6.0 HYDROGEOLOGY OF WINTERLAND ADA

6.1 General Description of Area

6.1.1 Location & Extent

The Winterland ADA covers an area of approximately 6,358 hectares in the south-central portion of the Burin Peninsula, encompassing the community of Winterland and located approximately 12 km west of the community of Marystown, and approximately 10 km east of the community of Garnish. The boundary of the Winterland ADA is shown on Drawing No. 1034406-6.1 in Appendix 6a.

The main access to the Winterland ADA is provided by Provincial Highway Route 210 (Burin Peninsula Highway), which leads southwest from the Trans Canada Highway at Goobies to the community of Fortune near the tip of the peninsula. At the community of Winterland, a secondary road branches off Highway Route 210, and provides access to the southern portion of the ADA. In addition, various graveled roads and ATV trails leading from Highway Route 210 and the secondary road through the community provide access to some areas within the ADAs.

6.1.2 Physiography, Topography & Drainage

The Winterland ADA is located on the Burin Peninsula, which forms the southeastern 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 and is characterized by rugged bedrock-controlled ridges and northeast-southwest trending coastal bays and inlets. Locally, the Winterland ADA is located in the southern portion of a relatively low-lying area, which extends from the Burin - Marystown area on the east coast to the Frenchmans Cove – Garnish area on the west coast and is bounded by upland areas to the north and south. Terrain within the ADA is undulating to gently sloping towards the southeast. Elevations within the ADA generally range from 15 to 60 m above sea level rising to a maximum elevation of approximately 275 m above sea level in the upland region to the south, approximately 5 km south of the ADA. The ADA is bordered to the north by a small ridge that separates the West Brook drainage system from the Garnish River drainage system, located approximately 3 km north of the site. An area of high ground, reaching maximum elevations of approximately 125 m above sea level, is also present along the western boundary of the ADA that acts as a drainage divide, separating drainage in the lowlands between Fortune Bay in the west and Placentia Bay in the east.

The Winterland ADA encompasses portions of the West Brook and Main Brook drainage systems, both of which ultimately drain into Southwest Arm, Mortier Bay. The most significant water course in the area is Main Brook, which drains into Freshwater Pond approximately 1.5 km southeast of the ADA, which in turn flows into Tides Brook, then to Southwest Arm, 2.5 km southeast of the ADA. West Brook, located along the northern extent of the ADA, drains directly into Southwest Arm, approximately 1 km southeast of the ADA. The headwaters of the West Brook and Main Brook drainage systems originate in the upland regions west and south of the ADA, respectively. Other smaller unnamed watercourses are also present in the ADA either discharging directly into Southwest Arm, or through the

Freshwater Pond – Tides Brook drainage system. Freshwater Pond is the most significant pond feature in the area. However, small ponds are also common in the area.

No Protected Public Water Supply Areas (PPWSAs) are present within the ADA or its drainage catchment area.

6.1.3 Climate, Vegetation & Agricultural Land Use

The Winterland 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 Winterland ADA is located within the Southeastern Barrens subregion, and is characterized by cool summers with frequent fog and relatively mild winters. Climate data obtained from Environment Canada's Winterland monitoring station dating back to 1971 indicates a monthly mean temperature in the area of 5.6°C, ranging from a high of 16.6°C in August to a low of -4.4°C in February. Average annual precipitation in the area is 1,461 mm, of which 88% falls as rainfall and 12% as snowfall. October is typically the wettest month, and August is typically the driest month (Environment Canada, 2008). In the ADA, there are an average of 1,356 growing degree days (base temperature 5^{o}C) for the year and 1,212 growing degree days for the vegetative season (i.e., May to September).

Vegetation in the Winterland ADA consists mainly of heathlands, while heavily wooded areas of predominantly balsam fir and black spruce exist on the better drained soils and in the valleys of major streams. Extensive basin and slope bog comprising sphagnum mosses, sedges and grasses are also present, particularly in the eastern portion of the ADA. 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 ADA, but rather the ADA is designated for future planning purposes.

6.2 Geology

6.2.1 Surficial Geology

The surficial geology of the Winterland ADA is summarized in Drawing No. 1034406-6-2 in Appendix 6a, and is based on most recent 1:50,000 scale mapping of the area by Vandeveer, *et al.* (2005), as well as descriptions of surficial geology provided in Van de Hulst (1992) and Batterson and Taylor (2007). 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 is present throughout the ADA occurring mainly as hummocky moraine deposits with local thicknesses up to 20 m, and comprising stony, loamy sand derived from the underlying volcaniclastic rocks. Various streamlined features including drumlins and flutes are present locally within the till. Within the ADA, sand and gravel material of glacial outwash and fluvial origin is also widespread, occurring as narrow deposits within the Main Brook and West Brook river valleys, as well as more extensive deposits buried beneath till and organic deposits in the vicinity of Winterland and Freshwater Pond. Along with glacial units, organic and peaty soils deposits are common throughout the ADA, and occur extensively in the area between Winterland and Freshwater Pond, where it over lies various till and sand and gravel deposits. No significant exposures of bedrock are present within the ADA. Streamlined glacial features in the area indicate southeastward-directed ice flow. Available well logs

indicate an average overburden thickness in the Winterland ADA and surrounding area of approximately 5 m.

6.2.2 Bedrock & Structural Geology

The bedrock geology of the Winterland ADA is summarized in Drawing No. 1034406-6-3 in Appendix 6a, 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, *et al.* (1977), O'Brien, *et al.* (1999) and Batterson and Taylor (2007).

The Winterland ADA lies within the Avalon tectonostratigraphic zone and is underlain by late Precambrian subaerial volcanic and coeval plutonic rocks and minor sedimentary rocks of the Marystown Group. In the eastern portion of the ADA, the Marystown Group is intruded by a large Devonian granitic pluton (St. Lawrence Granite). The Precambrian sedimentary and volcanic rocks that underlie the ADA have undergone regional-scale folding related to Devonian Acadian orogenesis, and form the core of a broad, regional northeast – southwest trending anticline, referred to as the Burin Anticline. No significant faults are present in the vicinity of the ADA. However, a series of joint sets and fracture zones occur within rocks underlying the ADA related to deformation.

6.3 Hydrogeology

6.3.1 Hydrostratigraphy

The groundwater potential of the various geological units within the Winterland 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 23 drilled bedrock wells from the community of Winterland 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 Winterland ADA, 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. 1034406-6-3 in Appendix 6a.

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 Winterland ADA 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 Winterland ADA is defined based on the estimated well yields obtained from the driller's records.

6.3.1.1 Surficial Hydrostratigraphic Units

The surficial deposits within the Winterland 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 6.1. No water well information was available for the till and sand and gravel deposits present in the ADA. 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

Till deposits are present throughout the ADA occurring mainly as hummocky moraine deposits and comprises a stony, loamy sand. There is no documented data on the groundwater potential of the till material in the Winterland ADA. 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 are also widespread within the ADA, occurring as narrow deposits confined to stream and river valleys, as well as more extensive deposits buried beneath till and organic deposits in the vicinity of Winterland and Freshwater Pond. These deposits are potentially significant groundwater aquifers. However, there are no documented data on their groundwater potential in the Winterland ADA. 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 6.1 Summary of Overburden Drilled Well Information for Winterland ADA

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

6.3.1.2 Bedrock Hydrostratigraphic Units

Well record information is available for the volcanic and sedimentary rocks of the Marystown Group that underlie the majority of the ADA. The well yield and depth characteristics of this unit are summarized in Table 6.2.

No water well information was available for the area of the Devonian granitic intrusive rocks that underlie the eastern portion of the ADA. Therefore groundwater potential within this unit was inferred based on well records for similar granitic rocks in the Terra Nova ADA.

Marystown Group

A total of 23 well records from the community of Winterland were used to characterize the groundwater potential of the Marystown Group in the ADA. This unit underlies the majority of the ADA. Based on well data, the Marystown Group strata are considered capable of providing wells with low to moderate yields, having water yields ranging from 4 to 90 L/min at well depths of 15 to 132 m, and an average yield of 39 L/min at 71 m depth. However, median yield and depth estimates of 34 L/min at 76 m depth are more likely representative of the typical groundwater potential of this unit.

Devonian granitic rocks

No documented data is available for the groundwater potential of the Devonian granitic intrusive rocks that underlie the eastern portion of the 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 6.2 Summary of Bedrock Drilled Well Information for Winterland ADA

Rock Group	Rock Type	Communities	No. of Wells	Well Depth (m)		Well Yield (L/min)	
				Mean (Median)	Range	Mean (Median)	Range
Marystown	Bimodal volcanic rocks, and minor siliciclastic sedimentary rocks	Winterland	23	71.4 (76.2)	15-132	38.8 (34)	4 - 90
Devonian granitic rocks*	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

6.3.2 Groundwater Flow System

The Winterland 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 areas of high ground and discharging in various wet lowland areas, ponds, lakes and rivers. 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 north and south. Based on a review of water well records for the area, groundwater levels are generally assumed to be within 7 m of the ground surface and to be a subdued reflection of the topography.

6.4 Water Quality

6.4.1 Surface Water Quality

Surface water quality data for the Winterland ADA is limited to ambient water quality monitoring data collected as part of the Canada–Newfoundland Water Quality Monitoring Agreement, from the Tides Brook monitoring site (NF02ZG0024) over the monitoring period from 1986 to 2004. A summary of chemical data obtained from this surface water source over the monitoring period is provided in Table 6.3 in Appendix 6b, 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 a sodium-calcium-chloride-sulfate-bicarbonate (Na-Ca-Cl-SO_4-HCO_3) type water. Surface water in the area is soft, 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, manganese, pH, and turbidity, concentrations of all other parameters tested meet CDWQG over the monitoring period. 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.

Concentrations of all parameters tested at the Tides Brook ambient water quality monitoring site meet CCME CWQG-AWU for irrigation and/or livestock water use.

Based on chemical data, surface water quality within the ADA is considered good, returning an average Canadian Water Quality Index (CWQI) value of 94. Tides Brook is not considered a potable water source, and would require treatment for disinfection, as well as to improve the aesthetic quality of the water.

6.4.2 Groundwater Quality

The groundwater quality data for the Winterland ADA consists of analyses from three (3) private drilled wells from the community of Winterland, as well as one (1) protected public supply drilled well for the community of Winterland (WS-G-0786) 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 6.4 and 6.5 in Appendix 6b, 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 a calcium-sodium-bicarbonate-chloride-sulfate (Ca-Na-HCO3-Cl-SO4) type water. Groundwater in the area ranges from soft to hard, slightly acidic to slightly basic, and of moderate alkalinity. Classification of groundwater according to dissolved-solids and specific conductance indicates fresh conditions.

With the exception of iron, manganese, pH, turbidity and color concentrations in several of the wells, as well as fluoride present in the Winterland protected public groundwater supply, concentrations of all other parameters tested in the wells meet CDWQG. The guidelines for iron, manganese, pH, turbidity, and color 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 color, and corrosion in the case of pH.

In addition, concentrations of fluoride present in the Winterland protected public groundwater supply, as well as fluoride and manganese present in two private drilled wells in Winterland exceeded CCME CWQG-AWU for both irrigation and livestock 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 indicates that water is unsaturated with calcium carbonate and will tend to be corrosive, leading to potential leaks in the distribution system. Treatment would be required to improve the aesthetic quality of the groundwater, as well as reduce fluoride in areas where elevated levels of this parameter that exceed CDWQG are identified. In addition, concentrations of fluoride present in the Winterland protected public groundwater supply, as well as fluoride and manganese present in two private drilled wells in Winterland that exceeded CCME CWQG-AWU may limit usage of these groundwater sources as potential agricultural water supplies without appropriate treatment.

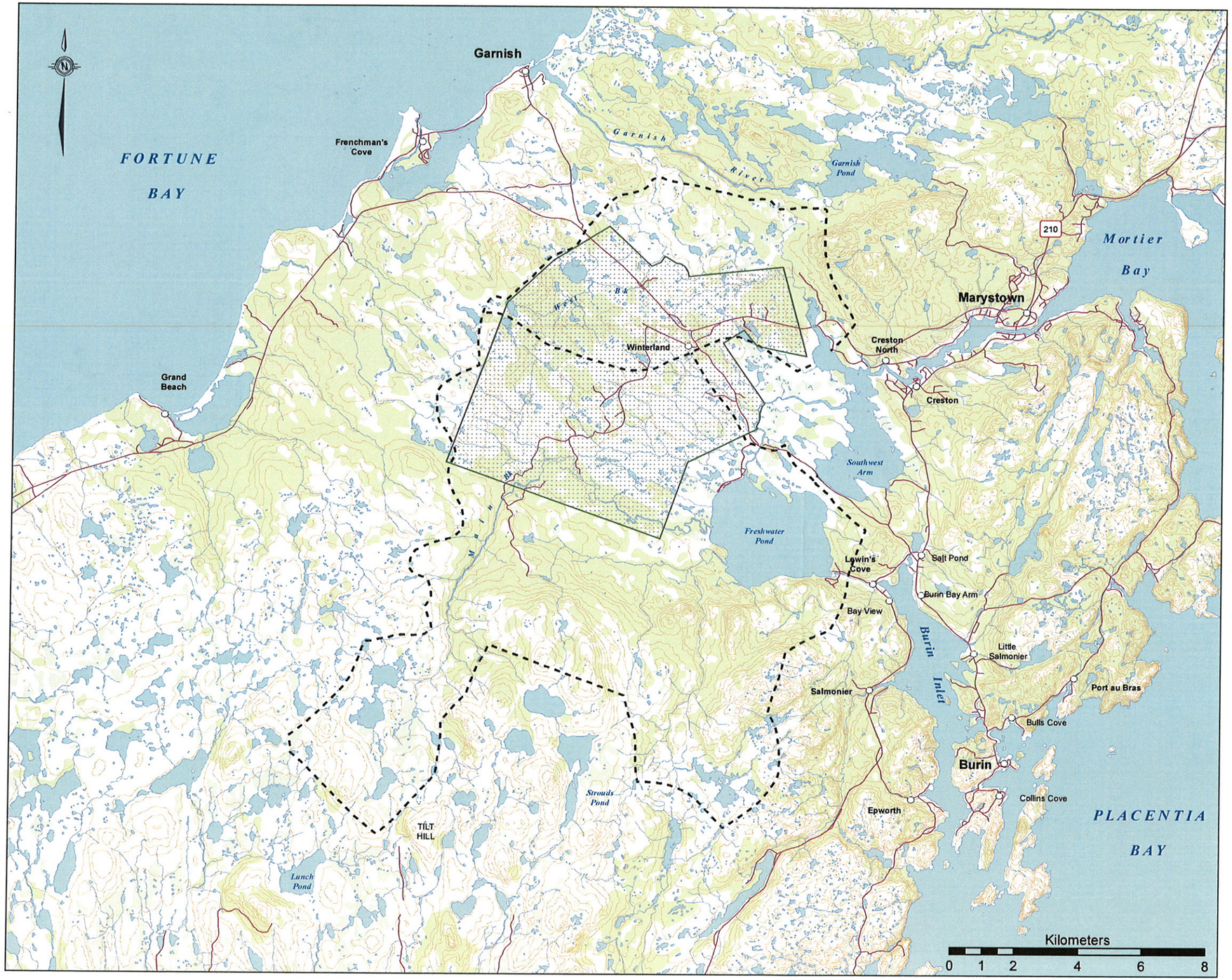
6.5 Groundwater Recharge & Availability

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 Winterland ADA is estimated on the basis of a local groundwater catchment area equivalent to the area of the ADA of approximately 6,358 hectares, and a conservative recharge coefficient of 10% of the mean annual rainfall (i.e., 10% of 1,461 mm, equivalent to 146 mm). Based on these values, the groundwater recharge to the Winterland ADA is estimated at $9.3x10^6 m^3$/year or 1,461 m^3/hectares/yr.

With the exception of one public groundwater supply for the community of Winterland (Water Supply No. WS-G-0786) that serves a population of approximately 337, groundwater use in the area is currently limited to minor individual domestic and industrial wells. No information is available regarding existing agricultural (i.e., irrigation and livestock) water demands in the Winterland 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 6a

Drawings



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

PROJECT TITLE:

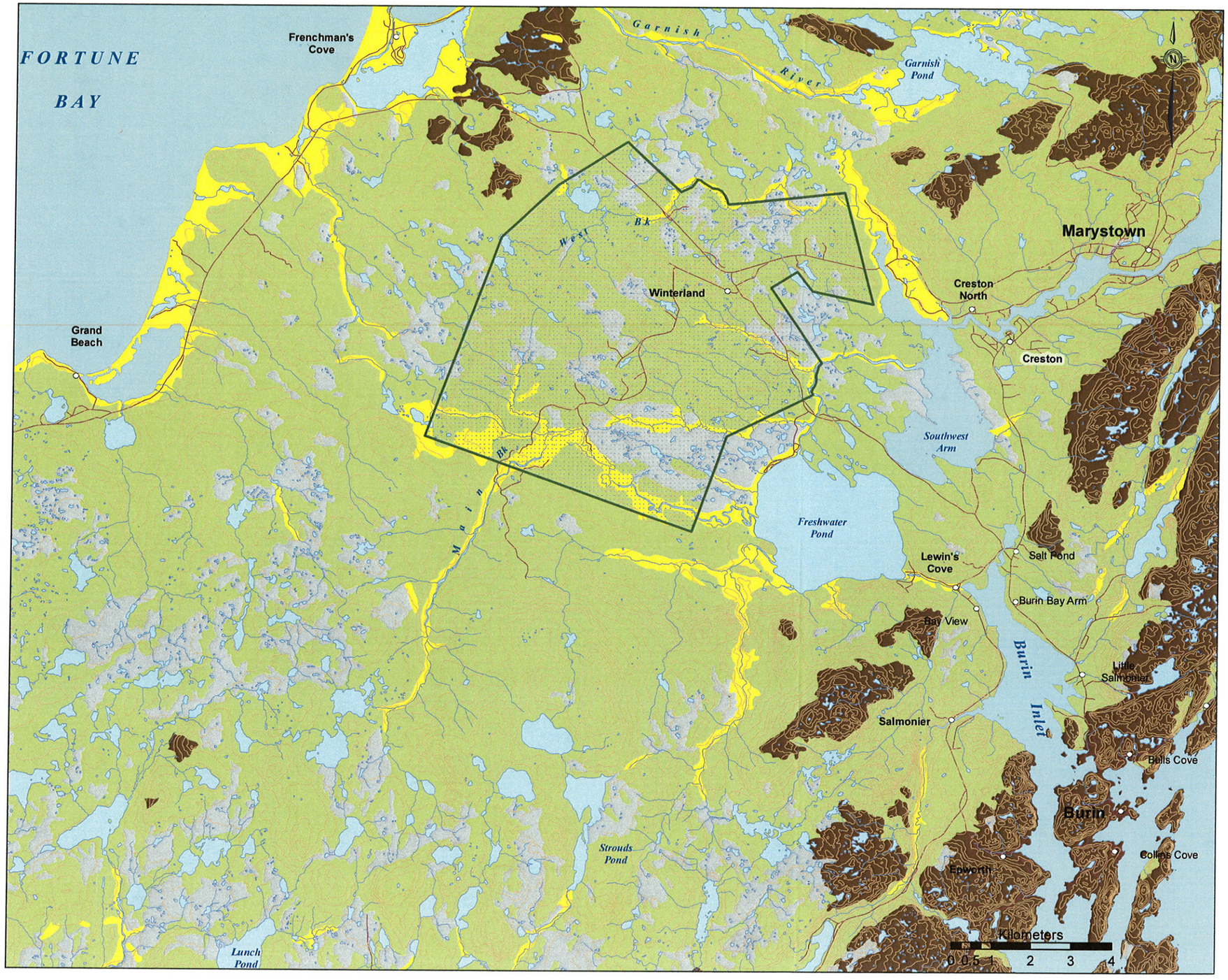
HYDROGEOLOGY OF AGRICULTURAL DEVELOPMENT AREAS, NEWFOUNDLAND AND LABRADOR

DRAWING TITLE:

WINTERLAND ADA LOCATION AND DRAINAGE

Jacques Whitford

SCALE: 1:125,000	DATE: 11/03/2008
DRAWN BY: JLB	CHECKED BY:
EDITED BY: MCH	REV. No. 0
DRAWING No.: 1034406-6-1	
MAP FILE: 1034406-XX.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

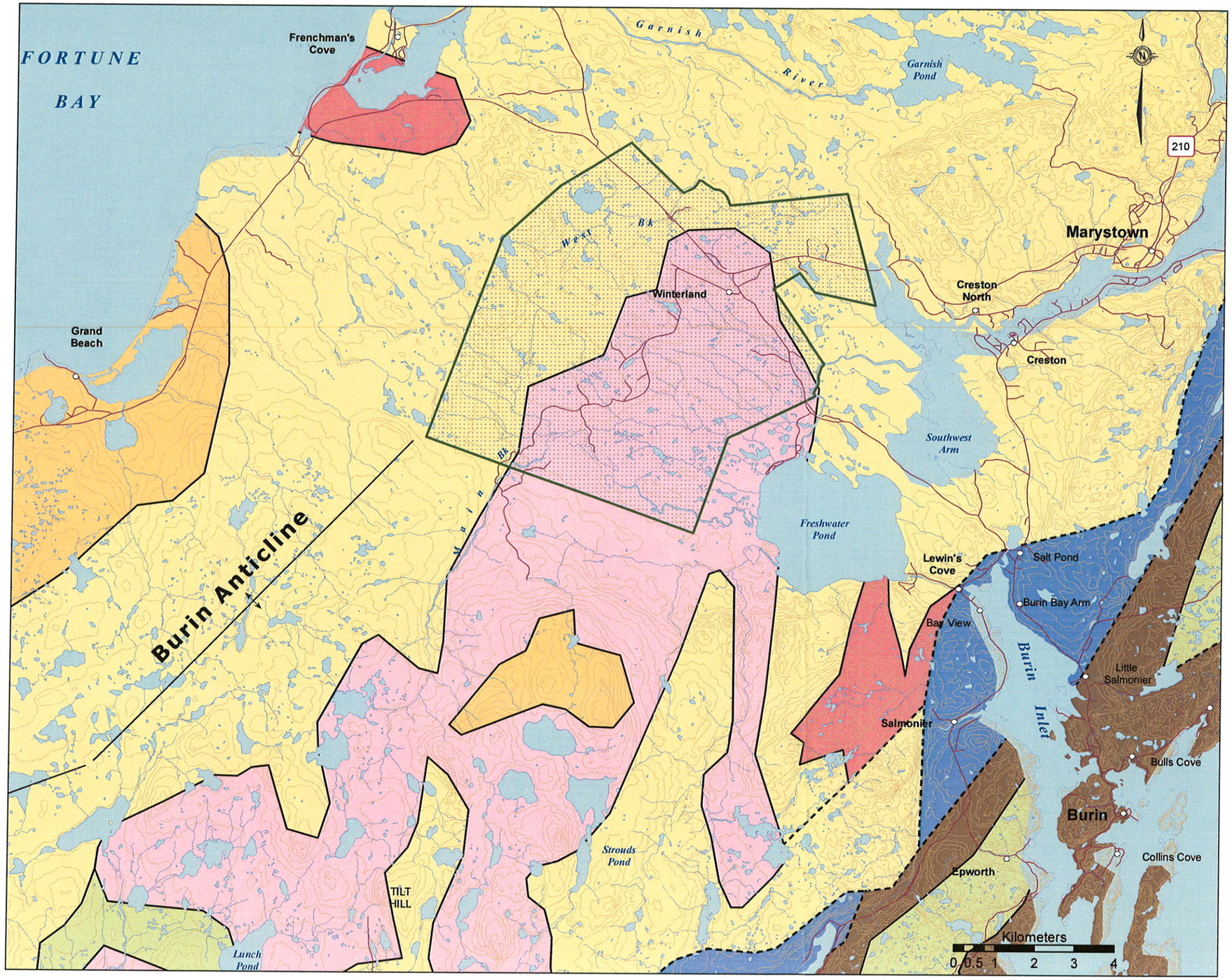
DRAWING TITLE:

WINTERLAND ADA SURFICIAL GEOLOGY

Jacques Whitford

SCALE: 1:100,000	DATE: 03/06/2008
DRAWN BY: JLB	CHECKED BY:
EDITED BY: MCH	REV. No. 0
DRAWING No.: 1034406-6-2	
MAP FILE: 1034406-XX.MXD	

DD/MM/YEAR



Generalized Bedrock Geology Legend

POST-ORDOVIAN OVERLAP SEQUENCES

Fluviatile and lacustrine, siliciclastic and carbonate rocks; subaerial, bimodal volcanic rocks; may include some Late Silurian rocks

POST-ORDOVIAN INTRUSIVE ROCKS

Devonian and Caboniferous

Granite and high silica granite (sensu stricto), and other granitoid intrusions that are posttectonic relative to mid-Paleozoic orogenies

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

Bimodal, submarine to subaerial volcanic rocks, including minor siliciclastic sedimentary rocks (Marystown Group)

Pillow basalt, mafic volcaniclastic rocks, siliciclastic sedimentary rocks, and minor limestone and chert (Burin Group)

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:

WINTERLAND ADA BEDROCK GEOLOGY

Jacques Whitford

SCALE: 1:100,000	DATE: 11/03/2008
DRAWN BY: JLB	CHECKED BY:
EDITED BY: MCH	REV. No. 0
DRAWING No.: 1034406-6-3	
MAP FILE: 1034406-XX.MXD	

APPENDIX 6b

Water Chemistry Data

Table 6.3 Surface Water Chemistry, NL Ambient Water Quality Monitoring Sites, Winterland ADA
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		Tides Brook NF02ZG0024 (1986-2004)[1]		
			Irrigation Water	Livestock Water	Min	Max	Mean
Alkalinity	mg/L $CaC0_3$	na	na	na	0.5	4.8	1.9
Aluminum	mg/L	na	5	5	0.05	0.45	0.11
Ammonia	mg/L	na	na	na	-	-	-
Antimony	mg/L	0.006	na	na	-	-	-
Arsenic	mg/L	0.01	0.1	0.025	0.0001	0.0004	0.0001
Barium	mg/L	1	na	na	0.01	0.02	0.01
Beryllium	mg/L	na	0.1	0.1	0.00002	0.05	0.035
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	0.0002	0.0001
Calcium	mg/L	na	na	na	1.34	1.87	1.52
Carbonate	mg/L $CaC0_3$	na	na	na	-	-	-
Chloride	mg/L	250*	100 - 700	na	-	-	-
Chromium	mg/L	0.05	0.005	0.05	0.0001	0.001	0.0003
Copper	mg/L	1*	0.2 - 1,000	0.5-5	0.0002	0.009	0.0007
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	0.07	1.40	0.21
Kjeldahl Nitrogen	mg/L	na	na	na	0.141	0.141	0.141
Langelier Index	-	na	na	na	-	-	-
Lead	mg/L	0.01	0.2	0.1	0.00009	0.0025	0.0005
Magnesium	mg/L	na	na	na	0.62	0.76	0.66
Manganese	mg/L	0.05*	0.2	na	0.01	0.15	0.03
Mercury	mg/L	0.001	na	0.003	0.000005	0.000028	0.000008
Nickel	mg/L	na	0.2	1	0.00007	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	5.1	7.29	6.12
Potassium	mg/L	na	na	na	0.22	0.35	0.26
Reactive Silica	mg/L SiO2	na	na	na	1.01	3	1.73
Selenium	mg/L	0.01	0.02 - 0.05	0.05	0.00006	0.0002	0.0001
Silver	mg/L	na	na	na	0.000023	0.0001	0.00007
Sodium	mg/L	200*	na	na	4	4.76	4.36
Specific Conductance	uS/cm	na	na	na	25.9	61.5	46.6
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	0.0017	0.03	0.005
Total Suspended Solids	mg/L	na	na	na	-	-	-
True Color	TCU	15*	na	na	-	-	-
Turbidity	NTU	0.3/1.0/0.1**	na	na	0.17	4.2	0.61
Uranium	mg/L	0.02	0.01	0.2	-	-	-
Vanadium	mg/L	na	0.1	0.1	0.0001	0.001	0.0002
Canadian Water Quality Index	-	-	-	-	-	-	94.2
Zinc	mg/L	5*	1 - 5	50	0.000	0.005	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 6.4 Groundwater Chemistry, Private Drilled Wells, Winterland ADA
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		Community[1]		
					Winterland		
			Irrigation Water	Livestock Water	13592	12273	14136
Alkalinity	mg/L $CaC0_3$	na	na	na	114	27.8	74.7
Aluminum	mg/L	na	5	5	-	-	0.03
Ammonia	mg/L	na	na	na	-	-	0.01
Antimony	mg/L	0.006	na	na	-	-	0.001
Arsenic	mg/L	0.01	0.1	0.025	-	-	0.003
Barium	mg/L	1	na	na	-	-	0.05
Beryllium	mg/L	na	0.1	0.1	-	-	-
Bicarbonate	mg/L $CaC0_3$	na	na	na	-	-	-
Boron	mg/L	5	0.5 - 6	5	-	-	0.2
Bromide	mg/L	na	na	na	-	-	0.10
Cadmium	mg/L	0.005	0.005	0.08	-	-	0.0001
Calcium	mg/L	na	na	na	37	23	22.5
Carbonate	mg/L $CaC0_3$	na	na	na	-	-	-
Chloride	mg/L	250*	100 - 700	na	15.2	30	10.2
Chromium	mg/L	0.05	na	na	-	-	0.0005
Copper	mg/L	1*	0.2 - 1	0.5-5	-	-	0.01
Dissolved Organic Carbon	mg/L	na	na	na	-	-	5
Fluoride	mg/L	1.5	1	1 - 2	**1.28**	**1**	0.52
Hardness	mg/L $CaC0_3$	na	na	na	99.7	64	67.80
Iron	mg/L	0.3*	5	na	0.78	0.15	0.21
Kjeldahl Nitrogen	mg/L	na	na	na	-	-	-
Langelier Index	-	na	na	na	-	-	-
Lead	mg/L	0.01	0.2	0.1	-	-	0.001
Magnesium	mg/L	na	na	na	1.77	1.6	2.82
Manganese	mg/L	0.05*	0.2	na	**0.52**	**0.26**	0.17
Mercury	mg/L	0.001	na	0.003	-	-	-
Nickel	mg/L	na	0.2	1	-	-	0.02
Nitrate	mg/L N	45	na	na	-	-	-
Nitrate + Nitrite	mg/L N	na	na	100	0.004	0.066	0.05
Nitrite	mg/L	na	na	10	0.001	0.001	0.05
Orthophosphate	mg/L P	na	na	na	-	-	-
pH	Units	6.5-8.5*	na	na	7.62	6.38	7.95
Potassium	mg/L	na	na	na	0.73	0.77	0.25
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	6.3	11	10.9
Specific Conductance	uS/cm	na	na	na	258	168	188
Sulphate	mg/L	500*	na	1,000	6.8	6.1	5
Sulphide	mg/L H2S	0.05*	na	na	-	-	-
Thallium	mg/L	na	na	na	-	-	0.001
Tin	mg/L	na	na	na	-	-	-
Total Dissolved Solids	mg/L	500*	500 - 3,500	3,000	183	171	100
Total Organic Carbon	mg/L	na	na	na	-	-	-
Total Phosphorus	mg/L	na	na	na	0.01	0.01	-
Total Suspended Solids	mg/L	na	na	na	-	-	15
True Color	TCU	15*	na	na	-	-	-
Turbidity	NTU	0.3/1.0/0.1**	na	na	-	-	0.7
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	0.02	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 from the NL Department of Environment - Water Resources Management Division Drinking Water Quality
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 6.5 Groundwater Chemistry, Protected Public Supply Drilled Wells, Winterland ADA
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		Winterland - Well Field WS-G-0786 (2001-2007)[1]		
			Irrigation Water	Livestock Water	Min	Max	Mean
Alkalinity	mg/L $CaC0_3$	na	na	na	7	107	85
Aluminum	mg/L	na	5	5	0	0.17	0.03
Ammonia	mg/L	na	na	na	0	0.14	0.02
Antimony	mg/L	0.006	na	na	0	0.0005	0.0001
Arsenic	mg/L	0.01	0.1	0.025	0	0.001	0.0003
Barium	mg/L	1	na	na	0	0.03	0.02
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	0.02
Bromide	mg/L	na	na	na	0	0.32	0.10
Cadmium	mg/L	0.005	0.005	0.08	0	0.00005	0.00001
Calcium	mg/L	na	na	na	2	43	33
Carbonate	mg/L $CaC0_3$	na	na	na	-	-	-
Chloride	mg/L	250*	100 - 700	na	18	37	29
Chromium	mg/L	0.05	na	na	0	0.002	0.0004
Copper	mg/L	1*	0.2 - 1	0.5-5	0	0.005	0.001
Dissolved Organic Carbon	mg/L	na	na	na	0	4	0.3
Fluoride	mg/L	1.5	1	1 - 2	0	**1.17**	0.83
Hardness	mg/L $CaC0_3$	na	na	na	13	128	96
Iron	mg/L	0.3*	5	na	0	0.04	0.01
Kjeldahl Nitrogen	mg/L	na	na	na	0	0.21	0.05
Langelier Index	-	na	na	na	-1.23	-0.29	-0.63
Lead	mg/L	0.01	0.2	0.1	0	0.001	0.0003
Magnesium	mg/L	na	na	na	2	5	4
Manganese	mg/L	0.05*	0.2	na	0	0.013	0.002
Mercury	mg/L	0.001	na	0.003	0	0.00005	0.00001
Nickel	mg/L	na	0.2	1	0	0.005	0.001
Nitrate	mg/L N	45	na	na	-	-	-
Nitrate + Nitrite	mg/L N	na	na	100	0	1.25	0.68
Nitrite	mg/L	na	na	10	-	-	-
Orthophosphate	mg/L P	na	na	na	-	-	-
pH	Units	6.5-8.5*	na	na	5.5	7.9	7.4
Potassium	mg/L	na	na	na	0	1	0.2
Reactive Silica	mg/L SiO2	na	na	na	-	-	-
Selenium	mg/L	0.01	0.02 - 0.05	0.05	0	0.001	0.0003
Silver	mg/L	na	na	na	-	-	-
Sodium	mg/L	200*	na	na	9	24	16
Specific Conductance	uS/cm	na	na	na	160	330	272
Sulphate	mg/L	500*	na	1,000	5	9	6
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	104	215	174
Total Organic Carbon	mg/L	na	na	na	-	-	-
Total Phosphorus	mg/L	na	na	na	0.005	0.13	0.04
Total Suspended Solids	mg/L	na	na	na	-	-	-
True Color	TCU	15*	na	na	0	15	2
Turbidity	NTU	0.3/1.0/0.1**	na	na	0.05	2.5	0.51
Uranium	mg/L	0.02	0.01	0.2	0	0	0
Vanadium	mg/L	na	0.1	0.1	-	-	-
Water Quality Index (WQI)	-	-	-	-	100	100	100
Zinc	mg/L	5*	1 - 5	50	0	0.02	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 Water) (October, 2005)

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 the detection limit were reported as half of the detection

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