FUGRO AIRBORNE SURVEYS

Report #04078

A HELICOPTER-BORNE GEOPHYSICAL SURVEY
FOR
GEOLOGICAL SURVEY OF CANADA

BRITISH COLUMBIA, 2004

PARTS OF NTS 92P, 93A, 93G, 93K, 93N and 93O

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MAY, 2006

NOTE:

These surveys have been renamed from the contractor block name, and some of the individual blocks were merged into super-blocks for release. The alphabetic IDs remain the same. The various data blocks were also renamed for release as Open Files, resulting in some further possible confusion. The table below denotes the Contractor block names used in this report, versus the GSC Survey Names used in the database, and the published Open File names and numbers.

Alphabetic ID	Contractor Block Name	GSC Survey Name	GSC DB #	GSC Open File (OF) Map Name	GSC OF number
A	Mount Sylvester	BC 2004 - A - Sylvester Creek	413-01	Sylvester Creek	5285
B	Fran	BC 2004 - B - Wittichica Creek	413-02	Wittichica Creek	5286
C	Helene Lake	BC 2004 - C - Taltapin Lake	413-03	Taltapin Lake	5287
D	Tisdale Lake	BC 2004 - D,F - Eagle Lake - McKinley Creek	413-04	***McKinley Creek***	5293
F	Horsefly-Canim Lake			***Eagle Lake***	5292
E	Murphy Lake	BC 2004 - E - Lac la Hache	413-05	Lac la Hache	5291
G	Mount Polley Infill	BC 2004 - G - Hydraulic	413-06	Hydraulic	5290
H	Mouse Mountain	BC 2004 - H-J - Cottonwood	413-07	Cottonwood	5288
I	Ahbau				
J	Ahbau Infill				
K	Mostique	BC 2004 - K-N - Wells	413-08	Wells	5289
L	Atis				
M	Ahbau Lake				
N	Umiti Creek				
AA	Fraser Lake	BC 2004 - AA - Indata Lake	413-09	Indata Lake	5284

John Carson, Scientific Authority, and
Greg Boyce, Database Administrator,
Geological Survey of Canada,
Natural Resources Canada,
September 2014

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1. INTRODUCTION

A high sensitivity helicopter-borne Magnetic and Gamma-ray Spectrometric airborne geophysical survey was carried out for the Geological Survey of Canada over several blocks in the central region of British Columbia. The survey was flown by Fugro Airborne Surveys under the terms of an agreement with the Geological Survey of Canada, dated August 19, 2004 and accepted September 2, 2004. Appendix A lists the personnel involved in the acquisition, processing and presentation of the survey data.

Geophysical equipment comprised a high-sensitivity cesium magnetometer mounted in a stinger configuration and a 256-channel spectrometer with 33.6 litre downward looking crystal. Ancillary equipment included analog and digital recorders, radar, laser and barometric altimeters, a video flight path camera, and a global positioning system (GPS), which provided accurate real-time navigation and subsequent flight path recovery. Surface equipment included magnetic and GPS base stations, and a PC-based field workstation, which was used to check the data quality and completeness on a daily basis.

This report describes the acquisition, processing and presentation of data for the British Columbia 2004-2005 survey blocks.

2. SURVEY AREA

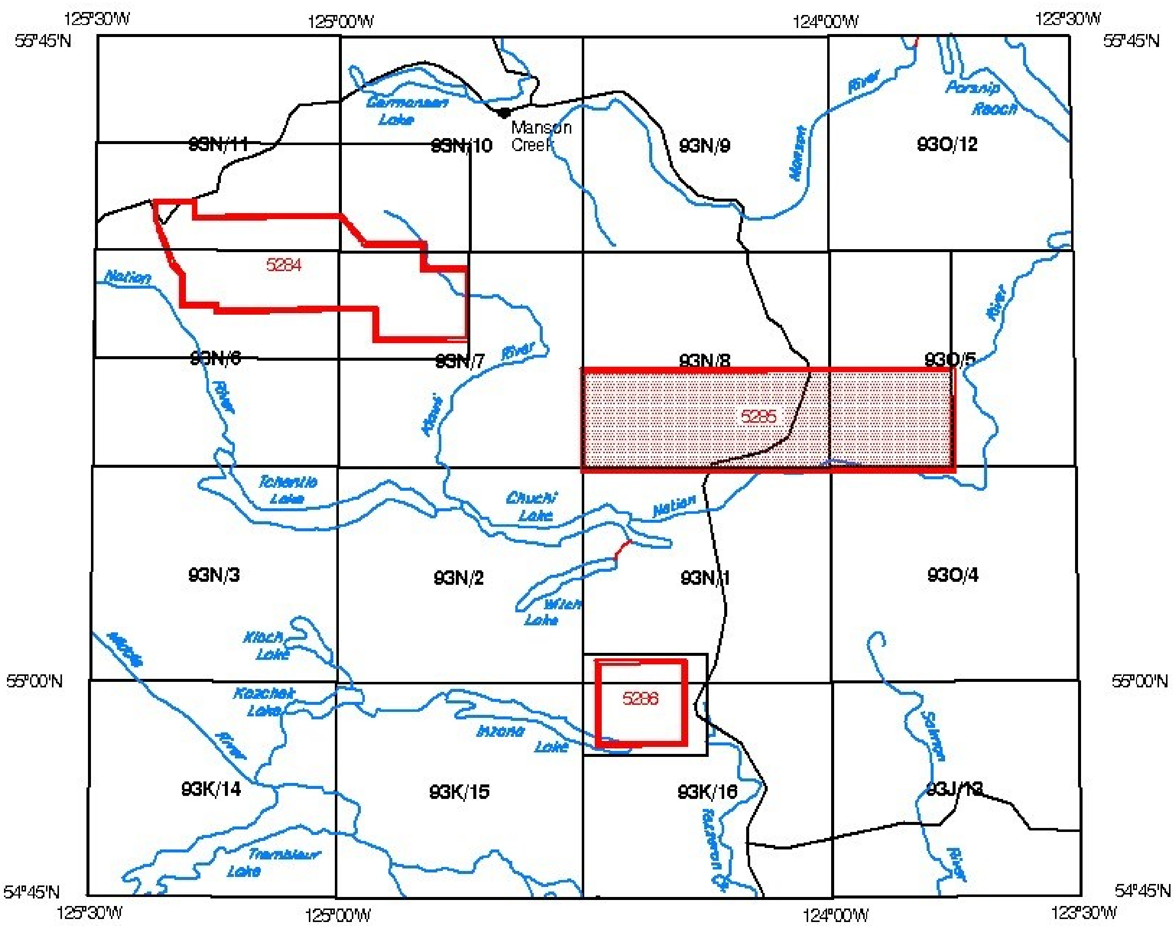
The survey project consisted of fifteen (15) blocks grouped into nine (9) discrete survey areas (Figures 2-A through 2-I) which covered portions of NTS sheets 92P, 93A, 93G, 93K, 93N and 93O in the central region of British Columbia. Tables 2-1 lists the corner points of the survey areas in coordinates for the Universal Transverse Mercator (UTM) (Zone 10N) projection using North American Datum 1983 (GRS80). The final maps and data products for this survey are presented in UTM Zone 10N coordinates, NAD83.

The survey blocks were flown for the Geological Survey of Canada, The British Columbia and Yukon Chamber of Mines, Yekooche First Nation and five industry partners, including Serengeti Resources Inc., Richfield Ventures Corp., GWR Resources Inc., Yankee Hat Minerals Ltd. And Amarc Resources Ltd.. The Geological Survey of Canada provided survey supervision and quality control. Total coverage of the British Columbia survey blocks consisted of 14226 line-kilometres as per the flight planning. The surveys were carried out over two seasons, from September 18 to November 17, 2004 and June 15 to August 8, 2005.

Line spacing and direction for survey and control lines were selected for each block to ensure the best intersection of local geological features. These parameters are summarized for each of the fifteen blocks in tables 2-1.

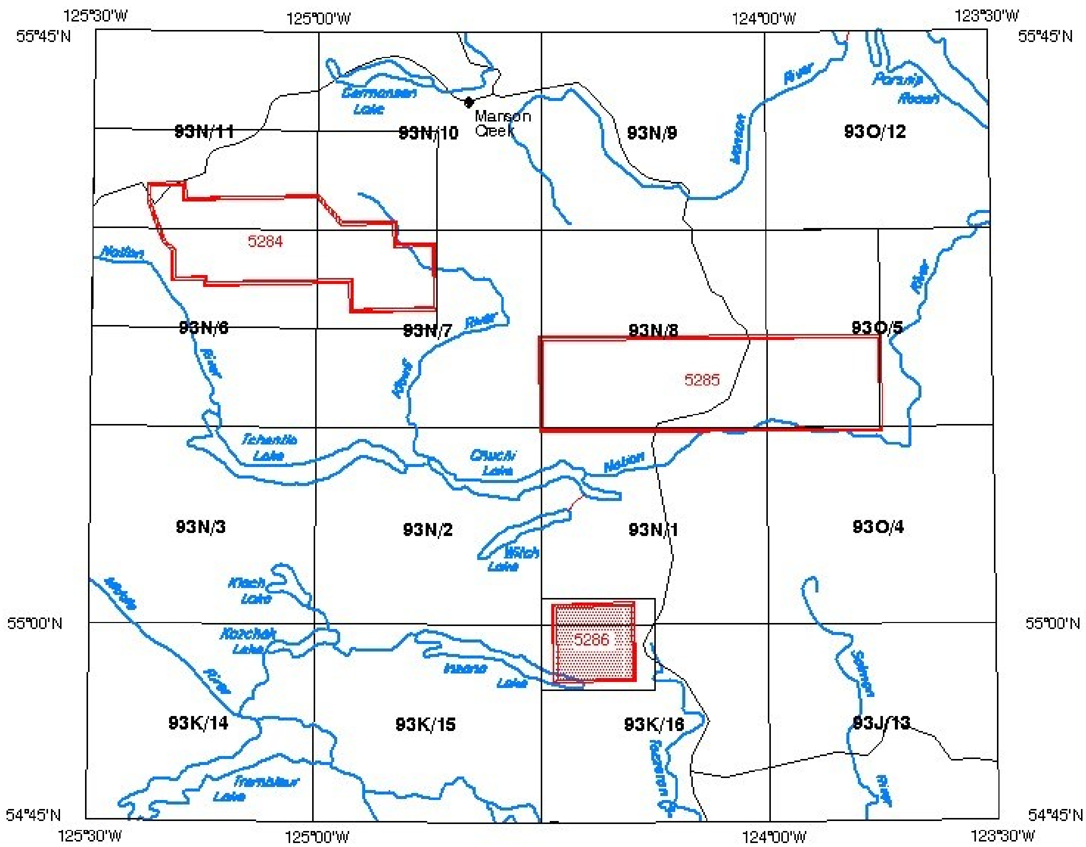
Survey blocks were flown at a sensor survey altitude of either 90 or 120 m and the terrain clearance was monitored by radar altimeter. Laser altimeter data was also available for the surveying completed in the 2005 season. The average speed of the helicopter was 90 km/hr.

Figure 2-A
Location/Index Map of Block A, Mount Sylvester Block



NATIONAL TOPOGRAPHICAL SYSTEM REFERENCE AND GEOPHYSICAL MAP INDEX
SYSTÈME NATIONAL DE RÉFÉRENCE CARTOGRAPHIQUE ET INDEX DES CARTES GÉOPHYSIQUES

Figure 2-B
Location/Index Map of Block B, Fran Block



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SYSTÈME NATIONAL DE RÉFÉRENCE CARTOGRAPHIQUE ET INDEX DES CARTES GÉOPHYSIQUES

Figure 2-C
Location/Index Map of Block C, Helene Lake Block

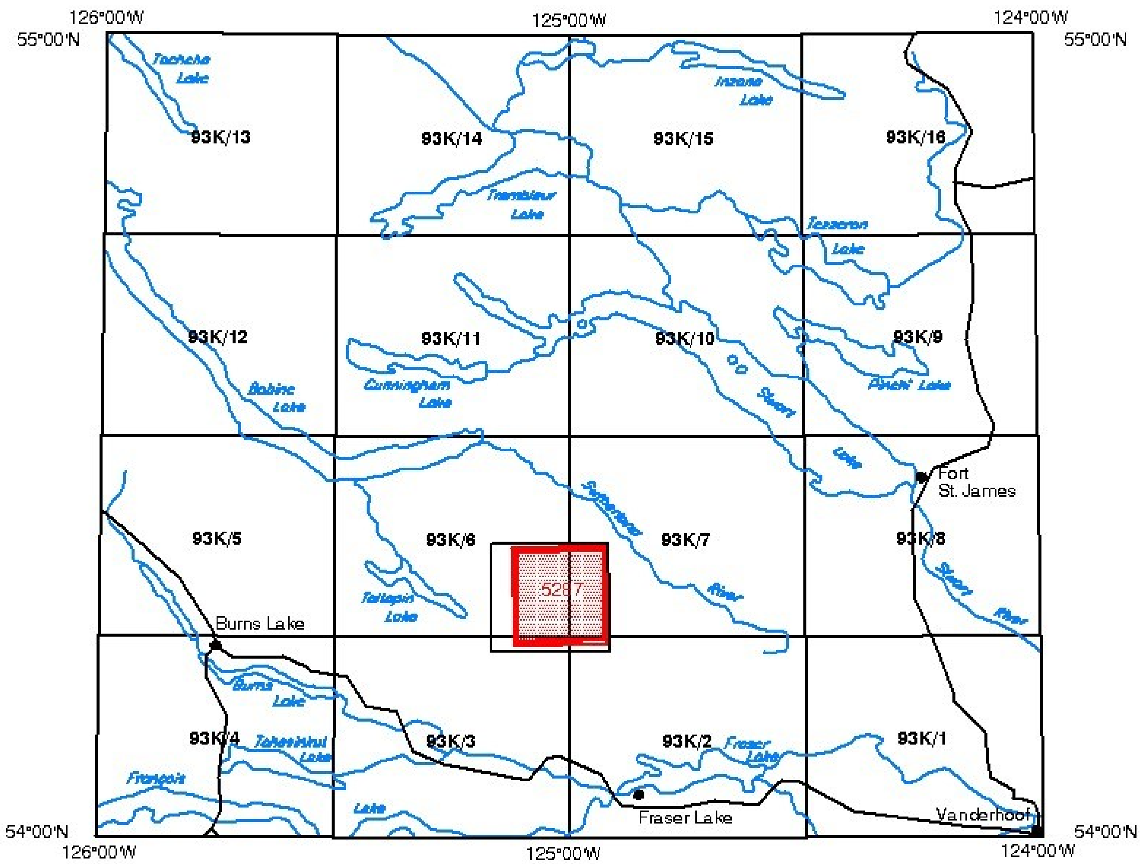

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Figure 2-D
Location/Index Map of Blocks D and F, Tisdale Lake and Horsefly-Canim Lake Block

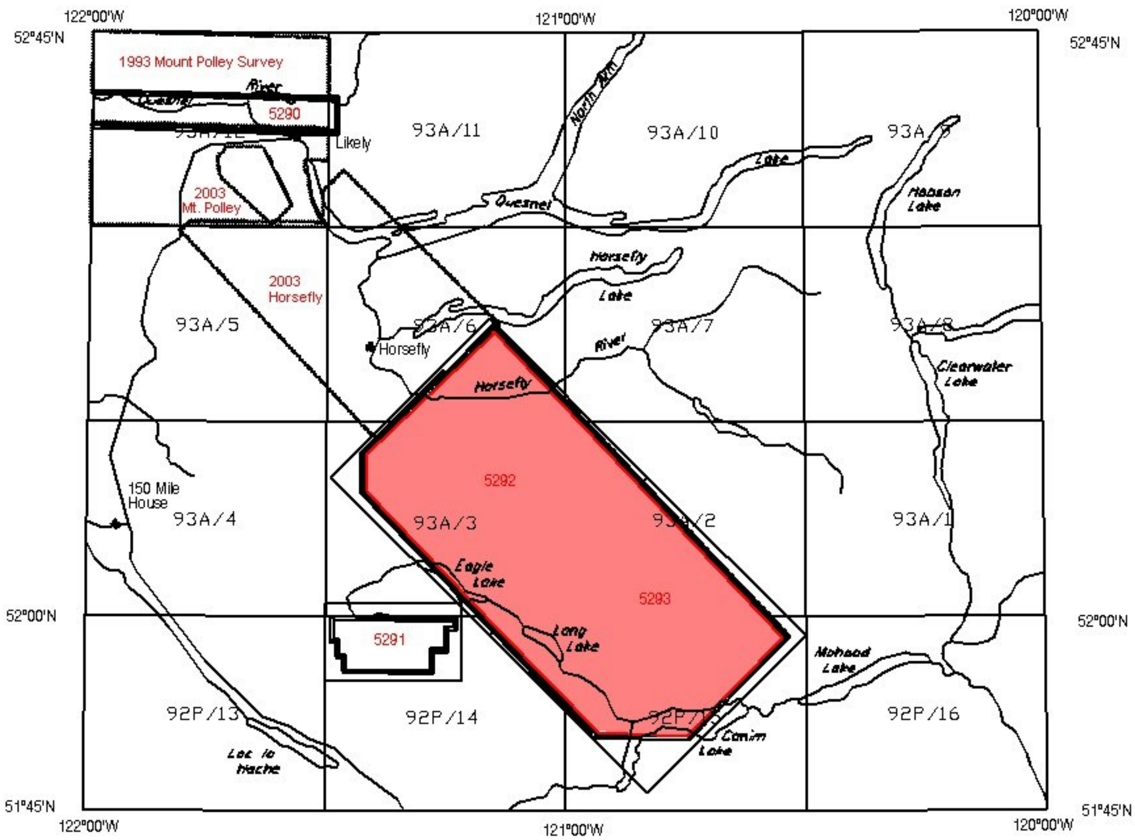

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Figure 2-E
Location/Index Map of Block E, Murphy Lake Block

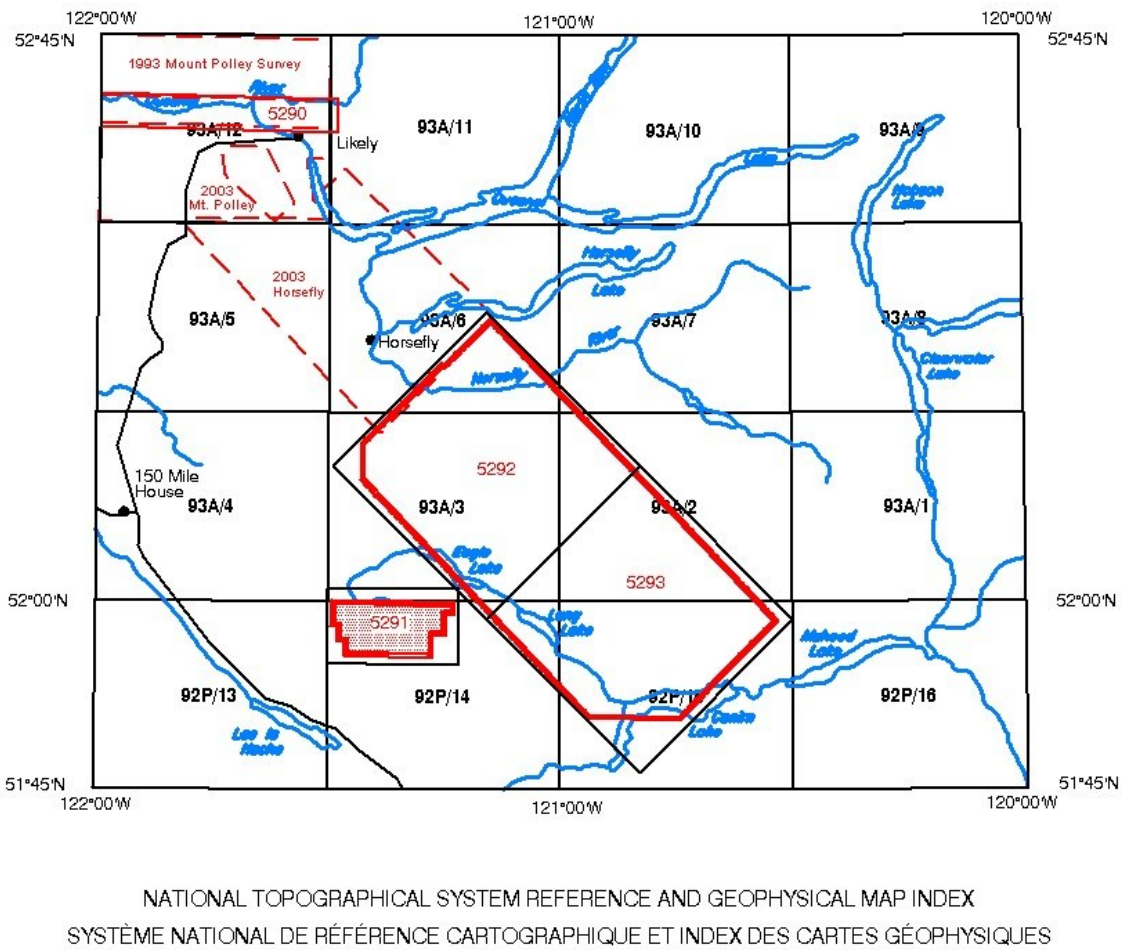

Figure 2-F
Location/Index Map of Block G, Mt. Polley infill Block

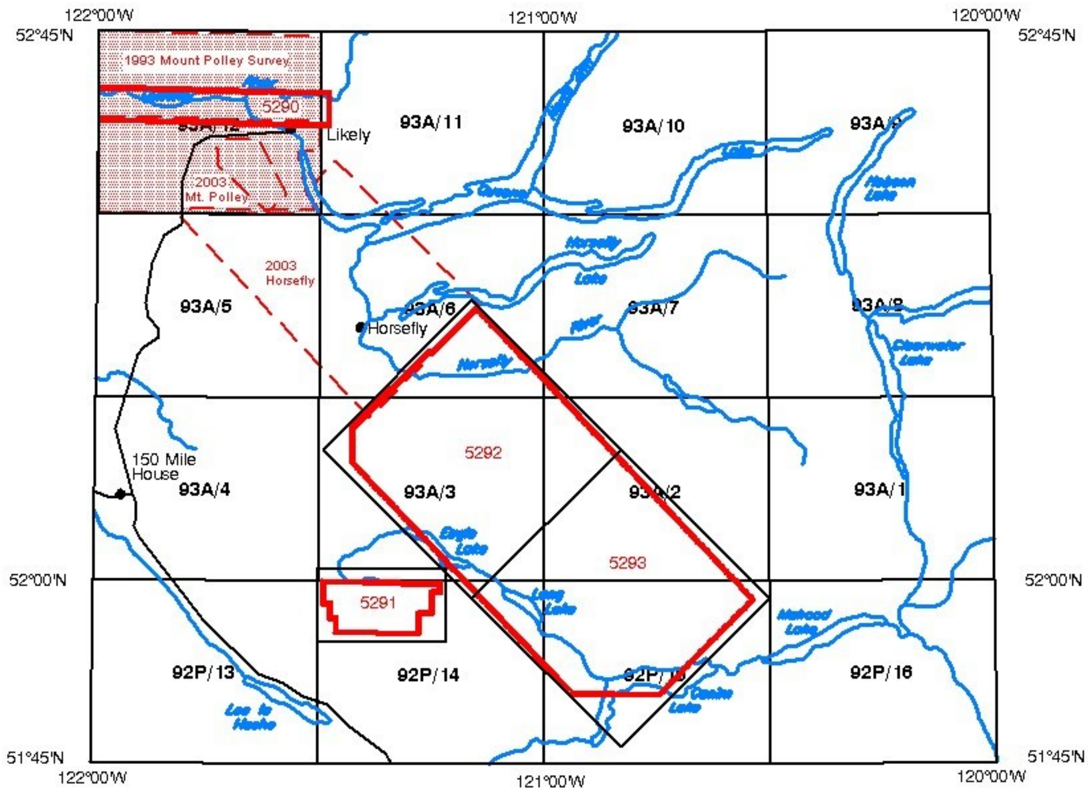

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Figure 2-G
Location/Index Map of Blocks H-J, Mouse Mountain, Abhau and Abhau infill Blocks

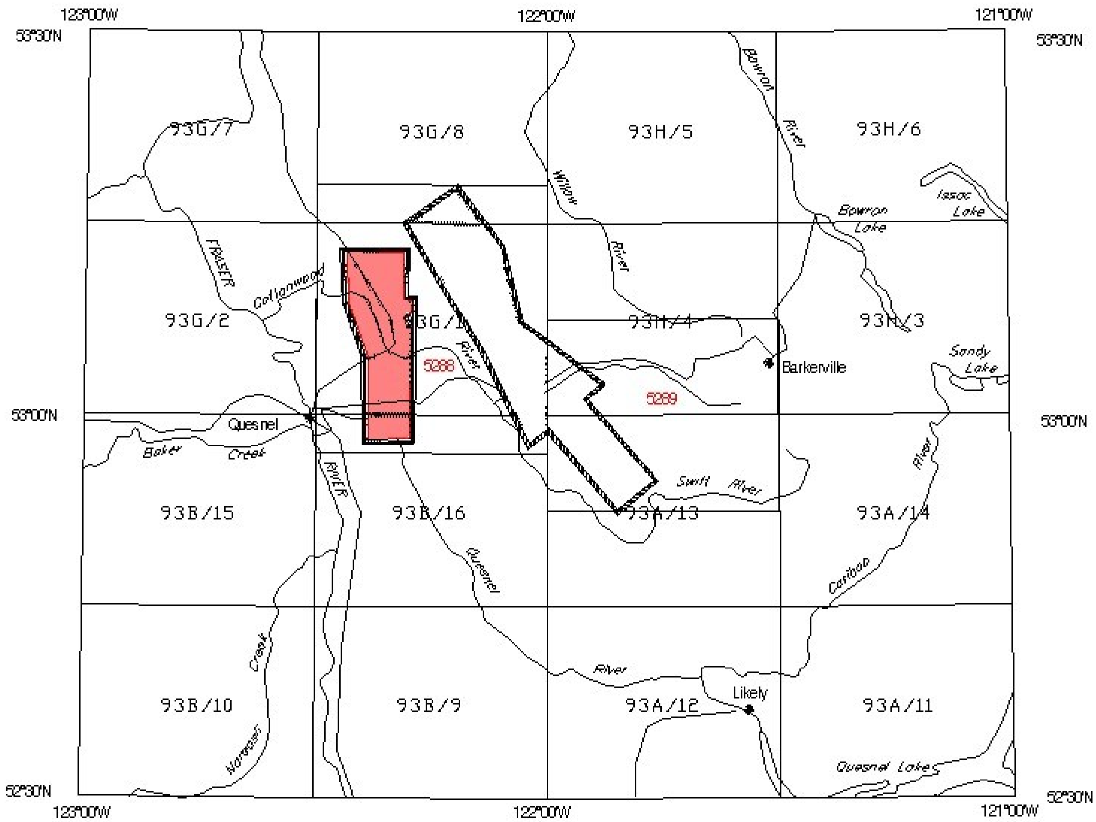

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Figure 2-H
Location/Index Map of Blocks K - N, Mostique, Atis, Ahbau Lake and Umiti Creek Blocks

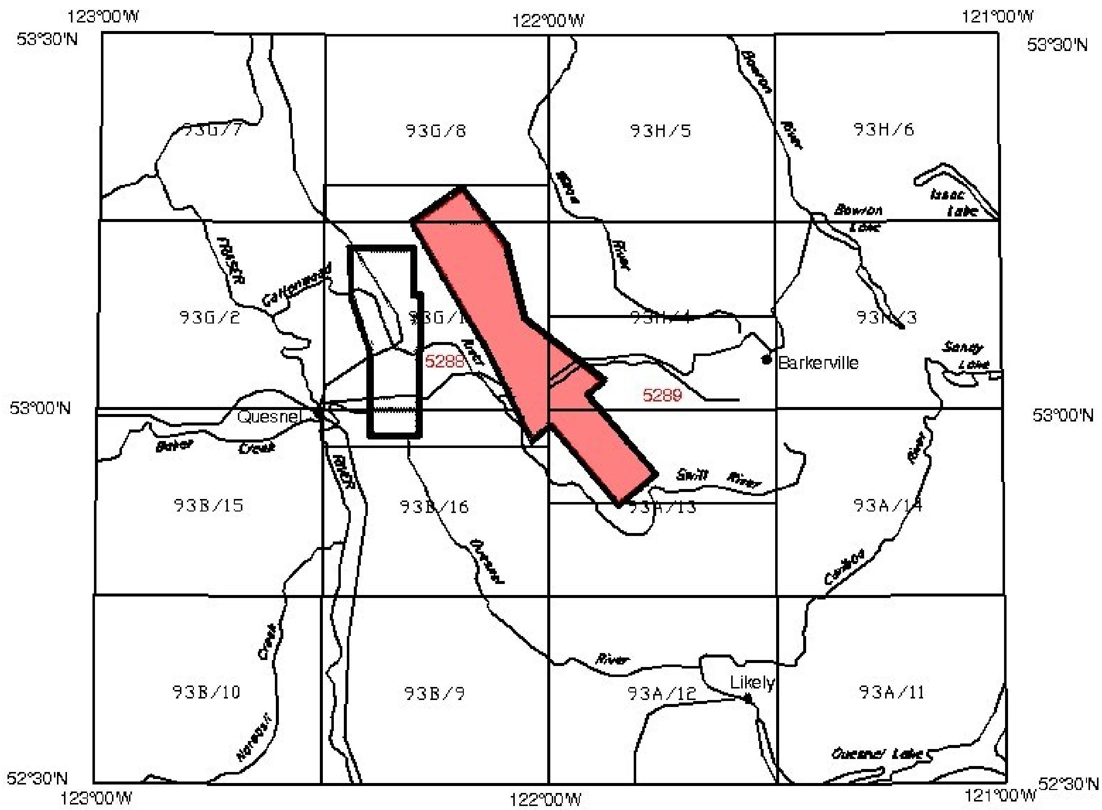

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Figure 2-I
Location/Index Map of Block AA, Fraser Lake

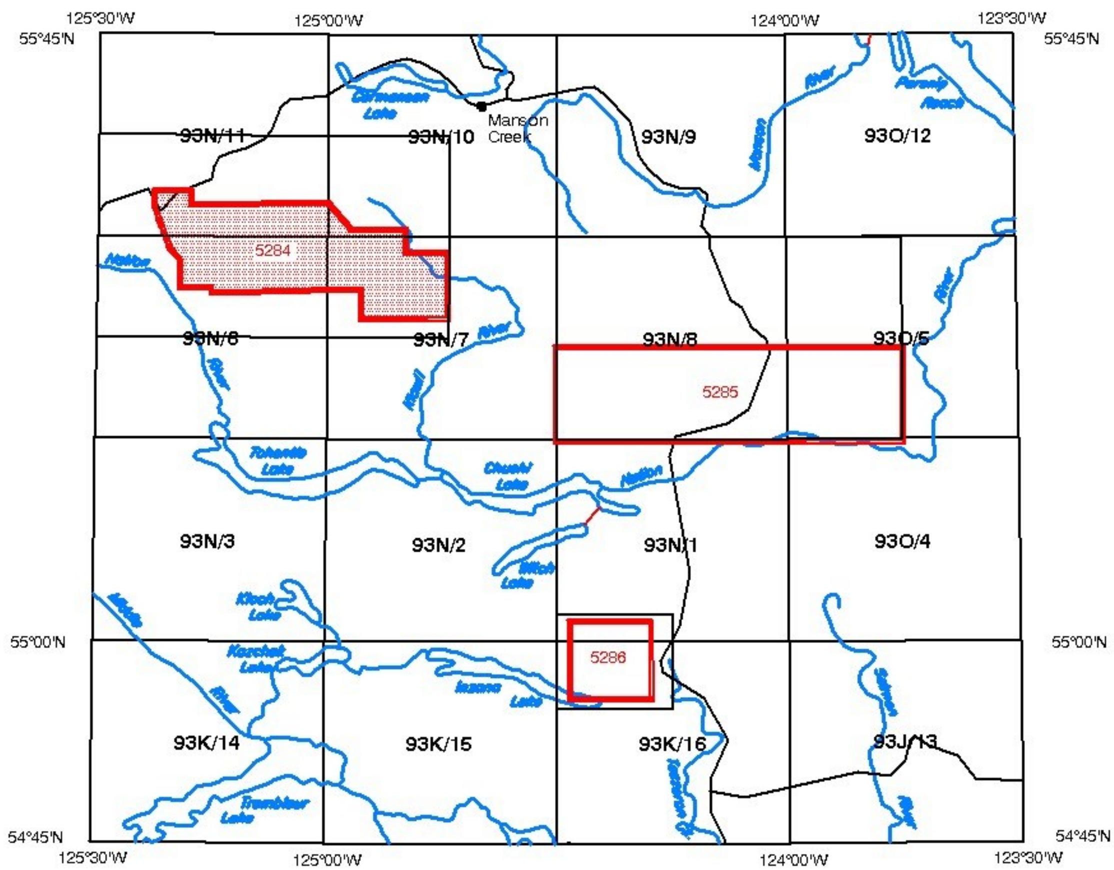

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Table 2-1
British Columbia Survey Block Specifications
(Nad83 Utm Zone 10)

Block A Mount Sylvester Block: British Columbia and Yukon Chamber of Mines

The survey specifications were as follows:

Parameter	Specifications
Traverse line direction Traverse line spacing Tie line direction Tie line spacing Sample interval Aircraft mean terrain clearance Mag sensor mean terrain clearance	90° azimuth 500 m 0° azimuth 4000 m 10 Hz, 3.0 m @ 90 km/hr 120 m 120 m

Nad83 Utm Zone 10

04078-1	404648	6123637
Block A	404888	6137264
	452443	6136496
	452323	6122868

Block B Fran Property: Yankee Hat Minerals Ltd.

The survey specifications were as follows:

Parameter	Specifications
Traverse line direction Traverse line spacing Tie line direction Tie line spacing Sample interval Aircraft mean terrain clearance Mag sensor mean terrain clearance	90° azimuth 150 m 0° azimuth 2000 m 10 Hz, 3.0 m @ 90 km/hr 90 m 90 m

Nad83 Utm Zone 10

04078-2	405900	6088200
Block B	405900	6098200
	416900	6098200
	416900	6088200

Block C Helene Lake Block: Yekooche First Nations

The survey specifications were as follows:

Parameter	Specifications
Traverse line direction	90° azimuth
Traverse line spacing	200 m
Tie line direction	0° azimuth
Tie line spacing	2000 m
Sample interval	10 Hz, 3.0 m @ 90 km/hr
Aircraft mean terrain clearance	90 m
Mag sensor mean terrain clearance	90 m

Nad83 Utm Zone 10

04078-3	362296	6025500
Block C	374724	6025500
	374724	6012650
	362296	6012650

Block D Tisdale Lake Block: Amarc Resources Ltd.

The survey specifications were as follows:

Parameter	Specifications
Traverse line direction	45° azimuth
Traverse line spacing	250 m
Tie line direction	135° azimuth
Tie line spacing	2500 m
Sample interval	10 Hz, 3.0 m @ 90 km/hr
Aircraft mean terrain clearance	120 m
Mag sensor mean terrain clearance	120 m

Nad83 Utm Zone 10

04078-4	662200	5754600
Block D	619700	5796800
	626200	5803700
	668800	5761300

Block E Murphy Lake Block: GWR Resources Inc.

The survey specifications were as follows:

Parameter	Specifications

Traverse line direction Traverse line spacing Tie line direction Tie line spacing Sample interval Aircraft mean terrain clearance Mag sensor mean terrain clearance	90° azimuth 200 m 0° azimuth 2000 m 10 Hz, 3.0 m @ 90 km/hr 90 m 90 m

Nad83 Utm zone 10

04078-5	603900	5762025
Block E	621600	5762025
	621600	5760825
	621600	5760825
	620350	5760825
	620350	5757625
	618450	5757625
	618450	5754425
	605900	5754425
	605900	5756425
	604900	5756425
	604900	5758625
	603900	5758625

Block F Horsefly-Canim Lake Block: British Columbia & Yukon Chamber of Mines

The survey specifications were as follows:

Parameter	Specifications
Traverse line direction Traverse line spacing Tie line direction Tie line spacing Sample interval Aircraft mean terrain clearance Mag sensor mean terrain clearance	45° azimuth 500 m 135° azimuth 4000 m 10 Hz, 3.0 m @ 90 km/hr 120 m 120 m

04078-6	607681	5785517
Block F	618939	5797415
	662735	5753928
	655353	5746127
	641922	5746127
	607681	5780127

Block G Mt. Polley infill Block: British Columbia and Yukon Chamber of Mines

The survey specifications were as follows:

Parameter	Specifications
Traverse line direction	90° azimuth
Traverse line spacing	500 m
Tie line direction	0° azimuth
Tie line spacing	4000 m
Sample interval	10 Hz, 3.0 m @ 90 km/hr
Aircraft mean terrain clearance	120 m
Mag sensor mean terrain clearance	120 m

Nad83 Utm Zone 10

04078-7	566500	5831200
Block G	566500	5836200
	602600	5836200
	602600	5831200

Block H Mouse Mountain Block: Richfield Ventures Corp.

The survey specifications were as follows:

Parameter	Specifications
Traverse line direction	90° azimuth
Traverse line spacing	150 m
Tie line direction	0° azimuth
Tie line spacing	1500 m
Sample interval	10 Hz, 3.0 m @ 90 km/hr
Aircraft mean terrain clearance	90 m
Mag sensor mean terrain clearance	90 m

Nad83 Utm Zone 10

04078-8	540325	5880957
Block H	547702	5881034
	547694	5880434
	547606	5880433
	547755	5868584
	540554	5868509
	540400	5880749

Block I Ahbau Block: Richfield Ventures Corp.

The survey specifications were as follows:

Parameter	Specifications
Traverse line direction Traverse line spacing Tie line direction Tie line spacing Sample interval Aircraft mean terrain clearance Mag sensor mean terrain clearance	90° azimuth 150 m 0° azimuth 1500 m 10 Hz, 3.0 m @ 90 km/hr 90 m 90 m

Nad83 Utm Zone 10		
04078-9	537079	5896374
Block I	546704	5896474
	546603	5889573
	547805	5889586
	547792	5888523
	537515	5888428

Block J Ahbau infill Block: Richfield Ventures Corp.

The survey specifications were as follows:

Parameter	Specifications
Traverse line direction Traverse line spacing Tie line direction Tie line spacing Sample interval Aircraft mean terrain clearance Mag sensor mean terrain clearance	90° azimuth 300 m 0° azimuth 3000 m 10 Hz, 3.0 m @ 90 km/hr 90 m 90 m

Nad83 Utm Zone 10		
04078-10	537633	5888431
Block J	547792	5888523
	547702	5881034
	540325	5880957

Block K Mostique Block: Richfield Ventures Corp.

The survey specifications were as follows:

Parameter	Specifications

Traverse line direction Traverse line spacing Tie line direction Tie line spacing Sample interval Aircraft mean terrain clearance Mag sensor mean terrain clearance	50° azimuth 200 m 140° azimuth 2000 m 10 Hz, 3.0 m @ 90 km/hr 90 m 90 m

Nad83 Utm Zone 10

04078-11	557537	5881901
Block K	562878	5886512
	575179	5877314
	564567	5868155

Block L Atis Block: Richfield Ventures Corp.

The survey specifications were as follows:

Parameter	Specifications
Traverse line direction Traverse line spacing Tie line direction Tie line spacing Sample interval Aircraft mean terrain clearance Mag sensor mean terrain clearance	50° azimuth 200 m 140° azimuth 2000 m 10 Hz, 3.0 m @ 90 km/hr 90 m 90 m

Nad83 Utm Zone 10

04078-12	567295	5870509
Block L	572657	5875137
	583028	5863482
	577554	5858757

Block M Ahbau Lake Block: Richfield Ventures Corp.

The survey specifications were as follows:

Parameter	Specifications
Traverse line direction Traverse line spacing Tie line direction Tie line spacing Sample interval Aircraft mean terrain clearance	55° azimuth 300 m 145° azimuth 3000 m 10 Hz, 3.0 m @ 90 km/hr 90 m

Mag sensor mean terrain clearance	90 m

Nad83 Utm Zone 10

04078-13	546187	5900329
Block M	553596	5905673
	560295	5897188
	551763	5891035

Block N Umiti Creek Block: Richfield Ventures Corp.

The survey specifications were as follows:

Parameter	Specifications
Traverse line direction Traverse line spacing Tie line direction Tie line spacing Sample interval Aircraft mean terrain clearance Mag sensor mean terrain clearance	55° azimuth 300 m 145° azimuth 3000 m 10 Hz, 3.0 m @ 90 km/hr 90 m 90 m

Nad83 Utm Zone 10

04078-14	551763	5891035
Block N	560180	5897105
	563447	5885468
	557825	5881413

Block AA Fraser Lake: Serengeti Resources Inc.

The survey specifications were as follows:

Parameter	Specifications
Traverse line direction Traverse line spacing Tie line direction Tie line spacing Sample interval Aircraft mean terrain clearance Mag sensor mean terrain clearance	90° azimuth 250 m 0° azimuth 4000 m 10 Hz, 3.0 m @ 90 km/hr 90 m 90 m

Nad83 Utm Zone 10

04078-15	350000	6159138

Block AA	355069	6159138
	355069	6157005
	373848	6157005
	377053	6153029
	384526	6153029
	384526	6149755
	390000	6149755
	390000	6140704
	378129	6140704
	378129	6144948
	357591	6144948
	357591	6145792
	353232	6145792
	353232	6149715
	351986	6151085
	350000	6156792

Summary of Total Kilometres Flown per Survey Block:

BLOCK	Traverse Lines (km)	Control Lines (km)	Total Kilometres (km)	Industry Sponsor
Block A	1243.6	169	**1412.6**	
Block B	799	67.2	**866.2**	**Yankee Hat Industries**
Block C	302.4	34.8	**337.2**	**Yekooche First Nations**
Block D	2353.4	366	**2726**	**Amarc Resources Ltd.**
Block E	1262.5	143.3	**1407**	**GWR Resources Inc.**
Block F	2589.6	467.7	**3051**	
Block G	363	50	**413**	
Block H	598.3	75.6	**691**	**Richfield Ventures Corp.**
Block I	495.6	63.7	**564**	**Richfield Ventures Corp.**
Block J	218.6	30.6	**277**	**Richfield Ventures Corp.**
Block K	790.4	109.8	**903**	**Richfield Ventures Corp.**
Block L	558.4	62.4	**623**	**Richfield Ventures Corp.**
Block M	353.8	65	**426**	**Richfield Ventures Corp.**
Block N	328.7	57.5	**388**	**Richfield Ventures Corp.**
Block AA	1780.1	133.7	**1914**	**Serengeti Resources Inc.**

3. SURVEY EQUIPMENT

The instrumentation was installed in both an Aerospatiale AS350B3 and a AS350B2 turbine helicopter (Registrations C-GECL and C-FGSC respectively), provided by Questral Helicopters and Great Slave Helicopters Ltd. Respectively. The helicopter was equipped with an emergency locator transmitter (ELT), a satellite phone, a VHF communications system, and all necessary emergency survival equipment. All field personnel were briefed on safety measures and SAR and emergency procedures.

Figure 3-A: Airborne Survey System

A brief description of the geophysical instruments used to acquire the survey data follows:

Geophysical Flight Control System

Type: HeliDAS

The HeliDAS controls, monitors and records the operation of all the geophysical and ancillary sensors. Input from the various sensors is monitored every 0.01 seconds for precise coordination of geophysical and positional measurements. GPS positional coordinates and terrain clearance is presented to the pilot by means of a LCD touch screen display and optional pilot indicator. The magnetometer response, 4th difference, altimeter profile and profiles of the radiometric windows are also shown on the LCD touch screen display for real-time monitoring of equipment performance.

Magnetometer

2004:
Model: Geometrics 822

Type:	Optically pumped cesium vapour
Sensitivity:	0.01 nT
Sample rate:	10 per second

2005:
Model: Scintrex CS-2

Type:	Optically pumped cesium vapour
Sensitivity:	0.01 nT
Sample rate:	10 per second

The magnetometer was mounted in a forward facing stinger configuration on the helicopter. The Larmor frequency output was processed by the magnetometer counter board that provides a resolution, without filtering, of 10 (ten) times per second (in a magnetic field of 50,000 nT this resolution is equivalent to 0.005 nT).

Magnetic Base Station

PRIMARY (CF1)
Model: Scintrex CS-3

Type:	Digital recording cesium vapour
Sensitivity:	0.01 nT
Sample rate:	1 per second

SECONDARY
Model: GEM Systems GSM-19T

Type:	Digital recording proton precession
Sensitivity:	0.10 nT
Sample rate:	0.1 per second

A digital recorder is operated in conjunction with the base station magnetometer to record the diurnal variations of the earth's magnetic field. The clock of the base station is synchronized with that of the airborne system to permit subsequent removal of diurnal drift.

Magnetic Compensation

Type: RMSAADC
Sensitivity: .01

The proximity of the helicopter to the magnetic sensors creates a measurable anomalous response as a result of the helicopter movement. The orientation of the aircraft with respect to the sensors and the motion of the aircraft through the earth's magnetic field are contributing factors to the strength of this response. A special calibration flight is flown to record the information necessary to remove these effects.

The maneuvers consist of flying a series of calibration lines at high altitude to gain information in each of the required line directions. During this procedure, the pitch, roll and yaw of the aircraft are varied. Each variation is conducted in succession (first vary pitch, then roll, then yaw). This provides a complete picture of the effects of the aircraft at designated headings in all orientations. A three-axis fluxgate magnetometer measures the orientation and rates of change of the magnetic field as measured at the aircraft, away from localized terrestrial magnetic anomalies. The digital compensation algorithm is applied to generate a correction factor to compensate for permanent, induced and eddy current magnetic responses generated by the aircraft movement.

The RMSAADC compensation system allows the geophysicist to derive a set of coefficients for all line directions and for each magnetometer sensor. Once determined, the coefficients are applied real-time.

Spectrometer

Manufacturer: Exploranium
Model: GR-820
Type: 256 multi-channel, Thorium stabilized
Accuracy: 1 count/sec.
Update: 1 integrated sample/sec.

The GR-820 Airborne Spectrometer is connected to eight downward looking crystals (33.6 litres) and one upward looking crystal (4.2 litres). The downward crystals record the radiometric spectrum from 410 KeV to 3 MeV over 256 discrete energy windows, as well as a cosmic ray channel that detects photons with energy levels above 3.0 MeV. From these 256 channels, the standard Total Count, Potassium, Uranium and Thorium channels are extracted. The upward crystal is used to measure and correct for Radon.

The shock-protected Sodium Iodide (Thallium) crystal package is unheated and is automatically stabilized with respect to the Thorium peak. The GR-820 provides raw or Compton stripped data that has been automatically corrected for gain, base level, ADC offset and dead time.

The system is calibrated before and after each flight using three accurately positioned hand-held sources. Additionally, tests are carried out to determine if there are any differences in background. This procedure allows corrections to be applied to each survey flight to eliminate any differences that might result from changes in temperature or humidity.

Radar Altimeter

Manufacturer:	Sperry
Model:	RT220/RT330
Indicator:	TRI 30
Type:	Single antenna, FMCW
Range:	40 to 2500 feet
Accuracy:	40 to 100 feet, ±5 feet
	100 to 500 feet, ±5%
	500 to 2500 feet, ±7%

Laser Altimeter

2005 only:

Manufacturer:	Optech
Model:	G150
Type:	Fixed pulse repetition rate of 2 kHz
Sensitivity:	±5 cm from 10ºC to 30ºC
	±10 cm from -20ºC to +50ºC
Sample rate:	2 per second

The laser altimeter is mounted underneath the helicopter, and measures the distance from the helicopter to ground, except in areas of very dense tree cover.

Barometric Pressure

Manufacturer:	Rosemount
Model:	1241M B2

Output:	VDC
Accuracy:	±5.1 feet @ sea level
	±6.9 feet @ 10,000 feet

Digital Data Acquisition System

Manufacturer:	Fugro Airborne Surveys
Model:	HeliDAS
Recorder:	IBM Microdrive

The output data is recorded digitally on a flashcard and internal hard drive ten times per second and then downloaded to the field workstation PC at the survey base for verification, backup and preparation of in-field products.

Video Flight Path Recording System

Camera:	Sony DXC-101
Type:	Panasonic VHS Video Recorder (NTSC)
Model:	AG 720

Information overlain on the video image includes flight number, line number, DOS time, GPS week second, and latitude and longitude. The videotapes were manually labeled with the flight number and date for external identification.

Navigation (Global Positioning System)

Airborne Receiver:

Model:	NovAtel Millenium
Type:	twelve-channel L1,L2 PC GPScard
Accuracy:	±2 metres post-processed

Base Station:

Model:	NovAtel Millenium
Type:	twelve-channel L1,L2 GPScard
Accuracy:	0.75 metres real-time differential
	±2 metres post-processed

For the central British Columbia survey, there were several bases of operation and therefore base station locations. They are summarized below:

2004
Blocks A and B

Mackenzie , B.C.	55° 18’ 15.656” N 123° 08’ 05.632” W 596.34m

Block D

Minac , B.C.	51° 51’ 33.254” N 120° 51’ 38.338” W 775.19m

2005
Blocks H - N

Quesnel Airport	53° 01’ 39.612” N 122° 30’ 29.880” W 528.07m
Quesnel – survey area	53° 05’ 11.040” N 122° 34’ 02.748” W 486.17m
Quesnel 2	53° 06’ 50.076” N 122 14’ 37.176” W 768.59m
Quesnel GSC	53° 01’ 39.612” N 122° 12’ 39.600” W 893.58m
Quesnel Novatel	53° 00’ 48.420” N 122° 18’ 08.532” W 539.00m

Blocks E and F

108 Mile House	51° 26’ 34.116” N 121° 12’ 02.844” W 943.41m

Block C

Fraser Lake	54° 02’ 06.720” N 124° 31’ 51.132” W 663.03m

Block AA

Germansen Landing	55° 28’ 15.096” N 124° 25’ 13.476” W 752.00m

The GPS records data in WGS84 coordinates, which are relative to the GRS80 ellipsoid, which is the basis of the revised North American Datum (NAD83).

Barometric Pressure and Temperature Sensors – Base Station

Model:	DIGHEM D 1300
Type:	Motorola MPX4115AP analog pressure sensor
	AD592AN high-impedance remote temperature sensors
Sensitivity:	Pressure: 150 mV/kPa
	Temperature: 100 mV/°C or 10 mV/°C (selectable)
Sample rate:	10 per second

The D1300 circuit included one barometric sensor (1 KPA) and one temperature sensor (3 TDC). The two sensors were used to monitor pressure and external operating temperatures.

The pressure data are used to correct the radar altimeter data to effective altitude in the radiometric data processing. The barometric altimeter data can also be used to confirm the

GPSZ elevations and to produce approximate terrain maps by subtraction of the radar altimeter data. The barometric base station data can be used to estimate changes in air pressure throughout the survey flight.

Field Data Verification System

Manufacturer:	Fugro
Type:	Pentium IV Laptop PC
Software:	Geosoft Oasis Montaj + Atlas proprietary software

A portable PC-based field workstation was used at the survey base to process the data, to verify data quality and completeness, and to confirm that all data were within the stated specifications. Data checks were carried out at the end of every survey day. Flight data were transferred to the PC hard drive to permit the creation of a database. This process allowed the field operators to display both the positional (flight path) and geophysical data on a screen or printer.

4. SURVEY LOGISTICS, CALIBRATION AND FIELD PROCESSING

Survey Field Operations

The survey was flown over two seasons, from September 18 to November 17, 2004 using AS350B3 helicopter C-GECL and then from June 15 to August 8, 2005 using first C-GECL followed by the AS350B2, C-FGSC. Survey operations were flown out of several bases throughout each season. Personnel are listed in Appendix A. Aircraft ground speed was maintained at approximately 90 km/hr for the survey. A mean terrain clearance of either 90 or 120 metres, depending on the survey block and consistent with the safety of the aircraft and crew, was achieved although terrain clearance was highly variable throughout the survey block.

Survey results were compiled and inspected daily. Preliminary field plots were produced in order to monitor data production, completeness and quality. The daily checks enabled those responsible for quality control to determine which lines, if any, did not meet the technical specifications. Any lines or line segments that did not meet the stipulated criteria could be reflown the following day, while the survey crew was still in the immediate area.

For the surveys, the primary GPS station locations were summarized as follows:

2004

Blocks A and B

Mackenzie , B.C.	55° 18' 15.656" N	123° 08' 05.632" W	596.34m

Block D

Minac , B.C.	51° 51' 33.254" N	120° 51' 38.338" W	775.19m

2005

Blocks H - N

Quesnel Airport	53° 01' 39.612" N	122° 30' 29.880" W	528.07m
Quesnel – survey area	53° 05' 11.040" N	122° 34' 02.748" W	486.17m
Quesnel 2	53° 06' 50.076" N	122 14' 37.176" W	768.59m
Quesnel GSC	53° 01' 39.612" N	122° 12' 39.600" W	893.58m
Quesnel Novatel	53° 00' 48.420" N	122° 18' 08.532" W	539.00m

Blocks E and F

108 Mile House	51° 26' 34.116" N	121° 12' 02.844" W	943.41m

Blocks C

Fraser Lake	54° 02' 06.720" N	124° 31' 51.132" W	663.03m

Block AA

Germansen Landing	55° 28' 15.096" N	124° 25' 13.476" W	752.00m

At each setup, the basestation magnetometers (CF1) were setup near the GPS base. The first production flight was on September 18, 2004 and survey operations were concluded in 2004 on November 17. Surveying restarted in 2005 on June 15. The last survey flight was completed on August 8, 2005 and the crew demobilized on August 10, 2005. Test flights and system calibrations were carried out over the Meanook test site on September 29, 2004 and June 5, 2005 and a test range established by the Geological Survey of Canada (GSC) in Quesnel, British Columbia on July 12, 2005. The results of these tests were accepted by the Geological Survey of Canada's technical authority as valid calibrations, for acceptance of the change over to the AS350B2 helicopter and for the determination of coefficients for conversion of radiometric count rates to equivalent ground concentrations. These tests also determined the spectrometer system response and magnetic lag/heading corrections.

Figure 4-A: CF1 Base Station in Quesnel, BC

Figure 4-B: CF1 Base Station in 108 Mile House, BC

Figure 4-C: CF1 Base Station in 108 Mile House, BC

Figure 4-D: CF1 Base Station in Germansen Landing, BC

Field Inspections

Field inspection by the Geological Survey of Canada Technical Authorities was carried out in July, 2005 by John Carson, Radiometric Data Analysis Expert and Regis Dumont, Magnetic Data Analysis Expert. Data was reviewed routinely by the Technical Authorities throughout the period of data acquisition. The purpose of this review was to ensure that operational and processing procedures were being followed according to the survey specifications

Navigation

The HeliDAS acquisition unit was operated in conjunction with an Ashtech GG24 GPS system to provide navigational guidance to the programmed flight plan.

Pre-Survey Spectrometer Calibrations

Pre-survey calibrations and testing of the GR820 airborne gamma-ray spectrometry system were carried out on July 13, 2005. For these calibrations and tests a Eurocopter AS 350 B2 helicopter, registration C-FGSC, owned by Great Slave Helicopters, was mobilized in survey configuration. The installed equipment and configurations were selected to conform to contract technical specifications.

Calibration of the spectrometer system is a vital process to airborne radiometrics or airborne gamma-ray spectrometry. The calibration of the spectrometer system involved three tests which enabled the conversion of airborne data to ground concentration of natural radioactive elements. These tests included:

- **Calibration Pad** measurements which were used to determine the “spectral overlap” (Compton scattering) coefficients.
- **Cosmic Flight Test**, which was used to determine the aircraft background values and cosmic coefficients,
- **Ground-Airborne Test,** including the ***dynamic calibration range (dcr)*** measurements, which determined the altitude attenuation coefficients and the radio-element sensitivity of the airborne spectrometer system.

Measurements were made in accordance with Fugro Airborne Surveys procedures for airborne gamma-ray spectrometry (AGS) data acquisition, which were designed in accordance with IAEA technical report series No. 323, “Airborne Gamma Ray Spectrometer Surveying”, and AGSO Record 1995/60, “A Guide to the Technical Specification for Airborne Gamma-Ray Surveys”.

Spectrometer System

For the GSC flying, the spectrometer crystal packs and console were installed and calibrated in both C-GECL and C-FGSC. The Calibration Pad Test was carried out on C-GECL. For both machines, one crystal pack was installed on the floor of the passenger compartment. The other was installed in a basket on the left skid.

Gamma Ray Detectors	Downward: 33.6 litres NaI (Tl) Upward 4.2 litres NaI (Tl)	
Spectrometer Analyzer	Exploranium GR-820	

Gamma Peak Positions

Fugro Airborne Surveys configures the GR-820 spectrometer so that the energy versus channel number intercept equals zero. The spectrometer is kept stable in the energy range of interest (400 – 3000keV) in order to maintain constant gamma peak positions. The most important peaks and their corresponding channel numbers are as follows:

Source Name	Peak Energy (keV)	Position (channel no.)
Cs-137	662	55.5
K(potassium/K-40)	1460	121.7
U(uranium/Bi-214)	1764	147.0
Th(thorium/Tl-208)	2615	217.5

Energy Windows

The airborne radiometric technique requires measurement of count rates for specific energy regions or windows in the natural gamma-ray spectrum. The standard energy regions (in accordance with IAEA 323) and their corresponding channel limits are:

Downward Spectrometer Energy Windows				
Designation	**Energy Limit (keV)**		**Channel Limit (inclusive)**	
			Unit Values	
	Lower	**Upper**	**Lower**	**Upper**

Total Count	=TC	410	2810	32	234
Potassium	=K	1370	1570	114	131
Uranium	=U	1660	1860	138	155
Thorium	=Th	2410	2810	201	234
Upward U	=Uranup	1660	1860	138	155
Cosmic	=Cosmic	3200	infinity		

Calibration Pad Test

The GR-820 spectrometer consists of eight downward looking crystals and one upward looking crystal, each with a volume of 256 cubic inches, recording regions of interest (ROI's) once per second. These ROI's are written to five channels: Total Count (TC), Potassium (K), Uranium (U), Thorium (Th), and Uranup (upward facing U). In addition, Livetime and Cosmic channels are recorded. The total count window refers to the sum of all counts within the 0.4 to 2.8 keV energy window, while the K, U and Th windows refer to spectral peaks within the total count window. Some of the counts in the K, U, and Th windows originate from gamma rays from other isotopes. Removal or "stripping" of this spectral overlap in the survey data is achieved using the Compton stripping coefficients or ratios calculated from the calibration pad test data.

In June, 2005 the calibration pad test was conducted at the Sander Geophysics hangar in Ottawa, Ontario using aircraft C-GECL. This test required a total of four transportable 1mx1m concrete slabs, which were provided by the Geological Survey of Canada and manufactured under the supervision of Dr. R.L. Grasty. Reference:

"Transportable Calibration Pads for Ground and Airborne Gamma-Ray Spectrometers" by R.L. Grasty, P.B. Holman and Y.B. Blanchard. Geological Survey of Canada paper 90-23.

Three of the concrete slabs contained higher concentrations of potassium, uranium and thorium respectively, while the fourth slab (the background slab) contained lower concentrations of the radioelements. The calibration pad concentrations, as provided by the Geological Survey of Canada, were as follows:

Test Pad Designation	**Radio-Element Concentration**		
	Potassium (%)	Uranium (ppm)	Thorium (ppm)
B	1.34 +/- 0.01	1.05 +/- 0.03	2.10 +/- 0.06
K	6.74 +/- 0.03	2.24 +/- 0.10	5.89 +/- 0.67
U	1.25 +/- 0.01	53.33 +/- 0.39	3.20 +/- 0.09
Th	1.34 +/- 0.02	2.52 +/- 0.07	122.9 +/- 0.71

Setup Procedure

Upon arriving at the test site, the helicopter was positioned away from any surrounding traffic where it remained undisturbed throughout the course of the test. All hand sources (thorium, uranium, cesium, etc.) and transportable concrete slabs were placed approximately 50m from the helicopter and spectrometer system. The initial positions of each of the concrete slabs and hand sources were marked, and therefore returned to their respective positions after each measurement was taken. As well, the exact position of the spectrometer unit was marked in the helicopter and matched to the position that would be used during survey flights.

Power was consistently applied to the spectrometer units for a minimum of 12 hours prior to the calibration pad measurements to ensure that the crystals were stable.

Measurement Procedure

1. The spectrometer unit was stabilized on cesium and thorium following standard stabilizing procedures with the hand sources. In order to maintain consistency, a jig was used. The jig consisted of a 2” x 4” piece of wood with cut-outs at each end of the board in the shape of the helicopter skid tubes, which allowed the jig to be placed against the helicopter skids to give a constant placement of the jig for all measurements. The hand sources were placed on an established marker on the jig under the spectrometer pack, for precise measurement location.
2. Once the spectrometer unit was stabilized, the jig was removed and the background block was placed under the helicopter, with the crystal pack over its centre.
3. Digital survey data were then recorded for 60 seconds.
4. Steps 2-3 were then repeated for the potassium, uranium, thorium and background block. By completing the series of block tests with the background block, it could be confirmed that the background had remained constant, thus improving the statistics for background determination.
5. Using standard procedures with the jig described in step 1, the thorium source test was undertaken again to ensure consistency of the results between the pre-test and post-test.

Results from Calibration Pad Test

The measured count rates (downward crystal) were corrected for spectrometer livetime and averaged.

John Carson, Radiometric Data Analysis Expert of the Geological Survey of Canada analyzed the collected data and calculated the stripping ratios using the program “ZPADWIN”. The program ZPADWIN was developed at RISO National Laboratory, Denmark. It uses non-linear statistical techniques to extract the Compton stripping coefficients and estimated errors (standard deviations) from test pad data. Reference: “Pad Facility for the Calibration of Gamma-Ray Measurements on Rock”, RISO-R-454 (1981) by L.Lovborg et al. The following is the result of the program.

Stripping Ratios	Spectrometer Unit	Ideal Values
Th into U (alpha = a23/a33)	0.224	0.250
Th into K(beta = a13/a33)	0.375	0.400
U into K (gamma = a12/a22)	0.714	0.810
U into Th (a = a32/a22)	0.053	0.060
K into Th(b = a31/a11)	-0.001	0.000
K into U (g = a21/a11)	0.000	0.003

Comparison of the coefficients obtained and the "ideal" coefficients calculated by the manufacturer (Exploranium) shows that the values were well within an acceptable range.

Cosmic Flight Test

In each of the spectral windows, the radiation increases exponentially with height due to radiation of cosmic origin. As well, the aircraft itself contributes a constant background to the count rate. By completing a series of flights over a range of altitudes above sea level, these backgrounds can be determined.

Setup Procedure

Throughout the course of the cosmic flight test, the spectrometer was operated with very few counts to the stabilization peak. In order to ensure that the detectors were stable prior to take off, the crystals were stabilized on the ground for at least 2 hours. During the test, the stabilizer was turned off.

Prior to the cosmic flight test, the spectrometer unit remained powered for at least 12 hours. This ensured that the crystals were stable.

Measurement Procedure

1. A source check was completed at the helicopter base using the jig described previously (calibration pad test).
2. Once the aircraft reached the desired altitude of 8,000 feet, survey data were recorded for 20 minutes.

3. Step 2 was then repeated at altitudes of 9000, 10000, 11000, and 12,000 feet.
4. After the cosmic flight test was completed, the spectrometer unit was stabilized on thorium at the helicopter base. After this, a post-flight thorium source test was completed. The values obtained were found to be within 3% of the pre-flight source test. The collected data are summarized below.

	Cosmic Test Flight Data (measured corrected counts)					
Altitude (ft)	Cosmic	K	U	Th	TC	Uranup
12000.0	560.7	41.4	29.8	35.3	681.5	3.6
11000.0	493.2	38.6	26.9	31.7	618.2	2.9
10000.0	410.7	33.8	23.2	27.7	535.3	2.5
9000.0	349.8	30.7	19.9	24.4	480.3	2.5
8000.0	298.2	27.9	18.0	21.8	433.3	2.1

Results from Cosmic Flight Test

At each altitude, the data for the five windows of interest (Th, K, U, TC and Uranup) were evaluated for quality and corrected for livetime. The mean values were then extracted and plotted against the cosmic window. The result is a linear trend where the slope and intercept represent the cosmic stripping ratio and the aircraft background respectively. The results from the five graphs are summarized below.

	Cosmic Flight Test Result	
	Cosmic stripping	Aircraft background
K	0.0523	12.393
U	0.0457	4.258
Th	0.0512	6.554
TC	0.9500	148.315
Uranup	0.0053	0.499

Ground Calibration Test

The ground calibration site was used to calibrate the height attenuation and sensitivity parameters of the spectrometer system by flying a series of passes over a line of known, uniform radioelement ground concentration. The ideal calibration ranges are located

adjacent to bodies of water. This permits accurate background corrections for the acquired data.
This calibration was completed on July 13, 2005 with aircraft C-FGSC in AGS survey configuration, over a test strip established near Dragon Lake, Quesnel, B.C.. The test range was flown by acquiring data on a series of 7 passes over a fixed length, at constant ground clearances ranging from 100 to 600 feet. These passes alternated between the land and adjacent fresh water sections of the range.

Radiometric Ground Concentrations

The radiometric ground concentration was measured using a calibrated portable spectrometer (Exploranium GR-320) on the same day as the airborne measurements. Thirty-two 100-second measurements were taken over the length of the calibration range. The sensor was positioned one metre above the soil and away from the operators' body. Four 300-second measurements were taken over the adjacent water to serve as background for the portable spectrometer. The resulting mean radiometric equivalent ground concentrations for the calibration range on July 13, 2005 were as follows:

Radio Element	Ground Concentration
Potassium	1.39 %
Equivalent Uranium	1.1 ppm
Equivalent Thorium	5.16 ppm
Total	37.24 nGy/h

Results from the Dynamic Calibration Range Test

The airborne data from the calibration range were checked for quality, edited and divided into lines for each pass. All AGS windows were corrected for livetime. Mean values were calculated for each pass over water. The radiometric windows were then corrected for background (aircraft, cosmic and radon) by subtracting the over water mean values from the corresponding over land data values. After averaging the data for each line, the natural logs of the four windows of interest (K, U, Th, and total count) were plotted against the altimeter in order to obtain the height attenuation and sensitivity parameters. The results were obtained using a linear regression where the slope represents the attenuation coefficient and the intercept represents the counts at 0 feet. Using the ground concentrations noted previously, and the intercept, the sensitivity coefficients were obtained.

	Spectrometer Unit – 2005 System	
	Height Attenuation cps/m	Sensitivity @ 120 m
K	-0.009297	56.9544 cps/%

U	-0.008396	8.3733 cps/ppm
Th	-0.007610	3.6791 cps/ppm
TC	-0.007455	20.6605 cps/nGy/h

The correction coefficients used in processing the radiometric data are given in Appendix B.

Meanook Test Range

Prior to commencement, the Meanook, Alberta test site was used to determine the heading error and calibrate the system for the C-GECL, the AS350B3 which originally started data collection in both 2004 and 2005 in British Columbia. A cloverleaf pattern of lines was flown at 500 feet in the cardinal directions (North, South, East, and West) over the Meanook observatory with a centre point of 347759.2, 6054576.2. These tests were flown September 29, 2004 and June 6, 2005. The tests used the Magnetic Observatory Monitor to allow for the correction of diurnal variations. The electronic navigation system was also checked at Meanook. These tests complied with GSC contract specifications. The Meanook tests also included a determination of the heading error, by flying at the specified altitude in two (2) directions. Magnetic verification checks of the replacement AS350B2 helicopter, C-FGSC, were made when it was deployed in mid-July 2005. These checks were made in Quesnel, B.C. to verify consistency with the data from the original helicopter. Acceptance of this procedure was given by the Technical Authority for the Geological Survey of Canada prior to commencing any further survey acquisition on the BC blocks with the replacement helicopter.

Radon Calibration

Throughout the survey, repeat test lines were flown twice daily to monitor the system operation and atmospheric radon variations. This information was used to monitor the upward looking crystal coefficients for this system.

Field Survey Monitor Tests

During the field survey, data quality and instrument tests were completed as follows:

Airborne Magnetometer

The airborne magnetic data were monitored in the aircraft by means of a fourth difference calculation which was displayed on the airborne acquisition system display. Where the fourth difference exceeded the allowable specification, that portion of the flight line was reflown.

The fourth difference is defined as:

$$FD_i = X_{i+2} - 4x_{i+1} + 6x_i - 4x_{i-1} + X_{i-2}$$

where X_i is the i^{th} total field sample. The fourth difference in this form has units of nT. High frequency noise should be such that the fourth differences divided by 16 are generally less than ± 0.1 nT.

A test of the measurement platform's compensation system was made before starting the survey. This measures the ability of the system to remove the effects of aircraft motion on the magnetic measurement. The results of the FOM test were measured as less than 2.0 nT with an average noise envelope of 0.1 nT and are presented in Appendix E.

Magnetic Base Station Data Verification

The ground stations were monitored to ensure that the diurnal variation was within the peak to peak envelope of 3.0 nT from a long chord distance equivalent to a period of one minute. Where reflights were necessary, the reflown portions of lines began and ended at control lines.

Flight Path

The GPS mobile data were differentially corrected using the base station data, on a daily basis. The flight path video was used to confirm the fiducial locations with respect to visible features on the map. Preliminary flight path maps and magnetic maps were plotted and updated, to monitor coverage of the survey area.

5. DATA PROCESSING AND PRESENTATION

Base Maps

The topographic base data were supplied as digital files by Geomatics Canada, Natural Resources Canada and were used in the map production. The digital topography was supplied in NAD83.

Flight Path

The mobile GPS data were differentially corrected post-survey, using the GPS base station data. The results were inspected in the field and edited to remove any noise spikes, offsets, or gaps in coverage. The preliminary flight path maps displayed fiducial increments which are tied to the UTC time. Each tick mark on the 1:50000 scale maps represents 10 seconds, with numerical labels every 100 seconds. Each tick mark on the 1:20000 scale maps represents 5 seconds, with numerical labels every 50 seconds.

The WGS84 latitude/longitude coordinates were converted to NAD83 UTM coordinates for Zone 10N, with a central meridian of 123º West. All final maps display Lat/Long coordinates. The data archives also contain the xy coordinates in UTM NAD83. As the GRS80 ellipsoid forms the basis of the NAD83 datum no datum shifts were required.

After confirming the accuracy of the flight path, the ends of the survey lines were trimmed to the survey boundary, leaving an over fly of approximately 100 meters. Each line or line segment shown on the map sheets carries a unique line number.

Magnetic Data

Magnetic Levelling

The raw magnetic data were checked for spikes, using the 4th difference calculation as a flag. Obvious spikes were checked and then manually removed. As a result of the unpredictable activity of an engine cooling fan on the helicopter, the raw magnetic data contains a number of offsets throughout the flight data. The locations of these events are clearly identified by the 4th difference trace. Corrections to the raw magnetic data were made on a flight basis to ensure consistency of the magnetic signal from one flight line to the next. After correcting for the offsets, the compensated magnetics were lagged according to the lag determined from the lag test. The long wavelength diurnal component was then removed from the lagged traverse and control line data. Diurnal corrections were made after appropriate base level removals from the diurnal field for each block.

The total field strength of the International Geomagnetic Reference Field (IGRF) was calculated for every data point, based on the spot values of Latitude, Longitude and GPS altitude, using appropriated Epochs for each block. These are as follows:

Block A Mount Sylvester Block	October 3, 2004
Block B Fran Block	October 19, 2004
Block C, Helene Lake Block	August 2, 2005
Block D, Tisdale Lake Block	November 17, 2004
Block E, Murphy Lake Block	July 22, 2005
Block F, Horsefly-Canim Block	July 25, 2005
Block G, Mt. Polley infill Block	July 20, 2005
Block H – J, Mouse Mountain, Ahbau and Abhau infill Blocks	June 20, 2005
Block K – N, Mostique, Atis, Ahbau Lake and Umiti Creek Blocks	July 17, 2005
Block AA, Fraser Lake Block	August 6, 2005

This IGRF was removed from the measured survey data on a point by point basis.

A survey line/control line network was created in order to determine differences in the diurnally corrected, IGRF removed, magnetic field at the line intercepts. The differences were calculated and tabulated, and were used to guide subsequent manual levelling on any lines or line segments which required adjustments. After the initial and subsequent network corrections interim grids and maps, were submitted to the Technical Inspector for approval, prior to generating the final 50 m grids and maps.

In order to check the quality of the levelling process, a first vertical derivative grid was calculated from the corrected total field data. This product helped to locate subtle differences between lines that were not evident on the total field data. There was no microlevelling applied

The final IGRF removed magnetic field data were gridded using a minimum curvature method with a grid cell size of 50 metres.

<u>Calculated Vertical Gradient</u>

The vertical gradient grids were calculated from the magnetic grid, using 2-D FFT algorithms.

Radiometric Data

All radiometric data reductions followed the procedures described in the IAEA Technical Report[1] and AGSO Record 1995/60[2].

All processing of radiometric data was undertaken at the natural sampling rate of the spectrometer, i.e., one second. The archived data were interpolated to match the fundamental 0.1 second interval of the database.

The following sections describe each step in the process.

Pre-filtering

The radar altimeter data were processed with a 15-point median filter to remove spikes.

Reduction to Standard Temperature and Pressure

The radar altimeter data were converted to effective height (h_e) in feet using the acquired temperature and pressure data, according to the following formula:

$$h_e = h * \frac{273.15}{T + 273.15} * \frac{P}{1013.25}$$

where: *h* is the observed radar altitude in metres
T is the measured air temperature in degrees Celsius
P is the barometric pressure in millibars

Live Time Correction

The spectrometer, an Exploranium GR-820, uses the notion of "live time" to express the relative period of time the instrument was able to register new pulses per sample interval. This is the opposite of the traditional "dead time", which is an expression of the relative period of time the system was unable to register new pulses per sample interval.

The GR-820 measures the live time electronically, and outputs the value in milliseconds. The live time correction is applied to the total count, potassium, uranium, thorium, upward uranium and cosmic channels. The formula used to apply the correction is as follows:

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1 Exploranium, I.A.E.A. Report, Airborne Gamma-Ray Spectrometer Surveying, Technical Report No. 323, 1991.

2 AGSO Record 1995/60, "A Guide to the Technical Specifications for Airborne Gamma-Ray Surveys".

$$C_{lt} = C_{raw} * \frac{1000.0}{L}$$

where: C_{lt} is the live time corrected channel in counts per second
C_{raw} is the raw channel data in counts per second
L is the live time in milliseconds

Intermediate Filtering

Two parameters were filtered, but not returned to the database:

- Radar altimeter was smoothed with a 7-point Hanning filter (h_{ef}).
- The Cosmic window was smoothed with a 9-point Hanning filter (Cos_f).

Aircraft and Cosmic Background

Aircraft background and cosmic stripping corrections were applied to the total count, potassium, uranium, thorium and upward uranium channels using the following formula:

$$C_{ac} = C_{lt} - (a_c + b_c * \mathrm{Cos}_f)$$

where: C_{ac} is the background and cosmic corrected channel
C_{lt} is the live time corrected channel
a_c is the aircraft background for this channel
b_c is the cosmic stripping coefficient for this channel
Cos_f is the filtered cosmic channel

Radon Background

The determination of calibration constants that enable the stripping of the effects of atmospheric radon from the downward-looking detectors through the use of an upward-looking detector is divided into two parts:

1) Determine the relationship between the upward- and downward-looking detector count rates for radiation originating from the ground.
2) Determine the relationship between the upward- and downward-looking detector count rates for radiation due to atmospheric radon.

The procedures to determine these calibration factors are documented in IAEA Report #323 on airborne gamma-ray surveying. The calibrations for the first part were determined as outlined in the report.

The latter case normally requires many over-water measurements where there is no contribution from the ground. Where this is not possible, it is standard procedure to establish a test line over which a series of repeat measurements are acquired. From these repeat flights, any change in the downward uranium window due to variations in radon background would be directly related to variations in the upward window and the other downward windows.

The validity of this technique rests on the assumption that the radiation from the ground is essentially constant from flight to flight. Inhomogeneities in the ground, coupled with deviations in the flight path between test runs, add to the inaccuracy of the accumulated results. Variations in flying heights and other environmental factors also contribute to the uncertainty.

The use of test lines is a solution for a fixed-wing acquisition platform. The ability of rotary wing platforms to hover at a constant height over a fixed position would appear to eliminate a number of the variations which degrade the accuracy of the results required for this calibration.

One test line was established in the survey area. Test flights were carried out daily. Data were acquired over a four-minute period at the nominal survey altitude (120 m). The data were then corrected for livetime, aircraft background and cosmic activity.

Once the survey was completed, the relationships between the counts in the downward uranium window and in the other four windows due to atmospheric radon were determined using linear regression for the test site. The equations solved for were:

$$u_r = a_u Ur + b_u$$
$$K_r = a_K U_r + b_K$$
$$T_r = a_T U_r + b_T$$
$$I_r = a_I U_r + b_I$$

where: u_r is the radon component in the upward uranium window
K_r, U_r, T_r and I_r are the radon components in the various windows of the downward detectors; the various "a" and "b" coefficients are the required calibration constants

In practice, only the "a" constants were used in the final processing. The "b" constants are normally near zero for over-water calibrations. The values of a_I, a_K, a_T and a_u are summarized in Appendix D1.

The thorium, uranium and upward uranium data for each line were copied into temporary arrays, then smoothed with 21, 21 and 51 point Hanning filters to product Th_f, U_f, and u_f respectively. The radon component in the downward uranium window was then determined using the following formula:

$$U_r = \frac{u_f - a_1 * U_f - a_2 * Th_f + a_2 * b_{Th} - b_u}{a_u - a_1 - a_2 * a_{Th}}$$

where: U_r is the radon component in the downward uranium window
u_f is the filtered upward uranium
U_f is the filtered uranium
Th_f is the filtered thorium
a_1, a_2, a_u and a_{Th} are proportionality factors and
b_u and b_{Th} are constants determined experimentally

The effects of radon in the downward uranium are removed by simply subtracting U_r from U_{ac}. The effects of radon in the total count, potassium, thorium and upward uranium are then removed based upon previously established relationships with U_r. The corrections are applied using the following formula:

$$C_{rc} = C_{ac} - (a_c * U_r + b_c)$$

where: C_{rc} is the radon corrected channel
C_{ac} is the background and cosmic corrected channel
U_r is the radon component in the downward uranium window
a_c is the proportionality factor and
b_c is the constant determined experimentally for this channel

Compton Stripping

Following the radon correction, the potassium, uranium and thorium are corrected for spectral overlap. First α, β, and γ the stripping ratios, are modified according to altitude. Then an adjustment factor based on a, the reversed stripping ratio, uranium into thorium, is calculated. (Note: the stripping ratio altitude correction constants are expressed in change per metre. A constant of 0.3048 is required to conform to the internal usage of height in feet):

$$\alpha_h = \alpha + h_{ef} * 0.00049$$

$$\beta_h = \beta + h_{ef} * 0.00065$$

$$\gamma_h = \gamma + h_{ef} * 0.00069$$

where: α, β, γ are the Compton stripping coefficients
α_h,β_h,γ_h are the height corrected Compton stripping coefficients
h_{ef} is the height above ground in metres

The stripping corrections are then carried out using the following formulas:

$$\alpha_r = \frac{1}{1 - a\alpha_h - g\gamma_h + ag\beta_h}$$

$$Th_c = ((1 - g\gamma_h)Th_{rc} - aU_{rc} + agk_{rc}) * \alpha_r$$

$$U_c = (Th_{rc}(g\beta_h - \alpha_h) + U_{rc} - K_{rc}{}^{g}) * \alpha_r$$

$$K_c = (Th_{rc}(a\alpha_h - \beta_h) + U_{rc}(a\beta_h - \gamma h) + K_{rc}(1 - a\alpha_h)) * \alpha_r$$

where: U_c, Th_c and K_c are corrected uranium, thorium and potassium
$\alpha_h, \beta_h, \gamma_h$ are the height corrected Compton stripping coefficients
U_{rc}, Th_{rc} and K_{rc} are radon-corrected uranium, thorium and potassium
α_r is the backscatter correction
a is the reverse stripping ratio U into Th
g is the reverse stripping ratio K into uranium

Attenuation Corrections

The total count, potassium, uranium and thorium data are then corrected to a nominal survey altitude, in this case 110 m (361 ft). This is done according to the equation:

$$C_a = C * e^{\mu(h_{ef} - ho)}$$

where: C_a is the output altitude corrected channel
C is the input channel
μ is the attenuation correction for that channel
h_{ef} is the effective altitude, usually in m
h_0 is the nominal survey altitude used as datum

Conversion to Apparent Radioelement Concentrations

At this point the corrections are complete. The final step is to convert the corrected potassium, uranium and thorium to apparent radioelement concentrations using the following formula:

$$eE = C_{cor} / s$$

where: eE is the element concentration K(%) and equivalent element concentration of U(ppm) & Th(ppm)
s is the experimentally determined sensitivity
C_{cor} is the fully corrected channel

Finally, the natural air absorption dose rate is determined using the following formula:

$$E = 13.08 * K + 5.43 * eU + 2.69 * eTh$$

where: E is the absorption dose rate in nG/h
K is the concentration of potassium (%)
eU is the equivalent concentration of uranium (ppm)
eTh is the equivalent concentration of thorium (ppm)

A description of how most of the constants were determined can be found in: Exploranium, I.A.E.A. Report, Airborne Gamma-Ray Spectrometer Surveying, Technical Report No. 323, 1991.

Radiometric Ratios

The procedure to calculate the radiometric ratios follows the guidelines in the IAEA report. Due to statistical uncertainties in the individual radioelement measurements, some care was taken in the calculation of the ratio in order to obtain statistically significant values. Following IAEA guidelines, the method of determining ratios of the eU/eTh, eU/K and eTh/K was as follows:

1. Any data points where the potassium concentration was less than 0.15 were neglected.
2. The element with the lowest corrected count rate was determined.
3. The element concentrations of adjacent points on either side of each data point were summed until they exceeded a certain threshold value. This threshold was set to be equivalent to 100 counts of the element with the lowest count rate. Additional minimum thresholds of 1.0% for Potassium, 5 ppm for thorium, and 5 ppm for uranium were set up to insure meaningful ratios in this low count survey area.
4. The ratios were calculated using the accumulated sums.

With this method, the errors associated with the calculated ratios will be similar for all data points.

Radioelement Ternary Maps

The radioelement ternary map was produced by creating separate grids for each of the three radioelements and assigning a specific colour to each radioelement. Cyan represents thorium, yellow represents uranium, and magenta represents potassium. The relative concentrations of the three radioelements are represented by the mixing of the three colours. For example, equal concentrations of potassium and uranium would yield a red, grading through orange, towards yellow as the relative concentration of uranium increases.

Each of the normalized radioelement concentrations and the exposure rate are then non-linearly quantized using histogram equalization. The radioelement concentrations are quantized into 49 levels, and the exposure rate into five levels. The three quantized radioelement concentrations were normalized once more by the sum of their components and assigned cyan (Th), magenta (K) and yellow (U) values according to their relative amounts. The final colour intensities were then modulated by the quantized exposure rate, with five representing high intensity and one being low intensity.

The triangular icon which appears on the ternary radioelement maps shows the colours associated with each radioelement and their combinations at full intensity exposure rate. This scale is not linear, and accounts for approximately 90% of the data in the survey area. This facilitates the recognition of colours that would otherwise fall within a very small range on a linear scale diagram.

6. DELIVERABLES

Map Products

Preliminary line/grid data archives were created during the data processing phase and supplied via FTP transfer to the Geological Survey of Canada and industry client offices, so that checks could be carried out. Final map proofs were also submitted for inspection and approval prior to printing the final copies

The map products were presented on a digital topographic base that showed NAD83 coordinates.

Final Products

Maps

FOR BLOCKS AA, A, DF, G, H-N

Colour maps at 1:50,000 scale (in 5 copies):

- total magnetic field
- calculated vertical gradient
- natural air absorbed dose rate
- potassium concentration
- equivalent Uranium
- equivalent Thorium
- eU/eTH ratio
- eTH/K ratio
- eU/K
- radiometric ternary

FOR BLOCKS B,C and E

Colour maps at 1:20,000 scale (in 5 copies):

- total magnetic field
- calculated vertical gradient
- natural air absorbed dose rate
- potassium concentration
- equivalent Uranium
- equivalent Thorium
- eU/eTH ratio
- eTH/K ratio

- eU/K
- radiometric ternary

COMPILATION : Mt. Polley

Colour maps at 1:250,000 scale (in 5 copies):

- total magnetic field
- calculated vertical gradient
- natural air absorbed dose rate
- potassium concentration
- equivalent Uranium
- equivalent Thorium
- eU/eTH ratio
- eTH/K ratio
- eU/K
- radiometric ternary

<u>Digital Data Archives</u>

1) Digital archive of all gridded data in Geosoft format at 50 m grid cell size:
   - Residual magnetic field
   - Calculated vertical gradient (first vertical magnetic derivative)
   - Natural air absorbed dose rate
   - % Potassium
   - Equivalent uranium
   - Equivalent thorium
   - eTh/K ratio
   - eU/eTh ratio
   - eU/K ratio

2) Digital line data in GDB format of all gamma-ray magnetic and radiometric data presented at 10 times per second.

3) Maps: Digital map files of all final products in both Postscript and PDF format

The raw, and final processed digital data, including both the profile/line and the gridded data were presented on DVD

<u>Operational Reports</u>

Two (2) copies of the Operational Report.

7. SUMMARY

This report describes the logistics of the survey, equipment used, field procedures, data acquisition and presentation of results.

The various maps included with this report display the magnetic and radiometric properties of the survey area. It is recommended that the survey results be reviewed in detail, in conjunction with all available geophysical, geological and geochemical information.

The information content of the data is greater than can be presented on the maps alone. Further processing of the data may enhance subtle features that can be of importance for exploration purposes.

It is also recommended that image processing of existing geophysical data be considered, in order to extract the maximum amount of information from the survey results. Current software and imaging techniques often provide valuable information on structure and lithology, which may not be clearly evident on the contour and colour maps. These techniques can yield images which define subtle, but significant, structural details.

Respectfully submitted,
FUGRO AIRBORNE SURVEYS

Emily Farquhar
Geophysicist

APPENDIX A

LIST OF PERSONNEL

APPENDIX A

LIST OF PERSONNEL

The following personnel were involved in the acquisition, processing, interpretation and presentation of data, relating to an airborne geophysical survey carried out for Geological Survey of Canada and their Industry Partners, Fugro Airborne Surveys job #04078

David Miles	Manager, Helicopter Operations
Emily Farquhar	Project Manager/Geophysicist
Duane Griffith	Operations Manager
Yuri Mironenko	Geophysical Operator
John Douglas	Geophysical Operator
Darcy Blouin	Geophysical Operator
Lesley Minty	Geophysicist/Processor (Field) (2005)
Amanda Heydorn	Geophysicist/Processor (Field) (2005)
Chris Sawyer	Geophysicist/Processor (Field) (2004)
Brett Robinson	Supervisor Field Geophysicists (2005)
Glen Charbonneau	Pilot (Great Slave Helicopters)
Greg Charbonneau	Pilot (Great Slave Helicopters)
Craig Cable	AME (Great Slave Helicopters)
Jeff Fullerton	Pilot (Questral Helicopters)
Wally Zec	Pilot (Questral Helicopters)
Ashley Stotts	AME (Questral Helicopters)
Mark April	AME (Questral Helicopters)
Lyn Vanderstarren	Drafting Supervisor

With the exception of the pilots and mechanics, all personnel were employees of Fugro Airborne Surveys.

APPENDIX B

RADIOMETRIC COEFFICIENTS

APPENDIX B

RADIOMETRIC COEFFICIENTS

FOR AS350B2 Installation in C-FGSC

```
/////////////////////////////////////////////////
// Atlas Control/Workspace File
// # or // for commment
/////////////////////////////////////////////////

CONTROL_BEGIN

 PROGRAM  = AGSCorrection
 VERSION  = 1.4.0

  ### Input data source type ###
     InputLineDataType = Survey Line

  ### Corrections to apply ###
     CorrectionType = Yes   Filtering
     CorrectionType = Yes  LiveTimeCorrection
     CorrectionType = Yes  CosmicAircraftBGRemove
     CorrectionType = Yes  CalcEffectiveHeight
     CorrectionType = Yes  RadonBGRemove
     CorrectionType = Yes  ComptonStripping
     CorrectionType = Yes  HeightCorrection
     CorrectionType = Yes  ConvertToConcentration

  ### Main I/O settings ###
     MainChannelIO|TC       = tc_down --> tc_down_Cor
     MainChannelIO|K        = k_down  --> k_down_Cor
     MainChannelIO|U        = u_down  --> u_down_Cor
     MainChannelIO|Th       = th_down --> th_down_Cor
     MainChannelIO|UpU      = U_UP       --> U_UP_COR
     MainChannelIO|Cosmic   = COSMIC     --> COSMIC_COR
     MainChannelIO|Spectrum =            -->

  ### Control Channel I/O settings ###
     ControlChannel|RadarAltimeter     = ALTM_F      [metres]
     ControlChannel|Pressure/Barometer = ALTB_KPA    [kPa]
     ControlChannel|Temperature        = TEMP


  ### Pre-filtering settings ###
     Filtering|TC      = 0
     Filtering|K       = 0
     Filtering|U       = 0
     Filtering|Th      = 0
     Filtering|UpU     = 0
     Filtering|Cosmic  = 9
     Filtering|RadarAltimeter     = 7
     Filtering|Pressure/Barometer = 9
     Filtering|Temperature        = 3
```

```
  ### Live-time correction settings ###
    LiveTimeChannel            = LIVE_TIME
    LiveTimeUnits              = mili-seconds
    ApplyDTCorrToUpU           = Yes
    ApplyDTCorrToSpectrum      = No

  ### Cosmic correction settings ###
    CosmicCorrParam|TC      = 0.950089,  148.290000
    CosmicCorrParam|K       = 0.052280,  12.391300
    CosmicCorrParam|U       = 0.045686,  3.257250
    CosmicCorrParam|Th      = 0.051165,  6.552490
    CosmicCorrParam|UpU     = 0.005280,  0.498797

  ### Effective-Height settings ###
    EffectiveHeightOutputChannel = EFFECTIVEHEIGHT
    EffectiveHeightOutputUnits   = metres

  ### Radon correction settings ###
    RadonCorrMethod            = UpU
    RadonCorrParam_Filter      = 3
    RadonOutputChannel         = RADON
    RadonCorrParam_UgInUpU(A1) = 0.002000
    RadonCorrParam_ThInUpU(A2) = 0.009700
    RadonCorrParam|TC      = 14.180000,  0.000000
    RadonCorrParam|K       = 0.930000,  0.000000
    RadonCorrParam|Th      = 0.080000,  0.000000
    RadonCorrParam|UpU     = 0.121000,  0.000000

  ### Special Stripping (Compton Stripping) ###
    ComptonCorrParam_Stripping_Alpha     = 0.224000
    ComptonCorrParam_Stripping_Beta      = 0.375000
    ComptonCorrParam_Stripping_Gamma     = 0.714000
    ComptonCorrParam_AlphaPerMetre       = 0.000000
    ComptonCorrParam_BetaPerMetre        = 0.000000
    ComptonCorrParam_GammaPerMetre       = 0.000000
    ComptonCorrParam_GrastyBackscatter_a = 0.053000
    ComptonCorrParam_GrastyBackscatter_b = -0.001000
    ComptonCorrParam_GrastyBackscatter_g = 0.000010

  ### Height Correction settings ###
    SurveyHeightDatum     = 120.000000
    HeightCorrParam|TC      = -0.007454, 300.000000
    HeightCorrParam|K       = -0.009297, 300.000000
    HeightCorrParam|U       = -0.008396, 300.000000
    HeightCorrParam|Th      = -0.007610, 300.000000

  ### Concentration settings ###
   ConcentrationParam|K       = CONCENTRATION_K,  56.9544
   ConcentrationParam|U       = CONCENTRATION_U,  8.37329
   ConcentrationParam|Th      = CONCENTRATION_TH,  3.67909
   AirAbsorbedDoseRateParam   = DOSERATE,  20.6605
   NaturalAirAbsorbedDoseRateParam = NATURALDOSERATE,  13.08, 5.43, 2.69

CONTROL_END
```

FOR AS350B3 Installation in C-GECL

```
////////////////////////////////////////////////////
// Atlas Control/Workspace File
// # or // for commment
////////////////////////////////////////////////////

CONTROL_BEGIN

  PROGRAM  = AGSCorrection
  VERSION  = 1.4.0

   ### Input data source type ###
       InputLineDataType = Survey Line

   ### Corrections to apply ###
       CorrectionType = Yes   Filtering
       CorrectionType = Yes  LiveTimeCorrection
       CorrectionType = Yes  CosmicAircraftBGRemove
       CorrectionType = Yes  CalcEffectiveHeight
       CorrectionType = Yes  RadonBGRemove
       CorrectionType = Yes  ComptonStripping
       CorrectionType = Yes  HeightCorrection
       CorrectionType = Yes  ConvertToConcentration


   ### Main I/O settings ###
       MainChannelIO|TC       = tc_down --> tc_down_Cor
       MainChannelIO|K        = k_down  --> k_down_Cor
       MainChannelIO|U        = u_down  --> u_down_Cor
       MainChannelIO|Th       = th_down --> th_down_Cor
       MainChannelIO|UpU      = U_UP       --> U_UP_COR
       MainChannelIO|Cosmic   = COSMIC     --> COSMIC_COR
       MainChannelIO|Spectrum =            -->

   ### Control Channel I/O settings ###
       ControlChannel|RadarAltimeter     = ALTM_F      [metres]
       ControlChannel|Pressure/Barometer = ALTB_KPA    [kPa]
       ControlChannel|Temperature        = TEMP


   ### Pre-filtering settings ###
       Filtering|TC      = 0
       Filtering|K       = 0
       Filtering|U       = 0
       Filtering|Th      = 0
       Filtering|UpU     = 0
       Filtering|Cosmic  = 9
       Filtering|RadarAltimeter     = 7
       Filtering|Pressure/Barometer = 9
       Filtering|Temperature        = 3
```

```
  ### Live-time correction settings ###
    LiveTimeChannel            = LIVE_TIME
    LiveTimeUnits              = mili-seconds
    ApplyDTCorrToUpU           = Yes
    ApplyDTCorrToSpectrum      = No

  ### Cosmic correction settings ###
    CosmicCorrParam|TC      = 0.790590,  119.070000
    CosmicCorrParam|K       = 0.045590,  11.970000
    CosmicCorrParam|U       = 0.035800,  5.190000
    CosmicCorrParam|Th      = 0.042610,  3.140000
    CosmicCorrParam|UpU     = 0.004530,  0.420000

  ### Effective-Height settings ###
    EffectiveHeightOutputChannel = EFFECTIVEHEIGHT
    EffectiveHeightOutputUnits   = metres

  ### Radon correction settings ###
    RadonCorrMethod            = UpU
    RadonCorrParam_Filter      = 3
    RadonOutputChannel         = RADON
    RadonCorrParam_UgInUpU(A1) = 0.002000
    RadonCorrParam_ThInUpU(A2) = 0.009700
    RadonCorrParam|TC      = 14.180000,  0.000000
    RadonCorrParam|K       = 0.930000,  0.000000
    RadonCorrParam|Th      = 0.080000,  0.000000
    RadonCorrParam|UpU     = 0.121000,  0.000000

  ### Special Stripping (Compton Stripping) ###
    ComptonCorrParam_Stripping_Alpha     = 0.224000
    ComptonCorrParam_Stripping_Beta      = 0.375000
    ComptonCorrParam_Stripping_Gamma     = 0.714000
    ComptonCorrParam_AlphaPerMetre       = 0.000000
    ComptonCorrParam_BetaPerMetre        = 0.000000
    ComptonCorrParam_GammaPerMetre       = 0.000000
    ComptonCorrParam_GrastyBackscatter_a = 0.053000
    ComptonCorrParam_GrastyBackscatter_b = -0.001000
    ComptonCorrParam_GrastyBackscatter_g = 0.000010

  ### Height Correction settings ###
    SurveyHeightDatum     = 120.000000
    HeightCorrParam|TC      = -0.007772, 300.000000
    HeightCorrParam|K       = -0.009459, 300.000000
    HeightCorrParam|U       = -0.009038, 300.000000
    HeightCorrParam|Th      = -0.008274, 300.000000

  ### Concentration settings ###
   ConcentrationParam|K       = CONCENTRATION_K,  58.3163
   ConcentrationParam|U       = CONCENTRATION_U,  7.80133
   ConcentrationParam|Th      = CONCENTRATION_TH,  3.71105
   AirAbsorbedDoseRateParam   = DOSERATE,  20.7825
   NaturalAirAbsorbedDoseRateParam = NATURALDOSERATE,  13.08, 5.43, 2.69

CONTROL_END
```

COSMIC CORRECTION

$$C_{ac} = C_{lt} - (a_c + b_c * \mathrm{Cos}_f)$$

where: C_{ac} is the background and cosmic corrected channel
C_{lt} is the live time corrected channel
a_c is the aircraft background for this channel
b_c is the cosmic stripping coefficient for this channel
Cos_f is the filtered cosmic channel

TC	$a_{TC=}$0.950089 $b_{TC=}$148.290000
K	$a_{K=}$0.052280 $b_{K=}$12.391300
U	$a_{U=}$0.045686 $b_{U=}$4.257250
Th	$a_{Th=}$0.051165 $b_{Th=}$6.552490
U_Up	$a_{Th=}$0.005280 $b_{Th=}$0.498797

RADON REMOVAL

$$U_r = \frac{u_f - a_1 * U_f - a_2 * Th_f + a_2 * b_{Th} - b_u}{a_u - a_1 - a_2 * a_{Th}}$$

where: U_r is the radon component in the downward uranium window
u_f is the filtered upward uranium
U_f is the filtered uranium
Th_f is the filtered thorium
a_1, a_2, a_u and a_{Th} are proportionality factors and
b_u and b_{Th} are constants determined experimentally

a1 = 0.0020
a2 = 0.0097

This correction is applied using the following formula:

$$C_{rc} = C_{ac} - (a_c * U_r + b_c)$$

where: C_{rc} is the radon corrected channel
C_{ac} is the background and cosmic corrected channel
U_r is the radon component in the downward uranium window
a_c is the proportionality factor and
b_c is the constant determined experimentally for this channel

TC	a_{Tc}, b_{Tc}	= 14.18, 0.000000
K	a_K, b_K	= 0.930, 0.000000
Th	a_{Th}, b_{Th}	= 0.080, 0.000000
UpU	a_{UpU}, b_{UpU}	= 0.121, 0.000000

COMPTON STRIPPING

where: $\alpha_h, \beta_h, \gamma_h$ are the height corrected Compton stripping coefficients
α_r is the backscatter correction
a is the reverse stripping ratio U into Th
g is the reverse stripping ratio K into uranium

α_h = 0.224
β_h = 0.375
γ_h = 0.714
α_r = 0.000
a = 0.053
g = 0.0001

ATTENUATION CORRECTION

$$C_a = C * e^{\mu(h_{ef} - ho)}$$

where: C_a is the output altitude corrected channel
C is the input channel
μ is the attenuation correction for that channel
h_{ef} is the effective altitude, usually in m
h_0 is the nominal survey altitude used as datum

TC	μ_{TC} = -0.007454
K	μ_K = -0.009297
U	μ_U = -0.008396
Th	μ_{Th} = -0.007610

CONVERSION TO APPARENT RADIOELEMENT CONCENTRATIONS

At this point the corrections are complete. The final step is to convert the corrected potassium, uranium and thorium to apparent radioelement concentrations using the following formula:

$$eE = C_{cor} / s$$

where: eE is the element concentration K(%) and equivalent element concentration of U(ppm) & Th(ppm)
s is the experimentally determined sensitivity
C_{cor} is the fully corrected channel

TC	s_{TC} = 20.6605 at 120 metres
K	s_K = 56.9544 at 120 metres
U	s_U = 8.3733 at 120 metres
Th	s_{Th} = 3.6791 at 120 metres

APPENDIX C

RADIOMETRIC SOURCE CHECKS

RADIOMETRIC SOURCE CHECKS

Date	AM / PM	U Cnts	U Ave	U % Dev	Th Cnts	Th Ave	Th % Dev	Cs Peak	Cs Res
6-Jun-05	AM	14095	-	-	18641	-	-	54.8	7.5%
6-Jun-05	PM	13990	14043	-0.37	18794	18718	0.41	54.9	7.5%
7-Jun-05	AM	13905	13997	-0.65	18953	18796	0.84	54.7	7.5%
7-Jun-05	PM	13960	13988	-0.20	19016	18851	0.88	54.9	7.6%

Date	AM / PM	U Cnts	U Ave	U % Dev	Th Cnts	Th Ave	Th % Dev	Cs Peak	Cs Res
11-Jun-05	AM	14356	-	-	19796	-	-	54.7	7.5%
15-Jun-05	AM	14680	14518	1.12	19872	19834	0.19	54.6	7.6%
15-Jun-05	PM	14287	14441	-1.07	19344	19671	-1.66	54.8	7.6%
17-Jun-05	AM	13729	14263	-3.74	19254	19567	-1.60	54.6	7.6%
17-Jun-05	PM	14262	14263	-0.01	19434	19540	-0.54	54.6	7.7%
19-Jun-05	AM	14253	14261	-0.06	19824	19587	1.21	54.5	7.6%
19-Jun-05	PM	13820	14198	-2.66	18720	19463	-3.82	54.7	7.6%
20-Jun-05	AM	13724	14139	-2.93	18637	19360	-3.74	54.7	7.6%
20-Jun-05	PM	14126	14137	-0.08	19127	19334	-1.07	54.8	7.6%
21-Jun-05	AM	14046	14128	-0.58	19382	19339	0.22	54.6	7.7%
28-Jun-05	AM	14165	14132	0.24	19117	19319	-1.04	55.0	7.5%
28-Jun-05	PM	13842	14108	-1.88	18790	19275	-2.51	54.8	7.6%
7-Jul-05	AM	14190	14114	0.54	19866	19320	2.82	54.9	7.5%
11-Jul-05	AM	14767	14161	4.28	19937	19364	2.96	54.6	7.6%
11-Jul-05	PM	14743	14199	3.83	19794	19393	2.07	54.7	7.6%
12-Jul-05	AM	14600	14224	2.64	20001	19431	2.93	54.9	7.5%
13-Jul-05	AM	13705	14194	-3.44	18427	19372	-4.88	55.0	7.4%
13-Jul-05	PM	14117	14190	-0.51	19014	19352	-1.75	55.2	7.7%
14-Jul-05	AM	14069	14183	-0.81	19126	19340	-1.11	54.7	7.5%
14-Jul-05	PM	14071	14178	-0.75	19078	19327	-1.29	54.8	7.6%
16-Jul-05	AM	14111	14174	-0.45	18929	19308	-1.96	54.8	7.4%
17-Jul-05	AM	14128	14172	-0.31	18903	19290	-2.00	54.8	7.6%
17-Jul-05	PM	14116	14170	-0.38	19136	19283	-0.76	54.8	7.5%
18-Jul-05	AM	14298	14175	0.87	19114	19276	-0.84	54.8	7.5%
18-Jul-05	PM	13975	14167	-1.36	19212	19273	-0.32	54.8	7.6%
19-Jul-05	AM	13819	14154	-2.37	19165	19269	-0.54	54.6	7.6%
19-Jul-05	PM	13722	14138	-2.94	18719	19249	-2.75	54.8	7.6%
20-Jul-05	AM	13657	14121	-3.28	18569	19225	-3.41	54.7	7.5%
20-Jul-05	PM	13957	14115	-1.12	18894	19213	-1.66	54.9	7.5%

Date	AM / PM	U Cnts	U Ave	U % Dev	Th Cnts	Th Ave	Th % Dev	Cs Peak	Cs Res
22-Jul-05	AM	13745	-	-	18794	-	-	54.5	7.6%
22-Jul-05	PM	13657	13701	-0.32	18836	18815	0.11	54.9	7.6%
23-Jul-05	AM	13763	13722	0.30	18830	18820	0.05	54.6	7.6%
24-Jul-05	AM	13575	13685	-0.80	18696	18789	-0.49	54.7	7.5%
24-Jul-05	PM	13601	13668	-0.49	18694	18770	-0.40	54.8	7.6%
25-Jul-05	AM	13651	13665	-0.10	18815	18778	0.20	54.6	7.6%
25-Jul-05	PM	13394	13627	-1.71	18637	18757	-0.64	54.7	7.6%
26-Jul-05a	AM	13545	13616	-0.52	18726	18754	-0.15	54.6	7.6%
26-Jul-05b	AM	13559	13610	-0.37	18609	18737	-0.69	54.8	7.5%
26-Jul-05b	PM	13357	13585	-1.68	18570	18721	-0.80	54.8	7.6%
27-Jul-05	AM	13457	13573	-0.86	18454	18696	-1.30	54.6	7.6%
27-Jul-05	PM	13598	13575	0.17	18690	18696	-0.03	0.0	0.0%
28-Jul-05	AM	13549	13573	-0.18	18693	18696	-0.01	54.6	7.6%
29-Jul-05	AM	13354	13558	-1.50	18892	18710	0.97	54.6	7.6%
29-Jul-05	PM	13407	13547	-1.04	18599	18702	-0.55	54.7	7.6%
2-Aug-05	AM	13799	13563	1.74	19300	18740	2.99	54.5	7.6%
2-Aug-05	PM	13692	13571	0.89	19159	18764	2.10	54.7	7.6%
3-Aug-05	AM	13986	13594	2.88	19327	18796	2.83	54.5	7.6%
3-Aug-05	PM	13870	13608	1.92	19027	18808	1.17	54.6	7.6%

Date	AM / PM	U Cnts	U Ave	U % Dev	Th Cnts	Th Ave	Th % Dev	Cs Peak	Cs Res
5-Aug-05	AM	13702	-	-	19211	-	-	54.6	7.6%
5-Aug-05	PM	13742	13722	0.15	18901	19056	-0.81	0.0	0.0%
6-Aug-05	AM	13679	13708	-0.21	18950	19021	-0.37	54.5	7.6%
6-Aug-05	PM	13708	13708	0.00	19020	19021	0.00	54.8	7.5%
7-Aug-05	AM	13514	13669	-1.13	19085	19033	0.27	54.5	7.6%
7-Aug-05	PM	13664	13668	-0.03	18699	18978	-1.47	0.0	0.0%
8-Aug-05	AM	13560	13653	-0.68	18906	18967	-0.32	54.5	7.6%
8-Aug-05	PM	13627	13650	-0.16	18569	18918	-1.84	54.5	7.6%

APPENDIX D

MAGNETIC COMPENSATION TEST

Compensation Calibration

Date Test Conducted: 07 Jun, 2005

Figure of Merit: 1.4

Compensation of magnetic readings is required when the magnetometers are mounted on, or in close proximity to, the aircraft. The aircraft with its metallic parts and surfaces creates secondary magnetic fields while the aircraft moves through the earth's magnetic field. Therefore the compensation calibration test is flown to calculate the effects of the aircraft and its control surfaces on the magnetic field. The test is flown at high altitude, outside the effect of geology on the magnetic readings. The aircraft flies in each of the survey directions performing a series of manoeuvres (pitch, roll and yaw) that moves the aircraft along each of its three axis of rotation. The aircraft's affect on the magnetic data is calculated and then subtracted from the magnetic data collected during the survey. The raw uncompensated total magnetic field (TF1U) is shown in green and the compensated total magnetic field (TF1C) is shown in red. The effect of the aircraft is clearly removed from the total field. The residual values are shown in blue which is the difference between the compensated mag and the filtered mag.

This test must be repeated when moving more than 100 km and for each survey line direction.

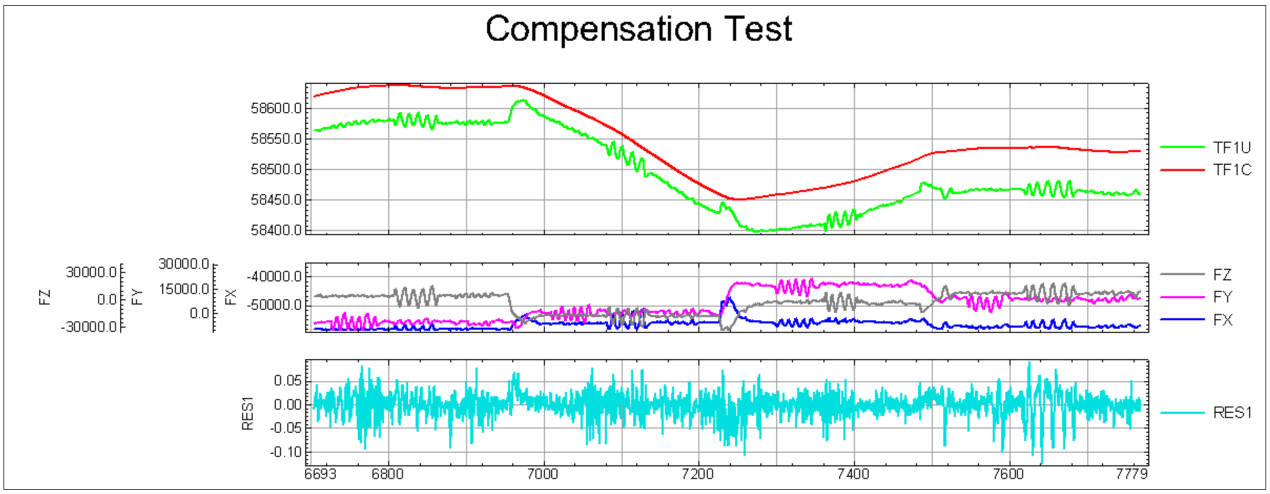


Figure 20: Compensation Calibration Results (Figure of Merit)

The figure of merit (FOM) is then calculated by summing the amplitude of the residual for each maneuver and is found to be 1.4 which is acceptable. The amplitudes chosen for the FOM calculation are shown in the following table.

Chart 2: Compensation Calibration Results (Figure of Merit)

Direction	Maneuver	Peak to Peak of Residual		Amplitude
N	Pitch	0.0364	-0.0473	0.0837
N	Roll	0.0533	-0.0761	0.1294
N	Yaw	0.0388	-0.0308	0.0696
E	Pitch	0.0453	-0.0297	0.0750
E	Roll	0.0768	-0.1259	0.2027
E	Yaw	0.0314	-0.0496	0.0810
S	Pitch	0.0823	-0.0939	0.1762
S	Roll	0.0473	-0.0561	0.1034
S	Yaw	0.0781	-0.0823	0.1604
W	Pitch	0.0328	-0.0518	0.0846

W	Roll	0.0748	-0.0509	0.1257
W	Yaw	0.0381	-0.0461	0.0842

The compensation test was repeated for the survey blocks in the Quesnel area with line directions E-W and N-S on June 13, 2005

Date Test Conducted: 13 Jun, 2005

Figure of Merit: 1.6

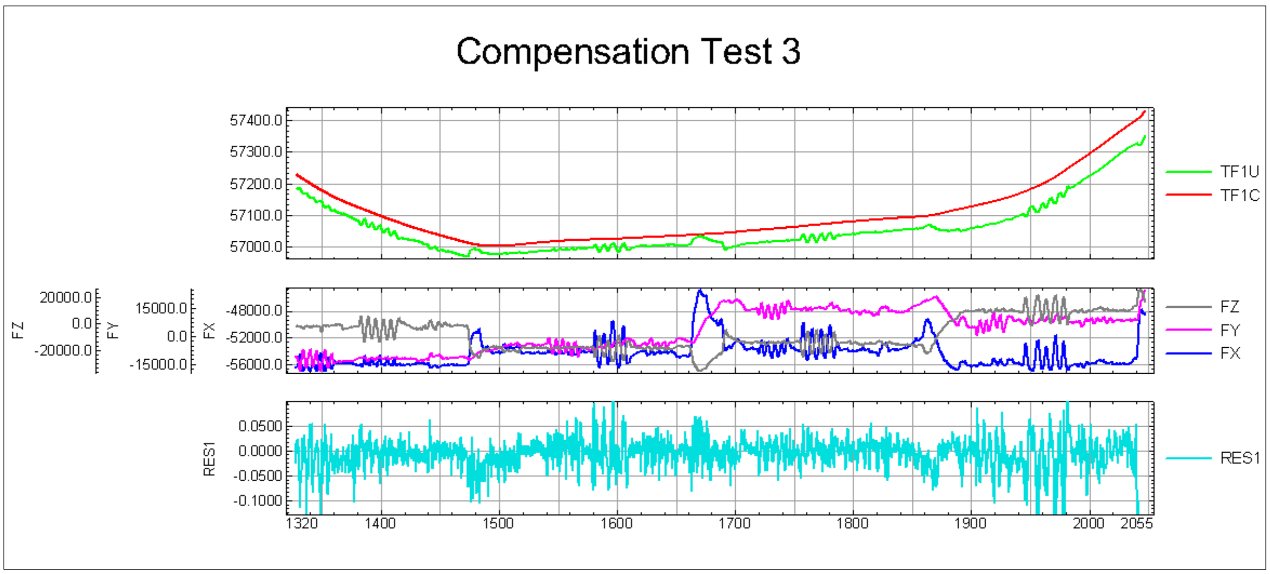


Figure 21: Compensation Calibration Results (Figure of Merit)

Chart 3: Compensation Calibration Results (Figure of Merit)

Direction	Maneuver	Peak to Peak of Residual		Amplitude
S	Pitch	0.0539	-0.14	-0.14
S	Roll	0.0414	-0.0658	-0.0658
S	Yaw	0.063	-0.0435	-0.0435
W	Pitch	0.0674	-0.0579	-0.0579
W	Roll	0.0466	-0.0783	-0.0783
W	Yaw	0.0367	-0.0589	-0.0589
N	Pitch	0.0478	-0.0583	-0.0583
N	Roll	0.0552	-0.0423	-0.0423
N	Yaw	0.078	-0.04	-0.04
E	Pitch	0.0742	-0.1055	-0.1055
E	Roll	0.0546	-0.2025	-0.2025
E	Yaw	0.0381	-0.0907	-0.0907

The compensation test was repeated for the survey blocks in the Quesnel area with line directions E-W and N-S on June 26, 2005 due to crew change and helicopter maintenance

Date Test Conducted: 25 Jun, 2005

Figure of Merit: 1.0

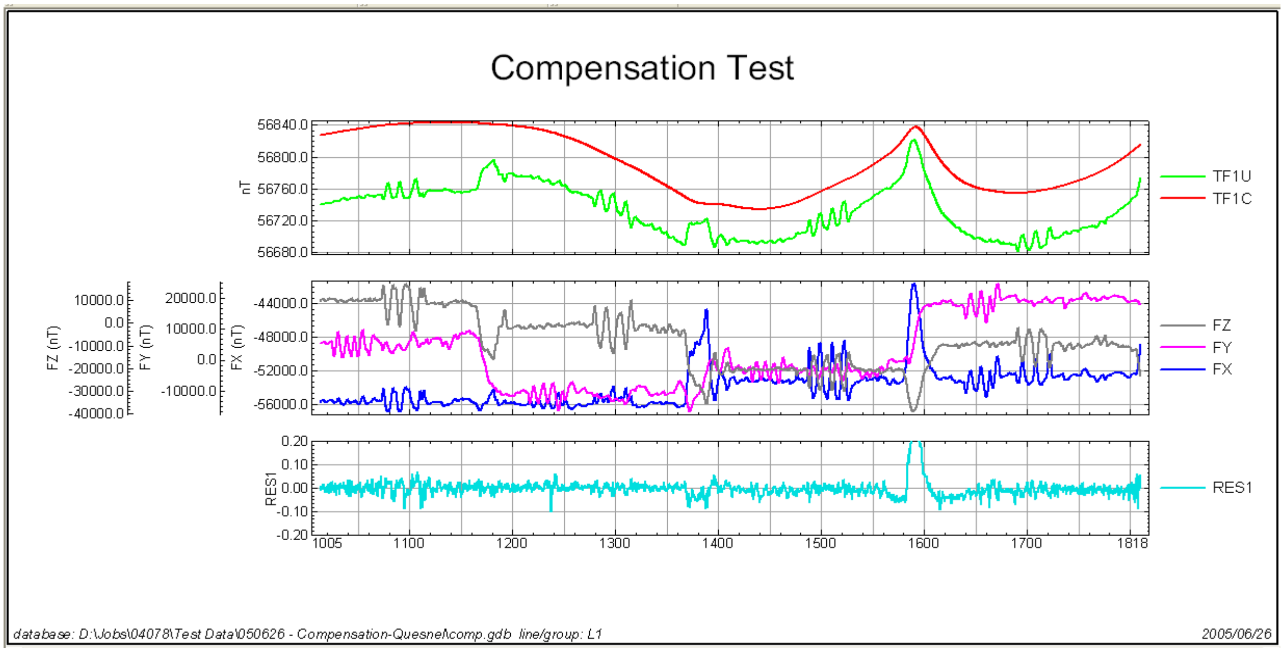


Figure 21: Compensation Calibration Results (Figure of Merit)

Chart 3: Compensation Calibration Results (Figure of Merit)

Direction	Maneuver	Peak to Peak of Residual			Amplitude
90	Pitch	0.0539	-0.14		-0.14
90	Roll	0.0414	-0.0658		-0.0658
90	Yaw	0.063	-0.0435		-0.0435
180	Pitch	0.0674	-0.0579		-0.0579
180	Roll	0.0466	-0.0783		-0.0783
180	Yaw	0.0367	-0.0589		-0.0589
270	Pitch	0.0478	-0.0583		-0.0583
270	Roll	0.0552	-0.0423		-0.0423
270	Yaw	0.078	-0.04		-0.04
360	Pitch	0.0742	-0.1055		-0.1055
360	Roll	0.0546	-0.2025		-0.2025
360	Yaw	0.0381	-0.0907		-0.0907

The compensation test was repeated for the survey blocks in the Quesnel area with line directions 050-230 and 140-320 on June 26, 2005

Date Test Conducted: 26 Jun, 2005

Figure of Merit: 1.1

Figure 21: Compensation Calibration Results (Figure of Merit)

Chart 3: Compensation Calibration Results (Figure of Merit)

Direction	Maneuver	Peak to Peak of Residual			Amplitude
50	Pitch	0.0697	-0.059		0.1287
50	Roll	0.0731	-0.0371		0.1102
50	Yaw	0.038	-0.0178		0.0558
140	Pitch	0.0469	-0.04		0.0869
140	Roll	0.0329	-0.0477		0.0806
140	Yaw	0.0149	-0.0292		0.0441
230	Pitch	0.0729	-0.0457		0.1186
230	Roll	0.0517	-0.0291		0.0808
230	Yaw	0.0304	-0.0352		0.0656
320	Pitch	0.0468	-0.0327		0.0795
320	Roll	0.0734	-0.0677		0.1411
320	Yaw	0.0694	-0.0515		0.1209

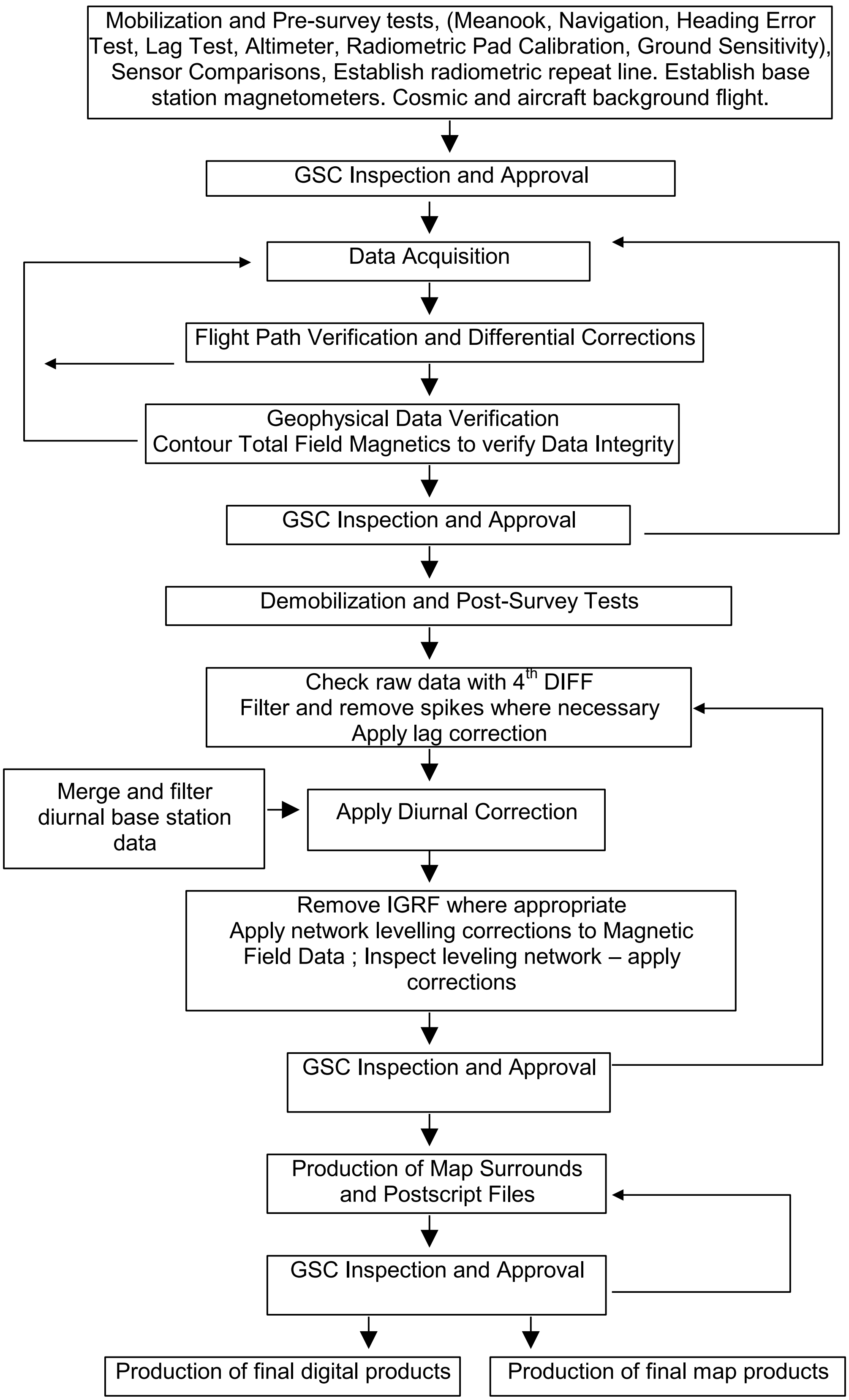
APPENDIX E

PROCESSING FLOW CHARTS

APPENDIX E

PROCESSING FLOW CHARTS

Survey Procedures and Magnetic Processing



Spectrometer Processing