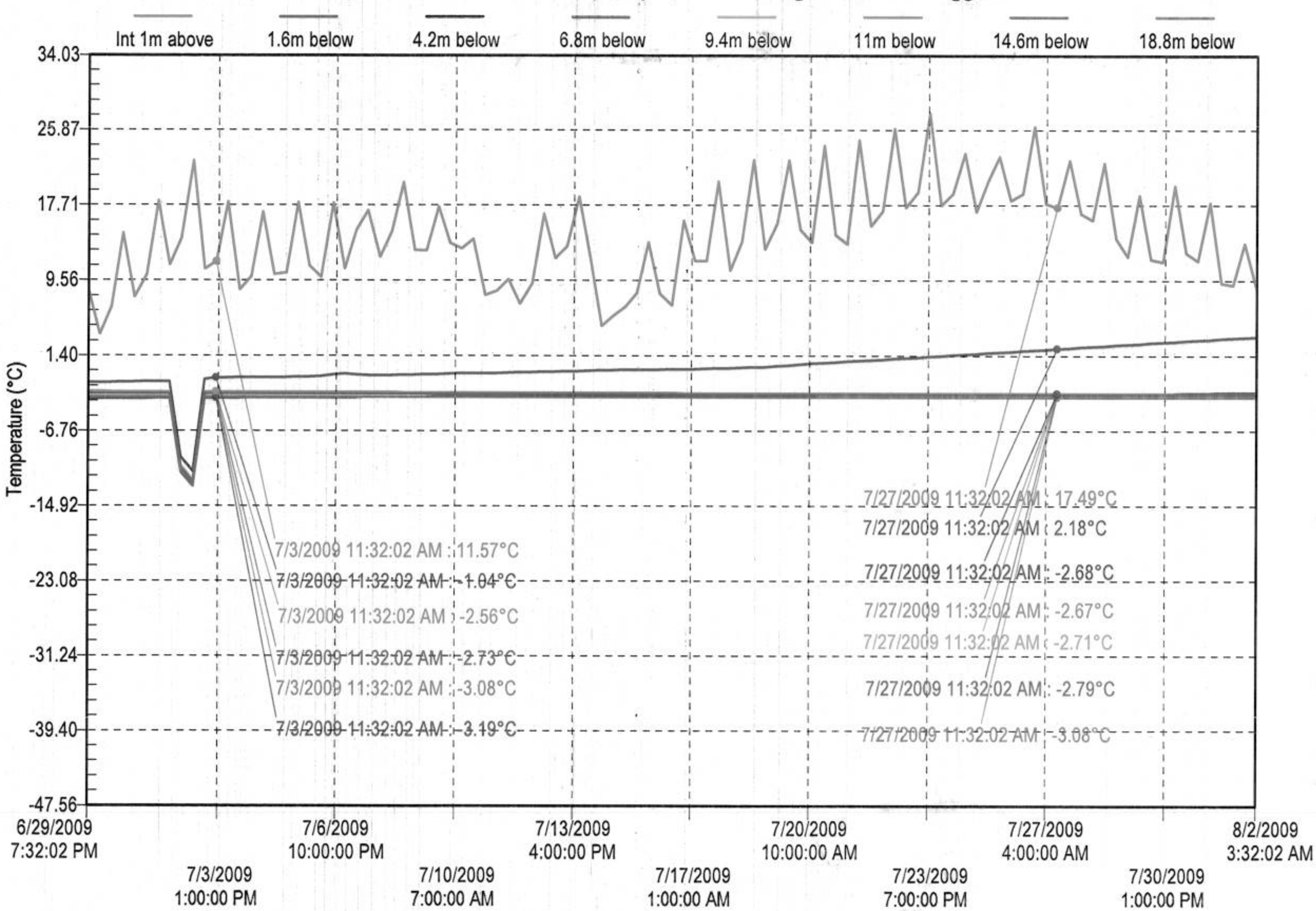
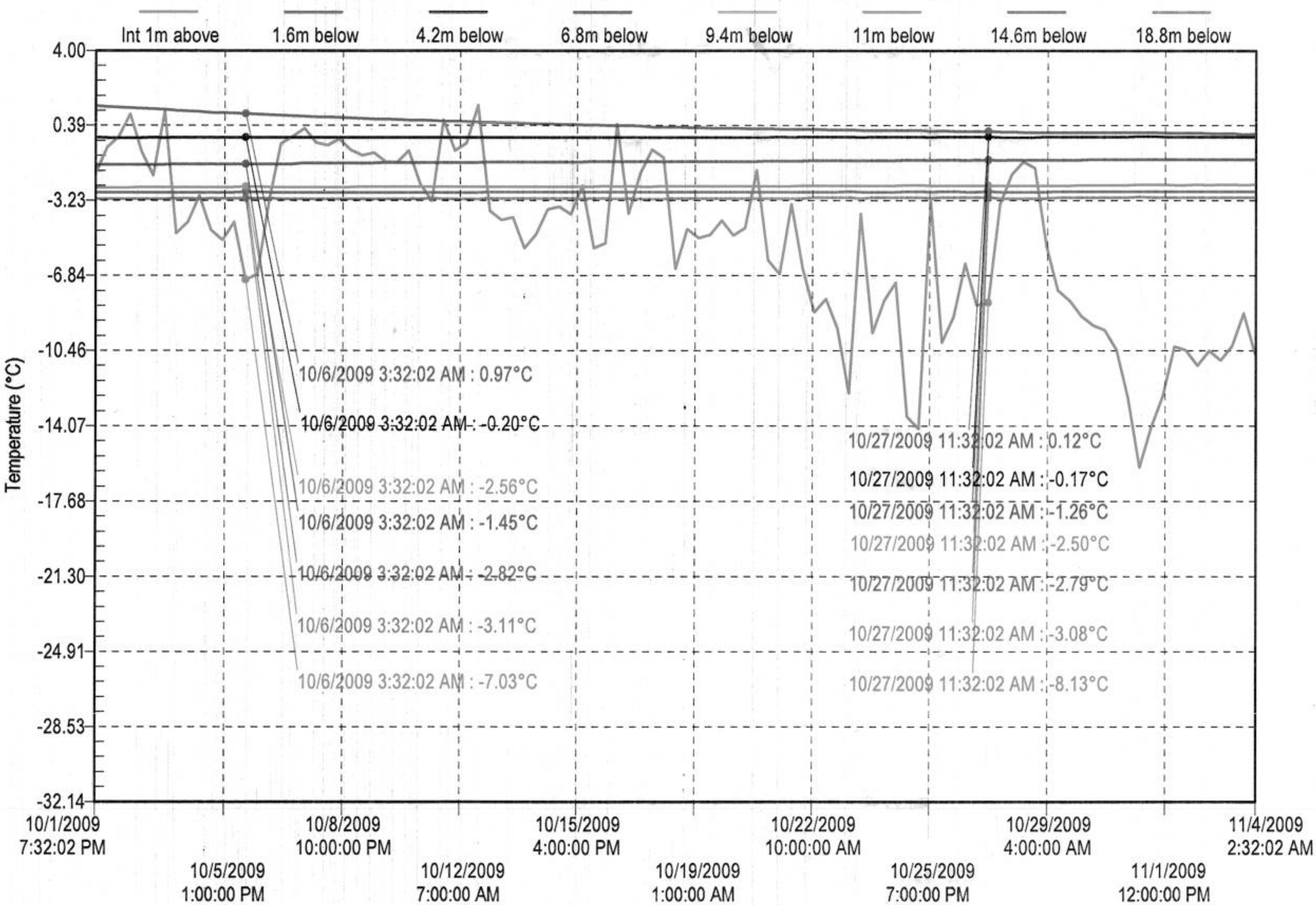
88357 SRP-8-32K

Cape Dorset recorded Temp July 1, 2009 to August 1, 2009 Logger #3



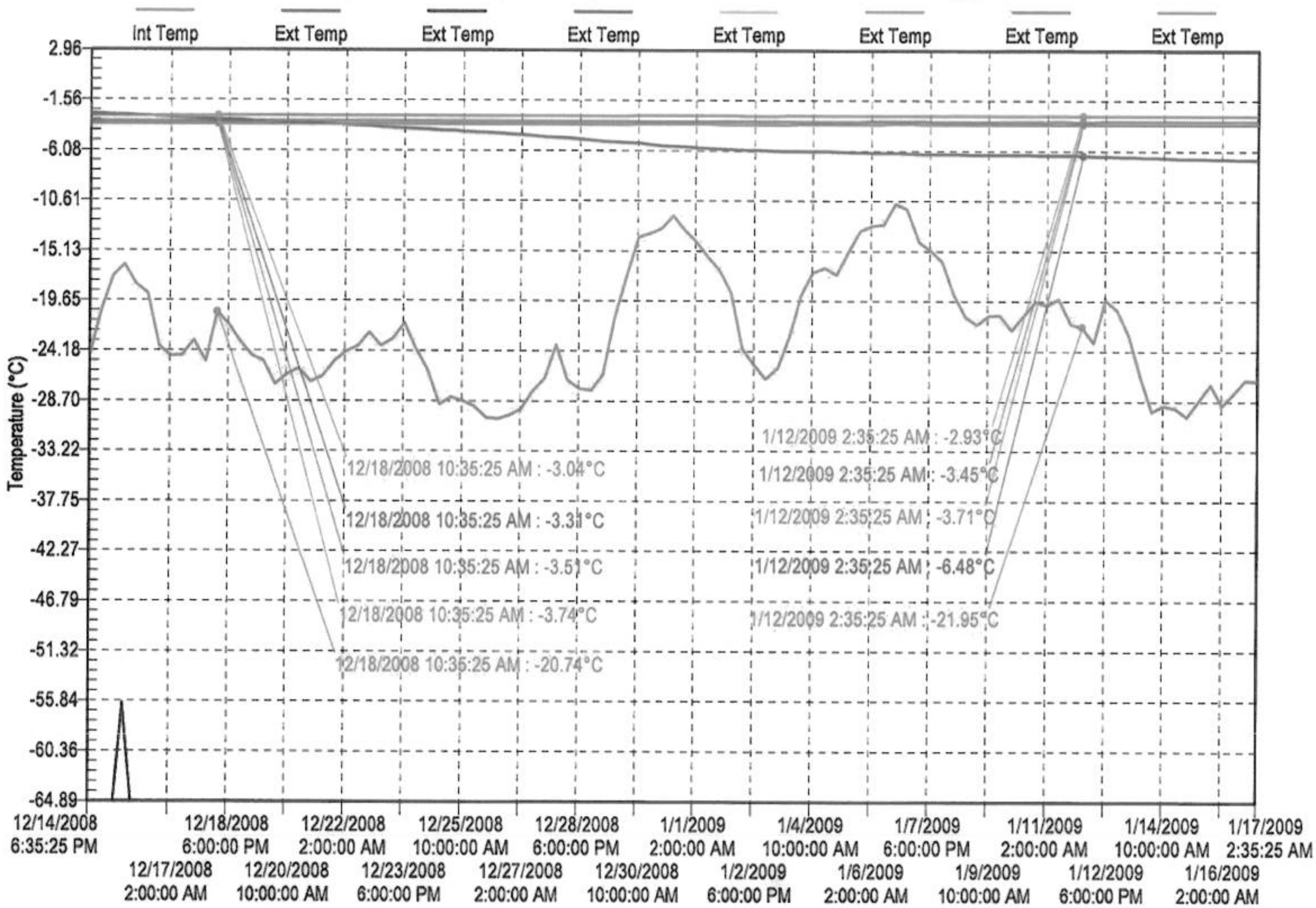
88357 SRP-8-32K

Cape Dorset recorded Temp Oct. 1, 2009 to Nov. 1, 2009 Logger #3



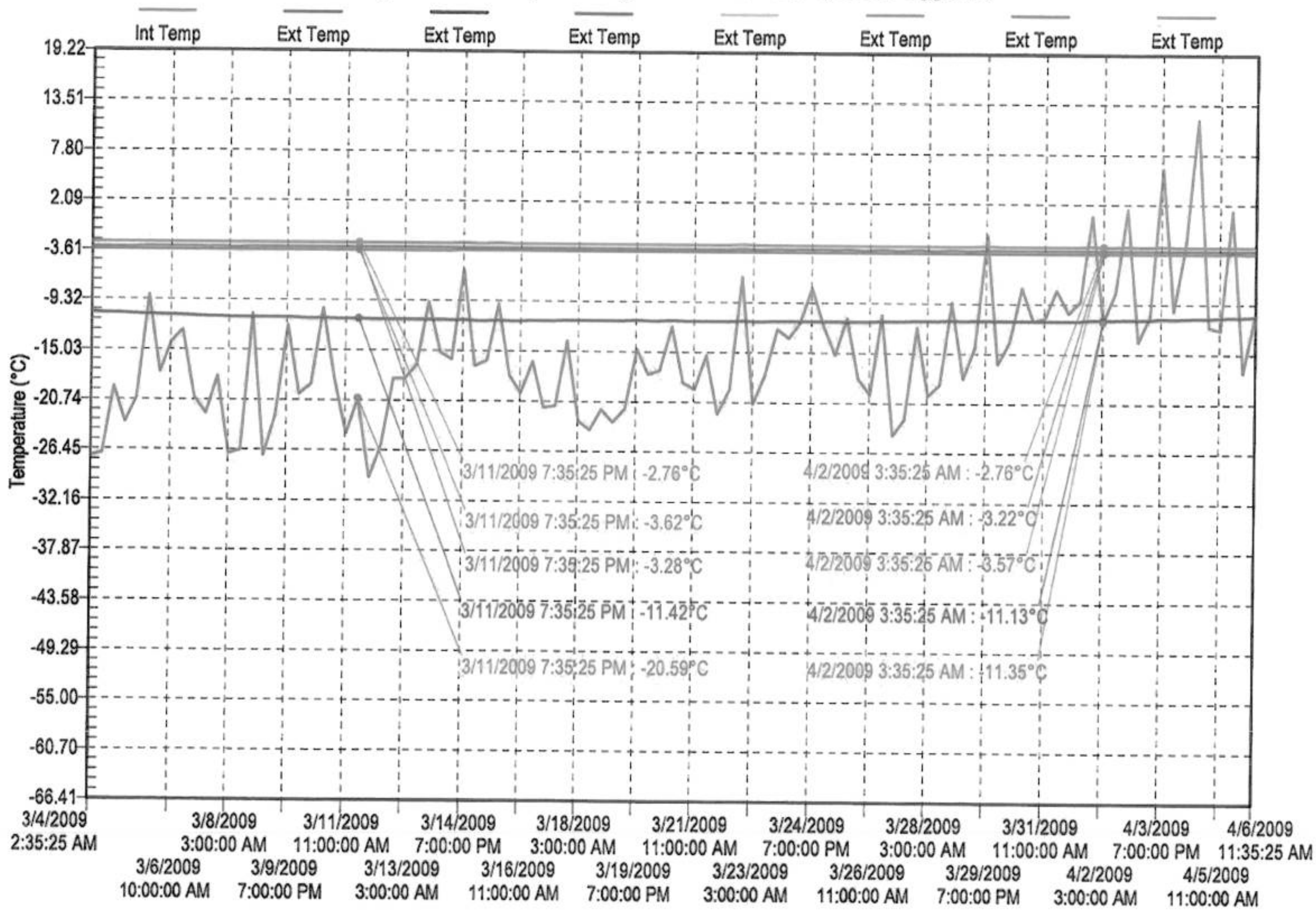
88358 SRP-8-32K

Cape Dorset Temp. readings Dec.15, 2008 to Jan. 15, 2009 Logger #4



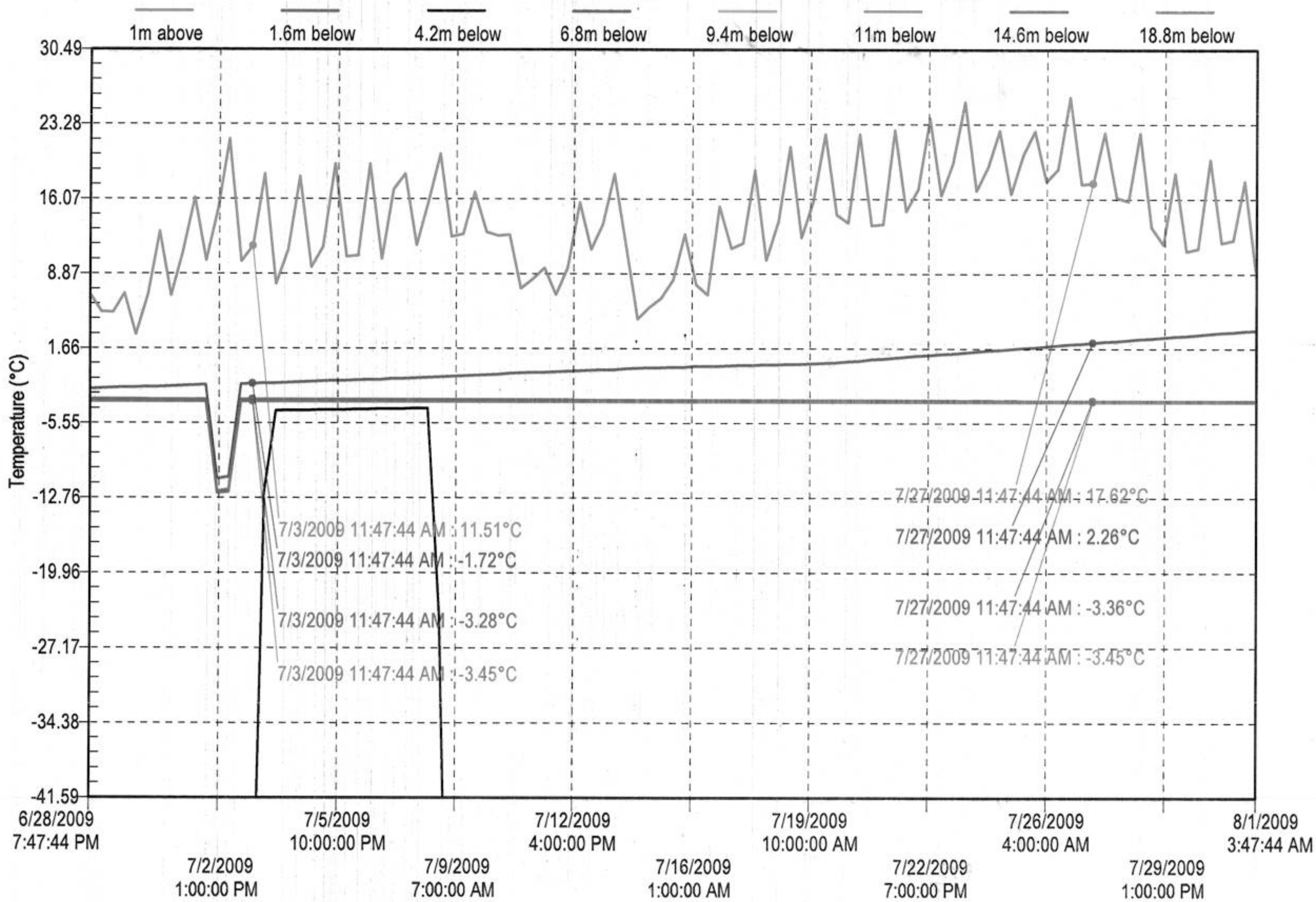
88358 SRP-8-32K

Cape Dorset Temp. readings March 6 to May 6, 2009 Logger #4



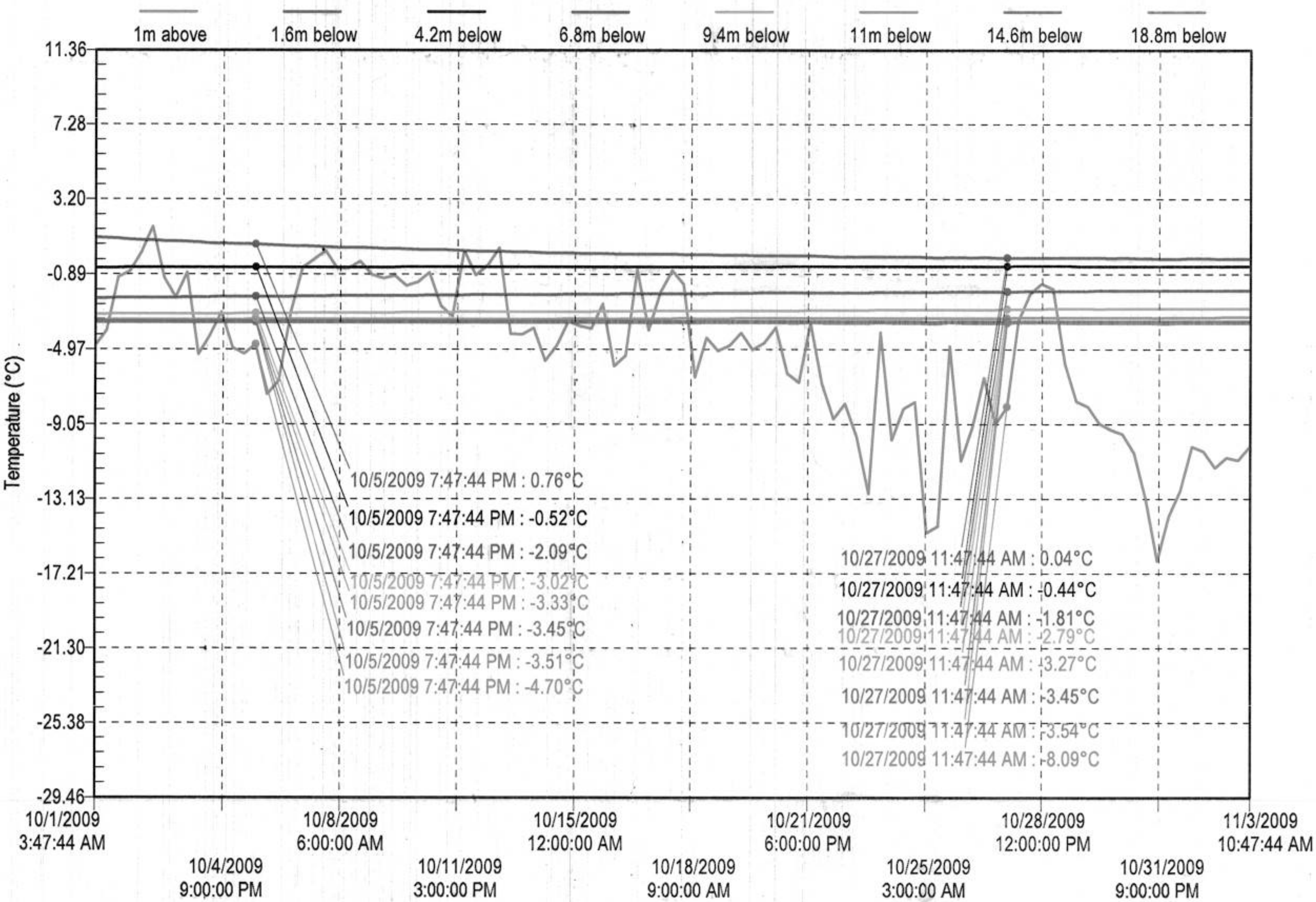
88358 SRP-8-32K

Cape Dorset recordeed Temp July 1, 2009 to August 1, 2009 Logger #4



88358 SRP-8-32K

Cape Dorset recordeed Temp Oct. 1, 2009 to Nov. 1, 2009 Logger #4



materials. Table 3 summarizes the material physical and thermal properties applied for the geothermal analyses.

Table 3: Physical and Thermal Soil Properties

Soil Type	Dry Density, kN/m^3	Moisture Content, %	Thermal Conductivity, W/m/°C		Heat Capacity, $MJ/m^3/°C$	
			Frozen	Unfrozen	Frozen	Unfrozen
Bedrock	28	2	2.90	2.90	2.58	2.58
Unsaturated overburden and dyke sand and gravel	20	7	2.90	2.73	2.26	2.68
Saturated rockfill, overburden and dyke sand and gravel	19.6	15	2.61	2.26	2.26	2.51
Unsaturated rockfill	20	5	2.9	2.73	2.09	2.26
Water	10	---	2.20	0.58	1.95	4.19

8.3 Grid and Soil Layers Description

The following soils/materials were identified within the sewage dyke cross-section:

- Unsaturated Rockfill
- Saturated Rockfill
- Unsaturated dyke core and overburden
- Saturated dyke core and overburden
- Bedrock
- Water

Dimensions of each of the individual layers are shown at Figures 3 through 7, which also present the results of the modeling at the end of summer (September 30). Physical and thermal properties of the constituent soils/materials identified are provided in Section 7.2.

The geothermal modeling grid extended about 104 m below the crest of the dyke and contained 9350 finite elements and 4816 nodes. The dyke and active layer initial temperatures were taken as +2 °C, corresponding to the assumed dyke material temperature and active layer temperature at the end of summer. The initial water temperature also was taken as +2 °C. The initial soil temperature from the base of the active layer and to a depth of 12 m was taken to decrease gradually from 0 °C to -5 °C; the soil temperature then was warmed gradually down to the bottom of the grid with the geothermal gradient of 0.02 °C/m.

Zero heat flux was applied at lateral boundaries of the grid, while the heat flux at the mesh bottom corresponded to the geothermal gradient of 0.02 °C/m.

8.4 Results of Geothermal Modelling

Figure 4, Appendix A shows that after the first year of the dyke operation, the active layer at the dyke crest is about 2 m. The majority of the dyke core has a temperature in a range from 0 °C to -1 °C while the ground temperature under the dyke is about -2 °C. One can see that due to a warming effect of the lagoon water, the ground temperature beyond the upstream slope of the dyke is at about 1 degree warmer than the ground temperature beyond the downstream slope of the dyke.

Figures 5 through 8 show that no considerable changes of the dyke temperature regime are observed from the fifth to thirtieth year of the dyke operation (dyke temperature remains in a range from 0 °C to -2 °C). It can be observed that a thickness of the unfrozen zone under the lagoon is increased, while the ground temperature under the dyke is decreased down to -5 °C.

The analyses did not include any component of climate warming over the expected life of the lagoon and following decommissioning. Typical climate warming values could be in the range of 0.1 °C/year (1 °C/decade). Applying a climate warming scenario to the analysis would result in warmer dyke temperatures.

The following conclusions may be drawn from the investigations and thermal analyses:

- The concept of a frozen core dyke to provide the primary containment of lagoon waters is considered to technically tenuous at best, and likely not technical feasible, given the applied input conditions.
- No assessment of seepage under or through the cut-off curtain below the dyke has been made. Further, AMEC has not assess whether the proposed 2 m deep cut-off system under the dyke is sufficient, although thermal modelling suggests that the subgrade will remain frozen (see Figures 4 to 8, Appendix A).

9.0 CLOSURE

The engineering recommendations presented herein are based on the results of the field reconnaissance, aerial photograph interpretation and reviewing of the available information. No drilling was undertaken at the prospective borrow source locations to estimate soil composition.

Results of the geothermal modeling have shown that the dyke temperature will remain relatively warm (range from 0 °C to -2 °C) during the operation years. Thus, it is essential to install a reliable liner as shown at Figures 2 or 3, Appendix A. An alternative option would be to construction a clayey cut-off core of the dyke. However, an implementation of this option depends on quality and quantity of the available clayey material within the Cape Dorset area.

It should be stated that the results of modelling are valid for boundary conditions and soil properties described in Sections 7.1 and 7.2. If actual boundary conditions (soil properties) differ considerably from the assumed parameters, then the actual temperatures of the dyke could vary from the predicted temperatures.

This report has been prepared for the exclusive use of Dillon Consulting Limited and its agents for the specific application described in this report. The use of this report by third parties is done so at the sole risk of those parties. It has been prepared in accordance with generally accepted permafrost and foundation engineering practices. No other warranty, expressed or implied, is made.

Respectfully submitted,

AMEC Earth & Environmental

REGISTERED PROFESSIONAL ENGINEER
13 Oct 2005
K.G. BARNES
LICENSEE
NWT/NU

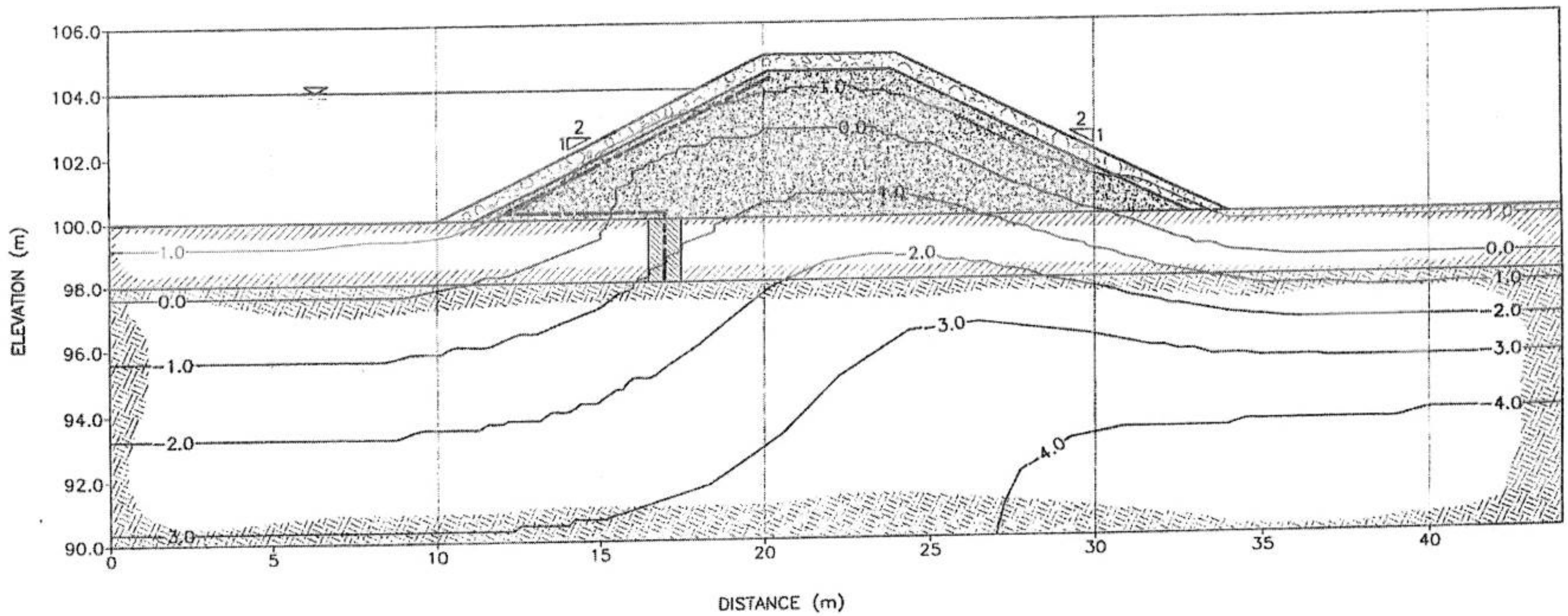
REGISTERED PROFESSIONAL ENGINEER
A. TCHEKHOVSKI
LICENSEE
NWT/NU

Keith Barnes, P.Eng.
Geotechnical/Permafrost Engineer

Alexandre Tchekhovski, Ph.D., P. Eng.,
Senior Permafrost Engineer

Reviewed by: Jim Oswell, Ph.D., P.Eng
Senior Permafrost Engineer

PERMIT TO PRACTICE
AMEC Earth & Environmental, a Division of AMEC Americas Limited
Signature Keith Barnes
Date 13 Oct 2005
PERMIT NUMBER: P 047
The Association of Professional Engineers, Geologists and Geophysicists of the NWT / NU



LEGEND:

- ROCKFILL
- SAND AND GRAVEL
- OVERBURDEN
- BEDROCK
- HDPE LINER
- CLAY OR GROUT

SCALE
1:200
0 1 2 3 4 m

amec Earth & Environmental	PROJECT: GEOTECHNICAL INVESTIGATION FOR P-LAKE SEWAGE LAGOON, CAPE DORSET				
	TITLE: DYKE TEMPERATURES AFTER 1 YEAR OF OPERATION				
CLIENT: DILLON CONSULTING LIMITED	DATE: OCTOBER 2005	JOB No.: YX00748	CAD FILE: 00748B00.dwg	FIGURE No.: FIGURE 4	REV. A