DIAVIK™
DIAMOND MINES INC.

Mackenzie Valley Land & Water Board
File
NOV 24 2005
Application # N7L2-1645
Copied To JM/PLM/Reg.
CD on file in Registry

November 24, 2005

Todd Burlingame, Chair
Mackenzie Valley Land and Water Board
7th Floor – 4910 50th Ave.
P.O. Box 2130
Yellowknife, NT, X1A 2P6

Re: Plume Delineation Report

Attached is DDMI's Plume Delineation Report. It is being submitted in accordance with:

- Part H Item 26 – Ammonia Fate Study, and;
- Part K Item 7(i)(ii) – Special Effects Study – Plume Delineation

If you have any questions please contact the undersigned.

Diavik Diamond Mines Inc.

Regards,

Gord Macdonald

cc: Peter Lennie-Misgeld
Jalil Mustafa

Attachment – Plume Delineation Report (CD)

PLUME DELINEATION REPORT

VERSION #2

NOVEMBER 2005

DIAVIK
DIAMOND MINES

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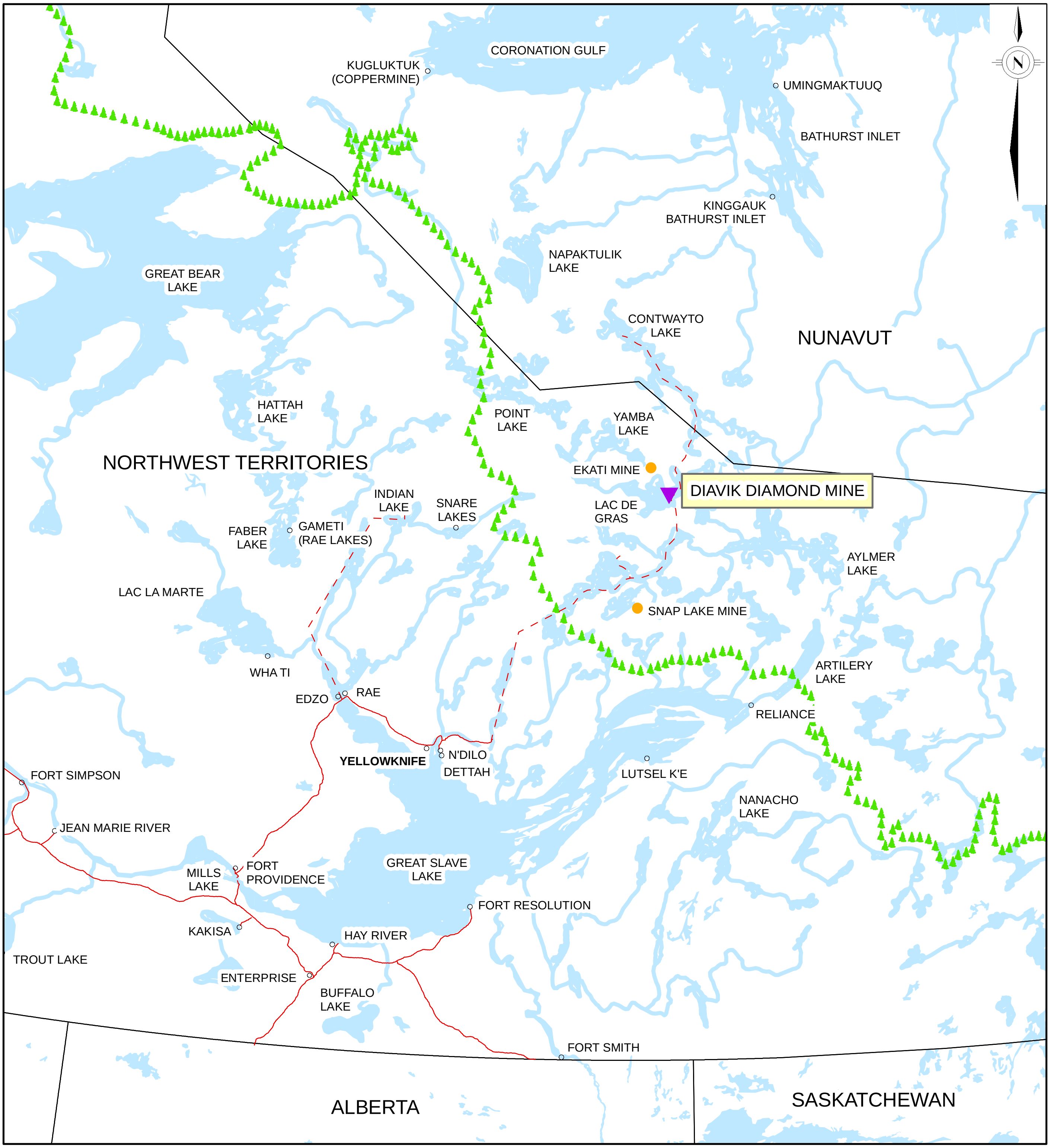
1. INTRODUCTION

Diavik Diamond Mines Inc. (DDMI) operates a diamond mine in the Northwest Territories, located 300 kilometres (km) northeast of Yellowknife (Figure 1-1). As part of the operations of the mine, the North Inlet Water Treatment Plant (NIWTP) treats water from the mine and discharges it to Lac de Gras through a diffuser. The discharged effluent from the NIWTP has created a plume, the shape and characteristic of which are expected to be different during ice-covered and ice-free conditions.

The objective of this study was to collect information to delineate the extent, shape and characteristics of the plume in Lac de Gras from the NIWTP effluent during ice-covered and ice-free conditions. The specific objectives of the study were as follows:

- assess the shape (in all three dimensions) and extent of the plume in Lac de Gras;
- determine the extent of the one percent (1%) effluent concentration zone for effluent discharging from the NIWTP;
- compare characteristics of the plume under ice-covered and ice-free conditions; and,
- assess whether nitrification (bacterial conversion of ammonia to nitrate) was occurring within the plume.



100 0 100

Scale 1: 5,000,000 KM

LEGEND

- ALL WEATHER ROADS
- WINTER ROADS
- TREELINE
- COMMUNITIES

REFERENCE

UTM Zone 12, NAD 83.

I:\2005\05-1328\05-1328-003\Mxd\Fig1.1_LocationMap.mxd

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE

LOCATION OF DIAVIK DIAMOND MINE

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	JRC	19 May. 2005	FIGURE: 1-1	
GIS	JRC	19 May. 2005		
CHECK	AH	16 Aug. 2005		
REVIEW	AH	16 Aug. 2005		

2. METHODS

2.1 Field Methods

The following section provides a summary of the field methods used to collect relevant water quality data for delineating the effluent plume. Specifically, information on sampling design, site locations, sample timing, methods for collecting *in-situ* data, and an introduction to the quality assurance and quality control (QA/QC) plan are provided below.

2.1.1 Sampling Design

Original Design

The water quality sampling program was designed monitor the plume during ice-covered and ice-free conditions in Lac de Gras. Water quality samples and field measurements were collected during April (ice-covered conditions) and August (ice-free conditions) of 2005. During each of these months, two separate surveys were completed, which will be referred to as the Phase I and Phase II surveys. The Phase I survey was intended to identify areas within the 1% effluent concentration zone based on a minimal sampling program. The Phase II survey was intended to delineate the limit of where the plume was detectable and, therefore, encompassed a larger area compared to the Phase I survey. The sampling locations established for the Phase I survey included stations closer to the effluent outlet and stations were more closely spaced compared to the Phase II survey. Data collected during these surveys provided information that was used to delineate the effluent plume.

Modified Phase I Sampling Design

The Phase I survey was split into two sets of stations: Part A and Part B stations. During Phase I of the ice-covered survey, twenty five (25) sampling stations were selected within an 800 m x 800 metre (m) grid area around the discharge outlet (Part A stations), which was originally expected to contain the zone of 1% effluent concentration. After reviewing the monitoring results from these 25 stations, it was determined that the 1% effluent concentration zone extended beyond the 800 m x 800 m grid area. Therefore, the Phase I survey was expanded to include an additional 15 stations beyond the original grid area (Part B). During Phase I of the ice-free survey, all 40 stations (i.e., Part A and B) were re-sampled to ensure that the zone of 1% effluent concentration was captured.

2.1.2 Site Locations and Samples Collected

The Phase I and Phase II samples were collected at the locations identified in Figure 2.1-1 during both the ice-covered and ice-free seasons. The approximate location of the discharge outlet is also shown in Figure 2.1-1. The outlet location was estimated from the DDMI's Surveillance Network Program (SNP) stations 1645-19A, 1645-19B and 1645-19C, which are located 60 m from the outlet. These SNP stations are monitored monthly as required by DDMI's Water License.

There was some overlap between sampling stations for the Phase I and Phase II surveys. Of the Phase II stations, eleven were located within the Phase I area and 14 stations were outside of the Phase I area. Stations sampled during Phase II of the ice-covered survey were re-sampled during the ice-free season.

The Universal Transverse Mercator (UTM) coordinates, distance from the discharge outlet and total depth for each station monitored during the Phase I and Phase II surveys are presented in Table 2.1-1.

Table 2.1-1 Location, Distance from the Discharge Outlet and Water Depth for Each Site Sampled during the Ice-Covered and Ice-free Seasons in 2005

Sampling Site	UTM East	UTM North	Distance (m)	Water Depth (m)
Phase I Part A				
AF-01	535677	7153487	158	18.6
AF-02	535837	7153440	17	23.8
AF-03	535984	7153376	172	19.1
AF-04	535694	7153628	220	18.1
AF-05	535803	7153589	135	17.2
AF-06	535914	7153561	133	20.1
AF-07	536036	7153519	213	18.6
AF-08	536175	7153472	343	19.4
AF-09	535803	7153725	270	16.3
AF-10	535939	7153683	250	17.9
AF-11	536113	7153631	331	22.3
AF-12	536256	7153591	445	14.6
AF-13	536378	7153546	553	11.4
AF-14	535781	7153854	401	23.2
AF-15	535924	7153819	374	22.1
AF-16	536075	7153782	406	16.5
AF-17	536251	7153737	504	21.1
AF-18	536375	7153703	596	16.6
AF-19	536479	7153673	682	15.5
AF-20	535892	7153968	515	23.6
AF-21	536051	7153938	529	24.1
AF-22	536244	7153896	602	22.5
AF-23	536422	7153859	714	20.9
AF-24	536587	7153819	837	24.3
AF-25	535931	7154063	614	27.1

Table 2.2-1 Location, Distance from the Discharge Outlet and Water Depth for Each Site Sampled in 2004 (continued)

Sampling Site	UTM East	UTM North	Distance (m)	Water Depth (m)
Phase I Part B				
AF-26	535660	7154009	578	16.4
AF-27	535731	7154294	843	28.2
AF-28	535832	7154454	997	7.6
AF-29	535961	7154312	865	17.1
AF-30	536113	7154418	1002	14.1
AF-31	536138	7154246	847	17.3
AF-32	536338	7154342	1020	13.7
AF-33	536321	7154133	835	18.6
AF-34	536583	7154209	1063	25.6
AF-35	536565	7154040	937	11.6
AF-36	536847	7154103	1203	24
AF-37	536755	7153963	1053	14.6
AF-38	537000	7153997	1287	23.7
AF-39	536824	7153789	1046	22.5
AF-40	536668	7153606	849	9.8
Phase II				
AF-41	535790	7153863	408	24
AF-42	536079	7153787	412	16
AF-43	536238	7153585	426	16
AF-44	535944	7154065	619	26
AF-45	536433	7153863	725	20
AF-46	536651	7153637	839	10
AF-47	536309	7154137	831	18
AF-48	536806	7153783	1027	24
AF-49	536309	7154363	1024	12
AF-50	535385	7154280	937	16
AF-51	535730	7154295	844	28
AF-52	535583	7154553	1124	16
AF-53	535012	7154776	1553	12
AF-54	536583	7154212	1065	24
AF-55	536107	7154625	1200	8
AF-56	536877	7154295	1340	20
AF-57	537214	7153934	1462	30
AF-58	537591	7153950	1827	36
AF-59	537119	7154799	1860	10
AF-60	537369	7154379	1793	12
AF-61	537643	7154672	2181	8
AF-62	538080	7155204	2847	26
AF-63	538278	7154240	2568	38
AF-64	538099	7153875	2305	32
AF-65	538131	7153188	2315	14

Note: Distance is straight-line distance from the discharge outlet based on UTMs. Datum is NAD83.

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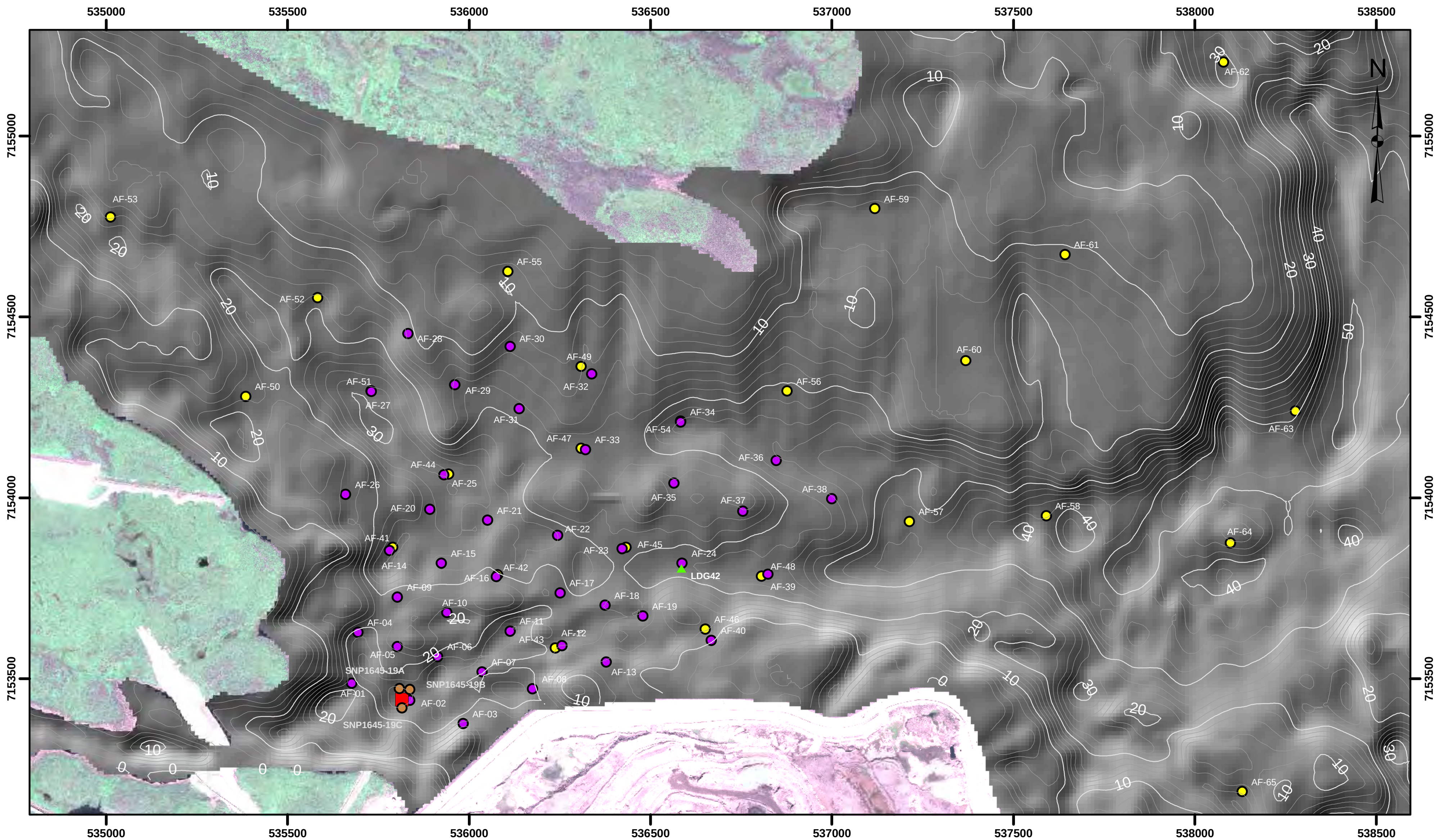

LEGEND

- PHASE I SAMPLE LOCATIONS
- PHASE II SAMPLE LOCATIONS
- SNP WATER QUALITY MONITORING STATION *
- AEMP WATER QUALITY MONITORING STATION *
- DISCHARGE OUTLET
- 2 METRE EAST ISLAND BATHYMETRY

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

IKONOS Imagery provided by Space Imaging Inc; Captured July 19, 2004
Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12
* These stations are not part of the Plume Delineation Monitoring Program

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE

PHASE I AND PHASE II MONITORING STATIONS

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005		
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

FIGURE: 2.1-1

2.1.3 Study Timing

Ice-Covered Survey

Phase I of the 2005 ice-covered field program was completed between March 26 and April 16, 2005. The initial 25 stations of the Phase I survey (Part A) were sampled from March 26 to March 29, 2005 and the remaining 15 stations (Part B) were sampled on April 15 and 16, 2005. The Phase II survey was conducted between April 29 and May 2, 2005.

Ice-free Survey

Phase I of the 2005 ice-free field program was completed between August 4 and August 12, 2005. The initial 25 stations of Phase I survey (Part A) were sampled from August 4 to August 10, 2005 and the remaining 15 stations (Part B) were sampled on August 11 and 12, 2005. The Phase II survey was conducted between August 17 and 24, 2005.

2.1.4 Water Quality Sampling and Field Measurements

Detailed field procedures are provided in Appendix A. Key elements of the program are summarized below.

Field measurements and water quality samples were collected during Phase I and Phase II of both the ice-covered and ice-free surveys. Depth profiles were completed at each sampling location to determine maximum depth and to measure field variables (i.e., water temperature, dissolved oxygen [DO], pH and conductivity). Field variables were measured at 2 m depth intervals using a calibrated HydroLab DataSonde 4a multiprobe water quality meter. A water sample was collected from 2 m above the bottom, 2 m below the surface of the ice and at the midpoint in the water column using a 3.2 litre (L) Beta Bottle.

Samples were shipped to Enviro-Test Laboratories in Edmonton for analysis of the water quality variables described in Table 2.1-2.

Method detection limits for each analyte are provided with the detailed listing of results in Appendix B.

Table 2.1-2 Water Quality Variables Analyzed During Phase I and Phase II of the Ice-Covered and Ice-free Surveys

Water Quality Variable Group	Water Quality Variable	Phase I	Phase II
Conventional Variables	conductivity, pH, turbidity, alkalinity, hardness, total dissolved solids, ion balance		✓
Major Ions	calcium, chloride, magnesium, potassium, sodium, sulphate, bicarbonate, carbonate, hydroxide, potassium		✓
Total Metals	aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, uranium, vanadium, zinc	✓	✓
Nutrients	total phosphorus, dissolved phosphorus, ortho-phosphate, nitrate, nitrite, ammonia, total Kjeldahl nitrogen [TKN]		✓

2.2 Quality Assurance and Quality Control (QA/QC) Plan

A QA/QC program was implemented to ensure that results from the sampling program were unbiased, repeatable and accurate. The QA/QC plan for environmental monitoring includes the following components:

1. Clearly defined and documented field procedures were followed by trained field staff.
2. Travel blanks, field blanks, equipment blanks and replicate samples were collected during each survey. QC samples comprised ten percent of the water quality samples collected during the study.
3. Quality assurance was ensured through adherence to the DDMI Laboratory QA/QC Program (DDMI 2004).

Quality control (QC) criteria were established for testing blank and duplicate sample results. When evaluating QC data for water quality, differences between concentrations of a parameter in duplicate samples were considered significant if they were greater than 20%. This evaluation was limited to variables with concentrations above five times the detection limit because effects of analytical variability are proportionally higher at concentrations near the detection limit. In the field blanks, concentrations greater than five times the analytical detection limit were considered to be significant, indicating the possibility of contamination.

2.3 Data Analysis

The Phase I data have been included in Appendix B for reference, with the primary data analysis focusing on the Phase II surveys. The Phase II survey data were analyzed to delineate the plume from the NIWTP and to assess the degree of nitrification that occurred within the plume during ice-covered and ice-free conditions. Plume delineation also included identifying the location of the 1% effluent concentration zone.

A detailed description of the methods used to delineate the effluent plume is presented in Section 2.3.1, followed by a description of the process used to determine the degree of nitrification within the effluent plume in Section 2.3.2.

2.3.1 Delineation of Plume

The objective of the plume delineation was to determine the shape and extent of the plume as measured during the Phase II ice-covered and ice-free surveys,

The shape and extent of the plumes during Phase II surveys were determined using the following approaches:

- Isopleth (concentration contour) maps were prepared for selected water quality variables and these were reviewed to determine the spatial extent that the effluent plume can be detected in Lac de Gras.
- Percent effluent concentration isopleth maps were prepared, which included the 1% effluent concentration isopleth.
- Vertical profile plots of conductivity and total barium were assessed to determine the vertical shape of the plume within the water column in Lac de Gras.

Conductivity and total barium were the key water quality variables used to characterize the plume. Field conductivity, which was measured at 2-m depth intervals, was used to assess the vertical profile of the plume and to estimate the centre of the plume. Conductivity is often used as a surrogate measure of total dissolved solids, which are found at higher concentrations in the effluent (200 to 300 mg/L) compared to the lake (5 to 30 mg/L). Conductivity in the effluent was approximately 700 µS/cm during ice-covered and approximately 500 µS/cm under ice-free conditions, whereas background lake values were between 10 and 20 µS/cm in both seasons. Total barium was selected as a tracer because it is a relatively conservative water quality variable (i.e., it is largely present in dissolved form and does not tend to undergo biological or chemical transformation) and its concentration in the mine effluent is high compared to the background lake concentrations. Barium concentrations in the effluent were approximately 0.33 mg/L and 0.21 mg/L during the ice-covered and ice-free seasons, respectively. In contrast, background lake concentrations of barium were between 0.0015 and 0.0017 mg/L in both seasons. Ammonia and nitrate were primarily used to assess whether nitrification occurred to a measurable extent within the plume.

Isopleth Mapping of Conductivity and Barium Results

Isopleth maps of field measurements and barium concentrations within Lac de Gras were produced using Geographic Information System (GIS) tools to show:

- the location of the centre-line of the plume based on maximum values of barium and conductivity; and,
- the horizontal extent and the shape of the plume at different depth layers in Lac de Gras, based on measured concentrations of barium, nitrate and ammonia.

Maps showing the location of the plume were used to assess the general shape and extent of the plume, as well as the location of the centre-line, if present. In this study, the centre-line of the plume is defined as the line representing the most concentrated portion of the plume. The vertical centre-line of the plume was evaluated using maximum values of field conductivity measurements and barium concentrations from each sampling location, regardless of depth. These maximum values during the ice-covered and ice-free surveys at each sampling location were plotted on isopleth maps of Lac de Gras. The corresponding depth of the maximum value was included in the sample label on the map.

The shape of the plume in the maximum conductivity maps were compared to the shape of the plume in the maximum barium maps to determine whether results from the three depth samples adequately delineated the centre-line of the plume. Because field measurements of conductivity were collected at 2-m intervals, maximum conductivity may more accurately show the vertical centre-line of the plume compared to the maximum barium concentrations from three samples.

Barium isopleth maps were plotted separately for each depth layer (bottom, mid-depth and surface) to evaluate the vertical location of the plume and the shape of the plume at different depths. The isopleth maps of the bottom and mid-depth results do not show concentrations on one horizontal plane. Rather, the figures illustrate concentrations on an irregular surface that correspond to 2 m above the lake bottom and at the middle depth of water column, which are dependent on the bathymetry of the lake. The bathymetry of Lac de Gras was also shown on each map, with depth isopleths labelled at 10-m intervals.

The software used to create the isopleth mapping was ArcMap 9.1, Spatial Analyst, and Geostatistical Analyst (Johnston et al. 2001). Environmental Systems Research Institute (ESRI) geographic information system (GIS) shape files were created from the UTM coordinates of each sampling location. This resulted in a series of “real world” coordinate points with the field conductivity measurements as attributes of the points. Using these shape files as input, a continuous surface was interpolated with the simple kriging process within the geostatistical analyst extension in ESRI ArcMap 9.1. Kriging was chosen because it is a quick interpolator that will create a surface based on known measured values and will predict values at unmeasured locations based on distance from known values as well as the spatial arrangement of the known values. The output of the interpolation process was an ESRI GRID. The surface was then visualized on the map using a graduated colour gradient with appropriate number of classes at equal intervals.

Because the GIS methods used to delineate areas of similar conductivity or concentrations are not based on a physical model, they do not take into account physical factors that may influence the actual shape of the plume such as the location of the shoreline or islands, the presence of currents, or the bathymetry of the lake. The isopleth maps rely entirely on the values of the results to generate a potential shape of the plume. As the number of sampling locations increases, the accuracy of the isopleths would be expected to increase.

Lake concentrations at the discharge location were not measured during the ice-covered and ice-free Phase II surveys and were, therefore, approximated to provide a more realistic representation of the shape of the plume near the discharge point on isopleth maps. In the Phase II surveys, the closest monitoring locations to the discharge location were AF-41, AF-42 and AF-43, which are approximately 400 m from the discharge. The SNP stations are located 60 m from the discharge outlet (SN1645-19A, B and C); however, for both the ice-free and ice-covered surveys, the SNP stations were sampled prior to the Phase II survey and may not be representative of conditions during the Phase II surveys. Without results from locations that are near the discharge outlet, the GIS interpolation process can produce isopleths near the effluent discharge that are unrealistically low. For example, total barium concentrations might appear to be lower near the discharge point than at sites AF-41 to AF-43; however, concentrations at the discharge point must be as high, or higher, than concentrations observed at the nearby stations. To produce a realistic view of the plume, concentrations at the effluent discharge location were assumed to be equal to the maximum concentration observed at any of the stations monitored in Phase II. Based on this assumption, the assigned maximum would actually represent the lowest possible lake concentration at the discharge point.

Mapping of Percent Effluent Concentration Zones

Maps were produced that presented the zones of percent effluent concentrations, including the 1% effluent concentration zone. The following equation was used to calculate percent effluent concentrations at each sampling point:

Percent Effluent Concentration = $(C – C_b)/(C_{NIWTP} - C_b) \times 100$.

Where: C = concentration from Phase II survey

C_b = background concentration of Lac de Gras during ice-covered or ice-free conditions

C_{NIWTP} = concentration of NIWTP effluent during Phase II surveys

Recalculating monitoring results as a percent of the effluent concentration provides an intuitive measure of the mixing characteristics of the effluent from the NIWTP. The percentage value of a tracer indicates the percentage of effluent present in the water column at each sampling point.

Background concentrations in Lac de Gras were obtained from locations that were not expected to be affected by the discharge. As part of DDMI's Aquatic Effects Monitoring Program (AEMP) (DDMI 2001), 10 stations are sampled annually during April (ice-covered conditions) and August (ice-free conditions) for a number of water quality variables, including total barium, ammonia and nitrate (Figure 2.3-1). The average results from the stations farthest away from the outlet (LDG-46, LDG-48 and LDG-50) were used to establish the background concentrations of total barium, ammonia and nitrate in Lac de Gras.

DDMI's Surveillance Network Program (SNP) includes water quality monitoring of effluent from the NIWTP approximately every six days. Average total barium concentrations in the effluent were calculated for the time period when the Phase II surveys were conducted (Table 2.2-1).

Table 2.2-1 Dates for Calculating Average Effluent Concentrations

Survey Phase	Dates
Ice-covered Phase II	April 24 and 30
Ice-free Phase II	August 17, August 22 and August 28

Isopleths of percent effluent concentration were mapped based on the same methods used to produce the isopleth maps of conductivity measurements and barium concentrations. Similar to the barium and conductivity mapping, the percent effluent concentration at the discharge location was set to the maximum percent effluent concentration observed at the stations sampled during the Phase II survey. This estimate actually represents the lowest percent effluent concentration that could be possible for the discharge location.

Vertical Profiles

Vertical profiles of conductivity were plotted for each station monitored during the ice-covered and ice-free surveys to determine the vertical shape of the plume. Field conductivity profiles were assigned transects across the plume study area, from the northwest to the southeast (Figure 2.3-2).

g:\gis\Yellowkife\Diavik\2004\04-1328-016 2004 Fig 8-3 AEMP Monitoring Stations.mxd

LEGEND

- Water Quality Monitoring Stations
- SNP Water Quality Monitoring Stations
- Diavik Footprint

5 0 5

Scale 1: 250,000 Kilometers

REFERENCE

UTM Zone 12, NAD 83.

PROJECT	DIAVIK DIAMOND INC. PLUME DELINEATION STUDY
TITLE	AEMP MONITORING STATIONS

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	JRC	18 May. 2005	FIGURE: 2.3-1	
GIS	JRC	18 May. 2005		
CHECK	AH	16 Aug. 2005		
REVIEW	AH	16 Aug. 2005		

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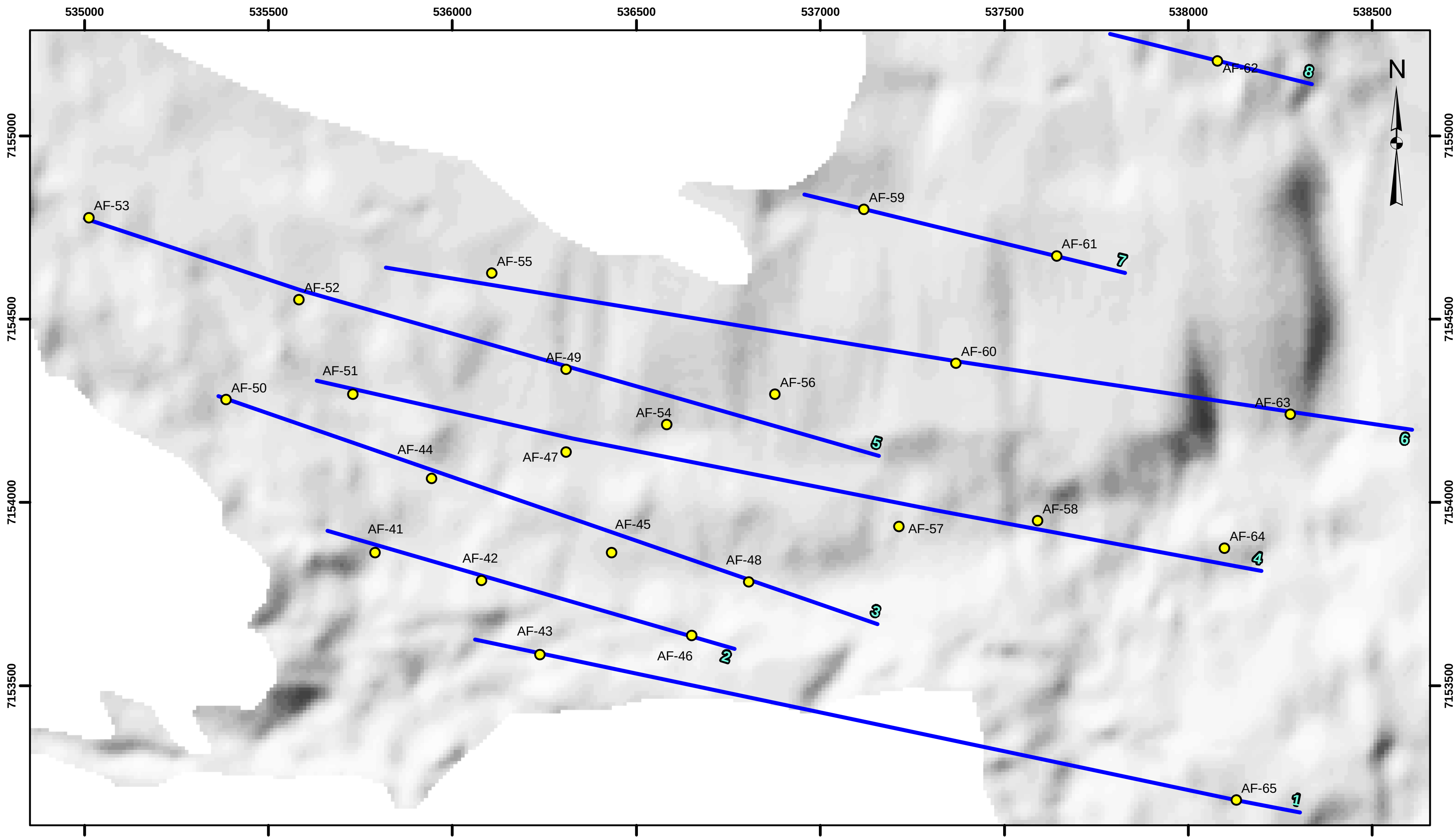


LEGEND

- PHASE II SAMPLE LOCATIONS
- PHASE II TRANSECT LINE

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE

TRANSECTS USED TO GROUP SAMPLING LOCATIONS FOR VERTICAL PROFILES (PHASE II)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005		
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

FIGURE: 2.3-2

Vertical profiles of conductivity and barium collected as part of the SNP were also compared. On April 28 and August 15, 2005, water quality samples and field measurements were collected at the three stations within 60 m from the discharge outlet (SNP1645-19A, 19B and 19C shown on Figure 2.1-1). Water quality samples at SNP1645-19 were collected 2 m below the surface and then at 5-m depth intervals. Field measurements were collected at 2-m depth intervals.

Depth profiles for total barium and conductivity were also plotted for the four AEMP stations closest to the discharge to determine whether the plume could be detected at these stations. In May and September 2005, water quality samples were collected 2 m above the bottom, 2 m below the surface and at mid-depth at these four AEMP stations (LDG-40, LDG-42, LDG-43, and LDG-45 shown on Figure 2.3-1).

2.3.2 Nitrification within Plume

If nitrification was occurring to a measurable extent within the plume, then the decrease in ammonia concentrations with distance from the discharge should be greater than for a conservative tracer. Similarly, measurable nitrification of ammonia to nitrate should result in a smaller decrease in nitrate concentrations with distance from the discharge compared to a conservative tracer. Barium was used as the conservative tracer. Nitrite can also be a product of nitrification, but in well oxygenated waters such as Lac de Gras any nitrite produced will be rapidly converted to nitrate. All measured values of nitrite were below detection limits during the ice-covered and ice-free surveys; therefore, nitrite was not included in the assessment of nitrification.

To correct for differences in background concentrations, concentrations of ammonia, nitrate and barium measured in the Phase II surveys were converted to percent effluent using the formula presented in Section 2.3.1. Percent effluent values were plotted against distance from the discharge outlet for the bottom, middle and surface samples. If nitrification were occurring to a measurable extent, the slope of the line for percent effluent versus distance from discharge would be steeper for ammonia compared to barium, and shallower for nitrate compared to barium.

Isopleth maps of ammonia and nitrate concentrations were also produced using the same methods described in Section 2.3.2 (Isopleth Mapping of Conductivity and Barium Results). Isopleth maps for ammonia and nitrate were compared with those generated for barium at similar depths. If the ammonia and nitrate concentrations appeared to decrease at a faster and slower rate with distance away from the discharge outlet, respectively, compared to barium concentrations, this would be consistent nitrification of ammonia within the effluent plume. Differences between percent effluent isopleth maps for ammonia, nitrate and barium can be directly compared because all concentrations were normalized to percent effluent, and each contains 20 isopleth intervals.

The bacterial conversion of ammonia to nitrate (i.e., nitrification), requires oxygen. If dissolved oxygen levels are low (i.e., below 2 -3 mg/L), nitrification may be inhibited. Therefore, minimum values of dissolved oxygen concentrations were reviewed to ensure that DO levels were sufficiently high to support nitrification.

3. ICE-COVERED RESULTS

Results from the ice-covered survey are presented below. Section 3.1 presents the results of the plume delineation assessment, including a description of the isopleth maps, the percent effluent zones and the vertical profiles. Nitrification, and the extent to which it might be occurring in the effluent plume, is discussed in Section 3.2, followed by a discussion of QA/QC results in Section 3.3.

All laboratory and field results from the ice-covered program are presented in Appendix B. QA/QC results are presented in Appendix C. Percent effluent calculations and results are presented in Appendix D.

3.1 Plume Delineation

3.1.1 Isopleths Maps of Conductivity and Barium

Five isopleth maps of conductivity measurements and barium concentrations from the Phase II results were used to help delineate the extent and shape of the plume, including:

- one map of maximum conductivity measurements;
- one map of maximum barium concentrations; and,
- three maps of barium concentrations at each sampled depth.

Maximum Conductivity Measurements

Maximum field measurements of conductivity for the Phase II survey are presented in Figure 3.1-1. The corresponding depths at which the maximum conductivity was observed were also shown on this figure. For example, at sample location AF-43, D8 indicates that the depth at which maximum concentration occurs was 8 m.

The results show the plume extended to the north and east of the discharge point with no distinct centre-line. Maximum conductivity measurements were within 800 to 1000 m from the discharge outlet (i.e., 30 to 40 µS/cm).

Maximum Barium Concentrations

The map of maximum barium concentrations observed during the Phase II survey is presented in Figure 3.1-2. The layer at which the maximum occurs was identified in the parentheses (e.g., T = top, M = mid-depth and B = bottom).

The shape of the plume in the barium and conductivity maps was similar near the discharge (i.e., within 1 km), which indicates that the barium results adequately capture the vertical centre-line of the plume.

Barium Concentrations at Three Sampled Depths

The isopleth maps of total barium from the Phase II survey are presented in Figures 3.1-3 to 3.1-5, which include a map for each of the three depths sampled (surface, mid-depth and bottom).

Concentrations for total barium were lowest and relatively constant near the surface (Figures 3.1-3), which indicates that the plume was not detectable at the surface of the lake. By contrast, concentrations of barium were highest near the bottom of the lake and decreased with distance from the discharge (3.1-5). These observations indicate that near the discharge, the plume was located near the bottom of Lac de Gras and becomes diluted at distances further from the discharge, which was consistent with the maps of maximum barium and conductivity results.

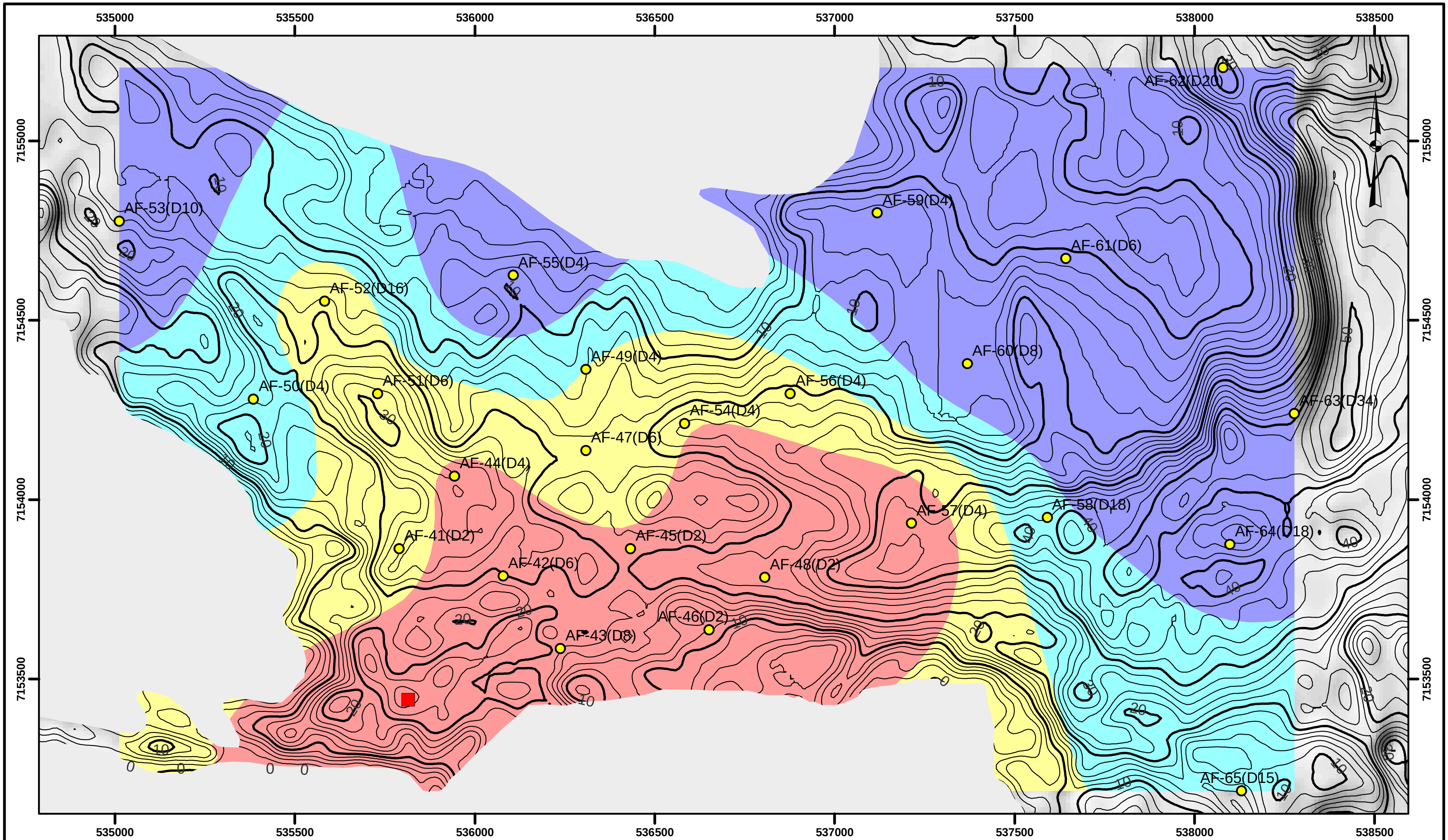
The patterns of dilution and the presence of the plume near the bottom of the lake, which was observed for barium, were also observed in the isopleth mapping of ammonia and nitrate concentrations. Ammonia and nitrate plume mapping is discussed below in Section 3.2 (Nitrification).

Highest concentrations were observed near the bottom close to the discharge, with the plume appearing to have pooled to the north and east of the discharge (Figure 3.1-5). At mid-depth (Figure 3.1-4), the plume had moved to the northeast.

The mid-depth concentration at station AF-45, was lower than concentrations closer to the discharge (AF-42 and AF-43) and further from the discharge (AF-48). One possible explanation for lower concentrations at AF-45 is that the centre-line of the plume was not exactly at mid-depth at this station. The conductivity profile at AF-45 (Figure 3.1-6) indicated that the maximum concentration occurred below the mid-depth concentration.

The effluent has a higher density than water in Lac de Gras because the effluent has a higher concentration of TDS. The higher density of the effluent plume would tend to cause it to sink, provided the temperatures of the effluent and lake were similar. Near the discharge, the highest concentrations were generally observed at the bottom stations; however, further from the discharge, the plume appears to have become detached from the bottom and have moved in the northeast direction. This suggests that the plume was neutrally buoyant (not sinking or floating) as it moved further from the discharge. Conductivity profiles at stations north and east of the discharge (Figure 3.1-6) show that maximum levels fall somewhere in the middle of the water column, generally near mid-depth.

I:\2005\05-1328\05-1328-003\Mxd\Summary\Fig3.1-01_PhaseII_Conductivity.mxd



LEGEND

FIELD CONDUCTIVITY VALUES (uS/cm)

- 14.2 - 23.2
- 23.2 - 30.2
- 30.2 - 35.8
- 35.8 - 42.8

- SAMPLE LOCATION
- DISCHARGE OUTLET *
- EAST ISLAND BATHYMETRY
- (D14) DEPTH OF MAXIMUM CONCENTRATION IN METRES

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum dilution zones observed during the Phase II sampling program was used to estimate the minimum concentration at the discharge point

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

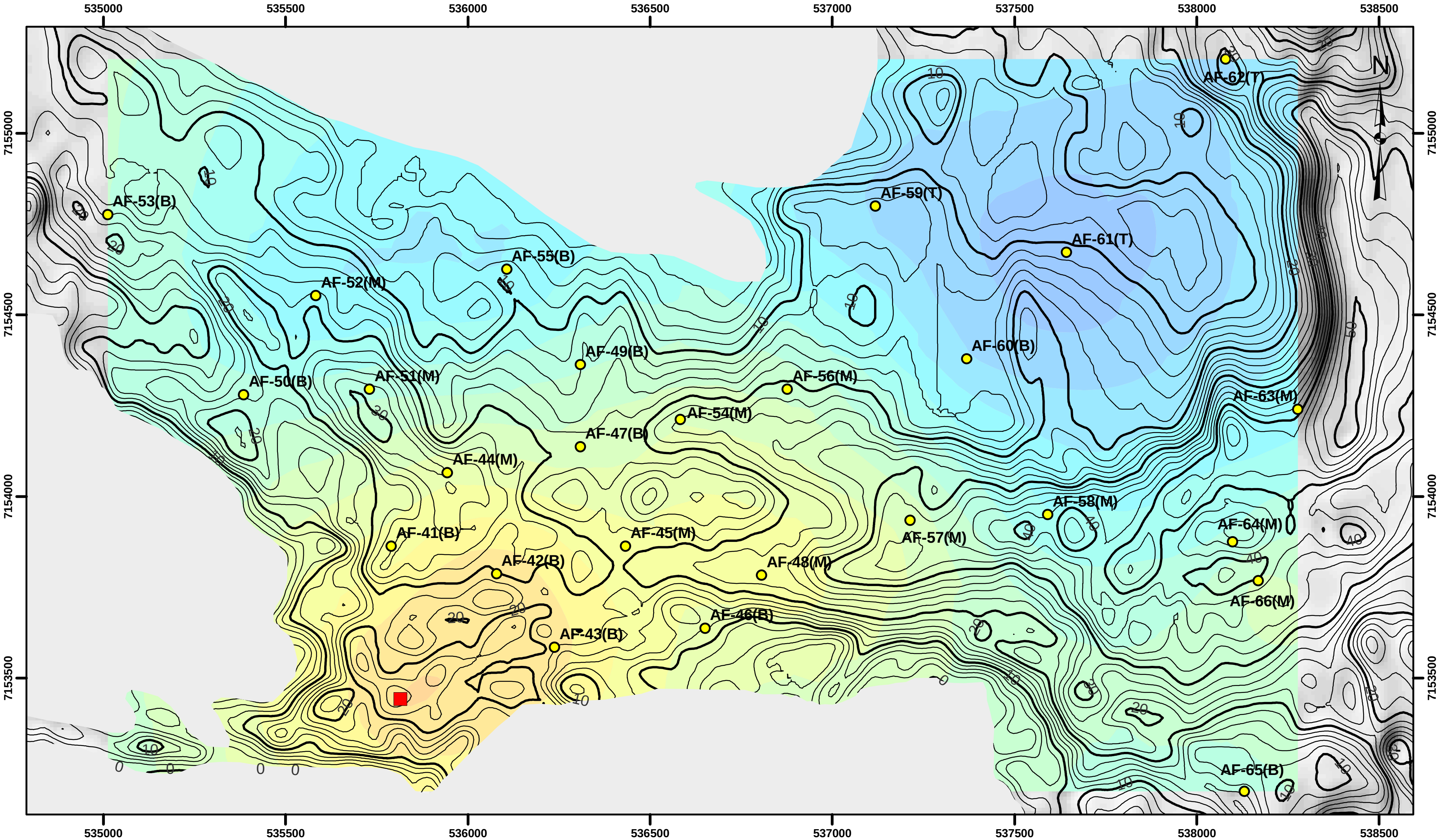
TITLE

MAXIMUM FIELD CONDUCTIVITY MEASUREMENTS (PHASE II - ICE-COVERED)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005	FIGURE: 3.1-1	
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

I:\2005\05-1328\05-1328-003\Mxd\Summary\Fig3.1-02_PhaseII_Max_Barium_Cond.mxd



LEGEND

BARIUM CONCENTRATIONS (mg/L)

0.0020 - 0.0032	0.0140 - 0.0152
0.0032 - 0.0044	0.0152 - 0.0164
0.0044 - 0.0056	0.0164 - 0.0176
0.0056 - 0.0068	0.0176 - 0.0188
0.0068 - 0.0080	0.0188 - 0.0200
0.0080 - 0.0092	0.0200 - 0.0212
0.0092 - 0.0104	0.0212 - 0.0224
0.0104 - 0.0116	0.0224 - 0.0236
0.0116 - 0.0128	0.0236 - 0.0248
0.0128 - 0.0140	0.0248 - 0.0260

SAMPLE LOCATION

DISCHARGE OUTLET *

EAST ISLAND BATHYMETRY

(T) LOCATION OF SAMPLING POINT (T=TOP, M=MIDDLE, B=BOTTOM)

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum concentration observed during the Phase II sampling program was used to estimate the minimum concentration at the discharge point

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

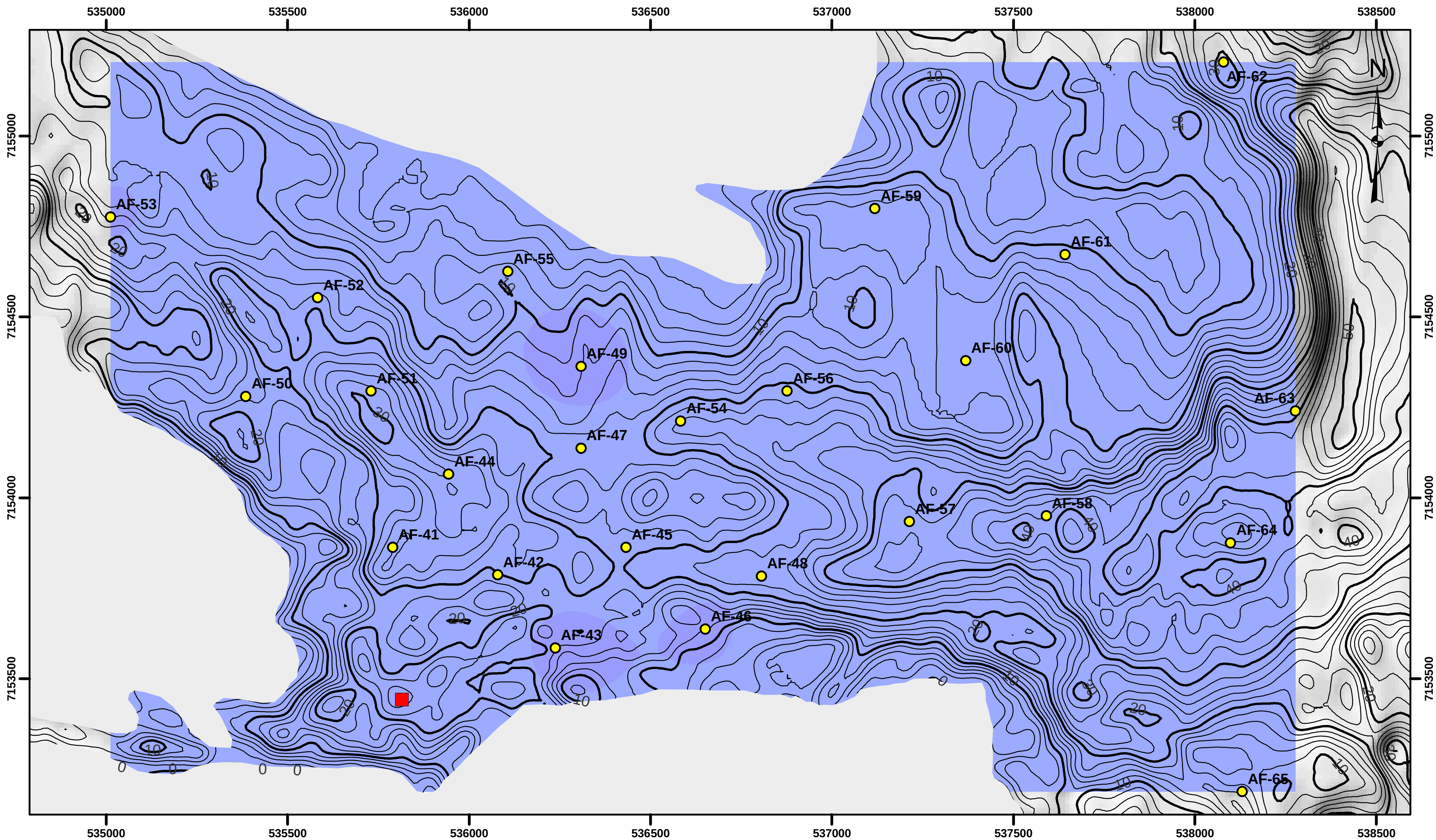
TITLE

MAXIMUM TOTAL BARIUM CONCENTRATIONS (PHASE II - ICE-COVERED)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005	FIGURE: 3.1-2	
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

I:\2005\05-1328\05-1328-003\Mxd\Summary\Fig3.1-03_PhaseII_Ba_Top.mxd



LEGEND

BARIUM CONCENTRATIONS (mg/L)

- 0.002 - 0.0032
- 0.0032 - 0.0044
- 0.0044 - 0.0056
- 0.0056 - 0.0068
- 0.0068 - 0.008
- 0.008 - 0.0092
- 0.0092 - 0.0104
- 0.0104 - 0.0116
- 0.0116 - 0.0128
- 0.0128 - 0.014
- 0.014 - 0.0152
- 0.0152 - 0.0164
- 0.0164 - 0.0176
- 0.0176 - 0.0188
- 0.0188 - 0.02
- 0.02 - 0.0212
- 0.0212 - 0.0224
- 0.0224 - 0.0236
- 0.0236 - 0.0248
- 0.0248 - 0.026

- SAMPLE LOCATION
- DISCHARGE OUTLET
- EAST ISLAND BATHYMETRY

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

PROJECT

DIAVIK DIAMOND MINE INC.
PLUME DELINEATION STUDY

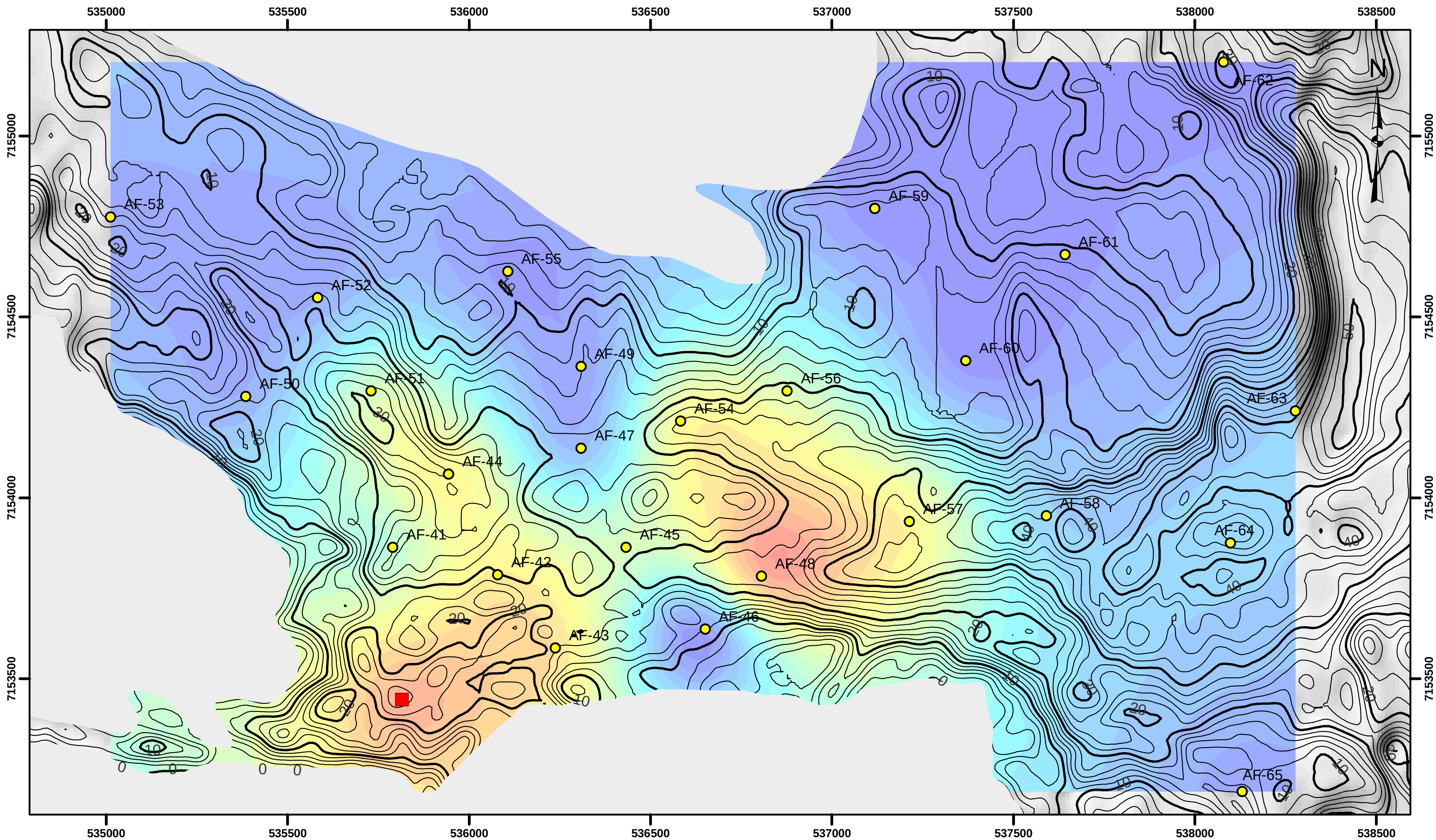
TITLE

TOTAL BARIUM CONCENTRATIONS AT SURFACE (PHASE II - ICE-COVERED)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005	FIGURE: 3.1-3	
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

I:\2005\05-1328\05-1328-003\Mxd\Summary\Fig3.1-04_PhaseII_Ba_Top.mxd



LEGEND

BARIUM CONCENTRATIONS (mg/L)

0.0020 - 0.0032	0.0140 - 0.0152
0.0032 - 0.0044	0.0152 - 0.0164
0.0044 - 0.0056	0.0164 - 0.0176
0.0056 - 0.0068	0.0176 - 0.0188
0.0068 - 0.0080	0.0188 - 0.0200
0.0080 - 0.0092	0.0200 - 0.0212
0.0092 - 0.0104	0.0212 - 0.0224
0.0104 - 0.0116	0.0224 - 0.0236
0.0116 - 0.0128	0.0236 - 0.0248
0.0128 - 0.0140	0.0248 - 0.0260

SAMPLE LOCATION

DISCHARGE OUTLET *

EAST ISLAND BATHYMETRY

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum concentrations observed during the Phase II sampling program was used to estimate the minimum concentration at the discharge point

PROJECT

DIAVIK DIAMOND MINES INC
PLUME DELINEATION STUDY

TITLE

TOTAL BARIUM CONCENTRATIONS AT MID-DEPTH (PHASE II - ICE-COVERED)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005		
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

FIGURE: 3.1-4

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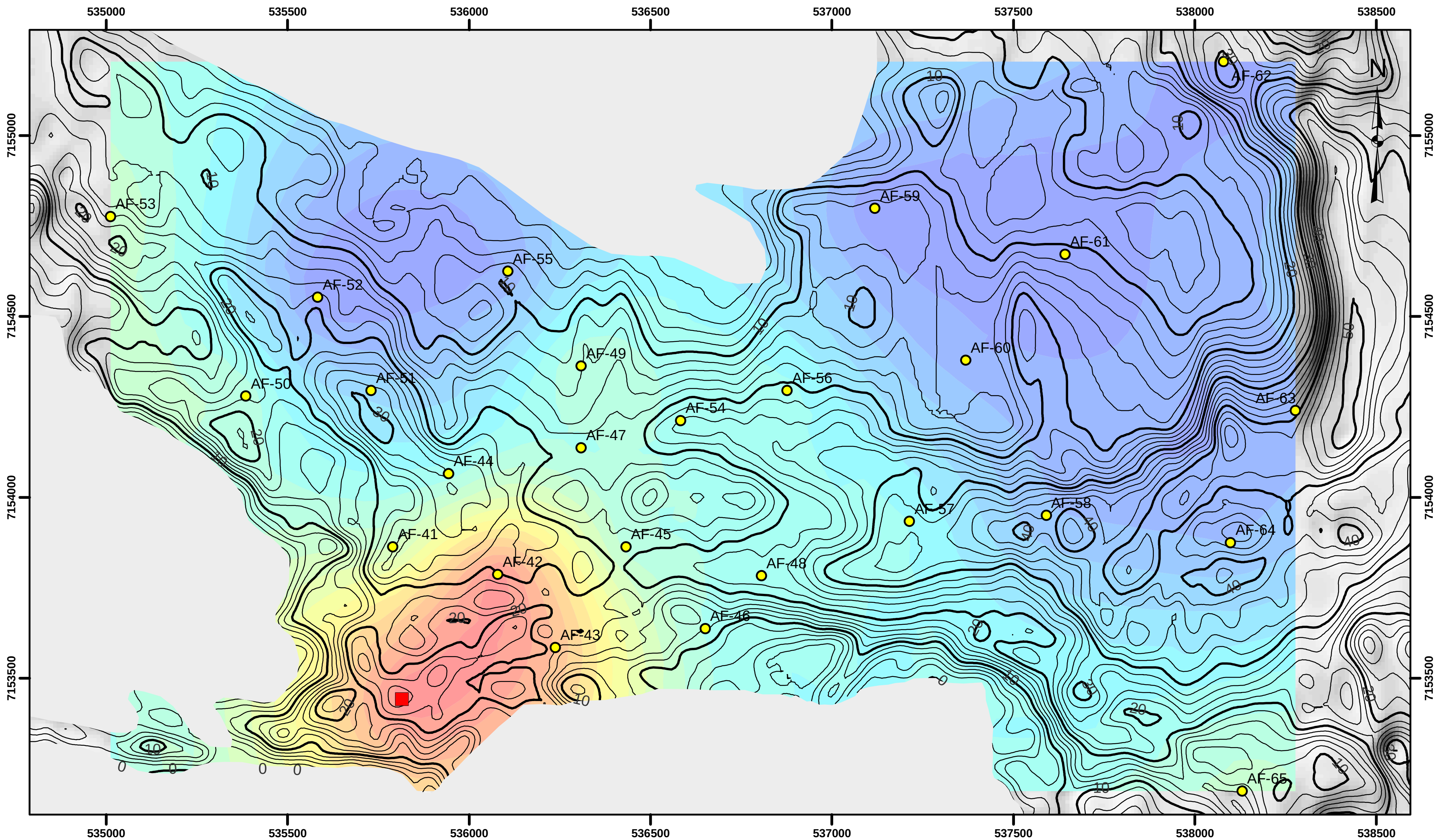


LEGEND

BARIUM CONCENTRATIONS (mg/L)

0.0020 - 0.0032	0.0140 - 0.0152
0.0032 - 0.0044	0.0152 - 0.0164
0.0044 - 0.0056	0.0164 - 0.0176
0.0056 - 0.0068	0.0176 - 0.0188
0.0068 - 0.0080	0.0188 - 0.0200
0.0080 - 0.0092	0.0200 - 0.0212
0.0092 - 0.0104	0.0212 - 0.0224
0.0104 - 0.0116	0.0224 - 0.0236
0.0116 - 0.0128	0.0236 - 0.0248
0.0128 - 0.0140	0.0248 - 0.0260

SAMPLE LOCATION

DISCHARGE OUTLET *

EAST ISLAND BATHYMETRY

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum concentrations observed during the Phase II sampling program was used to estimate the minimum concentration at the discharge point

PROJECT

DIAVIK DIAMOND MINES INC
PLUME DELINEATION STUDY

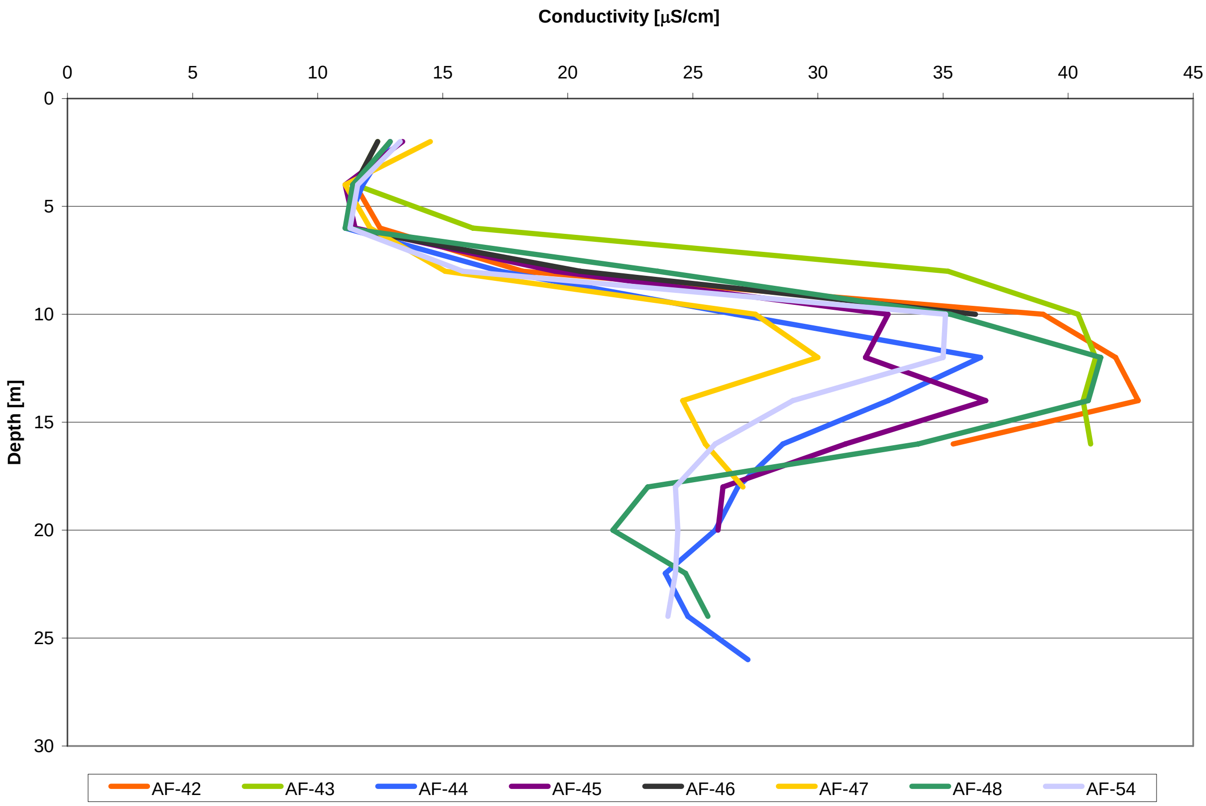
TITLE

TOTAL BARIUM CONCENTRATIONS AT BOTTOM (PHASE II - ICE-COVERED)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005	FIGURE: 3.1-5	
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

Figure 3.1-6 Vertical Profiles of Conductivity at AF-45 and Locations Adjacent to AF-45 (Ice-Covered)



3.1.2 Percent Effluent Concentration Zones

Isopleth maps showing the percent effluent concentrations based on barium results from the Phase II surveys for each of the three depths (defined as surface, mid-depth and bottom) are shown in Figures 3.1-7 through 3.1-9. Percent effluent isopleth maps are essentially normalized concentration isopleth maps; therefore, the spatial patterns are the same as those discussed in Section 3.1-2. Discussion here focuses on the 1% percent effluent concentration zone.

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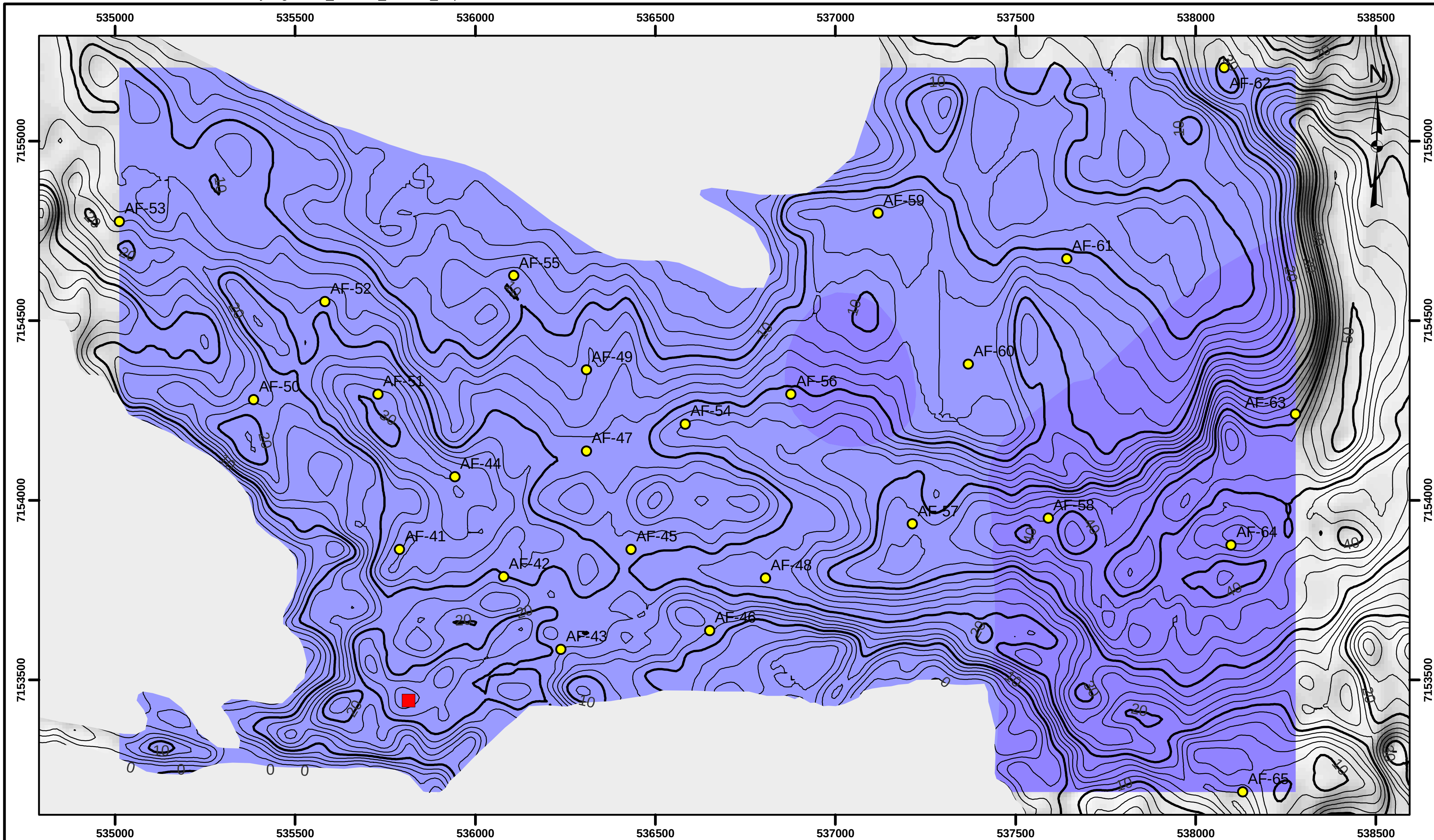

LEGEND

BARIUM PERCENT EFFLUENT

0.3% - 0.6%	3.7% - 4.1%
0.6% - 1.0%	4.1% - 4.4%
1.0% - 1.3%	4.4% - 4.8%
1.3% - 1.7%	4.8% - 5.1%
1.7% - 2.0%	5.1% - 5.5%
2.0% - 2.3%	5.5% - 5.8%
2.3% - 2.7%	5.8% - 6.2%
2.7% - 3.1%	6.2% - 6.5%
3.1% - 3.4%	6.5% - 6.9%
3.4% - 3.7%	6.9% - 7.2%

SAMPLE LOCATION

DISCHARGE OUTLET

EAST ISLAND BATHYMETRY

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE

ICE-COVERED PERCENT EFFLUENT CONCENTRATIONS AT SURFACE (TOTAL BARIUM - PHASE II)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005	**FIGURE: 3.1-7**	
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

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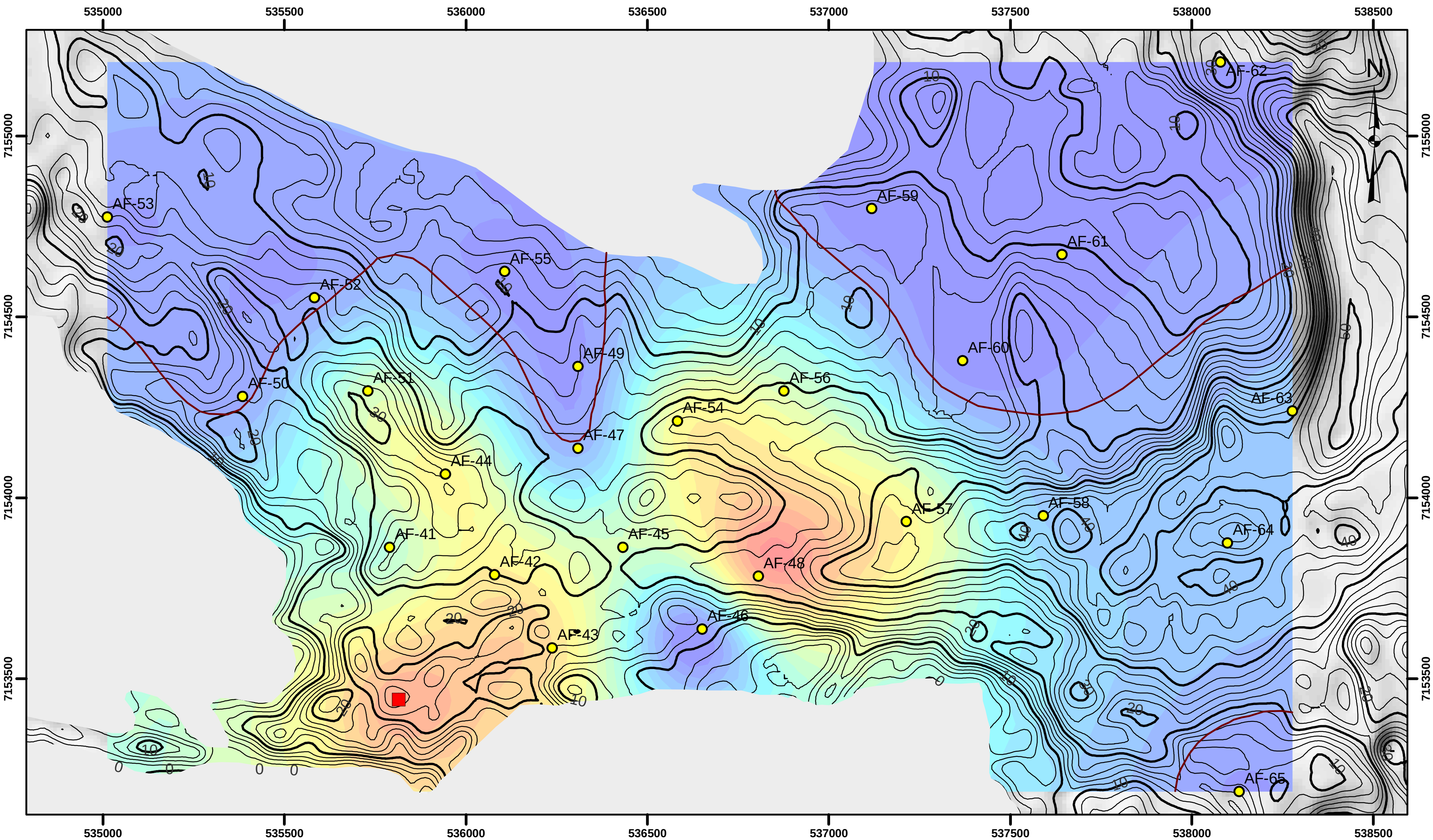

LEGEND

BARIUM PERCENT EFFLUENT

0.3% - 0.6%	3.7% - 4.1%
0.6% - 1.0%	4.1% - 4.4%
1.0% - 1.3%	4.4% - 4.8%
1.3% - 1.7%	4.8% - 5.1%
1.7% - 2.0%	5.1% - 5.5%
2.0% - 2.3%	5.5% - 5.8%
2.3% - 2.7%	5.8% - 6.2%
2.7% - 3.1%	6.2% - 6.5%
3.1% - 3.4%	6.5% - 6.9%
3.4% - 3.7%	6.9% - 7.2%

SAMPLE LOCATION

DISCHARGE OUTLET *

EAST ISLAND BATHYMETRY

ONE PERCENT EFFLUENT ZONE

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum percent effluent observed during the Phase II sampling program was used to estimate the minimum percent effluent at the discharge point

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE

ICE-COVERED PERCENT EFFLUENT CONCENTRATION AT MID-DEPTH (TOTAL BARIUM - PHASE II)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005	**FIGURE: 3.1-8**	
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

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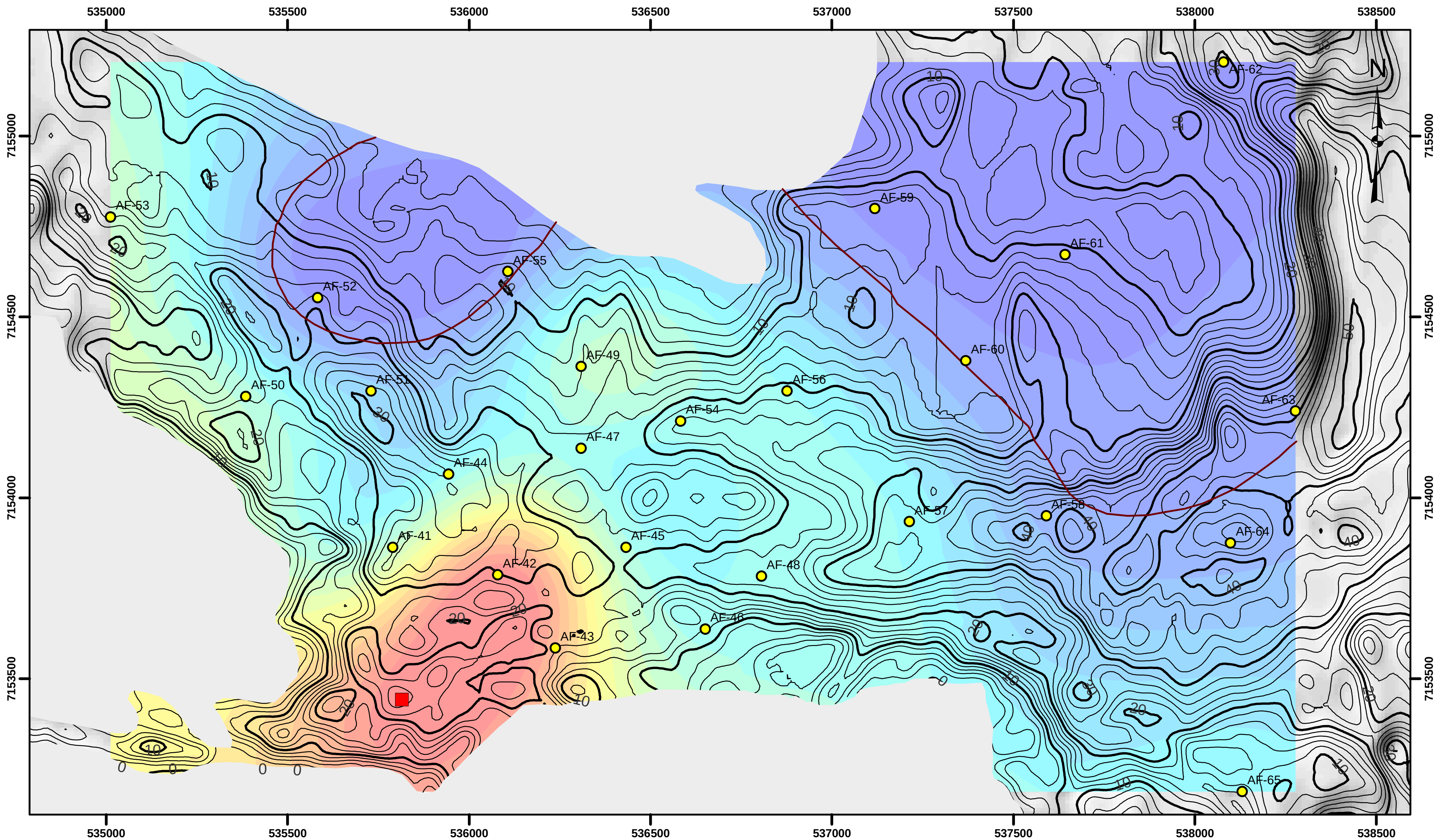


LEGEND

BARIUM PERCENT EFFLUENT

0.3% - 0.6%	3.7% - 4.1%
0.6% - 1.0%	4.1% - 4.4%
1.0% - 1.3%	4.4% - 4.8%
1.3% - 1.7%	4.8% - 5.1%
1.7% - 2.0%	5.1% - 5.5%
2.0% - 2.3%	5.5% - 5.8%
2.3% - 2.7%	5.8% - 6.2%
2.7% - 3.1%	6.2% - 6.5%
3.1% - 3.4%	6.5% - 6.9%
3.4% - 3.7%	6.9% - 7.2%

SAMPLE LOCATION
DISCHARGE OUTLET *
EAST ISLAND BATHYMETRY
ONE PERCENT EFFLUENT ZONE

250 125 0 250 500
SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12
*The maximum percent effluent observed during the Phase II sampling program was used to estimate the minimum percent effluent at the discharge point

PROJECT
DIAVIK DIAMOND MINE INC.
PLUME DELINEATION STUDY

TITLE
ICE-COVERED PERCENT EFFLUENT CONCENTRATIONS AT BOTTOM (TOTAL BARIUM - PHASE II)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005	**FIGURE: 3.1-9**	
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

All water samples at the surface depth (2 m below surface) were below 1% effluent concentration during the Phase II surveys, which was consistent with the effluent plume not reaching the surface under ice-covered conditions.

The 1% effluent concentration boundary at the bottom and at mid-depth occurred at a distance of approximately 1 km north of the discharge and 1.7 km to the northeast. East of the discharge, the 1% effluent concentration boundary extended beyond the boundary of the sampling grid.

3.1.3 Vertical Profiles

Vertical profiles were examined to evaluate the vertical position and shape of the plume at different locations and at different times. Profiles were examined for the Phase II surveys, and for the SNP and AEMP stations located near the discharge. For the purposes of presenting profiles, monitoring locations were grouped into transects, which are shown in Figure 2.3-2. The vertical profiles of field conductivity at all sampling locations are presented in Appendix B (Figures B-1 to B-18).

Vertical profiles indicate that concentrations in the plume near the discharge were similar at bottom and mid-depth. Profiles at monitoring locations northeast of the discharge showed that maximum concentrations in the plume were near the middle of the water column. An example of this pattern was seen in the profiles along transects 3 and 4 from the Phase II survey (Figures 3.1-10 and 3.11). The occurrence of maximum conductivity values near mid-depth at these stations was consistent with the pattern observed in barium concentrations and supports the conclusion that the plume was detached from the bottom further from the discharge.

Conductivity values were low and relatively constant throughout the water column in Phase II profiles for transects 6 and 7 (Figure 3.1-12), indicating that the plume was not clearly detectable at sampling locations furthest from the discharge.

Figure 3.1-10 Field Conductivity Profiles at Sampling Locations Along Transect 3 (Phase II Ice-Covered)

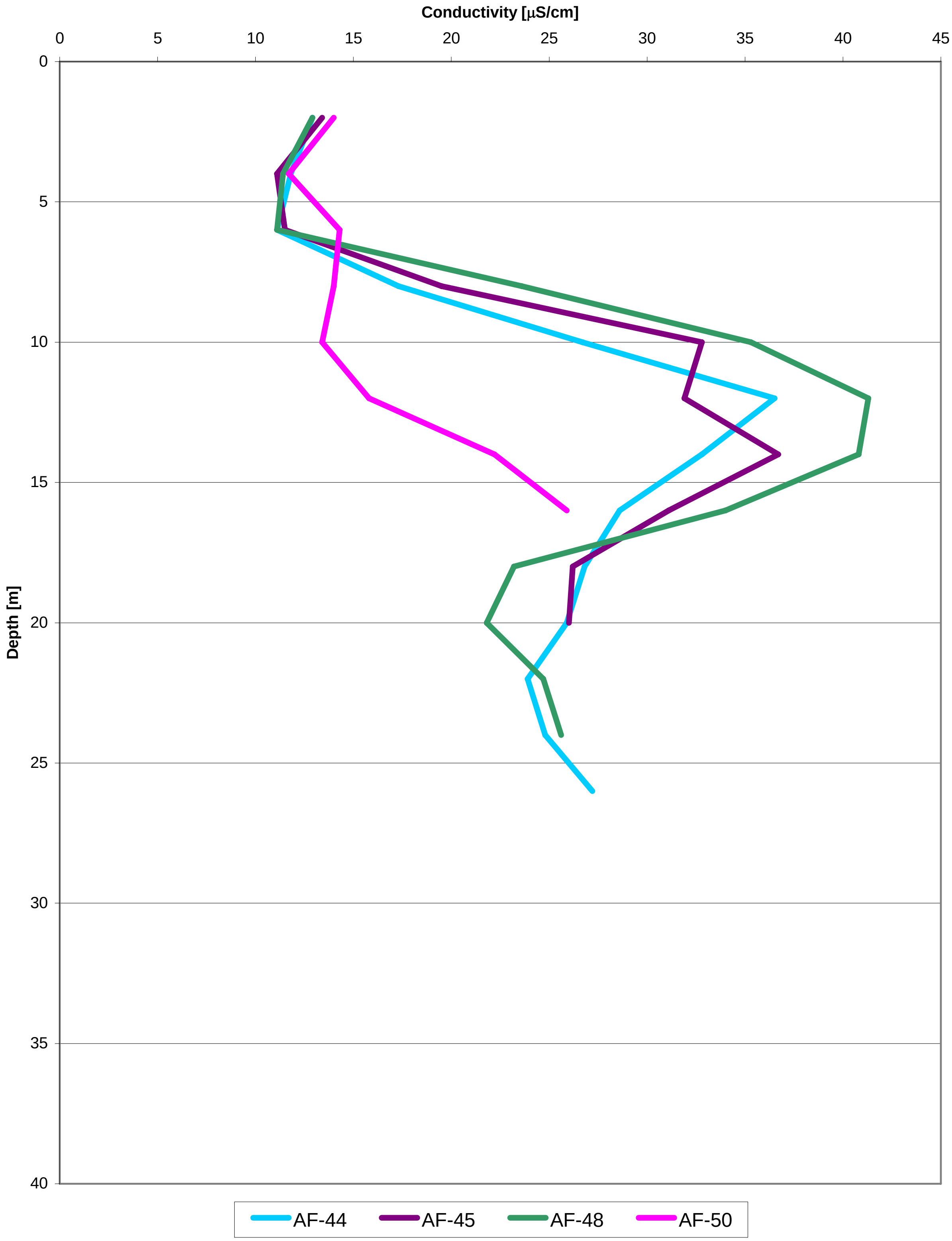


Figure 3.1-11 Field Conductivity Profiles at Sampling Locations Along Transect 4 (Phase II Ice-Covered)

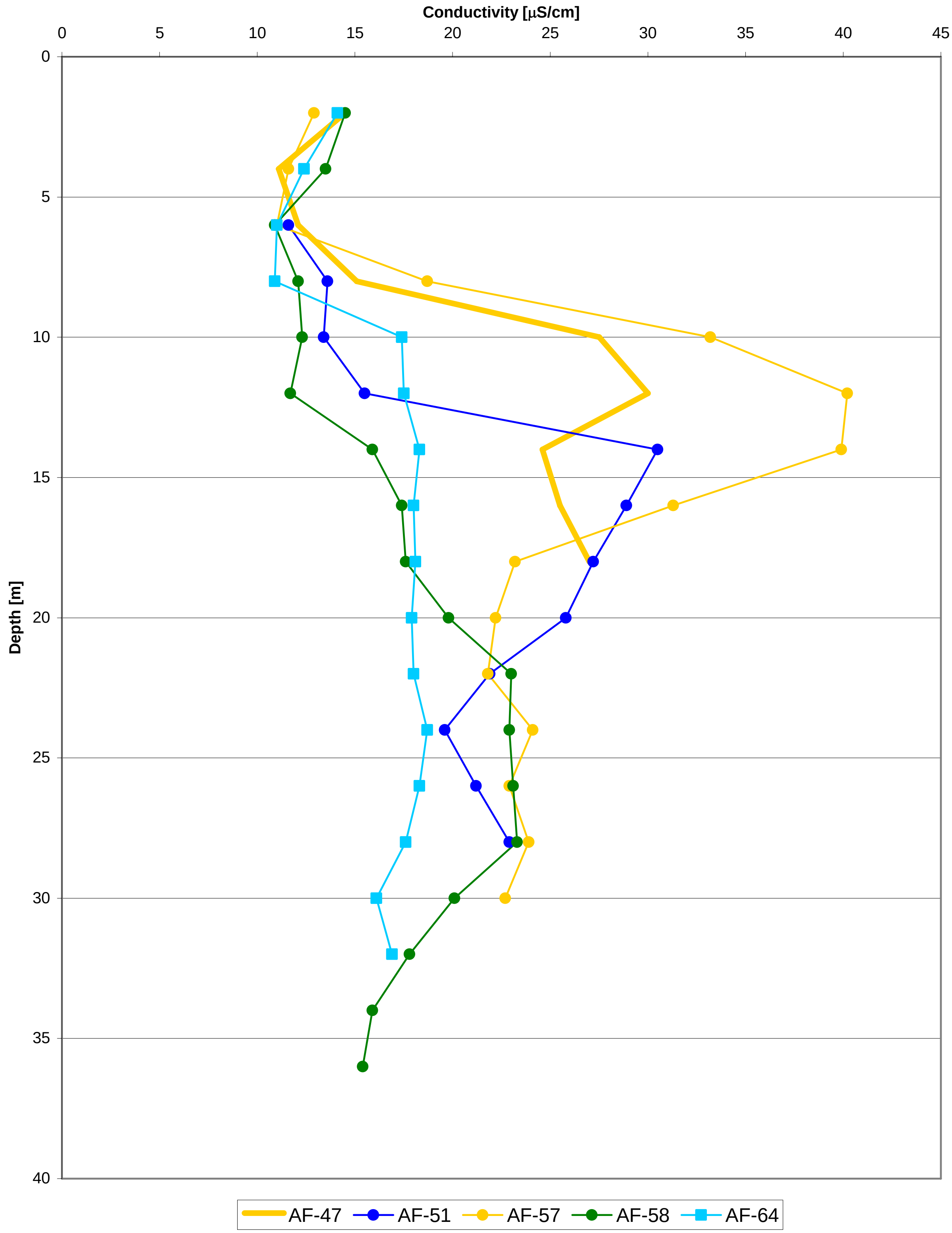
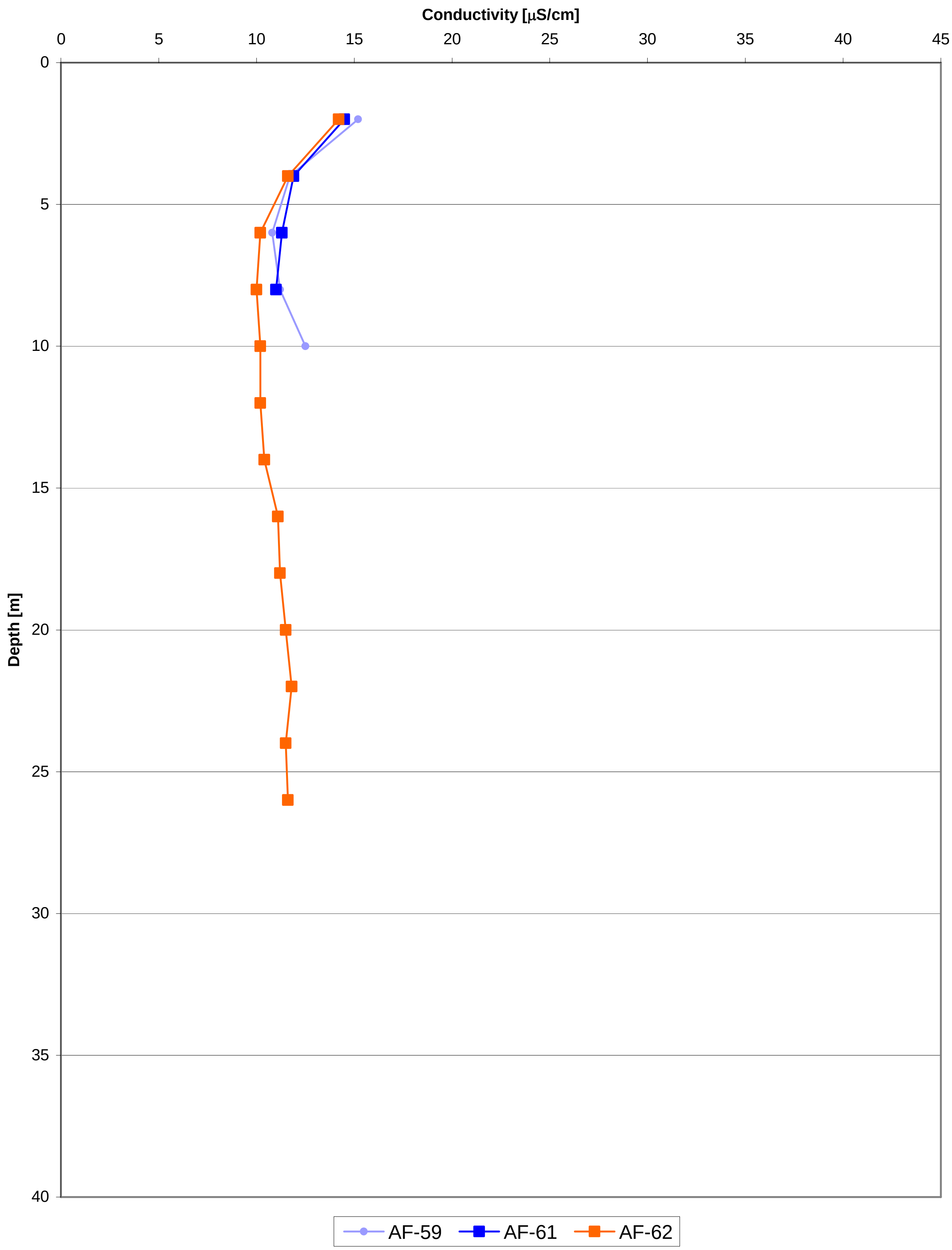
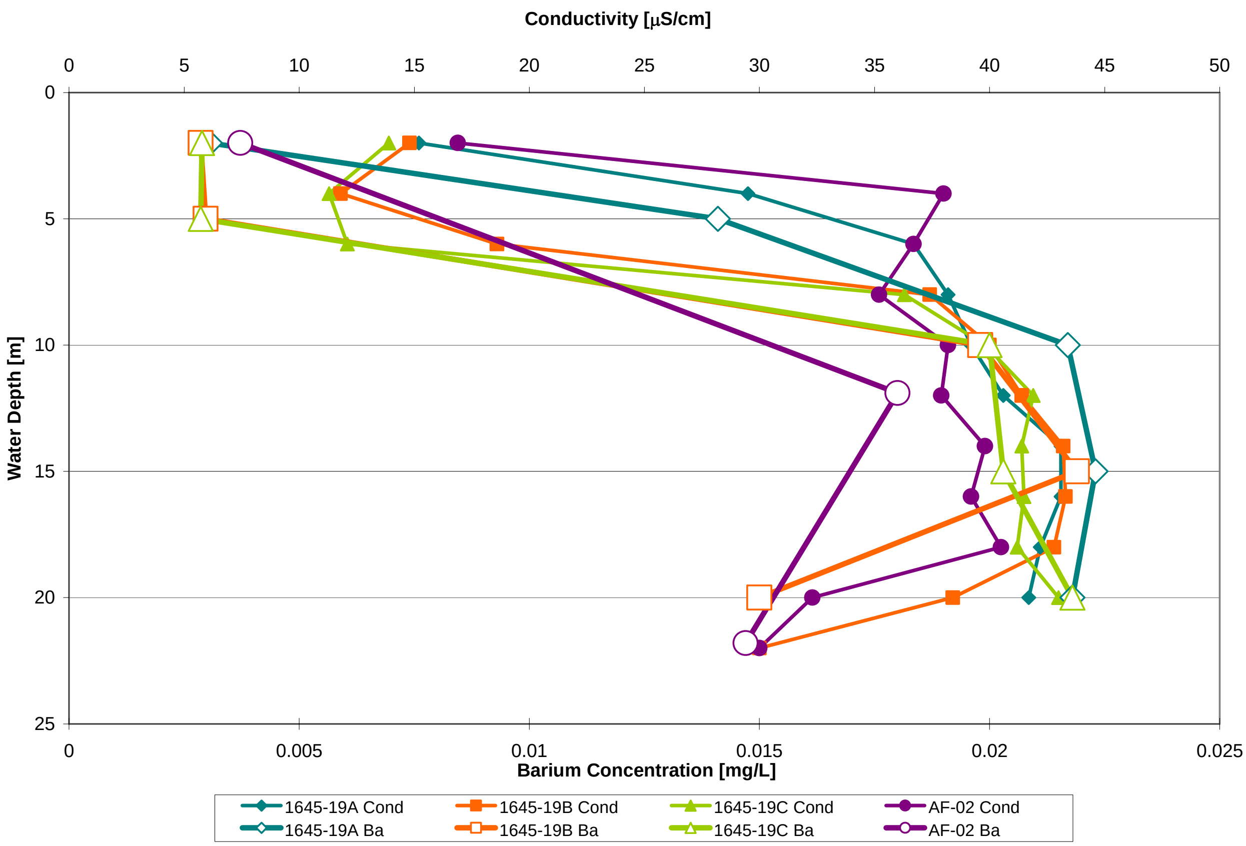


Figure 3.1-12 Field Conductivity Profiles at Sampling Locations Along Transects 6 and 7 (Phase II Ice-Covered)



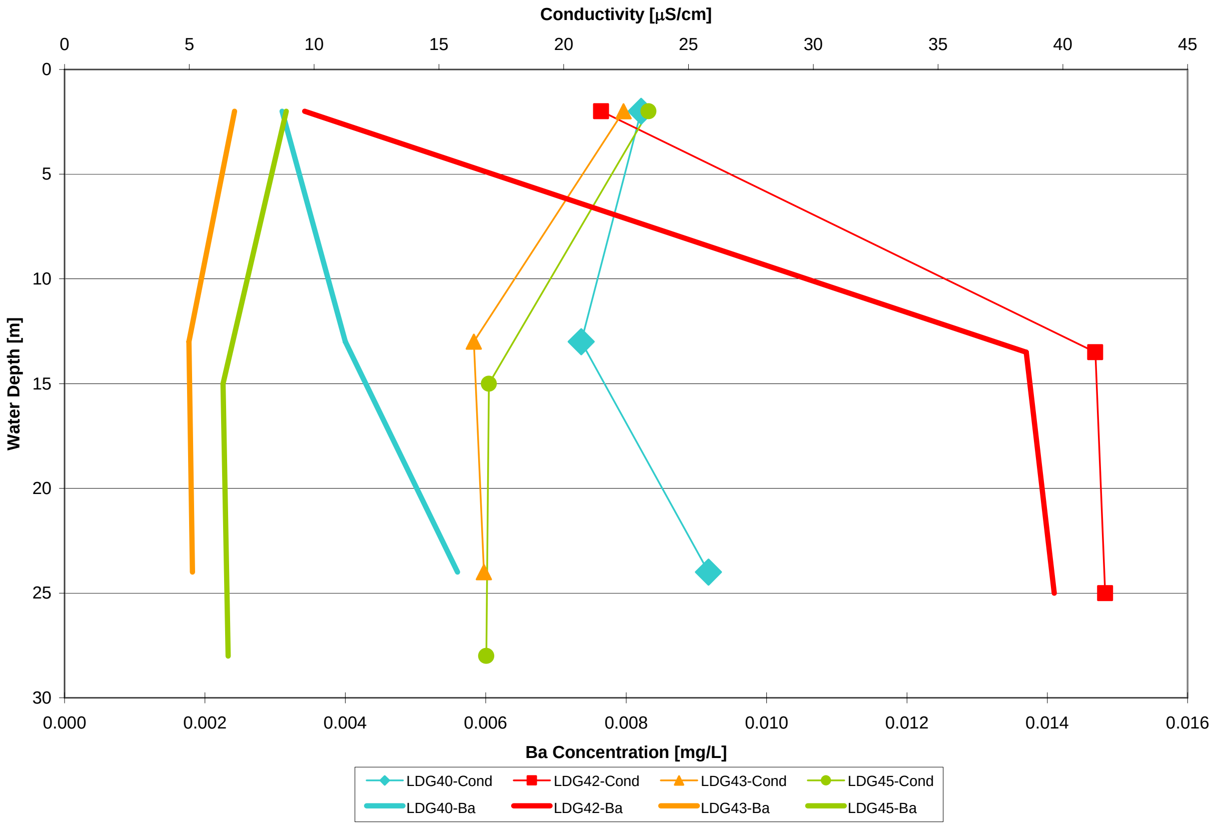
Vertical plots of conductivity and barium from the three SNP stations closest to the discharge (i.e., 1645-19 A, B and C) were compared to profiles at AF-2 in Figure 3.1-13 to determine whether the plume program results were consistent with the SNP results. AF-2 was selected because it was the closest monitoring location to SNP 1645-19. The profiles at the SNP stations follow a similar pattern compared to the profiles at AF-2 (Figure 3.1-13), which confirms that results from the plume delineation monitoring program were consistent with observations from DDMI's other monitoring programs.

Figure 3.1-13 Total Barium and Field Conductivity Profiles at SNP Station 1645-19 (April 28, 2005)



Depth profiles of total barium concentrations and field conductivity measurements at AEMP stations closest to the discharge, excluding SNP1645-19, are shown in Figure 3.1-14. The plume was only clearly detectable at Station LDG-42, which was the closest station to the discharge point, where barium and conductivity values increased between the depths of 2 m to 14 m. This observation was consistent with the conductivity and barium maps in Phase II which showed that the plume was detectable at the location of LDG-42 and was located in the bottom to middle of Lac de Gras.

Figure 3.1-14 Total Barium and Field Conductivity Profiles at AEMP Stations Closest to Discharge Outlet (excluding SNP1645-19) (May 2005)



In general, the vertical profile data was consistent with the interpretation of the isopleth and percent effluent concentration mapping and showed:

- The centre-line of the plume was located near the bottom close to the discharge.
- Further from the discharge (approximately 1 km), the centre-line of the plume was located at mid-depth northeast of the discharge outlet.
- At the Phase II stations furthest from the discharge, the plume was not clearly detectable.

3.2 Nitrification

The occurrence of nitrification within the plume was evaluated using two approaches:

- comparison of the rates of decrease in the percent effluent concentrations of barium, nitrate, and ammonia as a function of distance from the discharge outlet; and,
- the difference in percent effluent concentration between barium and ammonia, and barium and nitrate.

Levels of DO and the isopleth mapping were also reviewed to support the finding from the two above approaches.

The percent effluent concentrations of total barium, ammonia and nitrate as a function of distance away from the discharge outlet were reviewed to determine whether these results were consistent with nitrification occurring within the plume. All percent effluent concentration results are presented in Appendix D. Ammonia percent effluent values decrease more rapidly with distance from the discharge than either barium or nitrate (Figure 3.2-1), which was consistent with nitrification.. There is too much scatter in the plots of barium and nitrate versus distance from the discharge to distinguish a difference in slopes.

The difference in percent effluent concentration for barium and nitrate (barium minus nitrate) and barium and ammonia (barium minus ammonia) are shown in Figure 3.2-2. Ammonia percent effluent concentrations were consistently lower than barium percent values whereas nitrate percent effluent concentrations were consistently slightly higher than barium dilution values. The pattern observed in this plot was also consistent with nitrification. These patterns were also observed in the mid-depth plots of percent effluent concentration and difference in percent effluent concentrations for total barium, ammonia and nitrate (Figures 3.2-3 and 3.2-4).

All DO values measured during Phase II were greater than 2 mg/L; therefore, DO levels would not have inhibited nitrification from occurring within the plume.

Isopleth maps of ammonia and nitrate concentrations for the Phase II survey (Figure 3.2-5 to Figure 3.2-8) were also compared to barium isopleths maps from the Phase II survey. The qualitative comparison was to determine whether changes in concentrations were consistent with nitrification having occurred to a measurable extent within the plume. Surface concentration of ammonia and nitrate were not mapped because the plume does not appear to have reached the surface during the Phase II survey.

Bottom and mid-depth ammonia concentrations (Figures 3.2-5 and 3.2-6) in Phase II decrease more quickly compared to barium concentrations at the same depths (Figures 3.1-11 and 3.1-10). By contrast, the bottom and mid-depth nitrate concentrations (Figure 3.2-7 and 3.2-8) decrease more slowly compared to barium concentrations. This pattern was consistent with the process of nitrification which would cause ammonia concentrations to decrease and nitrate concentrations to increase as ammonia is converted to nitrate.

In general, the results of the rates of decreasing percent effluent concentrations, the differences in the percent effluent concentrations and the isopleth mapping were consistent with nitrification occurring within the plume during the Phase II ice-covered survey.

Figure 3.2-1 Percent Effluent Concentrations for Total Barium, Ammonia and Nitrate Near Lake Bottom (Phase II – Ice Covered)

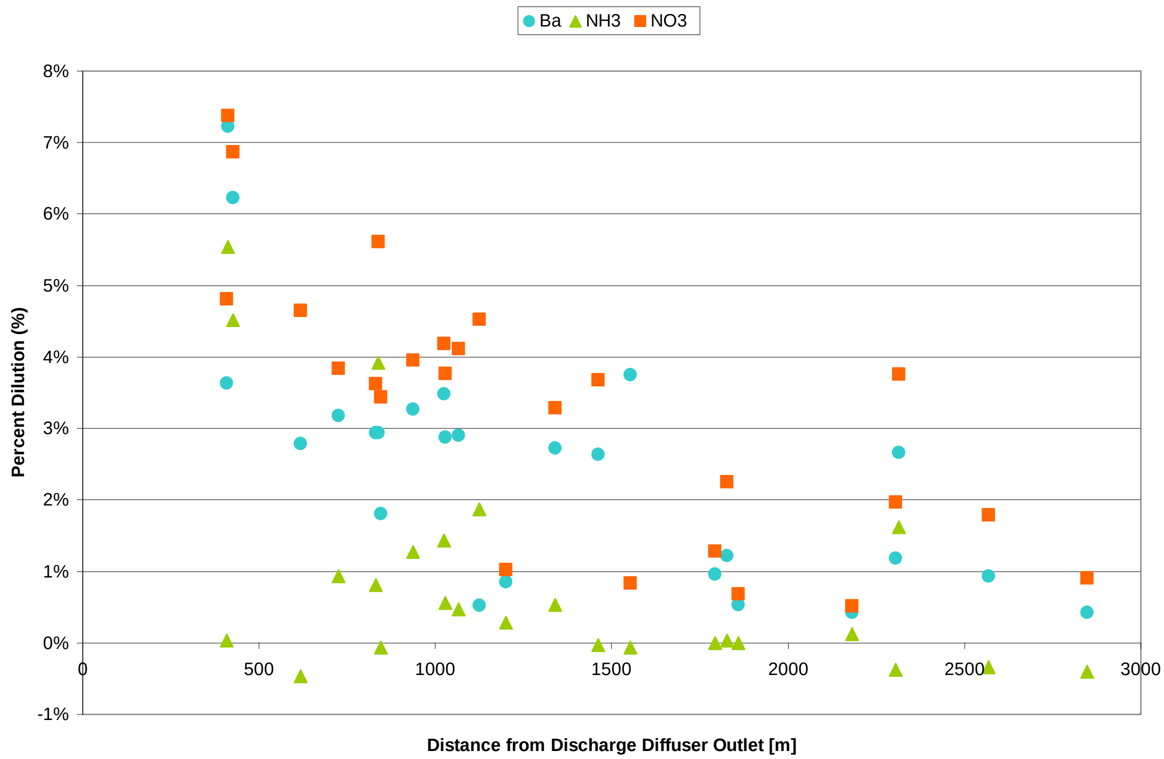


Figure 3.2-2 Difference in Percent Effluent Concentrations for Total Barium, Ammonia and Nitrate Near Lake Bottom (Phase II – Ice-Covered)

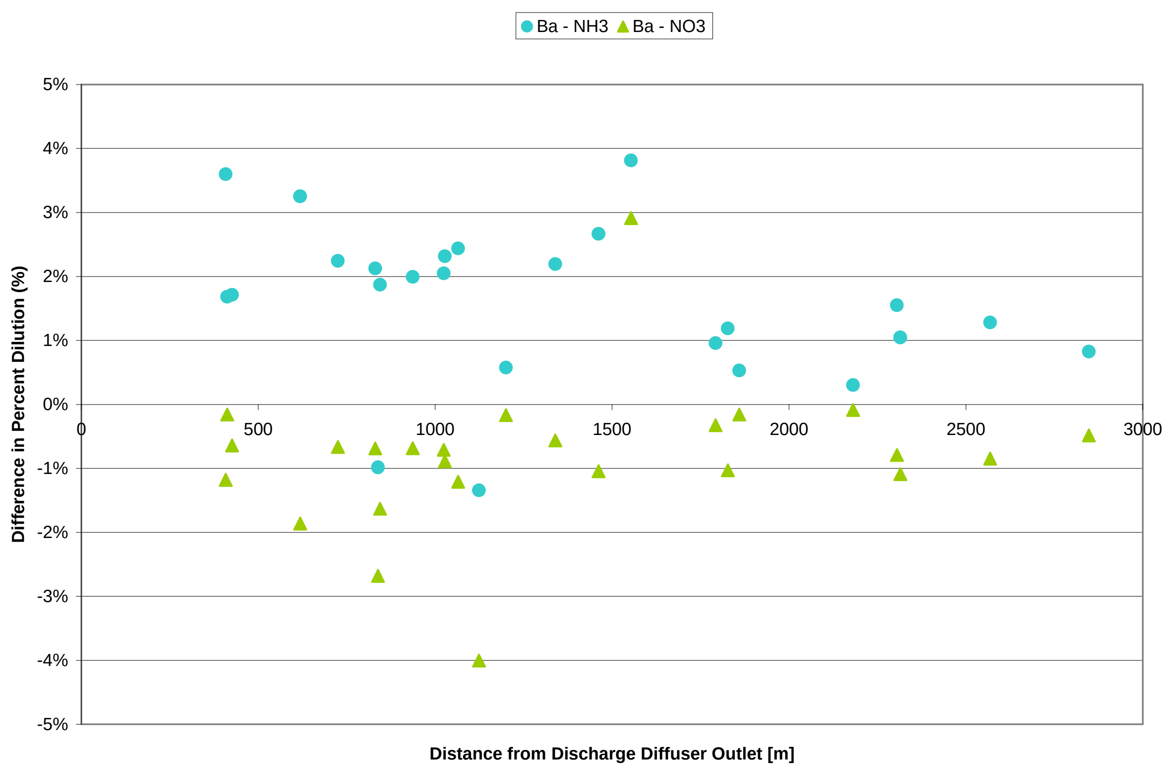


Figure 3.2-3 Percent Effluent Concentrations for Total Barium, Ammonia and Nitrate at Mid-Depth (Phase II – Ice-Covered)

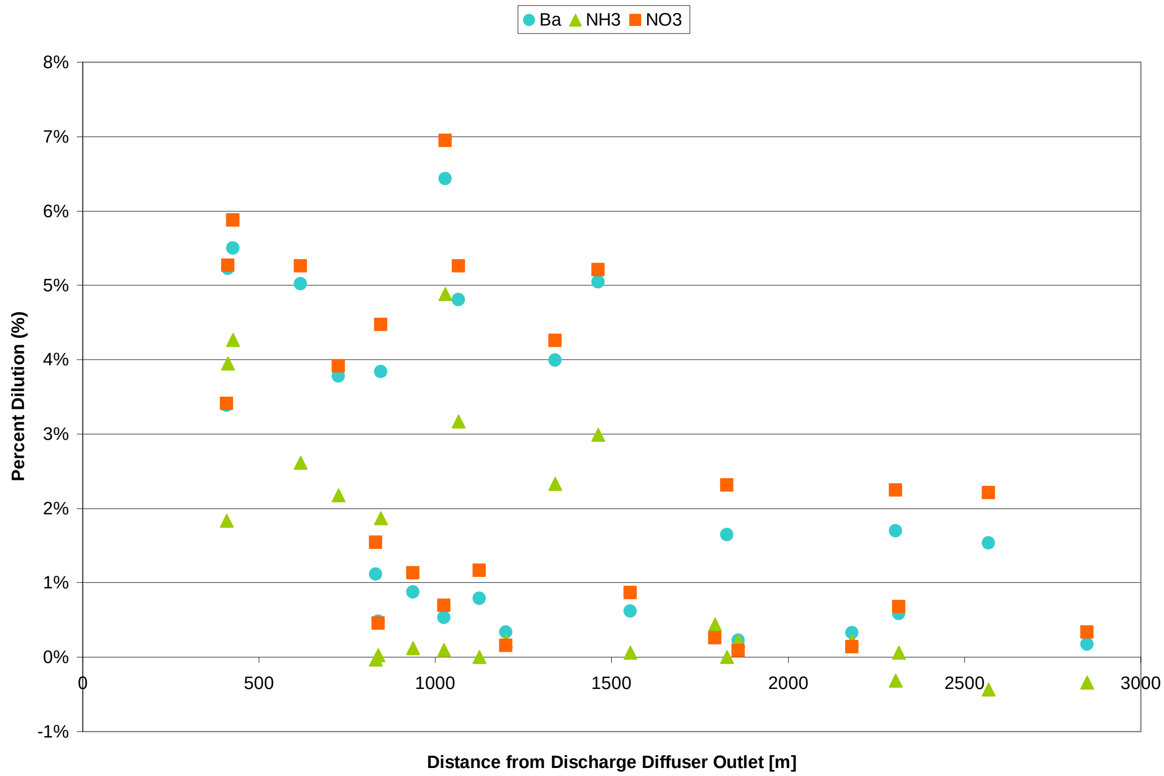
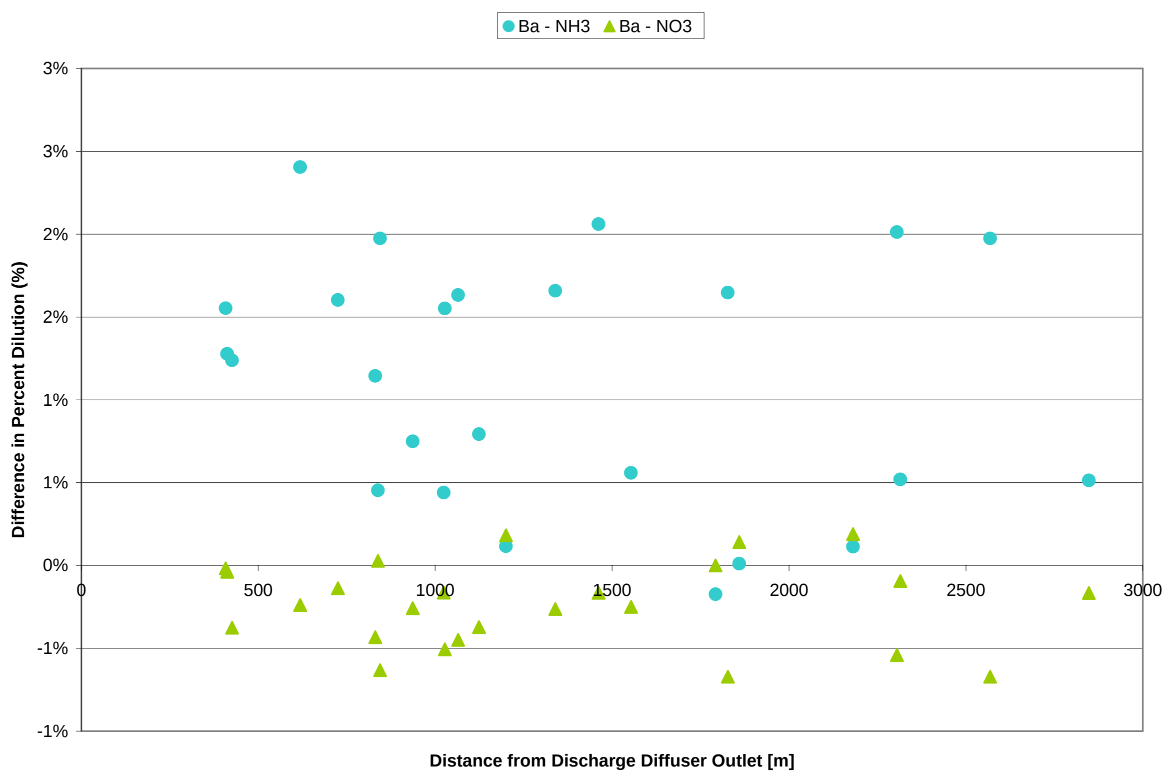


Figure 3.2-4 Difference in Percent Effluent Concentrations for Total Barium, Ammonia and Nitrate at Mid-Depth (Phase II – Ice Covered)



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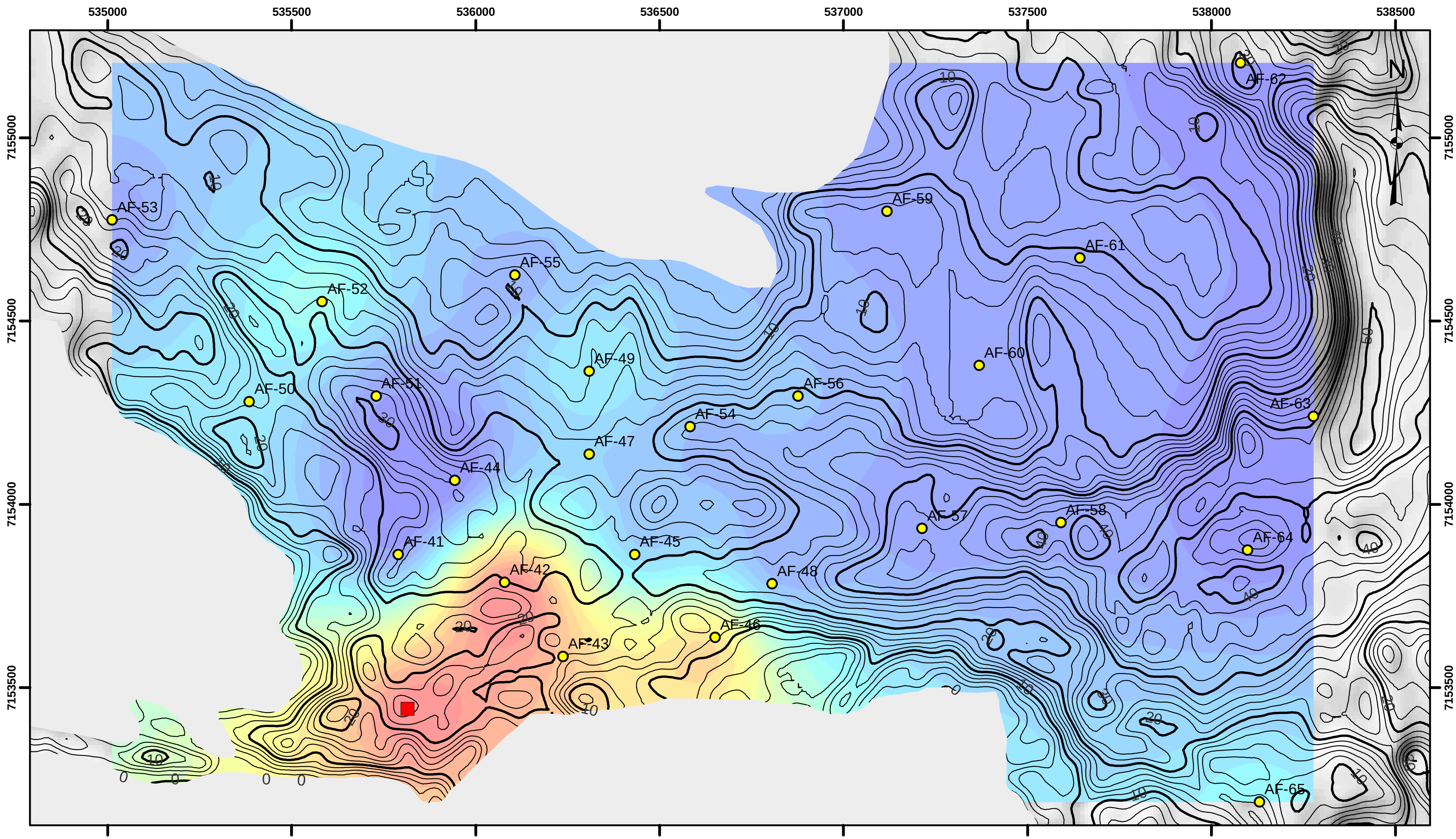

LEGEND

AMMONIA CONCENTRATIONS (mg/L)

- 0.0070 - 0.0166
- 0.0166 - 0.0262
- 0.0262 - 0.0358
- 0.0358 - 0.0454
- 0.0454 - 0.0550
- 0.0550 - 0.0646
- 0.0646 - 0.0742
- 0.0742 - 0.0838
- 0.0838 - 0.0934
- 0.0934 - 0.1030
- 0.1030 - 0.1126
- 0.1126 - 0.1222
- 0.1222 - 0.1318
- 0.1318 - 0.1414
- 0.1414 - 0.1510
- 0.1510 - 0.1606
- 0.1606 - 0.1702
- 0.1702 - 0.1796
- 0.1796 - 0.1894
- 0.1894 - 0.1990

SAMPLE LOCATION

DISCHARGE OUTLET *

EAST ISLAND BATHYMETRY

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum concentrations observed during the Phase II sampling program was used to estimate the minimum concentration at the discharge point

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE

TOTAL AMMONIA CONCENTRATIONS AT BOTTOM (PHASE II - ICE-COVERED)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005	**FIGURE: 3.2-5**	
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

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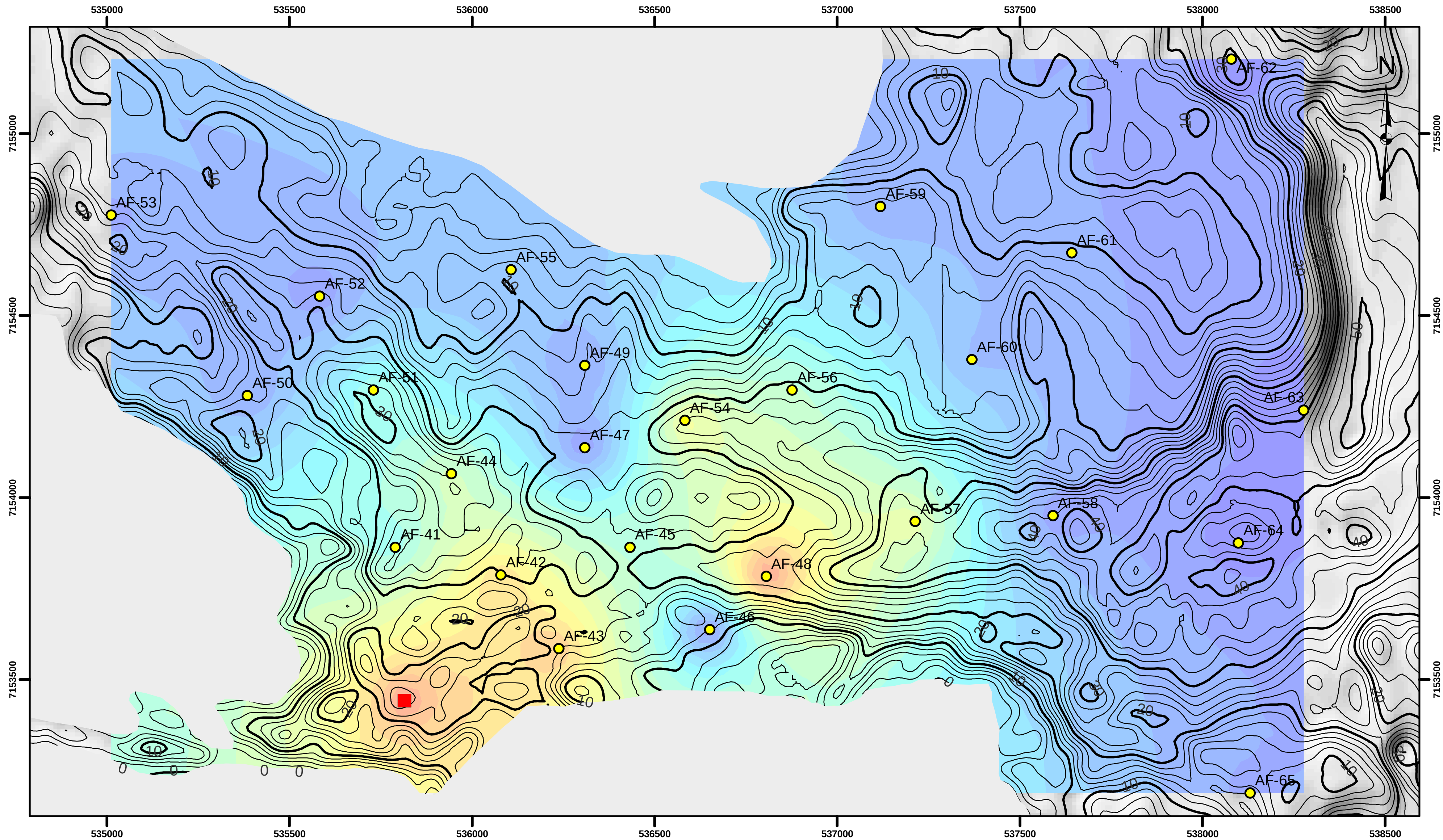

LEGEND

AMMONIA CONCENTRATIONS (mg/L)

0.0070 - 0.0166	0.1030 - 0.1126
0.0166 - 0.0262	0.1126 - 0.1222
0.0262 - 0.0358	0.1222 - 0.1318
0.0358 - 0.0454	0.1318 - 0.1414
0.0454 - 0.0550	0.1414 - 0.1510
0.0550 - 0.0646	0.1510 - 0.1606
0.0646 - 0.0742	0.1606 - 0.1702
0.0742 - 0.0838	0.1702 - 0.1796
0.0838 - 0.0934	0.1796 - 0.1894
0.0934 - 0.1030	0.1894 - 0.1990

SAMPLE LOCATION
DISCHARGE OUTLET *
EAST ISLAND BATHYMETRY

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum concentrations observed during the Phase II sampling program was used to estimate the minimum concentration at the discharge point

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE

TOTAL AMMONIA CONCENTRATIONS AT MID-DEPTH (PHASE II - ICE-COVERED)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005	**FIGURE: 3.2-6**	
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

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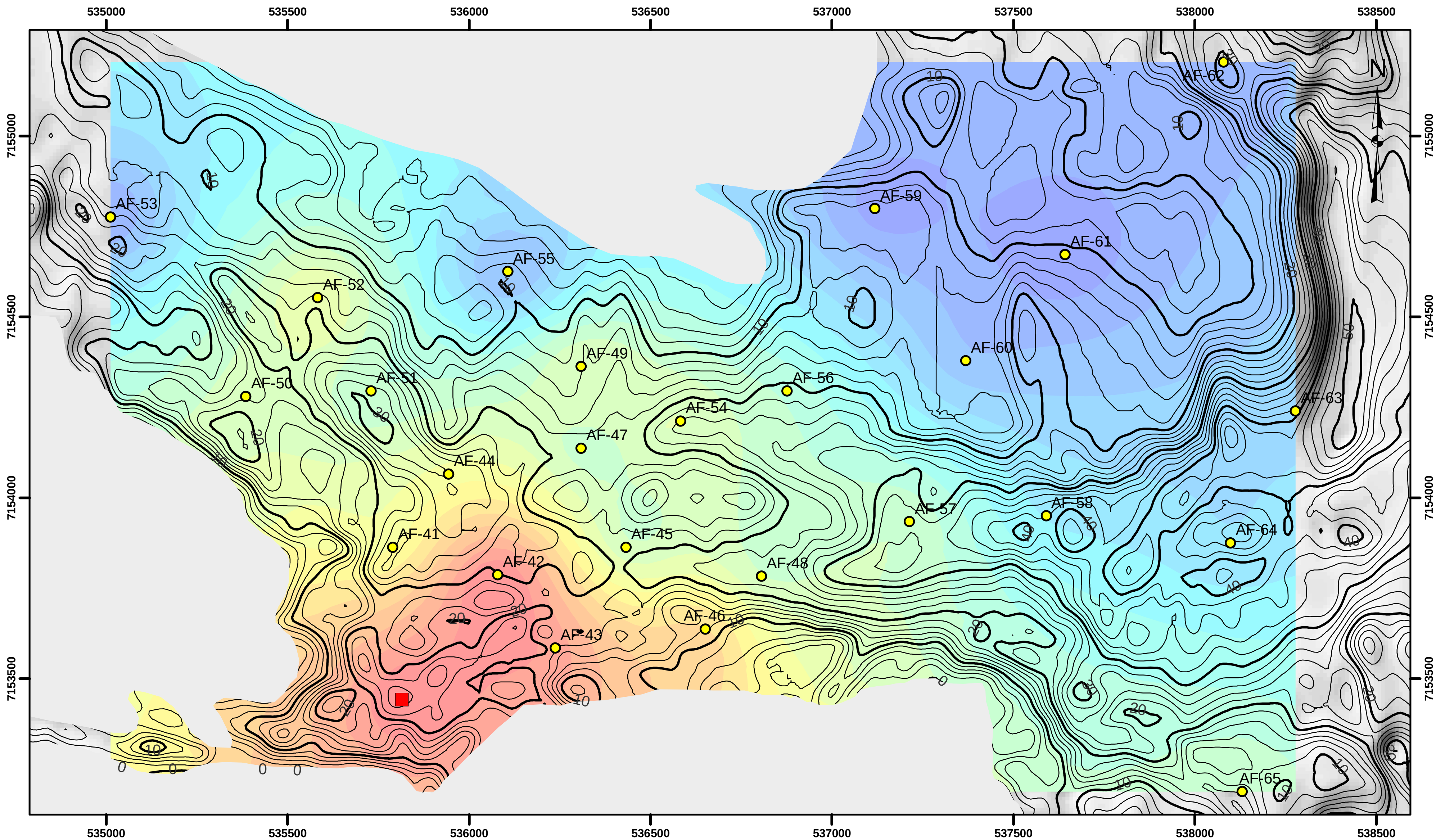

LEGEND

NITRATE CONCENTRATIONS (mg/L)

0.0160 - 0.0495	0.3525 - 0.3860
0.0495 - 0.0830	0.3860 - 0.4195
0.0830 - 0.1180	0.4195 - 0.4530
0.1180 - 0.1515	0.4530 - 0.4865
0.1515 - 0.1850	0.4865 - 0.5200
0.1850 - 0.2185	0.5200 - 0.5535
0.2185 - 0.2520	0.5535 - 0.5870
0.2520 - 0.2855	0.5870 - 0.6205
0.2855 - 0.3190	0.6205 - 0.6540
0.3190 - 0.3525	0.6540 - 0.6875

SAMPLE LOCATION
DISCHARGE OUTLET *
EAST ISLAND BATHYMETRY

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12
*The maximum concentrations observed during the Phase II sampling program was used to estimate the minimum concentration at the discharge point

250 125 0 250 500
SCALE 1:15,000 METRES

PROJECT
DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE
NITRATE CONCENTRATIONS AT BOTTOM (PHASE II - ICE-COVERED)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005	FIGURE: 3.2-7	
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

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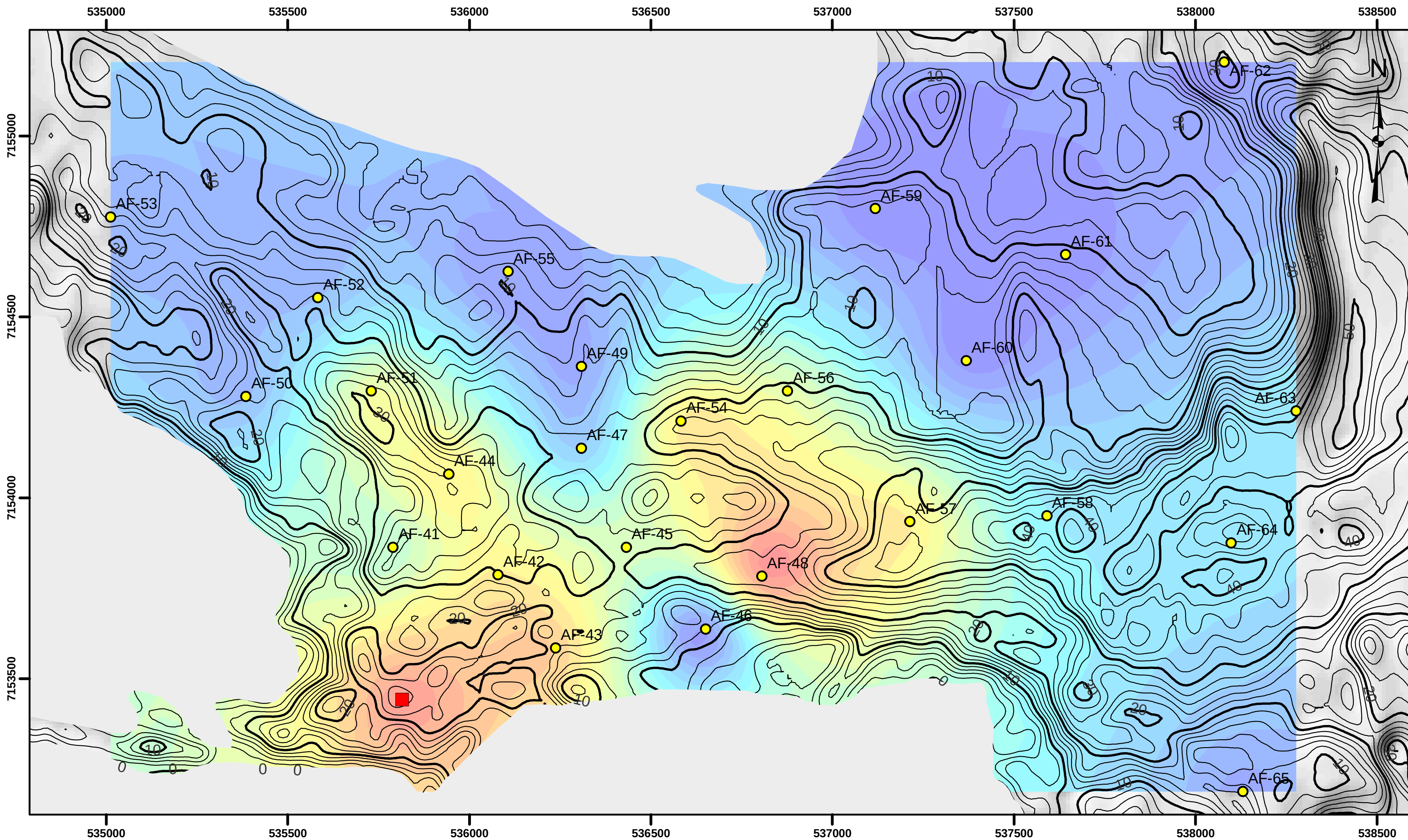

LEGEND

NITRATE CONCENTRATIONS (mg/L)

0.0160 - 0.0495	0.3525 - 0.3860
0.0495 - 0.0830	0.3860 - 0.4195
0.0830 - 0.1180	0.4195 - 0.4530
0.1180 - 0.1515	0.4530 - 0.4865
0.1515 - 0.1850	0.4865 - 0.5200
0.1850 - 0.2185	0.5200 - 0.5535
0.2185 - 0.2520	0.5535 - 0.5870
0.2520 - 0.2855	0.5870 - 0.6205
0.2855 - 0.3190	0.6205 - 0.6540
0.3190 - 0.3525	0.6540 - 0.6875

SAMPLE LOCATION

DISCHARGE OUTLET *

EAST ISLAND BATHYMETRY

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum concentrations observed during the Phase II sampling program was used to estimate the minimum concentration at the discharge point

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE

NITRATE CONCENTRATIONS AT MID-DEPTH (PHASE II - ICE-COVERED)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005		
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

FIGURE: 3.2-8

3.3 QA/QC

3.3.1 Water Quality

The results of duplicate and blank samples were compared to QA/QC criteria described in Section 2.2.

The variation in duplicate samples during the Phase I survey was above the criterion of 20% for three parameters, or 11.5% of the total number (26) of parameters (Appendix C). During the Phase II survey, 9 parameters, or 22.5% of the total number (40) of parameters, were above the criterion of 20% in the duplicate samples.

The number of parameters detected in blanks at concentrations greater than five times the detection limit during the Phase I survey ranged from 1 to 4, corresponding to 3.8 to 15.4% of the total number of parameters. During the Phase II survey, the number of parameters detected in blanks at concentrations greater than five times the detection limit ranged from 3 to 4, corresponding to 7.7 to 10.3% of the total number of parameters.

The QA/QC results for total barium, ammonia and nitrate were consistent with the overall QA/QC results (Table 3.3-1).

The analytical precision in duplicate samples and the number of parameters with significant concentrations in blanks were considered reasonable, given the low detection limits achieved by the analytical laboratory.

Table 3.3-1 Quality Control Results for Total Barium, Ammonia and Nitrate (Phase I and Phase II – Ice-Covered)

Parameter	Sampling Site	Units	Detection Limit	Duplicate 1	Duplicate 2	Travel Blank	Field Blank	Equipment Blank	Results
Phase I Part A									
Barium [Ba]	N/A	mg/L	0.00005					0.00032	Blank> 5X Detection Limit
	N/A						0.00007		valid
	N/A					0.00005			valid
	AF-05-M			0.0182	0.0181				valid
	AF-15-T			0.000298	0.00311				valid
	AF-19-B			0.0165	0.0166				valid
	AF-23-M			0.0196	0.0194				valid
	AF-23-M			0.00006	0.00006				Dup1&2 < 5X Detection Limit
	AF-23-M			0.0008	0.0008				Dup1&2 < 5X Detection Limit
Phase I Part B									
Barium [Ba]	AF-34-M	mg/L	0.00005	0.0146	0.0149				valid
	AF-37-B			0.0175	0.0174				valid
	AF-38-T			0.00308	0.00321				valid
	AF-40-M			0.00341	0.00338				valid
Phase II									
Ammonia [NH_3]	N/A	mg/L	0.005			0.005			valid
	N/A							0.005	valid
	N/A						0.005		valid
	AF-54-T			0.03	0.032				valid
	AF-59-B			0.021	0.029				Dup1 < 5X Detection Limit; Conc. Diff. > 20%
	AF-62-T			0.033	0.04				Conc. Diff. > 20%
	AF-65-T			0.026	0.028				valid
Barium [Ba]	N/A	mg/L	0.00005			0.00005			valid
	N/A							0.00005	valid
	N/A						0.00005		valid
	AF-54-T			0.00336	0.00341				valid
	AF-59-B			0.00343	0.00301				valid
	AF-62-T			0.00346	0.00354				valid
	AF-65-T			0.00439	0.00437				valid
Nitrate [NO_3]	N/A	mg/L	0.006			0.006			valid
	N/A							0.006	valid
	N/A						0.006		valid
	AF-54-T			0.049	0.049				valid
	AF-59-B			0.071	0.047				Conc. Diff. > 20%
	AF-62-T			0.02	0.021				valid
	AF-65-T			0.085	0.088				valid
	AF-50-M							0.02	valid
	AF-53-M						0.02		valid
	AF-54-T			0.72	0.73				valid
	AF-59-B			0.73	0.71				valid
	AF-62-T			0.7	0.9				valid
	AF-65-T			0.77	0.77				valid

Note: N/A=not applicable

3.4 Summary of Ice-Covered Results

3.4.1 Plume Delineation

Based on the results of the plume delineation surveys, descriptions of the shape, extent and characteristics of the plume from the NIWTP under ice-covered conditions in Lac de Gras are summarized below:

- During the Phase II survey, the plume appears to have pooled near the bottom of the lake near the discharge, spreading primarily in a north and easterly direction away from the East Island, which is the land mass to the west of the discharge.
- The plume was detected at bottom and mid-depth sampling locations, and became more diluted with distance from the discharge.
- The plume was not detected at the surface. Vertical conductivity profiles indicate that the plume was located within 5 m of the surface at some stations.
- Further from the discharge, a finger of the plume appears to have become detached from the bottom and moved in the north-easterly direction.
- The 1% effluent zone bound occurred approximately 1 km north and 1.7 km northeast of the discharge, but was beyond the sampling grid to the east.
- The results of the vertical profiles of conductivity measurements and barium concentrations at SNP and AEMP stations were consistent with the vertical profiles collected for the Phase II surveys.

3.4.2 Nitrification

The Phase II survey results were consistent with nitrification occurring within the plume. The combined effects of dilution and nitrification reduce ammonia concentrations to near background levels within a distance of approximately 1 km of the discharge outlet.

4. ICE-FREE RESULTS

Results from the ice-free survey are presented below. Section 4.1 presents the results of the plume delineation assessment, including a description of the isopleth maps, the percent effluent zones and the vertical profiles. Nitrification, and the extent to which it might be occurring in the effluent plume during ice-free conditions, is discussed in Section 4.2, followed by a discussion of the QA/QC program in Section 4.3.

All laboratory and field results from the ice-free program are presented in Appendix B. QA/QC results are presented in Appendix C. Percent effluent calculations and results are presented in Appendix D.

4.1 Plume Delineation

4.1.1 Isopleths of Barium and Conductivity

Five isopleth maps of conductivity measurements and barium concentrations were used to help delineate the extent and shape of the plume, including:

- one map of maximum conductivity measurements;
- one map of maximum barium concentrations; and,
- three maps of barium concentrations at each sampled depth.

Maximum Conductivity Measurements

Maximum field measurements of conductivity at each station for the ice-free program are presented in Figure 4.1-1. Similar to the figures produced for the ice-covered survey, the corresponding depths at which the maximum conductivity was observed are identified for each station.

The results show the plume extended primarily north of the discharge outlet. Maximum conductivity measurements typically occurred within a depth of range of 2 to 8 m within 1 km of the discharge outlet (Figure 4.1-1), which indicated that the plume was located at or near the surface of Lac de Gras.

Background conductivity levels from stations LDG-46, LDG-48 and LDG-50 in Lac de Gras were approximately 15 µS/cm during the ice-free period. Conductivity measurements reached background levels (i.e., the plume was no longer measurable), within approximately 700 from the discharge outlet.

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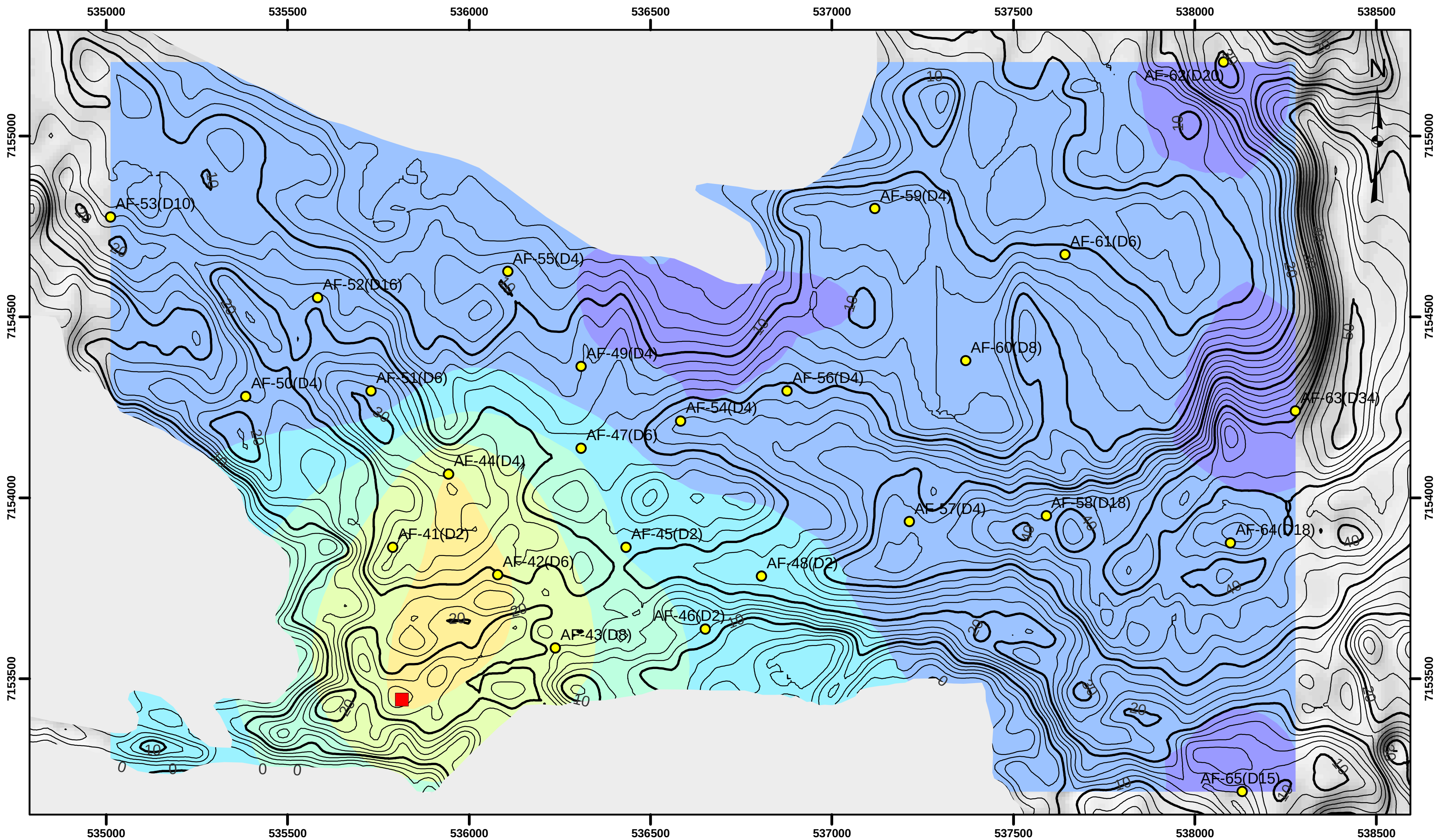


LEGEND

FIELD CONDUCTIVITY VALUES (uS/cm)

- 11.00 - 11.75
- 11.75 - 13.50
- 13.50 - 15.25
- 15.25 - 17.00
- 17.00 - 18.75
- 18.75 - 20.50
- 20.50 - 22.25
- 22.25 - 25.00

- SAMPLE LOCATION
- DISCHARGE OUTLET *
- EAST ISLAND BATHYMETRY
- (D14) DEPTH OF MAXIMUM CONCENTRATION IN METRES

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum concentration observed during the Phase II sampling program was used to estimate the minimum concentration at the discharge point

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE

MAXIMUM FIELD CONDUCTIVITY MEASUREMENTS (PHASE II - ICE-FREE)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005		
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

FIGURE: 4.1-1

Maximum Barium Concentrations

The map of maximum barium concentrations is shown in Figure 4.1-2. The layer at which the maximum occurs was identified in the parentheses (e.g., T = top, M = mid-depth and B = bottom). The shape of the plume in the barium and conductivity maps is similar, which indicates that the barium results adequately capture the vertical centre-line of the plume.

Barium Concentrations at Three Sampled Depths

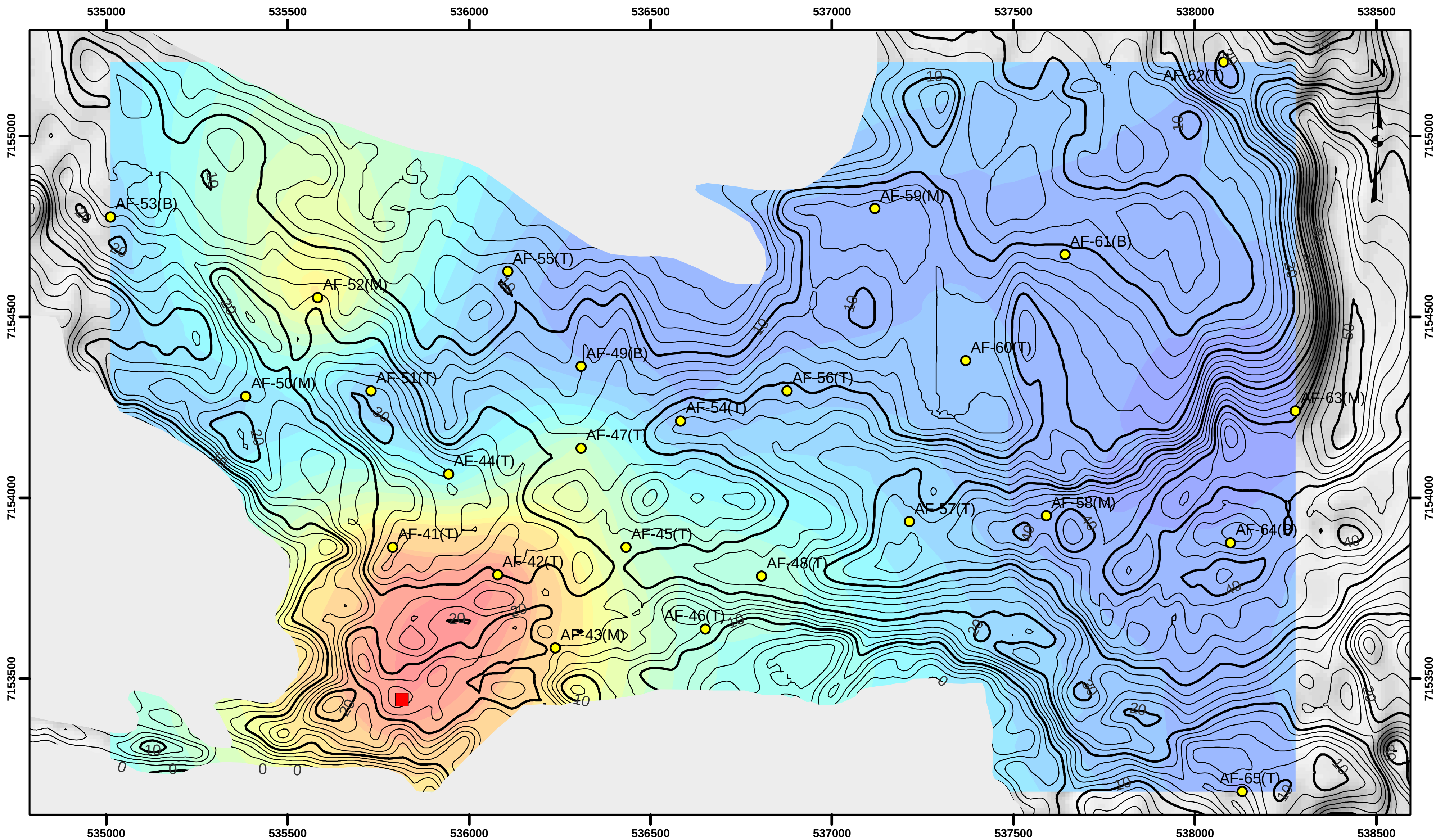
The isopleth maps of total barium concentrations are presented in Figures 4.1-3 to 4.1-5, which include a map for each of the three depths (i.e., surface, mid-depth and bottom).

During the Phase II ice-free survey, maximum barium concentrations were observed at or near the surface of the water column instead of at the bottom, indicating that the plume was located near the surface of the lake (Figures 4.1-3). The plume was not detectable in the sampling results at the bottom (4.1-5) and marginally detectable at mid-depth (4.1-4), which is likely due to the distance between the discharge point and the closest sampling location in the Phase II survey.

The patterns of dilution and the presence of the plume near the surface of the lake in Phase II, which were observed for barium, were also observed in isopleth mapping of nitrate concentrations. Nitrate plume mapping is discussed below in Section 4.2 (Nitrification).

Differences in the effluent discharge (flow rate) is the most likely explanation for the plume to be located near the surface during the ice-free survey and near the bottom during the ice-cover survey. The average flow rate during the ice-free program was approximately 24,000 m^3/day as compared with 13,000 m^3/day during the ice-covered survey. The diffuser has a constant number of nozzles that discharge the effluent in a vertical direction. The exit velocity from the diffuser nozzles is directly related to the effluent flow rate and a higher vertical exit velocity will bring the plume closer to the surface. Apparently an effluent discharge of 24,000 m^3/day the exit velocity was sufficient to bring the plume to the surface, but at a discharge of 13,000 m^3/day the exit velocity was insufficient to carry the plume to the surface.

I:\2005\05-1328\05-1328-003\Mxd\Summary\Fig4.1-02_PhaseII_Max_Barium_Cond.mxd



LEGEND

BARIUM CONCENTRATIONS (mg/L)

0.00236 - 0.00250	0.00374 - 0.00387
0.00250 - 0.00264	0.00387 - 0.00401
0.00264 - 0.00277	0.00401 - 0.00415
0.00277 - 0.00291	0.00415 - 0.00423
0.00291 - 0.00305	0.00423 - 0.00442
0.00305 - 0.00319	0.00442 - 0.00465
0.00319 - 0.00332	0.00465 - 0.00470
0.00332 - 0.00346	0.00470 - 0.00484
0.00346 - 0.00360	0.00484 - 0.00500
0.00360 - 0.00374	0.00500 - 0.00511

SAMPLE LOCATION
DISCHARGE OUTLET *
EAST ISLAND BATHYMETRY
(T) LOCATION OF SAMPLE POINT (T=TOP, M=MIDDLE, B=BOTTOM)

250 125 0 250 500
SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum concentration observed during the Phase II sampling program was used to estimate the minimum concentration at the discharge point

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE

MAXIMUM BARIUM CONCENTRATIONS (PHASE II - ICE-FREE)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005	**FIGURE: 4.1-2**	
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

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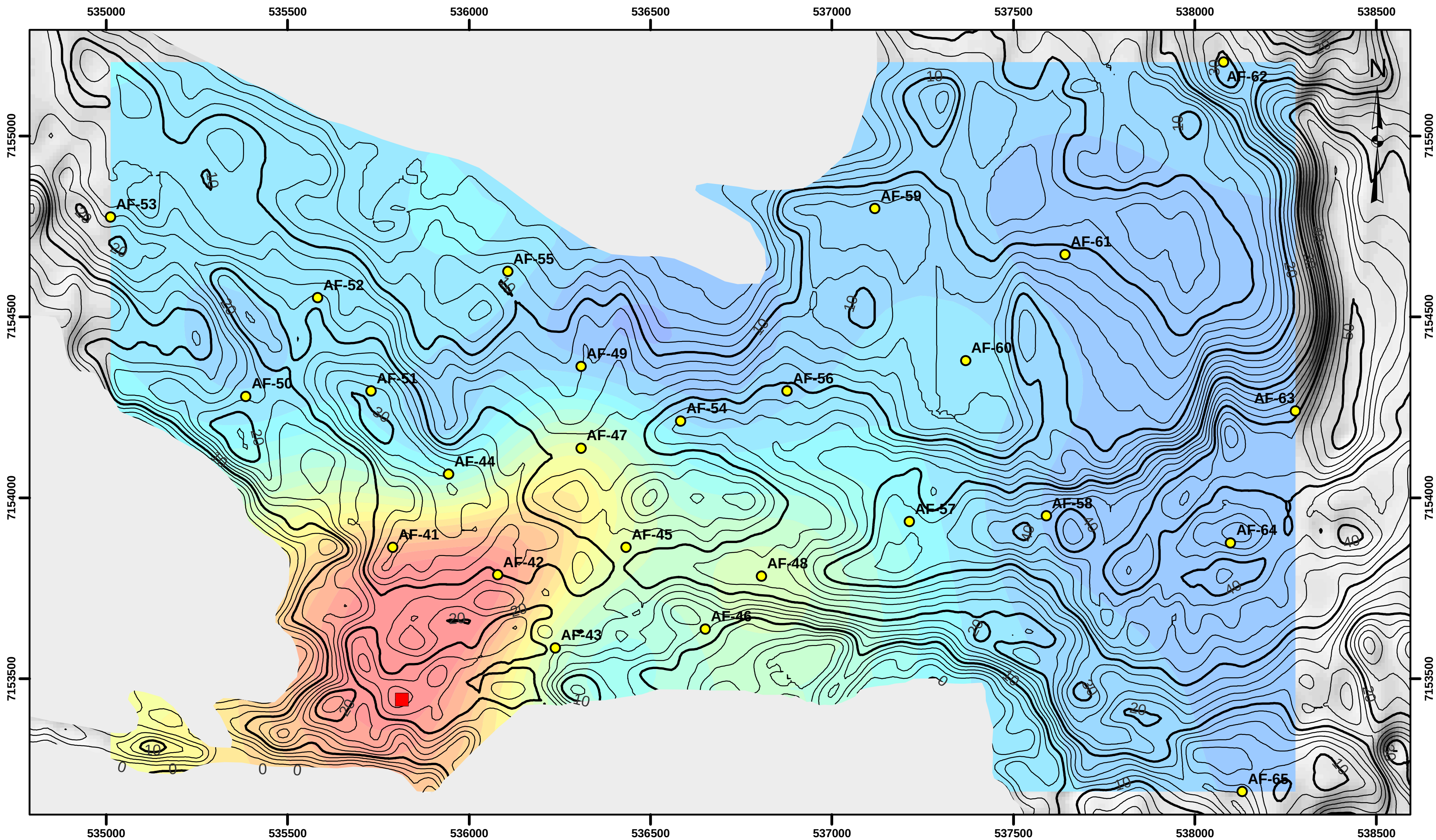

LEGEND

BARIUM CONCENTRATIONS (mg/L)

0.00200 - 0.00215	0.00356 - 0.00371
0.00215 - 0.00231	0.00371 - 0.00387
0.00231 - 0.00247	0.00387 - 0.00402
0.00247 - 0.00262	0.00402 - 0.00418
0.00262 - 0.00278	0.00418 - 0.00433
0.00278 - 0.00293	0.00433 - 0.00449
0.00293 - 0.00301	0.00449 - 0.00464
0.00301 - 0.00324	0.00464 - 0.00480
0.00324 - 0.00340	0.00480 - 0.00495
0.00340 - 0.00356	0.00495 - 0.00511

SAMPLE LOCATION

DISCHARGE OUTLET *

EAST ISLAND BATHYMETRY

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum concentration observed during the Phase II sampling program was used to estimate the minimum concentration at the discharge point

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE

TOTAL BARIUM CONCENTRATIONS AT SURFACE (PHASE II - ICE-FREE)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005	FIGURE: 4.1-3	
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

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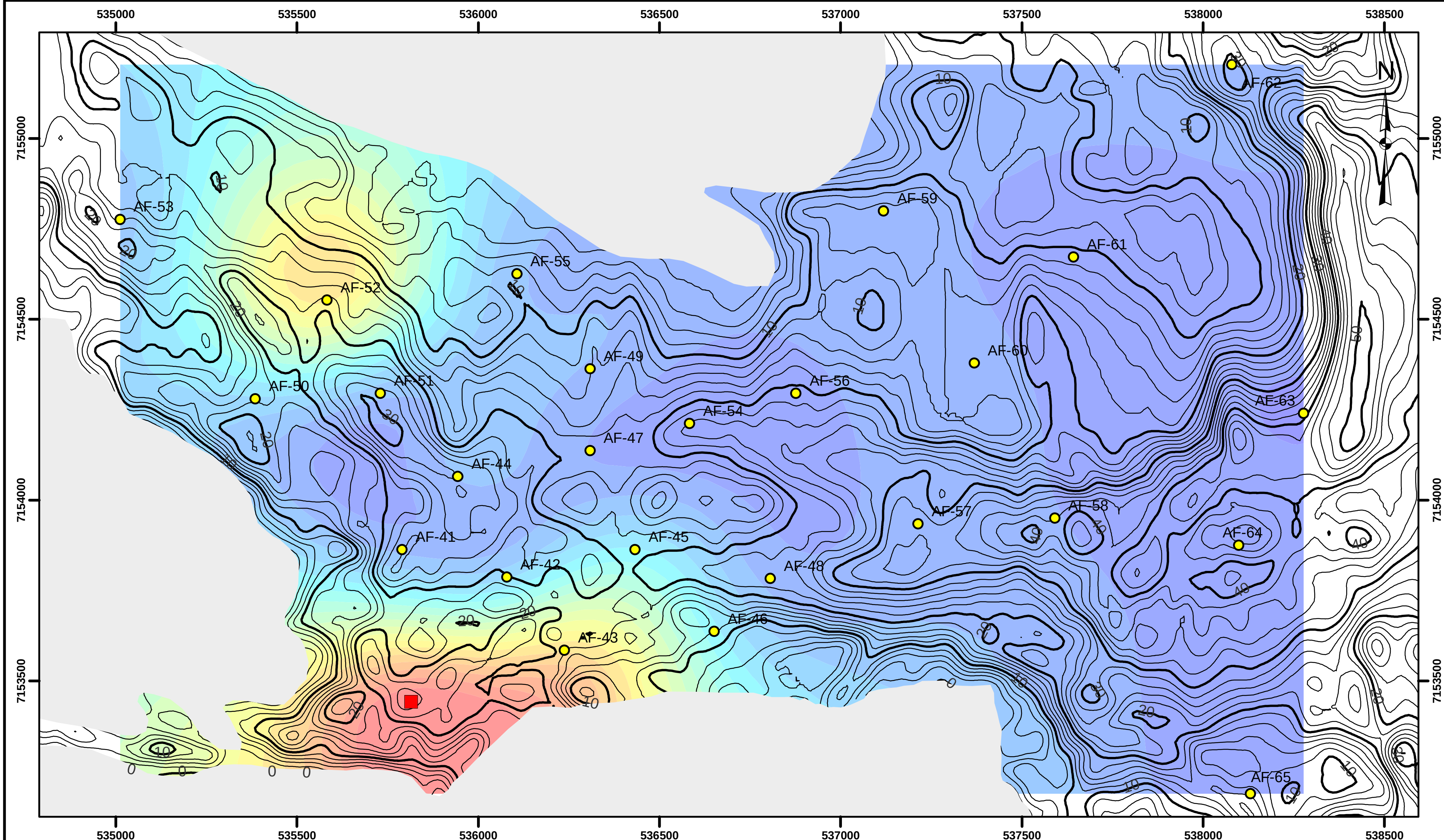

LEGEND

BARIUM CONCENTRATIONS (mg/L)

0.00200 - 0.00215	0.00356 - 0.00371
0.00215 - 0.00231	0.00371 - 0.00387
0.00231 - 0.00247	0.00387 - 0.00402
0.00247 - 0.00262	0.00402 - 0.00418
0.00262 - 0.00278	0.00418 - 0.00433
0.00278 - 0.00293	0.00433 - 0.00449
0.00293 - 0.00301	0.00449 - 0.00464
0.00301 - 0.00324	0.00464 - 0.00480
0.00324 - 0.00340	0.00480 - 0.00495
0.00340 - 0.00356	0.00495 - 0.00511

SAMPLE LOCATION

DISCHARGE OUTLET *

EAST ISLAND BATHYMETRY

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum concentration observed during the Phase II sampling program was used to estimate the minimum concentration at the discharge point

PROJECT

DIAVIK DIAMOND MINE INC
PLUME DELINEATION STUDY

TITLE

TOTAL BARIUM CONCENTRATIONS AT MID-DEPTH (PHASE II - ICE-FREE)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005	FIGURE: 4.1-4	
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

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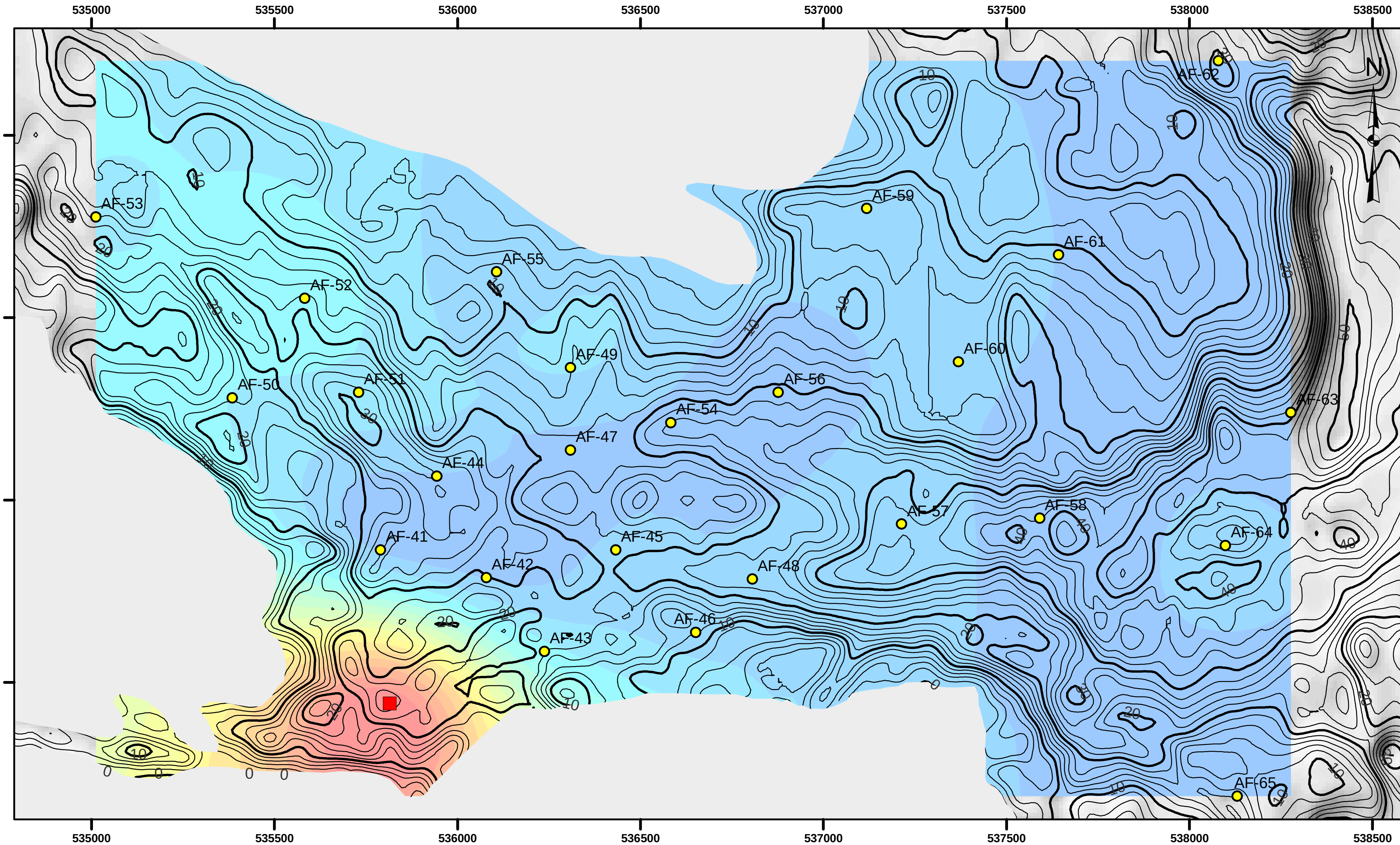


LEGEND

BARIUM CONCENTRATIONS (mg/L)

0.00200 - 0.00215	0.00356 - 0.00371
0.00215 - 0.00231	0.00371 - 0.00387
0.00231 - 0.00247	0.00387 - 0.00402
0.00247 - 0.00262	0.00402 - 0.00418
0.00262 - 0.00278	0.00418 - 0.00433
0.00278 - 0.00293	0.00433 - 0.00449
0.00293 - 0.00301	0.00449 - 0.00464
0.00301 - 0.00324	0.00464 - 0.00480
0.00324 - 0.00340	0.00480 - 0.00495
0.00340 - 0.00356	0.00495 - 0.00511

SAMPLE LOCATION

DISCHARGE OUTLET

EAST ISLAND BATHYMETRY

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum concentration observed during the Phase II sampling program was used to estimate the minimum concentration at the discharge point

PROJECT

DIAVIK DIAMOND MINES INC
PLUME DELINEATION STUDY

TITLE

TOTAL BARIUM CONCENTRATIONS AT BOTTOM (PHASE II - ICE-FREE)

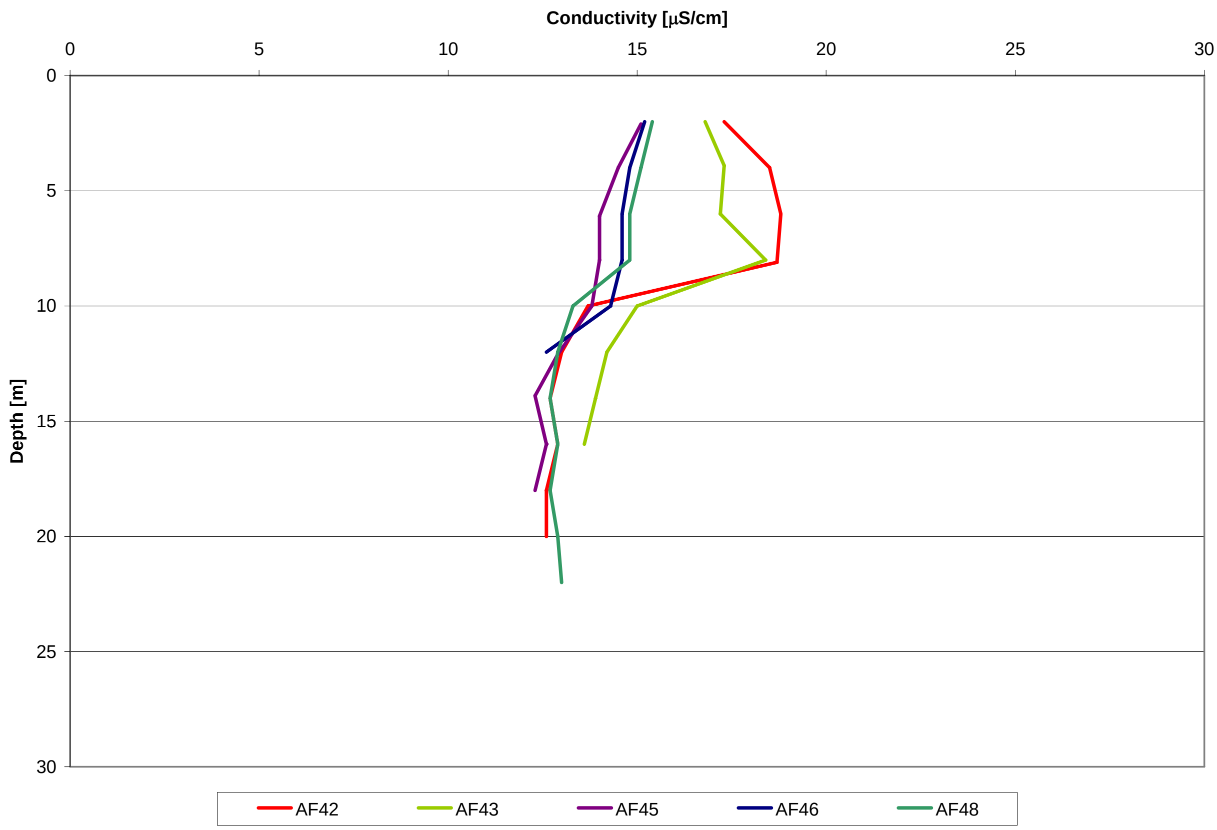
DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005		
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

FIGURE: 4.1-5

Anomalous results were observed in the ice-free Phase II survey, which were similar to the pattern observed in the ice-covered surveys. Maximum mid-depth concentrations were observed at site AF-42, AF-43 and AF-48, but not at site AF-47 and AF-46. This trend was also observed in the map of ice-free nitrate concentration at mid-depth, which is presented in Section 4.2 (Nitrification). Vertical profiles of field conductivity were plotted for sampling locations around stations AF-42 and AF-43 during the ice-free season to determine if there were any noticeable changes in the vertical gradient (Figure 4.1-6). The vertical patterns for AF-42 and AF-43 (near the discharge outlet were consistent with results for both barium and nitrate; the highest concentrations tended to occur at the surface. Conductivity increases at the mid-depth location of the profile were consistent with nitrate and barium concentrations observed in the mid-depth layer at site AF-43. The conductivity profile for AF-48 showed slightly higher concentrations at the surface, but in general, very little vertical gradient, which was similar to the results observed for barium. The source of the anomalous results at AF-48 and adjacent sites is still unknown.

Figure 4.1-6 Vertical Profiles of Conductivity at AF-45 and Locations Adjacent to AF-45 (Ice-free)



4.1.2 Percent Effluent Concentration Zones

Isopleth map showing the percent effluent concentrations, based on barium results from the Phase II ice-free survey for each of the three depths (defined as surface, mid-depth and bottom) are shown in Figures 4.1-7 through 4.1-9. Percent effluent isopleth maps are essentially normalized concentration isopleth maps; therefore, the spatial patterns are the same as those discussed in Section 4.1-2. Discussion here focuses on the 1% effluent concentration zone.

The area covered by the 1% plume was smaller for the ice-free zone as compared with the ice-covered. The maximum extent of the 1% limit for the ice-free was about 600 m north and 1 km east of the discharge outlet (Figure 4.1.7). In the ice-covered survey the 1% limit extended beyond the measurement boundary in some directions. Despite the higher discharge rates the effect of lake current on plume dimension is evident. The increased exit velocities at higher discharges are also expected to enhance the mixing of the effluent with the lake water, thereby increasing dilution.

4.1.3 Vertical Profiles

Vertical profiles were examined to evaluate the vertical position and shape of the plume at different locations and at different times. Profiles were examined for the Phase II surveys, and for the SNP and AEMP stations located near the discharge. For the purposes of presenting profiles, Phase II monitoring locations were grouped into transects, which are shown in Figure 2.3-2. The vertical profiles of field conductivity at all sampling locations are presented in Appendix B (Figures B-19 to B-36).

During the Phase II survey, the highest conductivity values occurred at the surface of the water column as opposed to the bottom (Figure 4.1-10). This pattern was consistent with patterns observed for barium concentrations in the isopleth mapping. Conductivity values were low and relatively constant through the water column for transect 5, indicating that the plume was not clearly detectable at and beyond this transect (Figure 4.1-11).

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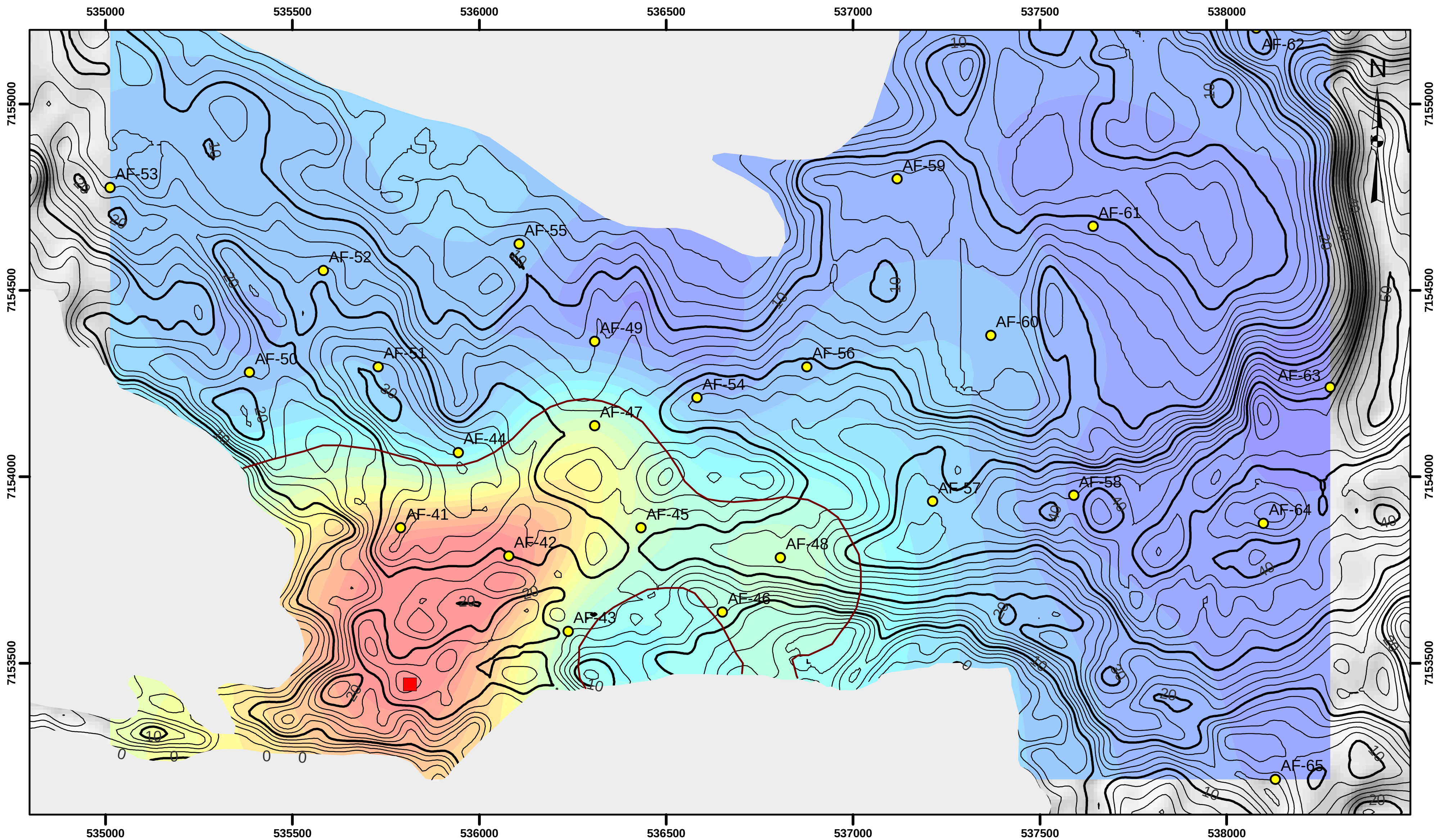

LEGEND

BARIUM PERCENT EFFLUENT

0.47% - 0.54%	1.13% - 1.20%
0.54% - 0.60%	1.20% - 1.27%
0.60% - 0.67%	1.27% - 1.33%
0.67% - 0.73%	1.33% - 1.40%
0.73% - 0.80%	1.40% - 1.47%
0.80% - 0.87%	1.47% - 1.53%
0.87% - 0.94%	1.53% - 1.60%
0.94% - 1.00%	1.60% - 1.67%
1.00% - 1.07%	1.67% - 1.73%
1.07% - 1.13%	1.73% - 1.80%

- SAMPLE LOCATION
- DISCHARGE OUTLET *
- EAST ISLAND BATHYMETRY
- ONE PERCENT EFFLUENT ZONE

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum percent effluent observed during the Phase II sampling program was used to estimate the minimum percent effluent at the discharge point

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE

ICE-FREE PERCENT EFFLUENT CONCENTRATIONS AT SURFACE (TOTAL BARIUM - PHASE II)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005		
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

FIGURE: 4.1-7

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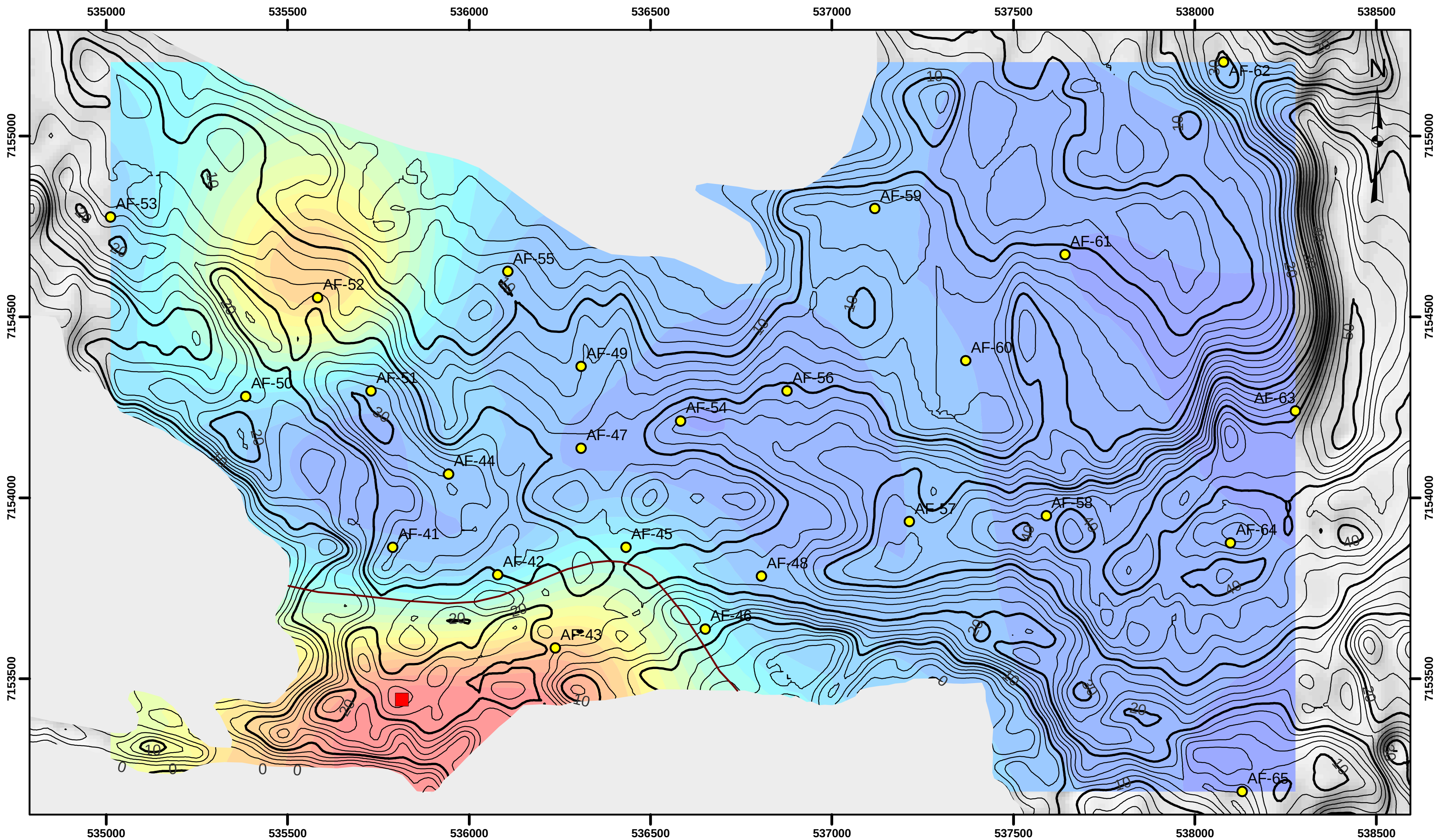

LEGEND

BARIUM PERCENT EFFLUENT

0.47% - 0.54%	1.13% - 1.20%
0.54% - 0.60%	1.20% - 1.27%
0.60% - 0.67%	1.27% - 1.33%
0.67% - 0.73%	1.33% - 1.40%
0.73% - 0.80%	1.40% - 1.47%
0.80% - 0.87%	1.47% - 1.53%
0.87% - 0.94%	1.53% - 1.60%
0.94% - 1.00%	1.60% - 1.67%
1.00% - 1.07%	1.67% - 1.73%
1.07% - 1.13%	1.73% - 1.80%

SAMPLE LOCATION

DISCHARGE OUTLET *

EAST ISLAND BATHYMETRY

ONE PERCENT EFFLUENT ZONE

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum percent effluent observed during the Phase II sampling program was used to estimate the minimum percent effluent at the discharge point

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE

ICE-FREE PERCENT EFFLUENT CONCENTRATIONS AT MID-DEPTH (TOTAL BARIUM - PHASE II)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005		
GIS	LL	21 Nov. 2005	**FIGURE: 4.1-8**	
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

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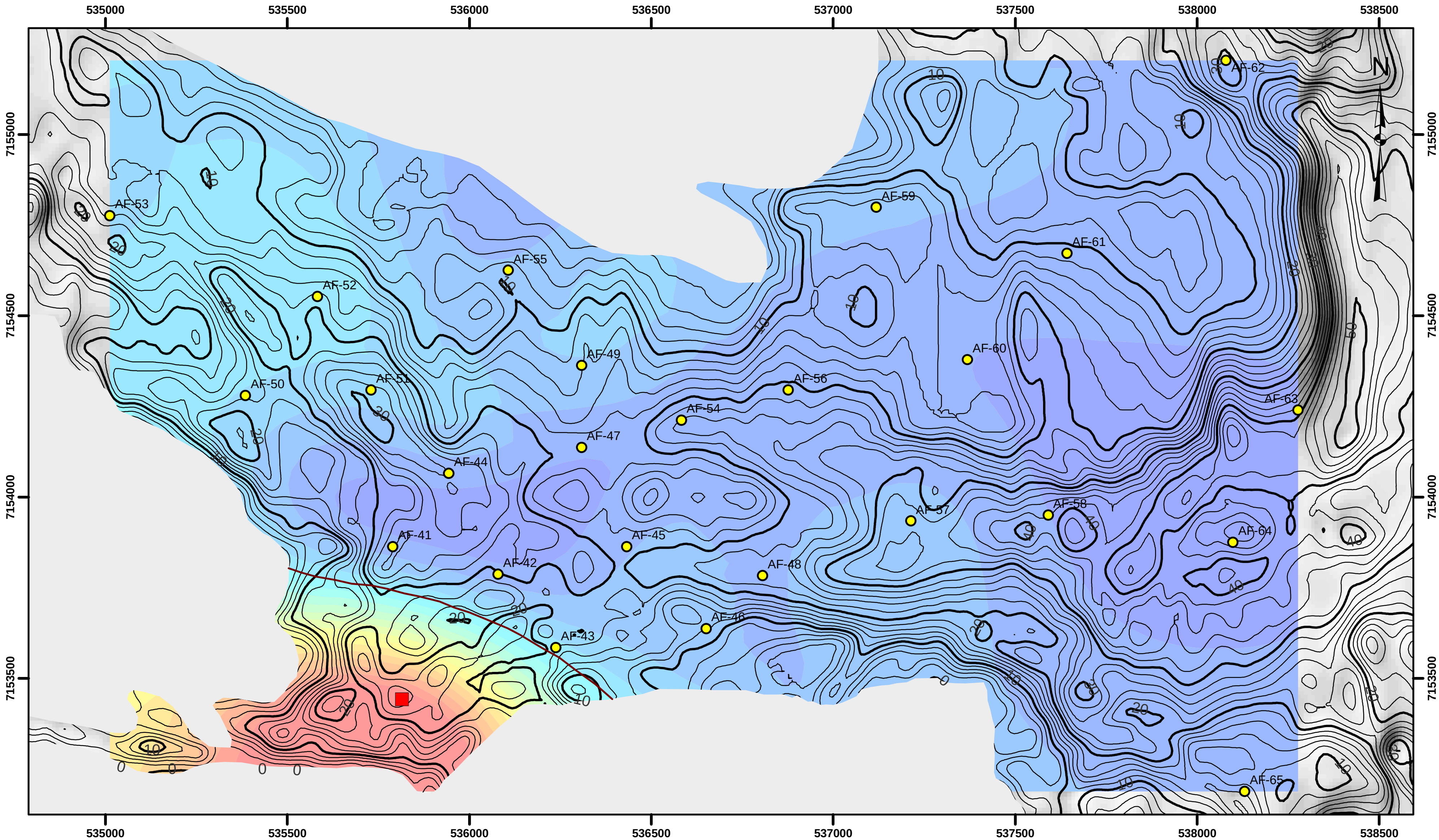


LEGEND

BARIUM PERCENT EFFLUENT

0.47% - 0.54%	1.13% - 1.20%
0.54% - 0.60%	1.20% - 1.27%
0.60% - 0.67%	1.27% - 1.33%
0.67% - 0.73%	1.33% - 1.40%
0.73% - 0.80%	1.40% - 1.47%
0.80% - 0.87%	1.47% - 1.53%
0.87% - 0.94%	1.53% - 1.60%
0.94% - 1.00%	1.60% - 1.67%
1.00% - 1.07%	1.67% - 1.73%
1.07% - 1.13%	1.73% - 1.80%

SAMPLE LOCATION

DISCHARGE OUTLET *

EAST ISLAND BATHYMETRY

ONE PERCENT EFFLUENT ZONE

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum percent effluent observed during the Phase II sampling program was used to estimate the minimum percent effluent at the discharge point

250 125 0 250 500

SCALE 1:15,000 METRES

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE

ICE-FREE PERCENT EFFLUENT CONCENTRATIONS AT BOTTOM (TOTAL BARIUM - PHASE II)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005	**FIGURE: 4.1-9**	
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

Figure 4.1-10 Field Conductivity Profiles at Sampling Locations during the Ice-free Phase II Survey (Stations 41 to 65)

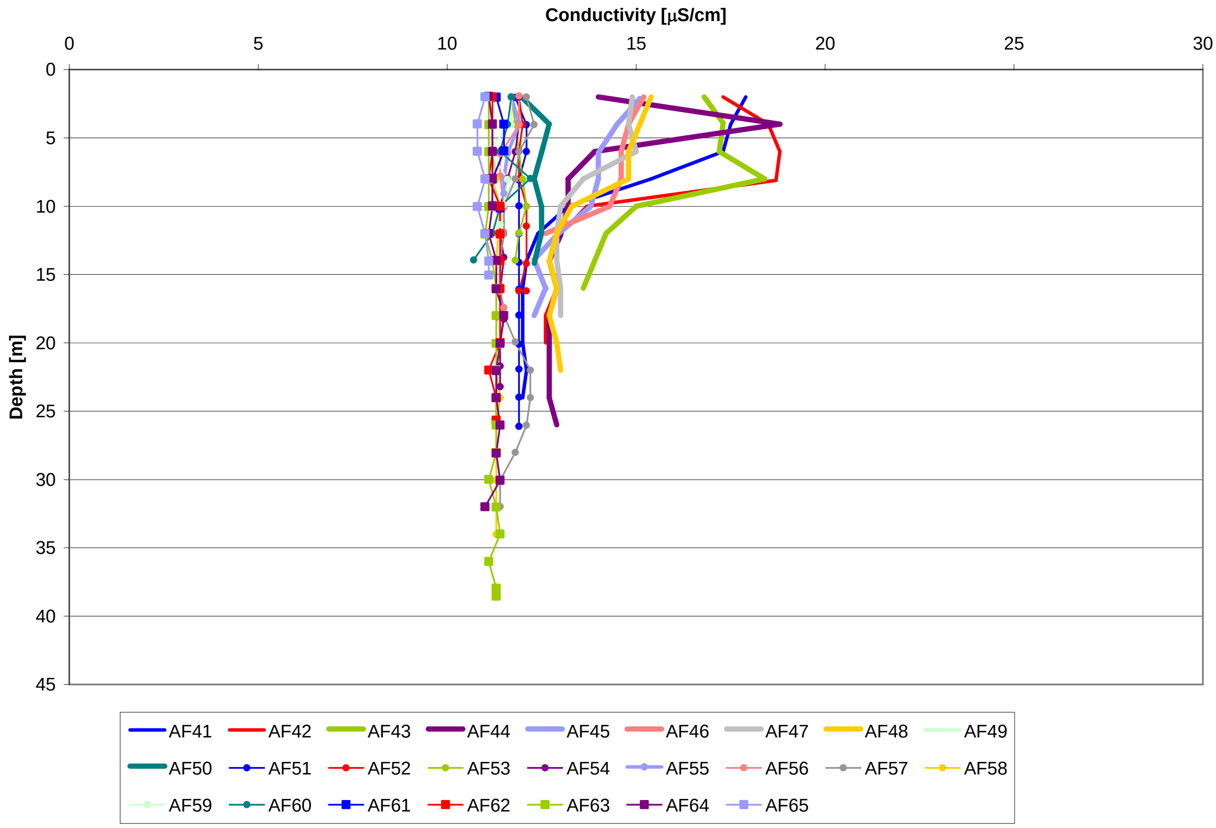
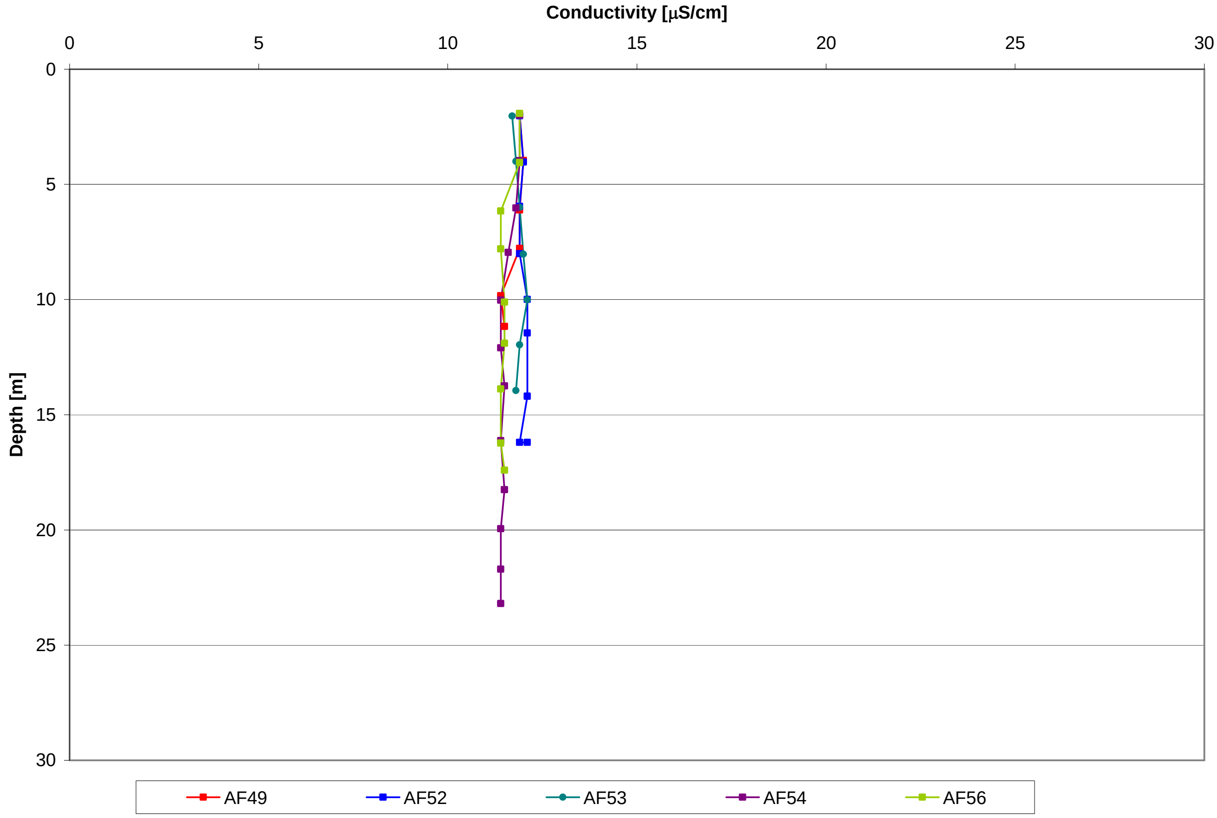
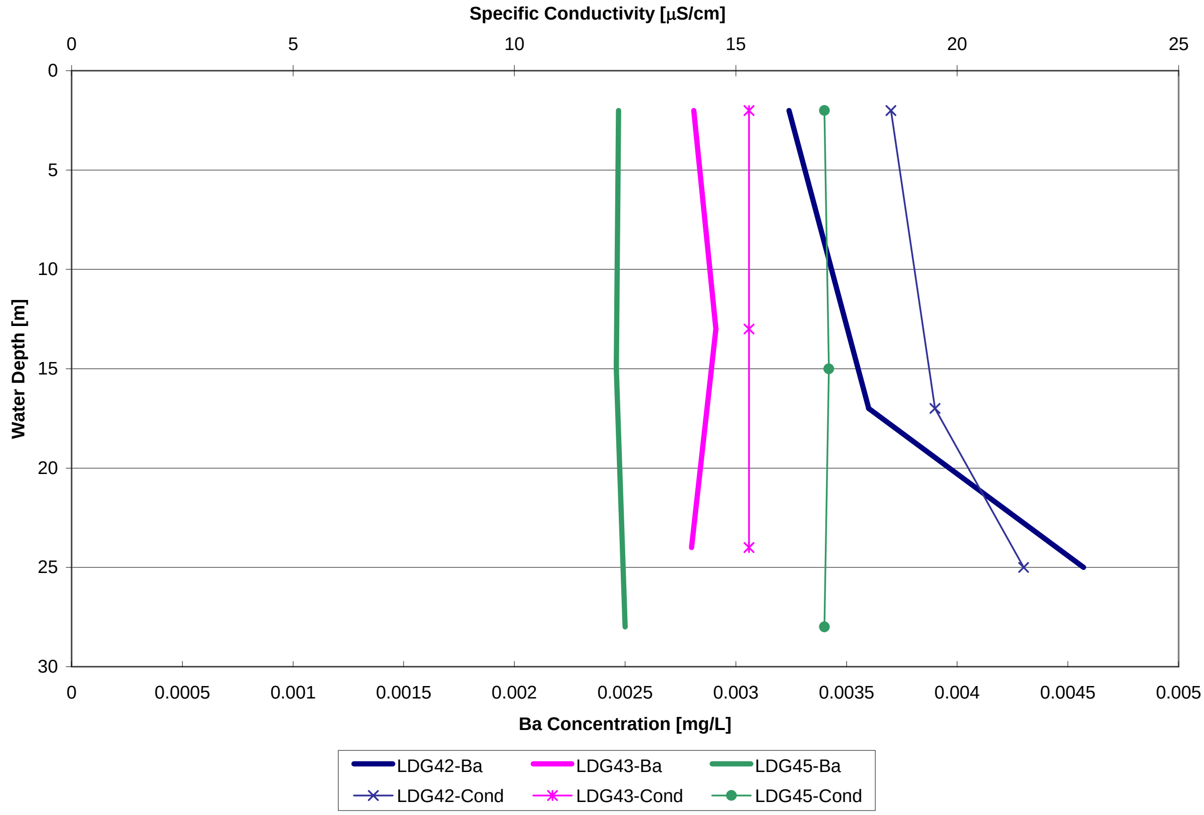


Figure 4.1-11 Field Conductivity Profiles at Sampling Locations Along Transect 5 (Phase II - Ice-free)



Depth profiles of total barium concentrations and field conductivity measurements at AEMP stations closest to the discharge, excluding SNP1645-19, are shown in Figure 4.1-12. Results at LDG-40 are not presented in Figure 4.1-12 because only bottom and top samples were collected. The plume was only detectable at Station LDG-42, which was the closest station to the discharge point, where barium and conductivity values increased between the depths of 17 m to 25 m. This observation was consistent with the conductivity and barium maps in Phase II which showed that the plume was detectable at the location of LDG-42. However, the concentrations in the plume appeared to be highest near the bottom of the lake based on results from the AEMP stations; whereas the Phase II survey results indicated the plume was near the surface.

Figure 4.1-12 Total Barium and Field Conductivity Profiles at AEMP Stations Closest to Discharge Outlet (excluding SNP1645-19) (September 2005)



4.2 Nitrification

The occurrence of nitrification within the effluent plume during ice-free conditions was evaluated based on results from the Phase II survey.

With the exception of a couple of samples, all ammonia results for the Phase II survey were reported as less than the analytical detection limit. The low ammonia levels observed at all sampling locations resulted from much higher dilution rates during ice-free conditions. Because concentrations were below detection limits, it was not possible to use the ice-free survey results to distinguish changes resulting from nitrification from dilution. Logically, if nitrification were occurring under ice-covered conditions, it would be expected under ice-free conditions; however, this can not be verified using the ice-free survey results.

During the ice-covered season, the average ammonia (as N) concentration in the effluent was approximately 4 mg/L, whereas average ice-free ammonia concentrations were only about 0.45 mg/L. Effluent ammonia concentrations were lower during the ice-free survey due to the addition of large volumes of low ammonia water to the North Inlet as part of the A418 dike construction.

As supporting evidence, isopleth maps of nitrate were also reviewed to determine whether a slower rate of dilution could be observed for nitrate compared to barium. The rate at which the barium and nitrate concentrations decreased at bottom and mid-depth layers was similar (Figure 4.2-1 and 4.2-2). This observation was consistent with the above conclusion that nitrification was not detectable within the plume.

4.3 QA/QC

The results of duplicate and blank samples were compared to the QA/QC criteria described in Section 2.2.

The variation in duplicate samples during the Phase I survey was above the criterion of 20% for one parameter (antimony) out of the total number (26) of parameters (Appendix C). During the Phase II survey, differences between duplicates for all parameters were less than the criterion of 20% for duplicate samples.

Two parameters (antimony and sodium) were detected in blanks at concentrations greater than five times the detection limit during the Phase I survey. During the Phase II survey, fifteen out of forty parameters were detected in the field blank at concentrations greater than five times the detection limit. The concentrations in all equipment and travel blanks were less than five times the detection limit.

The QA/QC results for antimony during the Phase I and Phase I surveys indicate that the sampling results for this parameter are likely not valid. In both phases, the antimony concentrations in all blanks were greater than five times the detection limit. In Phase I, the differences in antimony concentrations of all duplicate samples were greater than 20%.

The QA/QC results of the field blank sample collected during the Phase II survey indicated that this sample was potentially contaminated. Close to half of the parameters were above the detection limit in this field sample and results that were above detection limits were generally substantially greater than the detection limit However, the QA/QC results, with the exception of sodium and antimony, for all other blanks in both Phase I and Phase II were valid. The apparent contamination of the field sample in Phase II appears to be an isolated event and does not invalidate the results.

The QA/QC results for total barium, ammonia and nitrate were consistent with the overall QA/QC results (Table 4.3-1). All results, with the exception of barium and nitrate results in the field blank sample in Phase II, met the QA/QC criteria for duplicate and blank samples.

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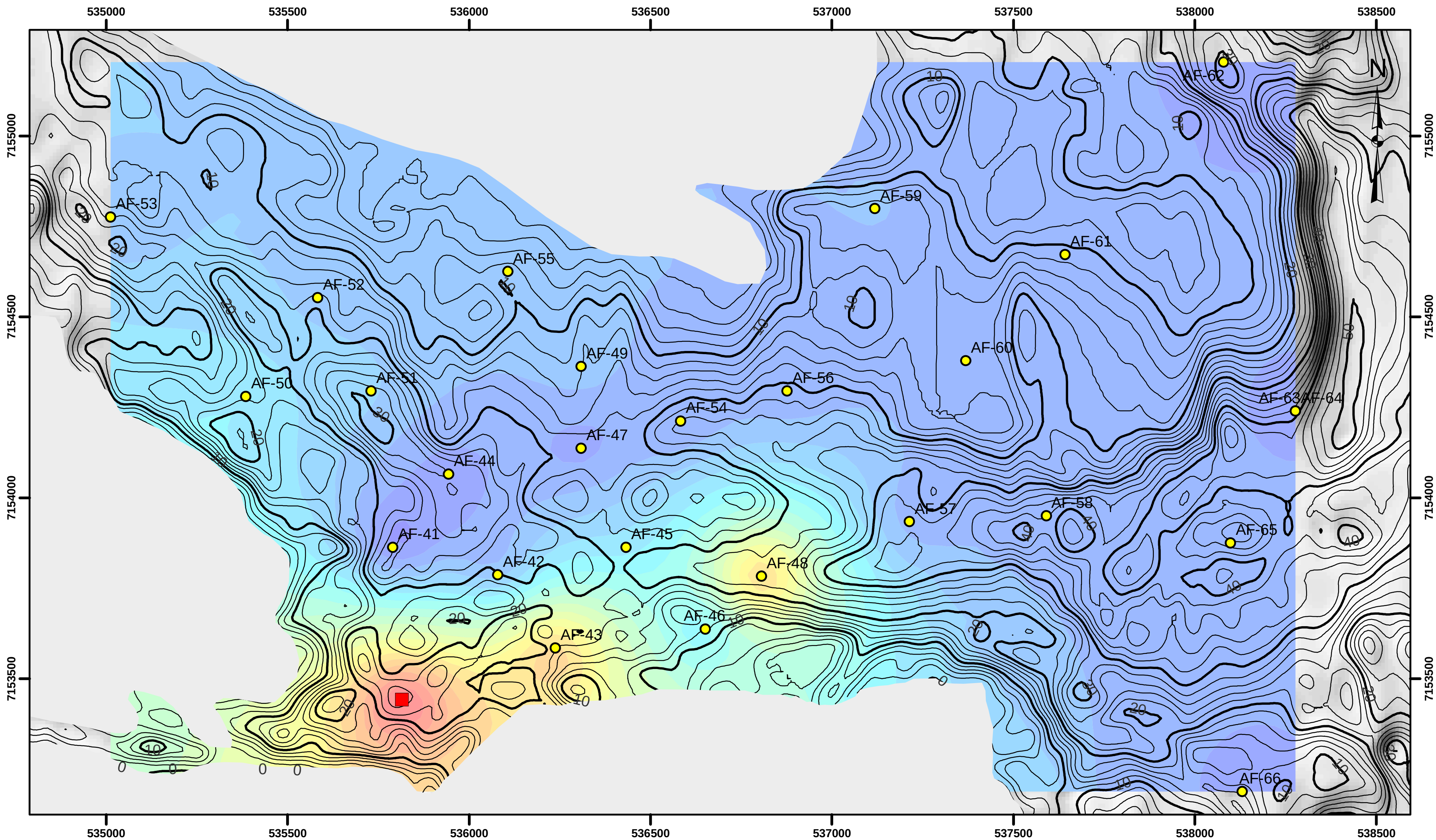

LEGEND

NITRATE CONCENTRATIONS (mg/L)

0.0060 - 0.0106	0.0520 - 0.0566
0.0106 - 0.0152	0.0566 - 0.0612
0.0152 - 0.0198	0.0612 - 0.0658
0.0198 - 0.0244	0.0658 - 0.0704
0.0244 - 0.0290	0.0704 - 0.0750
0.0290 - 0.0336	0.0750 - 0.0796
0.0336 - 0.0382	0.0796 - 0.0842
0.0382 - 0.0428	0.0842 - 0.0888
0.0428 - 0.0474	0.0888 - 0.0934
0.0474 - 0.0520	0.0934 - 0.0980

SAMPLE LOCATION

DISCHARGE OUTLET *

EAST ISLAND BATHYMETRY

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum concentration observed during the Phase II sampling program was used to estimate the minimum concentration at the discharge point

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE

NITRATE CONCENTRATIONS AT MID-DEPTH (PHASE II - ICE-FREE)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005	**FIGURE: 4.2-1**	
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

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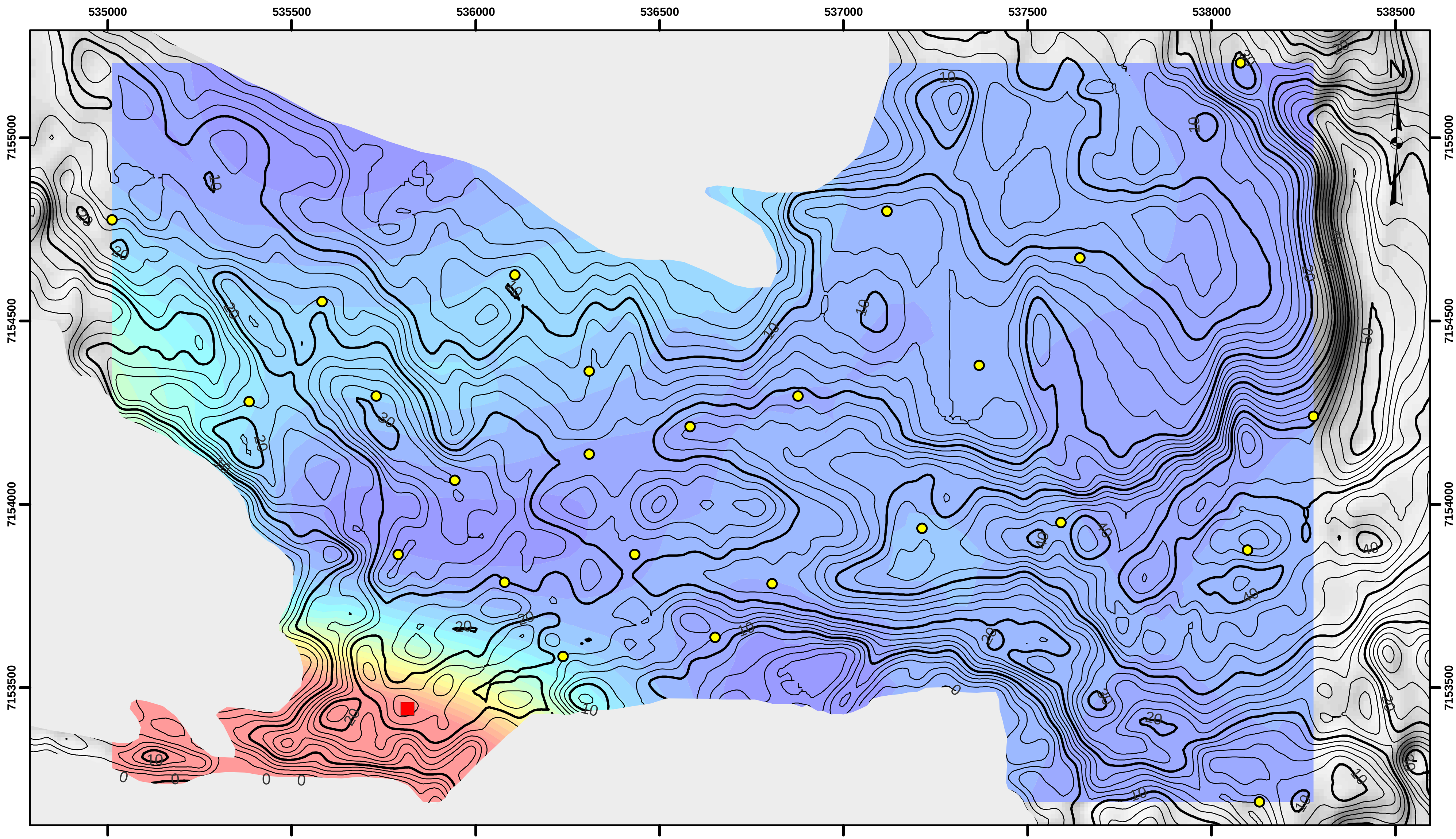

LEGEND

NITRATE CONCENTRATIONS (mg/L)

- 0.0060 - 0.0106
- 0.0106 - 0.0152
- 0.0152 - 0.0198
- 0.0198 - 0.0244
- 0.0244 - 0.0290
- 0.0290 - 0.0336
- 0.0336 - 0.0382
- 0.0382 - 0.0428
- 0.0428 - 0.0474
- 0.0474 - 0.0520
- 0.0520 - 0.0566
- 0.0566 - 0.0612
- 0.0612 - 0.0658
- 0.0658 - 0.0704
- 0.0704 - 0.0750
- 0.0750 - 0.0796
- 0.0796 - 0.0842
- 0.0842 - 0.0888
- 0.0888 - 0.0934
- 0.0934 - 0.0980

SAMPLE LOCATION

DISCHARGE OUTLET *

EAST ISLAND BATHYMETRY

250 125 0 250 500

SCALE 1:15,000 METRES

REFERENCE

Datum: NAD83 Projection: Transverse Mercator. Coordinate System: UTM Zone 12

*The maximum concentration observed during the Phase II sampling program was used to estimate the minimum concentration at the discharge point

PROJECT

DIAVIK DIAMOND MINES INC.
PLUME DELINEATION STUDY

TITLE

NITRATE CONCENTRATIONS AT BOTTOM (PHASE II - ICE-FREE)

DIAVIK DIAMOND MINES INC.

PROJECT No. 05-1328-003.4000			SCALE AS SHOWN	REV. 0
DESIGN	LL	21 Nov. 2005	FIGURE: 4.2-2	
GIS	LL	21 Nov. 2005		
CHECK	AH	21 Nov. 2005		
REVIEW	AH	21 Nov. 2005		

Table 4.3-1 Quality Control Results for Total Barium, Ammonia and Nitrate (Phase I and Phase II – Ice-free)

Parameter	Sampling Site	Units	Detection Limit	Duplicate 1	Duplicate 2	Travel Blank	Field Blank	Equipment Blank	Results
Phase I									
Barium (Ba)	N/A	mg/L	0.00005					<0.00005	VALID
	N/A							<0.00005	VALID
	N/A					<0.00005			VALID
	AF-31-M			0.00271	0.00282				VALID
	AF-30-T			0.00267	0.00279				VALID
	AF-37-T			0.00291	0.00282				VALID
	AF-40-M			0.00312	0.00306				VALID
Phase II									
Ammonia-N	N/A	mg/L	0.005				<0.005		VALID
	AF-42-T			<0.005	<0.005				Dup1&2 < 5X Detection Limit
Barium (Ba)	N/A	mg/L	0.00005					<0.00005	VALID
	N/A						0.00355		Blank > 5X Detection Limit
	N/A					<0.00005			VALID
	AF-42-T			0.00501	0.00458				VALID
	AF-51-T			0.00288	0.00285				VALID
	AF-59-B			0.00269	0.00265				VALID
	AF-63-M			0.00247	0.00251				VALID
Nitrate-N	N/A	mg/L	0.006				0.04		Blank > 5X Detection Limit
	AF-42-T			0.098	0.089				VALID

4.4 Summary of Ice-free Results

4.4.1 Plume Delineation

Based on the results of the plume delineation surveys, descriptions of the shape, extent and characteristics of the plume from the NIWTP under ice-free conditions in Lac de Gras are summarized below:

- During the ice-free survey, the plume was observed within the surface of the lake, which was likely due to high effluent flows observed during this survey.

- The plume appears to have moved primarily in a north easterly direction, away from the East Island.

- The zone of 1% effluent concentration was observed at the surface within approximately 600 m north and 1 km east of the discharge outlet.

- The vertical profiles of conductivity measurements and barium concentrations at AEMP stations were consistent with the extent of the plume observed in the Phase II survey. The plume appeared to be primarily at the bottom of the lake based on the AEMP results, whereas results from the Phase II survey showed the plume at the surface.

4.4.2 Nitrification

Under ice-free conditions, the combination of low ammonia concentrations in the effluent and rapid initial mixing resulted in most ammonia and nitrate concentrations in Lac de Gras being below detection limits. Because most ammonia and nitrate concentrations were below detection limits in Lac de Gras during ice-free conditions, it was not possible to detect nitrification within the plume.

5. COMPARISON OF PLUME DURING ICE-COVERED AND ICE-FREE CONDITIONS

The following similarities in the plume were observed between ice-covered and ice-free conditions:

- The plume appeared to be moving in an east to north-easterly direction, away from the East Island.

- The shape, location and extent of the plume appeared to be highly variable between sampling programs, which may be related to effluent flows and concentrations, under-ice or ice-free lake currents, and the bathymetry of the lake.

The following differences in the plume were observed between ice-covered and ice-free conditions:

- Lower concentrations (i.e., more dilution), were observed closer to the discharge during ice-free conditions compared to the ice-covered season. This was likely due to increased mixing effects from wind-driven lake currents during ice-free conditions.

- Nitrification appeared to be occurring within the plume during ice-covered conditions; however, the occurrence of nitrification could not be determined during the ice-free program because nearly all concentrations were below detection limits in Lac de Gras. Effluent concentrations of ammonia during ice-free conditions were substantially lower compared to ice-covered effluent concentrations

- During periods of lower effluent discharge flows (~14 000 m^3/day), the plume was located near the bottom and middle of the lake and did not appear to have reached the surface. During conditions of higher effluent discharge (~25 000 m^3/day) observed during the Phase II ice-free survey, the plume was detected at the surface of the lake.

6. REFERENCES

Diavik Diamond Mines Inc. 2001. Aquatic Effects Monitoring Program Study Design Report. Diavik Diamond Mines Inc., Yellowknife, NT.

Diavik Diamond Mines Inc. 2004. Diavik Diamond Mines Inc. Laboratory QA/QC Program. Version 2 – March 2004.

Johnston, Kevin; Krivoruchko, Konstantin; Lucas, Neil; Ver Hoef, Jay. "Using ArcGIS Geostatistical Analyst" ESRI 2001.