8.0 HYDROGEOLOGY OF LETHBRIDGE, WINTER BROOK & MUSGRAVETOWN ADAS

8.1 General Description of Area

8.1.1 Location & Extent

The Lethbridge, Winter Brook and Musgravetown ADAs are located in close proximity to each other at the head of Bonavista Bay in eastern Newfoundland. The Lethridge ADA is the largest of the three ADAs, covering an area of approximately 17,246 hectares, and extends across the Bonavista Peninsula from Goose Bay, Bonavista Bay in the north to Smith Sound, Trinity Bay in the south. The Winter Brook ADA is located approximately 5 km northeast of the Lethbridge ADA, covering an area of approximately 477 hectares at the southwest end of Northwest Arm, Bonavista Bay. The Musgravetown ADA is located approximately 3 km north of the Lethbridge ADA, and comprises two adjacent zones (Zone I and Zone II) covering a combined area of approximately 1,923 hectares along the northwest side of Goose Bay, Bonavista Bay. The boundaries of the Lethbridge, Winter Brook and Musgravetown ADAs are shown on Drawing No. 1034406-8-1 in Appendix 8a.

The Lethbridge ADA overlaps the communities of Lethbridge, Morley's Siding, and George's Brook. The Musgravetown ADA overlaps the community of Canning's Cove. No communities are present within the boundaries of the Winter Brook ADA.

The main access to the Lethbridge, Winter Brook and Musgravetown ADAs is provided by Provincial Highway Route 230 (Bonavista Peninsula Highway), which leads northeast from the Trans Canada Highway near the community of Clarenville to the community of Bonavista at the tip of the peninsula. Near the community of Lethbridge, secondary Highway Routes 233 (Cloude Sound Road) and 234 (Winter Brook Road) branch off Highway Route 230, and provide access to the Musgravetown ADA and Winter Brook ADA, respectively. In addition, various graveled roads and ATV trails leading from Highway Routes 230, 233 and 234 also provide access to some areas within the ADAs.

8.1.2 Physiography, Topography & Drainage

The Lethbridge, Winter Brook and Musgravetown ADAs are located within a low lying area that extends across the Bonavista Peninsula and forms the southeastern extent of the physiographic region referred to as the Northeast Trough. The upland regions of the Central Plateau and Eastern Upland are located east and west of the ADAs, respectively. Elevations in the low lying area underlying the ADAs are generally below 100 m above sea level, rising to higher elevations in the upland regions east and west of the ADAs. Maximum elevations of up to 330 m above sea level are present in the Blue Hills area, located approximately 6 km west of the Lethbridge ADA. In addition, a local topographic divide immediately south of Gull Pond separates surface drainage within the Lethbridge ADA between Southwest Brook in the north and Ryders Brook in the south. Coastal areas in the vicinity of the ADAs are irregular and incised by long, narrow, steep-sloped fjord valleys, including Clode Sound, Goose Bay, Sweet Bay and Southern Bay on the north coast, and Smith Sound and Northwest Arm on the south coast

The Lethbridge ADA encompasses the Southwest Brook drainage system, as well as the majority of the Ryders Brook drainage system. The Winter Brook ADA borders the lower course of Winter Brook along its southern boundary and the headwaters of Southeast Brook along its northern boundary. Several small stream and pond systems are present in the vicinity of the Musgravetown ADA, including the Northwest Pond system, which is located within Musgravetown ADA – Zone I and drains directly into Goose Bay. Small ponds are also common associated with other stream drainage systems in the area. The headwaters of the stream and pond systems in the area originate in the upland regions east and west of the ADAs. No Public Protected Water Supply Areas (PPWSA) are present within the drainage catchment areas of the Lethbridge, Winter Brook and Musgravetown ADAs. However, two unnamed ponds located immediately north of Musgravetown ADA – Zone II are designated as potential future water supplies.

8.1.3 Climate, Vegetation & Agricultural Land Use

The Lethbridge, Winter Brook and Musgravetown ADAs are located along the eastern edge of the Northshore ecoregion, a long narrow zone about 20 km wide along the northeastern coast of Newfoundland. Within this zone, summers are relatively warmer and drier than other coastal areas in the province, and soil moisture deficiencies may occur. The vegetation season is shorter and cooler than in central Newfoundland, but the frost-free period is several weeks longer. Climate data obtained from Environment Canada's Lethbridge monitoring station dating back to 1971 indicates a monthly mean temperature in the area of 4.7°C, ranging from a high of 16.3°C in July to a low of -6.5°C in January. Average annual precipitation in the area is 1,212 mm, of which 82% falls as rainfall and 18% as snowfall. October is typically the wettest month, and August is typically the driest month (Environment Canada, 2008). In the ADAs, there are an average of 1,321 growing degree days (base temperature 5^{o}C) for the year and 1,204 growing degree days for the vegetative season (i.e., May to September).

Vegetation in the vicinity of the Lethbridge, Winter Brook and Musgravetown ADAs consists of sparsely forested heath and moss barrens broken by large areas of patterned fens and sloping bogs. Patches of well developed Black Spruce and Balsam Fir forest occur primarily in protected valleys and on some hilltops and steep slopes. Based on agricultural land use information provided by the NL Department of Natural Resources Agrifoods Division, approximately 608 hectares (i.e., 4% of the total landmass of the ADA) is currently utilized for agriculture in the Lethbridge ADA; while approximately 216 hectares (i.e., 11% of the total landmass of the ADA) is currently utilized for agriculture in the Musgravetown ADA. Forage, pasture and vegetable crop land represent the most significant proportions of agricultural land use in these two ADAs. Based on agricultural land use information provided by the NL Department of Natural Resources Agrifoods Division, no significant commercial or non-commercial agricultural activities are currently carried out in the Winter Brook ADA, but rather the ADA is designated for future planning purposes.

8.2 Geology

8.2.1 Surficial Geology

The surficial geology of the Lethbridge, Winter Brook and Musgravetown ADAs is summarized in Drawing No. 1034406-8-2 in Appendix 8a, and is based on most recent 1:50,000 scale mapping of the area by Batterson and Taylor (2003b,c, and d), as well as descriptions of surficial geology provided in

Heringa and Woodrow (1991) and Batterson and Taylor (2001). For the purposes of this study, surficial geological units on existing maps have been simplified into four (4) groups, including exposed bedrock, areas of bog, areas of till and areas of sand and gravel.

Till deposits are present throughout the ADAs occurring as both thin discontinuous veneer (typically less than 2 m thick), and more extensive moraine deposits with local thicknesses up to 20 m. The composition and texture of the veneer and moraine tills that underlie the ADAs are variable and bedrock-controlled, mainly comprising a stony silty loam to loamy sand derived from the underlying sedimentary and igneous rocks. The veneer and moraine tills are locally eroded and dissected, particularly along stream and river channels. In addition, areas of lineated till are locally present within the Lethbridge ADA that are associated with crag and tail and flute features. Within the ADAs, sand and gravel deposits of glacial outwash and fluvial origin are limited and generally confined to stream and river valleys, with the most significant occurrences of these deposits present along George's Brook, Ryder's Brook and Southwest Brook. Sand and gravel units shown in Drawing No. 1034406-8-2 in Appendix 8a also include un-subdivided marine terraces that contain various silt and clay deposits in addition to sands and gravels and occur locally in coastal areas in the vicinity of the ADAs. Along with glacial units, extensive deposits of organic and peaty soils are common throughout the ADA, overlying either till or bedrock. Numerous ridges and knobs of bedrock outcrop are exposed within the till and various other surficial deposits that underlie the ADA, and typically occur as areas of high ground or coastal cliffs. Bedrock outcrops may be partially or fully concealed by thin mat vegetation and sparse forest. However, where exposed bedrock outcrops are commonly streamlined and display glacial striations. Streamlined glacial features in the area indicate eastward-directed flow in the central portion of the peninsula underlying the Lethbridge ADA, and northeastward-directed flow in the northern portion of the peninsula underlying the Winter Brook and Musgravetown ADAs. Available well logs indicate an average overburden thickness in the Lethbridge, Winter Brook and Musgravetown ADAs and surrounding area of approximately 7 m.

8.2.2 Bedrock & Structural Geology

The bedrock geology of the Lethbridge, Winter Brook and Musgravetown ADAs is summarized in Drawing No. 1034406-8-3 in Appendix 8a, and is based on the regional 1:1,000,000 scale compilation mapping by Colman-Sadd, *et al.*, (1990), as well as descriptions of bedrock geology provided in O'Brien and King (2005).

The Lethbridge, Winter Brook and Musgravetown ADAs lie within the Avalon tectonostratigraphic zone and are underlain by late Precambrian to Cambrian sedimentary and volcanic rocks. The oldest rocks in the area occur along the western boundary of the Lethbridge ADA, and comprise bimodal submarine to subaerial volcanic rocks, as well as minor volcaniclastic and sedimentary rocks of the Love Cove Group. In the eastern portion of the Lethbridge ADA and within the Winter Brook ADA, the Love Cove Group is overlain by the Conception Group, a marine sequence of dominantly green to grey fine-grained siliceous sedimentary rocks, as well as minor volcaniclastic rocks. In the northern portion of the Lethbridge ADA, as well as within the Musgravetown ADA, the Conception Group is unconformably overlain by the Musgravetown Group, which comprises a shoaling-upwards sequence of marine to terrestrial bimodal volcanic and sedimentary rocks. Within the Lethbridge ADA, the Musgravetown Group sequence is disconformably overlain by younger Cambrian sedimentary rocks comprising red and green carbonate-bearing mudstones (Adeytown Group) overlain by dark grey to black shale,

siltstone and sandstone (Harcourt Group). Along the western boundary of the Lethbridge ADA, Devonian granites intrude the Lower Cove Group.

The Late Precambrian and Cambrian volcanic and sedimentary rocks that underlie the ADAs have undergone regional deformation attributed to Devonian Acadian orogenesis, which produced large-scale, open to tight isoclinals folds with an associated steep to vertical northeast trending axial planar cleavage. In addition, normal and thrust faulting are common throughout the area, the most significant of which is the Come by Chance Fault, which extends north - south across the peninsula and separates volcanic rocks of the Lower Cove Group from younger marine sedimentary rocks of the Conception Group. In addition, various joint sets and fracture zones are present within rocks underlying the ADA related to deformation.

8.3 Hydrogeology

8.3.1 Hydrostratigraphy

The groundwater potential of the various geological units within the Lethbridge, Winter Brook and Musgravetown ADAs was assessed utilizing available records for water wells completed within each unit obtained from the NLDEC-Water Resources Management Division Drilled Water Well Database for wells drilled between 1950 and March, 2008. The data provided in the well records are organized by community and includes information on the well depth and yield, well casing depth and diameter, depths to water bearing zone(s), plus data on the quality and use of the water and the driller's description of the depth and lithology of the overburden and bedrock units encountered.

A total of 340 drilled bedrock wells from seven (7) communities in the ADAs and surrounding area had adequate well data to evaluate the groundwater potential of various bedrock strata in the ADA. No drilled overburden well records were available with sufficient data to characterize overburden materials within the ADAs, and alternatively well data from similar materials in other ADAs were used to characterize the groundwater potential of these materials. Since lithologic information provided in the well records was of insufficient detail to define the bedrock encountered in each individual drilled well, the wells were assigned to their respective geologic units based on the community in which the wells were located and the corresponding underlying geologic unit, as shown on the bedrock geology maps provided in Drawing Nos. 1034406-8-3 in Appendix 8a.

The groundwater potential of each geological unit was quantified by assessing the reported well yields and depths from the records of wells completed within each unit. Reported yields for drilled wells in the Lethbridge, Winter Brook and Musgravetown ADAs and surrounding areas is based on airlift testing carried out by the driller at the time of well installation to obtain a rough estimate of well capacity, and does not necessarily represent the short or long term safe yield of the well, or the groundwater yield characteristics of the corresponding aquifer. To accurately determine such values, aquifer testing, including step drawdown and constant rate pump testing must be conducted, ideally with monitoring of groundwater levels in nearby observation wells. No aquifer testing has been carried out on any of the drilled wells in the ADAs and surrounding areas. Therefore, in the absence of this data, the groundwater potential of the various geological strata in the Lethbridge, Winter Brook and Musgravetown ADAs is defined based on the estimated well yields obtained from the driller's records.

8.3.1.1 Surficial Hydrostratigraphic Units

The surficial deposits within the Lethbridge, Winter Brook and Musgravetown ADAs have been subdivided into two broad hydrostratigraphic units, including one comprised of till deposits, and the other predominantly of sands and gravels. The yield and depth characteristics of these units are summarized on Table 8.1. No water well information was available for the till and sand and gravel deposits present in the ADAs. Therefore groundwater potential within these units was inferred based on well records for similar overburden material in the St. John's and Terra Nova ADAs, respectively.

Till Deposits

The till deposits form both thin veneer and more extensive moraine deposits over much of the ADAs and comprises a stony silty loam to loamy sand. There are no documented data on their groundwater potential in the Lethbridge, Winter Brook and Musgravetown ADAs. However, based on records of water wells within similar till material in the St. John's ADA, the range of yields from wells within the till can be expected to vary from 10 to 70 L/min at depths of 9.5 to 35 m. The average yield is estimated to be approximately 40 L/min at 21 m depth. However, median yield and depth estimates of 34 L/min at 20 m depth are more likely representative of the typical groundwater potential of this unit.

Sand and Gravel Deposits

Sand and gravel deposits of glacial outwash and fluvial origin occur sparingly within the ADAs, and are generally confined to stream and river valleys, with the most significant occurrences of these deposits are present along George's Brook, Ryder's Brook and Southwest Brook in the Lethbridge ADA. Marine-derived sand and gravel units also occur locally along coastal areas of the ADAs. These deposits are potentially significant groundwater aquifers but there are no documented data on their groundwater potential in the Lethbridge, Winter Brook and Musgravetown ADAs. Based on records of water wells within similar sand and gravel deposits in the Terra Nova ADA, the range of yields from wells within the sand and gravel material can be expected to vary from 2 to 225 L/min at depths of 8 to 45 m. The average yield is estimated to be approximately 67 L/min at 21 m depth. However, median yield and depth estimates of 48 L/min at 18 m depth are more likely representative of the typical groundwater potential of this unit.

Table 8.1 Summary of Overburden Drilled Well Information for Lethbridge, Winter Brook and Musgravetown ADAs

Overburden Unit	Communities	No. of Wells	Well Depth (m)		Well Yield (L/min)	
			Mean (Median)	Range	Mean (Median)	Range
Till*	St. John's ADA	6	21.3 (19.6)	9.5 - 35	39.5 (33.5)	10 - 70
Sand & Gravel**	Terra Nova ADA	42	20.6 (18.3)	7.6 – 45.1	67 (48)	2 - 225

* Groundwater yield estimates for the till deposits based on well data from the St. John's ADA

** Groundwater yield estimates for the sand and gravel deposits based on well data from the Terra Nova ADA

8.3.1.2 Bedrock Hydrostratigraphic Units

Well record information is available for the majority of bedrock units located within the ADAs, including the Love Cove, Conception, Musgravetown groups, and the combined Cambrian sedimentary rocks of the Adeytown & Harcourt groups. The well yield and depth characteristics of these various strata are summarized in Table 8.2.

No water well information was available for the area of the Devonian granitic rocks that occur along the western boundary of the Lethbridge ADA. Therefore groundwater potential within this unit was inferred based on well records for similar granitic rocks in the Terra Nova ADA.

Love Cove Group

A total of 47 well records from the community of Bunyan's Cove was used to characterize the groundwater potential of the Love Cove Group. This unit occurs along the western boundary of the Lethbridge ADA. Based on well data, the Love Cove Group strata are considered capable of providing wells with low yields, having water yields ranging from 0.6 to 135 L/min at well depths of 18 to 125 m, and an average yield of 17 L/min at 62 m depth. However, median yield and depth estimates of 4 L/min at 58 m depth are more likely representative of the typical groundwater potential of this unit.

Conception Group

A total of seven (7) well records from the community of Winter Brook were used to characterize the groundwater potential of the Conception Group. This unit underlies the eastern portion of the Lethbridge ADA and all of the Winter Brook ADA. Based on well data, the Conception Group strata are considered capable of providing wells with low yields, having water yields ranging from 6 to 30 L/min at well depths of 31 to 58 m, and an average yield of 15 L/min at 41 m depth. However, median yield and depth estimates of 12 L/min at 43 m depth are more likely representative of the typical groundwater potential of this unit.

Musgravetown Group

A total of 283 well records from the communities of Lethbridge, Musgravetown, Bloomfield, and Cannings Cove were used to characterize the groundwater potential of the Musgravetown Group. This unit underlies the northern portion of the Lethbridge ADA, and all of the Musgravetown ADA. Based on well data, the Musgravetown Group strata are considered capable of providing wells with low yields, having water yields ranging from 0.3 to 273 L/min at well depths of 12 to 152 m, and an average yield of 21 L/min at 50 m depth. However, median yield and depth estimates of 9 L/min at 43 m depth are more likely representative of the typical groundwater potential of this unit.

Adeytown & Harcourt Groups

A total of three (3) well records from the community of Morley's Siding were used to characterize the groundwater potential of the combined Cambrian sedimentary rocks of the Adeytown & Harcourt groups. These units are present locally within the Lethbridge ADA. Based on well data, the Adeytown & Harcourt groups strata are considered capable of providing wells with moderate yields, having water yields ranging from 1 to 90 L/min at well depths of 40 to 79 m, and an average yield of 43 L/min at 65 m depth. However, median yield and depth estimates of 36 L/min at 76 m depth are more likely representative of the typical groundwater potential of this unit.

Devonian Granite

No documented data is available for the groundwater potential of the Devonian granitic rocks that occur along the western boundary of the Lethbridge ADA. However, based on records from two (2) water wells within similar granitic rocks in the Terra Nova ADA, this unit is considered capable of providing wells with low yields, reporting yields of 18 L/min at 73 m depth, and 20 L/min at 13 m depth, respectively.

Table 8.2 Summary of Bedrock Drilled Well Information for Lethbridge, Winter Brook and Musgravetown ADAs

Rock Group	Rock Type	Communities	No. of Wells	Well Depth (m)		Well Yield (L/min)	
				Mean (Median)	Range	Mean (Median)	Range
Love Cove	Submarine to subaerial volcanic rocks, incl. siliciclastic sedimentary rocks	Bunyan's Cove	47	62.1 (57.9)	18-125	16.9 (4)	0.6-135
Conception	Siliceous sandstone, shale and volcanoclastic rocks	Winter Brook	7	40.5 (42.7)	30.5–57.9	15.3 (12)	6-30
Musgravetown	Siliciclastic sedimentary rocks, and minor bimodal volcanic rocks	Lethbridge, Musgravetown, Bloomfield, Cannings Cove	283	49.9 (42.7)	12–152.4	21.4 (9.1)	0.3–272.8
Adeytown & Harcourt	Siliciclastic sedimentary rocks, including minor unseparated limestone and volcanic rocks	Morley's Siding	3	65.2 (76.2)	40–79.3	42.5 (36.4)	1-90
Granite*	Granite and other granitoid intrusions that are posttectonic relative to mid-Paleozoic orogenies	Terra Nova ADA	2	-	13.4, 73.2	-	18, 20

*Groundwater yield estimates for granitic rocks based on well data from the Terra Nova ADA

8.3.2 Groundwater Flow System

The Lethbridge, Winter Brook and Musgravetown ADAs and surrounding areas are underlain by an unconfined aquifer system contained within the overburden material and underlying shallow bedrock. The movement of groundwater through the overburden material is controlled by primary porosity, while groundwater flow within the underlying bedrock can be expected to mainly occur within secondary openings, such as fractures and joints, and will be variable depending on the frequency and interconnection of these structural features.

Shallow groundwater flow within the ADAs is controlled by water table conditions and local variations in topography. Groundwater is thought to be recharging along areas of high ground and discharging in various wet lowland areas, ponds, lakes and rivers, as well as along the coast. It is expected that the shallow groundwater system in the ADA will be largely controlled by surface runoff and local recharge, while at moderate depths the flow system may be influenced by lateral inflow of groundwater from up-gradient areas to the east and west. Based on a review of water well records for the area, groundwater levels are generally assumed to be within 5 m of the ground surface and to be a subdued reflection of the topography.

8.4 Water Quality

8.4.1 Surface Water Quality

Surface water quality data for the Lethbridge, Winter Brook and Musgravetown ADAs was obtained from two sources, including:

1. Ambient water quality data collected as part of the Canada–Newfoundland Water Quality Monitoring Agreement, from one (1) water quality monitoring site in the area of the ADAs –
    - Southern Bay River (NF02ZJ0024, 1986-2002)
2. Water quality monitoring data collected by the NL Department of Environment - Water Resources Management Division from two (2) protected public surface water supplies in the area of the ADAs -
    - George's Brook - George's Brook (WS-S-0276, 1991-2006); and,
    - Milton - Lilly Pond (WS-S-0463, 1988-2006).

A summary of chemical data obtained from these surface water sources over their respective monitoring periods is provided in Tables 8.3 and 8.4 in Appendix 8b, and is compared to the Canadian Drinking Water Quality Guidelines (CDWQG) (Health Canada, 2007), as well as the Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses (CWQG-AWU) (October, 2005).

Based on major ion chemistry, surface water in the ADAs and surrounding areas can be classified as calcium-sodium-chloride-sulfate-bicarbonate (Ca-Na-Cl-SO_4-HCO_3) type water. Surface water in the area is soft, slightly acidic, and of low alkalinity. Classification of surface water according to dissolved-solids and specific conductance indicates fresh conditions.

With the exception of pH, color and turbidity in the George's Brook and Milton protected public water supplies, and iron, manganese, pH and turbidity at the Southern Bay River ambient water quality monitoring station, concentrations of all other parameters tested meet CDWQG. The guidelines for iron, manganese, pH, turbidity and color are aesthetic objectives only and levels of these parameters detected at the surface water locations evaluated do not pose any health concerns, however problems may be experienced such as foul taste, deposition or staining in the case of iron, manganese, turbidity and color, and corrosion in the case of pH.

Concentrations of all parameters tested at the surface water sources meet CCME CWQG-AWU for irrigation and/or livestock water use.

Based on chemical data, surface water quality within the ADAs is generally considered good, returning average Canadian Water Quality Index (CWQI) values ranging from 82 to 93. However, a negative Langelier Index at all the public surface water supplies indicates that water is unsaturated with calcium carbonate and it will tend to be corrosive, leading to potential leaks in the distribution system. Southern Bay River is not considered a potable water source, and would require treatment for disinfection, as well as to improve the aesthetic quality of the water.

8.4.2 Groundwater Quality

The groundwater quality data for the ADAs consists of analyses from four (4) private drilled wells from the communities of Lethbridge, Musgravetown, and Canning Cove, as well as six (6) protected public supply drilled wells for the communities of Musgravetown (WS-G-0474), Lethbridge (WS-G-0408), Morleys Siding (WS-G-0469), and Canning Cove (WS-G-0114, WS-G-0115, and WS-G-0116) collected by the NL Department of Environment - Water Resources Management Division. A summary of chemical data obtained from these water wells is provided in Tables 8.5 and 8.6 in Appendix 8b, and is compared to the Canadian Drinking Water Quality Guidelines (CDWQG) (Health Canada, 2007), as well as the Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses (CWQG-AWU) (October, 2005).

Based on major ion chemistry, shallow groundwater in the ADA can be classified as both calcium-sodium-chloride-sulfate-bicarbonate ($Ca\text{-}Na\text{-}Cl\text{-}SO_4\text{-}HCO_3$) and calcium-sodium-bicarbonate-chloride-sulfate ($Ca\text{-}Na\text{-}HCO_3\text{-}Cl\text{-}SO_4$) type waters. Groundwater in the area ranges from slightly to very hard, neutral to slightly basic, and of moderate alkalinity. Classification of groundwater according to dissolved-solids and specific conductance generally indicates fresh conditions. However, slightly saline conditions are present in a private drilled well in Canning Cove, returning a specific conductance value and total dissolved solids value near 1,400 uS/cm and 1,000 mg/L, respectively.

With the exception of chloride, iron, manganese, pH and total dissolved solids concentrations in some of the wells, concentrations of all other parameters tested meet CDWQG. The guidelines for chloride, iron, manganese, pH and turbidity are aesthetic objectives only and levels of these parameters detected in the wells do not pose any health concerns, however problems may be experienced such as foul taste, deposition or staining in the case of iron, manganese, and total dissolved solids, and corrosion in the case of chloride and pH.

In addition, several of the private water wells in Musgravetown and Cannings Cove had concentrations of chloride, manganese and total dissolved solids that exceed CCME CWQG-AWU for irrigation water use.

Based on chemical data, groundwater quality within the ADA is considered excellent, returning an average Canadian Water Quality Index (CWQI) value of 100. However, a negative Langelier Index at all the protected public groundwater supplies indicates that water is unsaturated with calcium carbonate and it will tend to be corrosive, leading to potential leaks in the distribution system. Treatment would be required to improve the aesthetic quality of the water. In addition concentrations of chloride, manganese and total dissolved solids were present in several of the private water wells in Musgravetown and Cannings Cove that exceed CCME CWQG-AWU and may limit usage of these groundwater sources as potential agricultural water supplies without appropriate treatment. Further, the elevated specific conductance, total dissolved solids and chloride levels present in the well from Canning Cove is likely due to its coastal location and suggests that saltwater intrusion may be a potential issue for water wells installed in coastal areas of the ADAs.

8.5 Groundwater Recharge & Availability

Recharge to the shallow groundwater system underlying the Lethbridge, Winter Brook and Musgravetown ADAs is by direct infiltration of rainfall, after runoff and the requirements of evaporation and plant transpiration have been met, and is directly related to rainfall, infiltration characteristics and size of the recharge zone. A common practice in estimating the long term groundwater recharge for an

area is to multiply the groundwater catchment area by the percent of precipitation estimated as able to infiltrate. The recharge to groundwater in the Lethbridge, Winter Brook and Musgravetown ADAs is estimated on the basis of a local groundwater catchment area equivalent to the respective areas of the ADAs (i.e., Lethbridge ADA – 17,245 hectares, Winter Brook ADA – 477 hectares, and Musgravetown ADA – 1,923 hectares), and a conservative recharge coefficient of 10% of the mean annual rainfall (i.e., 10% of 1,212 mm, equivalent to 121 mm). Based on these values, the groundwater recharge to the Lethbridge ADA is $2.1x10^7 m^3$/year or 1,212 m^3/hectares/yr, the groundwater recharge to the Winter Brook ADA is $5.8x10^5 m^3$/year or 1,212 m^3/hectares/yr, and the groundwater recharge to the Musgravetown ADA is $2.3x10^6 m^3$/year or 1,212 m^3/hectares/yr.

Six (6) protected public groundwater supplies are present in the vicinity of the ADAs, including three public groundwater supplies for the community of Cannings Cove (Water Supply Nos. WS-G-0114, WS-G-0115, and WS-G-0116) that serve a population of approximately 279, one public groundwater supply for the community of Lethbridge (Water Supply No. WS-G-0408) that serves a population of approximately 548, one public groundwater supply for the community of Morleys Siding (Water Supply No. WS-G-0469) that serves a population of approximately 38, and one public groundwater supply for the community of Musgravetown (Water Supply No. WS-G-0474) that serves a population of approximately 583. The remainder of the water wells in the area of the ADAs is limited to minor individual domestic, commercial and industrial supply wells. No information is available regarding existing agricultural (i.e., irrigation and livestock) water demands in the Lethbridge, Winter Brook and Musgravetown ADAs, thus preventing an accurate balance of groundwater supply and demand to be estimated, and making it difficult to evaluate groundwater supply potential for future agricultural development in the area. However, considering the current, overall under-utilization of groundwater in the area from other users, it is expected that an adequate supply of groundwater of sufficient quality is available to meet and/or augment water supply requirements for various existing and future agricultural needs in the ADAs.

APPENDIX 8a

Drawings

Transportation Route
Stream
Drainage Catchment Area
Contour Line
Agricultural Development Area
Waterbody
Wetland/String Bog
Vegetated Area

PROJECT TITLE:

HYDROGEOLOGY OF AGRICULTURAL DEVELOPMENT AREAS, NEWFOUNDLAND AND LABRADOR

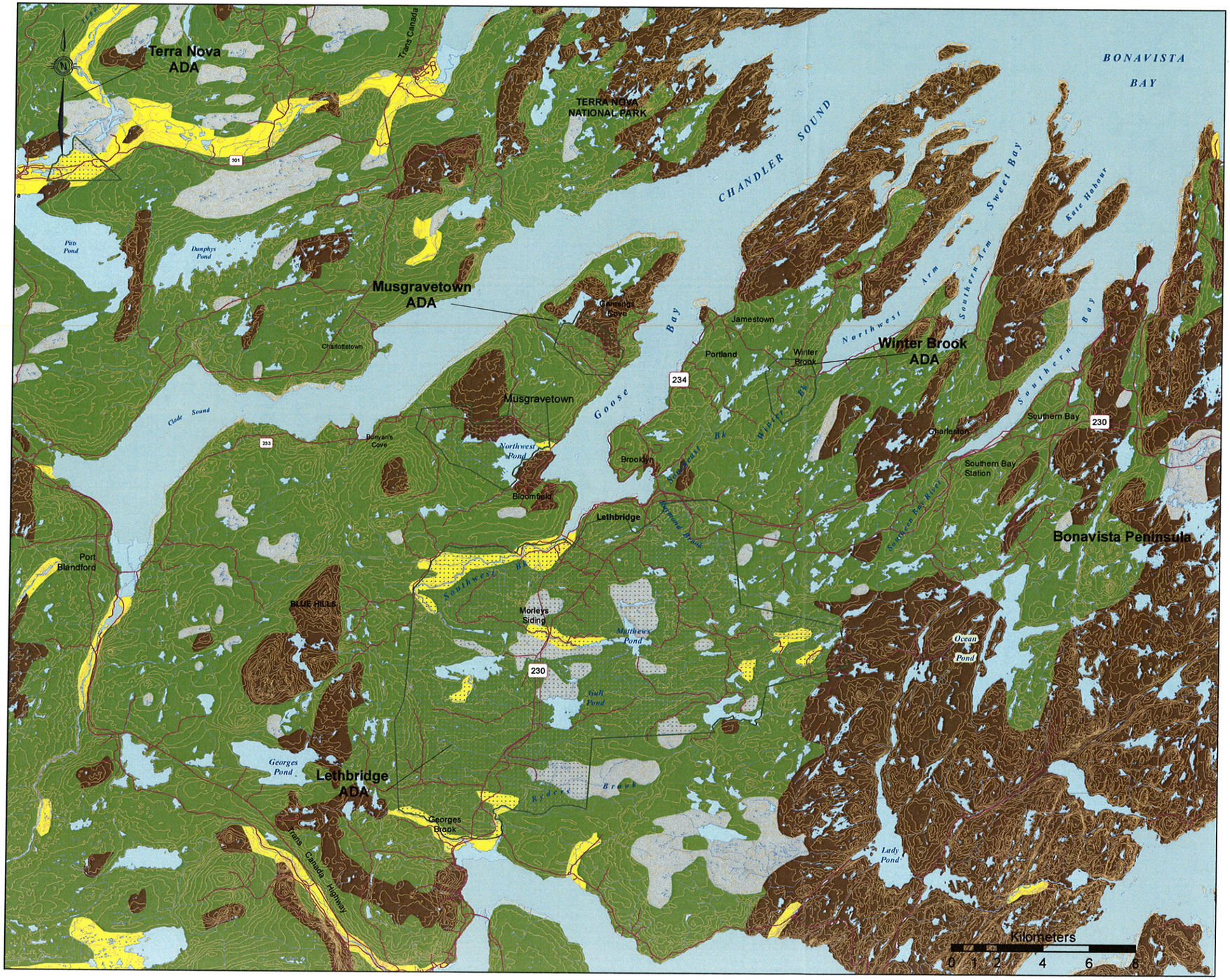
DRAWING TITLE:

LETHBRIDGE, WINTER BROOK AND MUSGRAVETOWN ADAs LOCATION AND DRAINAGE

Jacques Whitford

SCALE: 1:175,000	DATE: 11/03/2008
DRAWN BY: JLB	CHECKED BY:
EDITED BY: JLB	REV. No. 0
DRAWING No.: 1034406-8-1	
MAP FILE: 1034406-XX.MXD	

Jacques Whitford



Surficial Geology Legend

- Bog: Poorly drained accumulations of peat, peat moss and other organic matter; developed in areas of poor drainage
- Sand & Gravel: Sands, gravels and silts of glaciofluvial, fluvial, lacustrine or marine terrace origin
- Glacial Till: Till veneer and moraine deposits of varying thickness overlying bedrock. Composed of diamicton (poorly sorted sediment containing a mixture of grain sizes from clay to boulders)
- Rock: Exposed Bedrock, includes areas concealed by vegetation, till veneer, as well as colluvium

- Stream
- Transportation Route
- Contour Line
- Waterbody
- Agricultural Development Area

PROJECT TITLE:

HYDROGEOLOGY OF AGRICULTURAL DEVELOPMENT AREAS, NEWFOUNDLAND AND LABRADOR

DRAWING TITLE:

LETHBRIDGE, WINTER BROOK AND MUSGRAVETOWN ADAs SURFICIAL GEOLOGY

Jacques Whitford

SCALE: 1:200,000	DATE: 03/06/2008
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MAP FILE: 1034406-XX.MXD	

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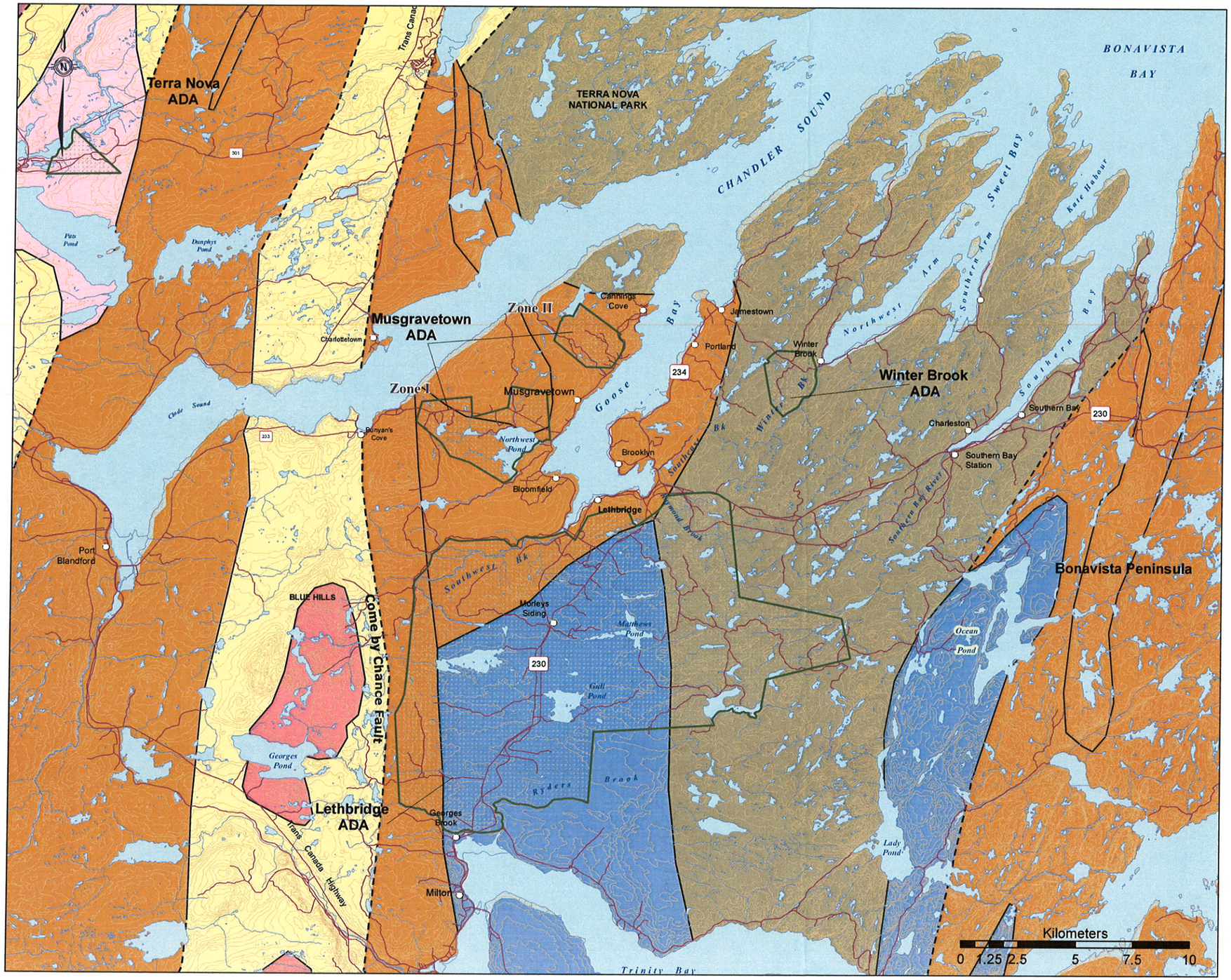

Generalized Bedrock Geology Legend

AVALON ZONE

Stratified Rocks

Precambrian to Early Ordovician

- Shallow marine, mainly fine grained, siliciclastic sedimentary rocks, including minor unseparated limestone and volcanic rocks (Adeyton and Harcourt groups)

Precambrian

- Fluviatile and shallow marine siliciclastic sedimentary rocks, including minor unseparated limestone and bimodal volcanic rocks (Signal Hill Group; parts of Musgravetown, Long Harbour, Connaigre Bay, Marystown and Love Cove groups)
- Marine deltaic siliciclastic sedimentary rocks (St. John's Group)
- Sandstone and shale turbidites, including minor unseparated tillite, olistostromes and volcanic rocks (Connecting Point and Conception groups)
- Bimodal, submarine to subaerial volcanic rocks, including minor siliciclastic sedimentary rocks (Harbour Main Group, parts of Love Cove and Marystown groups)

Intrusive Rocks

Neoproterozoic to Cambrian

- Mafic intrusions
- Granitoid intrusions, including unseparated mafic phases

- Syncline
- Anticline
- Contact
- Fault, Strike-Slip and High Angle
- Fault, Thrust
- Transportation Route
- Contour Line
- Stream
- Waterbody
- Agricultural Development Area

PROJECT TITLE:

HYDROGEOLOGY OF AGRICULTURAL DEVELOPMENT AREAS, NEWFOUNDLAND AND LABRADOR

DRAWING TITLE:

LETHBRIDGE, WINTER BROOK AND MUSGRAVETOWN ADAs BEDROCK GEOLOGY

Jacques Whitford

SCALE: 1:175,000	DATE: 11/03/2008
DRAWN BY: JLB	CHECKED BY:
EDITED BY: JLB	REV. No. 0
DRAWING No.: 1034406-8-3	
MAP FILE: 1034406-XX.MXD	

APPENDIX 8b

Water Chemistry Data

Table 8.3 Surface Water Chemistry, NL Ambient Water Quality Monitoring Sites, Lethbridge, Winter Brook, & Musgravetown ADAs Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		Southern Bay River near Southern Bay NF02ZJ0024 (1986-2002)[1]		
			Irrigation Water	Livestock Water	Min	Max	Mean
Alkalinity	mg/L $CaC0_3$	na	na	na	0.5	13.7	4
Aluminum	mg/L	na	5	5	0.01	0.29	0.15
Ammonia	mg/L	na	na	na	-	-	-
Antimony	mg/L	0.006	na	na	-	-	-
Arsenic	mg/L	0.01	0.1	0.025	0.0001	0.0003	0.0001
Barium	mg/L	1	na	na	0.003	0.05	0.01
Beryllium	mg/L	na	0.1	0.1	0.05	0.05	0.05
Bicarbonate	mg/L $CaC0_3$	na	na	na	-	-	-
Boron	mg/L	5	0.5 - 6	5	-	-	-
Bromide	mg/L	na	na	na	-	-	-
Cadmium	mg/L	0.005	0.005	0.08	0.0001	0.0001	0.0001
Calcium	mg/L	na	na	na	1.74	2.53	2.18
Carbonate	mg/L $CaC0_3$	na	na	na	-	-	-
Chloride	mg/L	250*	100 - 700	na	-	-	-
Chromium	mg/L	0.05	na	na	0.0002	0.007	0.0005
Copper	mg/L	1*	0.2 - 1	0.5-5	0.0002	0.0102	0.001
Dissolved Organic Carbon	mg/L	na	na	na	-	-	-
Fluoride	mg/L	1.5	1	1 - 2	-	-	-
Hardness	mg/L $CaC0_3$	na	na	na	-	-	-
Iron	mg/L	0.3*	5	na	0.01	0.60	0.25
Kjeldahl Nitrogen	mg/L	na	na	na	0.20	0.24	0.22
Langelier Index	-	na	na	na	-	-	-
Lead	mg/L	0.01	0.2	0.1	0.0002	0.003	0.0004
Magnesium	mg/L	na	na	na	0.48	0.62	0.56
Manganese	mg/L	0.05*	0.2	na	0.005	0.18	0.03
Mercury	mg/L	0.001	na	0.003	0.00001	0.00002	0.00001
Nickel	mg/L	na	0.2	1	0.0002	0.001	0.0003
Nitrate	mg/L N	45	na	na	-	-	-
Nitrate + Nitrite	mg/L N	na	na	100	-	-	-
Nitrite	mg/L	na	na	10	-	-	-
Orthophosphate	mg/L P	na	na	na	-	-	-
pH	Units	6.5-8.5*	na	na	5.68	7.22	6.39
Potassium	mg/L	na	na	na	0.19	0.26	0.22
Reactive Silica	mg/L SiO2	na	na	na	0.55	3.36	1.96
Selenium	mg/L	0.01	0.02 - 0.05	0.05	0.0001	0.0002	0.0001
Silver	mg/L	na	na	na	0	0	0
Sodium	mg/L	200*	na	na	2.05	2.79	2.48
Specific Conductance	uS/cm	na	na	na	21.5	66.3	32.0
Sulphate	mg/L	500*	na	1,000	-	-	-
Sulphide	mg/L H2S	0.05*	na	na	-	-	-
Thallium	mg/L	na	na	na	-	-	-
Tin	mg/L	na	na	na	-	-	-
Total Dissolved Solids	mg/L	500*	500 - 3,500	3,000	-	-	-
Total Organic Carbon	mg/L	na	na	na	-	-	-
Total Phosphorus	mg/L	na	na	na	0.001	0.02	0.01
Total Suspended Solids	mg/L	na	na	na	-	-	-
True Color	TCU	15*	na	na	-	-	-
Turbidity	NTU	0.3/1.0/0.1**	na	na	0.07	5.70	0.69
Uranium	mg/L	0.02	0.01	0.2	-	-	-
Vanadium	mg/L	na	0.1	0.1	0.0001	0.0005	0.0002
Canadian Water Quality Index (CWQI)	-	-	-	-	-	-	82
Zinc	mg/L	5*	1 - 5	50	0.0002	0.03	0.001

Notes:

CDWQG = Health Canada Canadian Drinking Water Quality Guidelines (March, 2007)

CWQG-AWU = CCME Canadian Water Quaility Guidelines for the Protection of Agricultural Water Uses (Irrigation and Livestock Water) (October, 2005)

1 = Summary statisitics calculated using chemicial data obtained from the NL Ambient Water Quaility Database available through the Canada and Newfoundland/Labrador Aqua Link (CANAL) website.

na = No applicable criteria

* = Aesthetic objective

** = Operational guideline value based on conventional treatment/slow sand or diatomaceous earth filtration/membrane filtration.

"-" = Not analyzed

Shaded = Value does not meet applicable criteria

Bolded = Value does not meet CWQG-AWU for irrigation and/or livestock water

Table 8.4 Surface Water Chemistry, Public Water Supply, Lethbridge, Winter Brook, & Musgravetown ADAs
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		George's Brook - George's Brook WS-S-0276 (1991-2006)[1]			Milton - Lilly Pond WS-S-0463 (1988-2006)[1]		
			Irrigation Water	Livestock Water	Min	Max	Mean	Min	Max	Mean
Alkalinity	mg/L $CaC0_3$	na	na	na	2.6	13	5.6	5.2	12.0	8.0
Aluminum	mg/L	na	5	5	0.02	0.21	0.11	0.08	0.30	0.13
Ammonia	mg/L	na	na	na	0	0.09	0.03	0	0	0
Antimony	mg/L	0.006	na	na	0	0.0005	0.0002	0	0	0
Arsenic	mg/L	0.01	0.1	0.025	0	0.003	0.001	0	0.003	0.002
Barium	mg/L	1	na	na	0	0.005	0.003	0	0	0
Beryllium	mg/L	na	0.1	0.1	-	-	-	-	-	-
Bicarbonate	mg/L $CaC0_3$	na	na	na	-	-	-	-	-	-
Boron	mg/L	5	0.5 - 6	5	0	0.03	0.01	0	0	0
Bromide	mg/L	na	na	na	0	0.03	0.02	0	0.03	0.02
Cadmium	mg/L	0.005	0.005	0.08	0	0.0005	0.0001	0	0.001	0.0004
Calcium	mg/L	na	na	na	1	4	2	2	5	3
Carbonate	mg/L $CaC0_3$	na	na	na	-	-	-	-	-	-
Chloride	mg/L	250*	100 - 700	na	3	7	4	2	5	3
Chromium	mg/L	0.05	na	na	0	0.0025	0.0006	0	0.005	0.003
Copper	mg/L	1*	0.2 - 1	0.5-5	0	0.005	0.002	0	0.01	0.003
Dissolved Organic Carbon	mg/L	na	na	na	4.3	10.7	6.8	2.8	7.1	5.0
Fluoride	mg/L	1.5	1	1 - 2	0	0.45	0.08	0	0.11	0.04
Hardness	mg/L $CaC0_3$	na	na	na	3	10	6	7	7	7
Iron	mg/L	0.3*	5	na	0.01	0.29	0.16	0.005	0.18	0.07
Kjeldahl Nitrogen	mg/L	na	na	na	0.05	0.68	0.24	0.18	0.48	0.33
Langelier Index	-	na	na	na	-5.8	-3.6	-4.34	-3.92	-1.95	-3.44
Lead	mg/L	0.01	0.2	0.1	0	0.001	0.001	0	0.001	0.001
Magnesium	mg/L	na	na	na	0	0.6	0.4	0	0.77	0.46
Manganese	mg/L	0.05*	0.2	na	0	0.034	0.02	0	0.02	0.01
Mercury	mg/L	0.001	na	0.003	0	0.00005	0.00003	0	0.0005	0.0003
Nickel	mg/L	na	0.2	1	0	0.005	0.003	0	0.005	0.003
Nitrate	mg/L N	45	na	na	-	-	-	-	-	-
Nitrate + Nitrite	mg/L N	na	na	100	0	0.05	0.02	0	0.057	0.02
Nitrite	mg/L	na	na	10	-	-	-	-	-	-
Orthophosphate	mg/L P	na	na	na	-	-	-	-	-	-
pH	Units	6.5-8.5*	na	na	6	6.9	6.47	6.3	6.9	6.6
Potassium	mg/L	na	na	na	0	0.5	0.27	0	0.64	0.25
Reactive Silica	mg/L SiO2	na	na	na	-	-	-	-	-	-
Selenium	mg/L	0.01	0.02 - 0.05	0.05	0	0.001	0.001	0	0	0
Silver	mg/L	na	na	na	-	-	-	-	-	-
Sodium	mg/L	200*	na	na	0	4	3	1	4	3
Specific Conductance	uS/cm	na	na	na	10.9	35	26.4	24.8	55.7	33.2
Sulphate	mg/L	500*	na	1,000	0	6	3	2	9	3
Sulphide	mg/L H2S	0.05*	na	na	-	-	-	-	-	-
Thallium	mg/L	na	na	na	-	-	-	-	-	-
Tin	mg/L	na	na	na	-	-	-	-	-	-
Total Dissolved Solids	mg/L	500*	500 - 3,500	3,000	16	41	25	17	50	28
Total Organic Carbon	mg/L	na	na	na	-	-	-	-	-	-
Total Phosphorus	mg/L	na	na	na	0	0.25	0.02	0.005	0.04	0.01
Total Suspended Solids	mg/L	na	na	na	2	2	2	1	4	2
True Color	TCU	15*	na	na	14	86	46	20	48	38
Turbidity	NTU	0.3/1.0/0.1**	na	na	0.2	2.25	0.57	0.21	0.77	0.55
Uranium	mg/L	0.02	0.01	0.2	0	0	0	0	0	0
Vanadium	mg/L	na	0.1	0.1	-	-	-	-	-	-
Canadian Water	-	-	-	-	91	93	93	83	83	83
Zinc	mg/L	5*	1 - 5	50	0	0.02	0.004	0	0.03	0.007

Notes:

CDWQG = Health Canada Canadian Drinking Water Quality Guidelines (March, 2007)

CWQG-AWU = CCME Canadian Water Quaility Guidelines for the Protection of Agricultural Water Uses (Irrigation and Livestock Water) (October, 2005)

1 = Summary statisitics calculated using chemicial data obtained from the NL Deprtment of Environment - Water Resources Management Division Drinking Water Quality Database. Note in the data base, prior to March 31, 2004 analytical results less than the detection limit were reported as half of the detection limit, while after March 31, 2004 analytical results less than the detection limit were reported as zero.

na = No applicable criteria

* = Aesthetic objective

** = Operational guideline value based on conventional treatment/slow sand or diatomaceous earth filtration/membrane filtration.

"-" = Not analyzed

Shaded = Value does not meet applicable criteria

Bolded = Value does not meet CWQG-AWU for irrigation and/or livestock water

Table 8.5 Groundwater Chemistry, Private Drilled Wells, Lethbridge, Winter Brook, & Musgravetown ADAs
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		Communities[1]			
					Lethbridge	Musgravetown		Cannings Cove
			Irrigation	Livestock	12838	14627	11838	12746
Alkalinity	mg/L $CaC0_3$	na	na	na	114	40.8	141	87
Aluminum	mg/L	na	5	5	-	-	-	-
Ammonia	mg/L	na	na	na	-	-	-	-
Antimony	mg/L	0.006	na	na	-	-	-	-
Arsenic	mg/L	0.01	0.1	0.025	-	-	-	-
Barium	mg/L	1	na	na	-	-	-	-
Beryllium	mg/L	na	0.1	0.1	-	-	-	-
Bicarbonate	mg/L $CaC0_3$	na	na	na	-	-	-	-
Boron	mg/L	5	0.5 - 6	5	-	-	-	-
Bromide	mg/L	na	na	na	-	-	-	-
Cadmium	mg/L	0.005	0.005	0.08	-	-	-	-
Calcium	mg/L	na	na	na	22.7	28	31	120
Carbonate	mg/L $CaC0_3$	na	na	na	-	-	-	-
Chloride	mg/L	250*	100 - 700	na	14	**222**	7.3	**380**
Chromium	mg/L	0.05	na	na	-	-	-	-
Copper	mg/L	1*	0.2 - 1	0.5-5	-	-	-	-
Dissolved Organic Carbon	mg/L	na	na	na	-	-	-	-
Fluoride	mg/L	1.5	1	1 - 2	0.16	0.11	0.12	0.05
Hardness	mg/L $CaC0_3$	na	na	na	78.1	115	91.1	337
Iron	mg/L	0.3*	5	na	0.04	0.43	0.01	0.01
Kjeldahl Nitrogen	mg/L	na	na	na	-	-	-	-
Langelier Index	-	na	na	na	-	-	-	-
Lead	mg/L	0.01	0.2	0.1	-	-	-	-
Magnesium	mg/L	na	na	na	5.2	11	3.32	9.1
Manganese	mg/L	0.05*	0.2	na	0.05	**0.25**	0.04	0.01
Mercury	mg/L	0.001	na	0.003	-	-	-	-
Nickel	mg/L	na	0.2	1	-	-	-	-
Nitrate	mg/L N	45	na	na	-	-	-	-
Nitrate + Nitrite	mg/L N	na	na	100	0.004	0.09	0.01	6.70
Nitrite	mg/L	na	na	10	-	0.01	0.003	0.001
Orthophosphate	mg/L P	na	na	na	-	-	-	-
pH	Units	6.5-8.5*	na	na	7.93	6.55	7.73	6.75
Potassium	mg/L	na	na	na	2.3	2.66	0.27	2
Reactive Silica	mg/L SiO2	na	na	na	-	-	-	-
Selenium	mg/L	0.01	0.02 - 0.05	0.05	-	-	-	-
Silver	mg/L	na	na	na	-	-	-	-
Sodium	mg/L	200*	na	na	24	-	-	110
Specific Conductance	uS/cm	na	na	na	279	-	-	1,204
Sulphate	mg/L	500*	na	1,000	14	7.2	1.5	17
Sulphide	mg/L H2S	0.05*	na	na	-	-	-	-
Thallium	mg/L	na	na	na	-	-	-	-
Tin	mg/L	na	na	na	-	-	-	-
Total Dissolved Solids	mg/L	500*	500 - 3,500	3,000	197	**546**	169	**972**
Total Organic Carbon	mg/L	na	na	na	-	-	-	-
Total Phosphorus	mg/L	na	na	na	0.01	0.03	0.03	0.01
Total Suspended Solids	mg/L	na	na	na	-	-	-	-
True Color	TCU	15*	na	na	-	-	-	-
Turbidity	NTU	0.3/1.0/0.1**	na	na	-	-	-	-
Uranium	mg/L	0.02	0.01	0.2	-	-	-	-
Vanadium	mg/L	na	0.1	0.1	-	-	-	-
Zinc	mg/L	5*	1 - 5	50	0.03	0.02	0.01	0.03

Notes:

CDWQG = Health Canada Canadian Drinking Water Quality Guidelines (March, 2007)

CWQG-AWU = CCME Canadian Water Quaility Guidelines for the Protection of Agricultural Water Uses (Irrigation and Livestock Water) (October, 2005)

1 = Chemicial data obtained from the NL Department of Environment - Water Resources Management Division Drinking Water Quality Database

na = No applicable criteria

* = Aesthetic objective

** = Operational guideline value based on conventional treatment/slow sand or diatomaceous earth filtration/membrane filtration.

"-" = Not analyzed

Shaded = Value does not meet applicable criteria

Bolded = Value does not meet CWQG-AWU for irrigation and/or livestock water

Table 8.6 Groundwater Chemistry, Protected Public Supply Drilled Wells, Lethbridge, Winter Brook, & Musgravetown ADAs
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		Musgravetown WS-G-0474[1]	Lethbridge WS-G-0408[1]		Morleys Siding WS-G-0469[1]	Canning Cove WS-G-0114 (2001-2007)[1]			Canning Cove WS-G-0115 (2001-2007)[1]			Canning Cove WS-G-0116 (2001-2007)[1]		
			Irrigation	Livestock	2001	2001	2002	2001	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Alkalinity	mg/L $CaC0_3$	na	na	na	59	86	-	107	73	86	81	79	101	89.6	40	92	65.5
Aluminum	mg/L	na	5	5	0.025	0.025	-	0.025	0.005	0.025	0.016	0	0.04	0.021	0	0.5	0.1
Ammonia	mg/L	na	na	na	0.01	0.01	-	0.01	0	0.02	0.008	0	0.05	0.014	0	0.01	0.005
Antimony	mg/L	0.006	na	na	-	-	-	-	0	0.0005	0.00025	0	0.0005	0.00025	0	0.0005	0.0002
Arsenic	mg/L	0.01	0.1	0.025	0.002	0.001	0.001	0.001	0.003	0.004	0.003	0.001	0.001	0.001	0	0.001	0.0005
Barium	mg/L	1	na	na	0.02	0.05	-	0.21	0	0.01	0.004	0	0.005	0.003	0	0.005	0.003
Beryllium	mg/L	na	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Bicarbonate	mg/L $CaC0_3$	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron	mg/L	5	0.5 - 6	5	0.03	0.03	-	0.03	0.01	0.03	0.02	0	0.03	0.01	0	0.03	0.02
Bromide	mg/L	na	na	na	0.03	0.03	-	0.03	0	0.03	0.018	0	0.03	0.018	0	0.03	0.02
Cadmium	mg/L	0.005	0.005	0.08	0.00005	0.00005	-	0.00005	0	0.00005	0.00003	0	0.00005	0.00003	0	0.0001	0.00005
Calcium	mg/L	na	na	na	6	22	-	32	17	20	18.4	28	37	31.2	13	28	20
Carbonate	mg/L $CaC0_3$	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloride	mg/L	250*	100 - 700	na	14	10	-	8	6	8	7	4	7	6	9	18	12
Chromium	mg/L	0.05	na	na	0.0005	0.0005	-	0.0005	0	0.0005	0.0003	0	0.0005	0.0003	0	0.0005	0.0003
Copper	mg/L	1*	0.2 - 1	0.5-5	0.04	**0.237**	-	0.002	0	0.011	0.003	0	0.011	0.0062	0	0.001	0.001
Dissolved Organic Carbon	mg/L	na	na	na	0.5	0.3	-	0.5	0	0.6	0.3	1	1.2	1.08	0	0.6	0.3
Fluoride	mg/L	1.5	1	1 - 2	0.12	0.1	-	0.14	0	0.15	0.102	0	0.1	0.05	0	0.14	0.09
Hardness	mg/L $CaC0_3$	na	na	na	23	76	-	95	42	50	45.8	74	101	83	33	78	54
Iron	mg/L	0.3*	5	na	0.005	0.005	-	0.005	0	0.03	0.009	0	0.04	0.013	0	0.03	0.009
Kjeldahl Nitrogen	mg/L	na	na	na	0.16	0.025	-	0.09	0	0.47	0.151	0	0.08	0.047	0	0.025	0.013
Langelier Index	-	na	na	na	-	-0.67	-	-0.3	-1.5	-0.74	-0.98	-1.35	-0.54	-0.94	-2.77	-0.48	-1.93
Lead	mg/L	0.01	0.2	0.1	-	0.011	0.002	0.001	0	0.001	0.0006	0	0.006	0.0024	0	0.001	0.0005
Magnesium	mg/L	na	na	na	2	5	-	3	0	0.5	0.3	1	2	1.2	0	2	1
Manganese	mg/L	0.05*	0.2	na	0.005	0.005	-	0.005	0	0.005	0.0026	0	0.005	0.003	0	0.005	0.003
Mercury	mg/L	0.001	na	0.003	0.00005	0.00005	-	0.00005	0	0.00005	0.00003	0	0.00005	0.00003	0	0.00005	0.00003
Nickel	mg/L	na	0.2	1	0.005	0.005	-	0.005	0	0.005	0.0022	0	0.005	0.0022	0	0.005	0.002
Nitrate	mg/L N	45	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate + Nitrite	mg/L N	na	na	100	1.49	0.66	-	0.65	0.1	0.23	0.184	0.11	0.86	0.376	0.11	1.38	0.58
Nitrite	mg/L	na	na	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthophosphate	mg/L P	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-
pH	Units	6.5-8.5*	na	na	7.1	7.6	-	7.9	7.5	7.9	7.72	7.2	7.8	7.5	7.1	7.9	7.5
Potassium	mg/L	na	na	na	0.5	0.5	-	0.5	0	0.5	0.3	0	0.5	0.3	0	1	0.4
Reactive Silica	mg/L SiO2	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-
Selenium	mg/L	0.01	0.02 - 0.05	0.05	0.001	0.001	-	0.001	0	0.001	0.0008	0	0.001	0.0006	0	0.001	0.0005
Silver	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/L	200*	na	na	28	11	-	12	18	21	19	6	8	7	6	20	12
Specific Conductance	uS/cm	na	na	na	181	204	-	243	174	194	183.8	169	222	191	110	255	175
Sulphate	mg/L	500*	na	1,000	6	5	-	9	5	7	6	3	5	4	4	7	5
Sulphide	mg/L H2S	0.05*	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-
Tin	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Dissolved Solids	mg/L	500*	500 - 3,500	3,000	118	133	-	158	113	126	119	110	144	124	72	166	114
Total Organic Carbon	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Phosphorus	mg/L	na	na	na	0.04	0.03	-	0.01	0	0.05	0.017	0	0.03	0.018	0.005	0.04	0.021
Total Suspended Solids	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-
True Color	TCU	15*	na	na	-	1	-	1	0	1	0.6	0	1	0.6	0	1	0.5
Turbidity	NTU	0.3/1.0/0.1**	na	na	1.1	2.9	-	0.2	0.1	0.3	0.2	0.3	0.7	0.5	0.1	0.4	0.2
Uranium	mg/L	0.02	0.01	0.2	-	-	-	-	0	0	0	0	0	0	0	0	0
Vanadium	mg/L	na	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Quality Index (WQI)	-	-	-	-	-	-	-	-	100	100	100	97	100	97.9	100	100	100
Zinc	mg/L	5*	1 - 5	50	0.005	0.09	-	0.005	0	0.005	0.003	0	0.005	0.003	0	0.005	0.003

Notes:
CDWQG = Health Canada Canadian Drinking Water Quality Guidelines (March, 2007)
CWQG-AWU = CCME Canadian Water Quaility Guidelines for the Protection of Agricultural Water Uses (Irrigation and Livestock
1 = Chemicial data obtained from the NL Department of Environment - Water Resources Management Division Drinking Water Quality Database. Note in the data base, prior to March 31, 2004 analytical results less than detection limit were reported as half of the detection limit, while after March 31, 2004 analytical results less than the detection limit were reported as zero.
na = No applicable criteria
* = Aesthetic objective
** = Operational guideline value based on conventional treatment/slow sand or diatomaceous earth filtration/membrane filtration.
"-" = Not analyzed
Shaded = Value does not meet applicable criteria
Bolded = Value does not meet CWQG-AWU for irrigation and/or livestock water