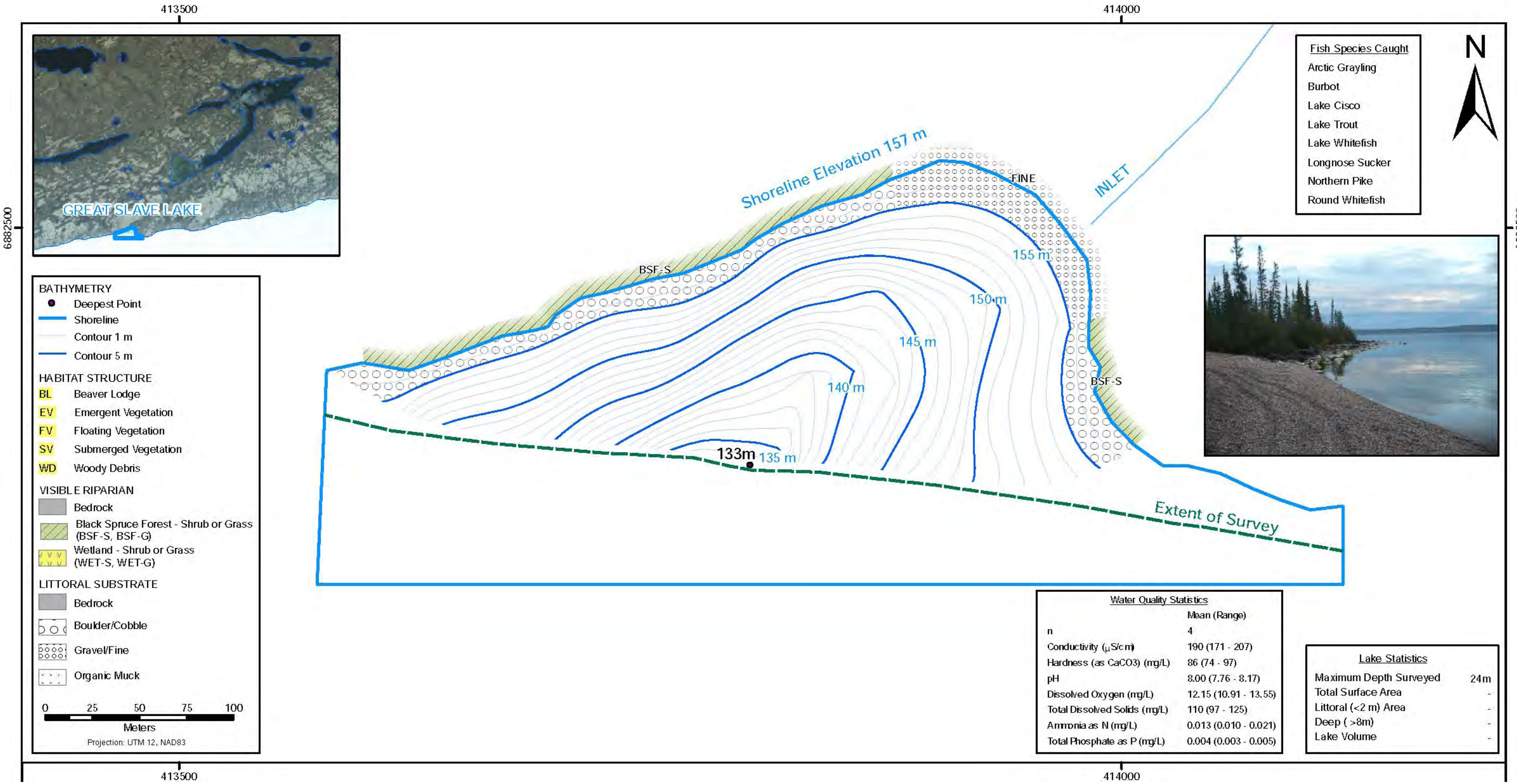
Lake Shoreline Habitat and Bathymetry

Bathymetry of the bay is provided in Figure 2.8-23. The maximum depth to the limits of the survey was 24 m. The drop-off from the shoreline is relatively uniform and is steeper on the western side of the bay, where the five-metre contour is approximately 10 m from shore and the 10 m contour is about 25 m from shore. On the eastern side of the bay, the 10 m contour is not reached until about 60 m from shore.

The littoral substrate in the bay consists of gravel and fines at the head of the bay, and boulders and cobbles on the east and west slopes. No aquatic vegetation was noted. Bedrock forms the shoreline on either side of the proposed dock site, although the actual dock location consists of gravel, sand and small cobble (Golder 1998a).



Water Quality Statistics

	Mean (Range)
n	4
Conductivity (µS/cm)	190 (171 - 207)
Hardness (as CaCO3) (mg/L)	86 (74 - 97)
pH	8.00 (7.76 - 8.17)
Dissolved Oxygen (mg/L)	12.15 (10.91 - 13.55)
Total Dissolved Solids (mg/L)	110 (97 - 125)
Ammonia as N (mg/L)	0.013 (0.010 - 0.021)
Total Phosphate as P (mg/L)	0.004 (0.003 - 0.005)

Lake Statistics

Maximum Depth Surveyed	24m
Total Surface Area	-
Littoral (<2 m) Area	-
Deep (>8m)	-
Lake Volume	-

NOTES
Figure Source: Appendix A, Figure 20. Stantec 2010c.

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THOR LAKE PROJECT

Great Slave Lake Bathymetry and Habitat

PROJECT NO.	DWN	CKD	REV
V15101007.006	SL	DM	0
OFFICE	DATE		
EBA-VANC	May 9, 2011		

Figure 2.8-23

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Water and Sediment Chemistry

Water quality data was collected from Great Slave Lake from October 2008 to September 2009. Low values for mean conductivity, hardness, dissolved solids, nutrients and metals are generally observed. Great Slave Lake has a relatively high mean nitrate concentration however, similar to that of Cressy and South Tardiff. This is likely a characteristic of Great Slave Lake.

The sediment in Great Slave Lake was relatively hard and difficult to sample; only one sample was obtained. Sediment chemistry shows low values for organic carbon, Kjeldahl nitrogen, phosphorus and most metals; nickel exceeded the CCME ISQG (22.6 mg/kg).

Aquatic Organisms

Chlorophyll *a* was similar at the sample station in June and September (1.03 μg/L and 1.08 μg/L, respectively) and was lower than at any of the other study lakes in September, indicating the oligotrophic nature of these waters.

Phytoplankton and zooplankton metrics are provided in Table 2.8-18. Phytoplankton richness and diversity for the two samples was low in June, and was lower than in the other study lakes. The cryptophyte *Chroomonas acuta* was predominant in June along with the blue-green alga *Lyngbya limnetica* in September.

Mean zooplankton richness was low and was one of the lowest among the study lakes. Mean zooplankton diversity was at an intermediate level; richness and diversity were similar between June and September. Copepods were dominant in June, but were replaced in September by rotifers.

TABLE 2.8-18: GREAT SLAVE LAKE – PHYTOPLANKTON AND ZOOPLANKTON RICHNESS, DIVERSITY, AND PREDOMINANT TAXA, 2009

Lake	Phytoplankton			Zooplankton		
	Richness	Diversity	Taxa	Richness	Diversity	Taxa
June 2009						
Great Slave	39	0.48	Cryptophytes (71%) Blue-green (7%) Diatoms (5%)	13	0.68	Copepods (82%) Rotifers (8%)
September 2009						
Great Slave	28	0.71	Cryptophytes (45%) Blue-green (35%) Yellow-brown (6%)	12	0.70	Rotifers (89%)

Fish Population

More fish species were caught in Great Slave Lake than any other lake, as expected given the high known species and habitat diversity in Great Slave Lake (see Section 2.8.4.5). The fish caught in Great Slave Lake included the largest lake whitefish (542 mm) and the largest lake cisco (405 mm) in the fisheries study. Catch rates were within the normal range for northern pike and lake whitefish, but were very high for lake cisco. Parasite frequencies in Great Slave Lake were very low for all species (internal parasites were observed in one lake cisco of 20 dissected, and no other parasites were observed).

Arctic grayling (*Thymallus arcticus*), burbot (*Lota lota*), longnose sucker (*Catastomus catastomus*), and round whitefish (*Prosopium cylindraceum*) were also caught within the bay.

Tissue mercury levels in lake whitefish taken from the bay were low. However, levels of cadmium and thallium in livers of some lake whitefish and lake cisco were relatively high, as were selenium and arsenic levels.

2.8.5.5 Reference Group

The Reference Group includes Kinnikinnick and Redemption lakes (Figure 2.8-1). These lakes are proposed as nearfield and farfield references, respectively, and will be used during the assessment of changes (if any) particularly to Thor Lake biotic and abiotic characteristics following construction and development of the Nechalacho site. For comparison purposes, Table 2.8-19 provides morphological characteristics of these three lakes.

TABLE 2.8-19: MORPHOLOGICAL CHARACTERISTICS OF THOR, KINNIKINNICK, AND REDEMPTION LAKES

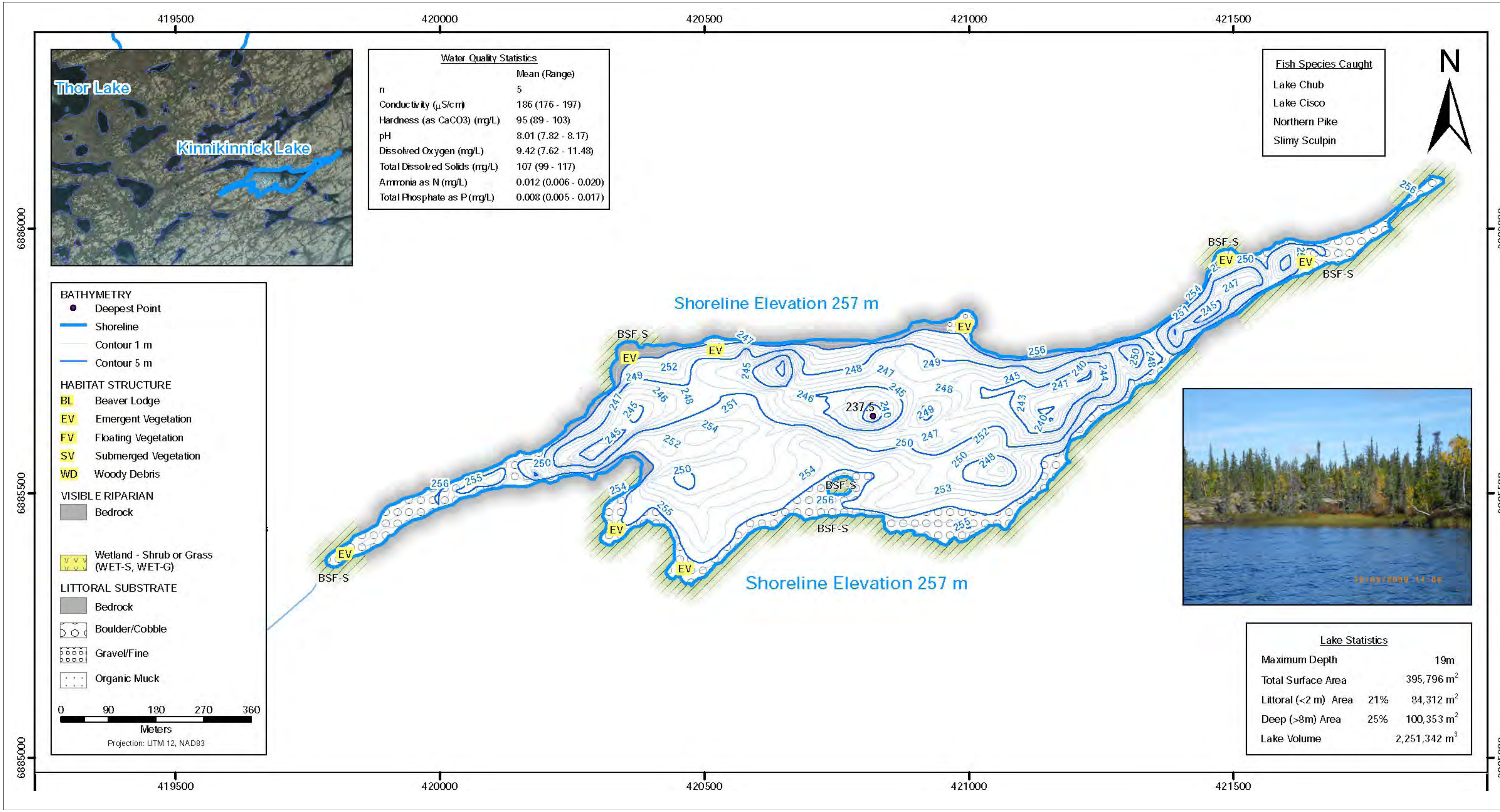
Lake Statistics	Thor Lake	Kinnikinnick Lake	Redemption Lake
Maximum depth (m)	16	19	15
Total surface area (m^2)	1,452,875	395,796	553,309
Littoral (<2 m) area (m^2)	436,939	84,312	143,256
Deep (> 8 m) depth (m^2)	99,361	100,353	114,089
Lake Volume (m^3)	5,054,270	2,251,342	2,795,944

Kinnikinnick Lake is contained within the Thor Lake syenite, while Redemption Lake is located outside the Blachford Intrusive Complex. Surface drainage has not been investigated, but is inferred from topographic maps. Kinnikinnick Lake appears to have two inlets and one outlet, draining south through a series of small lakes into Great Slave Lake. Redemption Lake appears to have two inlets at its northeast and northwest basins, and one outlet draining south and west through a similar sized lake into Blachford Lake.

Lake Shoreline Habitat and Bathymetry

Bathymetric and lake shoreline habitat information for Kinnikinnick is plotted on Figures 2.8-24 and 2.8-25, respectively. As shown in Table 2.8-19, the maximum depths of Thor, Kinnikinnick and Redemption lakes are similar, as are the areas of depth greater than eight metres. However, the surface area of Thor Lake is more than three times that of Kinnikinnick and more than twice that of Redemption.

Littoral substrate in Kinnikinnick Lake consists of boulders, cobbles, and steep bedrock, while in Redemption Lake it is largely made up of bedrock and boulders. Emergent plants were evident in Kinnikinnick Lake only in shallow bays; only floating and submerged plants were observed in shallow bays in Redemption Lake. Both Kinnikinnick and Redemption Lakes are ringed by Black Spruce Forest and bedrock bluff.



NOTES
Figure Source: Appendix A, Figure 21. Stantec 2010c.

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THOR LAKE PROJECT

Kinnikinnick Lake Bathymetry and Habitat

PROJECT NO.	DWN	CKD	REV
V15101007.006	SL	DM	0
OFFICE	DATE		
EBA-VANC	May 9, 2011		

Figure 2.8-24

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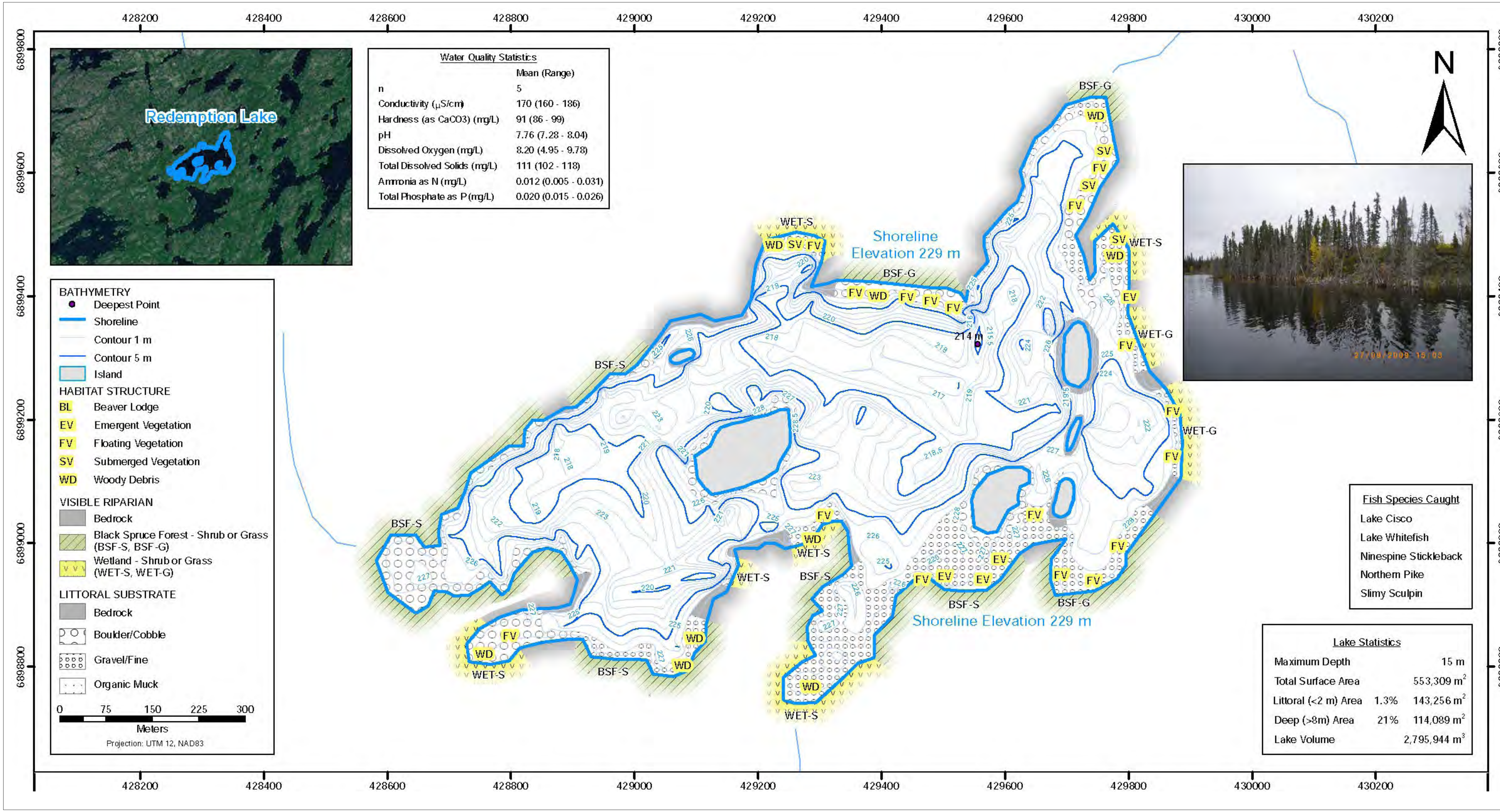

Water Quality Statistics

	Mean (Range)
n	5
Conductivity (µS/cm)	170 (160 - 186)
Hardness (as CaCO3) (mg/L)	91 (86 - 99)
pH	7.76 (7.28 - 8.04)
Dissolved Oxygen (mg/L)	8.20 (4.95 - 9.78)
Total Dissolved Solids (mg/L)	111 (102 - 118)
Ammonia as N (mg/L)	0.012 (0.005 - 0.031)
Total Phosphate as P (mg/L)	0.020 (0.015 - 0.026)

Fish Species Caught

- Lake Cisco
- Lake Whitefish
- Ninespine Stickleback
- Northern Pike
- Slimy Sculpin

Lake Statistics

Maximum Depth		15 m
Total Surface Area		553,309 m^2
Littoral (<2 m) Area	1.3%	143,256 m^2
Deep (>8m) Area	21%	114,089 m^2
Lake Volume		2,795,944 m^3

NOTES

Figure Source: Appendix A, Figure 15. Stantec 2010c.

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THOR LAKE PROJECT

Redemption Lake Bathymetry and Habitat

PROJECT NO.	DWN	CKD	REV
V15101007.006	SL	DM	0
OFFICE	DATE		
EBA-VANC	May 9, 2011		

Figure 2.8-25

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Water and Sediment Chemistry

Water quality data were collected at Kinnikinnick Lake from March, 2008 to September, 2009, and in Redemption Lake from September, 2009 to October, 2010. General chemistry is typical of large, deep lakes in the study area and is characterized by clear, moderately hard water with low conductance, nutrients and organic carbon, and a low buffering capacity. No exceedances of WQG for metals occurred in the dataset; most metal concentrations are low and relatively stable throughout the seasons sampled.

Sediment chemistry at Kinnikinnick Lake indicates high total phosphorus (1,740 mg/kg) and moderate organic carbon (23.4 mg/kg) and Kjeldahl nitrogen (2.38 mg/kg) levels. Copper and nickel exceeded ISQG, and cadmium was close to its ISQG. Sediment in Redemption Lake has slightly lower total phosphorus, organic carbon and Kjeldahl nitrogen levels than Kinnikinnick Lake, with ISQG exceedances for copper, nickel and arsenic in all samples, and PEL exceedances for arsenic in two of three replicate samples in 2010.

Aquatic Organisms

Chlorophyll *a* in Kinnikinnick Lake was low in June and September (1.40 and 1.14 µg/L, respectively) suggesting an ultraoligotrophic condition. Chlorophyll *a* in Redemption was low in June (1.87 µg/L), and eight times higher in September, 2010 (15 µg/L), although no corresponding increases in nutrients or organic carbon levels were noted between those two time periods.

Phytoplankton and zooplankton metrics are shown in Table 2.8-20. Phytoplankton richness in Kinnikinnik Lake was moderate in comparison to other lakes in the study area, although diversity was relatively high. Blue-green algae (*Pseudanabaena* and *Lyngbya* spp.), were predominant in Kinnikinnick Lake.

Phytoplankton richness and diversity in Redemption Lake were moderate in June 2010 and lower in September (the lowest richness and diversity of all eight lakes sampled in 2010). Two blue-green algae (*Pseudanabaena catenata, Lyngbya limnetica*) were predominant in the spring and *Lyngbya limnetica* was predominant in September.

Zooplankton taxon richness was relatively low in Kinnikinnick Lake in 2009, with moderate diversity compared with other study area lakes. Rotifers (three species, dominated by *Keratella cochlearis*) were predominant in 2009 and copepods were common in June.

In Redemption Lake, taxon richness was the highest among the eight lakes sampled in June, 2010, with moderately high diversity. Richness was lower in September 2010 but still higher than the other eight lakes, with the lowest diversity of all eight lakes.

TABLE 2.8-20: REFERENCE LAKE GROUP – PHYTOPLANKTON AND ZOOPLANKTON RICHNESS, DIVERSITY, AND PREDOMINANT TAXA, 2009 – 2010

Lake	Phytoplankton			Zooplankton		
	Richness	Diversity	Taxa	Richness	Diversity	Taxa
June 2009						
Kinnikinnick	67	0.74	Blue-green (71%) Green (6%)	15	0.65	Rotifers (73%) Copepods (22%)
September 2009						
Kinnikinnick	71	0.44	Blue-green (75%)	16	0.71	Rotifers (83%)
June 2010						
Redemption	67	0.79	Blue-green (58%) Cryptophytes (7%) Yellow-brown (5%)	29	0.73	Rotifers (54%) Copepods (28%)
September 2010						
Redemption	62	0.22	Blue-green (88%)	20	0.44	Rotifers (88%) Cladoceran (5%)

Benthic invertebrate data for 2009 and 2010 are summarized in Table 2.8-21; Kinnikinnick Lake was sampled in 2009 and Redemption Lake was sampled in both years. In 2009, taxon richness was low in Kinnikinnick and Redemption lakes, with moderate levels of diversity and evenness. Chironomidae were predominant in both lakes. In Redemption Lake, richness and predominant taxa were similar in 2009 and 2010, though diversity was lower in 2010 and lowest of all lakes sampled in 2010.

TABLE 2.8-21: REFERENCE GROUP LAKES – BENTHIC INVERTEBRATE METRICS, 2009 (STANTEC 2010C)

Station	Richness	Abundance (organisms/m^2)	Diversity	Evenness	Taxa
September 2009					
Kinnikinnick	5	899	0.53	0.42	Chironomidae (64%) Tubificidae (22%) Sphaeriidae (11%)
Redemption	4	173	0.40	0.42	Chironomidae (75%) Chaoboridae (19%)
September 2010					
Redemption	3	337	0.06	0.35	Chironomidae (97%)

Fish Population

Only Redemption Lake has a fish species assemblage suitable for comparison with the lakes that may be directly affected by Project activities (including Thor, Long, Elbow, and A). Kinnikinnick Lake may be is suggested as a suitable near-field reference lake for fisheries if lake whitefish are captured in future sampling (northern pike, lake cisco, slimy sculpin, ninespine stickleback and lake chub were caught in Kinnikinnick).

Catch rates in Redemption Lake were slightly lower than in the potentially affected lakes for lake whitefish (see Table 2.8-8). Catch rates for northern pike and lake cisco were within the ranges of these four lakes.

All size classes of fish present in other lakes in the study area were present in Redemption Lake. The second largest (528 mm) and second smallest (110 mm) lake whitefish caught in the baseline study were caught at Redemption (a 542 mm lake whitefish was caught in Great Slave and a 71 mm lake whitefish was caught at Thor). The largest northern pike (825 mm) in the study was caught in Redemption, and a broad range of sizes for lake cisco were present (106-292 mm; whole Project range 105-405 mm).

Fish sampling in Kinnikinnick Lake occurred only in September, 2009. As indicated above, no lake whitefish were captured at that time. Four lake cisco and 18 northern pike were caught for overall CPUE values of 0.1 and 0.5, respectively (see Table 2.8-8). From this one sampling, it appears that relative abundance of lake cisco is low, and northern pike is similar, to fish bearing lakes in the Nechalacho Project area.

Redemption Lake internal and external parasite frequencies were similar to those in Thor, Long, Elbow, and A lakes.

Mercury levels were generally higher in fish from Redemption Lake than Thor Lake, and the relationships between fish weight and liver total mercury were significantly different for northern pike and lake whitefish (Stantec 2010c). Metals levels in liver were generally similar in Thor and Redemption lakes, although aluminum levels in lake whitefish were higher on average in Redemption Lake.

2.8.5.6 Tributary Group

The Tributary Group includes all lakes considered upstream of the Thor Group, with the exception of the Tardiff lakes; it is comprised of Megan, Pistol, Porkchop, Thorn and Wasp lakes (Figure 2.8-11). Only Thorn Lake is situated partially within the Lake Zone ore body, while the others are located within the Thor Lake syenite.

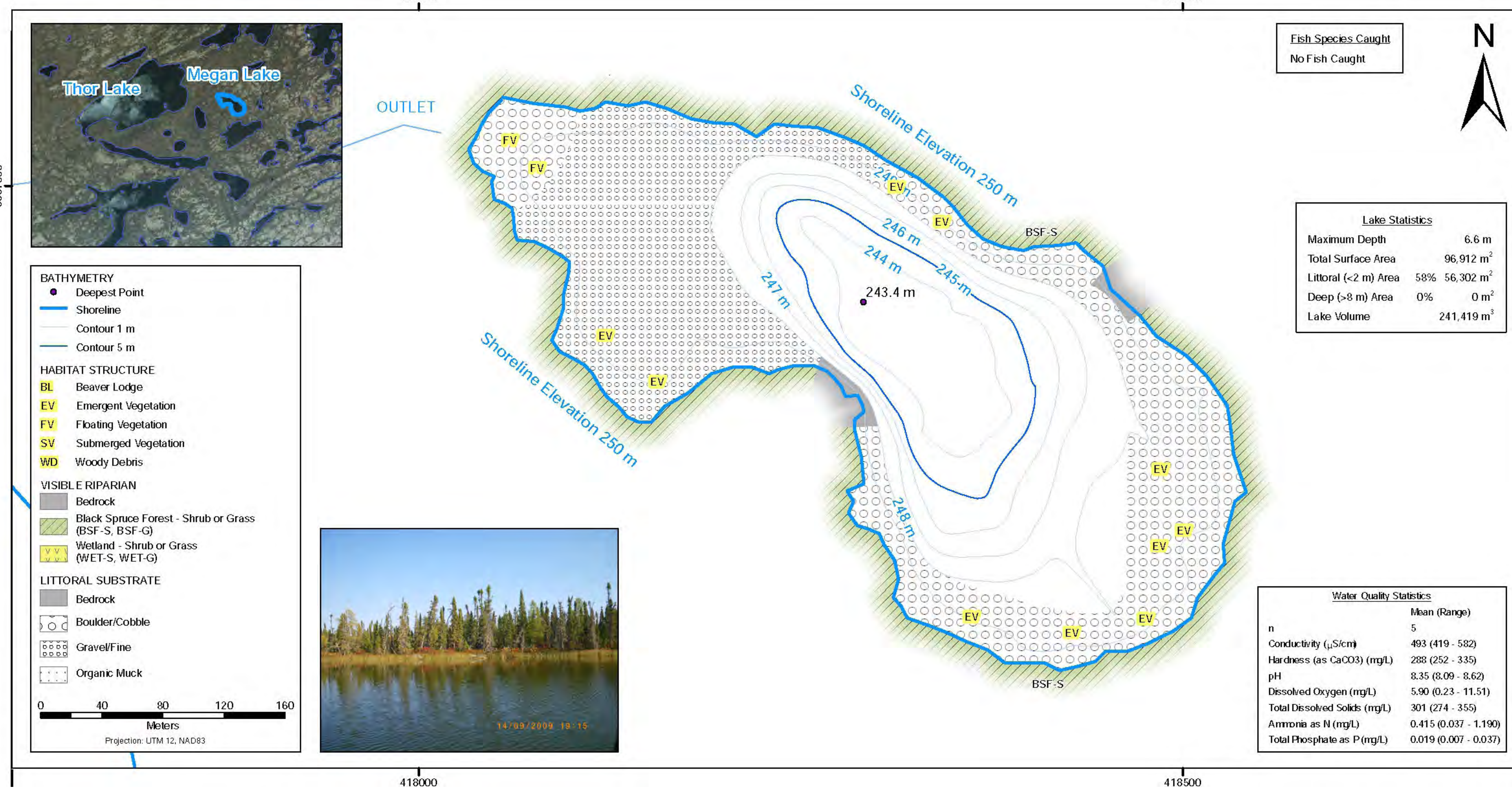
Surface drainage and bathymetry has been investigated for Thorn and Megan lakes, which have no defined surface inlets or outlets. Surface drainage from Wasp, Pistol and Porkchop lakes are inferred from topographic maps. Wasp and Porkchop lakes appear to have one outlet each, flowing into the west end of Long Lake. Pistol Lake appears to have one outlet, flowing south through two small lakes into Porkchop Lake; this drainage appears to be the only inlet of Porkchop Lake.

Bathymetry and shoreline habitat information for each lake in this group is provided in Figures 2.8-26 to 2.8-30.

Pistol and Wasp lakes are shallow with strong seasonal variation in water chemistry. This contrasts with conditions in Thorn and Porkchop lakes, which have less seasonal variability due to their greater depths. Megan Lake is an exception, having considerable seasonal variation despite being of moderate depth (maximum 6.6 m).

Chlorophyll *a* levels within this group also varied among lakes and seasons. Wasp Lake had the highest chlorophyll *a* level and Megan had the lowest. Phytoplankton and zooplankton richness and diversity were relatively high within the Tributary Group, although considerable variability in phytoplankton metrics and species representation were evident.

Fish sampling was conducted only in Megan and Thorn lakes. No fish were caught in two years of fishing effort. Neither of these lakes are considered to be fish habitats due to the lack of fishing success, the low winter dissolved oxygen level (in Megan Lake), the presence of large bodied zooplankton in Thorn Lake, and because no outlet watercourses were identified.



Lake Statistics

Maximum Depth		6.6 m
Total Surface Area		96,912 m^2
Littoral (<2 m) Area	58%	56,302 m^2
Deep (>8 m) Area	0%	0 m^2
Lake Volume		241,419 m^3

Water Quality Statistics

	Mean (Range)
n	5
Conductivity (μS/cm)	493 (419 - 582)
Hardness (as CaCO3) (mg/L)	288 (252 - 335)
pH	8.35 (8.09 - 8.62)
Dissolved Oxygen (mg/L)	5.90 (0.23 - 11.51)
Total Dissolved Solids (mg/L)	301 (274 - 355)
Ammonia as N (mg/L)	0.415 (0.037 - 1.190)
Total Phosphate as P (mg/L)	0.019 (0.007 - 0.037)

NOTES
Figure Source: Appendix A, Figure 23. Stantec 2010c.

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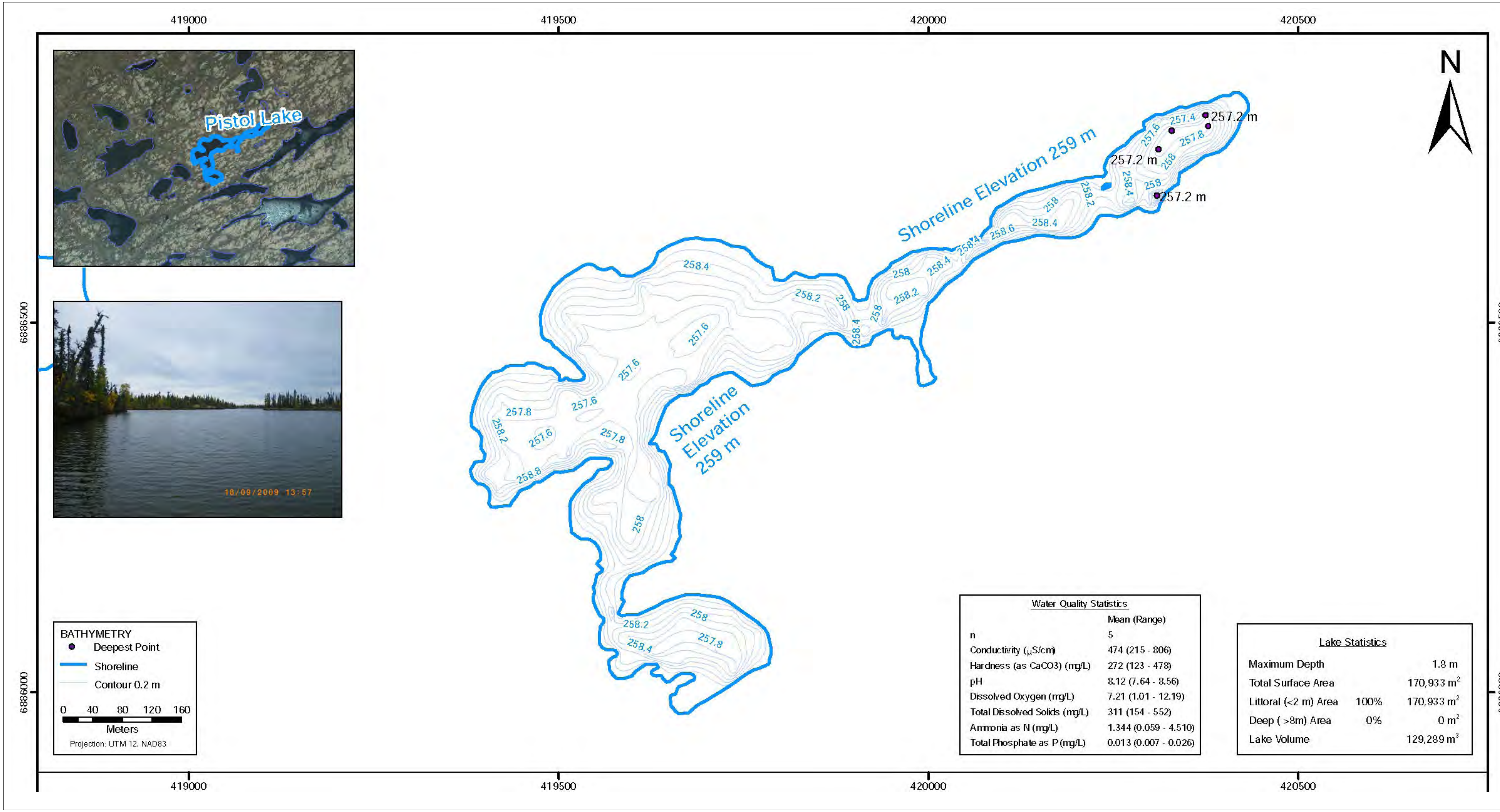
THOR LAKE PROJECT

Megan Lake Bathymetry and Habitat

PROJECT NO.	DWN	CKD	REV
V15101007.006	SL	DM	0
OFFICE	DATE		
EBA-VANC	May 9, 2011		

Figure 2.8-26



Water Quality Statistics	Mean (Range)
n	5
Conductivity (μS/cm)	474 (215 - 806)
Hardness (as CaCO3) (mg/L)	272 (123 - 478)
pH	8.12 (7.64 - 8.56)
Dissolved Oxygen (mg/L)	7.21 (1.01 - 12.19)
Total Dissolved Solids (mg/L)	311 (154 - 552)
Ammonia as N (mg/L)	1.344 (0.059 - 4.510)
Total Phosphate as P (mg/L)	0.013 (0.007 - 0.026)

Lake Statistics		
Maximum Depth		1.8 m
Total Surface Area		170,933 m^2
Littoral (<2 m) Area	100%	170,933 m^2
Deep (>8m) Area	0%	0 m^2
Lake Volume		129,289 m^3

NOTES
Figure Source: Appendix A, Figure 13. Stantec 2010c.

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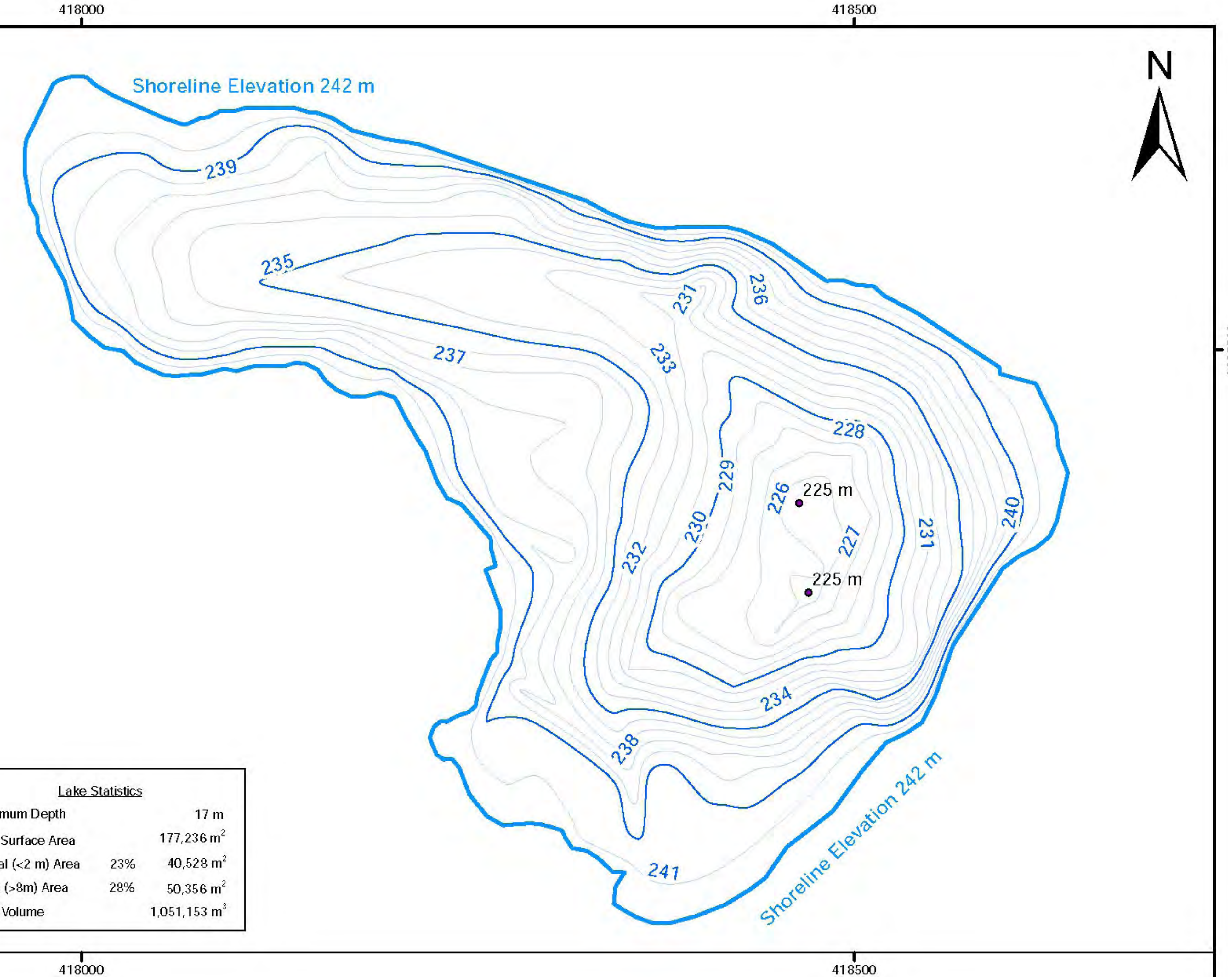
Pistol Lake Bathymetry and Habitat

PROJECT NO.	DWN	CKD	REV
V15101007.006	SL	DM	0
OFFICE	DATE		
EBA-VANC	May 9, 2011		

Figure 2.8-27



BATHYMETRY
- Deepest Point
- Shoreline
- Contour 1 m
- Contour 5 m

0 20 40 60 80
Meters

Projection: UTM 12, NAD83

Water Quality Statistics

	Mean (Range)
n	5
Conductivity (μS/cm)	259 (239 - 285)
Hardness (as CaCO3) (mg/L)	144 (133 - 155)
pH	8.11 (7.93 - 8.28)
Dissolved Oxygen (mg/L)	9.36 (8.23 - 11.25)
Total Dissolved Solids (mg/L)	159 (151 - 176)
Ammonia as N (mg/L)	0.019 (0.010 - 0.033)
Total Phosphate as P (mg/L)	0.007 (0.005 - 0.009)

Lake Statistics

Maximum Depth		17 m
Total Surface Area		177,236 m^2
Littoral (<2 m) Area	23%	40,528 m^2
Deep (>8m) Area	28%	50,356 m^2
Lake Volume		1,051,153 m^3

NOTES
Figure Source: Appendix A, Figure 14. Stantec 2010c.

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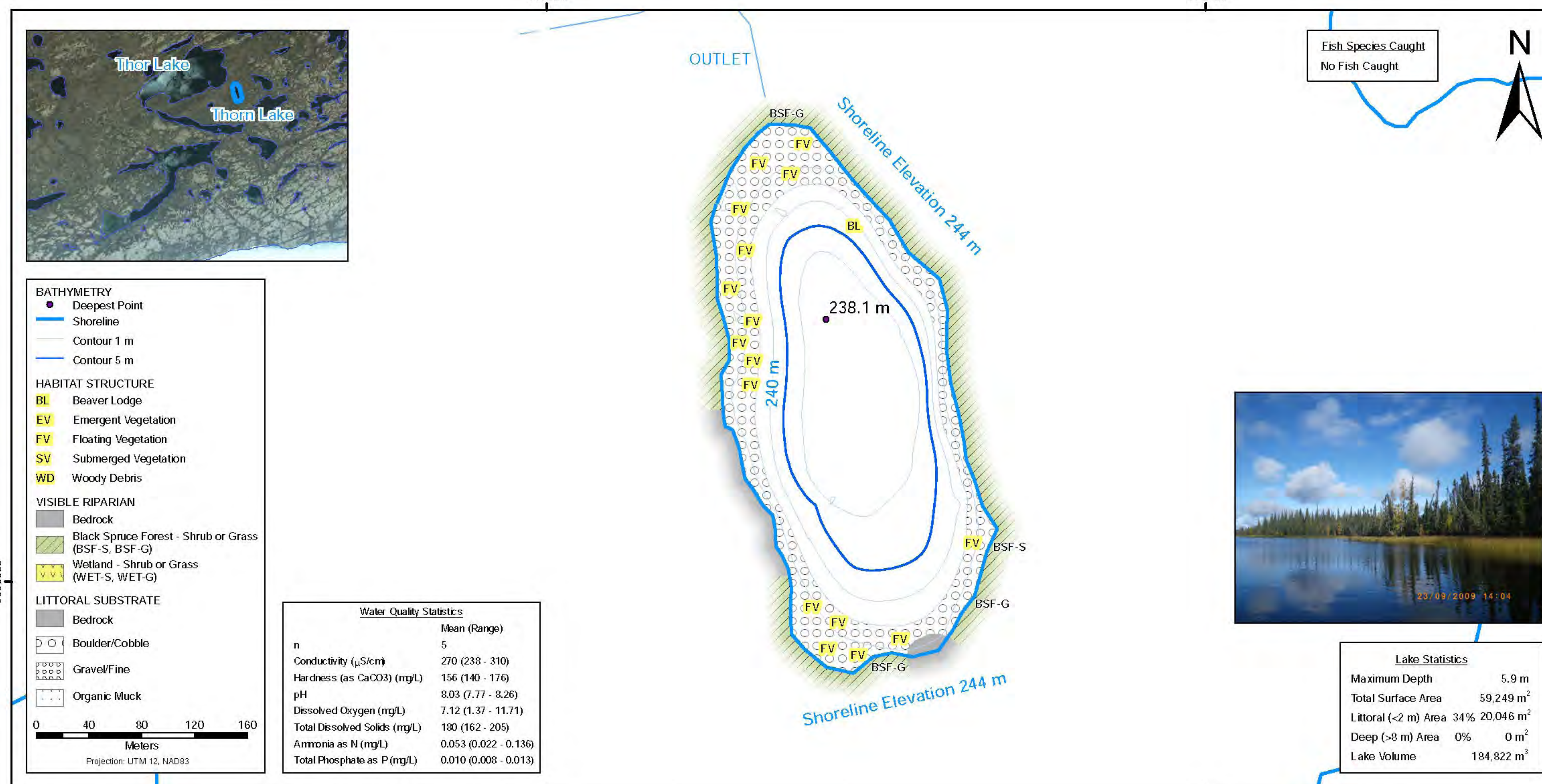
THOR LAKE PROJECT

Pork Chop Lake Bathymetry and Habitat

PROJECT NO.	DWN	CKD	REV
V15101007.006	SL	DM	0
OFFICE	DATE		
EBA-VANC	May 9, 2011		

Figure 2.8-28



Water Quality Statistics

	Mean (Range)
n	5
Conductivity (µS/cm)	270 (238 - 310)
Hardness (as CaCO3) (mg/L)	156 (140 - 176)
pH	8.03 (7.77 - 8.26)
Dissolved Oxygen (mg/L)	7.12 (1.37 - 11.71)
Total Dissolved Solids (mg/L)	180 (162 - 205)
Ammonia as N (mg/L)	0.053 (0.022 - 0.136)
Total Phosphate as P (mg/L)	0.010 (0.008 - 0.013)

Lake Statistics

Maximum Depth		5.9 m
Total Surface Area		59,249 m^2
Littoral (<2 m) Area	34%	20,046 m^2
Deep (>8 m) Area	0%	0 m^2
Lake Volume		184,822 m^3

NOTES
Figure Source: Appendix A, Figure 2. Stantec 2010c.

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THOR LAKE PROJECT

Thorn Lake Bathymetry and Habitat

PROJECT NO.	DWN	CKD	REV
V15101007.006	SL	DM	0
OFFICE	DATE		
EBA-VANC	May 9, 2011		

Figure 2.8-29

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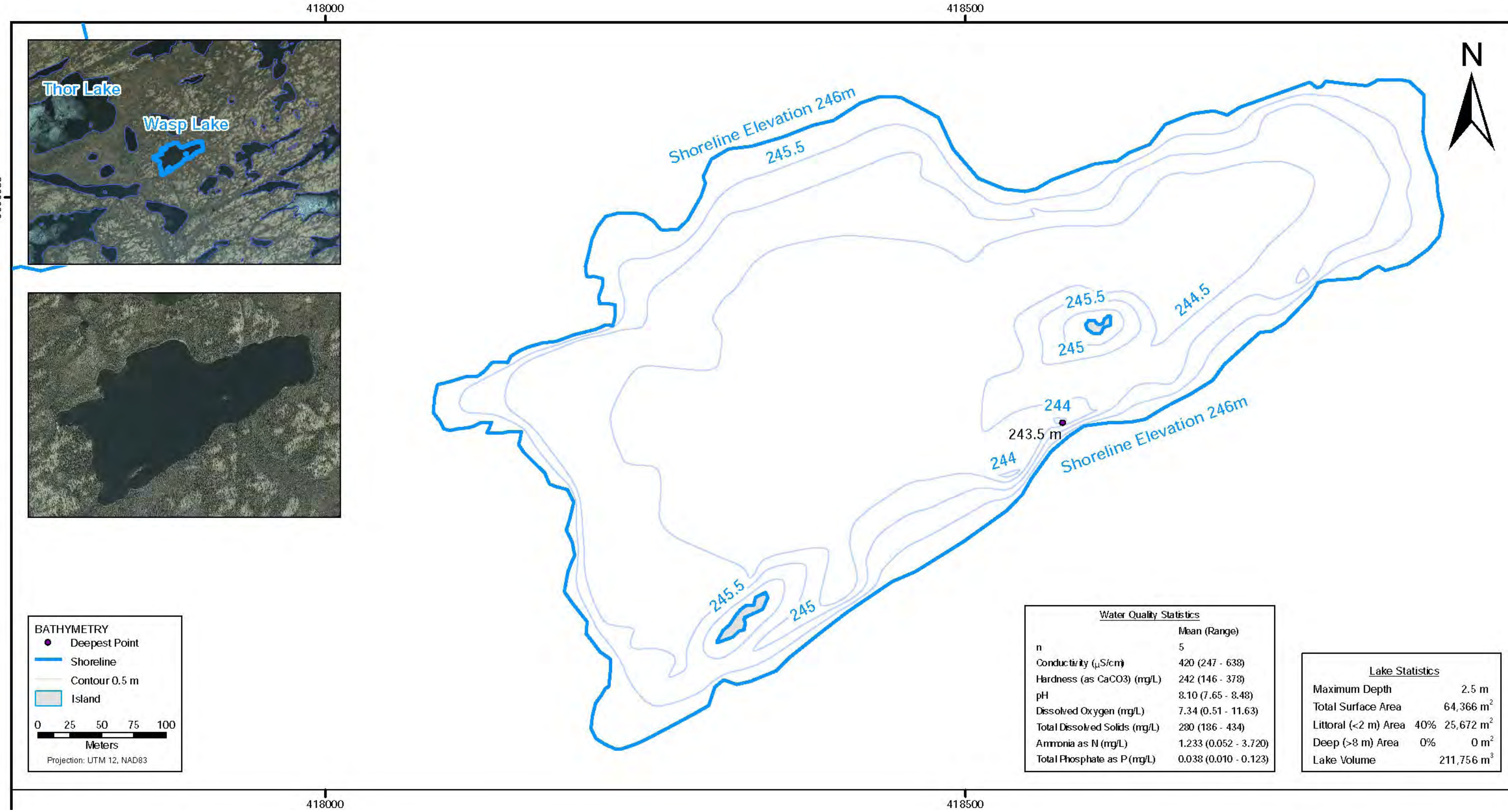

Water Quality Statistics	Mean (Range)
n	5
Conductivity (μS/cm)	420 (247 - 638)
Hardness (as CaCO3) (mg/L)	242 (146 - 378)
pH	8.10 (7.65 - 8.48)
Dissolved Oxygen (mg/L)	7.34 (0.51 - 11.63)
Total Dissolved Solids (mg/L)	280 (186 - 434)
Ammonia as N (mg/L)	1.233 (0.052 - 3.720)
Total Phosphate as P (mg/L)	0.038 (0.010 - 0.123)

Lake Statistics		
Maximum Depth		2.5 m
Total Surface Area		64,366 m^2
Littoral (<2 m) Area	40%	25,672 m^2
Deep (>8 m) Area	0%	0 m^2
Lake Volume		211,756 m^3

NOTES

Figure Source: Appendix A, Figure 16. Stantec 2010c.

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THOR LAKE PROJECT

Wasp Lake Bathymetry and Habitat

PROJECT NO.	DWN	CKD	REV
V15101007.006	SL	DM	0
OFFICE	DATE		
EBA-VANC	May 9, 2011		

Figure 2.8-30

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2.8.5.7 Tardiff Group

The Tardiff Group includes North Tardiff and South Tardiff lakes, two small lakes that are located south of Thor Lake and contained within the Lake Zone ore body (Figure 2.8-11). North Tardiff Lake has one outlet, which is primarily a peaty wetland with surface and subsurface flows but no defined channel; an inlet was not located. South Tardiff has one defined outlet with surface and subsurface flows, draining south into Long through a discontinuous channel. North Tardiff and South Tardiff lakes have been identified as possible thermokarst lakes, formed from and currently affected by the meltwater of underlying thawing permafrost.

Bathymetry and lakeshore habitat for North and South Tardiff lakes is provided in Figures 2.8-31 and 2.8-32.

North Tardiff Lake is a mainly circular, shallow lake has a maximum depth of 1.7 m, indicating the likelihood that it freezes nearly to the bottom in winter, precluding overwintering habitat for fish. The substrate of this lake consists entirely of organic muck.

South Tardiff Lake is approximately 2.5 times the area of North Tardiff Lake, although both have a similar depth profile. With a maximum depth of only 1.9 m, South Tardiff Lake would also freeze near to the bottom in winter. Similar to North Tardiff Lake, its substrate consists of organic muck and floating plants are abundant throughout.

Generally, North and South Tardiff are highly coloured with high dissolved organic carbon (DOC) levels, though they show lower mean values for conductivity, pH, hardness and alkalinity, and a reduced buffering capacity. Mean nutrient concentrations of the Tardiff lakes are comparable to other small shallow lakes in the study area, though they tend to have slightly greater mean nitrate and phosphate (total and ortho) concentrations. The Tardiff lakes exhibit strong seasonal fluctuations in general chemistry, with conductivity, hardness, dissolved solids, nutrients and several metals increasing 2 to 32-fold in concentration during winter. Aluminum (total) and iron (total and dissolved) exceeded applicable guidelines during winter in both lakes; dissolved aluminum also exceeded the BC dissolved guideline in winter at North Tardiff.

BATHYMETRY
- Deepest Point
- Shoreline
- Contour 1 m
- Contour 5 m

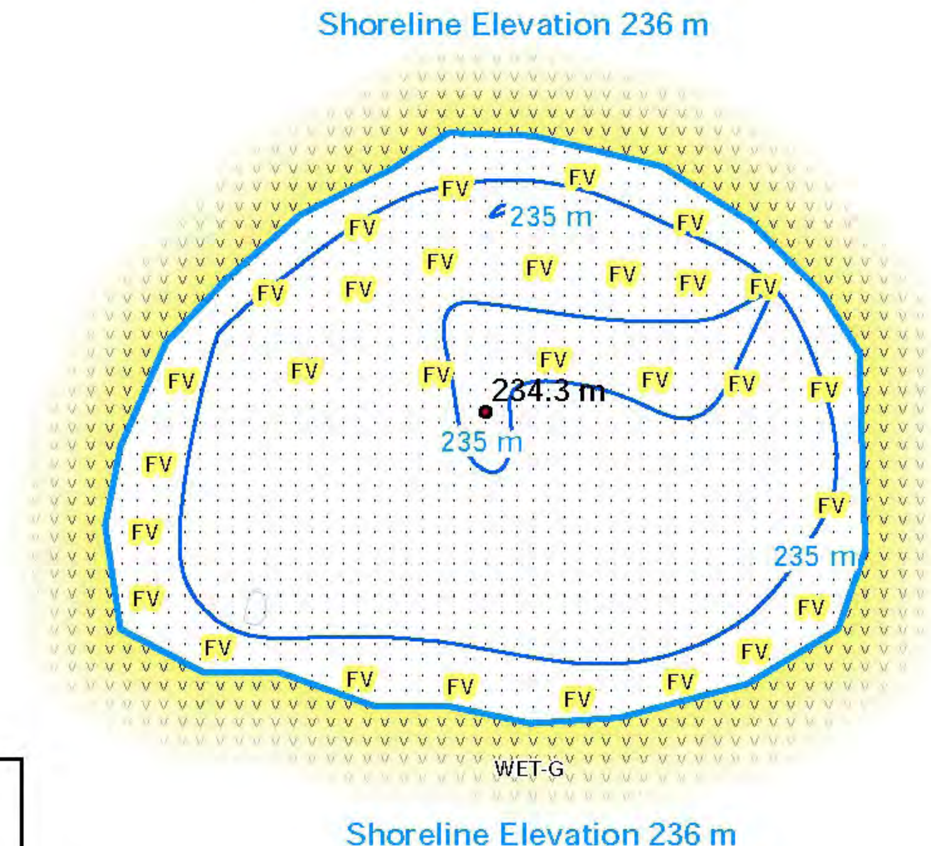
HABITAT STRUCTURE
- BL Beaver Lodge
- EV Emergent Vegetation
- FV Floating Vegetation
- SV Submerged Vegetation
- WD Woody Debris

VISIBLE RIPARIAN
- Bedrock
- Black Spruce Forest - Shrub or Grass (BSF-S, BSF-G)
- Wetland - Shrub or Grass (WET-S, WET-G)

LITTORAL SUBSTRATE
- Bedrock
- Boulder/Cobble
- Gravel/Fine
- Organic Muck

0 20 40 60 80
Meters
Projection: UTM 12, NAD83

417000
6886500



Water Quality Statistics	Mean (Range)
n	5
Conductivity (µS/cm)	157 (82 - 290)
Hardness (as CaCO3) (mg/L)	100 (50 - 193)
pH	7.58 (7.34 - 7.77)
Dissolved Oxygen (mg/L)	6.05 (0.47 - 11.00)
Total Dissolved Solids (mg/L)	206 (106 - 398)
Ammonia as N (mg/L)	0.474 (0.032 - 1.710)
Total Phosphate as P (mg/L)	0.044 (0.010 - 0.080)

Fish Species Caught
No Fish Caught

N

Lake Statistics		
Maximum Depth		1.7 m
Total Surface Area		14,109 m^2
Littoral (<2 m) Area	100%	14,109 m^2
Deep (>8 m) Area	0%	0 m^2
Lake Volume		14,260 m^3

417000
6886500

NOTES
Figure Source: Appendix A, Figure 4. Stantec 2010c.

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THOR LAKE PROJECT

North Tardiff Lake Bathymetry and Habitat

PROJECT NO.	DWN	CKD	REV
V15101007.006	SL	DM	0
OFFICE	DATE		
EBA-VANC	May 9, 2011		

Figure 2.8-31

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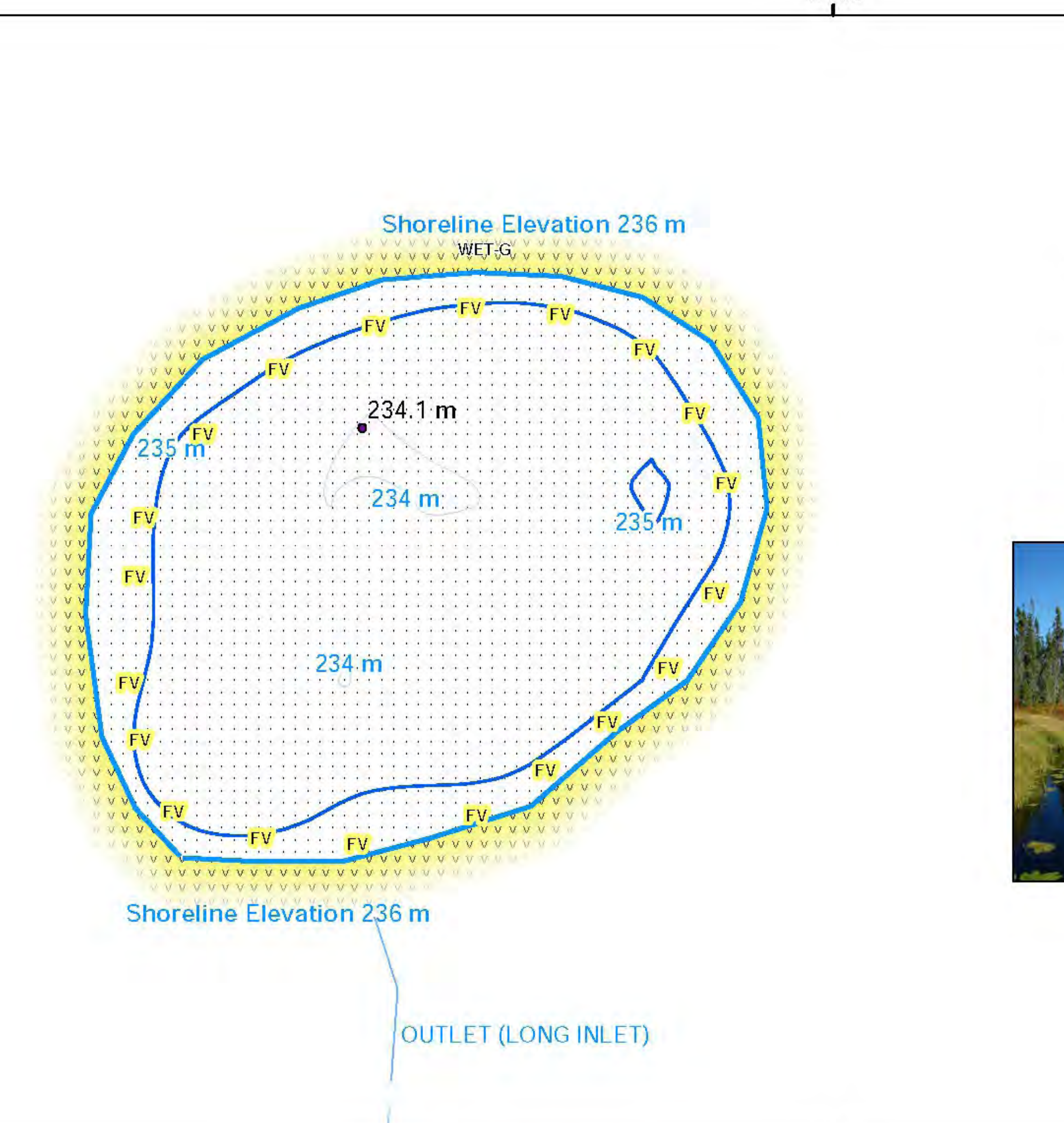

Fish Species Caught
No Fish Caught

BATHYMETRY
- Deepest Point
- Shoreline
- Contour 1 m
- Contour 5 m

HABITAT STRUCTURE
- BL Beaver Lodge
- EV Emergent Vegetation
- FV Floating Vegetation
- SV Submerged Vegetation
- WD Woody Debris

VISIBLE RIPARIAN
- Bedrock
- Black Spruce Forest - Shrub or Grass (BSF-S, BSF-G)
- Wetland - Shrub or Grass (WET-S, WET-G)

LITTORAL SUBSTRATE
- Bedrock
- Boulder/Cobble
- Gravel/Fine
- Organic Muck

0 20 40 60 80
Meters
Projection: UTM 12, NAD83

Water Quality Statistics

	Mean (Range)
n	5
Conductivity (µS/cm)	166 (96 - 283)
Hardness (as CaCO3) (mg/L)	100 (58 - 172)
pH	7.66 (7.47 - 7.95)
Dissolved Oxygen (mg/L)	6.09 (0.45 - 11.06)
Total Dissolved Solids (mg/L)	180 (107 - 317)
Ammonia as N (mg/L)	0.365 (0.027 - 1.310)
Total Phosphate as P (mg/L)	0.025 (0.014 - 0.044)

Lake Statistics

Maximum Depth		1.9 m
Total Surface Area		37,018 m^2
Littoral (<2 m) Area	100%	37,018 m^2
Deep (>8 m) Area	0%	0 m^2
Lake Volume		39,693 m^3

NOTES
Figure Source: Appendix A, Figure 3. Stantec 2010c.

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THOR LAKE PROJECT

South Tardiff Lake Bathymetry and Habitat

PROJECT NO.	DWN	CKD	REV
V15101007.006	SL	DM	0
OFFICE	DATE		
EBA-VANC	May 9, 2011		

Figure 2.8-32

High iron (total and dissolved) levels appear to be relatively consistent through all seasons at North Tardiff Lake (ranging from 232 to 3,110 µg/L dissolved iron). The dissolved iron guideline was also exceeded in June and September 2009. High iron concentrations through the year may be related to high DOC levels (mean of 56.9 mg/L), which provide organic compounds that act as chelators and prevent precipitation of iron from the water column in the open water season (Dodds 2002). South Tardiff also had a high mean DOC level (44.2 mg/L) but did not exhibit high iron in spring through fall. The disparity in iron concentrations between the Tardiff lakes may be an indication of differences in iron speciation, phytoplankton community composition and subsequent differences in phytoplankton-iron interactions (Öztürk et. al. 2003). High DOC levels, combined with higher nutrients and iron in the Tardiff lakes may be a result of their surrounding peatland environment, given that peatlands are a major source of DOC, phosphorus and iron (Dillon and Molot 1997), and may also be influenced by the release of carbon and nutrients from the thermokarst process (Mack et al. 2004).

Both Tardiff lakes presented the two highest levels of sediment organic carbon and total Kjeldahl nitrogen across the study area; however, low levels of metals were generally observed in the sediment samples and no exceedances of the CCME ISQG occurred (iron was not included in sediment analyses as there are no CCME ISQG for iron).

The Tardiff lakes had relatively high chlorophyll *a* levels in June, and South Tardiff had the highest chlorophyll *a* concentration of any study area lakes. In addition to being most productive, South Tardiff Lake also had high phytoplankton richness and diversity in June, 2009 compared to other lakes sampled in that year. Phytoplankton taxa in both Tardiff lakes were dominated by various species of blue-green algae.

Zooplankton taxon richness at the Tardiff lakes was among the highest across study area lakes; however, diversity was among the lowest, implying predominance of one or two species.

It is interesting to note that the calanoid copepod, *Limnocalanus macrurus*, was sampled in North Tardiff Lake. This species is normally restricted to cold, deep lakes, and is thought to be a good indicator of pollution and eutrophication.

No fish were captured in the Tardiff lakes in either 2008 and 2009. These lakes are considered to be fishless because of the lack of fish capture; they are shallow and have low winter oxygen concentrations (<1 mg/L); and, neither lake is connected to fish bearing habitat by a passable watercourse.

2.8.5.8 Elbow Group

Elbow Lake is primarily situated on the Blachford Lake Intrusive Complex, outside of the Thor Lake syenite. Surface drainage has been investigated at Elbow; it is relatively isolated from other lakes in the study area. Elbow has one defined outlet at its south bay, draining through several wetland areas and overland into Great Slave (Elbow Out has no defined channel). Topography data do not indicate any surface inlets.

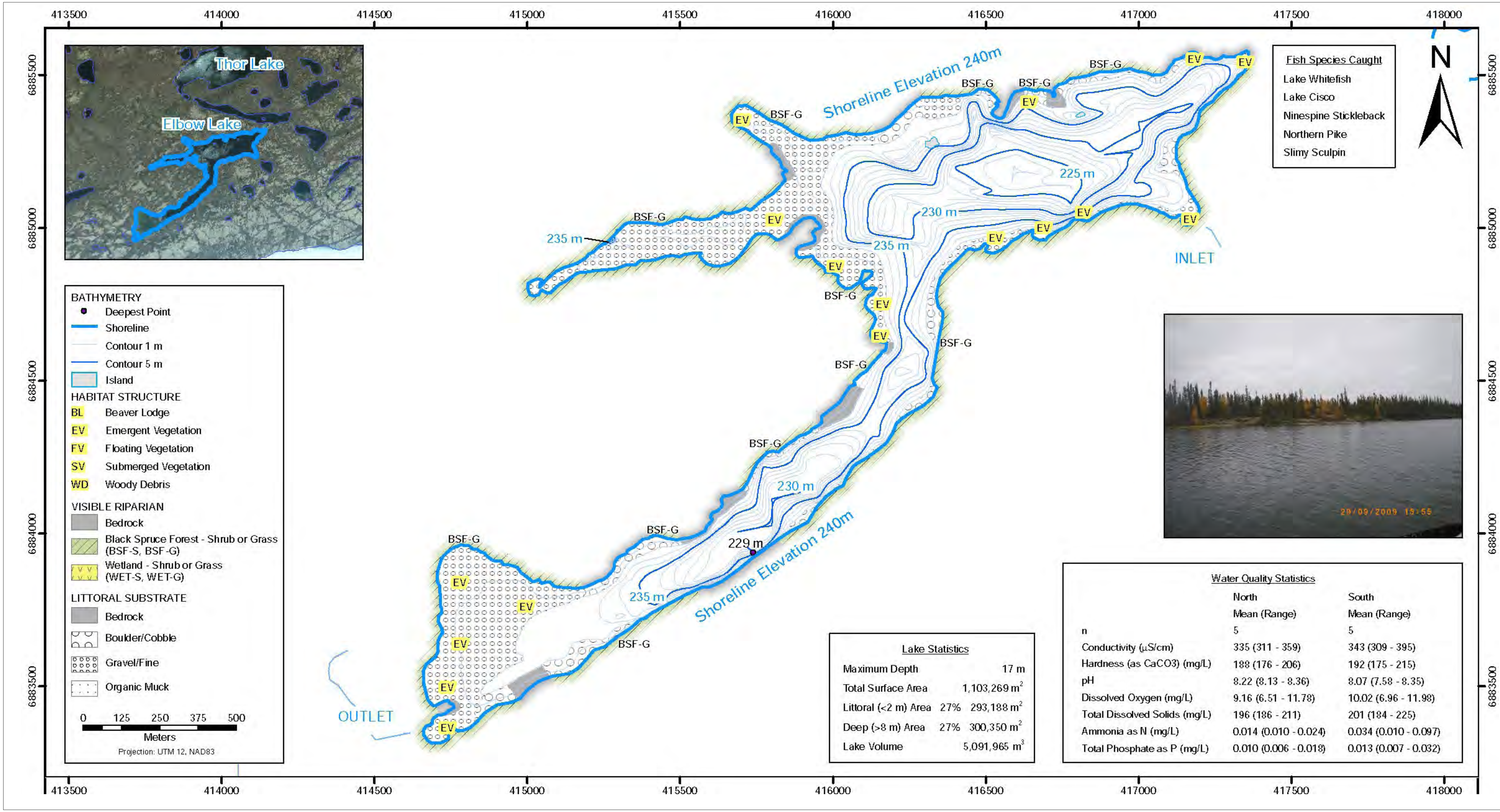
A bathymetric and habitat map of Elbow Lake is provided in Figure 2.8-33. The maximum depth of this lake is 17 m, which is similar to that in Thor Lake. However, the overall depth of Elbow Lake is greater than that of Thor since 22% of the surface area is greater than eight metres (compared with 6.8% for Thor Lake). The littoral zone lake bottom in the south bay and west arm of Elbow Lake consisted of organic muck, while the remainder of the lake had a substrate of gravel and cobble. Emergent plants were found to be common throughout the lake, which was surrounded by a riparian area dominated by black spruce forest interspersed with wetland and bedrock bluff.

Water quality data has been collected in Elbow Lake at two stations since March 2008. Overall, Elbow Lake shows intermediate values of mean conductivity, hardness and dissolved solids. Mean concentrations of some nutrients (nitrate and total phosphate) are higher in Elbow than other deep lakes of the study area (i.e., Long, Kinnikinnick) and greater variation through the dataset is observed. No metals exceeded CCME or BC guidelines through 2008 and 2009 in Elbow Lake, though one outlier was noted at Elbow South (total zinc at 40.3 μg/L).

Sediment quality is similar at the two Elbow stations, with the exception of mean organic carbon at Elbow South (twice the concentration of Elbow North). Metal concentrations were similar between the two Elbow stations; mean nickel was at the CCME ISQG at Elbow North (16.0 mg/kg) while just below the guideline at Elbow South (13.6 mg/kg).

Chlorophyll *a* concentration was intermediate in Elbow in June compared to other study area lakes, and increased in September. Elbow South generally had higher chlorophyll *a* concentrations than Elbow North in both June and September 2009, likely due to higher mean nutrient concentrations at this sample station.

Phytoplankton richness and diversity in Elbow was intermediate among study area lakes in June, and was similar among the two stations. Both sample stations were dominated by two blue-green algal species (*Lyngbya* cf. *limnetica* and *Aphanizomenon flos-aquae*); *Dinobryon* spp. (yellow-brown algae) were also present at both stations.



Lake Statistics		
Maximum Depth		17 m
Total Surface Area		1,103,269 m^2
Littoral (<2 m) Area	27%	293,188 m^2
Deep (>8 m) Area	27%	300,350 m^2
Lake Volume		5,091,965 m^3

Water Quality Statistics

	North Mean (Range)	South Mean (Range)
n	5	5
Conductivity (µS/cm)	335 (311 - 359)	343 (309 - 395)
Hardness (as CaCO3) (mg/L)	188 (176 - 206)	192 (175 - 215)
pH	8.22 (8.13 - 8.36)	8.07 (7.58 - 8.35)
Dissolved Oxygen (mg/L)	9.16 (6.51 - 11.78)	10.02 (6.96 - 11.98)
Total Dissolved Solids (mg/L)	196 (186 - 211)	201 (184 - 225)
Ammonia as N (mg/L)	0.014 (0.010 - 0.024)	0.034 (0.010 - 0.097)
Total Phosphate as P (mg/L)	0.010 (0.006 - 0.018)	0.013 (0.007 - 0.032)

NOTES
Figure Source: Appendix A, Figure 5. Stantec 2010c.

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THOR LAKE PROJECT

Elbow Lake Bathymetry and Habitat

PROJECT NO.	DWN	CKD	REV
V15101007.006	SL	DM	0
OFFICE	DATE		
EBA-VANC	May 9, 2011		

Figure 2.8-33

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Zooplankton richness was relatively low in Elbow Lake, although diversity in the June sampling was high, implying more than one species is dominant. There were three or four species of rotifers predominant at both stations, and unidentified copepods were common.

Melville et al. (1989) note the presence in Elbow Lake (and in A Lake) of the calanoid copepod, *Limnocalanus macrurus*, which is a glacial relict species that evolved as a marine organism, but now lives in both marine and fresh water. This species was not found in Elbow Lake during sampling by Stantec (2010c) in 2009, but was found in A, Great Slave Lake, and North Tardiff Lake. The significance of findings of this species is that it is believed to be a good indicator of eutrophication and pollution because of its normal restriction to the hypolimnion of large, cold lakes, and its intolerance of waters with low dissolved oxygen content (Balcer et al. 1984). It is therefore unusual that this species was found in North Tardiff Lake, which has a maximum depth of only 1.7 m.

Benthic taxon richness was relatively low at both stations in Elbow Lake. Abundance and diversity varied, and was higher at Elbow South than Elbow North, perhaps related to its shallower maximum depth (8 m at Elbow South vs. 14 m at Elbow North) and higher nutrient and phytoplankton levels. Evenness was also greater at Elbow South, where there were several common taxa. Predominant taxa included Chironomidae at Elbow North and fingernail clams (Sphaeriidae) at Elbow South.

Elbow Lake is fish bearing, with catch rates similar to the study area mean for northern pike and lake cisco, and greater than the mean for lake whitefish. Melville et al. (1989) found that the fish community in Elbow Lake was very similar to that in Thor Lake.

The most remarkable characteristic of the Elbow Lake fish was their very high parasitism frequency, the highest in the study area for the three large bodied species. Elbow Lake was the only lake in which any parasites were observed on northern pike (3 of the 16 northern pike had external parasites), and it also had the highest rates of external (38%) and internal (100%) parasitization for lake whitefish. Rates of external and internal parasitization for lake whitefish at other lakes varied from 0 to 21% (21% in Long Lake) for external parasites and 0 to 83% for internal parasites (83% in Thor Lake).

2.8.5.9 Blachford Group

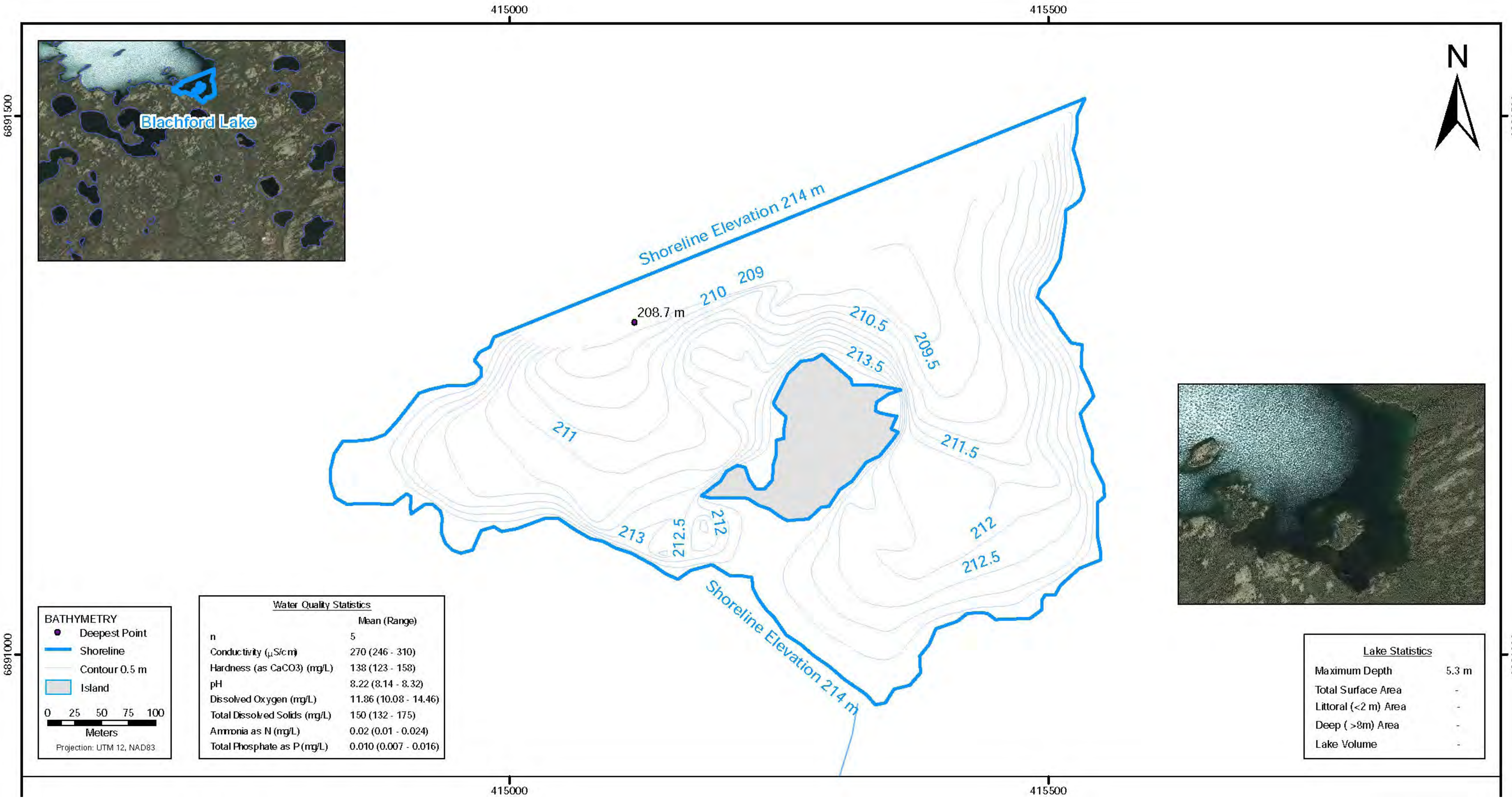
The Blachford group of lakes includes Dinosaur Lake and the sampled bay in Blachford Lake (Figure 2.8-1). Both lakes are situated within the Blachford Lake Intrusive Complex, outside the Thor Lake syenite. Surface drainage from these lakes has not been investigated and is inferred from topographic maps. Dinosaur Lake appears to have one inlet and one outlet, draining approximately north through a series of lakes into Blachford Lake. The south bay in Blachford Lake appears to have one inlet, draining from several small lakes in the study area.

Bathymetry for the sampled bay in Blachford Lake and Dinosaur Lake is provided in Figures 2.8-34 and 2.8-35. Littoral habitat features were not investigated during studies conducted by Stantec (2010c), however, Golder (1998a) provides limited descriptions of shoreline habitat in the south bay of Blachford Lake. The shoreline was described as being bedrock outcrop to the edge of the lake interspersed with areas of emergent vegetation. The bay itself is characterized by low sloping shorelines with long flats of emergent vegetation visible between small islands and the south shore. That part of the bay is very shallow (<2 m) and is heavily weeded.

Water quality data were collected in the Blachford group from March, 2008, to September, 2009. Due to the size and depth differences of the two lakes, general chemistry is dissimilar. Blachford Lake is a large, clear, lake and water quality in the sampled bay reflects this. Generally the Blachford sample station exhibited lower mean conductivity, hardness, and nutrients, with no metal exceedances; larger values for some nutrients and suspended solids shown at this station occurred in March 2008 when the station was located in a shallower area of the bay.

Dinosaur is a small lake, though with a maximum depth of 4.9 m, it is not considered shallow. Dinosaur Lake generally displayed seasonal variation in general chemistry parameters, with highest conductivity, hardness and dissolved solids levels in winter. Nutrient levels generally were low in Dinosaur Lake, though mean total phosphate was relatively high (29.6 μg/L) in comparison to other lakes across the study area. Total and dissolved iron exceeded applicable guidelines in winter and several other metals (i.e., manganese, strontium, uranium) also increased in concentration in winter.

Sediment chemistry is also dissimilar in these two lakes. Blachford Lake had low concentrations of organic carbon, Kjeldahl nitrogen and phosphorus, with no exceedances of guidelines for metals. Dinosaur Lake had relatively high values of organic carbon, Kjeldahl nitrogen and phosphorus, and arsenic exceeded its CCME ISQG.



Water Quality Statistics

	Mean (Range)
n	5
Conductivity (μS/cm)	270 (246 - 310)
Hardness (as CaCO3) (mg/L)	138 (123 - 158)
pH	8.22 (8.14 - 8.32)
Dissolved Oxygen (mg/L)	11.86 (10.08 - 14.46)
Total Dissolved Solids (mg/L)	150 (132 - 175)
Ammonia as N (mg/L)	0.02 (0.01 - 0.024)
Total Phosphate as P (mg/L)	0.010 (0.007 - 0.016)

Lake Statistics

Maximum Depth	5.3 m
Total Surface Area	-
Littoral (<2 m) Area	-
Deep (>8m) Area	-
Lake Volume	-

NOTES
Figure Source: Appendix A, Figure 17. Stantec 2010c.

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THOR LAKE PROJECT

Blachford Lake Bathymetry and Habitat

PROJECT NO.	DWN	CKD	REV
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OFFICE	DATE		
EBA-VANC	May 9, 2011		

Figure 2.8-34

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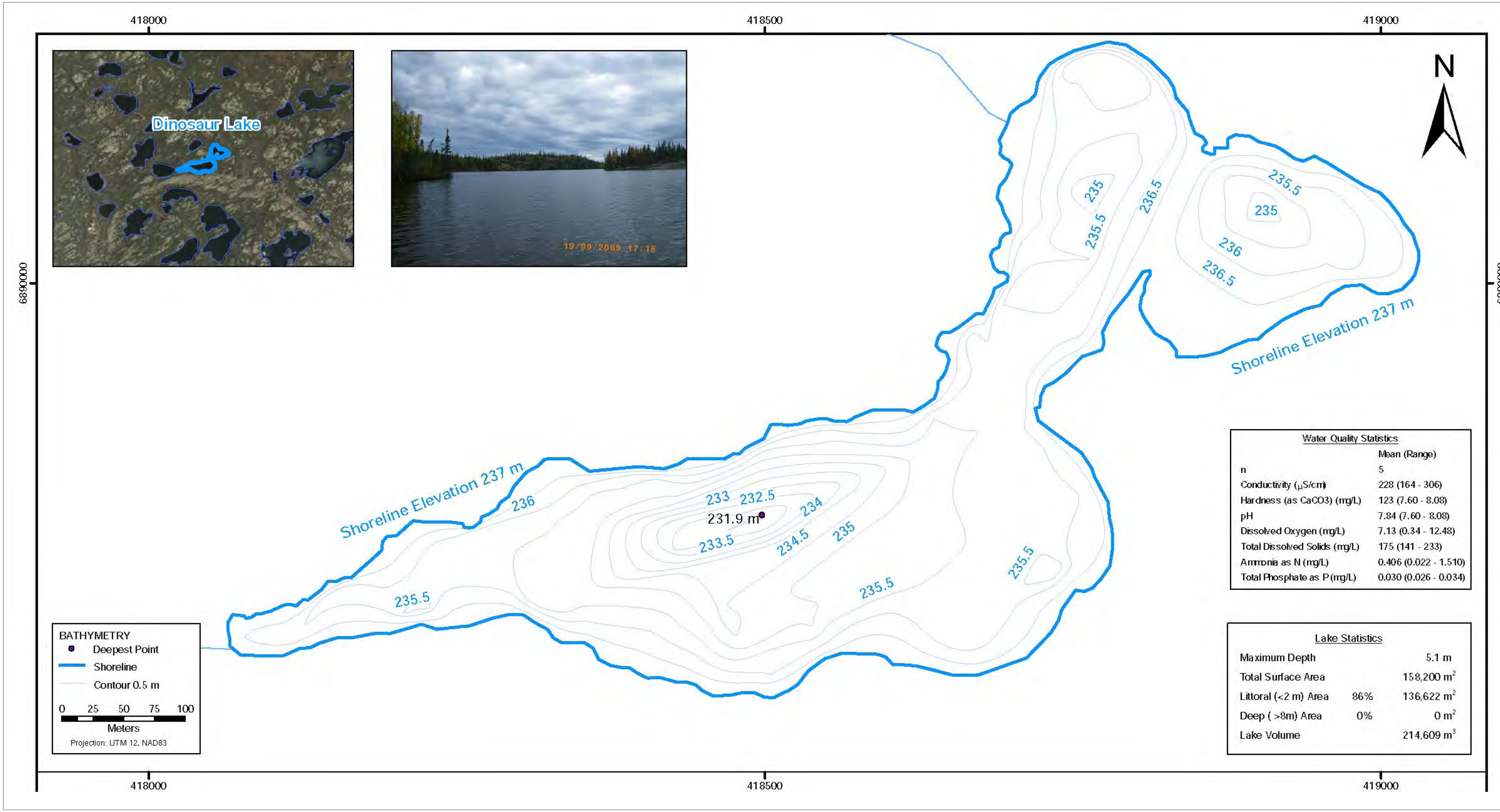

Water Quality Statistics

	Mean (Range)
n	5
Conductivity (μS/cm)	228 (164 - 306)
Hardness (as CaCO3) (mg/L)	123 (7.60 - 8.08)
pH	7.84 (7.60 - 8.08)
Dissolved Oxygen (mg/L)	7.13 (0.34 - 12.48)
Total Dissolved Solids (mg/L)	175 (141 - 233)
Ammonia as N (mg/L)	0.406 (0.022 - 1.510)
Total Phosphate as P (mg/L)	0.030 (0.026 - 0.034)

Lake Statistics

Maximum Depth		5.1 m
Total Surface Area		158,200 m^2
Littoral (<2 m) Area	86%	136,622 m^2
Deep (>8m) Area	0%	0 m^2
Lake Volume		214,609 m^3

NOTES
Figure Source: Appendix A, Figure 9. Stantec 2010c.

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THOR LAKE PROJECT

Dinosaur Lake Bathymetry and Habitat

PROJECT NO.	DWN	CKD	REV
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OFFICE	DATE		
EBA-VANC	May 9, 2011		

Figure 2.8-35