocessing of Current Water Demand for Hydraulic Fracturing Source Data

Topic	Query or Process
Well completion data with water volumes	Only well events (UWI) where stimulation fluid was used (i.e. Stimultn_vol>0). Stimulation volume was summed by UWI.

Table 89: Geoprocessing to Create a Current Water Demand for Hydraulic Fracturing Indicator Layer

Result	Source Layer	Target Layer	Action
Stimulation volume per well per AOI polygon (ha/km^2)	Stimulation volume per well	AOI polygon layer	Point Count as per Table 2

Future Disturbance Indicators

Future water demand is expected to be highest for unconventional gas development through hydraulic fracturing. Water demand for water flood operations and other petroleum development activities is not expected to be a major source of water demand in the future. Future demand related to mining is expected primarily from coal mining where water may be required for washing coal, slurries, dust maintenance and more. The agricultural sector may also demand water through irrigation. Irrigation practices are minimal at present, but are expected to increase according to climate change predictions for northeast B.C. of warmer temperatures and decreased snow in winter. The forest sector is not expected to place any significant demands on water quantity in the future.

Possible Future Water Demand for Hydraulic Fracturing (PotOGWater)

REPRESENTATION

Water demand for unconventional gas development is not uniform across northeast B.C. but varies according to geology. Water demand is a function of the hydraulic fracturing style necessary for development of a specific formation in specific area. This indicator layer, Potential Water Demand for Hydraulic Fracturing, addresses water demand by area as a function of geology and development style. It presents the average stimulation volume needed per well in a given pool where a pool represents both the region and the horizon at depth specifically being targeted.

The relative stimulation volumes currently needed across pools in northeastern B.C. is considered a proxy for future development needs. There has been rapid technological advancement in hydraulic fracturing. The style of hydraulic fracturing (e.g. high volume slickwater or energized foams) in a given pool is not expected to change very quickly. The water volume required by a select style of fracturing can be highly dynamic. For example, the stimulation volume of water per well for high volume slickwater fracturing has increased by ten-fold in the past seven years.

DATA SOURCES

Table 90: Data Sources for Possible Future Water Demand for Hydraulic Fracturing

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Oil and Gas Pools	WHSE_MINERAL_TENURE.OG_POOL_DESGNTN_AREA_PUB_SP	Y	OGC	Y	2015-03-31
Well completion data with water volumes	Well completion data File = compl_wo.csv	N	OGC	Y	2015-03-31
Well location by Unique Well identifier (UWI)	WHSE_MINERAL_TENURE.OG_BOTTOM_HOLE_EVENT_SP	Y	OGC	Y	2015-03-31

GEOPROCESSING METHOD

Table 91: Geoprocessing of Possible Future Water Demand for Hydraulic Fracturing Source Data

Topic	Query or Process
Well completion data with water volumes	Only well events (UWI) where stimulation fluid was used (i.e. Stimultn_vol>0). A pool identifier was created by concatenating Field Area, Formation and Pool Sequence. Stimulation volume was summed by UWI.
Oil and Gas Pools	A pool identifier was created by concatenating Field Area, Formation and Pool Sequence.
Well location by unique Well identifier	Well completion data table Joined to Location data by UWI.

Table 92: Geoprocessing to Create a Possible Future Water Demand for Hydraulic Fracturing Indicator Layer

Result	Source Layer	Target Layer	Action
Average stimulation volume per pool	Well completion data with water volumes	Oil and Gas Pools	Joined well point data to pool polygons. Pools assigned the average UWI stimulation volume per well.
Average stimulation volume per AOI polygon (m^3/km^2)	Average stimulation volume per pool	AOI polygon layer	Polygon Data as per Table 2

Possible Water Demand by Mining (Mine)

REPRESENTATION

Mining is primarily limited to coal operations in northeast B.C. The land area for active mines is represented by lease areas. Areas of future expansion are held by license. Mineral and placer-based mines are represented by licensed areas, if they exist. Potential future mining areas are not well captured under the current system. Claims represent a potential area much larger than that which may potentially be mined. Possible Water Demand by Mining therefore is limited mainly to coal leases and licenses. Mines use water for washing coal and equipment. Water is also used for dust control on roads.

DATA SOURCES

Table 93: Data Source for Possible Water Demand by Mining

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Mining Tenure	WHSE_MINERAL_TENURE.MTA_ACQUIRED_TENURE_SVW	Y	MEM	Y	2015-03-31

GEOPROCESSING METHOD

Table 94: Geoprocessing of Possible Water Demand by Mining Source Data

Topic	Query or Process
Mining Tenure	TENURE_SUB_TYPE_DESCRIPTION = Lease or License

Table 95: Geoprocessing to Create a Possible Water Demand by Mining Indicator Layer

Result	Source Layer	Target Layer	Action
Mining Tenure per AOI polygon (ha/km^2)	Mining Tenure	AOI polygon layer	Polygonal Area as per Table 2

Surface Water Restrictions (SWRestriction)

Occasionally a restriction notification is placed on water bodies to limit future water allocation decisions. A water allocation restriction is an indication that water demand has, at least temporarily, outpaced availability. A restriction may range from including minimum fish flow clauses in a water license, to suspending the issuance of any further licenses on a water body. Basins with more restrictions indicate stress or limitation on water resources.

REPRESENTATION

In areas of surface water shortage, restrictions can be placed on water bodies, either limiting or prohibiting further water extraction water license applicants. A water allocation restriction is an indication that water demand has, at least temporarily, outpaced availability. A restriction may range from including minimum fish flow clauses in a water license, to suspending the issuance of any further licenses on a water body. Basins with more restrictions indicate stress or limitation on water resources.

It is anticipated that there will be a greater future demand on groundwater as a result of surface water restrictions. Currently, restrictions are available in point form. There is a restriction lines layer that is generated on an annual basis using stream network base mapping. However, it isn't possible to represent all restrictions as stream network lines at this time.

DATA SOURCES

Table 96: Data Source for Surface Water Restrictions

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Surface Water Restrictions	WHSE_WATER_MANAGEMENT.WLS_WATER_RESTRICTION_LOC_SVW	Y	FLNRO	Y	2015-05-04

GEOPROCESSING METHOD

Table 97: Geoprocessing of Surface Water Restrictions Source Data

Topic	Query or Process
Surface Water Restrictions	All restrictions

Table 98: Geoprocessing to Create a Surface Water Restrictions Indicator Layer

Result	Source Layer	Target Layer	Action
Surface Water Restrictions per AOI polygon (ha/km^2)	Surface Water Restrictions	AOI polygon layer	Point Count as per Table 2

Layers Indicative of Human or Ecosystem Sensitivity

The stewardship of water resources for people and the environment is considered an important duty. This section is designed to flag basins where monitoring should be prioritized as a safeguarding feature. The indicator layers prioritize areas where it is most important that water condition and trend be tracked.

At this time, it is not feasible to include indicator layers for environmental sensitivity. In future, there may be sufficient data to include layers associated with groundwater-surface water interaction or drought associated with lowering of the groundwater table.

Population (Pop)

REPRESENTATION

Water of sufficient quantity and quality are a necessity of life and a requirement for regions of human habitation. There are two ways to capture domestic water needs: 1) by licensed volume and 2) by population concentration. Since volume data from government issued water licences does not capture First Nations water needs, the population data is used for this assessment.

DATA SOURCES

Table 99: Data Sources for Population

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Population Boundary	Population Boundary data	N	Statistics Canada	Y	
Population	Population data	N	Statistics Canada	Y	

GEOPROCESSING METHOD

Table 100: Geoprocessing of Population Source Data

Topic	Query or Process
Population by dissemination block area	Population boundary and population were joined BC dissemination blocks were selected and exported to a new feature class which was then reprojected from geographic to BC Albers. A new field was added "DisseminationBlock_AREA" and calculated to equal the SHAPE_AREA (using area-weighting, the new field can subsequently be used for estimating population in a dissemination block which has been split by intersection with a watershed/basin).

Table 101: Geoprocessing to Create a Population Indicator Layer

Result	Source Layer	Target Layer	Action
Population per AOI polygon (count/km^2)	Population by dissemination block area	AOI polygon layer	Polygonal Data as per Table 2

GROUNDWATER QUALITY

A disturbance-sensitivity based approach to enhanced groundwater monitoring is challenging. Groundwater occurs almost everywhere beneath the land surface but there is very limited information on whether the groundwater is part of an aquifer and the water quality within that aquifer. Substantially more groundwater mapping is required. This section focuses on assessing the relative importance of monitoring groundwater quality where it is potentially affected by current and future industrially related disturbance and in areas where groundwater quality is important for human and ecosystem needs. The indicator layers used to determine enhanced monitoring needs for groundwater quality are listed below.

Table 102: Indicator Layers for Groundwater Quality Monitoring

Topic	Indicator Layer
Current Disturbance	Disturbance from Agriculture
Current Disturbance	Disturbance from Forest Clear Cutting
Current Disturbance	Disturbance from Urban
Current Disturbance	Disturbance from Oil and Gas Industry Related Infrastructure
Current Disturbance	Disturbance from Linear Features (Roads, Railway Lines and Transmission Lines)
Current Disturbance	Disturbance from Mining
Future Disturbance	Potential Disturbance from Unconventional Gas Development
Future Disturbance	Potential Disturbance from Mining
Sensitivity	DRASTIC model of Groundwater Vulnerability

Current Disturbance Indicator Layers

Disturbance from Agriculture (Ag)

REPRESENTATION

Disturbance from agriculture can affect water quality through drainage of pesticides, herbicides and nutrients into nearby freshwater.

DATA SOURCES

Table 103: Data Source for Disturbance from Agriculture

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Agriculture	WHSE_BASEMAPPING.BTM_PRESENT_LAND_USE_V1_SVW	Y	FLNRO	Y	1997-07-01

GEOPROCESSING METHOD

Table 104: Geoprocessing of Disturbance from Agriculture Source Data

Topic	Query or Process
Agriculture	PRESENT_LAND_USE_LABEL = Agriculture (Land based agricultural activities undifferentiated as to crop (i.e. land is used as the producing medium) and Residential Agriculture Mixtures (Areas where agriculture activities are intermixed with residential and other buildings with a density of between 2 and 0.2 hectares).

Table 105: Geoprocessing to Create a Disturbance from Agriculture Indicator Layer

Result	Source Layer	Target Layer	Action
Agriculture per AOI polygon (ha/km^2)	Agriculture	AOI polygon layer	Polygonal Area as per Table 2

Disturbance from Forest Clear Cutting (ForCuts)

REPRESENTATION

Areas denuded of forest cover can shed sediment via overland flow into nearby freshwater Disturbance from agriculture can affect water quality through drainage of pesticides, herbicides and nutrients into nearby freshwater.

DATA SOURCES

Table 106: Data Sources for Disturbance from Forest Clear Cutting

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Consolidated cut blocks	Consolidated_Cutblocks_2013.gdb	N	FLNRO	Y	
Consolidated cut blocks	Consolidated_Cutblocks_2012.gdb	N	FLNRO	Y	
Harvest Authority	WHSE_FOREST_TENURE.FTEN_HARVEST_AUTH_POLY_SVW	Y	FLNRO	Y	2015-03-31

The process for capturing Consolidated Cut blocks changed for the 2013 model. It is speculated that wildfire data may have been dropped from the 2013 data.

Comparison of Consolidated Cut blocks for 2012 and 2013

Consolidated Cut block data set	Area
Common polygons (2012 and 2013)	242,055
2013 only	23,598 (includes some new 2013 cut blocks)

2012 only	43,584
Total	309,237

GEOPROCESSING METHOD

Table 107: Geoprocessing of Disturbance from Forest Clear Cutting Source Data

Topic	Query or Process
Consolidated cut blocks	None
Harvest Authority	Not used FTEN Harvest Authority contains information from occupant license to cut authorizations from tenures such as wind power; coal tenures; that are not documented in the consolidated cut blocks. Although geometry exists for these tenures, the current status of the tenures is unknown.

Table 108: Geoprocessing to Create a Disturbance from Forest Clear Cutting Indicator Layer

Result	Source Layer	Target Layer	Action
Union of Consolidated Cut blocks	Consolidated cut blocks 2012	Consolidated cut blocks 2013	Union
If one wanted to use Harvest Authority data	Harvest Authority	Union of Consolidated Cut blocks	Intersection
If one wanted to use Harvest Authority data (continued)	Intersection of Harvest Authority and Union of Consolidated cut blocks	Union of Consolidated Cut blocks	Union
Forestry Cut blocks per AOI polygon (ha/km^2)	Union of Consolidated Cut blocks	AOI polygon layer	Polygonal Area as per Table 2

Disturbance from Urban (Urban)

REPRESENTATION

Urban data is taken from a land use analysis of mostly Landsat 5 image mosaics. It is spatially accurate to 250m.

DATA SOURCES

Table 109: Data Source for Urban Disturbance

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Urban	WHSE_BASEMAPPING.BTM_PRESENT_LAND_USE_V1_SVW	Y	FLNRO	Y	1997-07-01

GEOPROCESSING METHOD

Table 110: Geoprocessing of Urban Disturbance Source Data

Topic	Query or Process
Urban	PRESENT_LAND_USE_LABEL = Urban (all compact settlements including built up areas of cities, towns and villages as well as units away from settlements such as manufacturing plants, rail yards and military camps. In most cases residential use will predominate in these areas. Open space which forms an integral part of the urban agglomeration, e.g. parks, golf courses, etc. are included as urban)

Table 111: Geoprocessing to Create an Urban Disturbance Indicator Layer

Result	Source Layer	Target Layer	Action
Urban per AOI polygon (ha/km^2)	Urban	AOI polygon layer	Polygonal Area as per Table 2

Disturbance from Oil and Gas Industry Related Infrastructure (OGinfr)

REPRESENTATION

Oil and Gas infrastructure data is a combination of pipelines, well pads, facilities and other ancillary activity such as borrow pits, decking sites and temporary disturbances. Data comes from a variety of sources in a variety of forms. If line data is provided, the line is buffered along its length to provide a representative area value.

DATA SOURCES

Table 112: Data Sources for Oil and Gas Infrastructure Related Disturbance

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
CROWN TENURES	WHSE_TANTALIS.TA_CROWN_TENURES_SVW	Y	FLNRO	Y	2015-03-31
TANTALIS – SURVEY PARCELS	WHSE_TANTALIS.TA_SURVEYED_ROW_PARCELS_SVW	Y	FLNRO	Y	2015-03-31
OG Pipeline RW	WHSE_MINERAL_TENURE_OG_PIPELINE_RW_PUB_SP	Y	OGC	Y	2015-03-31
OG Well Sites	WHSE_MINERAL_TENURE_OG_WELL_SITES_PUB_SP	Y	OGC	Y	2015-03-31
OG Facilities	WHSE_MINERAL_TENURE_OG_FACILITY_SITES_PUB_SP	Y	OGC	Y	2015-03-31
OG Ancillary	WHSE_MINERAL_TENURE_OG_ANCILLARY_OTHER_APPS_PUB_SP	Y	OGC	Y	2015-03-31
OG Surface Hole	WHSE_MINERAL_TENURE.OG_SURFACE_HOLE_STATUS_SP	Y	OGC	Y	2015-03-31
TRIM Pipelines	WHSE_BASEMAPPING.TRIM_CULTURAL_LINES	Y	FLNRO	N	

GEOPROCESSING METHOD

Table 113: Geoprocessing of Oil and Gas Infrastructure Related Disturbance Source Data

Topic	Query or Process
CROWN TENURES	TENURE_PURPOSE = UTILITY AND TENURE_SUBPURPOSE = GAS AND OIL PIPELINE OR TENURE_PURPOSE = ENERGY PRODUCTION And proposed tenures were removed from the analysis by two additional query conditions: TENURE_TYPE <> 'RESERVE/NOTATION' and TENURE_STAGE <> 'APPLICATION'
TANTALIS – SURVEY PARCELS	FCODE = FA91300120 or FCODE = FA91400120
OG Pipeline RW	Pipelines under application (not constructed) were removed from the analysis by a query: APPLICATION_STATUS <> 'APPROV'
OG Well Sites	All well site polygons
OG Facilities	Facilities under application (not constructed) were removed from the analysis by a query: APPLICATION_STATUS <> 'APPROV'
OG Ancillary	ANCILLARY_OTHER_APP_TYPE not equal to “ROAD” or “INV”
OG Surface Hole	Wells never constructed were removed from the analysis using the WELL_ACTIVITY field to query out wells cancelled before being constructed ('CANC') and wells authorized but not constructed ('WAG') Point data. Data may be duplicated in Tantalis and OGC datasets; buffer 1.44 hectares (60 metres buffer radius); In ArcGIS, use the Feature Envelope To Polygon tool to convert the circle buffer to a square buffer.
Trim Pipelines	FCODE = EA21400000; buffer 10 metres

Table 114: Geoprocessing to Create an Oil and Gas Infrastructure Related Disturbance Indicator Layer

Result	Source Layer	Target Layer	Action
Oil and Gas infrastructure	CROWN TENURES TANTALIS – SURVEY PARCELS OG Pipeline RW OG Well Sites OG Facilities OG Ancillary OG Surface Hole TRIM Pipelines	New layer (Oil and Gas Infrastructure)	Merge; dissolve created on outer boundaries
Oil and Gas infrastructure per AOI polygon (ha/km^2)	Oil and Gas infrastructure	AOI polygon layer	Polygonal Area as per Table 2

Disturbance from Linear Features (Linear)

Disturbance associated with linear features is calculated as an amalgamation of disturbance from roads, railway lines and transmission lines. Data comes from a variety of sources in a variety of forms. If line data is provided, the line is buffered along its length to provide a representative area value.

Disturbance from Linear Features - Roads

DATA SOURCES

Table 115: Data Sources for Road Disturbance

Topic	Source Location (with hyperlink where possible)	BCGW	Data Provider	Public Data	Data Last Modified
Digital Road Atlas (DRA)	WHSE_BASEMAPPING.DRA_DGTL_ROAD_ATLAS_MPAR_SP	Y	FLNRO	Y	2014-12-10
Forest Service Roads (FTEN)	WHSE_FOREST_TENURE.FTEN_ROAD_SECTION_LINES_SVW	Y	FLNRO	Y	2015-03-31
Petroleum Development Roads (PDR)	WHSE_MINERAL_TENURE.OG_PETRLM_DEV_ROADS_PUB_SP	Y	OGC	Y	2015-03-31
Petroleum Development Roads Pre06 (PDR)	WHSE_MINERAL_TENURE_OG_PETRLM_DEV_RDS_PRE06_PUB_SP	Y	OGC	Y	2010-03-25
Petroleum Access Roads (PDR)	WHSE_MINERAL_TENURE_OG_PETRLM_ACCESS_ROADS_PUB_SP	Y	OGC	Y	2015-03-31
Trails (TR)	WHSE_FOREST_TENURE.FTEN_RECREATION_LINES_SVW	Y	FLNRO	Y	2015-03-31

Note: Currently there is a provincial project to produce a consolidated road network product, the Integrated Transportation Network (ITN), which would replace the multiple sources used in this initial analysis.

GEOPROCESSING METHOD

Table 116: Geoprocessing of Road Disturbance Source Data

Topic	Query or Process
Digital Road Atlas (DRA)	Road Class = Highway; buffer 15 metres Road Surface = Paved; buffer 15 metres Road Surface = Loose; buffer 10 metres Road Surface = Rough; buffer 7.5 metres Road Surface = Overgrown; buffer 7.5 metres Road Surface = Decomissioned; buffer 7.5 metres Road Surface = Unknown; buffer 7.5 metres
Forest Service Roads (FTEN)	FILE_TYPE_DESCRIPTION = FSR; buffer 10 metres FILE_TYPE_DESCRIPTION = RP; buffer 7.5 metres
Petroleum Development Roads	PETRLM_DEVELOPMENT_ROAD_TYPE = High Grade; buffer 10 metres PETRLM_DEVELOPMENT_ROAD_TYPE = Low Grade; buffer 10 metres PETRLM_DEVELOPMENT_ROAD_TYPE = Winter; buffer 3.5 metres PETRLM_DEVELOPMENT_ROAD_TYPE = blank; buffer 3.5 metres
Petroleum Development Roads Pre06	PETRLM_DEVELOPMENT_ROAD_TYPE = High Grade; buffer 10 metres PETRLM_DEVELOPMENT_ROAD_TYPE = Low Grade; buffer 10 metres PETRLM_DEVELOPMENT_ROAD_TYPE = Winter; buffer 3.5 metres PETRLM_DEVELOPMENT_ROAD_TYPE = blank; buffer 3.5 metres
Petroleum Access Roads	PETRLM_ACCESS_ROAD_TYPE = High Grade; buffer 10 metres PETRLM_ACCESS_ROAD_TYPE = Low Grade; buffer 10 metres PETRLM_ACCESS_ROAD_TYPE = Winter; buffer 3.5 metres PETRLM_ACCESS_ROAD_TYPE = blank; buffer 3.5 metres

Topic	Query or Process
Trails (TR)	Right of Way not null; buffer ½ of RIGHT_OF_WAY attribute value Right of Way null; buffer 2.5 metres

Table 117: Geoprocessing to Create a Road Disturbance Indicator Layer

Result	Source Layer	Target Layer	Action
Consolidated Roads	Digital Road Atlas (DRA) Forest Service Roads (FTEN) Petroleum Development Roads Petroleum Development Roads Pre06 Petroleum Access Roads Trails (TR	New layer (Consolidated Roads)	Merge; dissolve created on outer boundaries
Consolidated Roads per AOI polygon (ha/km^2)	Consolidated Roads	AOI polygon layer	Polygonal Area as per Table 2

Disturbance from Linear Features – Railway Lines

DATA SOURCES

Table 118: Data Sources for Railway Line Disturbance

Topic	Source Location (with hyperlink where possible)	BCGW	Data Provider	Public Data	Data Last Modified
Trim Railways	WHSE_BASEMAPPING.TRIM_TRANSPORTATION_LINES	Y	FLNRO	N	2015-03-31
Federal Railways	National Railway Network (NRWN) - BC, British Columbia	N	NRCan	Y	2013-11-03
Tantalis Survey Parcels	WHSE_TANTALIS.TA_SURVEY_PARCELS_SVW	Y	FLNRO	Y	2015-03-31
Tantalis Transportation	WHSE_TANTALIS_TA_TRANSPORTATION_SVW	Y	FLNRO	Y	2014-12-11

Trim railway features are not available to the Public. This data was added to ensure as complete dataset as possible.

GEOPROCESSING METHOD

Table 119: Geoprocessing of Railway Line Disturbance Source Data

Topic	Query or Process
Trim Railways	DE22850000, DE22850110, DE22850120, DE22900000, DE22950000, DE22950001, DE22950120, DF28850000, F28850000; buffer 17.5 metres
Federal Railways	buffer 17.5 metres
Tantalis Survey Parcels	Feature Code = FA91200130

Topic	Query or Process
Tantalis Transportation	Feature Code = FA91200120

Table 120: Geoprocessing to Create a Railway Line Disturbance Indicator Layer

Result	Source Layer	Target Layer	Action
Merged Transportation and Survey Parcels	Tantalis Survey Parcels Tantalis Transportation	New layer Transportation and Survey Parcels	Merge
Consolidated Railway lines	Merged Transportation and Survey Parcels TRIM Railways Federal Railways	New layer (Consolidated Railways)	In areas where the merged Transportation and Survey Parcels layer does not have any polygons, TRIM Railways and National Railway Network were buffered and added. Then a dissolve to create the outer boundaries of railways.
Railway Lines per AOI polygon (ha/km^2)	Consolidated Railway lines	AOI polygon layer	Polygonal Area as per Table 2

Disturbance from Linear Features – Transmission Lines

DATA SOURCES

Table 121: Data Sources for Transmission Line Disturbance

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
CROWN TENURES	WHSE_TANTALIS.TA_CROWN_TENURES_SVW	Y	FLNRO	Y	2015-03-31
TANTALIS- SURVEY PARCELS	WHSE_TANTALIS.TA_SURVEYED_ROW_PARCELS_SVW	Y	FLNRO	Y	2015-03-31
BC Hydro Transmission	Circuit.shp	N	BC Hydro	Y	

GEOPROCESSING METHOD

Table 122: Geoprocessing of Transmission Line Disturbance Source Data

Topic	Query or Process
CROWN TENURES	Subpurpose = ELECTRIC POWER LINE
TANTALIS- SURVEY PARCELS	FEATURE_CODE = FA91400110
BC Hydro Transmission	Buffer 9.15 metres

Table 123: Geoprocessing to Create a Transmission Line Disturbance Indicator Layer

Result	Source Layer	Target Layer	Action
Merged Survey Parcels and Crown Tenure	Tantalis Survey parcels Crown Tenures	Merged Survey Parcels and Crown Tenure layer	Merge
Consolidated Transmission lines	Merged Survey Parcels and Crown Tenure BC Hydro Transmission	New layer (Consolidated transmission lines)	In areas where the Merged Survey Parcels and Crown Tenure layer does not have any polygons, BC Hydro Transmission lines were buffered and added. Then a dissolve to create the outer boundaries of transmission lines.
Transmission Lines per AOI polygon (ha/km^2)	Consolidated Transmission Lines	AOI polygon layer	Polygonal Area as per Table 2

Disturbance from Mining (Mining)

REPRESENTATION

Mining is primarily limited to coal operations in northeast B.C. The land area for active mines is represented by lease areas.

DATA SOURCES

Table 124: Data Source for Disturbance from Mining

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Mining Tenure	WHSE_MINERAL_TENURE.MTA_ACQUIRED_TENURE_SVW	Y	MEM	Y	2015-03-31

GEOPROCESSING METHOD

Table 125: Geoprocessing of Disturbance from Mining Source Data

Topic	Query or Process
Mining Tenure	TENURE_SUB_TYPE_DESCRIPTION = Lease

Table 126: Geoprocessing to Create a Disturbance from Mining Indicator Layer

Result	Source Layer	Target Layer	Action
Mining Tenure per AOI polygon (ha/km^2)	Mining Tenure	AOI polygon layer	Polygonal Area as per Table 2

Future Disturbance Indicator Layers

Future water quality expected to be most impacted by disturbance from the following industries: unconventional gas development, forestry and mining.

Potential Disturbance from Unconventional Gas Development (OGPlays)

REPRESENTATION

In this analysis, potential future oil and gas development is limited to unconventional gas plays because since 2005 a strongly increasing to dominant number of new well licenses is related to unconventional development. There are four large areas considered prospective for unconventional gas development on the basis of geology: the Montney Play Trend, the Horn River Basin, the Cordova Embayment and the Liard Basin. For future disturbance, land physically above any potential unconventional play is possibly subject to water quality impact from development activities.

DATA SOURCES

Table 127: Data Source for Potential Disturbance from Unconventional Gas Development

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Unconventional Gas Plays	WHSE_MINERAL_TENURE.OG_UNCONVENTNL_PLAY_TRENDS_SP	Y	OGC	Y	2010-03-25

GEOPROCESSING METHOD

Table 128: Geoprocessing of Potential Disturbance from Unconventional Gas Development Source Data

Topic	Query or Process
Unconventional Gas Plays	All four play trends (Montney, Horn River, Cordova, Liard)

Table 129: Geoprocessing to Create a Potential Disturbance from Unconventional Gas Development Indicator Layer

Result	Source Layer	Target Layer	Action
Unconventional Gas Development per AOI polygon (ha/km^2)	Unconventional Gas Plays	AOI polygon layer	Polygonal Area as per Table 2

Potential Disturbance from Mining (Mine)

REPRESENTATION

Mining is primarily limited to coal operations in northeast B.C. The land area for active mines is represented by lease areas. Areas of future expansion are held by license. Mineral and placer-based mines are represented by licensed areas, if they exist. Potential future mining areas are not well captured under the current system. Claims represent a potential area much larger than that which may potentially be mined. Possible impact to water quality by mining therefore is limited mainly to coal leases and licenses.

DATA SOURCES

Table 130: Data Source for Potential Disturbance from Mining

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
Mining Tenure	WHSE_MINERAL_TENURE.MTA_ACQUIRED_TENURE_SVW	Y	MEM	Y	2015-03-31

GEOPROCESSING METHOD

Table 131: Geoprocessing of Potential Disturbance from Mining Source Data

Topic	Query or Process
Mining Tenure	TENURE_SUB_TYPE_DESCRIPTION = Lease or License

Table 132: Geoprocessing to Create a Potential Disturbance from Mining Indicator Layer

Result	Source Layer	Target Layer	Action
Mining Tenure per AOI polygon (ha/km^2)	Mining Tenure	AOI polygon layer	Polygonal Area as per Table 2

Layers Indicative of Human or Ecosystem Sensitivity

The stewardship of water resources for people and the environment is considered an important duty. This section is designed to flag map sheets where monitoring should be prioritized as a safeguarding feature. The indicator layers prioritize areas where it is most important that water condition and trend be tracked.

Initially, the density of licensed springs was used as a proxy for the depth to groundwater. Recently a DRASTIC model for northeast B.C. has been completed. DRASTIC models provide an indication of the groundwater susceptibility. In future, there may be sufficient data to include layers associated with groundwater-surface water interaction or drought associated with lowering of the groundwater table.

DRASTIC model of Groundwater Vulnerability (DRASTIC)

REPRESENTATION

DRASTIC models provide an indication of the groundwater susceptibility to contamination. The DRASTIC model incorporates spatial data on depth to groundwater, hydraulic conductivity, recharge and more. A DRASTIC model was recently completed by Simon Fraser University and is publically available.

DATA SOURCES

Table 133: Data Source for Groundwater Vulnerability

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified

Topic	Source Location	BCGW	Data Provider	Public Data	Data Last Modified
DRASTIC model	Shannon Holding sholding@sfu.ca to be published later in 2015	N	Simon Fraser University	Y	2015-05-29

GEOPROCESSING METHOD

Table 134: Geoprocessing of Groundwater Vulnerability Source Data

Topic	Query or Process
DRASTIC model	Convert Tiff raster cells to polygons

Table 135: Geoprocessing to Create a Groundwater Vulnerability Indicator Layer

Result	Source Layer	Target Layer	Action
Average DRASTIC Index per AOI polygon (ha/km^2)	DRASTIC model	AOI polygon layer	Polygonal Data as per Table 2