2.0 HYDROGEOLOGY OF ST. JOHN'S ADA

2.1 General Description of Area

2.1.1 Location & Extent

The St. John's ADA is located on the northeast Avalon Peninsula in eastern Newfoundland. The ADA is the largest agricultural designated area on the island, covering a total combined area of approximately 12,780 hectares, and comprising eight individual sub-areas, several of which are further subdivided into zones. Table 2.1 provides a summary of subareas and zones within the St. John's ADA along with their respective areas. The boundaries of the various sub-ADAs that make-up the St. John's ADA are shown on Drawing No. 1034406-2-1 in Appendix 2a.

Table 2.1 St. John's ADA Subareas and Zones

Sub Area	Zone	Area (Hectares)
Goulds-Kilbride	Zone I	9,176
	Zone II	87
	Zone III	95
	Zone IV	68
Torbay-Flatrock	Zone I	374
	Zone II	738
	Zone III	66
Logy Bay-Middle Cove-Outer Cove	Zone I	62
	Zone II	40
	Zone III	48
	Zone IV	55
Windsor Heights	-	558
Indian Meal Line	-	73
Old Broad Cove Road	-	370
Manuels River	-	837
Foxtrap-Gull Pond	-	130
	St. John's ADA – Total Area	12,780

The Goulds-Kilbride sub-ADA is the largest sub-area within the St. John's ADA and includes a main zone (Zone I) and three small adjacent satellite zones (Zones II, III, and IV) that cover an area extending from the southern limits of the City of Mount Pearl to the Hawke Hills area in the south, and extending from the Trans Canada Highway in the west to Bay Bulls - Big Pond in the east. The Foxtrap – Gull Pond and Manuels River sub-ADAs are located west of the Goulds-Kilbride sub-ADA, along the eastern limits of the municipality of Conception Bay South, and approximately 20 km southwest of the City of St. John's. The Indian Meal Line, Old Broad Cove Road, and Windsor Heights sub-ADAs are located in close proximity to each other in the vicinity of the community of Portugal Cove - St. Philips, approximately 8 km northwest of the City of St. John's. The Logy Bay-Middle Cove-Outer Cove sub-ADA includes four small zones (Zones I, II, III, and IV) in the vicinity of Logy Bay-Middle Cove-Outer Cove, approximately 3 km north of the City of St. John's. The Torbay-Flatrock sub-ADA includes three small zones (Zone I, II, and III) in the vicinity of Flatrock, approximately 14 km north of the City of St. John's.

The St. John's ADA overlaps the communities of Mount Pearl, St. John's, Goulds, Doyles, Logy Bay, Outer Cove, and Windsor Heights.

The main access to the Goulds-Kilbride sub-ADA is provided by the Trans-Canada Highway and Provincial Highway Route 2 (Pitts Memorial Drive), which leads east to St. John's from the Trans-Canada Highway approximately 5 km west of the City of Mount Pearl. Provincial Highway Route 10 (Southern Shore Highway) branches off Highway Route 2 in the community of Kilbride leading south, and provides access to the eastern portion of Zone I, as well as Zones II, III and IV of the Goulds-Kilbride sub-ADA. The main access to the Manuels River sub-ADA is provided by the Trans-Canada Highway and Fowlers Road, a secondary paved road, which leads north from the Trans Canada Highway to the municipality of Conception Bay South, approximately 9 km south of the Trans Canada Highway – Pitts Memorial Drive interchange. The main access to the Foxtrap – Gull Pond sub-ADA is provided by the Trans-Canada Highway and Provincial Highway Route 61 (Foxtrap Access Road), which leads north to the municipality of Conception Bay South, approximately 14 km south of the Trans Canada Highway – Pitts Memorial Drive interchange. Main access to the Indian Meal Line, Old Broad Cove Road, and Windsor Heights sub-ADAs is provided by Provincial Highway Route 40 (Portugal Cove Road), which leads west to the community of Portugal Cove - St. Philips from the Trans Canada Highway in the City of St. John's. Main access to the Logy Bay-Middle Cove-Outer Cove and Torbay-Flatrock sub-ADAs is provided by Provincial Highway Route 20 (Torbay Road - Pouch Cove Road), which leads north from the Trans Canada Highway in the City of St. John's and connects communities along the northeast coast of the peninsula.

2.1.2 Physiography, Topography & Drainage

The St. John's ADA is located on the Avalon Peninsula, which forms the eastern extent of the physiographic region referred to as the Atlantic Uplands. This physiographic region is underlain by the remnants of an ancient peneplain that slopes in an easterly direction towards the North Atlantic, and is characterized by rugged bedrock-controlled ridges and northeast-southwest trending coastal bays and inlets. In general, the Avalon Peninsula comprises a highland area surrounding a central lowland, with the arms of the peninsula including in the vicinity of the St. John's ADA situated at relatively higher ground with respect to a large central lowland area located in the central part of the peninsula between Conception Bay and St. Mary's Bay. The St. John's ADA is generally underlain by a rough, rolling plateau of low relief with elevations ranging from sea level along coastal boundaries to approximately 200 m above sea level in inland regions. Maximum elevations of up to 300 m above sea level are present in the Hawke Hills area located south of the Goulds - Kilbride sub-ADA. Coastal regions in the vicinity of the St. John's ADA are rugged with cliffs ranging from a few metres high to more than 60 m high.

The Goulds-Kilbride sub-ADA encompasses portions of the Raymond Brook – Bay Bulls/Big Pond, Cochrane Pond and Waterford River – South Brook systems, all of which ultimately drain into the Atlantic Ocean along the east coast of the peninsula. In addition, the Goulds-Kilbride sub-ADA also encompasses the headwaters of the Manuels River, which drains into Conception Bay along the west coast of the peninsula. The Foxtrap – Gull Pond and Manuels River sub-ADAs are located within the Foxtrap River and Manuels River drainage systems, respectively. No significant stream and river drainage systems are present within Indian Meal Line, Old Broad Cove Road, Windsor Heights, Logy Bay-Middle Cove-Outer Cove, and Torbay-Flatrock sub-ADAs. However, a number of small watercourses are present in these areas that drain directly to the coast. In addition, numerous ponds

are scattered throughout the drainage catchment areas of the ADA, the most significant of which are present in the vicinity of the Goulds-Kilbride sub-ADA, and include Cochrane Pond, Paddys Pond, Thomas Pond, and Bay Bulls Big Pond. The large water bodies of Petty Harbour – Long Pond and Windsor Lake border the boundaries of several of the drainage catchment areas of the ADA, but do not contribute flow to these regions.

Four (4) surface water Public Protected Water Supply Areas (PPWSA) overlap the St. John's ADA and its drainage catchment areas, including St. John's - Bay Bulls – Big Pond, located in the vicinity of the Goulds-Kilbride sub-ADA, Torbay – North Pond and South Pond and Pouch Cove – North Three Island Pond, located in the vicinity of the Torbay-Flatrock sub-ADA, and Portugal Cove – St. Philips – Blast Hole Pond, located in the vicinity of the Indian Meal Line, Old Broad Cove Road, Windsor Heights sub-ADAs. No other PPWSAs are present within the St. John's ADA and its drainage catchment areas. However, the eastern boundary of the Goulds-Kilbride sub-ADA drainage catchment area borders the St. John's – Petty Harbour – Long Pond PPWSA, and the southern boundary of the Old Broad Cove Road and Windsor Heights sub-ADAs drainage catchment areas borders the St. John's – Windsor Lake PPWSA. In addition, two potential future water supplies have been identified within the drainage catchment areas of the ADA, including Great Pond, located within the drainage catchment area of the Torbay-Flatrock sub-ADA, and Thomas Pond, located within the drainage catchment area of the Goulds-Kilbride sub-ADA.

2.1.3 Climate, Vegetation & Agricultural Land Use

The St. John's ADA is located within the Maritime Barrens ecoregion, which extends from the east to the west coast of Newfoundland along the south-central portion of the island. The St. John's ADA is located within the Northeast Barrens subregion, and is characterized by lower fog frequency and somewhat warmer summers compared to other areas of the ecoregion. Climate data obtained from Environment Canada's St. John's West monitoring station dating back to 1971 was used to characterize climatic conditions in the ADA. The monthly mean temperature in the area is 5.0°C, ranging from a high of 15.7°C in July to a low of -5.2°C in February. Average annual precipitation in the area is 1,572 mm, of which 80% falls as rainfall and 20% as snowfall. January is typically the wettest month, and July is typically the driest month (Environment Canada, 2008). In the ADA, there are an average of approximately 1,269 growing degree days (base temperature 5^{o}C) for the year and 1,141 growing degree days for the vegetative season (i.e., May to September).

The landscape in the vicinity of the St. John's ADA is dominated by small stands of forest broken by huge expanses of heath barrens, particularly in coastal areas. The main tree species is balsam fir in association with black spruce and white birch. Slope and basin bogs and fens are scattered throughout. Based on agricultural land use information provided by the NL Department of Natural Resources Agrifoods Division, approximately 1,529 hectares (i.e., 12% of the total landmass of the ADA) is currently utilized for agriculture, with forage and pasture land representing the most significant proportion of the ADA's agricultural land use.

2.2 Geology

2.2.1 Surficial Geology

The surficial geology of the St. John's ADA is summarized in Drawing No. 1034406-2-2 in Appendix 2a, and is based on most recent 1:50,000 scale mapping of the area by Batterson (2000a & b) and Catto and Taylor (1998a & i), as well as descriptions of surficial geology provided in Heringa (1981) and King (1990). 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 ADA 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 of the veneer and moraine tills are variable and bedrock-controlled, but generally consist of a very stony, loamy sand derived from siliciclastic sediments. The veneer and moraine tills are locally eroded and dissected, particularly along stream and river channels, and are dissected with meltwater channel scars. Extensive areas of hummocky till are present in the vicinity of the Goulds – Kilbride sub-ADA, and are characterized by irregular drift hills and unoriented, rounded ridges. In addition, local areas of lineated and ridged till occur in the vicinity of the Logy Bay - Middle Cove - Outer Cove and Torbay - Flatrock sub-ADAs, and contain various streamlined features including drumlins, flutes and craig and tail structures. Sand and gravel deposits of glacial outwash and fluvial origin occur sparingly within the ADA, and are limited to narrow tracts along Raymond Brook within the Goulds – Kilbride sub-ADA and the Manuels River within the Manuels River sub-ADA. Along with glacial units, local deposits of organic and peaty soils are scattered 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 and coastal cliffs. Bedrock outcrops may be partially or fully concealed by a thin mat of vegetation and sparse forest. However, where exposed bedrock outcrops are commonly streamlined and display glacial striations. Streamlined glacial features in the area indicate both northwest and northeast coast - directed ice flow. Available well logs indicate an average overburden thickness in the St. John's ADA and surrounding area of approximately 8 m.

2.2.2 Bedrock & Structural Geology

The bedrock geology of the St. John's ADA is summarized in Drawing No. 1034406-2-3 in Appendix 2a, 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 by King (1990), Batterson & Taylor (2004) and Sparkes (2006).

The St. John's ADA lies within the Avalon tectonostratigraphic zone and is underlain by late Precambrian sedimentary and volcanic rocks. The oldest rocks in the area underlie the western extent of the Manuels River, Goulds - Kilbride, and Old Broad Cove Road sub-ADAs and comprise bimodal volcanic and volcaniclastic rocks of the Harbour Main Group. In the vicinity of the Foxtrap - Gull Pond sub-ADA, the volcanic rocks of the Harbour Main Group are intruded by Precambrain to Cambrain granitoid rocks of the Holyrood Intrusive Suite. The Harbour Main group is conformably overlain by a thick, shoaling-upward sequence of marine, deltaic, and fluvial siliciclastic rocks belonging to the Conception, St. John's and Signal Hill groups, respectively.

The Conception group is the most widespread marine siliciclastic sequence on the Avalon Peninsula, underlying significant portions of the ADA, and is characterized by green to grey fine-grained siliceous sedimentary rocks, as well as minor volcaniclastic rocks. The St. John's Group, which overlies the Conception Group, occurs within the eastern portions of the Goulds - Kilbride, Logy Bay - Middle Cove-Outer Cove, and Torbay - Flatrock sub-ADAs, and mainly comprises dark grey shale and sandstone. The Signal Hill group is gradational with the underlying St. John's Group along the eastern boundary of the ADA, and mainly comprises red sandstone, red conglomerate and greenish grey sandstone.

The Precambrian volcanic and sedimentary rocks that underlie the ADA have undergone regional-scale folding and eastward-directed trusting related to the Devonian Acadian orogenesis. Rocks in the area are folded into open to locally tight north-northeast trending anticlines and synclines with near vertical axial surfaces and with associated doubly plunging parasitic fold. Several examples of large-scale folds in the area include the Bay Bulls Syncline and Country Road Anticline located in the vicinity of the Goulds – Kilbride sub-ADA. Numerous high-angle and eastward-directed thrust faults are also common, the most significant of which is the Topsail Fault, which extends north-south along much of eastern Conception Bay and separates the Precambrian rocks to the east from Cambro-Ordovican rocks in the west. In addition, numerous joint sets and fracture zones occur within rocks underlying the ADA related to deformation.

2.3 Hydrogeology

2.3.1 Hydrostratigraphy

The groundwater potential of the various geological units within the St. John's ADA 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 2,281 drilled bedrock wells and 5 drilled surficial wells from fifteen communities in the ADA and surrounding area had adequate well data to evaluate the groundwater potential of various surficial and bedrock strata in the ADA. 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 map provided in Drawing No. 1034406-2-3 in Appendix 2a.

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 St. John's ADA and surrounding area 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 ADA and

surrounding area. Therefore, in the absence of this data, the groundwater potential of the various geological strata in the St. John's ADA is defined based on the estimated well yields obtained from the driller's records.

2.3.1.1 Surficial Hydrostratigraphic Units

The surficial deposits within the St. John's ADA 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 2.2. No water well information was available for the sand and gravel deposits present in the ADA. Therefore groundwater potential within this unit was inferred based on well records for similar overburden material in the Terra Nova ADA.

Till Deposits

The till deposits form both thin veneer and more extensive moraine deposits over much of the ADA and are comprised of a very stony, loamy sand. Five (5) wells from the communities of Doyles, Outer Cove, and St. Thomas were used to characterize the groundwater potential of this unit in the ADA. Based on records of these wells 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 ADA, and are limited to narrow tracts along Raymond Brook within the Goulds – Kilbride sub-ADA and Manuels River within the Manuels River sub-ADA. These deposits are potentially significant groundwater aquifers but there are no documented data on their groundwater potential in the St. John's ADA. However, 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 2.2 Summary of Overburden Drilled Well Information for St. John's ADA

Overburden Unit	Communities	No. of Wells	Well Depth (m)		Well Yield (L/min)	
			Mean (Median)	Range	Mean (Median)	Range
Till	Doyles, Outer Cove, St. Thomas	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 sand and gravel deposits based on well data from the Terra Nova ADA

2.3.1.2 Bedrock Hydrostratigraphic Units

Well record information is available for the majority of bedrock units located within the ADA, including the Harbour Main, Conception, St. John's, and Signal Hill groups. The well yield and depth characteristics of these various strata are summarized in Table 2.3.

No water well information was available for the Precambrian to Cambrian granitic rocks of the Holyrood Intrusive Suite that underlie the Foxtrap - Gull Pond sub-ADA. Therefore groundwater potential within this unit was inferred based on well records for similar granitic rocks in the Terra Nova ADA, located in Eastern Newfoundland (as described in Section 9.0).

Harbour Main Group

A total of 744 well records from the communities of Portugal Cove, Bauline, St. Philips, and St. Thomas were used to characterize the groundwater potential of the Harbour Main Group in the ADA. This unit underlies the western portion of the Manuels River and Goulds – Kilbride (Zone I) sub-ADAs. Based on well data, the Harbour Main Group strata in the St. John's ADA are considered capable of providing wells with low to moderate yields, having water yields ranging from 1 to 455 L/min at well depths of 5 – 228 m, and an average yield of 18 L/min at 74 m depth. However, median yield and depth estimates of 9 L/min at 73 m depth are more likely representative of the typical groundwater potential of this unit.

Conception Group

A total of 644 well records from the communities of Pouch Cove, Windsor Heights, Torbay and Bauline Line were used to characterize the groundwater potential of the Conception Group in the ADA. This unit underlies the majority of the ADA, occurring beneath Indian Meal Line, Windsor Heights, and Old Broad Cove Road sub-ADAs, Zones I and III of the Torbay – Flatrock sub-ADA, Zones I and III of the Logy Bay-Middle Cove-Outer Cove sub-ADA, as well as portions of Zone I of the Goulds - Kilbride sub-ADA, Zone II of the Torbay – Flatrock sub-ADA, and Manuels River sub-ADA. Based on well data, the Conception Group strata are considered capable of providing wells with low to moderate yields, having water yields ranging from 0.3 to 450 L/min at well depths of 12 to 213 m, and an average yield of 17 L/min at 72m depth. However, median yield and depth estimates of 9 L/min at 72 m depth are more likely representative of the typical groundwater potential of this unit.

St. John's Group

A total of 688 well records from the communities of St. John's, Mount Pearl, Middle Cove, and Goulds were used to characterize the groundwater potential of the St. John's Group in the ADA. This unit underlies the eastern portion of Zone I and the western portion of Zones II and III of the Goulds - Kilbride sub-ADA, and Zones II and IV of the Logy Bay-Middle Cove-Outer Cove sub-ADA. Based on well data, the St. John's Group strata are considered capable of providing wells with moderate yields, having water yields ranging from 1 to 546 L/min at well depths of 6 to 229 m, and an average yield of 24 L/min at 70 m depth. However, median yield and depth estimates of 10 L/min at 64 m depth are more likely representative of the typical groundwater potential of this unit.

Signal Hill Group

A total of 205 well records from the communities of Doyles, Logy Bay, and Outer Cove were used to characterize the groundwater potential of the Signal Hill Group in the ADA. This unit is locally present in several areas of the ADA, including within the eastern portion of Zone I of the Torbay – Flatrock sub-ADA, and Zones II, III, and IV of the Goulds - Kilbride sub-ADA. Based on well data, the Signal Hill Group strata are considered capable of providing wells with low to moderate yields, having water yields ranging from 0.6 to 225 L/min at well depths of 13 to 152 m, and an average yield of 23 L/min at 58 m depth. However, median yield and depth estimates of 9 L/min at 55 m depth are more likely representative of the typical groundwater potential of this unit.

Precambrian to Cambrian granitic rocks

No documented data is available for the groundwater potential of the Precambrian to Cambrian granitic rocks that underlie the Foxtrap – Gull Pond sub-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 2.3 Summary of Bedrock Drilled Well Information for St. John's ADA

Rock Group	Rock Type	Communities	No. of Wells	Well Depth (m)		Well Yield (L/min)	
				Mean (Median)	Range	Mean (Median)	Range
Harbour Main	Volcanic rocks and minor siliciclastic sedimentary rocks , mafic and felsic intrusions	Portugal Cove, Bauline, St. Philips, St. Thomas	744	73.7 (73)	5-228	18.3 (9)	0.5-454.6
Conception	Siliceous sandstone, shale and volcaniclastic rocks	Pouch Cove, Windsor Heights, Torbay, Bauline Line	644	72.1 (67.1)	12-213	16.6 (9)	0.3-450
St. John's	Shale and sandstone	Goulds, Mount Pearl, Middle Cove, St. John's	688	69.8 (64)	6.4-228.6	23.5 (10)	1-545.5
Signal Hill	Siliciclastic sedimentary rocks, and minor limestone and volcanic rocks	Doyles, Logy Bay, Outer Cove	205	58.3 (54.9)	13.2-152.4	22.9 (9.1)	0.6-225
Granite*	Granite and other granitoid intrusions	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

2.3.2 Groundwater Flow System

The St. John's ADA and surrounding area is 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 ADA is controlled by water table conditions and local variations in topography. Groundwater is thought to be recharging along the 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 along the interior of the northeast peninsula. 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.

2.4 Water Quality

2.4.1 Surface Water Quality

Surface water quality data for the St. John's ADA was obtained from two sources, including:

1. Ambient water quality data collected as part of the Canada–Newfoundland Water Quality Monitoring Agreement, from four (4) water quality monitoring sites in the ADA and surrounding area –
    - Raymond Brook (NF02ZM0017, 1986-2007);
    - South Brook (NF02ZM0176, 1997 – 2007);
    - Manuels River (NF02ZM0294, 2004-2007); and,
    - Kelligrews River (NF02ZM0183, 1998-2007).
2. Water quality monitoring data collected by the NL Department of Environment - Water Resources Management Division from five (5) protected public surface water supplies in the ADA and surrounding area -
    - St. John's – Goulds, Bay Bulls-Big Pond (WS-S-0691, 1988-2006);
    - St. John's – Petty Harbour, Long Pond (WS-S-0692, 1995-2002);
    - St. John's – Windsor Lake, Long Pond (WS-S-0693, 1995-2006);
    - Torbay, North Pond (WS-S-0740, 1988-2006); and,
    - Portugal Cove - St. Phillips, Blast Hole Pond (WS-S-0594, 1987 – 2003).

A summary of chemical data obtained from these surface water sources over their respective monitoring periods is provided in Tables 2.4 and 2.5 in Appendix 2b, 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 ADA and surrounding area can be classified as sodium-calcium-chloride-sulfate-bicarbonate (Na-Ca-Cl-SO_4-HCO_3) type water. Surface water in the area is soft to slightly hard, neutral to slightly acidic, and of low alkalinity. Classification of surface water according to dissolved-solids and specific conductance indicates fresh conditions.

With the exception of iron in the St. John's – Windsor Lake and Portugal Cove - St. Phillips public surface water supplies, manganese in the St. John's – Goulds, St. John's – Petty Harbour, and St. John's – Windsor Lake public surface water supplies, and pH and turbidity at all locations, concentrations of all other parameters tested at the public surface water supplies meet CDWQG. In addition, levels of arsenic, iron, lead, manganese, pH and turbidity that did not meet CDWQG were detected at some of the ambient water quality monitoring sites in the ADA and surrounding area. In particular, levels of arsenic at or slightly exceeding the CDWQG were detected at Raymond Brook and South Brook, and levels of lead that exceeded the CDWQG were detected at Manuels River, over the

respective monitoring periods. The guidelines for iron, manganese, pH and turbidity 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, and turbidity and corrosion in the case of pH.

Further, Raymond Brook, South Brook and Kelligrews River had concentrations of manganese over their respective monitoring periods that exceeded CCME CWQG-AWU for irrigation water use, and the Torbay – North Pond had concentrations of arsenic over its monitoring period that exceeded CCME CWQG-AWU for livestock water use.

Based on chemical data, surface water quality within the ADA is generally considered good to excellent, returning average Canadian Water Quality Index (CWQI) values ranging from 84.5 to 96. However, a negative Langelier Index in the public surface water supplies indicates that water is unsaturated with calcium carbonate and will tend to be corrosive, leading to potential leaks in the distribution system. Raymond Brook and South Brook are not considered potable water sources, and would require treatment for disinfection, as well as to reduce elevated concentrations of arsenic and lead, and to improve the aesthetic quality of the water. In addition, maximum concentrations of manganese in the Raymond Brook, South Brook and Kelligrews River, and arsenic in the Torbay – North Pond public surface water supply that exceeded CCME CWQG-AWU may limit usage of these surface water sources as potential agricultural water supplies without appropriate treatment.

2.4.2 Groundwater Quality

The groundwater quality data for the St. John's ADA consists of analyses from 19 private drilled wells from the communities of Goulds, Portugal Cove, Bauline Line, Bauline, Pouch Cove, St. John's and St. Philips, as well as one (1) protected public supply drilled well for the community of Goulds (WS-G-0865) 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 2.6 and 2.7 in Appendix 2b, 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-Na-Cl-SO_4-HCO_3) and calcium-sodium-bicarbonate-chloride-sulfate (Ca-Na-HCO_3-Cl-SO_4) type waters. Groundwater in the area ranges from slightly to very hard, neutral to slightly acidic, and of low to moderate alkalinity. Classification of groundwater according to dissolved-solids and specific conductance indicates fresh conditions.

With the exception of iron, chloride, manganese, pH, turbidity and total dissolved solids concentrations in some of the private and public supply wells, concentrations of all other parameters tested meet CDWQG. The guidelines for iron, manganese, chloride, pH, turbidity and total dissolved solids 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, turbidity and total dissolved solids, and corrosion in the case of chloride and pH.

Further, the concentrations of chloride, manganese, and total dissolved solids detected in several private wells in the communities of St. John's and Bauline Line also exceeded CCME CWQG-AWU for irrigation water use.

Insufficient monitoring data was available to determine Canadian Water Quality Index (CWQI) values for the wells. However, available chemical data indicates that shallow groundwater in the ADA and surrounding area is of good quality. However, treatment might be considered to improve the aesthetic quality of the water. In addition, concentrations of chloride, manganese, and total dissolved solids detected in several private wells in the communities of St. John's and Bauline Line that exceeded CCME CWQG-AWU may limit usage of these groundwater sources as potential agricultural water supplies without appropriate treatment.

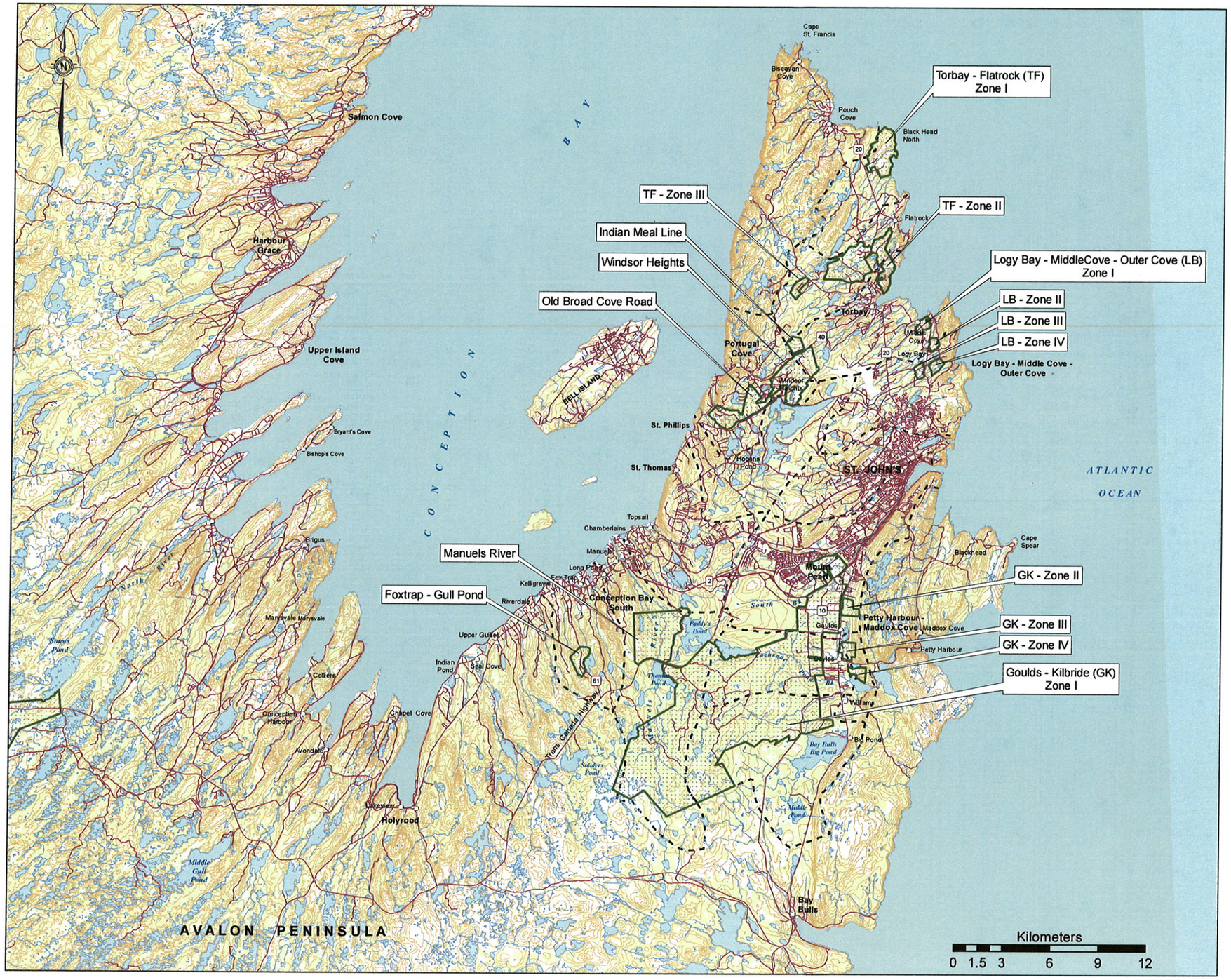
2.5 Groundwater Recharge & Availability

Recharge to the shallow groundwater system underlying the ADA 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 St. John's ADA is estimated on the basis of a local groundwater catchment area equivalent to the area of the ADA of approximately 12,780 hectares, and a conservative recharge coefficient of 10% of the mean annual rainfall (i.e., 10% of 1,572 mm, equivalent to 157 mm). Based on these values, the groundwater recharge to the St. John's ADA is estimated at $2x10^7 m^3$/year or 1,572 m^3/hectares/yr.

With the exception of one public groundwater supply in the vicinity of the Goulds – Kilbride sub-ADA that serves approximately 16 households (i.e., Goulds - Barton's Road (WS-G-0865)), groundwater use in the area is currently limited to minor domestic, commercial and industrial wells. No information is available regarding existing agricultural (i.e., irrigation and livestock) water demands in the St. John's ADA, 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 ADA.

APPENDIX 2a

Drawings



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

PROJECT TITLE:

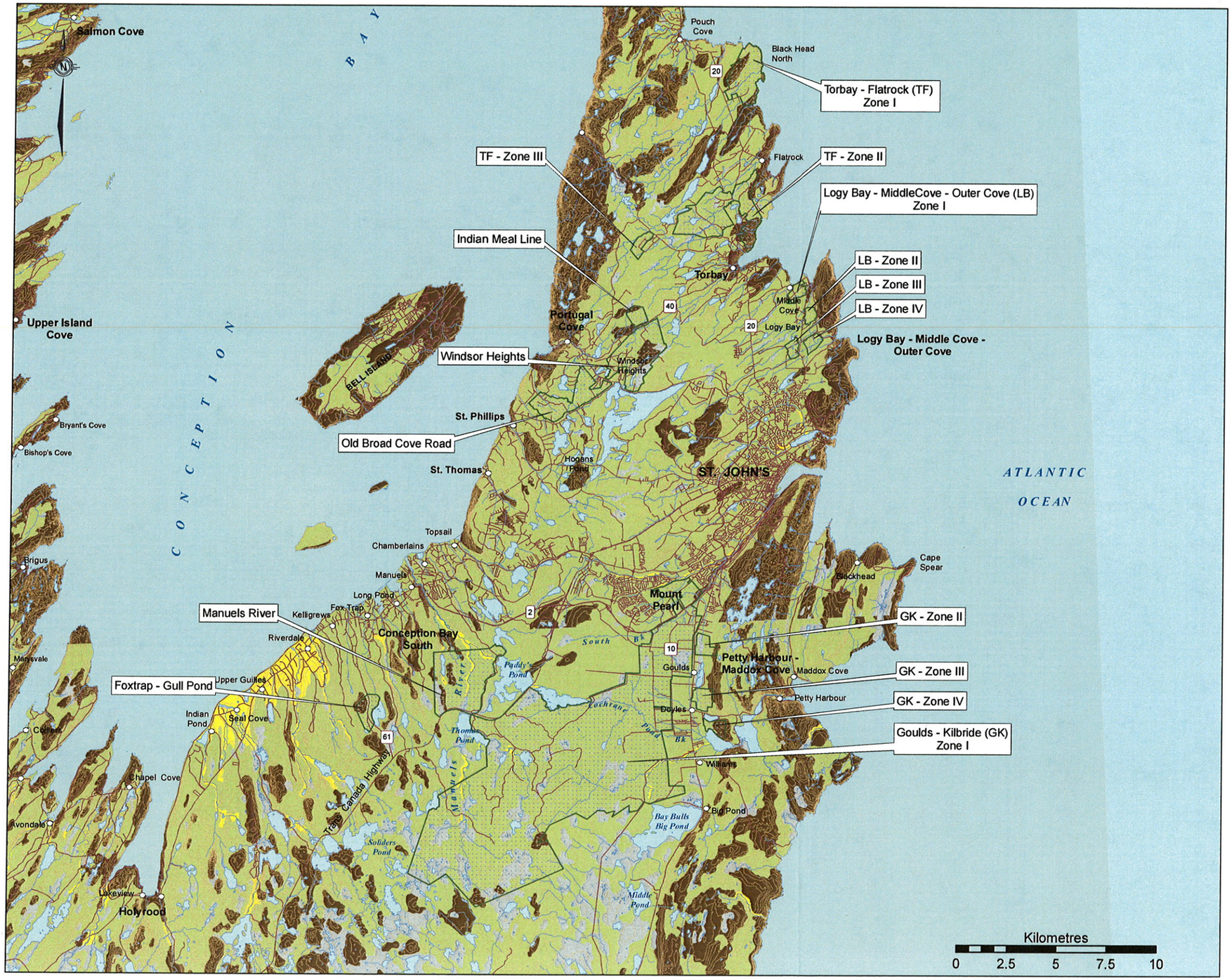
HYDROGEOLOGY OF AGRICULTURAL DEVELOPMENT AREAS, NEWFOUNDLAND AND LABRADOR

DRAWING TITLE:

ST. JOHN'S ADA LOCATION AND DRAINAGE

Jacques Whitford

SCALE: 1:250,000	DATE: 16/05/2008
DRAWN BY: JLB	CHECKED BY:
EDITED BY: EM	REV. No. 0
DRAWING No.: 1034406-2-1	
MAP FILE: 1034406_ADA1_Drainage.mxd	



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:

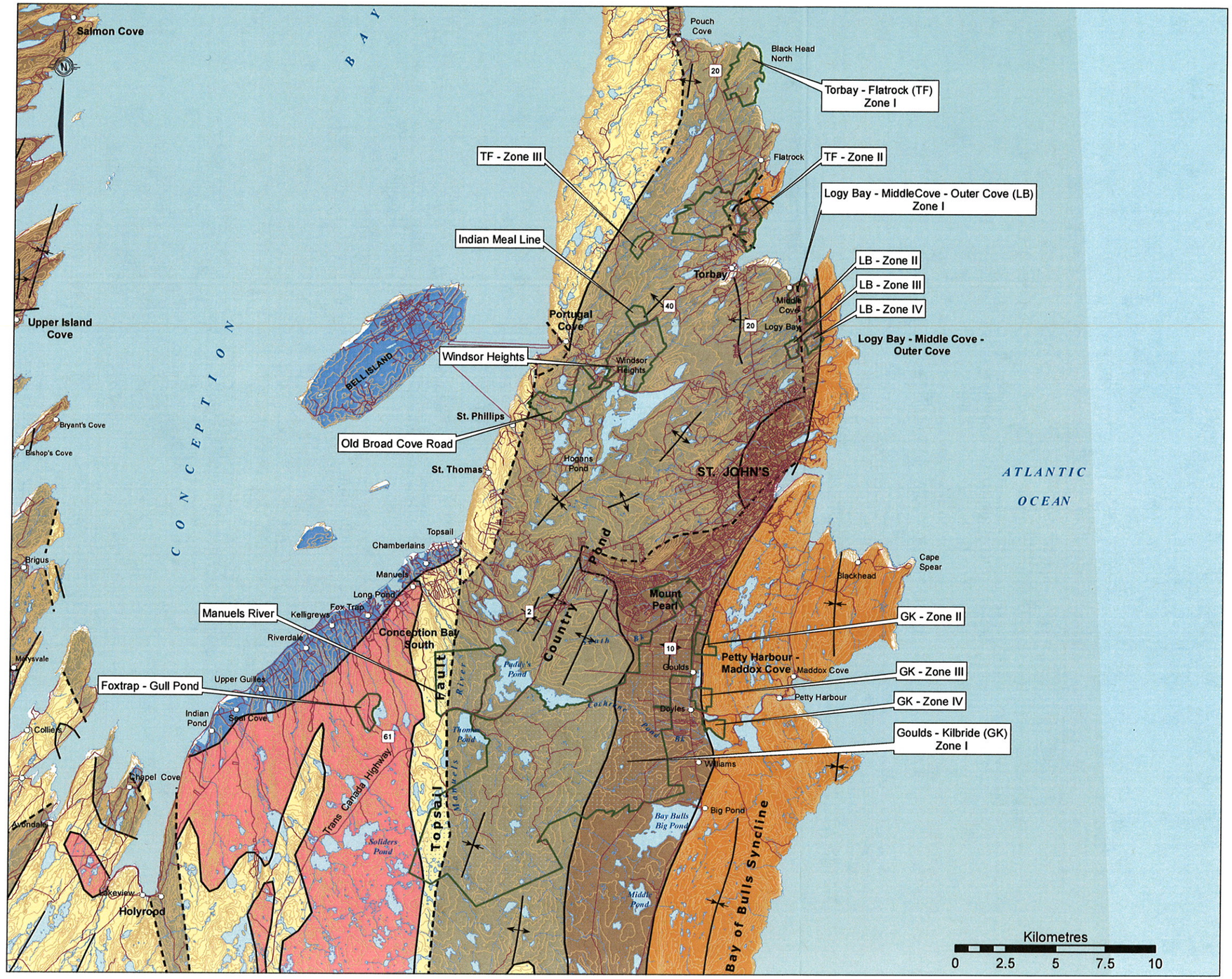
HYDROGEOLOGY OF AGRICULTURAL DEVELOPMENT AREAS, NEWFOUNDLAND AND LABRADOR

DRAWING TITLE:

ST. JOHN'S ADA SURFICIAL GEOLOGY

Jacques Whitford

SCALE: 1:200,000	DATE: 03/06/2008
DRAWN BY: JLB	CHECKED BY:
EDITED BY: MCH	REV-NO. 02
DRAWING No. 1034406-2-2	
MAP FILE: 1034406_ADA1_SurficialGeol.MXD	



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:

ST. JOHN'S ADA BEDROCK GEOLOGY

Jacques Whitford

SCALE:	1:200,000	DATE:	16/05/2008
DRAWN BY:	JLB	CHECKED BY:	
EDITED BY:	JLB	REV. No.	02
DRAWING No.:	1034406-2-3		
MAP FILE:	1034406-XX.MXD		

APPENDIX 2b

Water Chemistry Data

Table 2.4 Surface Water Chemistry, NL Ambient Water Quality Monitoring Sites, St. John's ADA Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		Raymond Brook NF02ZM0017 (1986-2007)[1]			South Brook NF02ZM0176 (1997-2007)[1]			Manuel's River NF02ZM0294 (2004-2007)[1]			Kelligrews River NF02ZM0183 (1998-2007)[1]		
			Irrigation Water	Livestock Water	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Alkalinity	mg/L $CaC0_3$	na	na	na	0.50	19.50	4.16	3.80	19.50	11.01	11.7	11.7	11.7	8.4	28.2	16.21
Aluminum	mg/L	na	5	5	0.02	0.66	0.12	0.02	0.66	0.12	0.02	0.18	0.10	0.03	0.50	0.23
Ammonia	mg/L	na	na	na	0.00004	0.0001	0.00006	0.00004	0.0001	0.0001	-	-	-	-	-	-
Antimony	mg/L	0.006	na	na	0.0001	0.0005	0.0002	0.0001	0.0005	0.0002	0.000008	0.00002	0.00001	0.000004	0.00004	0.00002
Arsenic	mg/L	0.01	0.1	0.025	0.0003	0.01	0.002	0.004	0.02	0.01	0.0001	0.0005	0.0002	0	0.0002	0.0001
Barium	mg/L	1	na	na	0.05	0.06	0.05	0.00001	0.06	0.03	0.01	0.03	0.01	0.02	0.05	0.03
Beryllium	mg/L	na	0.1	0.1	0.004	0.02	0.01	-	-	-	0.000006	0.00003	0.00002	0.00001	0.06	0.01
Bicarbonate	mg/L $CaC0_3$	na	na	na	0.00001	0.00005	0.00002	0.005	0.01	0.01	-	-	-	-	-	-
Boron	mg/L	5	0.5 - 6	5	0.005	0.01	0.01	-	-	-	0.002	0.006	0.005	0.01	0.03	0.01
Bromide	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/L	0.005	0.005	0.08	0.00001	0.0002	0.00008	0.00001	0.0001	0.0001	0	0.00002	0.00001	0.000008	0.0001	0.00003
Calcium	mg/L	na	na	na	0.86	14.2	7.69	2.65	14.2	8.83	-	-	-	6.24	9.98	8.00
Carbonate	mg/L $CaC0_3$	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-
Chloride	mg/L	250*	100 - 700	na	44.5	248	91.3	44.5	248	91.3	15.5	88	33.4	18.6	76.1	46.9
Chromium	mg/L	0.05	0.005	0.05	0.0001	0.003	0.0002	0.0001	0.004	0.0004	0.0001	0.0001	0.0001	0.0001	0.001	0.0002
Copper	mg/L	1*	0.2 - 1,000	0.5-5	0.0002	0.0101	0.0011	0.0008	0.01	0.002	0.0002	0.0004	0.0003	0.0003	0.007	0.0009
Dissolved Organic Carbon	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	2.5	15.70	6.75
Fluoride	mg/L	1.5	1	1 - 2	-	-	-	-	-	-	-	-	-	-	-	-
Hardness	mg/L $CaC0_3$	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-
Iron	mg/L	0.3*	5	na	0.06	1.20	0.28	0.10	1.07	0.29	0.06	0.64	0.29	0.21	0.65	0.34
Kjeldahl Nitrogen	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-
Langelier Index	-	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-
Lead	mg/L	0.01	0.2	0.1	0.0001	0.004	0.0005	0.0001	0.004	0.0005	0.02	0.13	0.05	0.00003	0.0009	0.0002
Magnesium	mg/L	na	na	na	0.44	2.87	1.67	0.71	2.87	1.88	-	-	-	1.33	2.01	1.675
Manganese	mg/L	0.05*	0.2	na	0.02	**0.47**	0.06	0.03	**0.47**	0.09	-	-	-	0.08	**0.45**	**0.20**
Mercury	mg/L	0.001	na	0.003	0.00001	0.00002	0.00001	0.00001	0.00001	0.00001	-	-	-	0.000005	0.000007	0.000006
Nickel	mg/L	na	0.2	1	0.0002	0.0066	0.0004	0.0002	0.0009	0.0004	0.0001	0.0003	0.0002	0.0004	0.003	0.001
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	5.36	7.48	6.27	6.34	7.48	6.96	6.32	7.43	6.70	5.73	7.58	6.86
Potassium	mg/L	na	na	na	0.26	0.26	0.26	0.57	1.63	1.20	-	-	-	0.82	1.15	0.94
Reactive Silica	mg/L SiO2	na	na	na	0.42	4.15	2.10	-	-	-	-	-	-	-	-	-
Selenium	mg/L	0.01	0.02 - 0.05	0.05	0.0001	0.0002	0.0001	0	0	0	0.00005	0.00009	0.0001	0.00006	0.0001	0.0001
Silver	mg/L	na	na	na	0	0	0	0.000001	0.0001	0.00002	0.000001	0.000004	0.000002	0	0.0002	0.00003
Sodium	mg/L	200*	na	na	3.05	74.8	36.34	14.4	74.8	41.88	-	-	-	21.5	33.6	24.93
Specific Conductance	uS/cm	na	na	na	-	-	-	-	-	-	71.2	321	137.50	85.9	339	215.27
Sulphate	mg/L	500*	na	1,000	5.62	14.3	8.53	5.62	14.3	8.53	2.48	6	3.69	4.82	16.5	9.22
Sulphide	mg/L H2S	0.05*	na	na	-	-	-	-	-	-	-	-	-	-	-	-
Thallium	mg/L	na	na	na	0.000001	0.000008	0.000003	0	0.000008	0.000002	0.000001	0.00004	0.00001	0.000001	0.00004	0.00001
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	0.34	0.02	0.01	0.34	0.05	0.001	0.007	0.005	0.002	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	0.07	4.60	0.58	0.21	7.60	1.29	0.16	1.2	0.44	0.14	2.97	0.74
Uranium	mg/L	0.02	0.01	0.2	0.000004	0.00002	0.000008	0.000004	0.00002	0.000008	0.000003	0.000006	0.000004	0.0001	0.001	0.0005
Vanadium	mg/L	na	0.1	0.1	0.0001	0.0005	0.0002	0.0001	0.0008	0.0002	0.0001	0.0004	0.0003	0.0002	0.001	0.0005
Canadian Water Quality Index	-	-	-	-	-	-	85.07	-	-	84.69	-	-	87.34	-	-	84.5
Zinc	mg/L	5*	1 - 5	50	0.0002	0.04	0.003	0.005	0.04	0.01	0.00053	0.00502	0.002	0.001	0.017	0.008

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 2.5 Surface Water Chemistry, Public Water Supply, St. John's ADA
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		St. John's - Bay Bulls Big Pond WS-S-0691 (1988 - 2006)[1]			St. John's - Petty Harbour Long Pond WS-S-0692 (1995 - 2002)[1]			St. John's - Windsor Lake WS-S-0693 (1995 - 2006)[1]			Torbay - North Pond WS-S-0740 (1988 - 2006)[1]			Portugal Cove-St. Phillips Blast Hole Pond WS-S-0594 (1987-2003)[1]		
			Irrigation	Livestock	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Alkalinity	mg/L $CaCO_3$	na	na	na	0	8	2.75	0.25	2.5	1.41	0	7	2	0	7	2.93	0.46	7	2.89
Aluminum	mg/L	na	5	5	0.025	0.28	0.09	0.025	0.49	0.12	0	0.14	0.05	0.005	0.11	0.04	0.025	0.33	0.13
Ammonia	mg/L	na	na	na	0	0.07	0.02	0.005	0.05	0.01	0	0.12	0.03	0	0.07	0.02	0.01	0.025	0.01
Antimony	mg/L	0.006	na	na	0	0.0005	0.0002	0.0005	0.0005	0.001	0	0.0005	0.0003	0	0	0	0.0005	0.0005	0.001
Arsenic	mg/L	0.01	0.1	0.025	0	0.005	0.001	0.001	0.001	0.001	0	0.001	0.0005	0	**0.025**	0.004	0.001	0.005	0.003
Barium	mg/L	1	na	na	0	0.005	0.002	0.005	0.005	0.01	0	0.005	0.003	0	0.025	0.01	0.005	0.025	0.01
Beryllium	mg/L	na	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bicarbonate	mg/L $CaCO_3$	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron	mg/L	5	0.5 - 6	5	0	0.03	0.01	0.03	0.03	0.03	0	0.03	0.01	0	0.1	0.02	0.02	0.07	0.04
Bromide	mg/L	na	na	na	0	0.03	0.02	0.03	0.03	0.03	0	0.03	0.02	0	0.03	0.02	0.03	0.03	0.03
Cadmium	mg/L	0.005	0.005	0.08	0	0.001	0.0003	0.00005	0.001	0.0004	0	0.001	0.0002	0	0.001	0.0003	0.00005	0.001	0.0003
Calcium	mg/L	na	na	na	0	7	0.97	0.38	9	1.84	0	10	1.77	0	2	1.17	0.5	3	1.26
Carbonate	mg/L $CaCO_3$	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloride	mg/L	250*	100 - 700	na	5	13	9.29	4	7	6.29	8	19	14.62	7	13	10.04	6	13	9.11
Chromium	mg/L	0.05	na	na	0	0.005	0.002	0.0005	0.005	0.003	0	0.005	0.001	0	0.005	0.002	0.00025	0.005	0.002
Copper	mg/L	1*	0.2 - 1	0.5-5	0.001	0.067	0.01	0.001	0.01	0.01	0	0.005	0.002	0	0.06	0.01	0.001	**0.2**	0.02
Dissolved Organic Carbon	mg/L	na	na	na	1.6	4.3	3.11	1.3	2.9	2.31	0.6	3.5	2.19	0.3	3.6	2.60	2.2	9.8	5.79
Fluoride	mg/L	1.5	1	1 - 2	0	0.39	0.04	0.005	0.05	0.03	0	0.11	0.03	0	0.28	0.04	0.005	0.37	0.07
Hardness	mg/L $CaCO_3$	na	na	na	0	18	2.94	0.5	23	11.75	0	29	6.06	0	5	2.67	0.5	12	6.00
Iron	mg/L	0.3*	5	na	0.005	0.24	0.07	0.005	0.18	0.06	0	0.44	0.06	0.005	0.08	0.03	0.005	0.36	0.16
Kjeldahl Nitrogen	mg/L	na	na	na	0	0.41	0.15	0.03	0.25	0.16	0.03	0.22	0.14	0.03	0.53	0.19	0.025	0.41	0.22
Langelier Index	-	na	na	na	-4.71	-2.53	-3.81	-4.81	-4.48	-4.64	-6.34	-1.66	-4.52	-7.3	-3.11	-4.79	-6.78	-3.6	-4.81
Lead	mg/L	0.01	0.2	0.1	0	0.004	0.001	0.001	0.001	0.001	0	0.001	0.001	0	0.005	0.001	0.001	0.002	0.001
Magnesium	mg/L	na	na	na	0	0.79	0.42	0.25	0.81	0.54	0	1	0.48	0	1.01	0.65	0.5	1.37	1.00
Manganese	mg/L	0.05*	0.2	na	0.002	0.106	0.02	0.019	0.05	0.03	0	0.11	0.02	0.003	0.046	0.02	0.003	0.045	0.02
Mercury	mg/L	0.001	na	0.003	0	0.00005	0.00002	0.00005	0.00005	0.0001	0	0.00005	0.00003	0	0.0005	0.0002	0.00005	0.0005	0.0003
Nickel	mg/L	na	0.2	1	0	0.005	0.003	0.003	0.005	0.004	0	0.005	0.002	0	0.005	0.003	0.003	0.005	0.004
Nitrate	mg/L N	45	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate + Nitrite	mg/L N	na	na	100	0	0.05	0.01	0.002	0.05	0.02	0	0.05	0.02	0	0.05	0.01	0.002	0.05	0.02
Nitrite	mg/L	na	na	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthophosphate	mg/L P	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pH	Units	6.5-8.5*	na	na	5.4	7	6.15	5.7	6.4	5.91	5.7	6.4	6.10	5.9	7.1	6.32	5.4	6.5	6.01
Potassium	mg/L	na	na	na	0	0.52	0.24	0.18	0.5	0.32	0	0.5	0.29	0	0.5	0.32	0.21	0.53	0.35
Reactive Silica	mg/L SiO2	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Selenium	mg/L	0.01	0.02 - 0.05	0.05	0	0.001	0.0004	0.001	0.001	0.001	0	0.001	0.001	0	0.005	0.001	0.001	0.005	0.002
Silver	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/L	200*	na	na	4	9	5	4	5	4	5	13	9	5	8	6	4	7	6
Specific Conductance	uS/cm	na	na	na	28	62	43.1	33.4	36	34.6	46.3	84	66.4	40	72.4	50.7	34.5	75.7	48.7
Sulphate	mg/L	500*	na	1,000	1	4	3	2	4	3	3	5	4	3	7	4	2	8	4
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	18	40	29	21	26	24	33	55	43	28	50	34	27	67	37
Total Organic Carbon	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Phosphorus	mg/L	na	na	na	0	0.04	0.01	0.005	0.01	0.01	0	0.03	0.01	0	0.03	0.01	0.003	0.06	0.01
Total Suspended Solids	mg/L	na	na	na	1	2	1.60	1	2	1.40	1	2	1.40	1	2	1.54	1	2	1.45
True Color	TCU	15*	na	na	5	34	21.07	6	17	11.29	2	12	5.85	5	17	11.48	5	76	35.00
Turbidity	NTU	0.3/1.0/0.1**	na	na	0.26	1.8	0.64	0.35	1.57	0.66	0.22	1.17	0.56	0.07	1.7	0.53	0.14	1	0.49
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	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canadian Water	-	-	-	-	92	97	95	-	-	-	94	96	95	94	95	95	-	-	-
Zinc	mg/L	5*	1 - 5	50	0	0.13	0.01	0.003	0.005	0.004	0	0.016	0.004	0	0.03	0.01	0.002	0.03	0.01

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 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 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 2.6 Groundwater Chemistry, Private Drilled Wells, St. John's ADA
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		Communities[1]																
					Goulds		Portugal Cove								Bauline Line	Bauline		Pouch Cove		St. John's			St. Philips
			Irrigation Water	Livestock Water	12673	16207	15596	14432	11845	8600	8601	8603	8612	8631	8458	16275	8460	8662	8672	14696	15771	17742	11455
Alkalinity	mg/L $CaCO_3$	na	na	na	83.5	88.3	-	100	104	14.2	48.2	93.4	73.6	3.6	69.8	101	42.6	103	87.6	46.7	9.02	57.6	44.9
Aluminum	mg/L	na	5	5	-	-	-	0.05	0.025	-	-	-	-	-	-	-	-	-	-	-	0.025	0.05	-
Ammonia	mg/L	na	na	na	0.02	0.03	0.02	0.02	0.01	-	-	-	-	-	-	0.02	-	-	-	0.02	0.01	0.02	-
Antimony	mg/L	0.006	na	na	-	-	-	0.005	0.001	-	-	-	-	-	-	-	-	-	-	-	0.001	0.005	-
Arsenic	mg/L	0.01	0.1	0.025	-	-	-	0.005	0.001	-	-	-	-	-	-	-	-	-	-	-	0.001	0.005	-
Barium	mg/L	1	na	na	-	-	-	0.5	0.05	-	-	-	-	-	-	-	-	-	-	-	0.05	0.5	-
Beryllium	mg/L	na	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bicarbonate	mg/L $CaCO_3$	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron	mg/L	5	0.5 - 6	5	-	-	-	0.05	0.2	-	-	-	-	-	-	-	-	-	-	-	0.2	0.05	-
Bromide	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/L	0.005	0.005	0.08	-	-	-	0.0005	0.0001	-	-	-	-	-	-	-	-	-	-	-	0.0001	0.0005	-
Calcium	mg/L	na	na	na	43	22	36	37	37	6.51	5.65	31.46	21.15	1.81	100.7	33	12.84	142.6	26.9	15	3.01	22	13
Carbonate	mg/L $CaCO_3$	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloride	mg/L	250*	100 - 700	na	**113**	9.2	9.5	19.3	16.7	25	27	31	25	22	**423**	79	20	82	31	26	11.4	15.7	3
Chromium	mg/L	0.05	na	na	-	-	-	0.005	0.0005	-	-	-	-	-	-	-	-	-	-	-	0.001	0.005	-
Copper	mg/L	1*	0.2 - 1	0.5-5	0.005	0.005	-	0.01	0.01	-	-	-	-	-	-	-	-	-	-	-	0.01	0.04	-
Dissolved Organic Carbon	mg/L	na	na	na	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fluoride	mg/L	1.5	1	1 - 2	0.12	0.05	-	0.07	0.1	-	-	-	-	-	-	0.14	-	-	-	0.05	0.1	0.12	0.05
Hardness	mg/L $CaCO_3$	na	na	na	130	68.1	96.6	109	107.9	22	14.6	91.2	56.2	8.5	331.4	104	46.4	388.8	76.8	56.8	13.8	74.3	43.5
Iron	mg/L	0.3*	5	na	0.01	0.01	0.6	0.01	0.363	0.05	0.04	-	-	0.05	-	-	-	0.03	0.04	0.2	0.01	0.01	0.98
Kjeldahl Nitrogen	mg/L	na	na	na	-	-	-	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	-
Langelier Index	-	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lead	mg/L	0.01	0.2	0.1	-	-	-	0.001	0.001	-	-	-	-	-	-	-	-	-	-	-	0.001	0.001	-
Magnesium	mg/L	na	na	na	5.6	3.2	1.62	4.1	3.76	1.36	0.08	3.08	0.82	0.92	19.43	5.2	3.27	7.94	2.33	4.7	1.53	4.7	2.7
Manganese	mg/L	0.05*	0.2	na	0.04	0.06	0.03	0.005	0.11	0.03	0.01	-	-	0.02	-	0.16	0.03	-	0.03	**0.23**	0.01	0.005	0.19
Mercury	mg/L	0.001	na	0.003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/L	na	0.2	1	-	-	-	0.005	0.02	-	-	-	-	-	-	-	-	-	-	-	0.02	0.005	-
Nitrate	mg/L N	45	na	na	0.22	0.004	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate + Nitrite	mg/L N	na	na	100	0.011	0.001	0.004	0.067	0.05	1	-	-	-	-	-	0.86	-	-	-	0.004	0.05	2.6	-
Nitrite	mg/L	na	na	10	-	-	-	0.001	0.05	-	-	-	-	-	-	0.001	-	-	-	0.001	0.05	0.002	-
Orthophosphate	mg/L P	na	na	na	-	-	0.57	-		-		-	-	-	-	-	-	-	-	-	-	-	-
pH	Units	6.5-8.5*	na	na	7.79	7.31	-	8.14	8.15	6.4	9.39	8.25	8.16	5.78	6.85	7.8	6.46	7.75	7.62	7.02	6.7	7.51	6.82
Potassium	mg/L	na	na	na	1.14	0.55	-	0.52	0.7	0.82	0.85	-	-	0.45	-	0.84	0.81	0.94	0.85	0.7	0.36	0.55	1.41
Reactive Silica	mg/L SiO2	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Selenium	mg/L	0.01	0.02 - 0.05	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-
Silver	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/L	200*	na	na	40	9.9	-	15	10.6	10.43	77.75	-	-	9.73	-	34	6.97	23.2	21.17	17	7.33	11	3.46
Specific Conductance	uS/cm	na	na	na	569	200	-	280	254	114.1	423.3	-	-	75.8	-	471	127	-	-	195.2	73.9	215	-
Sulphate	mg/L	500*	na	1,000	17	6.4	-	12	9.32	12	215	-	-	6	-	12	1	27	8	4.3	7.05	11	6.8
Sulphide	mg/L H2S	0.05*	na	na	0.01	0.01	-	-	-	-	-	-	-	-	-	0.02	-	-	-	-	-	-	-
Thallium	mg/L	na	na	na	-	-	-	-	0.001	-	-	-	-	-	-	-	-	-	-	-	0.001	-	-
Tin	mg/L	na	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Dissolved Solids	mg/L	500*	500 - 3,500	3,000	384	136	-	190	140	78	275	169	156	44	**1,128**	315	86	473	141	130	50	127	64
Total Organic Carbon	mg/L	na	na	na	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Total Phosphorus	mg/L	na	na	na	0.02	0.02	-	0.02	-	-	-	-	-	-	-	0.02	-	-	-	0.02	-	0.02	-
Total Suspended Solids	mg/L	na	na	na	-	-	-	4	15	-	-	-	-	-	-	-	-	-	-	-	15	4	-
True Color	TCU	15*	na	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turbidity	NTU	0.3/1.0/0.1**	na	na	0.62	0.75	-	0.02	3.4	-	-	-	-	-	-	-	-	-	-	-	0	0	-
Uranium	mg/L	0.02	0.01	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/L	na	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	mg/L	5*	1 - 5	50	0.005	0.005	-	0.005	0.01	-	-	-	-	-	-	0.005	-	-	-	0.36	0.01	0.01	-

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
na = No applicable criteria
* = Aesthetic objective
** = Operational guideline
"-" = Not analyzed
Shaded = Value does not meet applicable criteria
Bolded = Value does not meet CWQG-AWU for irrigation and/or livestock water

Table 2.7 Groundwater Chemistry, Protected Public Supply Drilled Wells, St. John's ADA
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		Goulds - Barton's Road (WS-G-0865)	
			Irrigation Water	Livestock Water	Feb. 2006	Sept. 2006
Alkalinity	mg/L $CaC0_3$	na	na	na	91	77
Aluminum	mg/L	na	5	5	0	0
Ammonia	mg/L	na	na	na	0	0
Antimony	mg/L	0.006	na	na	0	0
Arsenic	mg/L	0.01	0.1	0.025	0	0
Barium	mg/L	1	na	na	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	0.01	0.01
Bromide	mg/L	na	na	na	0	0.12
Cadmium	mg/L	0.005	0.005	0.08	0	0
Calcium	mg/L	na	na	na	48	38
Carbonate	mg/L $CaC0_3$	na	na	na	-	-
Chloride	mg/L	250*	100 - 700	na	85	62
Chromium	mg/L	0.05	na	na	0	0.001
Copper	mg/L	1*	0.2 - 1	0.5-5	0	0
Dissolved Organic Carbon	mg/L	na	na	na	0	1
Fluoride	mg/L	1.5	1	1 - 2	0.14	0
Hardness	mg/L $CaC0_3$	na	na	na	145	115
Iron	mg/L	0.3*	5	na	0	0
Kjeldahl Nitrogen	mg/L	na	na	na	0.14	0
Langelier Index	-	na	na	na	-	-
Lead	mg/L	0.01	0.2	0.1	0	0
Magnesium	mg/L	na	na	na	6	5
Manganese	mg/L	0.05*	0.2	na	0	0
Mercury	mg/L	0.001	na	0.003	0	0
Nickel	mg/L	na	0.2	1	0	0
Nitrate	mg/L N	45	na	na	-	-
Nitrate + Nitrite	mg/L N	na	na	100	0	0.64
Nitrite	mg/L	na	na	10	-	-
Orthophosphate	mg/L P	na	na	na	-	-
pH	Units	6.5-8.5*	na	na	7.3	7
Potassium	mg/L	na	na	na	0	0
Reactive Silica	mg/L SiO2	na	na	na	-	-
Selenium	mg/L	0.01	0.02 - 0.05	0.05	0	0
Silver	mg/L	na	na	na	-	-
Sodium	mg/L	200*	na	na	-	-
Specific Conductance	uS/cm	na	na	na	31	30
Sulphate	mg/L	500*	na	1,000	491	379
Sulphide	mg/L H2S	0.05*	na	na	12	10
Thallium	mg/L	na	na	na	-	-
Tin	mg/L	na	na	na	-	-
Total Dissolved Solids	mg/L	500*	500 - 3,500	3,000	319	246
Total Organic Carbon	mg/L	na	na	na	-	-
Total Phosphorus	mg/L	na	na	na	0.01	0.02
Total Suspended Solids	mg/L	na	na	na	-	-
True Color	TCU	15*	na	na	0	0
Turbidity	NTU	0.3/1.0/0.1**	na	na	0.4	0.3
Uranium	mg/L	0.02	0.01	0.2	0	0
Vanadium	mg/L	na	0.1	0.1	-	-
Water Quality Index (WQI)	-	-	-	-	-	-
Zinc	mg/L	5*	1 - 5	50	0	0.01

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

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