APPENDIX "D"

"RECEIVING WATER CHARACTERIZATION STUDY

FOR A FUTURE OUTFALL OF THE

BURNT CHURCH WASTEWATER TREATMENT PLANT"

NATECH Environmental Services Inc.

Receiving Water Characterization Study for a Future Outfall of the Burnt Church Wastewater Treatment Plant

Submitted to: **Crandall Engineering Ltd.**
1077 St George Blvd., Suite 400
Moncton, New Brunswick
E1E 4C9

Prepared by: **NATECH Environmental Services Inc.**
2492 Route 640
Hanwell, N.B.
E3E 2C2

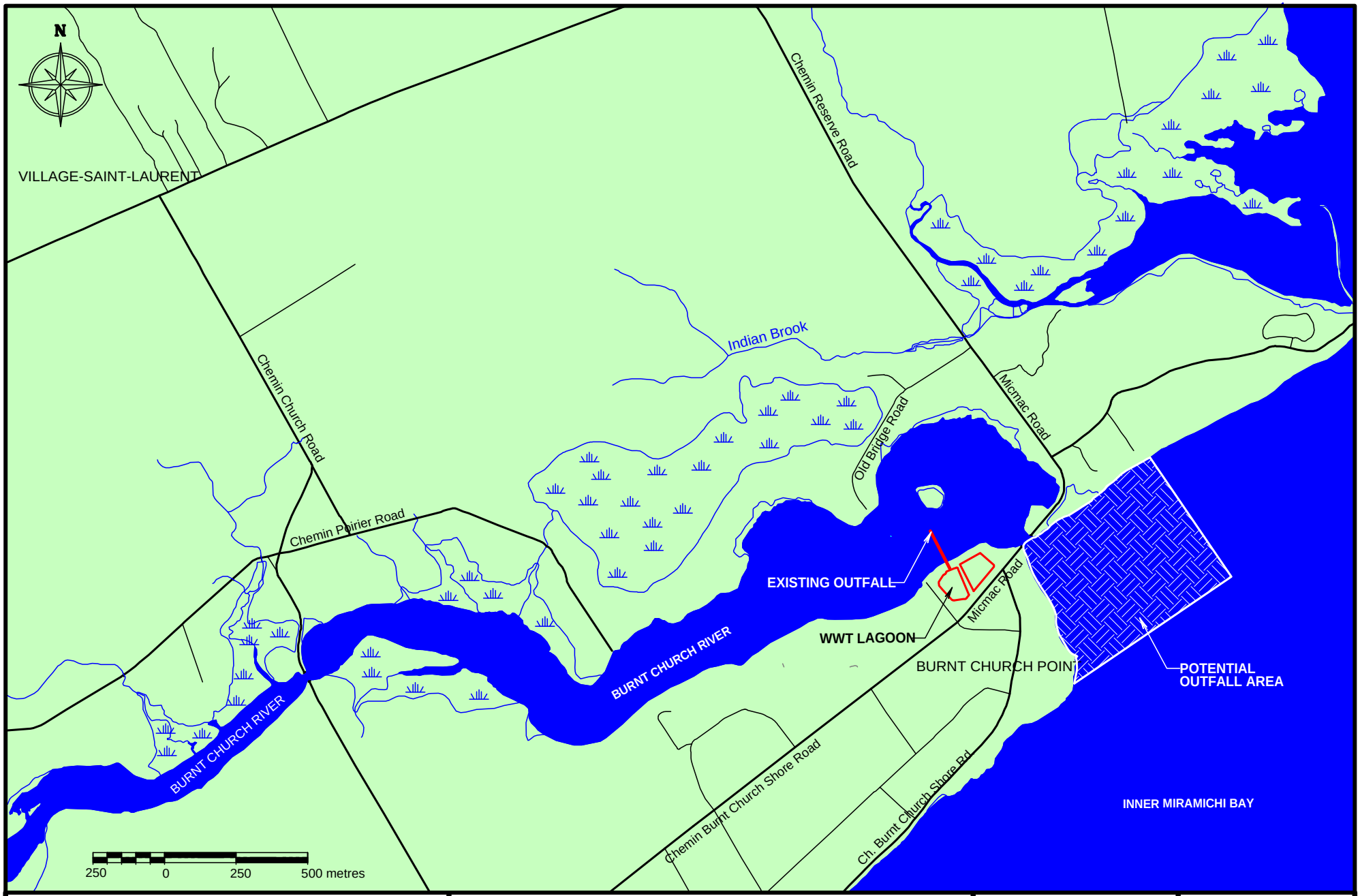
Date: **June 30, 2014**

TABLE OF CONTENTS

1. INTRODUCTION

Crandall Engineering Ltd. requested that NATECH Environmental Services Inc. conduct a Receiving Water Characterization Study in the vicinity of a potential future outfall from the Wastewater Treatment Plant (WWTP) in Burnt Church. The outfall would be located in Miramichi Inner Bay, east of the mouth of the Burnt Church River. Figures 1-1 and 1-2 show the potential outfall area. The hydrographic chart of Bay near Burnt Church (No. 4911) is provided on Figure 1-3 for reference.

The objective of the investigation is to provide the information necessary to select a suitable discharge point for a possible new outfall. Other pertinent information regarding the outfall design is provided as well, such as the effect of depth and diffuser configuration.



Receiving Water Characterization Study
Burnt Church
Location Map

NATECH

Environmental Services Inc.

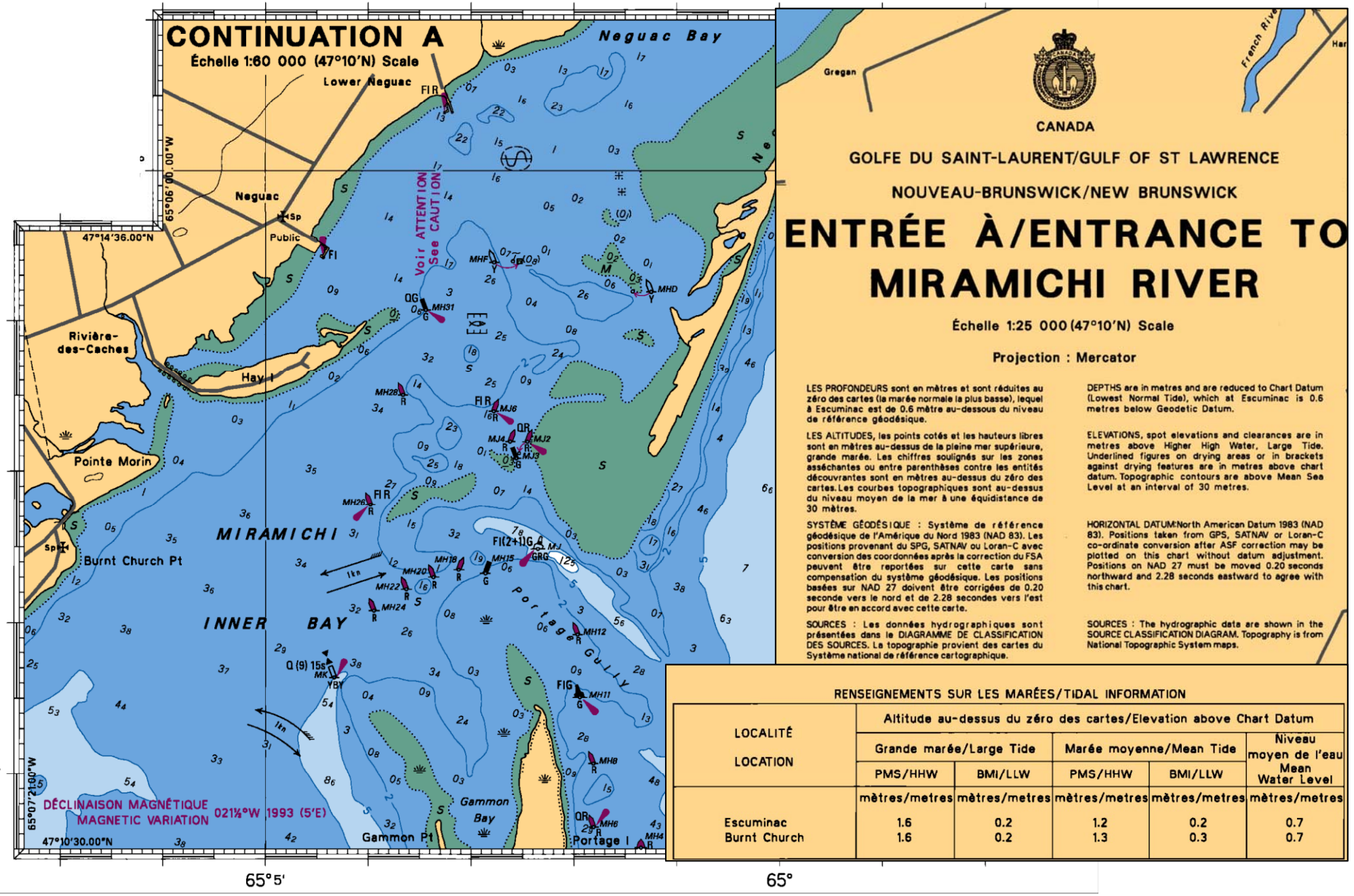
2492 Route 640, Hanwell, N.B., E3E 2C2
Ph: (506) 455-1085 Fax: (506) 455-1088

Date: 2014/05/23	Date:	File: CBC-14-01
Scale: AS SHOWN	Echelle:	Figure: 1-1

Receiving Water Characterization Study
Burnt Church
Potential Outfall Locations
& Water Sampling Locations

NATECH
Environmental Services Inc.
2492 Route 640, Hanwell, N.B., E3E 2C2
Ph: (506) 455-1085 Fax: (506) 455-1088

Date: / Date:	Project No.: / Nº du projet
2014/05/23	CBC-14-01
Scale: / Echelle:	**Sheet No.: / Nº de la feuille:**
AS SHOWN	1-2



LES PROFONDEURS sont en mètres et sont réduites au zéro des cartes (la marée normale la plus basse), lequel à Escuminac est de 0.6 mètre au-dessous du niveau de référence géodésique.

LES ALTITUDES, les points cotés et les hauteurs libres sont en mètres au-dessus de la pleine mer supérieure, grande marée. Les chiffres soulignés sur les zones asséchantes ou entre parenthèses contre les entités découvrantes sont en mètres au-dessus du zéro des cartes. Les courbes topographiques sont au-dessus du niveau moyen de la mer à une équidistance de 30 mètres.

SYSTÈME GÉODÉSIQUE : Système de référence géodésique de l'Amérique du Nord 1983 (NAD 83). Les positions provenant du SPG, SATNAV ou Loran-C avec conversion des coordonnées après la correction du FSA peuvent être reportées sur cette carte sans compensation du système géodésique. Les positions basées sur NAD 27 doivent être corrigées de 0.20 seconde vers le nord et de 2.28 secondes vers l'est pour être en accord avec cette carte.

SOURCES : Les données hydrographiques sont présentées dans le DIAGRAMME DE CLASSIFICATION DES SOURCES. La topographie provient des cartes du Système national de référence cartographique.

DEPTHS are in metres and are reduced to Chart Datum (Lowest Normal Tide), which at Escuminac is 0.6 metres below Geodetic Datum.

ELEVATIONS, spot elevations and clearances are in metres above Higher High Water, Large Tide. Underlined figures on drying areas or in brackets against drying features are in metres above chart datum. Topographic contours are above Mean Sea Level at an interval of 30 metres.

HORIZONTAL DATUM: North American Datum 1983 (NAD 83). Positions taken from GPS, SATNAV or Loran-C co-ordinate conversion after ASF correction may be plotted on this chart without datum adjustment. Positions on NAD 27 must be moved 0.20 seconds northward and 2.28 seconds eastward to agree with this chart.

SOURCES : The hydrographic data are shown in the SOURCE CLASSIFICATION DIAGRAM. Topography is from National Topographic System maps.

RENSEIGNEMENTS SUR LES MARÉES/TIDAL INFORMATION

LOCALITÉ LOCATION	Altitude au-dessus du zéro des cartes/Elevation above Chart Datum				
	Grande marée/Large Tide		Marée moyenne/Mean Tide		Niveau moyen de l'eau Mean Water Level
	PMS/HHW	BMI/LLW	PMS/HHW	BMI/LLW	
	mètres/metres	mètres/metres	mètres/metres	mètres/metres	mètres/metres
Escuminac	1.6	0.2	1.2	0.2	0.7
Burnt Church	1.6	0.2	1.3	0.3	0.7

Receiving Water Characterization Study
Burnt Church
Local hydrographic Chart (No. 4119)

NATECH
Environmental Services Inc.
2492 Route 640, Hanwell, NB E3E 2C2
ph: (506) 455-1085, fax (506) 455-1088

DATE: 2014/05/29

FILE: CBC-14-01

SCALE: –

FIGURE: 1-3

2. METHODOLOGY

2.1 Preparation for field investigation

2.1.1 Background information

Available documented information, including hydrographic mapping, aerial photography, design information, and our in-house files were reviewed.

2.1.2 Preliminary modeling

A preliminary evaluation into the dilution potential at the site was carried out using the Cormix model. A range of different depths and current velocities were assumed. The hydrographic chart for the area is not very detailed but indicates shallow depths (less than two metres several hundreds of metres from the shore). The option of using a diffuser was examined, and the associated improvement in dilution was documented in relation to the possible reductions in outfall length.

Design criteria: the outfall should achieve at least a 1 in 100 dilution within 250 m of the outfall at all times, based on the New Brunswick mixing zone limits (this approach will result in the highest possible Effluent Discharge Objectives (EDOs) for the effluent).

Five potential outfall locations were identified before carrying out the field measurements.

2.2 Field investigation

2.2.1 Water Level Variations

Two water level sensors were installed to automatically monitor the tidal water level variations. The locations were at the wharf on the southern shore of the community and downstream of the MicMac Road bridge. The water level was tied to three geodetic benchmarks using a total station:

- Top of nut on fire hydrant: 4.53 m
- Top of water valve on fire hydrant: 3.88 m
- Top of sanitary manhole beside lift station: 3.35 m

2.2.2 Bathymetry

The bathymetry of the estuary in the outfall area was surveyed using two boats equipped with GPS and echo sounder technology. The depths were originally recorded relative to the water surface and then converted to geodetic elevations, taking into account the measured tidal changes in the water level.

2.2.3 Current Direction and Speed

The local ocean currents were measured using six drogues equipped with GPS tracking devices that drifted with the currents. Three were surface drogues, and three were set underwater at a 1.00 m depth.

2.2.4 Water Quality

The water quality was measured in the field at four locations (three outfall locations plus the river under the bridge) using a YSI multi-parameter water quality probe. The parameters recorded included pH, Temperature, DO, TDS, conductivity, and salinity. In addition, water samples were taken at the same locations, and analysed at the RPC laboratory in Fredericton. The samples were analysed for $CBOD_5$, TSS, unionized ammonia, total ammonia, TKN, TP, E. Coli, Faecal Coliforms

Salinity and temperature were also measured over the depth of the water column in a few locations to determine whether stratification occurs. The recorders were left in place for the duration of the field work

2.2.5 Mixing Regime

The mixing regime in the receiving environment was measured by injecting Rhodamine WT dye as a tracer at several locations into Inner Miramichi Bay. The dye was released at the surface as the WWTP effluent is anticipated to be buoyant. Dye sensor readings along with corresponding GPS position and time were documented. Visual observations were sketched and the plume boundary shape was traced in the field using GPS tracking.

The purpose of the dye release was to simulate the release of effluent, and to verify dilution rates predicted by the mixing model. The dye studies were spread over two days to avoid interference between the different dye plumes. The dye was released several times during the tidal cycle (mid falling tide, slack low tide, and mid rising tide). The dye was monitored downstream of the discharge using a fluorometer, coupled with a GPS.

3. RESULTS

3.1 Preliminary Modeling

Model runs were carried out with the Cormix model assuming depths ranging from 0.5 m to 2.0 m and worst-case low velocities from 0.01 m/s to 0.1 m/s. At 0.01 m/s the model results are felt not be reliable. No temperature or salinity stratification was assumed. Also, the outfall was assumed to be an open-ended pipe with a diameter of 0.08 m, to provide an exit velocity of 2 m/s for the effluent peak future flow of 10.23 L/s (887 m^3/day).

The results in shallow water suggest that current speed has a greater influence on dilution than depth. This is due to the fact that regardless of the depth at discharge, the effluent is buoyant and tends to rise quickly before spreading in a thin layer at the surface of the ocean. Consequently when choosing a potential outfall location. Priority should be given to areas with the greatest ambient current velocities. According to the simulations, a current speed above 0.05 m/s appears sufficient to provide a dilution greater than 1 in 100 within 250 m from the outfall, provided that the outfall is at least 100 m away from the shore to avoid shoreline attachment of the plume.

Additional model runs were carried out to simulate several diffuser options: diffuser lengths of 10, 20 and 50 m, and various numbers of nozzles (with varying diameters to always provide an exit velocity of 2 m/s). The simulations suggests that the length of the diffuser (from the first to the last nozzle) matters more than the number of nozzles, to provide a significant improvement in dilution.

Table 3.1 Cormix preliminary simulations (various depths and current velocities)

Assumptions		Results of simulations					
		Distance to 1 in 100 dilution			Plume at 250 m		
Current speed (m/s)	Depth (m)	Upstream (m)	Down-stream (m)	Length of plume under 1:100 dilution	Dilution (1 in)	Thickness (cm)	Width (m)
0.01	0.5	220	200	420	6 US, 130 DS	2 US, 18 DS	800
	1	300	100	400	9 US, 210 DS	4 US, 23 DS	900
	1.5	360	80	440	10 US, 280 DS	8 US, 28 DS	1000
	2	420	75	495	11 US, 380 DS	14 US, 35 DS	1100
0.02	0.5	62	300	362	70	10	370
	1	64	300	364	75	10	370
	1.5	66	290	356	80	11	380
	2	68	290	358	85	11	390
0.05	0.5	5	200	205	150	20	160
	1	5	220	225	120	15	160
	1.5	5	230	235	115	14	160
	2	5	240	245	110	14	160
0.1	0.5	-	110	110	385	50	80
	1	-	120	120	440	54	80
	1.5	-	120	120	390	46	80
	2	-	110	110	350	43	80

Notes: “US” means upstream, “DS” means downstream

Other assumptions:

- No salinity or temperature stratification, salinity = 30 ppt
- Effluent peak future flow =10.23 L/s (887m3/day), effluent velocity = 2 m/s

Table 3.2 Cormix preliminary simulations (at **0.5 m depth**, for various current velocities)

Assumptions		**Results of simulations**					
		Distance to 1 in 100 dilution			**Plume at 250 m**		
Current speed (m/s)	**Nozzles**	**Upstream** (m)	**Down-stream** (m)	**Length of plume under 1:100dilution**	**Dilution** (1 in)	**Thick-ness** (cm)	**Width** (m)
0.01	1*	220	200	420	6 US, 130 DS	2 US, 18 DS	370
	11@1m spacing	140	200	340	130	18	370
	21@1m	145	170	315	150	20	390
	51@1m	130	80	210	200	25	410
0.02	1*	62	300	362	70	10	370
	11@1m	23	260	283	85	13	400
	3@5m	same	same	same	same	same	same
	21@1m	22	215	237	110	16	380
	51@1m	19	100	119	170	22	400
	21@2.5m	Same	Same	Same	Same	Same	Same
	11@5m	Same	Same	Same	Same	Same	Same
	3@25m	Same	Same	Same	Same	Same	Same
0.05	1*	5	200	205	150	20	380
0.1	1*	-	110	110	385	50	390

Notes: “US” means upstream, “DS” means downstream

* Open-ended pipe results from Table 3.1

Other assumptions:

- No salinity or temperature stratification, salinity = 30 ppt
- Effluent peak future flow =10.23 L/s (887m3/day), effluent velocity = 2 m/s

3.2 Field Measurements

The field investigations were carried out from May 12 to May 14, 2014. The weather conditions during the investigation consisted of cool temperatures with a slight wind, blowing toward the NW on May 12 and 13, and toward the NE on May 14.

3.2.1 Water Level Variations

The water level records during the survey are displayed on Figure 3-1, as well as tidal predictions for the area from the Canadian Hydrographic Service. Table 3.2 shows the typical water levels expected in Burnt Church obtained from the local hydrographic chart.

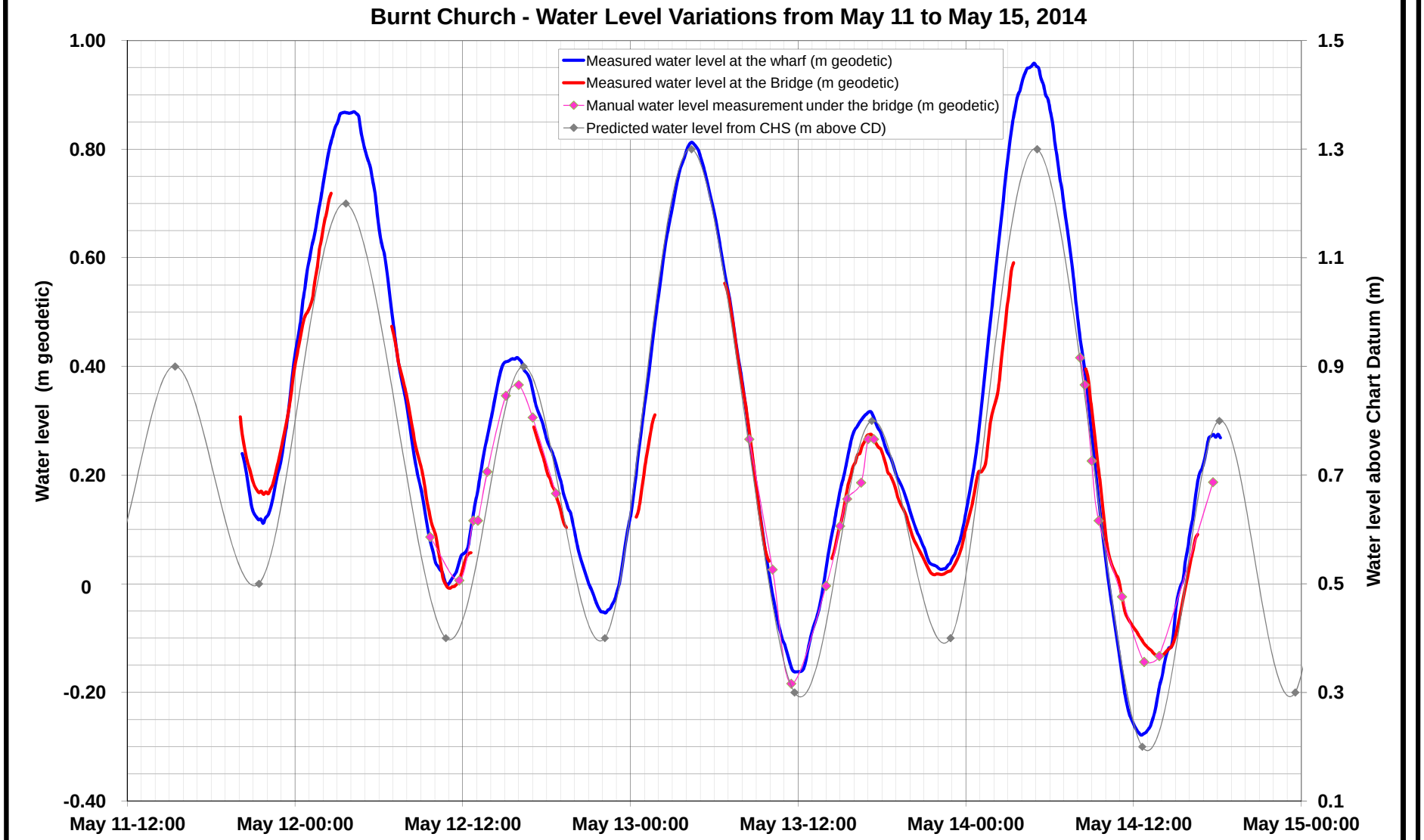
Table 3.2 Characteristics of tidal water levels in Burnt Church (from Nautical Chart No. 4911 partially shown on Figure 1-3), relative to chart datum (CD):

Parameter	Large tides	Mean tides
Low water level (m)	0.2	0.3
High water level (m)	1.6	1.3
Range (m)	1.4	1.0

Notes The mean water level is at 0.7 m above CD. According to the chart's legend, the high and low water level elevations above CD can be converted to geodetic elevations by substracting 0.6 m.

3.2.2 Bathymetry

Figures 3-2 and 3-3 depict the surveyed bathymetry in the outfall area. Figure 3-2 is a 3D perspective, rotated to better show the river channel. Figure 3-3 is a plan view (or looking straight down with the Y-axis pointing North). A cross-section of inner Miramichi Bay along the anticipated outfall pipeline is presented on Figure 3-4.



Receiving Water Characterization Study

Burnt Church

Water Level Variations

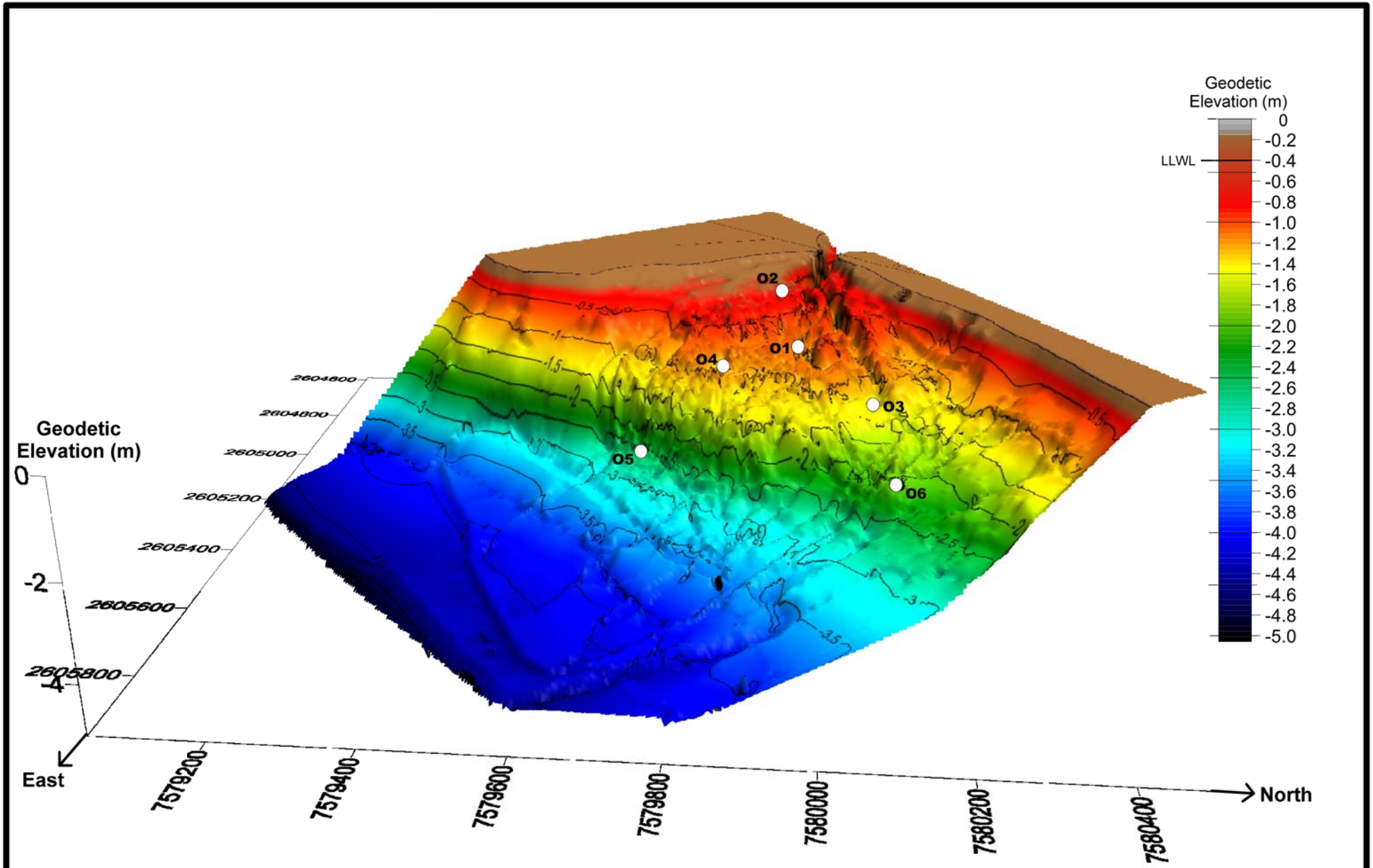
NATECH Environmental Services Inc.
2492 Route 640,
Hanwell, NB, CANADA,
E3E 2C2

SCALE: As shown

DATE: 2014/05/25

FILE: CBC-14-01

FIGURE: 3-1



Receiving Water Characterization Study
Burnt Church - Bathymetric Survey of May 2014
3D View of Bottom Contours and River Channel

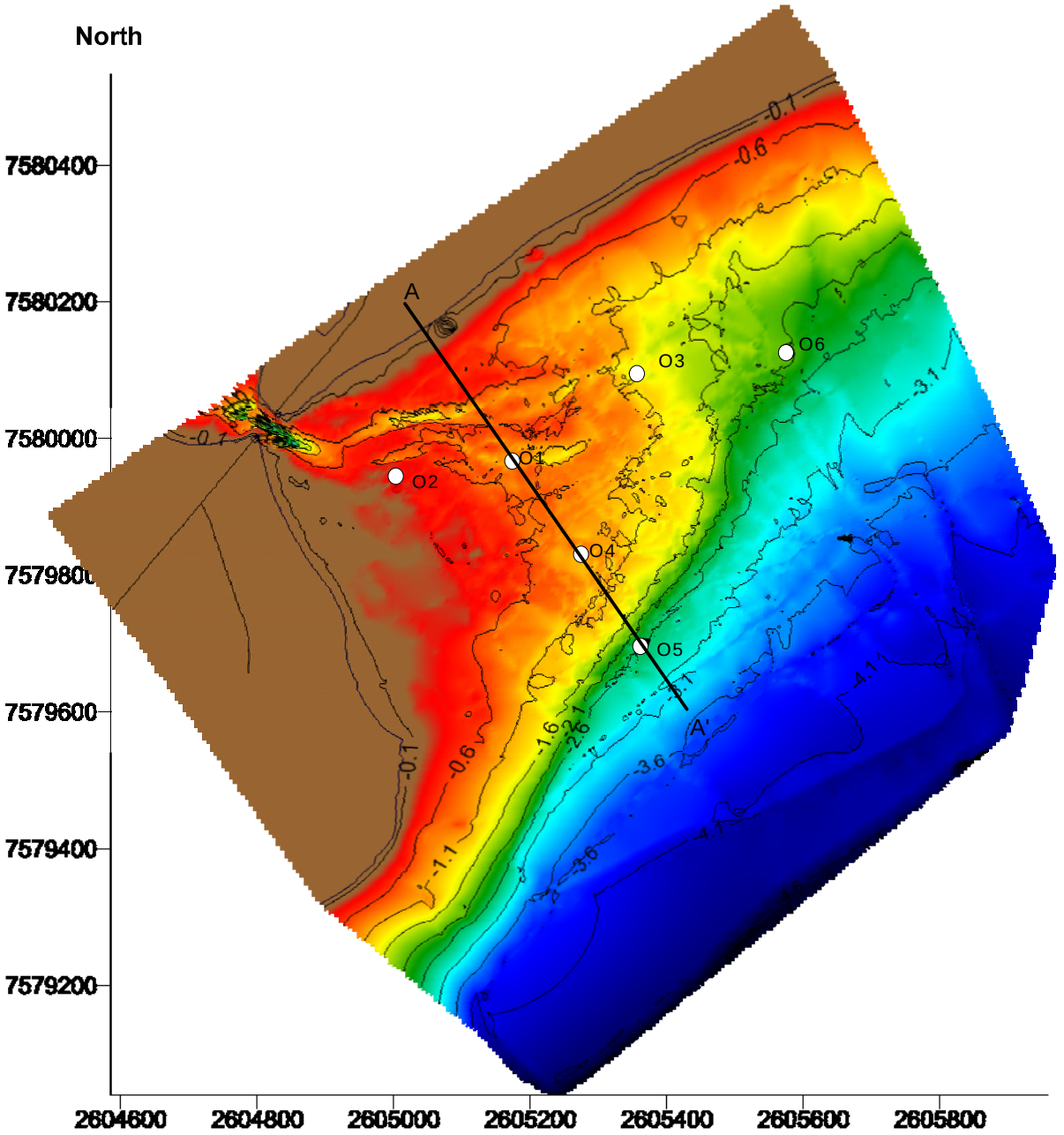
NATECH
Environmental Services Inc.
2492 Route 640, Hanwell, N.B. E3E 2C2
Ph.: (506) 455-1085 Fax: (506) 455-1088

DATE: 2014/06/27

FILE: CBC-14-01

SCALE: NB Coordinates System (m)

FIGURE: 3-2



Receiving Water Characterization Study
Burnt Church - Bathymetric Survey of May 2014
Plan View of Bottom Contours

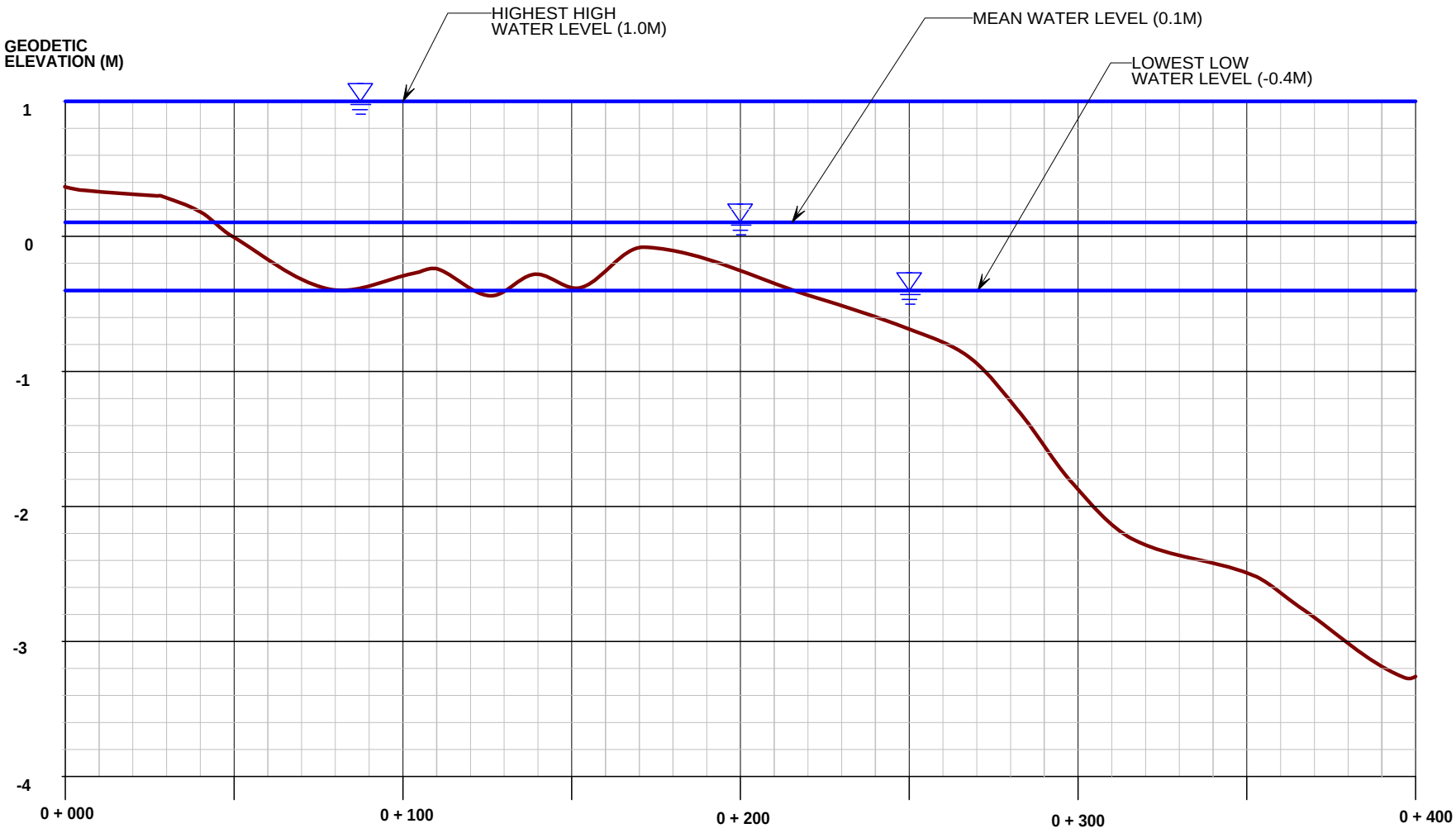
NATECH Environmental Services Inc.
2492 Route 640, Hanwell, N.B. E3E 2C2
Ph.: (506) 455-1085 Fax: (506) 455-1088

DATE: 2014/06/27

FILE: CBC-14-01

SCALE: NB Coordinates System (m)

FIGURE: 3-3



Mixing Zone Investigation
Burnt Church
Cross Section Through Locations O1, O4, O5

NATECH
Environmental Services Inc.
2492 Route 640, Hanwell, N.B., E3E 2C2
Ph: (506) 455-1085 Fax: (506) 455-1088

Date: / Date:	File:
2014/05/23	CBC-14-01
Scale: / Echelle:	Figure:
AS SHOWN	3-4

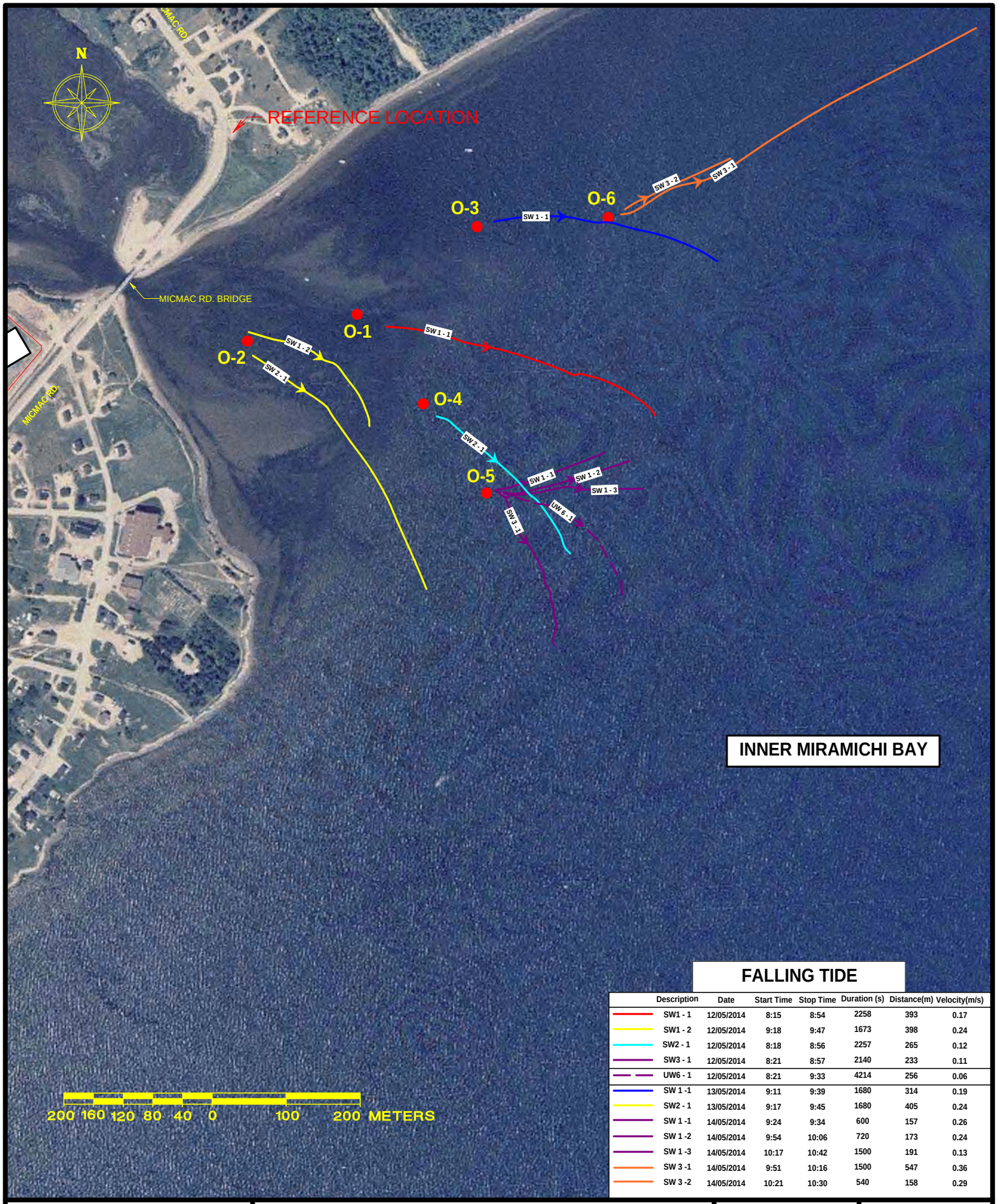
3.2.3 Current Direction and Speed

Figures 3-5 to 3-8 illustrate the current speed and direction measurements. The observed velocities were higher than anticipated. The velocities of the drogues varied from 0.04 m/s to 0.37 m/s, and the directions were different at every stage of the tide, with the most variability at high tide. The underwater drogues (1 m deep) behaved similarly to the drogues that were floating at the surface. The drogues did not appear to be significantly affected by the wind. Table 3.3 summarizes the range of velocities measured for different stages of the tide.

Table 3.3 Summary of current velocity measurements on May 12 to 14, 2014

Tidal stage	Minimum current speed (m/s)	Maximum current speed (m/s)	Current direction (toward)
Falling	0.06	0.36	SSE to ENE
Low	0.05	0.37	SE to SW
Rising	0.04	0.34	SW to NW
High	0.11	0.21	Very variable

The observed drogue tracks indicate that currents are variable in speed and direction and that gyres may be forming in the area. The frequency and magnitude of the gyres may be affected by tidal stages (rising, falling), tidal period (neap or spring), wind, and freshwater flows.



FALLING TIDE

Description	Date	Start Time	Stop Time	Duration (s)	Distance(m)	Velocity(m/s)
SW1 - 1	12/05/2014	8:15	8:54	2258	393	0.17
SW1 - 2	12/05/2014	9:18	9:47	1673	398	0.24
SW2 - 1	12/05/2014	8:18	8:56	2257	265	0.12
SW3 - 1	12/05/2014	8:21	8:57	2140	233	0.11
UW6 - 1	12/05/2014	8:21	9:33	4214	256	0.06
SW 1 -1	13/05/2014	9:11	9:39	1680	314	0.19
SW2 - 1	13/05/2014	9:17	9:45	1680	405	0.24
SW 1 -1	14/05/2014	9:24	9:34	600	157	0.26
SW 1 -2	14/05/2014	9:54	10:06	720	173	0.24
SW 1 -3	14/05/2014	10:17	10:42	1500	191	0.13
SW 3 -1	14/05/2014	9:51	10:16	1500	547	0.36
SW 3 -2	14/05/2014	10:21	10:30	540	158	0.29

Receiving Water Characterization Study
Burnt Church
MAY 12 - 14, 2014

NATECH
Environmental Services Inc.
2492 Route 640, Hanwell, NB E3E 2C2
Ph: (506) 455-1085 Fax: (506) 455-1088

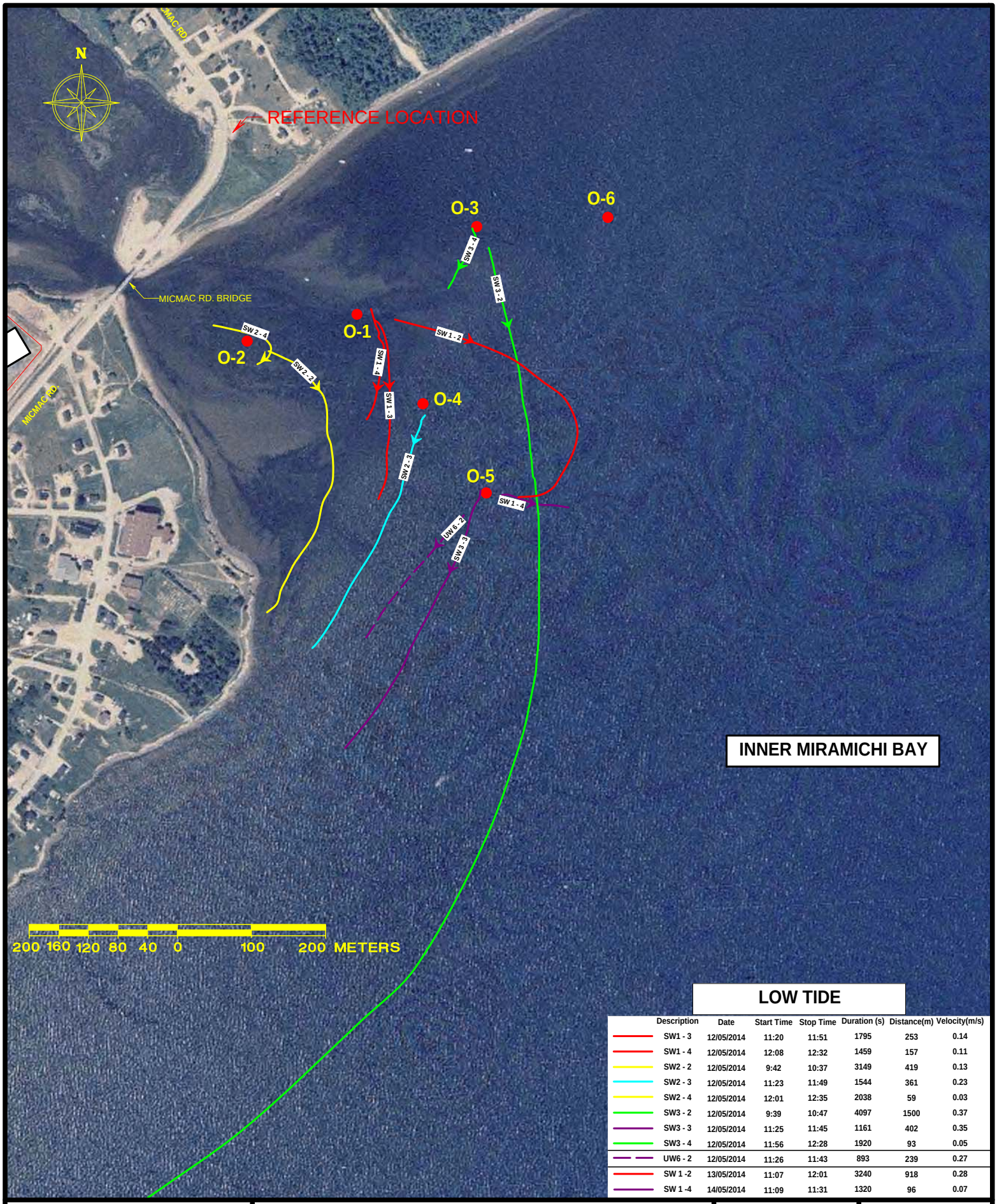
Date: 2014/05/20

Project No.: CBC-14-01

Scale: AS SHOWN

3-5

\\Computer13\documents\Docs 2014 JS\CCME Crandall\Burnt Church (new outfall)\Burnt Church drogue falling tide lm2.vcd 5/30/2014



LOW TIDE

Description	Date	Start Time	Stop Time	Duration (s)	Distance(m)	Velocity(m/s)
SW1 - 3	12/05/2014	11:20	11:51	1795	253	0.14
SW1 - 4	12/05/2014	12:08	12:32	1459	157	0.11
SW2 - 2	12/05/2014	9:42	10:37	3149	419	0.13
SW2 - 3	12/05/2014	11:23	11:49	1544	361	0.23
SW2 - 4	12/05/2014	12:01	12:35	2038	59	0.03
SW3 - 2	12/05/2014	9:39	10:47	4097	1500	0.37
SW3 - 3	12/05/2014	11:25	11:45	1161	402	0.35
SW3 - 4	12/05/2014	11:56	12:28	1920	93	0.05
UW6 - 2	12/05/2014	11:26	11:43	893	239	0.27
SW 1 -2	13/05/2014	11:07	12:01	3240	918	0.28
SW 1 -4	14/05/2014	11:09	11:31	1320	96	0.07

Receiving Water Characterization Study
Burnt Church
MAY 12 - 14, 2014

NATECH
Environmental Services Inc.
2492 Route 640, Hanwell, NB E3E 2C2
Ph: (506) 455-1085 Fax: (506) 455-1088

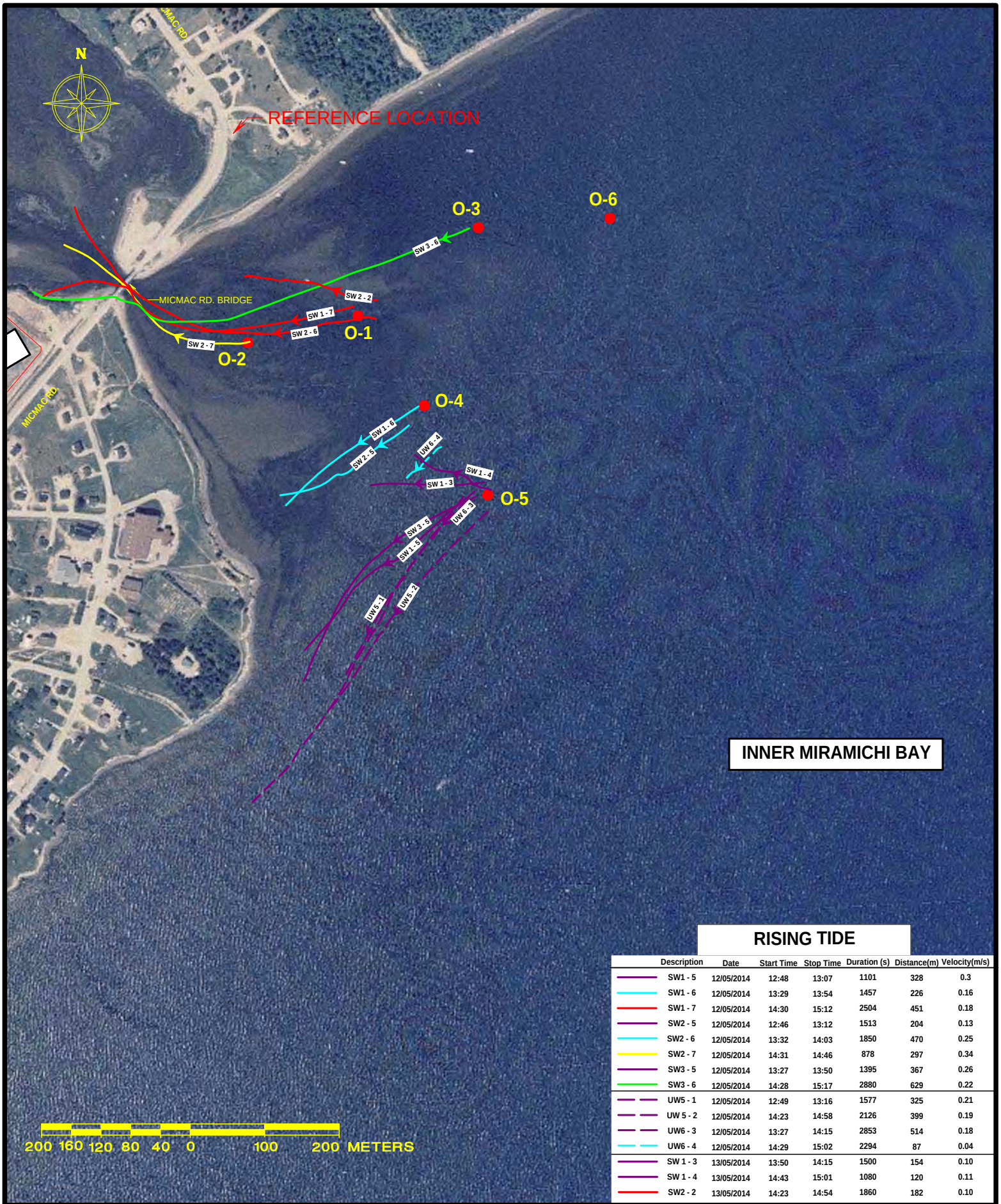
Date: 2014/05/20

Project No.: CBC-14-01

Scale: AS SHOWN

3-6

\\Computer13\documents\Docs 2014 JS\CCME Crandall\Burnt Church (new outfall)\Burnt Church drogue low tide lm2.vcd 5/30/2014



RISING TIDE

Description	Date	Start Time	Stop Time	Duration (s)	Distance(m)	Velocity(m/s)
SW1 - 5	12/05/2014	12:48	13:07	1101	328	0.3
SW1 - 6	12/05/2014	13:29	13:54	1457	226	0.16
SW1 - 7	12/05/2014	14:30	15:12	2504	451	0.18
SW2 - 5	12/05/2014	12:46	13:12	1513	204	0.13
SW2 - 6	12/05/2014	13:32	14:03	1850	470	0.25
SW2 - 7	12/05/2014	14:31	14:46	878	297	0.34
SW3 - 5	12/05/2014	13:27	13:50	1395	367	0.26
SW3 - 6	12/05/2014	14:28	15:17	2880	629	0.22
UW5 - 1	12/05/2014	12:49	13:16	1577	325	0.21
UW 5 - 2	12/05/2014	14:23	14:58	2126	399	0.19
UW6 - 3	12/05/2014	13:27	14:15	2853	514	0.18
UW6 - 4	12/05/2014	14:29	15:02	2294	87	0.04
SW 1 - 3	13/05/2014	13:50	14:15	1500	154	0.10
SW 1 - 4	13/05/2014	14:43	15:01	1080	120	0.11
SW2 - 2	13/05/2014	14:23	14:54	1860	182	0.10

Receiving Water Characterization Study
Burnt Church
MAY 12 - 14, 2014

NATECH
Environmental Services Inc.
2492 Route 640, Hanwell, NB E3E 2C2
Ph: (506) 455-1085 Fax: (506) 455-1088

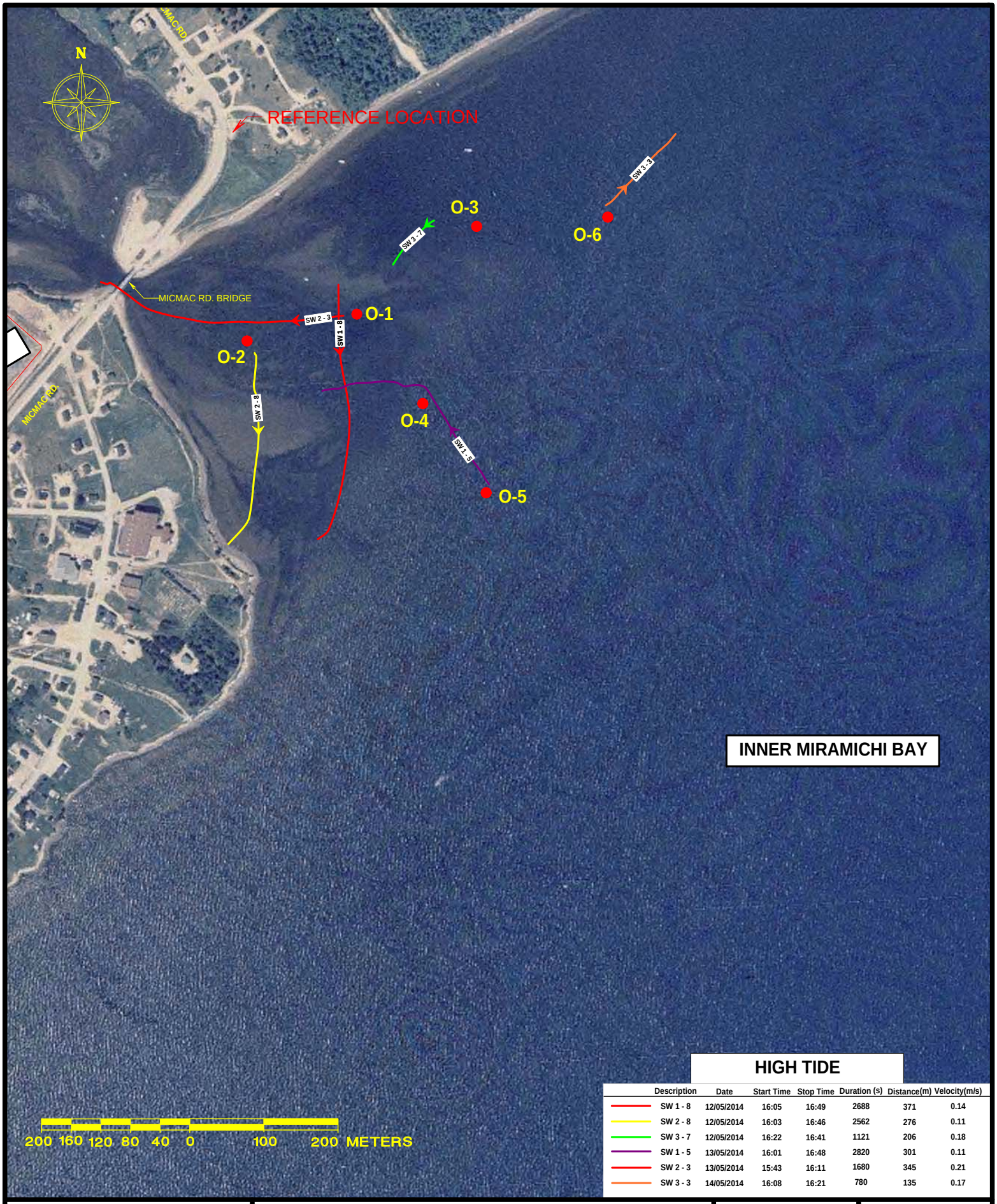
Date: 2014/05/20

Project No.: CBC-14-01

Scale: AS SHOWN

3-7

\\Computer13\documents\Docs 2014 JS\CCME Crandall\Burnt Church (new outfall)\Burnt Church drogue rising tide lm2.vcd 5/30/2014



HIGH TIDE

Description	Date	Start Time	Stop Time	Duration (s)	Distance(m)	Velocity(m/s)
SW 1 - 8	12/05/2014	16:05	16:49	2688	371	0.14
SW 2 - 8	12/05/2014	16:03	16:46	2562	276	0.11
SW 3 - 7	12/05/2014	16:22	16:41	1121	206	0.18
SW 1 - 5	13/05/2014	16:01	16:48	2820	301	0.11
SW 2 - 3	13/05/2014	15:43	16:11	1680	345	0.21
SW 3 - 3	14/05/2014	16:08	16:21	780	135	0.17

Receiving Water Characterization Study
Burnt Church
MAY 12 - 14, 2014

NATECH
Environmental Services Inc.
2492 Route 640, Hanwell, NB E3E 2C2
Ph: (506) 455-1085 Fax: (506) 455-1088

Date: 2014/05/20

Project No.: CBC-14-01

Scale: AS SHOWN

3-8

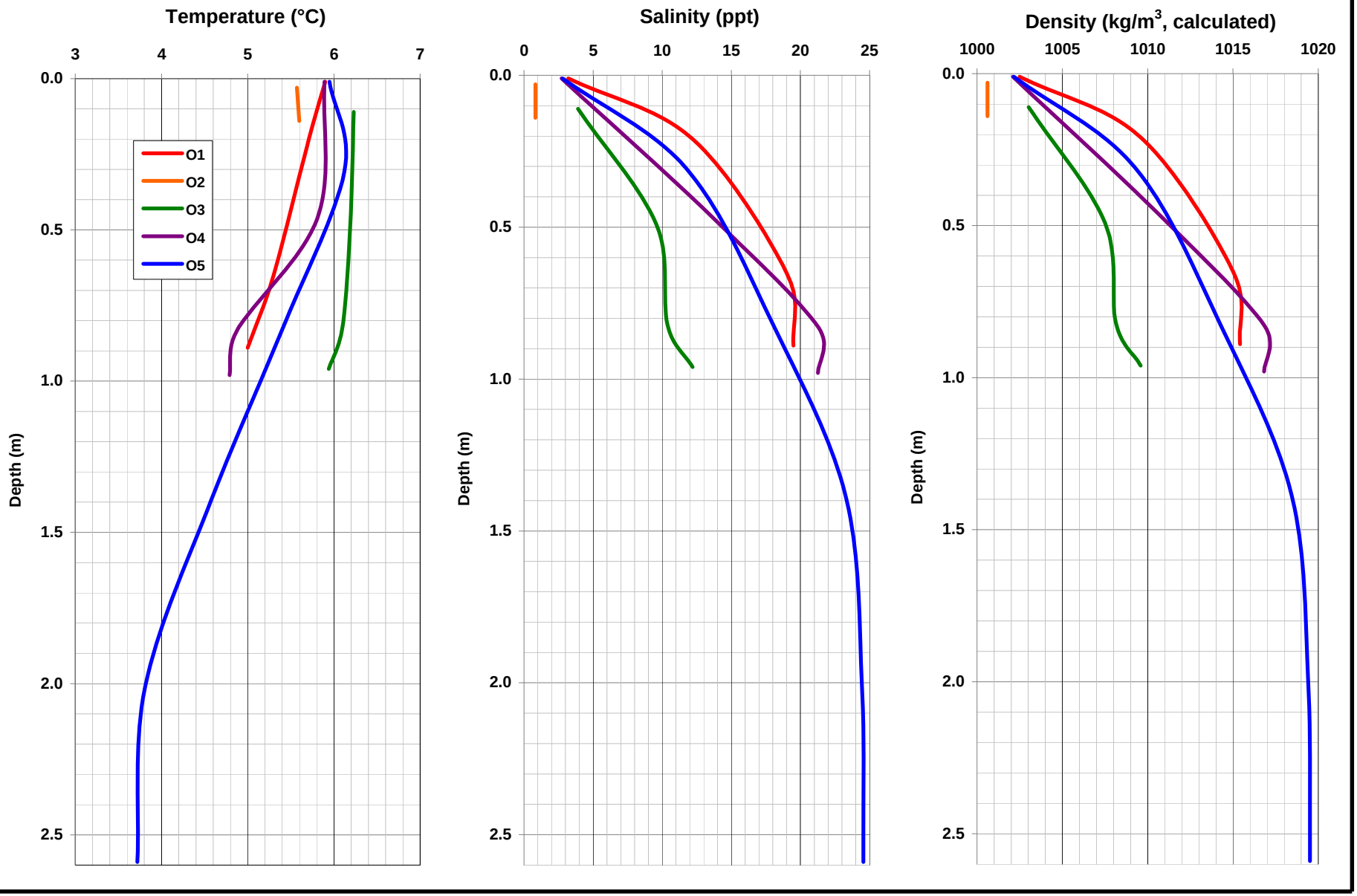
\\Computer13\DOCUMENTS\Docs 2014 JS\CCME Crandall\Burnt Church (new outfall)\Burnt Church drogue high tide lm2.vcd 5/30/2014

3.2.4 Water Quality

The water quality testing locations are shown on Figure 1-2. Table 3.4 lists the water quality measurements carried out in the field, and the laboratory analyses. The laboratory reports are attached in Appendix B. Figures 3-9 to 3-11 detail temperature/salinity/density profiles. Figures 3-12 to 3-15 show variations in temperature and conductivity over time and depth.

Table 3.4. Measured Water Quality in Burnt Church on May 14, 2014

Parameter	Unit	At bridge	At O1	At O5	At O6
Time	hours	12h00	11h18	10h48	10h58
Time before low tide	hours	0h30	1h12	1h42	1h32
Field measurements					
Temperature	℃	14.5	9.1	8.1	7.2
pH	units	7.5	7.5	8.3	8.3
Conductivity	mS/cm	6.2	2.2	27.8	28.4
Salinity	ppt	4.0	1.2	17.6	17.2
TDS	mg/L	3.4	1.5	18.1	18.4
Dissolved oxygen	%	109	97	110	106
Dissolved oxygen	mg/L	10.9	11.1	11.7	11.5
Laboratory analyses					
CBOD5	mg/L	<6	<6	<6	<6
TSS	mg/L	23	34	8	18
Total ammonia	mg/L	<0.05	<0.05	<0.05	<0.05
Unionized ammonia	mg/L	<0.001	<0.001	<0.001	<0.001
TKN	mg/L	0.3	0.4	<0.25	<0.25
TP	mg/L	0.065	0.080	0.035	0.046
E. Coli	MPN/100mL	28	20	32	40
Faecal Coliforms	MPN/100mL	48	40	32	48

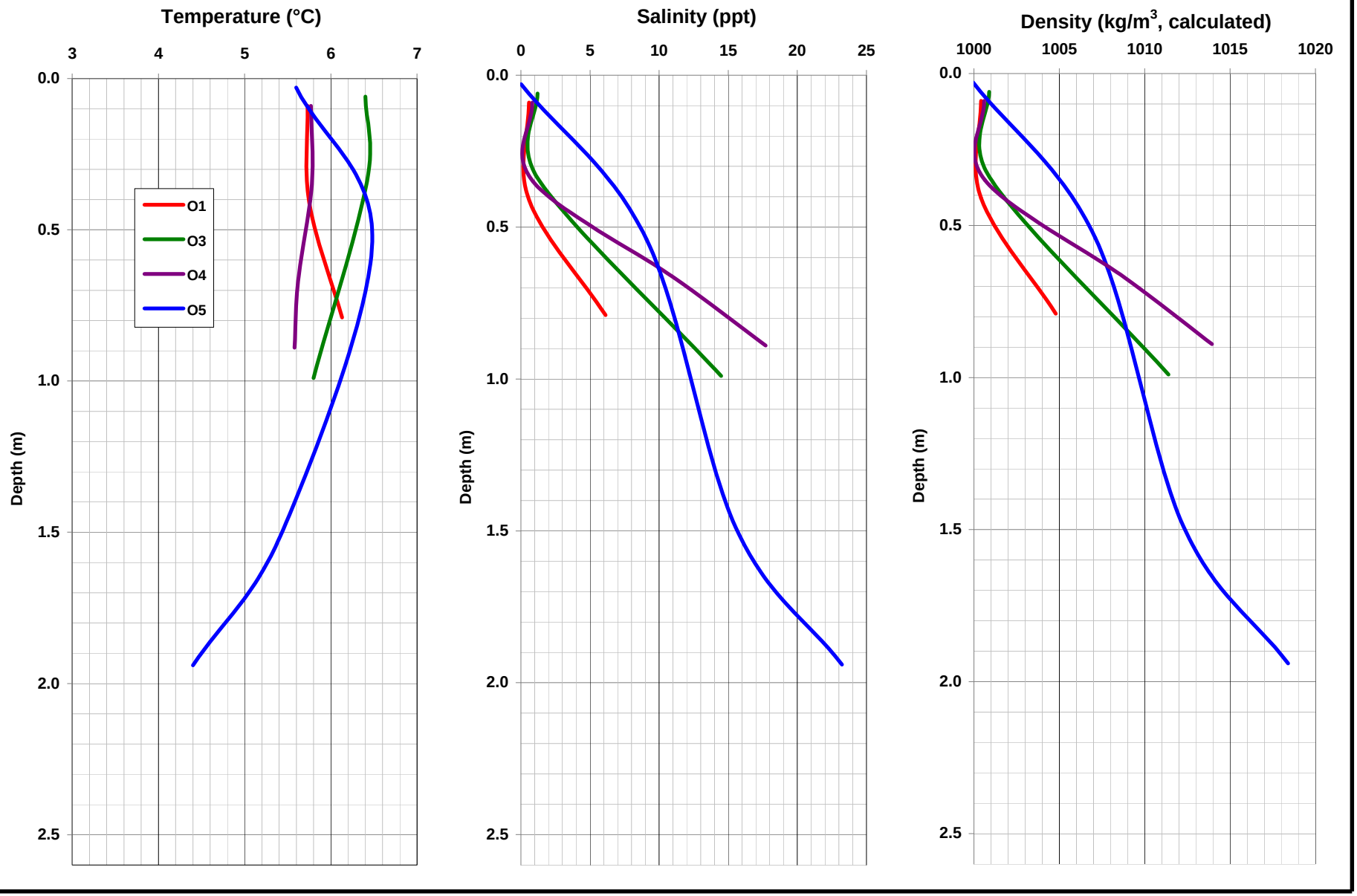


Receiving Water Characterization Study
Burnt Church - May 12-14, 2014
Falling tide

NATECH Environmental Services Inc.
2492 Route 640, Hanwell, NB, E3E 2C2
Phone: (506) 455-1085 Fax: (506) 455-1088

DATE: 2014/05/29 | **FILE: CBC**-14-01

SCALE: As shown | **FIGURE:** 3-9

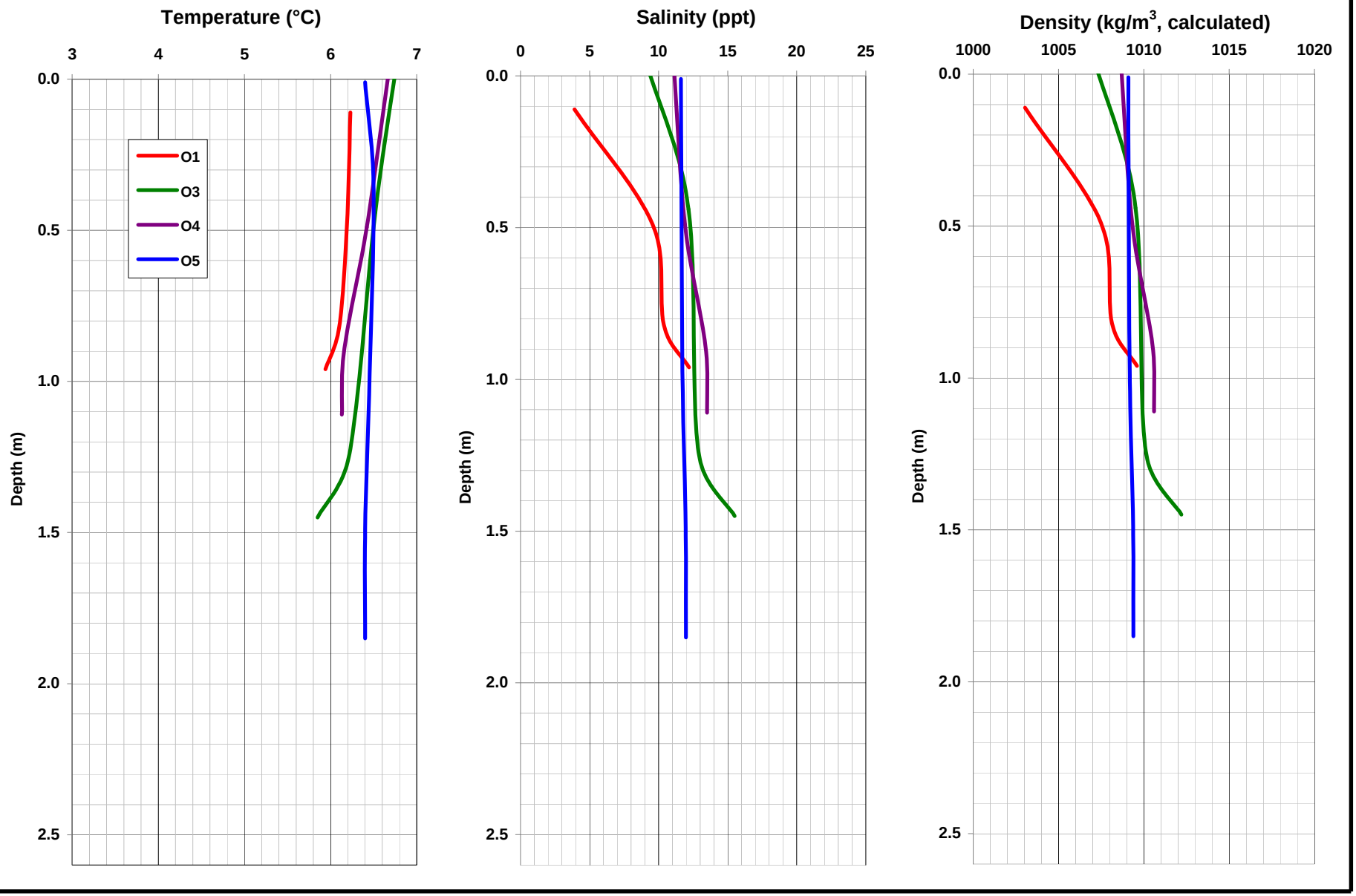


Receiving Water Characterization Study
Burnt Church - May 12-14, 2014
Low tide

NATECH **Environmental Services Inc.**
2492 Route 640, Hanwell, NB, E3E 2C2
Phone: (506) 455-1085 Fax: (506) 455-1088

DATE: 2014/05/29 | **FILE: CBC**-14-01

SCALE: As shown | **FIGURE:** 3-10



Receiving Water Characterization Study
Burnt Church - May 12-14, 2014
Rising tide

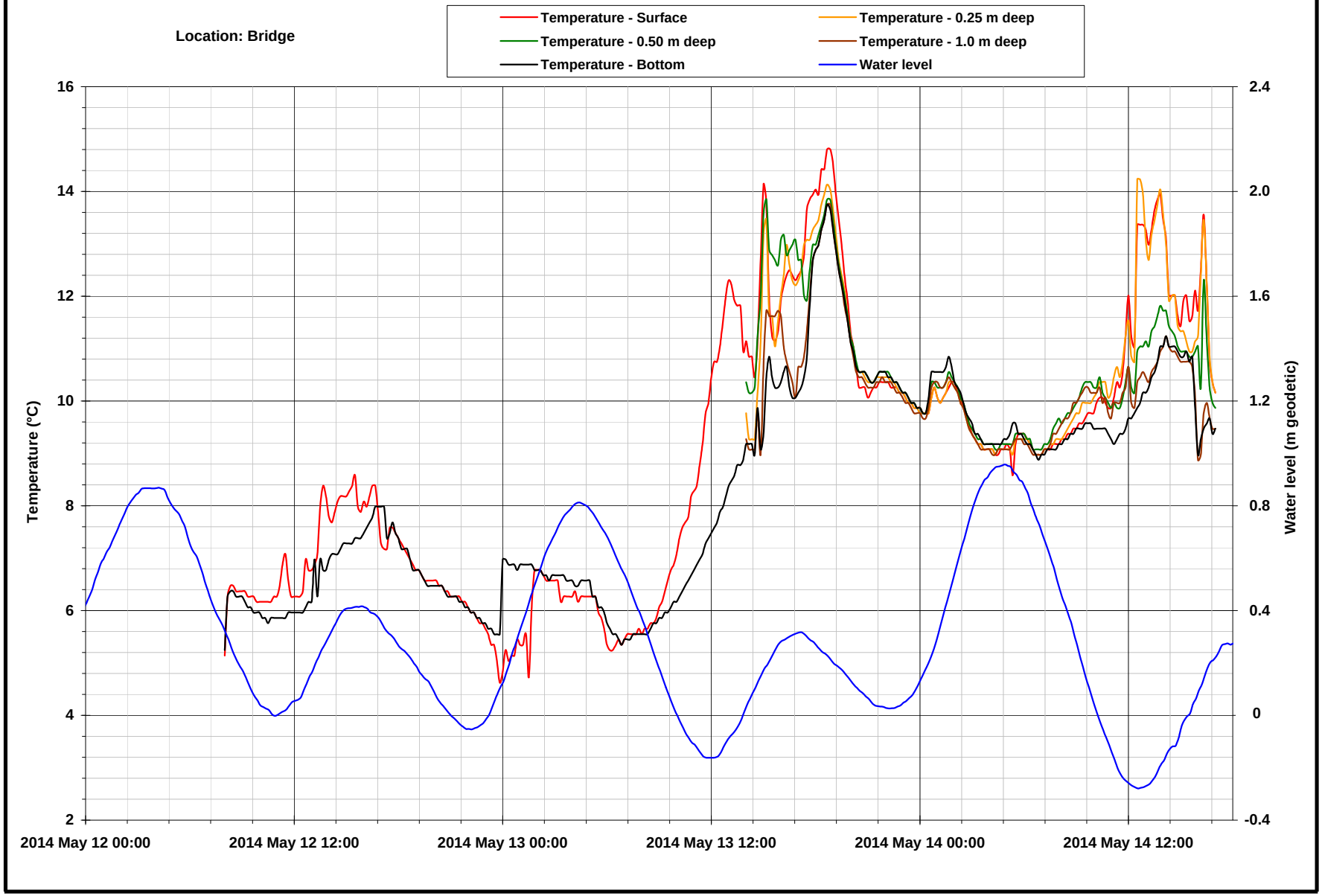
NATECH Environmental Services Inc.
2492 Route 640, Hanwell, NB, E3E 2C2
Phone: (506) 455-1085 Fax: (506) 455-1088

DATE: 2014/05/29

FILE: CBC-14-01

SCALE: As shown

FIGURE: 3-11



Receiving Water Characterization Study
Burnt Church
Water Temperature Variations - At Bridge

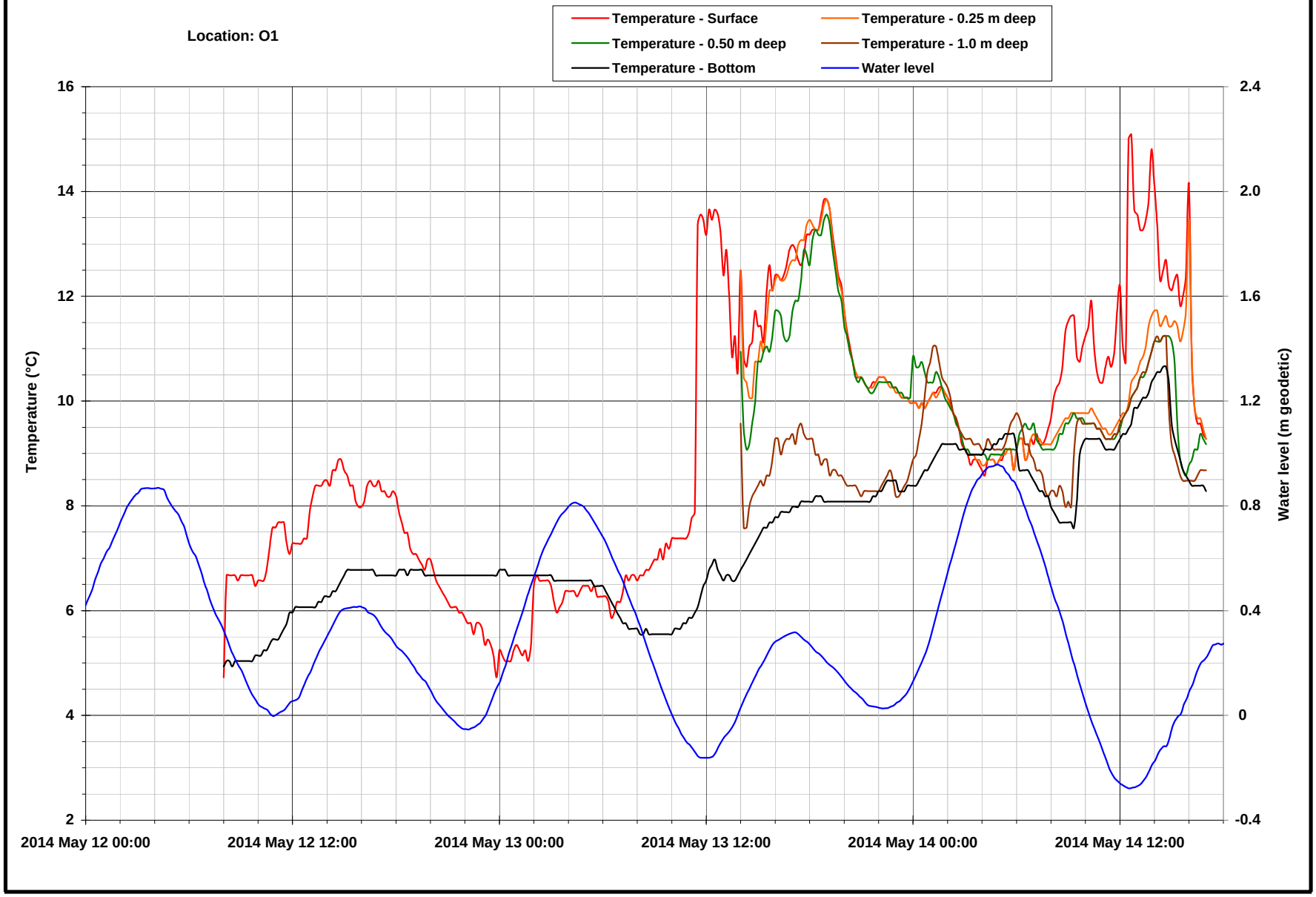
NATECH Environmental Services Inc.
2492 Route 640, Hanwell, NB, E3E 2C2
Phone: (506) 455-1085 Fax: (506) 455-1088

DATE: 2014/05/25

FILE: CBC-14-01

SCALE: As shown

FIGURE: 3-12

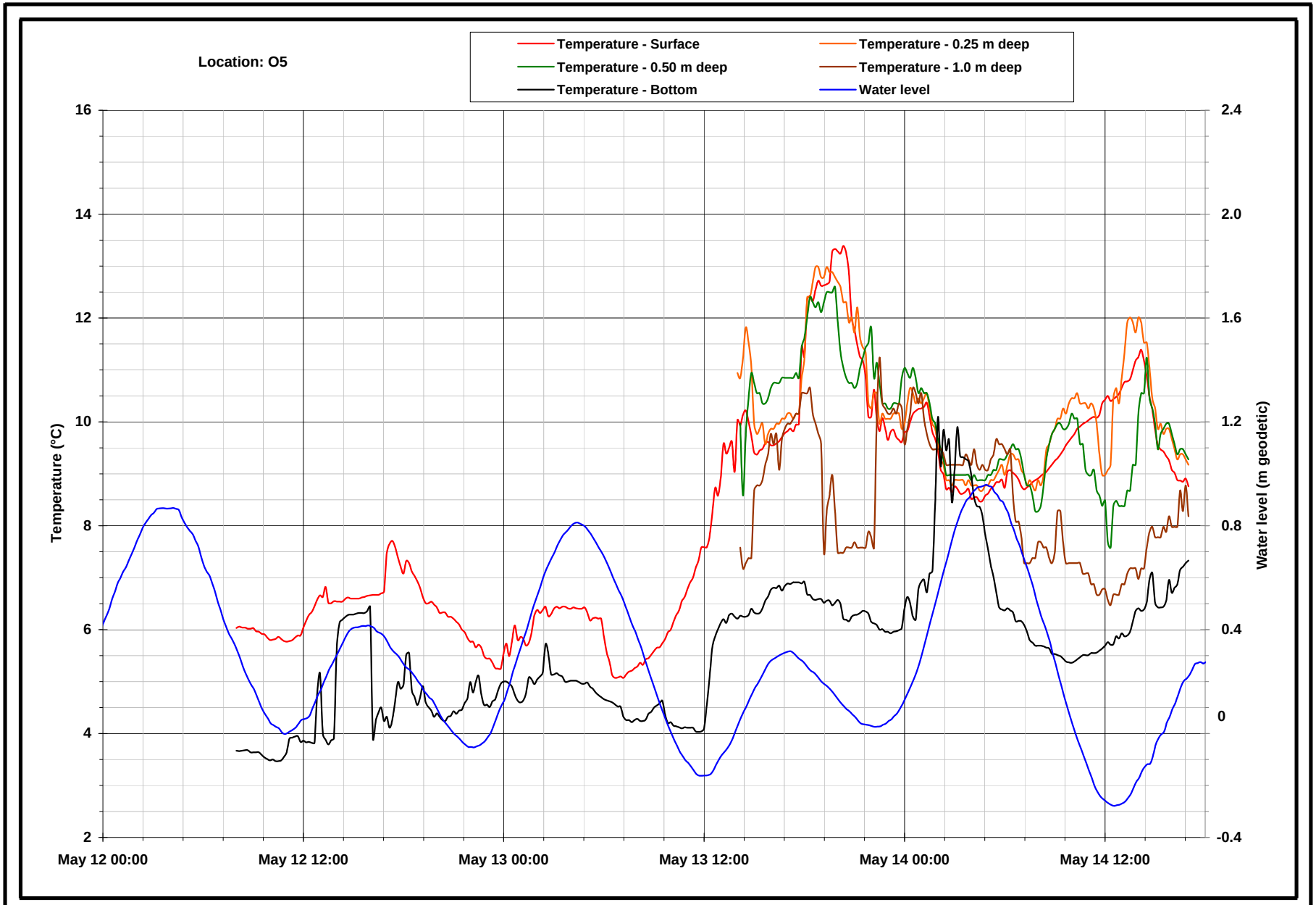


Receiving Water Characterization Study
Burnt Church
Water Temperature Variations - At O1

NATECH Environmental Services Inc.
2492 Route 640, Hanwell, NB, E3E 2C2
Phone: (506) 455-1085 Fax: (506) 455-1088

DATE: 2014/05/25 | **FILE:** CBC-14-01

SCALE: As shown | **FIGURE:** 3-13

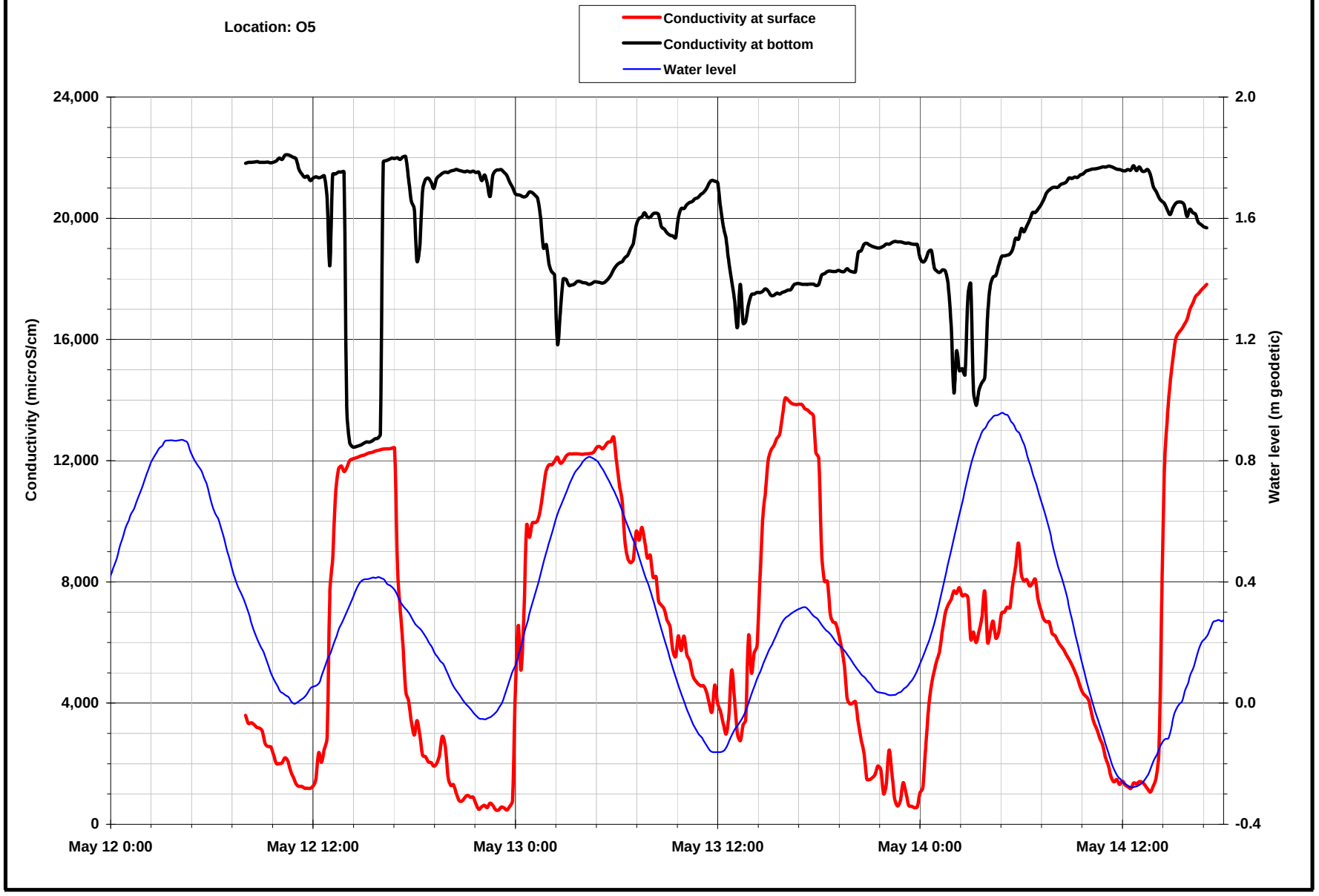


Receiving Water Characterization Study
Burnt Church
Water Temperature Variations - At O5

NATECH Environmental Services Inc.
2492 Route 640, Hanwell, NB, E3E 2C2
Phone: (506) 455-1085 Fax: (506) 455-1088

DATE: 2014/05/25 | **FILE:** CBC-14-01

SCALE: As shown | **FIGURE:** 3-14



Receiving Water Characterization Study
Burnt Church
Water Conductivity Variations - At O5

NATECH Environmental Services Inc.
2492 Route 640, Hanwell, NB, E3E 2C2
Phone: (506) 455-1085 Fax: (506) 455-1088

DATE: 2014/05/25 | **FILE:** CBC-13-01

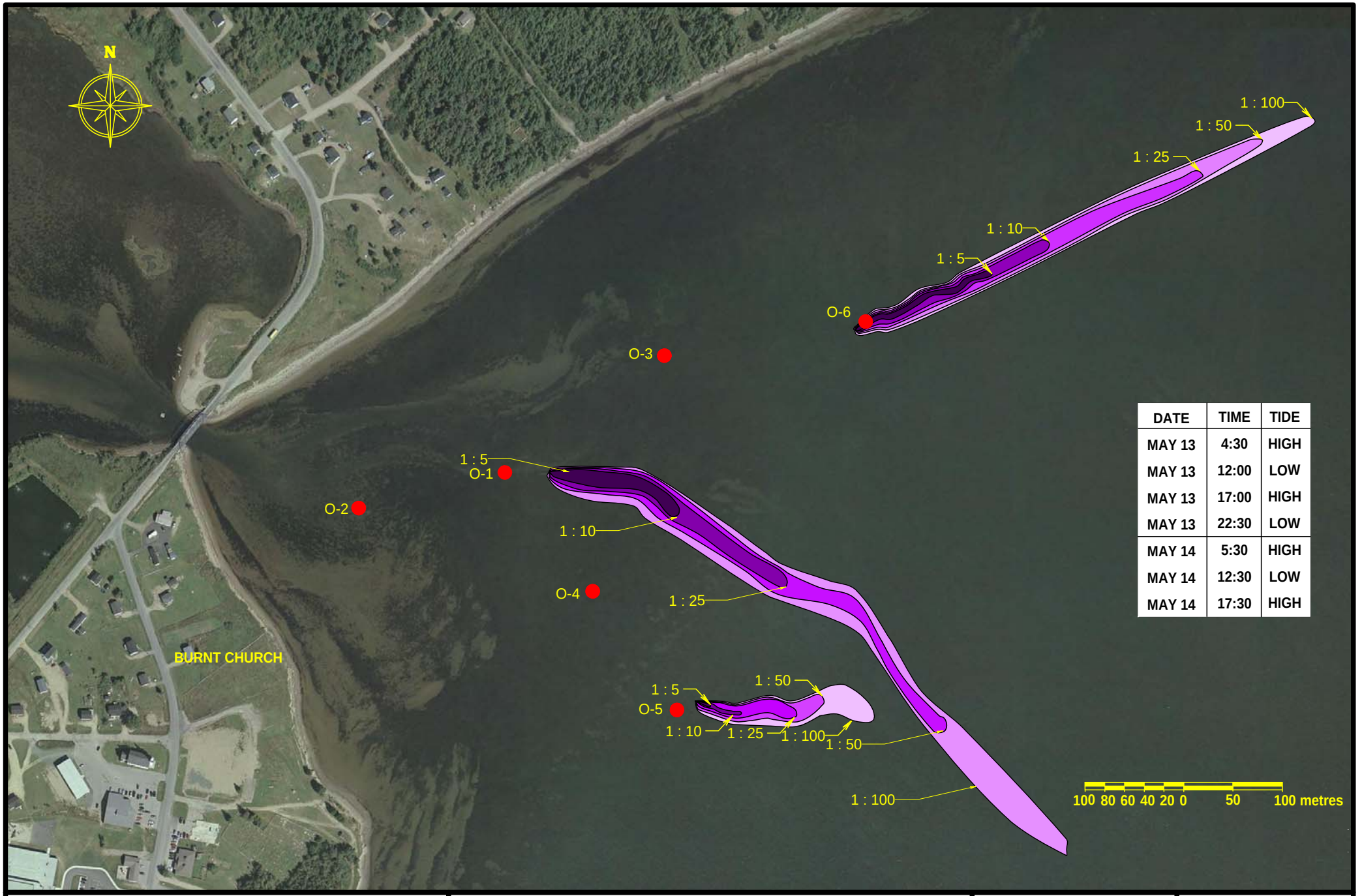
SCALE: As shown | **FIGURE:** 3-15

3.2.5 Mixing Regime

Initially, Rhodamine WT dye was injected at location O1. O1 is the closest location from the shore along the anticipated future outfall pipeline route. The drogues simultaneously released at O1, O2 and O3 were carried under the bridge during the rising tide and these locations are not ideal for an effluent release. Subsequently, dye was released at locations O5 and O6.

Figures 3-16 and 3-17 show the measured dilution contours. Table 3.6 summarises the plume characteristics at different stages of the tide. Table 3.7 lists the coordinates of locations O1 to O6.

The orientation of the plumes were found to vary significantly depending on the tidal stage and the location. The observations confirm that there may be gyres forming at times during the rising tide and rotating in a counterclockwise direction between O5 and the mouth of the river.



DATE	TIME	TIDE
MAY 13	4:30	HIGH
MAY 13	12:00	LOW
MAY 13	17:00	HIGH
MAY 13	22:30	LOW
MAY 14	5:30	HIGH
MAY 14	12:30	LOW
MAY 14	17:30	HIGH

Receiving Water Characterization Study
Burnt Church
Measured Dilution During
Falling Tides

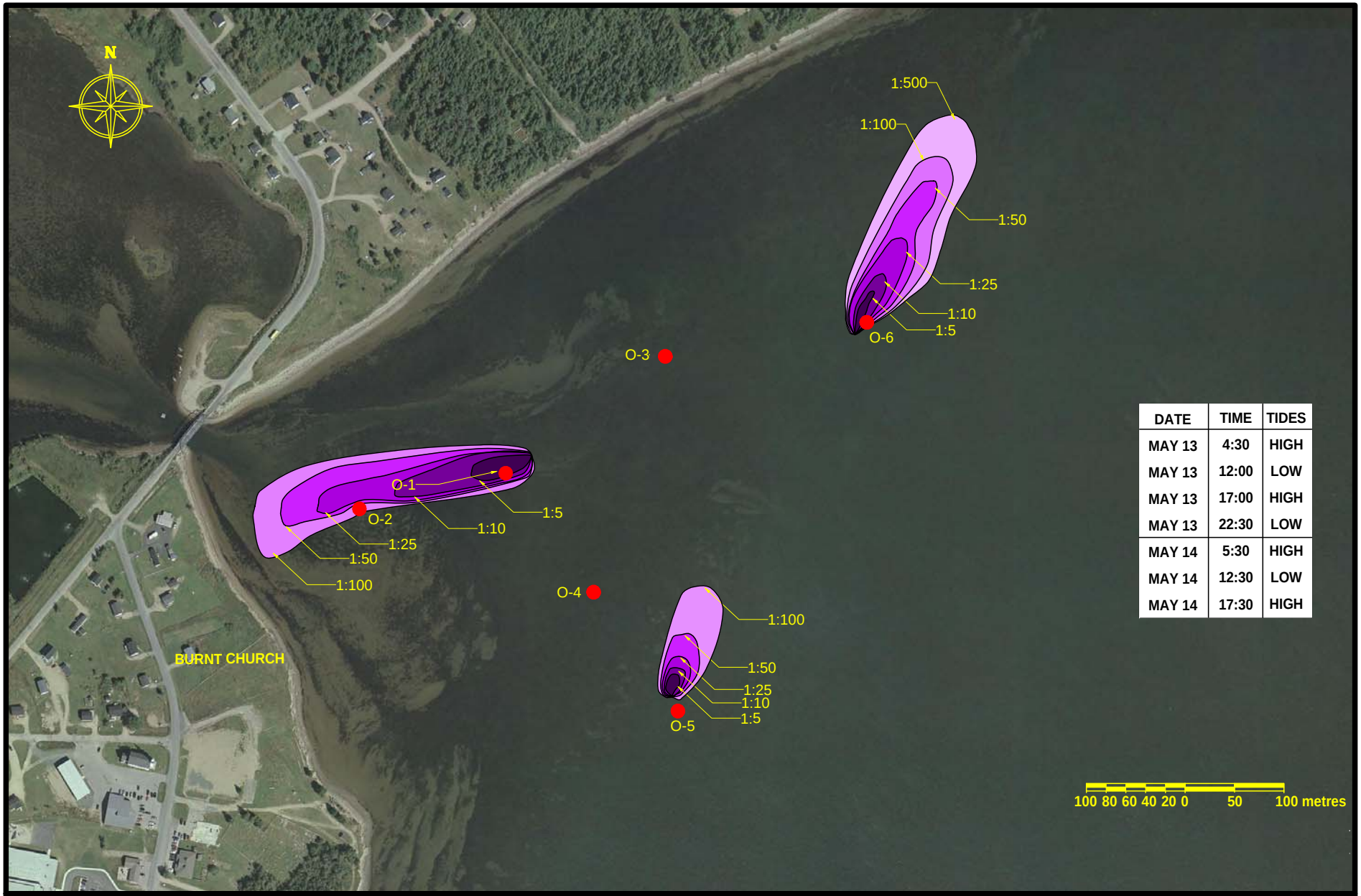
NATECH
Environmental Services Inc.
2492 Route 640, Hanwell, N.B., E3E 2C2
Ph: (506) 455-1085 Fax: (506) 455-1088

Date: 2014/05/23 Date:

Project No.: CBC-14-01 Nº du projet

Scale: AS SHOWN Echelle:

Sheet No.: 3-16 Nº de la feuille:



DATE	TIME	TIDES
MAY 13	4:30	HIGH
MAY 13	12:00	LOW
MAY 13	17:00	HIGH
MAY 13	22:30	LOW
MAY 14	5:30	HIGH
MAY 14	12:30	LOW
MAY 14	17:30	HIGH

Receiving Water Characterization Study
Burnt Church
Measured Dilution During
Rising Tides

NATECH Environmental Services Inc.
2492 Route 640, Hanwell, N.B., E3E 2C2
Ph: (506) 455-1085 Fax: (506) 455-1088

Date: 2014/05/23 Date:

Project No.: CBC-14-01 Nº du projet

Scale: AS SHOWN Echelle:

Sheet No.: 3-17 Nº de la feuille:

Table 3.6. Characteristics of the dye plumes at several potential outfall location

Location	Tidal stage	Distance to 1 in 100 dilution (m)	Dilution at 250 m
O1	Falling	675	1 in 25
	Low	400	1 in 20
	Rising	290	1 in 50
O5	Falling	180	> 1 in 100
	Low	150	> 1 in 100
	Rising	120	> 1 in 100
O6	Falling	510	1 in 15
	Low	>350	1 in 30
	Rising	200	1 in 500

Table 3.7. Potential outfall locations studied (NB Stereographic coordinates)

Location	Easting (m)	Northing (m)
O1	2,605,185	7,579,948
O2	2,605,036	7,579,911
O3	2,605,346	7,580,066
O4	2,605,550	7,580,100
O5	2,605,273	7,579,827
O6	2,605,359	7,579,706

4. CONCLUSIONS AND RECOMMENDATIONS

Outfall Design Considerations:

- ❑ Current related sediment transport can be expected in the future outfall area. Also ice rafting along the bay side of the causeway beach is experienced most years, particularly during the spring ice break up. Slabs 1.0 to 1.5 m thick sometimes pile up on the shore and into the Bay. An outfall pipe would have to be buried deeply into the ground.

- ❑ A minimum water depth of 2.0 m at low tide is desired for the termination point of the outfall. Such depths are observed at locations O5 (500 m from the shore) and O6 (300 m from the shore).

- ❑ Currents in the study area are very variable in direction and magnitude. A strong landward current can be expected during rising tides. Should more information on the variability of currents be desired, the application of a two dimensional hydraulic model is recommended.

- ❑ The vicinity of Point O6 appears to be best suited for an outfall in terms of distance from shore, water depth and current directions.

- ❑ An alternative to building a long outfall pipe would be to install a discharge next to the Micmac Rd. bridge. This, coupled with a new reservoir that contains the effluent for four to six hours during a rising tide would ensure that the effluent is directed toward the ocean only (during ebbing tides).

- ❑ Growth of sea eel grass is an ongoing phenomenon observed in the area. Any outfall should not direct nutrient rich water into the near-shore area. Additional nutrient removal may be required, should a near shore outfall be considered.

APPENDIX A - SITE PHOTOGRAPHS

Bridge on MicMac Road

Shellfish harvesting closure advisory

Bridge seen from further away

Wharf where the water level was monitored

Mixing Zone Investigation **Burnt Church** **Photographs**	**Environmental Services Inc.** **2492 Route 640, Hanwell, NB E3E 2C2** **ph: (506) 455-1085, fax (506) 455-1088**	DATE: 2014/05/29	FILE: CBC-14-01
		SCALE: –	FIGURE: A-1

Northern shoreline near low tide (May 14, 2014 at 11:26)

Inner Miramichi Bay near low tide (May 13, 2014 at 11:31)

Mixing Zone Investigation **Burnt Church** **Photographs**	**Environmental Services Inc.** **2492 Route 640, Hanwell, NB E3E 2C2** **ph: (506) 455-1085, fax (506) 455-1088**	DATE: 2014/05/29	FILE: CBC-14-01
		SCALE: –	FIGURE: A-2

Inner Miramichi Bay near low tide (May 14, 2014 at 12:45)

Inner Miramichi Bay near low tide (May 13, 2014 at 11:43)

Mixing Zone Investigation **Burnt Church** **Photographs**	**Environmental Services Inc.** **2492 Route 640, Hanwell, NB E3E 2C2** **ph: (506) 455-1085, fax (506) 455-1088**	DATE: 2014/05/29	FILE: CBC-14-01
		SCALE: –	FIGURE: A-3

Dye plume flowing away from the shore

Dye injection setup

Dye plume going toward the bridge

Long and narrow dye plume

Mixing Zone Investigation
Burnt Church
Photographs

Environmental Services Inc.
2492 Route 640, Hanwell, NB E3E 2C2
ph: (506) 455-1085, fax (506) 455-1088

DATE: 2014/05/29

FILE: CBC-14-01

SCALE: –

FIGURE: A-4

APPENDIX B - LABORATORY ANALYSES

Report ID: 170664-IAS
Report Date: 29-May-14
Date Received: 15-May-14

CERTIFICATE OF ANALYSIS

for

Natech Environmental Services
2492 Route 640
Hanwell, NB E3E 2C2

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Attention: Jochen Schroer
Project #: Not Available
Location: Burnt Church

Analysis of Water

RPC Sample ID:			170664-1	170664-2	170664-3	170664-4
Client Sample ID:			B.C. - River	B.C. - OF1	B.C. - OF5	B.C. - OF6
Date Sampled:			14-May-14	14-May-14	14-May-14	14-May-14
Analytes	**Units**	**RL**				
Ammonia (as N)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05
Un-ionized @ 5ºC	mg/L	-	< 0.001	< 0.001	< 0.001	< 0.001
Un-ionized @ 15ºC	mg/L	-	< 0.001	< 0.001	< 0.001	< 0.001
Un-ionized @ 20ºC	mg/L	-	< 0.001	< 0.001	< 0.001	< 0.001
Kjeldahl Nitrogen	mg/L	0.25	0.3	0.4	< 0.25	< 0.25
pH	units	-	7.3	7.1	7.1	7.2
Phosphorus - Total	mg/L	0.002	0.065	0.080	0.035	0.046
CBOD	mg/L	6	< 6	< 6	< 6	< 6
Solids - Total Suspended	mg/L	5	23	34	8	18

This report relates only to the sample(s) and information provided to the laboratory.

RL = Reporting Limit

A. Ross Kean, M.Sc.
Department Head
Inorganic Analytical Chemistry

Peter Crowhurst, B.Sc., C.Chem
Analytical Chemist
Inorganic Analytical Chemistry

Report ID: 170664-IAS
Report Date: 29-May-14
Date Received: 15-May-14

CERTIFICATE OF ANALYSIS

for
Natech Environmental Services
2492 Route 640
Hanwell, NB E3E 2C2

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Methods

Analyte	RPC SOP #	Method Reference	Method Principle
Ammonia	4.M47	APHA 4500-NH_3 G	"Phenate" Colourimetry
Kjeldahl Nitrogen	4.M16	APHA 4500-NORG	Digestion, phenate colorimetry
pH	4.M03	APHA 4500-H^+ B	pH Electrode - Electrometric
Phosphorus - Total	4.M17	APHA 4500-P E	Digestion, Manual Colourimetry
Solids - Total Suspended	4.M05	APHA 2540 D	Filtration, Gravimetry

Report ID: 170664-ML-W1
Report Date: 20-May-14
Date Received: 15-May-14

CERTIFICATE OF ANALYSIS

for

Natech Environmental Services
2492 Route 640
Hanwell, NB E3E 2C2

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1368
Fax: 506.452.1395
www.rpc.ca

Attention: Jochen Schroer / Cody Sipkema

Client Location: Burnt Church

Microbiological Examination of Water

RPC Sample ID:				170664-1	170664-2	170664-3	170664-4
Client Sample ID:				B.C. - River	B.C. - OF1	B.C. - OF5	B.C. - OF6
Date Sampled:				14-May-14	14-May-14	14-May-14	14-May-14
Time Sampled:				2:00:00 PM	2:00:00 PM	2:00:00 PM	2:00:00 PM
Analytes	**Method ID**	**Date Analyzed**	**Units**				
Total Coliforms	FFA01	15-May-14	MPN/100mL	236	244	212	196
E. coli	FFA01	15-May-14	MPN/100mL	28	20	32	40
Faecal Coliforms	FFA01	15-May-14	MPN/100mL	48	40	32	48

This report relates only to the sample(s) and information provided to the laboratory.

Tests were performed according to the corresponding Compendium of Analytical Methods, Health Protection Branch and/or AOAC Official Methods.

Cathy Hay
Micro Supervisor
Food, Fisheries & Aquaculture

Gillian Hodges
Micro Technician
Food, Fisheries & Aquaculture

APPENDIX C - HISTORICAL AERIAL PHOTOGRAPHS

1944

1955

1963

1974

1984

2002

2012