SECTION 9.0

EXISTING ENVIRONMENT

GOLDBORO LNG

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9.0 EXISTING ENVIRONMENT

Some of the information presented in this section is based on the previous Keltic Project EA, supplemented by a site visits in 2012 and 2013. The site survey has confirmed that conditions remain largely unaltered, since the Keltic Project. All available information sources (past and present) have been referenced accordingly.

9.1 Geophysical Environment

9.1.1 Topography and Geomorphology

The Project is located within the Southern Upland physiographic region (Figure 9.1-1). The topography in this region is somewhat varied, with low ridges and intervening hollows that are swampy flats. The soil is generally thin and acidic. Drainage is poor because of deposits of glacial drift. Peat bogs are common, and in some areas there are wide level expanses of heath and meadow. Chains of lakes, streams, and still-water occur. River channels are shallow. The area is mainly forest country. The terrain in the Project area is generally inclined in southerly and westerly direction towards the ocean. Topography is characterized by two low ridges that run in roughly east to west direction with elevation of 50 to 65 m (AMEC, 2006).

Goldboro is located in the Meguma Zone on the Atlantic Coast of NS (Figure 9.1-2). This zone occupies the southern mainland of NS extending seaward beneath younger sedimentary rocks. It is a good example of a terrane; i.e., a fault-bounded rock body of regional extent, characterized by a geologic history different from that of adjoining terrane. It is an exotic fragment of continental material added to ancestral North America by continental collision (Nova Scotia Museum of Natural History (NSMNH), 1996). The sedimentary rocks of the Meguma Zone consist almost entirely of fine-grained sandstones and shales with minor amounts of volcaniclastic, conglomeratic and carbonate rocks (NSMNH, 1996).

The Meguma stratigraphic succession consists of three major groups of sandstone (Goldenville Formation) that alternate vertically with two thick groups of shale (Halifax Formation). The Goldenville Formation contains alternating layers of sandstone and finer grained beds and is interpreted as a submarine mid-fan deposit (NSMNH, 1996). The Halifax Formation consists of slate, siltstone, minor sandstone. Faribault (1914, in Keppie, 1977) recorded a thickness of at least 5,600 m for the Goldenville Formation, and about 500 to 4,400 m has been recorded for the Halifax Formation.

9.1.2 Geology

9.1.2.1 Past Work

An extensive review of the area geology was conducted as part of the Keltic assessment using the sources outlined below. Additional sources of information for that analysis included site assessments and the review of information acquired as part of the monitoring well installation program:

- mapping by Schiller (1961) and Hill (1991);
- assessment reports by the Geological Survey of Canada (GSC) (1985);
- bedrock mapping by Fletcher and Faribault (1891, 1893a, 1893b, 1893c, 1893d) and Faribault (1899, 1904);
- bedrock mapping by Stevenson (1959, 1964);
- summary report by Keppie (1979, 2000) summarized the work of all others;
- mine inspector's reports, exploration assessment reports and mining assessment reports; and
- MapleLNG NSUARB Permit to Construct (2008).

9.1.2.2 Geological Context

The nature of the bedrock geology of the Project area is a direct result of complex tectonic events. There has been a significant amount of folding and faulting resulting in complex structural geology. Figure 9.1-3 depicts the structural and bedrock geology in the Project area.

Steeply dipping rocks of the Goldenville Formation underlie the entire Goldboro LNG site. Halifax Formation slates are present generally as narrow bands at major syncline axis (Fletcher and Faribault, 1893b) to the north of the proposed LNG facility and south of Meadow Lake, and within the Loon Lake Synclinorium, which encompasses two small (2 by 6 km) granitic plutons and one thin elongate pluton, all situated within the north-northwest part of the Isaac's Harbour River watershed (AMEC, 2006).

The Halifax Formation is sulphide bearing and has the potential to become acidic when exposed to oxygen and water. This can occur through natural processes or be the result of construction activities. Sulphide exposed during construction will result in renewed acid generation. This acid may enter the surface or groundwater regime contaminating water and habitat. The potential for acid drainage is expected to be greatest where the Halifax Formation is in contact with or in close proximity to granitic plutons. Certain rocks of the Goldenville Formation may also be a source of acid drainage, particularly (in small areas) where highly mineralized zones are present.

Borehole logs documented during the installation of monitoring wells for the Keltic Project EA indicate that much of the Project site is underlain by bedrock consisting of greywacke with some occurrences of argillite. Argillite with pyrite and arsenopyrite associated with the Halifax Formation was identified approximately 1.5 km northwest of the Project area and along the southern edge of Meadow Lake.

There were 24 test pits excavated in the area where the LNG liquefaction facilities and storage tanks are to be located. These pits were excavated to depths between 1.2 to 4.5 m as part of the geotechnical investigation required for MapleLNG's Permit to Construct. Where possible, bedrock was excavated resulting in 11 samples being taken (Figure 9.1-4). All bedrock samples consisted of weathered greywacke of the Goldenville Formation. A total of 11 samples were analyzed for the presence of sulphide mineralization. Sulphur measurements ranged from 0.008% to 0.085%, well below the 0.4% sulphur limit established by NSE with respect to mineralized rock (MapleLNG, 2008).

For an assessment of the interaction between the Project and the herein described environment, refer to Section 10.1.

9.1.2.3 Past Mining and Economic Geology

As a result of the folding and faulting and associated mineralization, the greater Goldboro area, including the Goldboro LNG site, has been the subject of gold mining activities for well over 100 years. The geology and mineralogy of the area was described in detail by Corey (1992). Gold in the area is commonly found in nugget form, as flakes of visible gold, or as gold associated with arsenopyrite and, to a lesser degree, pyrite. Locally, arsenopyrite is the predominant metallic mineral, usually making up 65% to 75% of the total. Pyrite accounts for most of the remainder. Galena, sphalerite, and chalcopyrite may, together, be 2% of the total sulphides (Tilsley, 1996).

Several mines were established in what was known as the Seal Harbour Lake and the Upper Seal Harbour Lake (now known as Gold Brook Lake) zones, including the Boston Richardson Mine and Dolliver Mountain Mine north of the Project area, the Seal Harbour Mine (Victoria Belt) east of the Project area, the McMillan Mine, west of Dung Cove, and the Mulgrave and Giffin Mines (also known as the Hattie Belt, Skunk Den Mine, or the Malloy, Eureka, Economy or Bluenose properties) within the Project area (Figure 9.1-5).

Renewed interest in the area in the early 1980's resulted in a major exploration program at the Boston Richardson property. This work is on-going, with the latest drilling program by Orex consisting of three campaigns in 2010/11 with a total of 59 drill holes (12,995.5 m). Orex has recently completed (August 2012) a validation of all of the recent drilling and previous drilling in order to develop a new geological model of their Goldboro Gold Property. The Company is planning to conduct a Preliminary Economic Assessment to examine the economic feasibility of a production scenario at Goldboro (Mercator Geological Services Limited, 2013) (www.orexexploration.ca).

Figure 9.1-6 shows the distribution of exploration licenses in the immediate area as at March, 2013.

9.1.2.4 Old Mine Workings

Figure 9.1-5 was developed using the NSDNR Mines Branch database that shows the location of former mine and associated workings on the site and surrounding areas. Field work by Keltic in 2005 identified numerous shafts and trenches that were not identified in the NSDNR database. The geotechnical site investigation done for MapleLNG as part of their NSUARB Permit to Construct revealed the existence of old mine workings south of Highway 316 including numerous small abandoned mine openings (AMOs) (Figure 9.1-5). This suggests that there may be other undocumented workings although they are expected to be concentrated mainly in the areas where workings have already been documented (AMEC, 2006). New “unmapped” AMOs have been discovered during recent site surveys in 2013 and are indicated on Figure 9.1-5.

Very little information exists in the way of maps or cross sections of underground mine workings, the actual quantities of ore removed from the underground, and gold recovered. Prior to about 1930, production statistics for Isaac's Harbour Gold District were recorded collectively with those from other nearby gold producing areas under the general heading “Stormont Gold District” (Tilsley, 1988).

For an assessment of the interaction between the Project and the herein described environment, refer to Section 10.1.

9.1.2.5 Inactive Tailings Disposal Sites

Gold mill tailings deposits from past mining activity exist in the Project area. Stamp milling and mercury amalgamation were the primary methods used for gold extraction in NS including the Goldboro area, much of which was done on-site (AMEC, 2006). Investigations by Parsons *et al.* (2012) just outside the Project area and at other sites in NS have documented high concentrations of mercury (up to 350 milligrams per kilogram (mg/kg)) and arsenic (up to 31% by weight) in mine wastes. Figure 9.1-5 depicts the location of tailings disposal areas within the Project area.

The remains of three former gold mills and three tailings disposal areas have been identified within the Project area:

- One mill was located west of Dung Cove a short distance north of Red Head. There were no tailings found associated with this site suggesting that they may have been disposed of directly into the sea.
- Another mill foundation was located about mid-way between Route 316 and Dung Cove. Tailings from it were disposed of directly into Dung Cove. Four samples were taken of these tailings for mercury and arsenic analysis.
- The third mill, a part of the Giffin Mine, was found a short distance southeast of the SOEI gas plant road. Nine samples were taken of the tailings for mercury and arsenic analysis.

- Another tailings disposal area was identified on the eastern portion of the Project area by Seabright Resources Inc. (1984). It was sampled by Seabright and gold was found to be present. This suggests that it was a tailings disposal pond and that it is likely to contain mercury and arsenic.

All of the tailings samples exceeded the CCME guideline values for Mercury for freshwater and marine sediments (CCME, 2001). All of the tailings samples collected exceed the CCME guideline values for arsenic for sediments in both fresh water and marine environments as well as for soil under all land uses. The results are presented in Table 9.1-1.

Table 9.1-1 Tailings Sample Results from Giffin Mine and Dung Cove Areas (AMEC, 2006)

Sample ID	Mercury		Arsenic		Location (UTM[1])	
	mg/kg	Detection Limit	mg/kg	Detection Limit	Easting	Northing
102F01-GMA1	24	1	1600	2	607496	5002544
102F01-GMA2	30	2	6700	2	607500	5002527
102F01-GMA2 Dup			6100	2		
102F01-GMA3	13	0.4	8000	2	607503	5002510
102F01-GMA4	11	0.2	2600	2	607516	5002513
102F01-GMA5	9.9	0.2	1100	2	607528	5002515
102F01-GMA6	19	1	2200	2	607525	5002527
102F01-GMA7	21	1	1600	2	607523	5002539
102F01-GMA8	26	1	1300	2	607510	5002541
102F01-GMA9	31	1	3400	2	607512	5002529
102F01-T1	4.7	0.1	1700	2		
102F01-T2	3.1	0.1	150	2	607056	5001928
102F01-T2 Dup			160	2		
102F01-T3	8.1	0.1	14	2	607069	5001912
102F01-T4	6.4	0.1	1100	2	607046	5001941
CCME[2]						
Soil – agricultural	6.6		12			
Soil – residential/parkland	6.6		12			
Soil – commercial	24		12			
Soil – industrial	50		12			
Sediment – fresh water (SQG[3])	0.170		5.900			
Sediment – fresh water (PEL[4])	0.486		17.000			
Sediment – marine (SQG)	0.130		7.240			
Sediment – marine (PEL)	0.700		41.600			

Notes:
1. UTM = Universal Transverse Mercator.
2. CCME, 2001.
3. SQG = Sediment quality guidelines.
4. PEL = probable effect level.

For an assessment of the interaction between the Project and the herein described environment, refer to Section 10.1.

9.1.2.6 Seismic Considerations

Eastern Canada is located within a stable continental part of the North American Tectonic Plate. As such, it has a relatively low rate of earthquake activity. Nevertheless, within Canada's eastern seismic region, large earthquakes have occurred in the past and will inevitably occur in the future. The causes of earthquakes in eastern Canada are not well understood but seem to be related to the regional stress fields (Ruffman, 1994), with the earthquakes concentrated in regions of crustal weakness (Bent, 1995) at depths varying from surface to 30 km (GSC, 2003).

The known earthquake seismic source zones of most concern to the populated areas of eastern Canada are the Charlevoix, Passamaquoddy and offshore Laurentian Slope seismic zones where major earthquakes of magnitudes 7.0, 5.7 and 7.2 occurred in 1925, 1869 and 1929, respectively (AMEC, 2006). The magnitude 7.2 1929 earthquake on the Laurentian Slope (known also as the Grand Banks earthquake of 1929) triggered a large submarine slump, which ruptured 12 transatlantic cables and generated a tsunami that was recorded along the eastern seaboard as far south as South Carolina and across the Atlantic Ocean in Portugal, and caused the loss of 28 lives on the Burin Peninsula in Newfoundland (AMEC, 2006).

For an assessment of the interaction between the Project and the herein described environment, refer to Section 10.18.

9.1.2.7 Tsunami

Ruffman and Tuttle (2005) have noted that written history of tsunami by European settlers on the western side of the Atlantic Ocean is relatively short and little oral history from first nations peoples or Viking visitors survives. Ruffman and Tuttle’s work cited nine tsunami events dating back to 1755. The tsunami that is most relevant to the proposed Project site occurred on November 18, 1929, as a result of a magnitude 7.2 earthquake along the southern edge of the Grand Banks. In NS, there was minimal damage due to earthquake vibrations in Cape Breton Island; however, the earthquake triggered a tsunami that traveled to the coast of the Burin Peninsula. It claimed a total of 28 lives in Newfoundland, one life in Cape Breton, NS, and caused significant damage. This represents Canada's largest documented loss of life directly related to an earthquake.

The proposed Goldboro LNG site was shown by the GSC (2005) to be just at the edge of the "minor damage" zone for the 1929 tsunami.

For an assessment of the interaction between the Project and the herein described environment, refer to Section 10.18.

9.1.3 Soils/Sediment

9.1.3.1 Surficial Geology

About 94% of the soils in Guysborough County have developed from glacial till consisting of quartzite till and/or stony plain deposits. For the most part, these soils reflect the geology of the underlying bedrock. Onshore glacial deposits in NS were classified into till and glaciofluvial units by Stea and Fowler (1979). The surficial geology of the Project area and surrounding region were mapped by Cann and Hilchey (1954), Hilchey *et al.* (1964), Stea and Fowler (1979) and Stea *et al.* (1992). Riverport, Thom, Halifax, Danesville and Aspotogan series soils and peat are present at and near the Project area.

9.1.3.2 A and B Horizons

Figure (9.1-7) depicts the A and B soil horizons in the Project area. The Hebert series, Aspotogan series, Halifax, and Danesville series soils overlay the Project area. The southern portion of the main Project area is comprised of soils from the Aspotogan Series. The Aspotogan series is comprised of medium and moderately coarse-textured glacial tills derived from granite or quartzitic materials and is poorly draining. The central portion of the main Project area is comprised of Halifax series soils (Hilchey *et al*., 1964). Both the Danesville and Halifax series soils are comprised of medium and moderately coarse-textured glacial tills that have developed from sandy loam quartzitic till with some slate and granite material present. The work camp area is comprised of both the Halifax and Aspotogen. The soils along the water supply pipeline and Meadow Lake are comprised of Aspotogan series, Halifax, and Danesville series. Red Head Peninsula is dominated by the Hebert series, consisting of interbedded coarse sand and gravel usually derived from coarse-textured, stratified parent material. The Hebert series is usually found along existing rivers, or where rivers and streams flowed in glacial or post glacial times.

There are several bogs located to the north and west of the site (Hilchey *et al.*, 1964). In addition, there is a test pit excavated by MapleLNG south of Highway 316 on the LNG facility that encountered a 0.5 m layer of peat beneath the topsoil (MapleLNG, 2008).

9.1.3.3 C Horizon

The C horizon materials or “mineral soil” consists generally of quartzite till and/or stony till plain deposits in Guysborough County. Glacial-age kame fields and esker systems, and post-glaciation alluvial deposits are also present at various locations near the Project area (AMEC, 2006).

The ground moraine till material is comprised of a mixture of gravel, sand, and mud of direct glacial origin. It is variable in thickness from 2 to 25 m and forms local ridges, depressions or pits (kettles). The stony till unit consists of material released at the base of ice sheets and is described by Stea (1979) as a bluish-greenish-grey, loose, cobbly, silt-sand till, which will grade into a sandier, coarser till, sometimes with red clay inclusions. It is generally thin (less than 10 m) with a matrix made up of 80% sand, 15% silt, and 5% clay. It is derived of locally eroded quartzite and slate bedrock (AMEC, 2006).

Quartzite till is shown by Stea (1979) and Stea *et al.* (1992) to extend northward along the eastern half of the Isaac’s Harbour River watershed. Granite ablation till, or silty till plain deposits, are present along the western periphery in the upper reaches of the Isaac’s watershed. These deposits are described by Stea (1979) as yellow-grey, bouldery sand till. A total of 24 test pits were done on the Goldboro LNG property in 2007 by MapleLNG as part of the geotechnical investigation required for their Permit to Construct (Figure 9.1-4). The subsurface conditions were described as 1 to 4 m of overburden overlying Goldenville

Formation bedrock (MapleLNG, 2008). The results indicate that the average thicknesses of the topsoil, silty sand/sandy silt layer, and the glacial till are 0.28 m, 0.34 m, and 1.96 m, respectively; and the average depth to bedrock is 2.72 m (Table 9.1-2).

Topographic features suggest that there may be a few low-lying drumlins near the Project area; however, maps by Stea (1979), and Stea *et al.* (1992) do not show any (AMEC, 2006).

Table 9.1-2 Site Subsurface Conditions

Test Pit No.	Rootmat/Topsoil Thickness (m)	Silty Sand/Sandy Silt Thickness (m)	Glacial Till Thickness (m)	Depth to Bedrock (m)
1	0.15	0.30	0.90	1.80
2	0.45	0.30	3.00	3.75
3	0.00	0.60	1.20	2.25
4	0.30	0.15	3.35	3.80
5	0.75	0.45	1.50	2.70
6	0.45	0.30	1.80	2.55
7	0.30	0.45	1.20	1.95
8	0.30	0.30	4.00	4.10
9	0.15	0.30	1.65	3.90
10	0.30	0.45	0.75	2.10
11	0.15	0.45	1.50	2.10
12	0.30	0.30	1.20	1.80
13	0.45	0.15	2.10	2.70
14	0.30	0.30	2.70	3.30
15	0.30	0.15	2.55	3.00
16	0.15	0.00	2.40	3.30
17	0.15	0.45	2.40	3.00
18	0.45	0.30	3.00	3.75
101	0.15	0.15	1.65	1.95
102	0.15	0.60	2.25	3.00
103	0.30	0.45	1.50	2.25
104	0.30	0.45	1.25	2.00
105	0.15	0.45	2.40	3.00
106	0.15	0.30	0.75	1.20
Averages	**0.28**	**0.34**	**1.96**	**2.72**

Source: MapleLNG, Permit to Construct, 2008

9.1.3.4 Marine Sediment

The Project area is located within the Guysborough Harbours Unit, a coastal ecological zone characterized by long, narrow inlets with steep valley sides. The coastline is submerged, with parallel inlets and estuaries separated by headlands typically composed of greywacke or granitic bedrock covered with a thin layer of quartzite till. Glaciofluvial deposits of coarse sand and gravel are found in many of the river valleys, while the coastline is generally rockier with few sand beaches (NSMNH, 1996).

Stormont Bay is predominantly covered with fine sand and silt with scattered rock shoals with a subtidal zone extending to depths of about 15 m below mean low water (NSMNH, 1996). The near-shore marine habitat at Red Head has a substrate of boulders, cobbles, and pebbles, with finer materials such as sand and gravel in more protected bays (AMEC, 2006).

Baseline monitoring in 2008 performed by MapleLNG as part of their EA conditions sampled the marine sediments in the Dung Cove, Isaac's Harbour, Stormont Bay area for the presence of metals (Figure 9.1-4). All values were below the probable effects limits for soils in marine sediments except for manganese which was two to three times the limit of 112 mg/kg in all samples. Both arsenic and mercury were below the probable effects limit in all samples. Arsenic was one and a half to five times above the Canadian Environmental Quality Guideline value of 7.24 mg/kg in all but two samples; whereas mercury values were marginally exceeded in three samples, one in the Dung Cove area and the other two further up Isaac's Harbour.

9.1.3.5 Terrestrial Soil

According to Hilchey *et al.* (1964) the Soil Capability Class for this area is "unsuited for agriculture".

In addition, historical gold mining activity has left abandoned mine sites and more than 3,000,000 t of tailings dump across the province including the Isaac's Harbour – Seal Harbour area. Most of the mined gold was recovered using mercury amalgamation, and an estimated 10 to 25% of the mercury used was lost to the tailings and atmosphere. Arsenic, which occurs naturally in the ore, is present at high concentrations in the mine wastes (Parsons *et al*., 2012). Elevated levels of arsenic, mercury and other elements are associated with the mining activity in surrounding terrestrial and marine environments (Parsons, 2005; Parsons *et al.*, 2012). Additionally, the weathering of mine waste since the cessation of mining activities has permitted the continual release of these elements to surrounding environments.

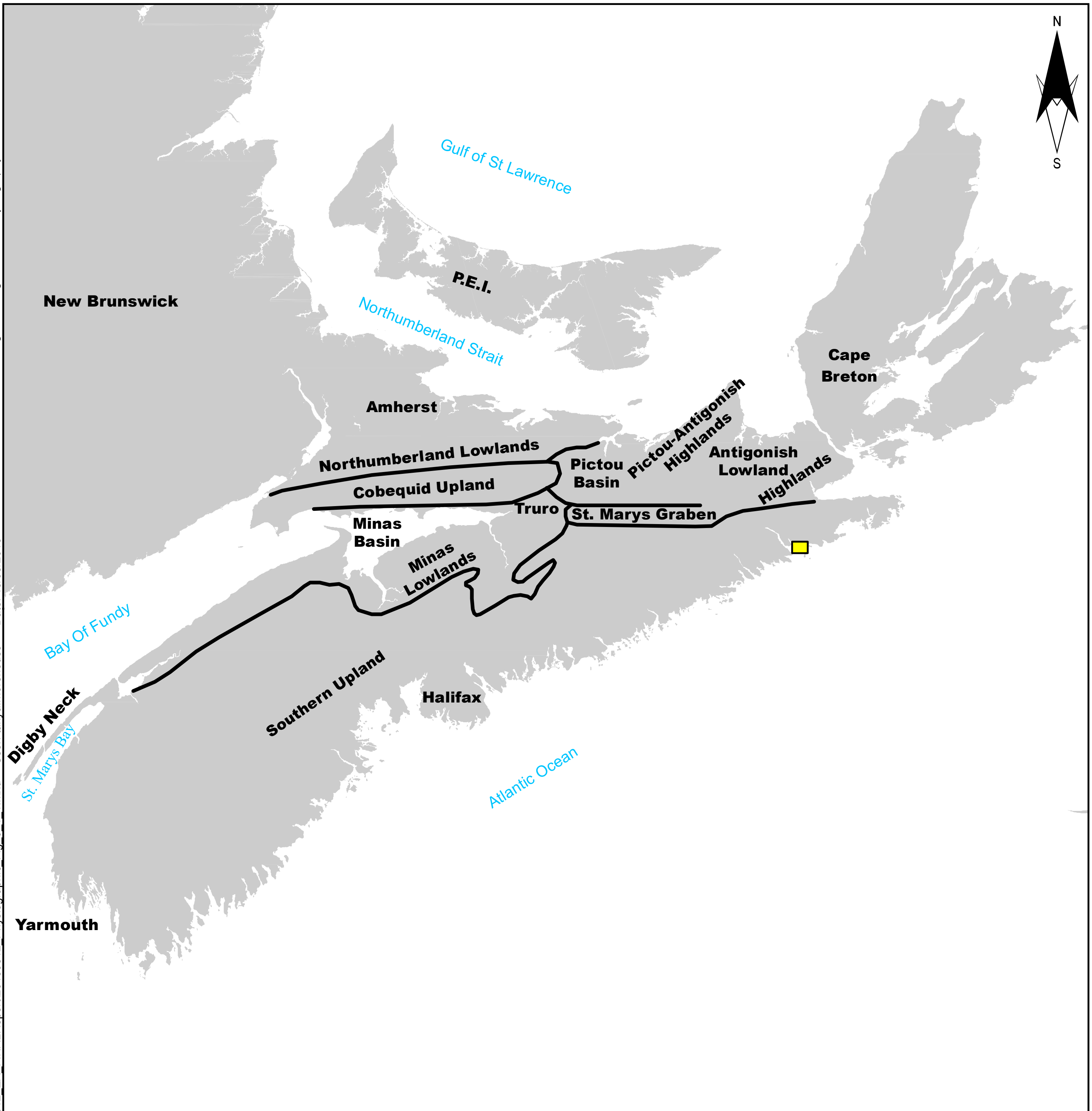
An analysis of the environmental geochemistry of tailings, sediments and surface waters in historical gold mining districts in NS was published by Parsons and others in a 2012 Open File Report. Upper and Lower Seal Harbour (4 km east and 2 km north of the LNG facility) were extensively studied in this report. The report presents the results of a multi-disciplinary investigation of the dispersion, speciation and fate of metal(loid)s in terrestrial and shallow marine environments surrounding 14 abandoned gold mines in NS. It is anticipated that the data published in this report will be used by industry in their assessment of environmental characteristics in Meguma gold districts to minimize environmental impacts associated with development in these areas.

The 2003 to 2006 sampling program included approximately 225 samples from tailings, sediment, and surface water in the Seal Harbour – Isaac's Harbour area. Field studies reveal that most mine sites contain large volumes of unconfined tailings that have been transported off-site by streams and rivers. Tailings and stream sediments near these sites exceed the CCME (2001) SQGs for arsenic, whereas the values for mercury are lower reflecting both the natural mercury levels in the Meguma Terrane and, in the case of Lower Seal Harbour, the use of cyanide during the latter stages of mining (Parsons *et al.*, 2012). As well, follow-up surface water and streambank sediment analyses were done within 20 km of the Upper and Lower Seal Harbour gold districts to establish regional background concentrations for arsenic and mercury in both mineralized and unmineralized areas. This data demonstrates that both arsenic and mercury are elevated in both stream waters and stream sediments closely associated with mine tailings when compared to the background values (Table 9.1-3). See also Section 9.1.2.5 for a discussion on the arsenic and mercury values of tailings on site. Sediment samples collected by EnCana from Betty's Cove Brook in September 2006 do not indicate elevated levels of arsenic or mercury (EnCana, 2006).

For an assessment of the interaction between the Project and the herein described environment, refer to Section 10.1.

Table 9.1-3 Background and Tailings Impacted Arsenic and Mercury Concentrations in Goldboro Gold District

Stream Waters		
Element	**Medium**	**Concentration Range**
Arsenic	Lower Seal Harbour tailings drainages	17 – 406 micrograms per litre (µg/L)
Arsenic	Background streams	0.3 – 14 µg/L
Mercury	Lower Seal Harbour tailings drainages	8 – 16 nanograms per litre (ng/L)
Mercury	Background streams	1.6 – 10 ng/L
Streambank Sediments		
Element	**Medium**	**Concentration Range**
Arsenic	Lower Seal Harbour tailings drainages	370 – 6500 mg/kg
Arsenic	Background streams	2.5 – 70 mg/kg
Mercury	Lower Seal Harbour tailings drainages	300 – 3900 micrograms per kilogram (µg/kg)
Mercury	Background streams	19 – 300 µg/kg



LEGEND:

Project Location

CLIENT:

Pieridae Energy (Canada) Limited

SCALE:

50,000 25,000 0 50,000

Metres

1:2,600,000

PROJECT:

GOLDBORO LNG

ENVIRONMENTAL ASSESSMENT

DWN BY: JT

CHK'D BY: TM/GB

DATE: May 2013

AMEC Environment and Infrastructure
A Division of AMEC Americas Ltd.

50 Troop Avenue, Unit 300
Dartmouth, N.S., B3B 1Z1
(P) 902-468-2848 (F) 902-468-1314

DATUM: UTM Zone 20

PROJECTION: NAD83

PROJECT NO: TV121039

TITLE:

NOVA SCOTIA'S MAIN PHYSIOGRAPHIC REGIONS

REV. NO: N/A

FIGURE NO: 9.1-1

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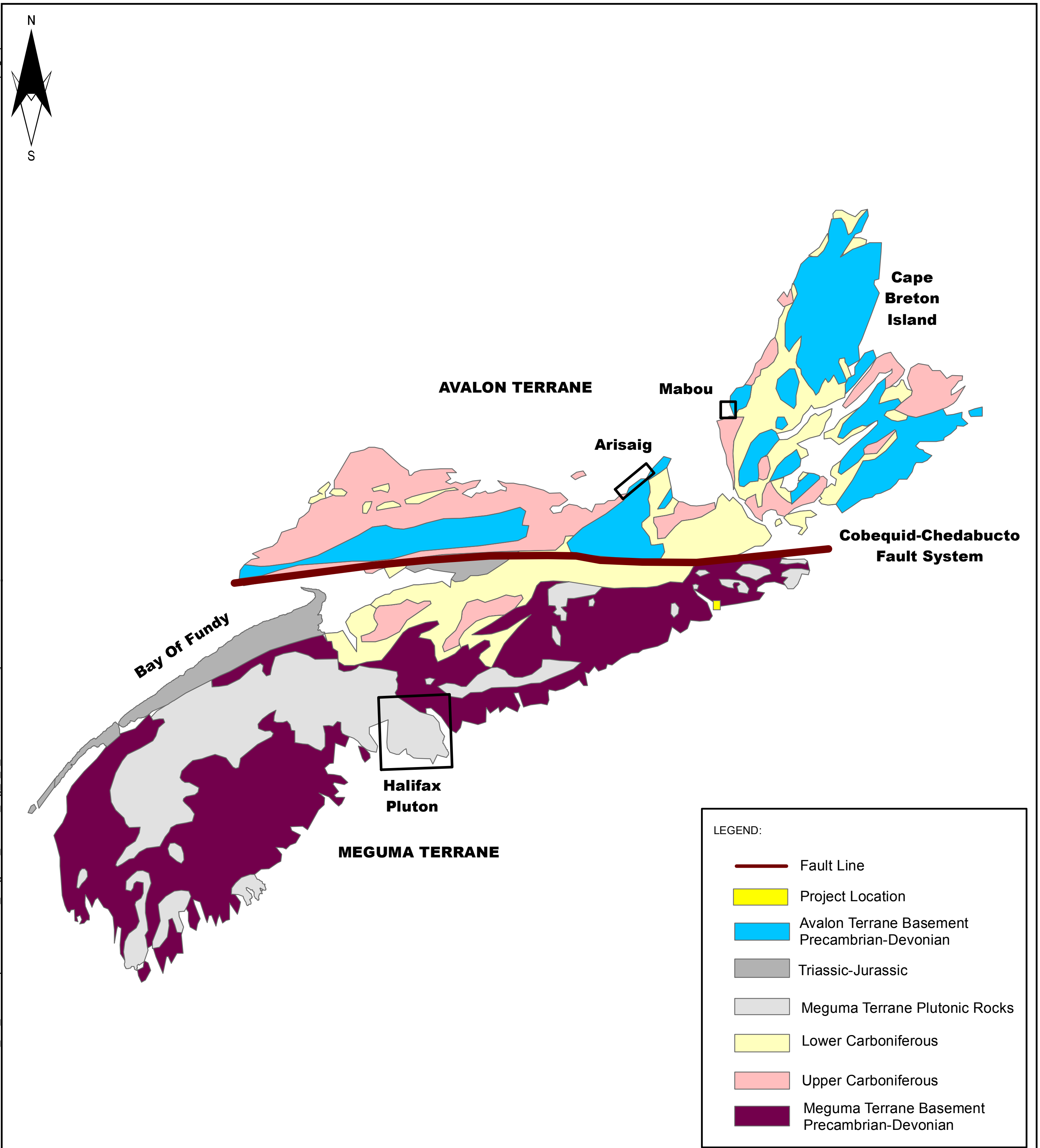

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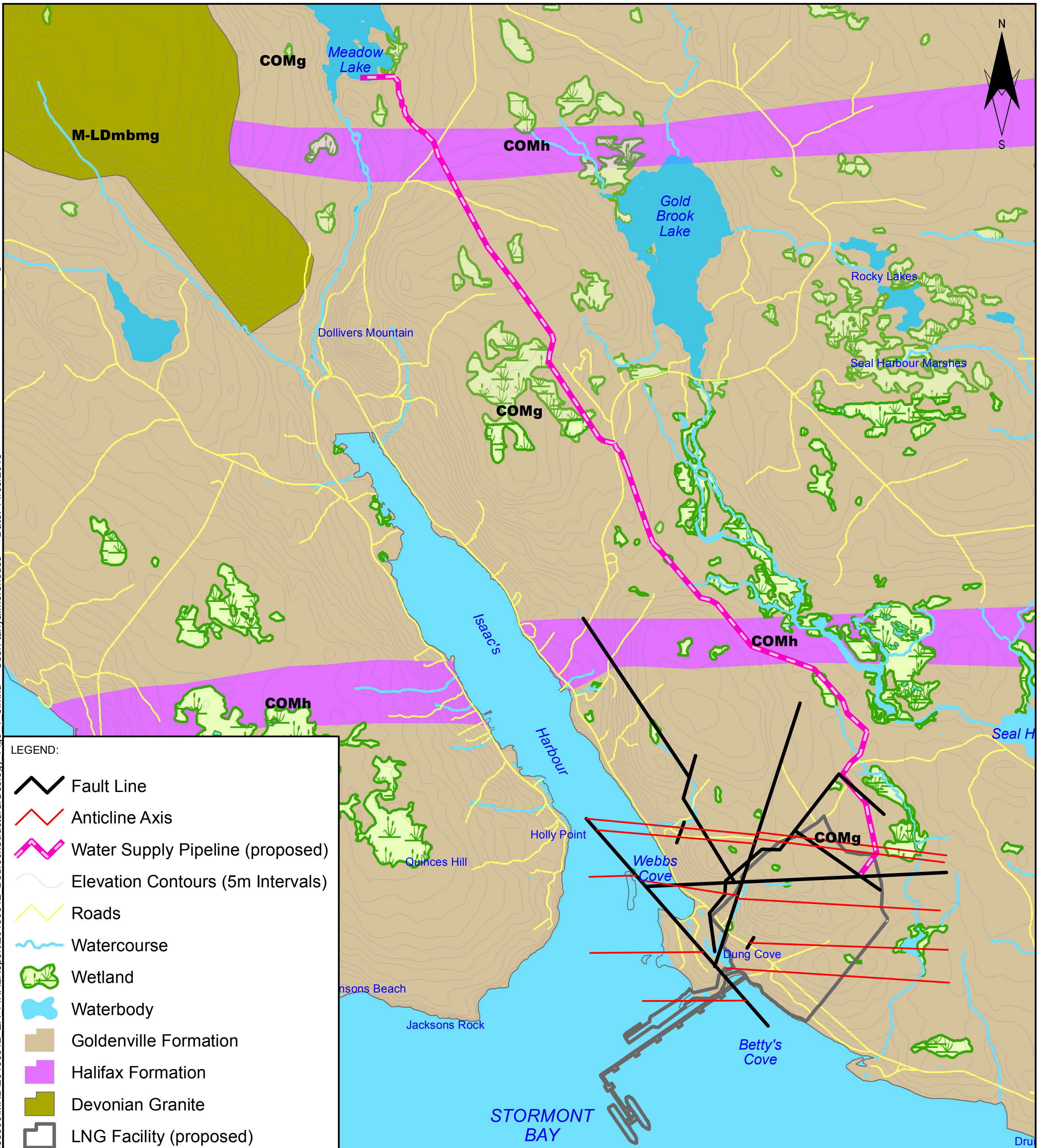

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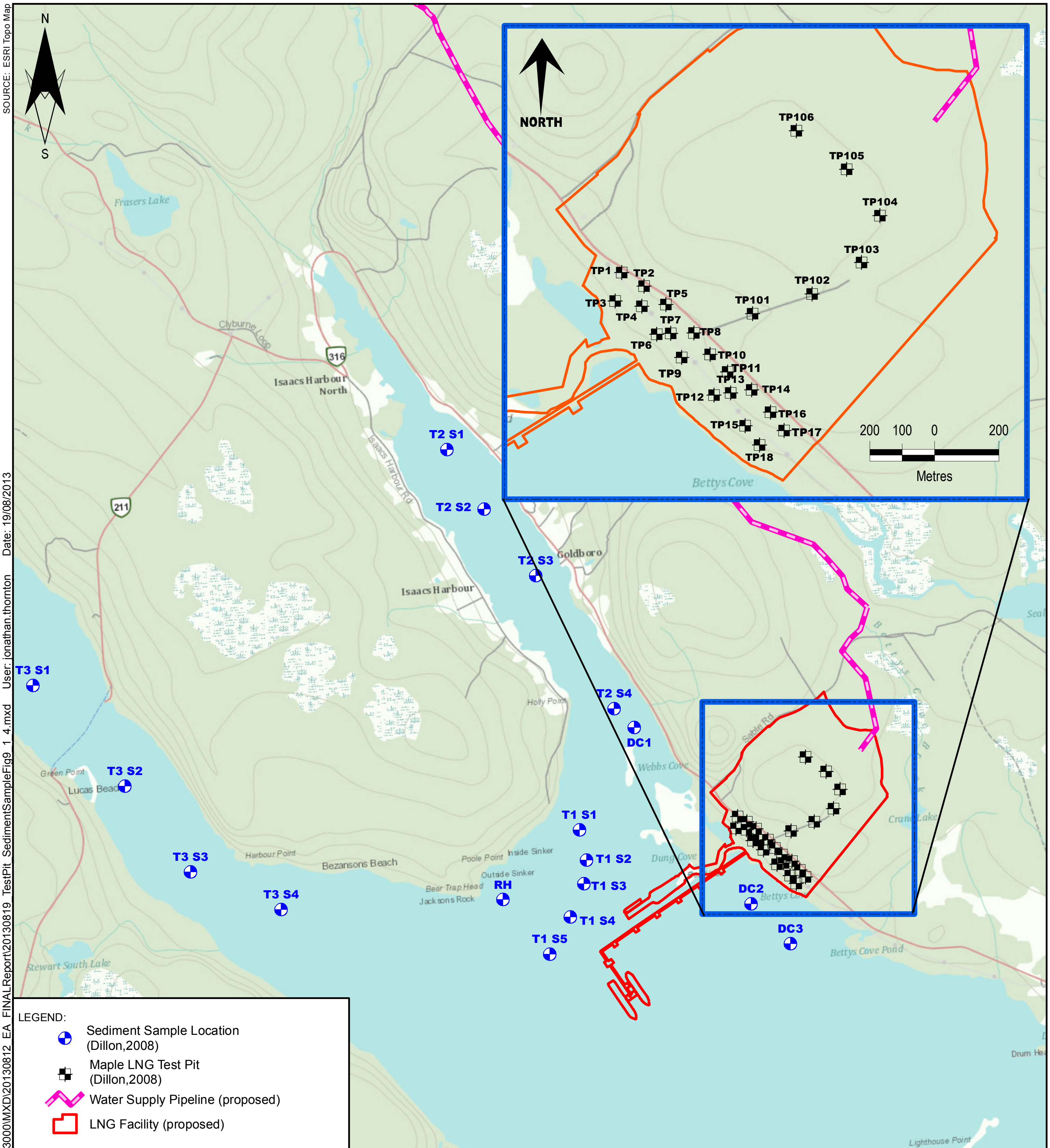

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AMEC Environment and Infrastructure A Division of AMEC Americas Ltd. 50 Troop Avenue, Unit 300 Dartmouth, N.S., B3B 1Z1 (P) 902-468-2848 (F) 902-468-1314 amec	DATUM: UTM Zone 20 PROJECTION: NAD83 PROJECT NO: TV121039	TITLE: LOCATION OF MAPLE LNG TEST PITS / MARINE SEDIMENT SAMPLES	DATE: Aug 2013 REV. NO: N/A FIGURE NO: 9.1-4

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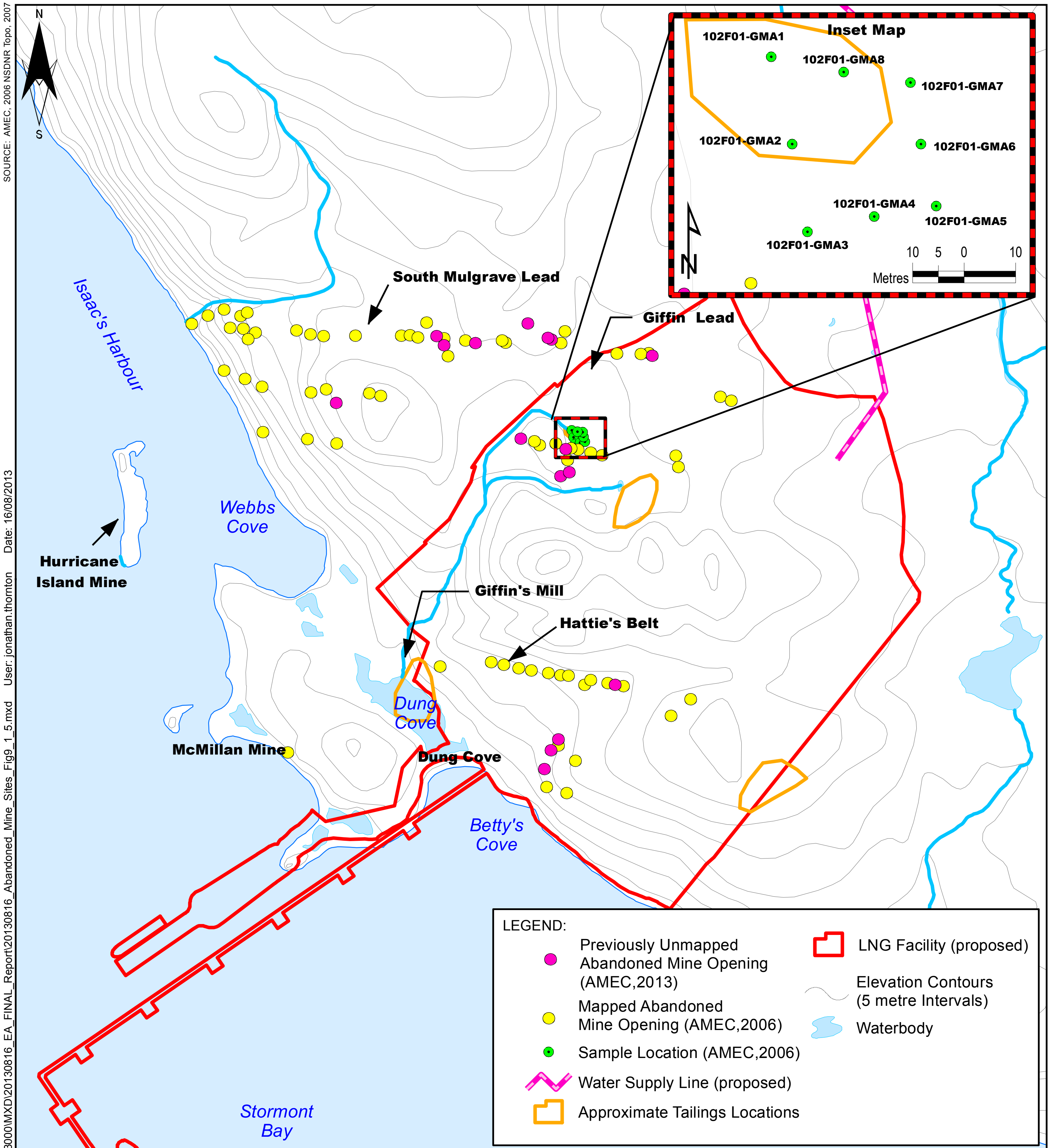

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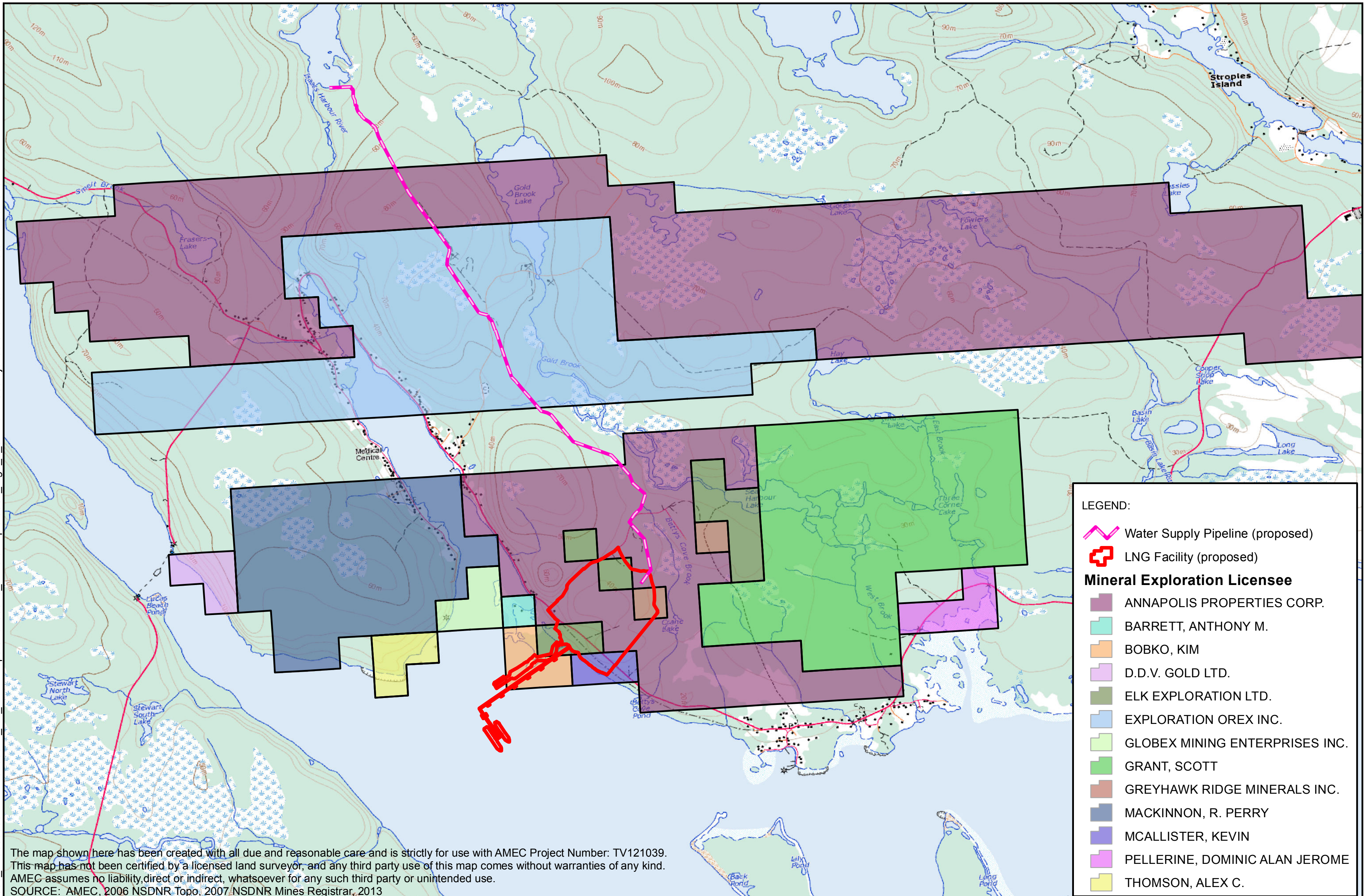
AMEC Environment and Infrastructure A Division of AMEC Americas Ltd. 50 Troop Avenue, Unit 300 Dartmouth, N.S., B3B 1Z1 (P) 902-468-2848 (F) 902-468-1314 amec	DATUM: UTM Zone 20 PROJECTION: NAD83 PROJECT NO: TV121039	TITLE: ABANDONED MINE SITES, TAILINGS, AND SAMPLE LOCATIONS	DATE: Aug 2013 REV. NO: N/A FIGURE NO: 9.1-5



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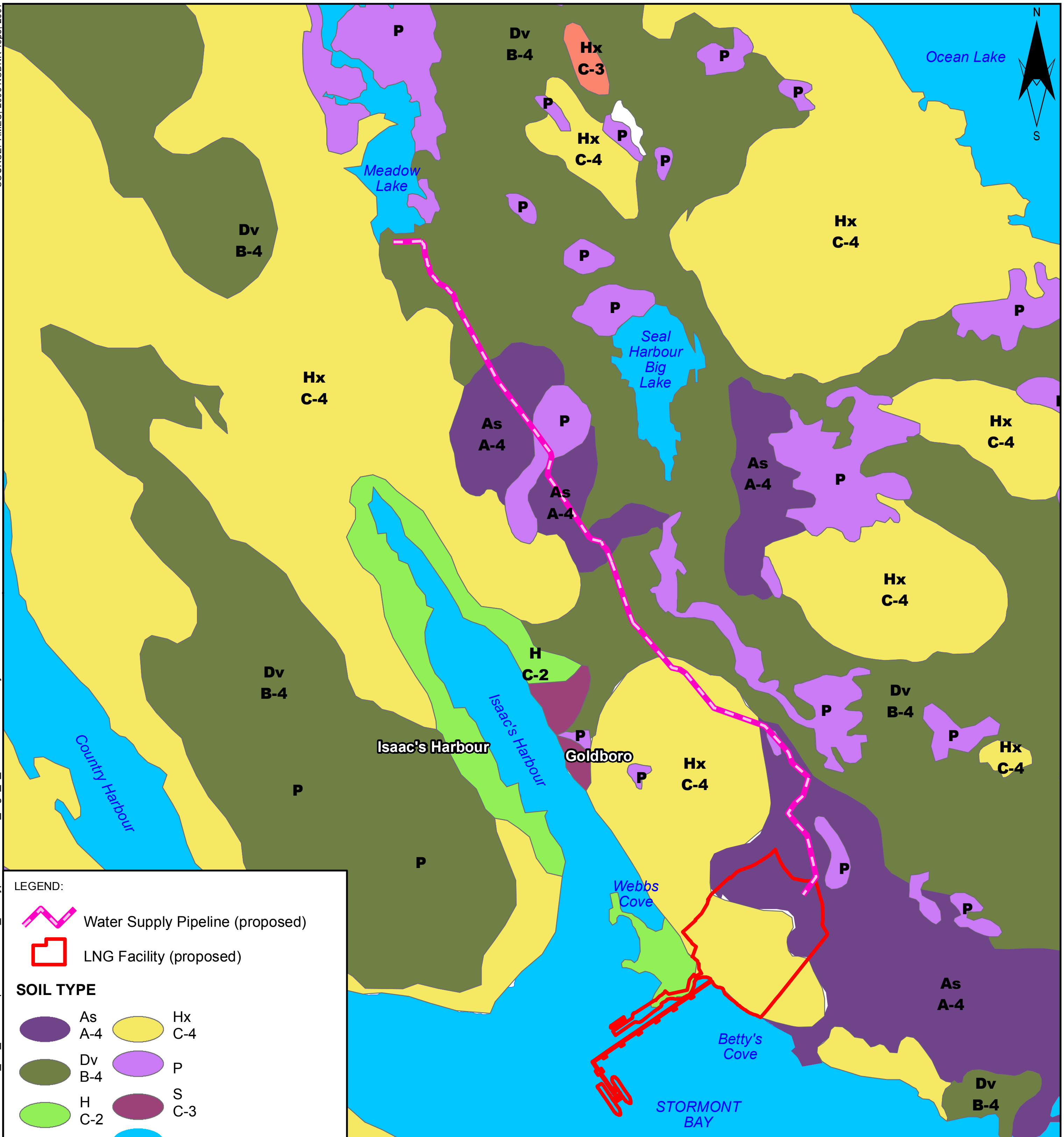
SOURCE: AMEC, 2006 NSDNR Topo, 2007 NSDNR Mines Registrar, 2013

Path: G:\GIS\PROJECTS\TV121039_Phase3000\MXD\20130812_EA_FINALReport\20130813_MineralExploration_Fig9_1_6.mxd User: jonathan.thornton Date: 14/08/2013

CLIENT: Pieridae Energy (Canada) Limited	DATUM: UTM Zone 20	PROJECT: ENVIRONMENTAL ASSESSMENT (GOLDBORO LNG)	DWN BY: JT
			DATE: June 2013
AMEC Environment and Infrastructure A Division of AMEC Americas Ltd. 50 Troop Avenue, Unit 300 Dartmouth, N.S., B3B 1Z1 (P) 902-468-2848 (F) 902-468-1314	PROJECTION: NAD83	TITLE: THE DISTRIBUTION OF EXPLORATION INTERESTS IN THE IMMEDIATE AREA	CHK'D BY: TM/GB
	PROJECT NO: TV121039		REV. NO: N/A
			SCALE: 1:65,000
			FIGURE NO: 9.1-6



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CLIENT: Pieridae Energy (Canada) Limited	SCALE: 800 400 0 800 Metres 1:50,000	PROJECT: GOLDBORO LNG ENVIRONMENTAL ASSESSMENT	DWN BY: JT CHK'D BY: TM/GB DATE: June 2013
AMEC Environment and Infrastructure A Division of AMEC Americas Ltd. 50 Troop Avenue, Unit 300 Dartmouth, N.S., B3B 1Z1 (P) 902-468-2848 (F) 902-468-1314 amec	DATUM: UTM Zone 20 PROJECTION: NAD83 PROJECT NO: TV121039	TITLE: SOIL TYPE DISTRIBUTION (A and B Horizons)	REV. NO: N/A FIGURE NO: 9.1-7

SOURCE: AMEC, 2006 NSDNR Topo, 2007

Path: G:\GIS\PROJECTS\TV121039_Phase3000\MXD\20130812_EA_FINALReport\20130813_SoilTypeDistribution_Fig9_1_7.mxd User: tanya.morehouse Date: 14/08/2013

9.2 Water Resources

9.2.1 Groundwater

Groundwater has a dynamic relationship with surface water, and provides a potable water supply to all of the unserviced residences adjacent to the proposed Goldboro LNG site. Obtaining a proper understanding of groundwater also requires having a clear understanding of the soil and bedrock through which it flows (AMEC, 2006). Soil and bedrock are discussed in Section 9.1 of this report.

A description of the hydrogeology of the proposed Project area was documented in the 2006 Keltic Project EA (AMEC, 2006) and the 2008 Keltic Meadow Lake Screening Report (AMEC, 2008a) by conducting:

- a review of all available published maps and reports;
- reconnaissance-level and detailed geologic assessments of the hydrogeologic Project areas in 2004 and 2005;
- monitoring well installations, slug hydraulic testing and groundwater sampling at the proposed Project site to help characterize the hydrogeology of the site and to provide baseline groundwater quality data;
- a reconnaissance-level survey of all homes and wells present within 1 km of the proposed Project site; and
- a door-to-door well survey with water sampling within 1 km of the proposed Project site boundaries to further assess the hydrogeology of the area and to provide baseline information.

Both the information compiled and reported for the Keltic Project EA (AMEC, 2006) and the 2013 Dillon Consulting Limited (Dillon) *Assessment of the Water Supply for Plant Production Requirements of Goldboro LNG* (Appendix C; Dillon. 2013a) have been used for purposes of the Project EA.

9.2.1.1 General Hydrogeology

The physical and general chemical hydrogeology of the various hydrostratigraphic units underlying and within 1 km of the Goldboro LNG Site are presented below. Information obtained from the NSE well log database provides an overview of typical well depth and yield.

9.2.1.2 Underlying Geology

The site is underlain by the Meguma Group (Halifax and Goldenville Formations, and granitic plutons). Refer to Section 9.1 for more detail on the geology of the area. The Meguma Group contains no primary permeability due to its lithologic composition and degree of metamorphism. Well production from these bedrock units is nearly entirely dependent on fracture flow.

The Goldenville and Halifax Formations of the Meguma Group are typically only slightly hard to moderately hard with low to moderate concentrations of total dissolved solids, neutral to slightly acidic pH and low alkalinity. Iron and manganese concentrations often exceed guideline values, arsenic concentrations can be elevated, and elevated values for uranium have also been reported (AMEC, 2006).

The granites generally produce calcium bicarbonate type waters mostly, although sodium chloride type waters can be found. The granites generally yield waters that are very soft to only slightly hard, with low pH, low alkalinity and low total dissolved solids. Iron, manganese, radon, and uranium concentrations often exceed their respective guidelines (AMEC, 2006).

9.2.1.3 Direction of Groundwater Flow/Hydrogeology

Influences on groundwater flow direction may include water table hydraulic gradient (piezometric), hydraulic conductivity, and fracture orientation. Groundwater is expected to follow relief on a regional scale; however, this may not always be the case (AMEC, 2006).

The predominance of secondary permeability within the bedrock of the Goldenville Formation, the large number of shear zones known to be present at the site, and the large number of possibly extensive abandoned underground workings, can be expected to have a significant influence on groundwater flow pathways and on overall groundwater flow velocity within and beyond the site.

A monitoring well network was installed by Maple LNG in 2008 for baseline and construction monitoring purposes. There were ten wells in total, constructed as five shallow/deep water couplets ranging in depth from 7.6 to 8.8 m for the shallow water wells to 15.4 to 42.7 m for the deep water well (Dillon, pers. comm., 2013b). An assessment of the groundwater data was included in the MapleLNG Permit to Construct, 2008 and indicated, “Hydraulic communication was found to exist between many of the monitoring well pairs during hydraulic testing, suggesting both vertical and lateral bedrock fracturing. Groundwater is expected to flow from higher elevations northwest of the site, in a southeast direction across the site towards Betty’s Cove Brook to the east, southeast and south, Dung Cove to the southwest, and Stormont Bay to the south. However, possible groundwater flow paths of potential least resistance are indicated from the current knowledge of faults, shear zones and abandoned underground workings on the site. These are expected to have an influence on the actual routes groundwater would flow.”

Additionally, subsurface assessments of the area were conducted in 2004 and 2005 as part of the Keltic Project EA process. The hydrogeology was evaluated via the construction of monitoring wells, installed as piezometer pairs at seven locations at depths ranging from 7 to 25 m. Two of these pairs were positioned on the western boundary of the Goldboro LNG site, two were positioned just north of the site (within 1 km), and the other three were positioned further northwest. Both the Keltic and MapleLNG monitoring well locations are shown in Figure 9.2-1.

9.2.1.4 Physical Site Hydrogeology

The data presented in the Keltic Project EA (AMEC, 2006) indicate that the proposed LNG facility is in a groundwater recharge zone (groundwater recharge conditions are considered present when piezometric levels for shallow horizons are higher than for deeper horizons (Table 9.2-1). Data in both the Keltic Project EA (AMEC, 2006) and MapleLNG (MapleLNG, 2008) reports indicate that hydraulic communication was found to exist between many of the monitoring well pairs during hydraulic testing suggesting both vertical and lateral bedrock fracturing.

Groundwater fluctuations were found to range from about 3 to 48 centimetre (cm) on the shores of Isaac's Harbour. Water level fluctuations in the order of 2 to 3 m might be expected seasonally (MapleLNG, 2008).

Table 9.2-1 Groundwater Elevations at Keltic Monitoring Wells (Elevations Reference Mean Sea Level)

Location	Measurement Event [1]			Measurement Event [2]		
	Date	Elevation (m)	Δh[3] (m)	Date	Elevation (m)	Δh[3] (m)
MW05-1a	16/04/05	73.27	+0.05	na	na	na
MW05-1b		73.21			na	
MW05-2a	10/04/05	54.19	-1.2	14/04/05	54.36	-0.81
MW05-2b		55.39			55.17	
MW05-3a	11/04/05	37.01	+0.07	14/04/05	36.90	+0.08
MW05-3b		36.94			36.82	
MW05-4a	13/04/05	34.97	-0.05	14/04/05	35.00	0
MW05-4b		35.02			35.00	
MW05-5a	17/04/05	33.88	+0.95	18/04/05	33.85	+0.95
MW05-5b		32.93			32.90	
MW05-6a	18/04/05	na	na	19/04/05	14.54	+0.53
MW05-6b		14.47		19/04/05	14.01	
MW05-7a	21/04/05	6.17	+0.05	03/05/05	6.65	+0.09
MW05-7b		6.12		03/05/05	6.56	

Notes:
1. Source: AMEC, 2006
2. Source: MapleLNG, 2008
3. (+) and (-) values designate groundwater recharge and discharge conditions, respectively.

Figure 9.2-1 is a piezometric contour map (based on Keltic data only, MapleLNG details were not available) of the site developed using the second set of groundwater level measurements for the "a" (deeper) well series (Table 9.2-1). The piezometric contours for the "b" (shallow) well series would be similar. This figure also depicts the probable groundwater flow direction which is expected to flow radially from around the northwest boundary of the Goldboro Industrial Park to Gold Brook and Betty's Cove Brook to the east, southeast and south, the hamlet of Goldboro to the north and northwest, and the ocean to the west and southwest (AMEC, 2006).

The hydraulic conductivity values obtained at these monitoring wells are within the upper end of the generally recognized spectrum for fractured metamorphic bedrock. The distribution of values suggests that hydraulic conductivity in the vicinity of MW05-3 and MW05-4, just north of the proposed LNG facility, are highest (AMEC, 2006).

The hydraulic conductivity values obtained at the deep and shallow piezometers at each monitoring well pair are for the most part quite similar. The hydraulic conductivity values obtained for the shallower wells are general slightly higher than those for the neighbouring deeper well. This is likely a function of the greater degree of bedrock weathering expected at the shallower depths (AMEC, 2006). The reverse appears to be the case at MW05-6 and

MW05-7 where hydraulic conductivity for the deeper bedrock horizon was found to be greater than in the shallower horizons. The overall hydraulic conductivity at these wells was lower than in other places. This reverse relationship may suggest a greater relative degree of bedrock fracturing at depths below the wells at those locations (AMEC, 2006).

With few exceptions, the glacial till appears to be relatively thin throughout the Project area (Table 9.1-2) and as such, the low permeability till is expected to influence only very local groundwater flows at the site. The more intermediary to regional groundwater flows present within bedrock should be considered as the more significant flow components at this site.

9.2.1.5 Chemical Hydrogeology

Organic and general chemistry was performed during the 2003 and 2005 field seasons and the results were reported in the Keltic Project EA (AMEC, 2006). The groundwater chemistry collected from the monitoring wells was compared to the chemical data from dug and drilled water supply wells located in the Goldboro area and surface water samples. The Piper diagram in Figure 9.2-2 shows the relative distribution of major ions in water and gives a comparison of the groundwater samples to well and surface water samples.

The major ion chemistry is similar for most of the monitoring and drilled well samples and exhibit mostly calcium bicarbonate type waters. The surface waters are distinct from groundwater in that they are predominantly sodium sulphate type waters. The monitoring wells generally produce soft to only slightly hard waters with low total dissolved solids, low alkalinity, and generally near neutral pH.

The Langelier Index calculations for waters from the monitoring wells are all slightly negative – these are all under saturated with respect to calcium carbonate. A few monitoring wells have elevated aluminum concentrations, several have iron and manganese concentrations that exceed guideline values for aethstetics (bad odour or taste), and arsenic concentrations were elevated at MW05-5a, MW05-5b, MW05-6a and MW05-6b, all of which are located within or near highly mineralized areas (AMEC, 2006).

The data reported from monitoring wells installed by MapleLNG in 2007 (Figure 9.2-1) indicate generally good quality water with few CCME parameter exceedances. Both arsenic and manganese were above the CCME guidelines for drinking water as was the pH (Dillon, pers. comm.; 2013b).

9.2.1.6 Area Wells

Wells drilled into Meguma Group bedrock are highly variable and may be expected to yield anywhere from less than 1 Lpm to amounts in excess of 1,000 Lpm (NSE, 2013d). Yield is dependent on location and fracture frequency, aperture size and interconnectedness. Well yields in the order of 4 to 18 Lpm are more the norm (AMEC, 2006).

Pieridae commissioned Dillon to provide an assessment of the Goldboro LNG water supply requirements for plant production. This new information was added to community based information obtained from NSE well log database for the period January 1, 1920, to December 31, 2012, and the data is presented in Table 9.2-2 below.

Table 9.2-2 Project Area Well Data Summary, (NSEL Well Log Database)

Community	No. of Wells	Average Depth (m)	Average Yield (Lpm)	Extreme yields (Lpm)	
				Low	High
Isaac's Harbour	12	49	116.4	2.3	1000
Goldboro	13	57	28.3	2.3	68.2
Drum Head	4	55	3	2.3	4.5
MapleLNG well 1"	1	n/a	1.0	n/a	n/a
MapleLNG well 2"	1	n/a	.75	n/a	n/a
Wells closest to site*	15	n/a	11	2.0	68.0

Source: NSE, 2013d
*Dillon, pers. comm., 2013b

Keltic performed a door-to-door survey of the water supply wells located in the area. Up to 40 wells were identified in the community of Goldboro (see Figure 9.2-3), most of which are dug wells. There are only thirteen drilled wells in the community of Goldboro (NSE, 2013d).

Fourteen of the wells identified in the survey area were sampled for general chemistry, total metals, and coliform analysis. A newly drilled well located off-site was also sampled to serve as a groundwater quality benchmark. Detailed analytical results for these wells were reported in AMEC, 2006.

The dug wells generally produce water classed as soft, sodium-chloride type waters with low total dissolved solids, low alkalinity and low pH. The relative proportions of sodium and chloride appear to increase with increased total dissolved solids concentration, suggesting a possible road salt (less likely) and/or sea spray (more likely) influence on these wells. The values for pH and aluminum are generally outside of acceptable guideline limits. Nearly all of the dug wells showed positive for total coliform. This is likely a function of well construction and maintenance (AMEC, 2006).

The drilled wells sampled inside the survey area generally produce soft to only slightly hard, calcium-bicarbonate type waters with low total dissolved solids, low alkalinity and neutral to just below neutral pH. Aluminum, iron, and manganese concentrations were found to be outside of acceptable guideline limits. Only one well indicated the presence of coliform. The chemistry for water from drilled wells inside the survey area was in general very similar to that of the off-site benchmark well.

The two potable water wells drilled by MapleLNG in 2007 were sampled shortly after pumping so the analytical results might not be representative of the true groundwater quality (Dillon, pers. comm.; 2013b). The analysis revealed the following CCME exceedances: turbidity was above the CCME guideline (samples were 47 Nephelometric Turbidity Units (NCU) and 640 NCU compared to a guideline value of 1 NCU); as were manganese and pH (Dillon, pers. comm.; 2013b).

For an assessment of the interaction between the Project and the herein described environment, refer to Section 10.2.

9.2.2 Surface Water

Surface water in NS is generally of good quality and suitable for expected uses such as drinking water supply, swimming, and fish habitat. However, there are several types of naturally occurring and anthropogenic water quality problems that can occur.

The Atlantic coast is dissected by many fault-controlled river and lake systems that drain into the ocean. At the mouths of most rivers, wetlands receive both tidal and freshwater influences. Surface waters tend to be soft and acidic, field-measured pH levels are also low, ranging from 3.4 to 5.51(AMEC, 2006).

A detailed analysis of the surface water quantity and quality in the Project area was performed for the Keltic Project EA (AMEC, 2006). Additionally, surface water was sampled as part of the MapleLNG environmental approvals (Dillon, pers. comm., 2013b). Much of the information presented here has been consolidated from those reports.

9.2.2.1 Water Uses and Users

Surface water uses at or near the Project site include recreational fishing and commercial fishing in the near-shore area and several fish farm operations in Isaac's Harbour (Table 9.2-3). With respect to permanent downstream users of Meadow Lake and the area where the Project footprint is located; none were identified.

9.2.2.2 Data Sources and Field Work

Precipitation data for the area were taken from EC's Canadian Climate Normals (1971-2000) for the area (EC, 2007a). Additional information was taken from the Keltic Project EA where detailed field work and analyses on water quality and quantity was performed on all the surface water bodies in and adjacent to the Goldboro LNG site. This work included: water-quality surveys on Gold Brook Lake, Seal Harbour Lake, and Meadow Lake along with the major tributaries to these lakes in 2001; and water quantity surveys from 2001 to 2003. In the spring and summer of 2004, water quality surveys were expanded to include Ocean Lake and New Harbour River. In 2005, key aquatic features were again surveyed. Additionally, surface water sampling was done in 2007 as MapleLNG's EA conditions of approval.

9.2.2.3 Surface Water Quantity

The proposed LNG facility encompasses sections of two watersheds. The Project components and sub-watershed identities based on NSE (1980) designation are given in the Project-watershed matrix in Table 9.2-4. The watershed locations are shown in Figure 9.2-4. It is of note that the Project footprint does not impinge on any of the major watercourses/bodies for these watersheds.

Table 9.2-3 Known, Assumed, and Possible Water Uses in the Project Area

Water Body	Past Uses						Current Uses					
	Commercial Fishing	**Recreational Fishing**	**Other Recreation**	**Mining**	**Drinking Supply**	**Industrial (Other)***	**Commercial Fishing**	**Recreational Fishing**	**Other Recreation**	**Mining**	**Drinking Supply**	**Industrial (Other)***
Gold Brook Lake		x	x	x		x		x	X			x
Seal Harbour Lake		x		x		x		x				
Gold Brook		x		x		x		x				
Isaac's Harbour River		x		x		x		x				
Dung Cove		x		x				x				
Red Head Ponds												
Crusher Brook				x		x						
Betty's Cove Brook		x						x				
Unnamed tributary to Dung Cove				x		x						

Note:
* Industrial (other) implies use for logging or as energy to run small mills (AMEC, 2006)

Table 9.2-4 Watersheds in the Project Area

Watershed	Sub-Watershed		Total Land Area	Total Water Area
	NSEL Designation	**Major Watercourse or Water Body**		
New Harbour River	1EP-SD1	None	550 km^2	18 km^2
	1EQ-SD31	Gold Brook		
	1EQ-SD32	None		
	1EQ-4H	Ocean Lake		
	1EQ-4J	New Harbour River		
Isaac's Harbour River	1EP-1A	Meadow Lake	1019 km^2	70 km^2
	1EP-1B	tributary to Meadow Lake		
	1EP-1C	tributary to Isaac's Harbour River		
	1EP-1D	Garry River		
	1EP-1E	Costley Lake, Isaac's Harbour River		

Source: NSMNH, 1996

Annual precipitation is quite high (1300 mm) in NS and the geology and prevailing slope of the terrain produces an average surface water runoff of about 70% (NSE, 2013e). Large areas of impermeable rock and thin soils, and the effects of glaciation, have resulted in many lakes, streams, and wetlands (NSE, 2013e). Overall, approximately 4% of NS's land surface is covered by freshwater.

The hydrologic regime within this region is largely driven by pluvial (rainfall) and nival (snowmelt) processes. Mean annual precipitation according to the Canadian Climate Normals (1971-2000) measured at nearby stations is presented in Table 9.2-5 (EC, 2007a). Historical data from Clam Harbour River and St. Mary's Stillwater in provincial drainage basin 1EP, watersheds adjacent to the Country Harbour and New Harbour watersheds, shows that mean monthly stream discharge is highest in March and April due to snow melt, dropping to its lowest level in July to September when precipitation is low and evapotranspiration is at its highest. There is a second stream discharge peak in late fall, corresponding with a seasonal increase in precipitation. These patterns are consistent with those watersheds that fall within the Atlantic divide of NS (NSMNH, 1996).

Table 9.2-5 Average Annual Precipitation

Station Name	Location	Average Annual Precipitation
Deming	45° 12' N, 61° 10' W	1427.5 mm
Sherbrooke-Stillwater	45° 08' N, 61° 58' W	1516.4 mm
Collegeville	45° 29' N, 62° 01' W	1384.3 mm
Keltic Project EA	Gold Brook Lake (2002 only)	1557 mm
Provincial Average	n/a	1300 mm

Sources: EC, 2007a; and AMEC, 2006

9.2.2.4 Surface Water Quality

Surface water quality in NS is generally good. However, surface waters can be impacted by a number of naturally-occurring and human-made substances including silt, acids, nutrients, metals such as mercury, petroleum products, chlorides from road salt, and coliform bacteria (NSE, 2013b).

Some areas of the province have highly coloured surface waters which are naturally occurring and result from drainage from peat bogs and other wetlands (NSE, 2013e). These waters have high acidity and low pH and can be less suited for drinking water supplies and recreational uses. They are also sensitive to other acid inputs such as acid rain, and some have become less suited for fish habitat.

Regional conductivity of surface water at the Project site is generally low, reflecting the natural geology associated with this watershed; iron and manganese are both present in varying concentrations, sometimes exceeding both the CCME aquatic habitat (1999) and drinking water guidelines (Health Canada, 2012).

There are a number of small streams in the liquefaction/tank farm area, as well as several small ponds on the Red Head peninsula (Figure 9.2-5), and Meadow Lake and associated tributaries (Figure 9.2-6).

Meadow Lake

Meadow Lake is the largest body of water in the Isaac's Harbour River - Meadow Lake watershed. Water quantity and quality of this lake was evaluated by AMEC as part of the Keltic Project in 2006 and 2008 (AMEC, 2008a).

This lake is relatively shallow; with a maximum depth of about 2 m. Dissolved oxygen levels were within normal ranges during all surveys, conductivity is low, humic substances, total organic carbon, colour, and aluminum (which may be present as an organic chelate) concentrations are all elevated. Aluminum values exceeded the CCME guideline in all samples. Copper and lead were found present above CCME guideline values in only one water sample collected in March 2002. This result may represent an anomalous event or a sampling error. Iron and manganese are both present in varying concentrations, sometime exceeding both, the CCME aquatic habitat (1999) and drinking water guidelines (Health Canada, 2012).

The water-quality survey in this lake revealed low field-measured pH values, ranging from 3.4 to 4.96 during the 2004 Keltic surveys (Table 9.2-6). These values are likely reflective of acid precipitation and the low alkalinity of study-area waters due to the underlying bedrock geology. The lab-measured pH values were slightly higher, ranging between 4.7 and 5.1, but it is normal for pH values in the lab to differ from those taken in the field. The field-measured values are considered to be more representative of lake conditions.

Table 9.2-6 Surface Water Quality - Meadow Lake

Aquatic System	Location	Survey	Temperature (°C)	Conductivity (μS/m)[1]	Dissolved Oxygen (mg/L)[2]	pH
Meadow Lake	Northeast Inlet 0603321 E 5011240 N	Spring, 2004	13.8	26.3	11.03	4.2
Meadow Lake	Northwest Inlet 0603301 E 5011301 N	Spring, 2004	11.7	35.3	12.25	3.4
Meadow Lake	East Branch Tributary Inlet 0604555 E 5010807 N	Spring, 2004	14.3	33.8	9.68	4.14
Meadow Lake	Western Shore 0604228 E 5009951 N	Spring, 2004	15.6	-	9.95	4.19
Meadow Lake	Centre of South Bay 0604284 E 5009138 N	Spring, 2004	16.9	33.1	9.53	4.24
Meadow Lake	Outlet 0604284 E 5008371 N	Spring, 2004	18.9	32.8	8.57	4.96

Source: AMEC 2008a
Notes:

1. μS/m = microseimens per minute
2. mg/L = milligrams per litre

These low pH levels are thought to be the reason why Atlantic Salmon are not spawning in Meadow Lake as Atlantic salmon cannot spawn successfully in waters with such low pH levels (AMEC, 2008a).

The AMEC (2008a) report also noted highly negative Langelier Index Values, high colour, and elevated values of iron and manganese. Water from this lake should be considered to be very corrosive. This profile is unusual when compared to other surface municipal and/or industrial water supplies in NS, and corrective treatment is possible.

Red Head Ponds

Three of the six ponds, located on the Red Head peninsula, are in the footprint of the proposed LNG facility, including: Dung Cove Pond (Pond 6) and two much smaller ponds, Ponds 4 and 5, which are located near the headland. Ponds 4 and 5 are saline, while Pond 6 is freshwater, receiving input from an unnamed tributary to the north. Water samples collected in the spring of 2005 indicated that conductivity, dissolved oxygen, and pH in all ponds are within ranges considered normal although pH levels were higher than regional waters and were generally close to neutral. All ponds support at least one species of fish (AMEC, 2006).

Betty’s Cove Brook

Betty's Cove Brook originates in a wet forested area northwest of the Project area and flows southward around the northern and eastern edges of the property to Crane Lake, then southerly to discharge to the Atlantic Ocean at Betty’s Cove Pond. All parameters in Betty's Cove Brook are within normal ranges for the area with low values for pH and elevated levels of colour and aluminum, which exceeded CCME (1999b) guideline values for aesthetic objective and aquatic life, respectively.

Further sampling and testing was done in 2007 by MapleLNG as part of their environmental approvals (Figure 9.2-7). Samples were compared to the Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 1999) and the Atlantic PIRI (Partners in RBCA (Risk-Based Corrective Action) Implementation (various countries; environmental program) Guidelines for petroleum hydrocarbons. Observations on the general chemistry of these samples were made by Dillon in a February 2013 assessment provide to Pieridae and include:

- pH was below the recommended range of 6.5 to 9.0 and aluminum was above the guideline of 0.005 to 0.001 mg/L (pH dependent) in all samples.
- Arsenic was above the guideline of 0.005 mg/L in the majority of samples except one location which was only sampled once.
- Cadmium was above the guideline of 10 mg/L (hardness dependent) in all samples except one in October 2007.
- Copper was above the guideline of 0.002 to 0.004 mg/L (hardness dependent) in one sample.
- Iron was above the guideline of 0.3 mg/L on several occasions.
- Zinc was above the guideline of 0.03 mg/L in one sample.

9.2.2.5 Water Supply Potential

The average water requirement for the Project, during both construction and operation, has been established as 600 m^3 of water per day. Given the yields of wells in the vicinity of the Project (Section 9.2.1.6), groundwater is unlikely to yield sufficient water to meet development needs (Dillon, pers. comm.; 2013b). The suitability of water bodies in the area to provide adequate supplies of process water for industrial projects was evaluated by Keltic in 2006 and 2008. A water supply assessment for the Project was conducted in early 2013 (Dillon, 2013a; Appendix C) using data obtained from the Keltic Project EA and using a preliminary calculation of water volume required, based on a single process train. Analysis using maximum allowable withdrawal of 10% of baseflow demonstrated that Meadow Lake, Gold Brook Lake and Seal Harbour Lake would be potentially suitable (Tables 9.2-7 and 9.2-8).

Although both Seal Harbour Lake and Gold Brook Lake are closer to the Project area (see Figure 1.7-1) and would therefore require less pipe length (thus reducing the environmental footprint), the relatively low available water supply in June may require limiting operational water usage in order to prevent exceeding the maximum allow withdrawal limit of 10% of baseflow.

Meadow Lake has a much larger watershed than the other two lakes (Figure 9.2-7) and the expected peak water withdrawal volume, even in the lowest flowing part of the year, is only 1.2% of baseflow, and 12% of the allowable withdrawal amount. Therefore, Meadow Lake was chosen to source the water supply as it has abundant water supply year round. It is reasonable to anticipate increased future demands on Meadow Lake; which could be easily accommodated without affecting the Project operation. More detailed study of the water requirement and the Meadow Lake water supply will be undertaken during FEED.

Based on the results of the analysis of surface water conducted to date and outlined in Section 9.2.2, it is expected that water treatment would be required for pH adjustment, arsenic, and other metals (Dillon, pers. comm., 2013b).

Table 9.2-7 Availability of Water from Gold Brook and Seal Harbour Lakes

Month	Estimated Monthly Flow Gold Brook Lake m^3/month	Gold Brook Lake Proposed Allowable Withdrawal m^3/month	Estimated Monthly Flow Seal Harbour Lake m^3/month	Seal Harbour Lake Proposed Allowable Withdrawal m^3/month	Average Flow Required m^3/month
January	1,106,576	110,658	2,291,395	229,139	18,600
February	1,815,575	181,558	3,759,525	375,952	16,800
March	2,043,285	204,329	4,231,046	423,105	18,600
April	1,393,630	139,363	2,885,800	288,580	18,000
May	1,119,086	111,909	2,317,299	231,730	18,600
June	196,913	19,691	407,750	40,775	18,000
July	621,496	62,150	1,286,937	128,694	18,600
August	1,138,605	113,861	2,357,718	235,772	18,600
September	386,286	38,629	799,886	79,989	18,000
October	809,718	80,972	1,676,689	167,669	18,600
November	1,422,499	142,250	2,945,579	294,558	18,000
December	1,255,676	125,568	2,600,137	260,014	18,600

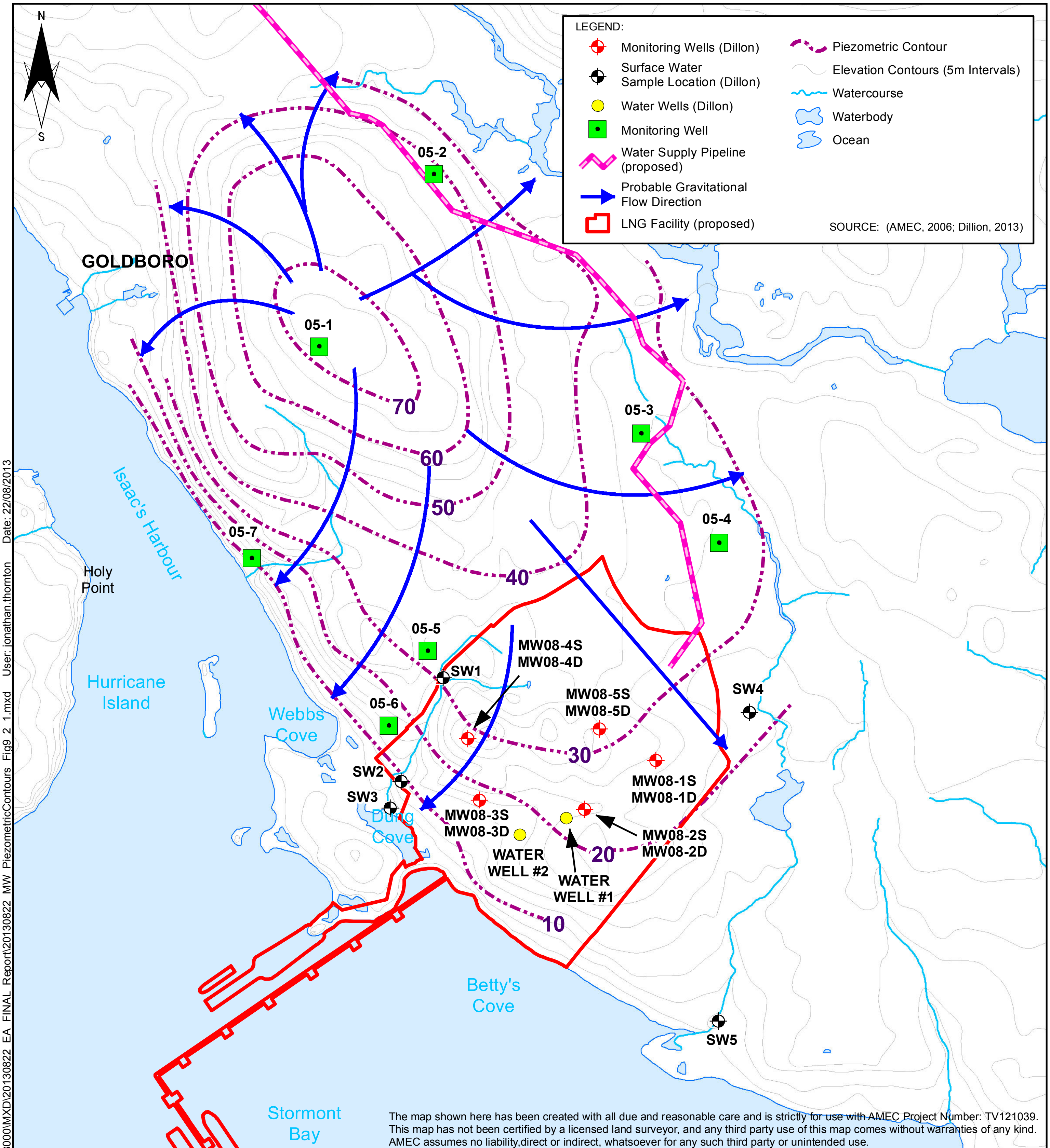
Source: Dillon, pers. comm.; 2013b

Table 9.2-8 Availability of Water from Meadow Lake

Month	Estimated Monthly Flow Meadow Lake m^3/month	Meadow Lake Proposed Allowable Withdrawal m^3/month	Average Flow Required m^3/month
January	8,869,995	887,000	18,600
February	14,553,131	1,455,313	16,800
March	16,378,389	1,637,839	18,600
April	11,170,939	1,117,094	18,000
May	8,970,270	897,027	18,600
June	1,578,400	157,840	18,000
July	4,981,735	498,174	18,600
August	9,126,733	912,673	18,600
September	3,096,361	309,636	18,000
October	6,490,466	649,047	18,600
November	11,402,344	1,140,234	18,000
December	10,065,137	1,006,514	18,600

Source: Dillon, pers. comm.; 2013b

For an assessment of the interaction between the Project and the herein described environment, refer to Section 10.3.



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CLIENT: Pieridae Energy (Canada) Limited

SCALE: 300 150 0 300 Metres 1:20,000

PROJECT: GOLDBORO LNG ENVIRONMENTAL ASSESSMENT

DWN BY: JT

CHK'D BY: GB/UW

DATE: Aug 2013

AMEC Environment and Infrastructure
A Division of AMEC Americas Ltd.

50 Troop Avenue, Unit 300
Dartmouth, N.S., B3B 1Z1
(P) 902-468-2848 (F) 902-468-1314

amec

DATUM: UTM Zone 20

PROJECTION: NAD83

PROJECT NO: TV121039

TITLE: MONITORING WELL LOCATIONS AND PIEZOMETRIC CONTOURS

REV. NO: N/A

FIGURE NO: 9.2-1

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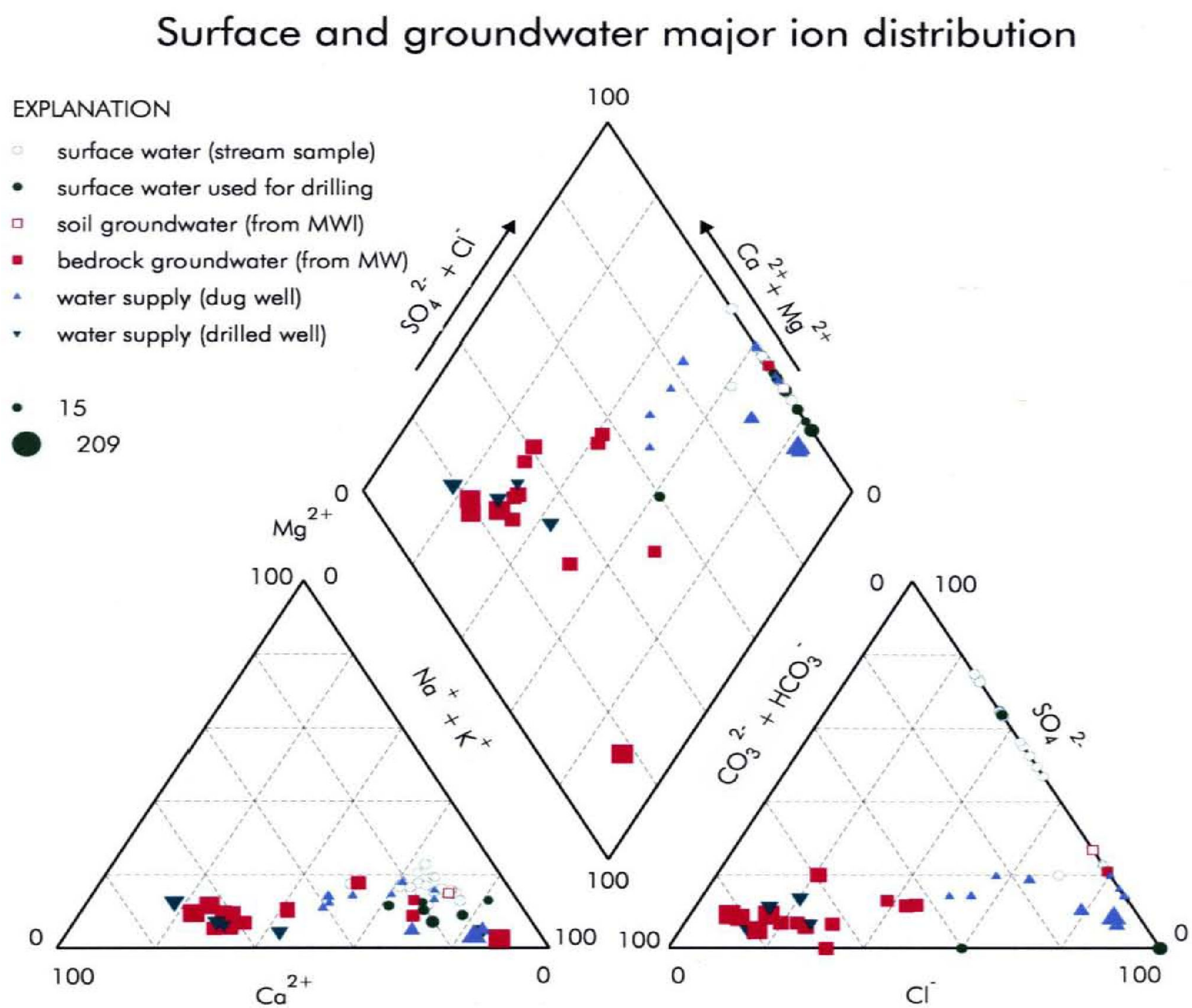
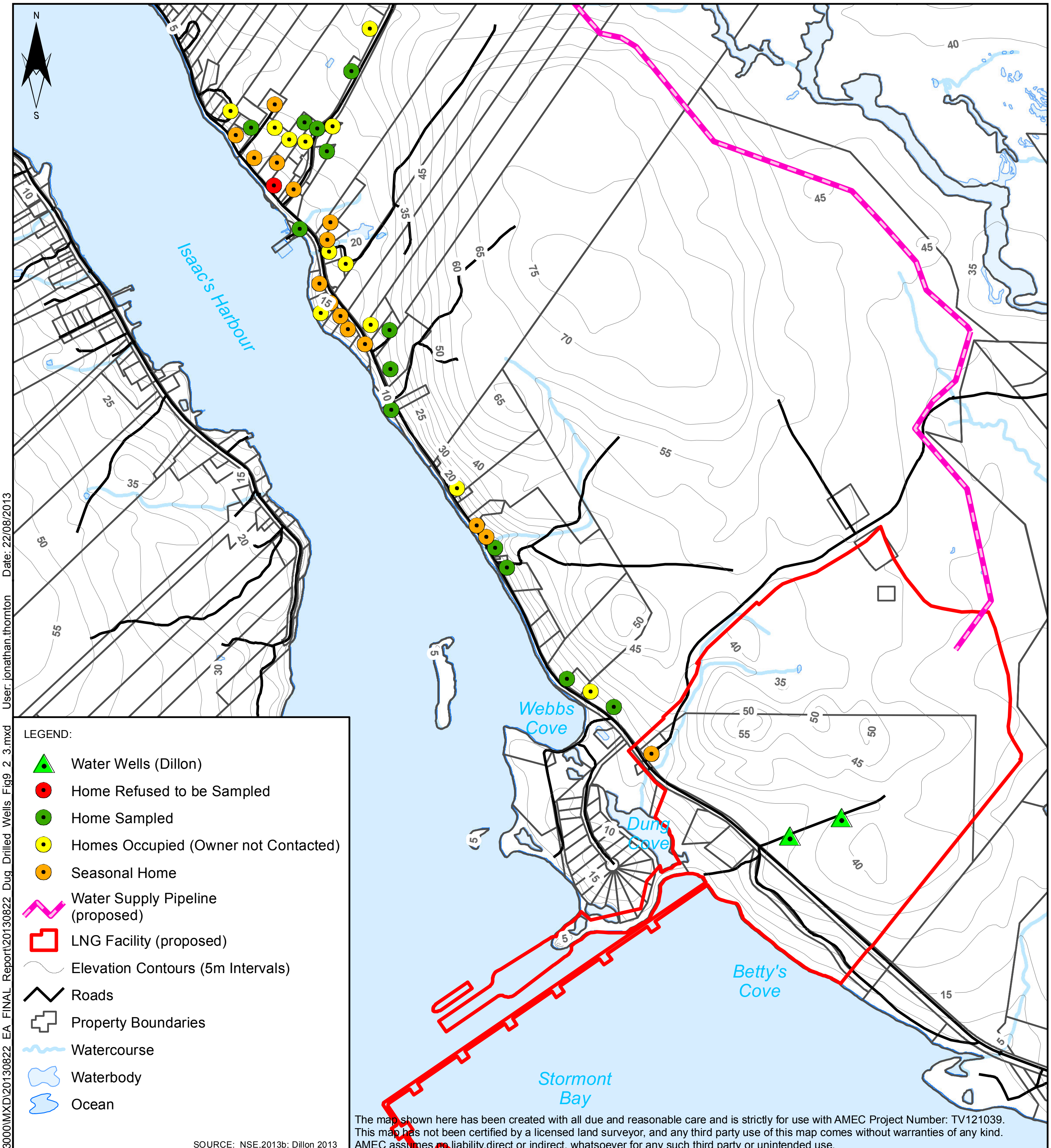


SOURCE: AMEC, surface and groundwater major ion distribution

CLIENT: Pieridae Energy (Canada) Limited		PROJECT: ENVIRONMENTAL ASSESSMENT GOLDBORO LNG	DWN BY: JT	DATE: Aug 2013
	DATUM:		CHK'D BY: TM/GB	REV. NO: N/A
AMEC Environment and Infrastructure A Division of AMEC Americas Ltd. 50 Troop Avenue, Unit 300 Dartmouth, N.S., B3B 1Z1 (P) 902-468-2848 (F) 902-468-1314	PROJECTION:	TITLE: **PIPER DIAGRAM FOR THE WATER SAMPLES IN THE KELTIC STUDY**	SCALE:	FIGURE NO: 9.2-2
	PROJECT NO: TV121039			



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CLIENT: Pieridae Energy (Canada) Limited

SCALE: 200 100 0 200 400 Metres 1:18,000

PROJECT: GOLDBORO LNG ENVIRONMENTAL ASSESSMENT

DWN BY: JT

CHK'D BY: TM/GB

DATE: Aug 2013

AMEC Environment and Infrastructure
A Division of AMEC Americas Ltd.

50 Troop Avenue, Unit 300
Dartmouth, N.S., B3B 1Z1
(P) 902-468-2848 (F) 902-468-1314

amec

DATUM: UTM Zone 20

PROJECTION: NAD83

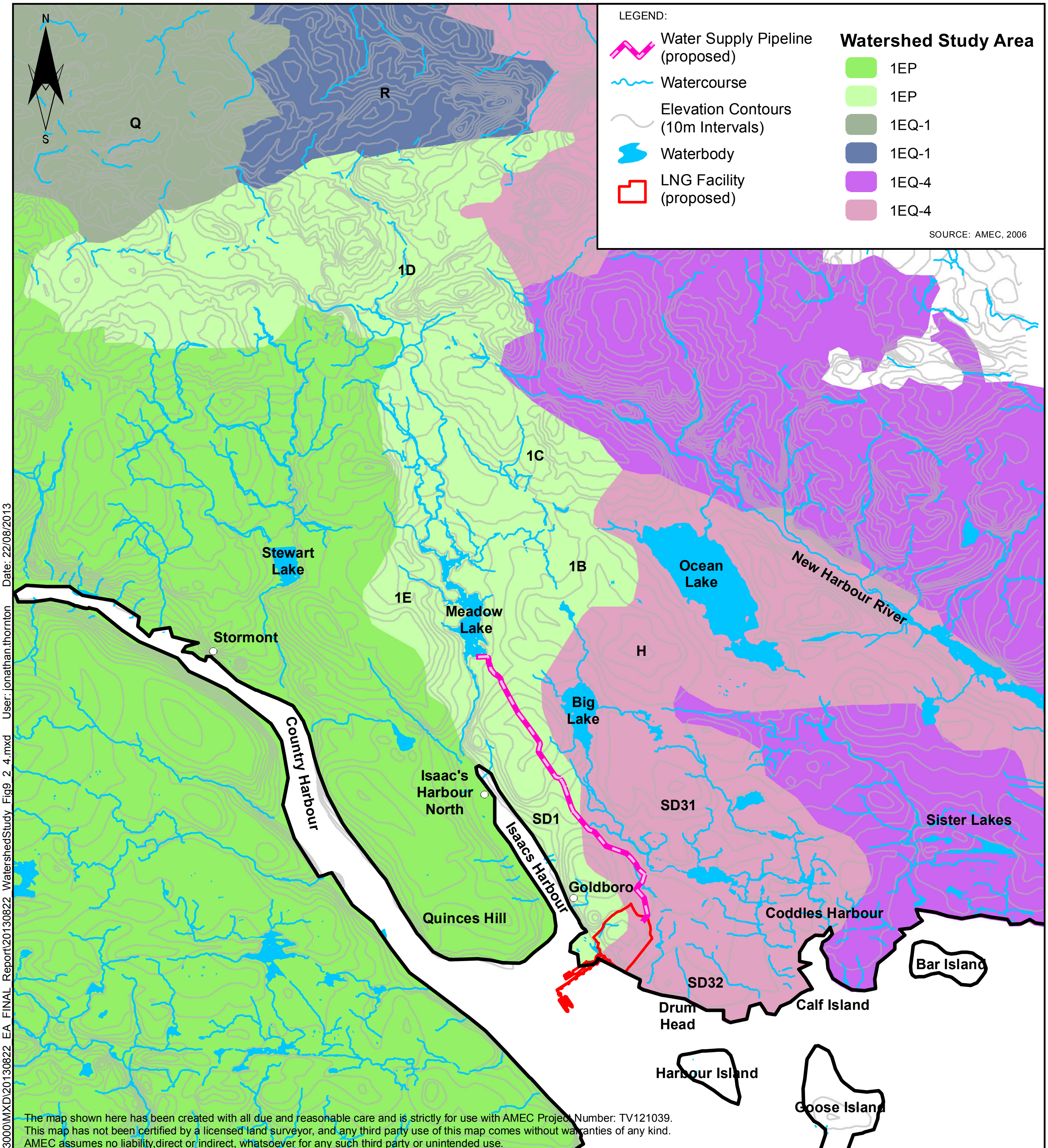
PROJECT NO: TV121039

TITLE: DUG AND DRILLED DOMESTIC WELLS IN GOLDBORO AREA

REV. NO: N/A

FIGURE NO: 9.2-3

Path: G:\GIS\PROJECTS\TV121039 Phase3000\MXD\20130822 EA FINAL Report\20130822 Dug Drilled Wells Fig9 2 3.mxd User: jonathan.thornton Date: 22/08/2013



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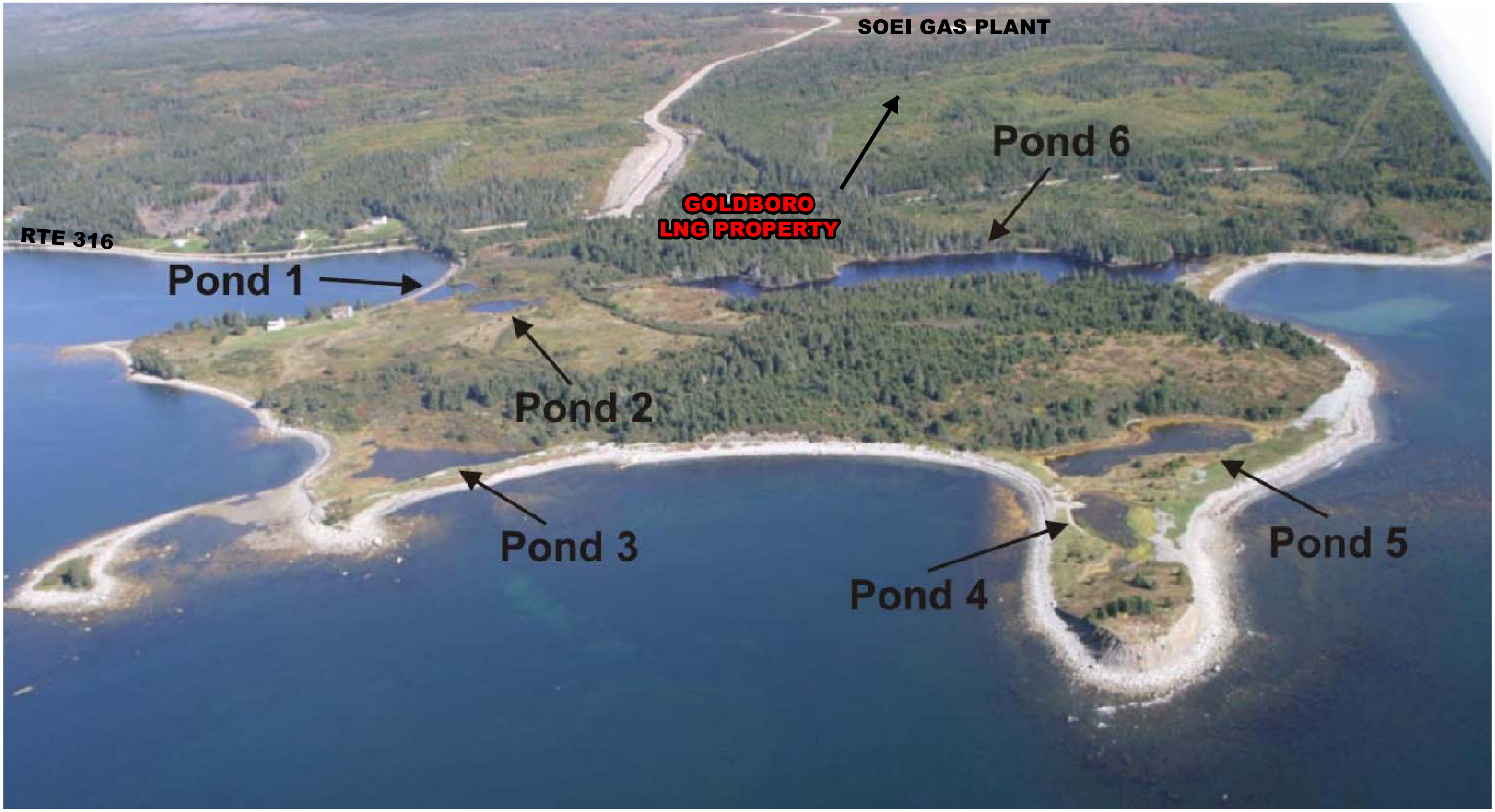
Path: G:\GIS\PROJECTS\TV121039 Phase3000\MXD\20130822 EA FINAL Report\20130822 WatershedStudy Fig9 2 4.mxd User: jonathan.thornton Date: 22/08/2013

CLIENT: Pieridae Energy (Canada) Limited	SCALE: 2,000 1,000 0 2,000 Metres 1:120,000	PROJECT: GOLDBORO LNG ENVIRONMENTAL ASSESSMENT	DWN BY: JT CHK'D BY: TM/GB
AMEC Environment and Infrastructure A Division of AMEC Americas Ltd. 50 Troop Avenue, Unit 300 Dartmouth, N.S., B3B 1Z1 (P) 902-468-2848 (F) 902-468-1314 amec	DATUM: UTM Zone 20 PROJECTION: NAD83 PROJECT NO: TV121039	TITLE: PROJECT AREA WATERSHEDS	DATE: Aug 2013 REV. NO: N/A FIGURE NO: 9.2-4



SOURCE: AMEC, 2006

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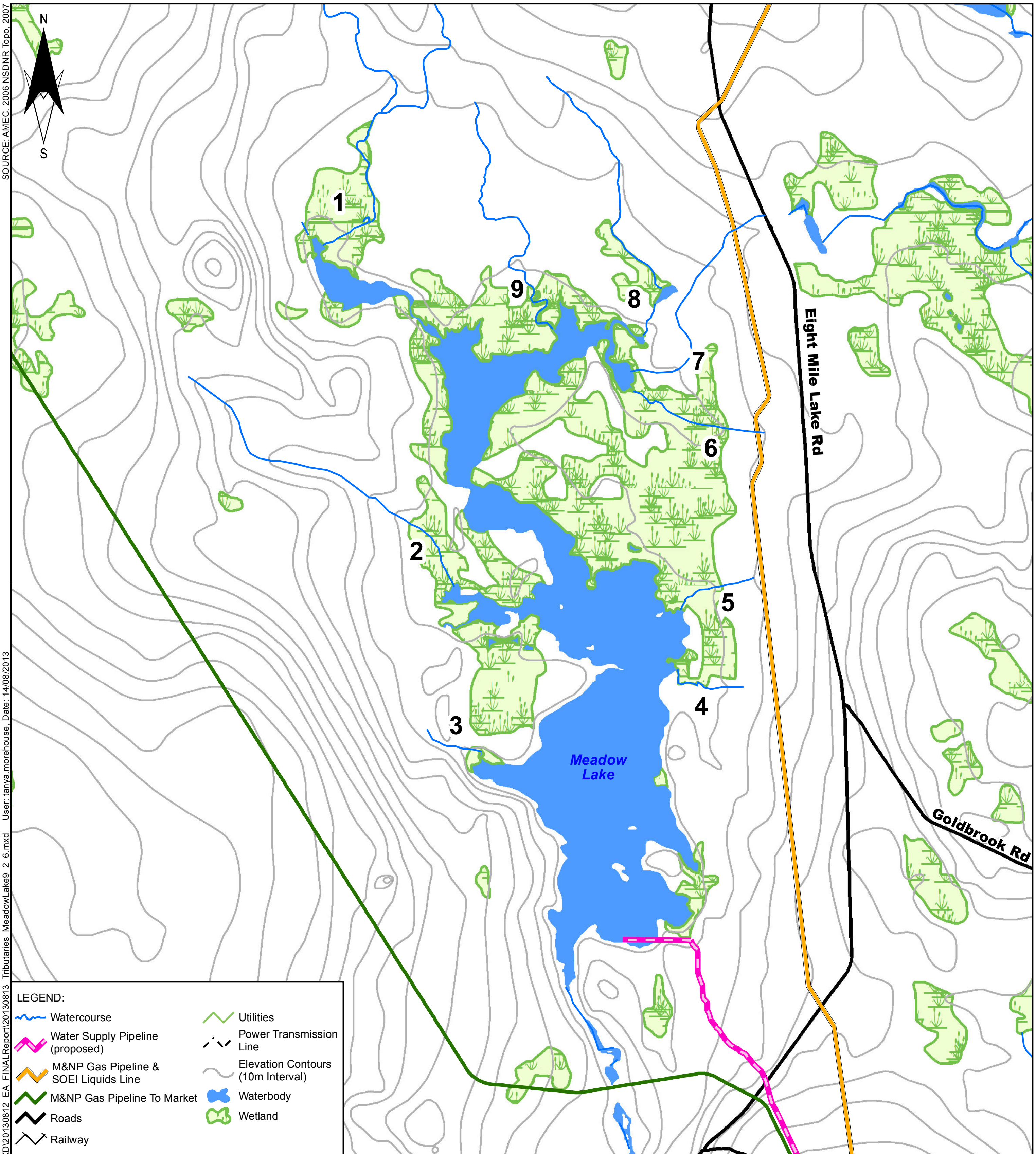
CLIENT: Pieridae Energy (Canada) Limited	0 75 150 Metres	PROJECT: ENVIRONMENTAL ASSESSMENT (GOLDBORO LNG)	DWN BY: JT	DATE: June 2013
	DATUM: UTM Zone 20		CHK'D BY: TM/GB	REV. NO: N/A
AMEC Environment and Infrastructure A Division of AMEC Americas Ltd. 50 Troop Avenue, Unit 300 Dartmouth, N.S., B3B 1Z1 (P) 902-468-2848 (F) 902-468-1314	PROJECTION: NAD83	TITLE: RED HEAD PENINSULA SURFACE WATER FEATURES	SCALE: 1:5,300	FIGURE NO: 9.2-5
	PROJECT NO: TV121039			



SOURCE: AMEC, 2006 NSDNR Topo, 2007

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CLIENT: Pieridae Energy (Canada) Limited	SCALE: 400 200 0 400 Metres 1:20,000	PROJECT: GOLDBORO LNG ENVIRONMENTAL ASSESSMENT	DWN BY: JT
			CHK'D BY: TM/GB
AMEC Environment and Infrastructure A Division of AMEC Americas Ltd. 50 Troop Avenue, Unit 300 Dartmouth, N.S., B3B 1Z1 (P) 902-468-2848 (F) 902-468-1314 amec	DATUM: UTM Zone 20	TITLE: TRIBUTARIES FEEDING MEADOW LAKE	DATE: June 2013
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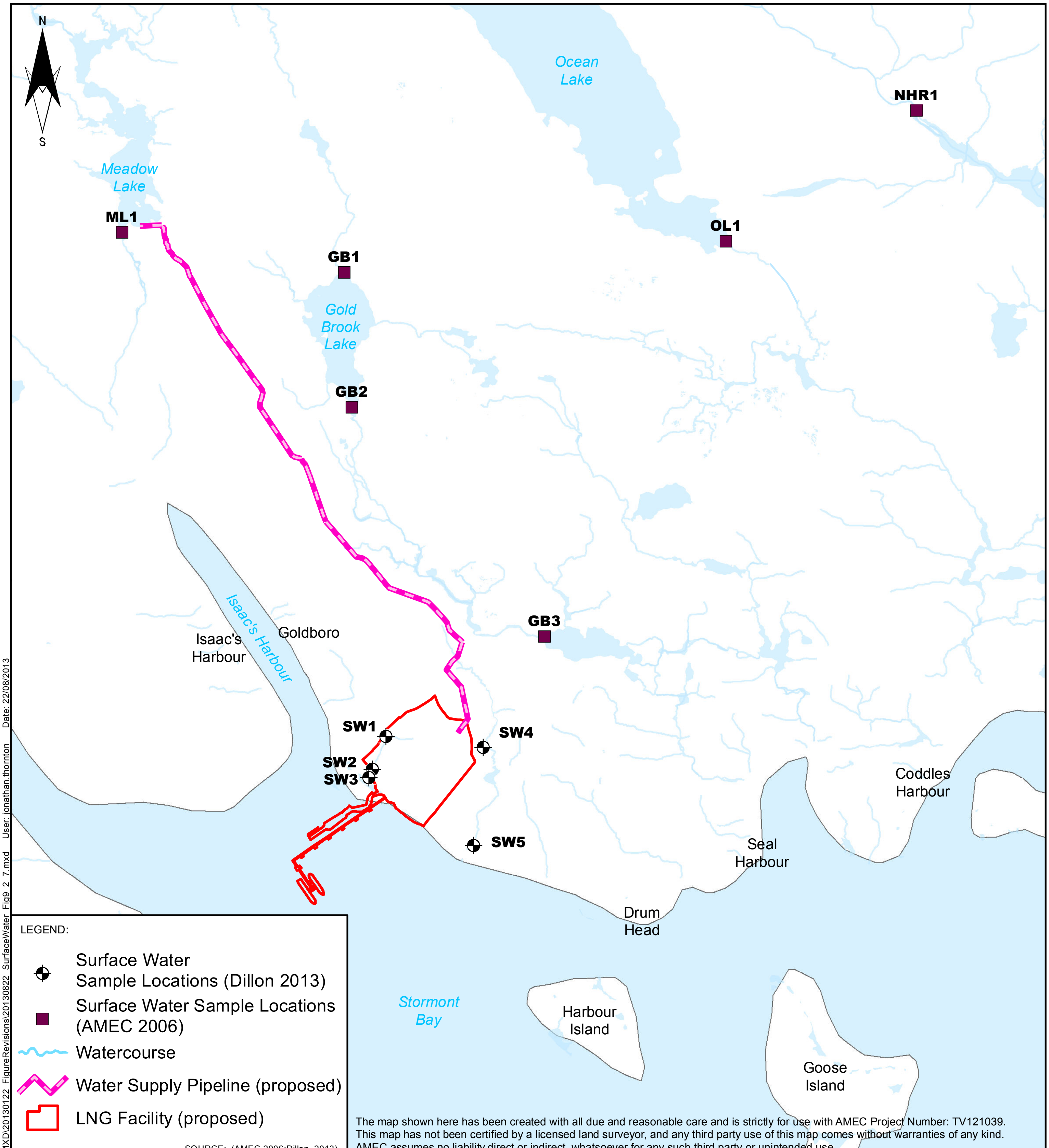

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CLIENT: Pieridae Energy (Canada) Limited	SCALE: 1,000 500 0 1,000 Metres 1:63,000	PROJECT: GOLDBORO LNG ENVIRONMENTAL ASSESSMENT	DWN BY: JT CHK'D BY: TM/GB DATE: Aug 2013
AMEC Environment and Infrastructure A Division of AMEC Americas Ltd. 50 Troop Avenue, Unit 300 Dartmouth, N.S., B3B 1Z1 (P) 902-468-2848 (F) 902-468-1314 amec	DATUM: UTM Zone 20 PROJECTION: NAD83 PROJECT NO: TV121039	TITLE: SURFACE WATER SAMPLE LOCATIONS	REV. NO: N/A FIGURE NO: 9.2-7

Path: G:\GIS\PROJECTS\TV121039_Phase3000\MXD\20130122_FigureRevisions\20130822_SurfaceWater_Fig9_2_7.mxd User: jonathan.thornton Date: 22/08/2013