Project Report
Aeromagnetic/Spectrometer Survey
USGS Requisition No. 04CRPR00479
Brownsville Area Texas - 2004

For:

United States Geological Survey

Flown by:

SANDER GEOPHYSICS LIMITED

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I. INTRODUCTION

Sander Geophysics Limited, (SGL), conducted a high-sensitivity aeromagnetic and gamma-ray survey over the Rio Grande Valley in Texas, more specifically in the Brownsville area, under contract with the United States Geological Survey. Please refer to *Appendix I* for a Company Profile on Sander Geophysics Limited. *Figure 1* shows the geographical position of the survey area. Production flights took place from May 12 to June 2, 2004. Twenty-three flights were required to complete 11,069 kilometres of planned survey lines (see *Appendix II*).

Survey operations were conducted from the Mid-Valley Airport in Weslaco, Texas, located within the survey block. The aircraft used for this survey was SGL's Cessna 208B Grand Caravan, registration C-GSGU. The Brownsville area was flown with traverse lines spaced at 200 m and oriented at 90^{o} and control lines spaced at 2,000 m and oriented at 0^{o}. The survey was generally flown at 150 m above ground level, but higher altitudes were required over built up areas and various antennae within the survey block. The survey flying speed was approximately 110 knots indicated air speed.

II. SURVEY AREA

The survey block is situated in southeastern Texas, USA, approximately 60 km to the northwest of Brownsville and immediately adjacent to the Mexican border. The terrain within the survey block is relatively flat with elevations averaging 20 m above sea level. There is considerable infrastructure in the area, consisting mainly of built-up areas in the southern part of the block along Highway No. 83, and a number of antennae concentrated in the south-eastern segment of the block. Other isolated features, such as roads, antennae, farms and residential areas are also scattered throughout the block.

Line coordinates of all flown survey lines are listed in *Appendix III*. The block is defined by the following coordinates in UTM zone 14N referenced to the WGS-84 datum (see *Table 1*).

Figure 1: Map of Survey Area Showing Survey Blocks

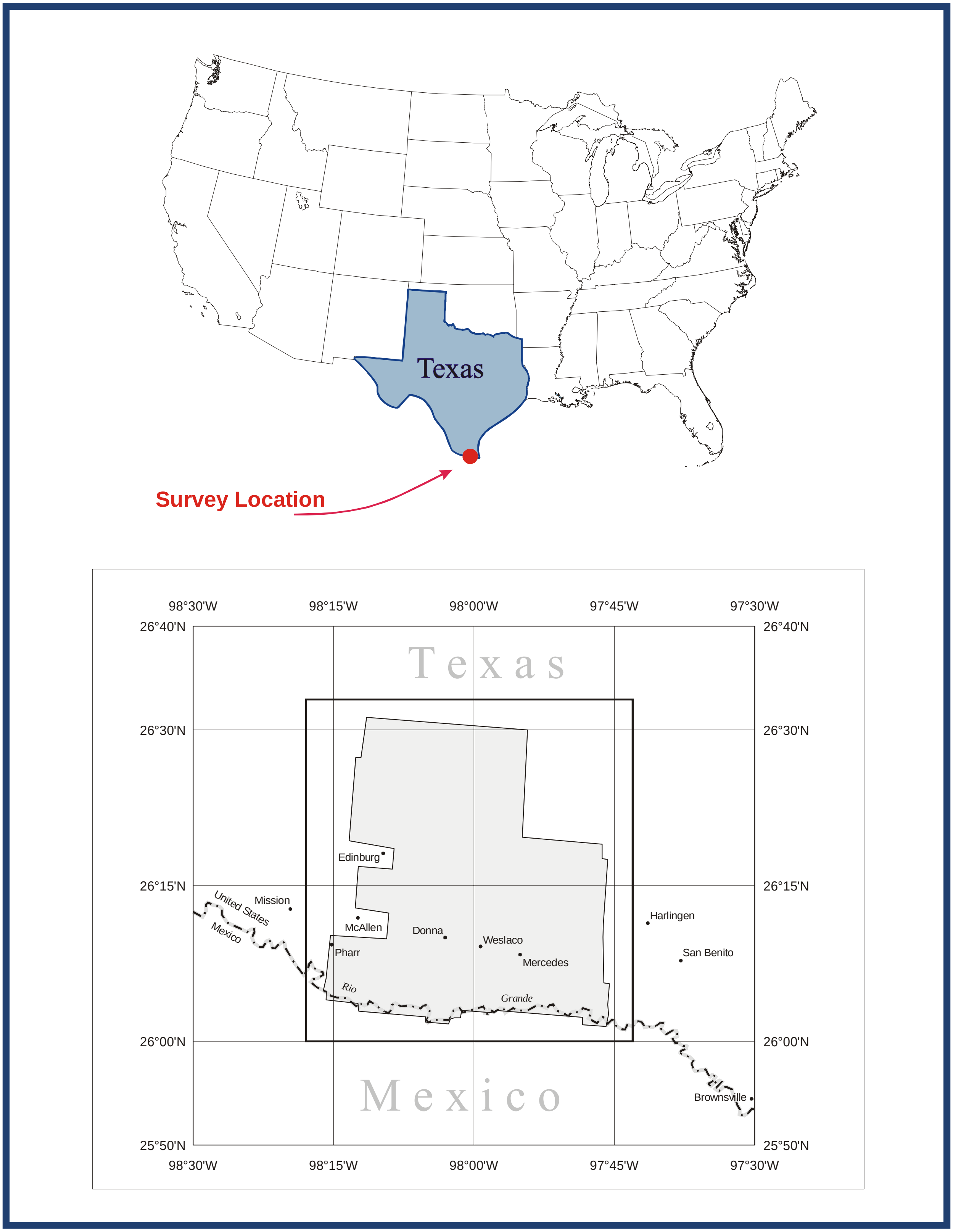


Table 1: Coordinates in WGS-84 UTM 14N

Corner	X (m)	Y (m)	Corner	X (m)	Y (m)
1	614915	2881677	13	586319	2881312
2	613199	2882292	14	583727	2881278
3	608991	2881558	15	583126	2882696
4	606435	2881693	16	580511	2881540
5	602675	2881318	17	573317	2884400
6	602599	2882259	18	581519	2933476
7	598958	2882049	19	607355	2931335
8	596759	2882158	20	607365	2910744
9	596514	2880253	21	619627	2911403
10	592193	2879799	22	619742	2910932
11	592212	2881800	23	618745	2881118
12	588260	2882939			

III. SURVEY EQUIPMENT

SGL provided the following instrumentation for this survey. See *Appendix IV* for further details.

Aerial and Ground Magnetometers

Geometrics G-822A

Both the ground and airborne systems used a non-oriented (strap-down) optically-pumped cesium split-beam sensor. These magnetometers have a sensitivity of 0.005 nT, and a range of 15,000 to 100,000 nT with a sensor noise of less than 0.02 nT. The airborne sensor was mounted in a fibreglass stinger installed on the tail of the aircraft. Total field magnetic measurements were recorded at an interval of 0.1 s in the aircraft and 0.5 s in the ground system.

Automatic Aeromagnetic Digital Compensator

RMS AADC MkII

The RMS AADC Mk II compensator is a fully automatic, 27-term compensator system utilizing a 3-axis fluxgate magnetometer for heading information. Magnetic information was output to the serial port at 0.1 s intervals, with a resolution of 0.001 nT. The system provides a complete real-time compensation of the aircraft manoeuvre noise.

Gamma Ray Spectrometer System

Exploranium GR820 with Crystal Detector Packs GPX-1024/256 (3 packs, 14 crystals)

The Exploranium spectrometer system includes an on-board computer for real-time signal processing and analysis, which allows automatic gain control for individual crystals using the natural thorium peak, and multi-channel recording and analysis. The system utilized a (Tl)NaI detector volume of 58.8 L consisting of 12 downward-looking and two upward-looking parallelepipedic crystals of 4.2 L each, housed in three detector packs. Data was recorded in 256 channel spectral mode and windowed data mode at an interval of 1 s.

Navigation and Flight Path Recovery System

NovAtel 3951R

Navigation and flight path recovery were provided by the SGL NavDAS system. The system utilizes a NovAtel GPSCard 3951R 12-channel GPS receiver mounted in the navigation computer with a sampling rate of 0.1 s. In addition to providing essential post-mission positional data, the navigation computer processes user-received GPS or real-time differentially corrected GPS (RDGPS) data and compares the data to the coordinates of a theoretical flight plan in order to guide the pilot along the desired survey line in three dimensions.

Real-Time Differential GPS

Omnistar 3100LM

The Omnistar 3100LM receiver provides real-time differential GPS for the NavDAS on-board navigation system. The differential data set was relayed via a geosynchronous satellite serving North America to the aircraft where the receiver optimized the corrections for the current location.

Airborne Data Acquisition Systems

Sander NavDAS

The NavDAS is the latest version of airborne data acquisition computers developed by SGL. It displays all incoming data on a flat panel screen for real time monitoring. The data is recorded on a solid-state internal hard drive and copied to a removable hard drive post-mission for transfer of data to the field office. The NavDAS incorporates a magnetometer coupler, an altimeter analogue to digital converter and a GPS receiver. The UTC time base of the NavDAS system is automatically provided by the GPS receiver.

Ground Data Acquisition System

SGL Gnd-Acq

The ground data acquisition computer is a portable PC-Pentium with a Sander Cesium magnetometer frequency counter to process the signal from the magnetometer sensor and an internal GPS card. The ground station magnetometer sensor is mounted on a 2 m pole in a specially constructed composite cap. The noise level of the base station is less than 0.1 nT. The GPS receiver automatically provides the UTC time base for both the ground and airborne systems, ensuring accurate synchronization of the two data sets. The ground data acquisition computer displays all incoming data on an LCD flat panel screen. The magnetic and GPS data was recorded on a removable hard drive for easy transfer of data to the field office. The entire ground data acquisition system is fully automatic and was set for unattended recording.

GPS Base Station Receiver

NovAtel Millennium

The NovAtel Millennium 12-channel receiver forms an integral part of the SGL GND-ACQ system. It provides averaged position and raw range information of all satellites in view, sampled every 0.1 s. The comparative navigation data supplied during all production flights allows for post-processed differential GPS (DGPS) corrections for every survey flight.

Video System

Costar CV 950N camera

Panasonic C1TB0030 VCR

The video camera is mounted in the floor of the aircraft and oriented to look vertically below while in flight. An intervalometer and fiducial marking system required for flight path verification are incorporated. The video information was recorded on VHS videotapes in NTSC format.

Altimeters

King KRA-10A Radar Altimeter

The King radar altimeter measures height above ground to a resolution of 0.5 m and an accuracy of 1% over a range up to 2,500 ft. The radar altimeter data is sampled at 4Hz. This altimeter was used for production flights 2 - 23.

TRT Digital Radar Altimeter ERT-530A

The TRT radar altimeter measures height above ground to a resolution of 0.5 m and an accuracy of 1% over a range up to 8,192 ft. The radar altimeter data is sampled at 4Hz. This altimeter was used only on the first production flight; after which it failed.

Sander Digital Barometric Pressure Sensor

The barometric pressure sensor measures static pressure to an accuracy of ± 4 m and resolution of 2 m over a range up to 30,000 ft above sea level. The barometric altimeter data is sampled at 4Hz.

Outside Air Temperature System

The outside air temperature is sampled at 4Hz with a resolution of 0.1°C. The temperature sensor has a range of +/-50°C and an accuracy of +/-0.2°C. The temperature sensor is mounted in an air inlet duct at the point where the wing strut attaches to the right hand wing.

Survey Aircraft

Cessna 208B, Grand Caravan (C-GSGU)

The Cessna 208B Grand Caravan is an all-metal, high wing, single-engine aircraft powered by a Pratt & Whitney Canada PT6A-114A engine driving a constant speed, fully feathering, reversible propeller. The aircraft is equipped with full de-icing equipment and sufficient avionics for instrument flying (IFR) including flight control system and weather radar. The Caravan is certified for IFR flights in known icing conditions.

A rigid aluminium and composite material stinger is attached to the tail of the aircraft, designed to accommodate the magnetometer sensor in a location 3.2m behind the tail of the aircraft well removed from potential sources of magnetic interference. A window in the belly of the aircraft allows a vertically oriented field of view for the video camera. A complete description of the aircraft is given in Appendix V.

Data Processing Hardware and Software

The following equipment was used in the field office:

Hardware:

a) Two Pentium 4 3.0 GHz computers with each approx. 200Gb of hard drive space, 1 Gb RAM, Sony DVD-RW drive, an internal bay for swappable hard drive (P4-39 P4-40),
b) Aspire 1710 Laptop (Note-42) Acer 17" P4 2.8 GBz with 80GB hard drive, 512MB RAM, CDRW/DVD,
c) Epson 1520 colour inkjet printer capable of producing 14" wide continuous plots.

Software:

a) SGL data processing and imaging software,
b) SGL Differential GPS processing software

IV. SURVEY SPECIFICATIONS

Data Recording

The following parameters were recorded during the course of the survey:

- Aircraft altitude: measured by the barometric altimeter at intervals of 0.25 s;
- Terrain clearance: provided by the radar altimeter at intervals of 0.25 s;
- Airborne outside air temperature: recorded at intervals of 0.25 s;
- A continuous video tape record of the terrain passing below the aircraft;
- Time markers: synchronously impressed on the video and digital data;
- Airborne GPS positional data: (altitude, longitude, height, time and raw range from each satellite being tracked) recorded at intervals of 0.1 s;
- Airborne total magnetic field: recorded at intervals of 0.1 s;
- Airborne spectrometer data: recorded at intervals of 1.0 s.
- Ground total magnetic field: recorded at intervals of 0.5 s;
- Ground based GPS positional data: (latitude, longitude, height, time and raw range from each satellite being tracked) recorded at intervals of 0.1 s;

Flight Specifications

The following technical specifications were adhered to:

a) A higher elevation than the specified flight elevation can be used locally to permit safe terrain clearance. Local deviations from the planned flight altitude occurred where communication towers and urban areas were encountered. Terrain clearance did not exceed 372 m at any point and mean terrain clearance was approximately 165 m considering the entire survey area.

b) Deviations from the planned (pre-flight) paths shall not exceed 10 percent of the designated flight line spacing. Gaps between adjacent flight lines greater than 1.5 times the designated flight line spacing for more than 2 linear miles (3.2 km) require fill-in intermediate flight lines.

c) A pre-planned drape surface was calculated with a climb and descent gradients of 350 feet/nautical mile. The drape surface was not implemented due to: high towers and build-up areas present in the area. The survey was flown using radar and pilot expertise to avoid these areas.

d) The aircraft shall be capable of a sustained climb and descent gradient of 5% or better.

e) Airborne survey data shall not be acceptable when gathered during magnetic storms or short term disturbances of magnetic activity at the ground station used that exceeds the following:

1. Monotonic changes in the magnetic field of 5 nT in any five-minute period.
2. Pulsations having periods of 5 minutes or less shall not exceed 2 nT.
3. Pulsations having periods between 5 and 10 minutes shall not exceed 4 nT.
4. Pulsations having periods between 10 and 20 minutes shall not exceed 8 nT.

The period of a pulsation is defined as the time between adjacent peaks or troughs. The amplitude of a pulsation is one-half the sum of the positive and negative excursions from trough to trough or peak to peak.

Survey Line Specifications

Survey lines were flown with the following specifications:

	Line Direction	Line Spacing (m)
Traverse Lines	90°	200
Control Lines	0°	2000

Flying Altitude

The survey block was flown using radar altimeter guidance to achieve a mean terrain clearance of 150 m wherever practical. The use of a drape surface was judged to be unnecessary by the client and SGL due to the relatively flat terrain in the survey block.

V. SYSTEM TESTS

AADC Compensation

Compensation tests determine the magnetic influence of aircraft manoeuvres and the effectiveness of the RMS compensator to mitigate these effects. The aircraft performed sets of three pitches (±5°), rolls (±10°) and yaws (±5°), while flying in each of the four flight line directions at high altitude over a magnetically quiet area. A solution to compensate for the noise generated by the manoeuvres is determined by the AADC and the solution is tested, by repeating the same set of manoeuvres. The total compensated signal noise that results from the twelve manoeuvres, referred to as the Figure of Merit (FOM), is calculated from the maximum peak-to-peak value resulting from each manoeuvre. A compensation test was flown near the Mid-Valley airport in Weslaco, Texas on May 11th 2004, and a solution with an FOM of 0.9 nT was obtained. This solution was used for all the production flights of this survey. The trace of the compensation test flight data can be found in *Appendix VI*.

Magnetometer Calibration and Heading Error Test

A calibration and heading error test was performed on April 28th, 2004 over the Geological Survey of Canada (GSC) calibration range in Bourget near Ottawa. The test comprised of two passes in each of the four cardinal directions over a point of known magnetic intensity, corrected for diurnal variation using the nearby Ottawa Geomagnetic Information Node at Mer Bleu. The average error for the Bourget tests assumes a difference of –556 nT between the GSC ground station data and the airborne data. The test result is given in *Table 2*.

The test determined that the airborne system has a heading error of 0.2 nT in the East-West direction, a heading error of 0.9 nT in the North-South direction, and an overall absolute calibration error of 1.4 nT.

Table 2: Aeromagnetic Survey System Calibration

AEROMAGNETIC SYSTEM CALIBRATION IN BOURGET, ONTARIO

Aircraft type:	Cessna Grand Caravan	Date:	April 28, 2004
Registration:	C-GSGU	Height flown:	500 feet
Organization:	Sander Geophysics	Magnetometer:	Geometrics G-822A
Pilot:	Todd Svarckopf	Compensator:	RMS AADCII
Co-Pilot:	François Genest	Sampling rate:	10/s
Instrument Operator:	Adam Jones	Data acquisition system:	Sander ADAC Computer
Observer:	N/A	Camera:	Video
		Camera sampling rate:	Continuous

CONSTANT At 500' : 556.0

Dir	Line No.	GMT	Total Field Aircraft TI	Grnd Stn Prev Min T2	Grnd Stn Subs Min T3	Interpolated Reading T4	Calculated T5	Error Value T6	Variation from Average
N	1	23:45:03	55,155.3	55,709.6	55,706.6	55709.5	55153.5	1.9	0.5
S	2	23:49:59	55,153.2	55,708.2	55,708.1	55708.1	55152.1	1.1	-0.3
E	3	23:32:28	55,154.4	55,708.9	55,709.2	55709.0	55153.0	1.4	0.0
W	4	23:28:20	55,154.7	55,709.4	55,709.4	55709.4	55153.4	1.3	-0.1
N	5	23:54:18	55,155.6	55,709.6	55,710.0	55709.7	55153.7	1.8	0.4
S	6	23:59:05	55,157.0	55,712.2	55,712.6	55712.2	55156.2	0.8	-0.6
E	7	23:39:57	55,153.7	55,708.6	55,708.0	55708.0	55152.0	1.6	0.2
W	8	23:35:57	55,153.3	55,708.1	55,708.0	55708.0	55152.0	1.3	-0.1

Total	11.2
Average	1.4

Average North-South Heading Error:	0.9 nT
Average East-West Heading Error:	0.2 nT

Instrumentation Lag

The lag in the magnetometer system was determined by flying a test on April 28th, 2004 over a bridge on the Ottawa River. The test involved flying in opposite directions over the bridge and measuring the apparent positional shift of the associated sharp magnetic anomaly. The shift in the location of the raw data reflects the time taken for the magnetic field measured by the magnetometer in the stinger to be recorded on the acquisition computer, and the physical offset between the sensor and the GPS antenna. The data is corrected by applying a time shift or "lag" correction to the magnetometer values. The lag correction was found to be 0.71 seconds, which is consistent with previous tests using the Grand Caravan airborne system. The lag correction was automatically applied to the magnetic data during processing.

Stripping Ratios

The stripping ratios for the gamma-ray spectrometer were determined before the aircraft departed for the survey using the GSC calibration pads which are stored at the SGL hangar in Ottawa. The tests were performed with the crystal packs installed in survey configuration onboard the aircraft. See *Table 3*.

The following procedure was carried out:

1. Cesium stabilization carried out.
2. Thorium stabilization carried out.
3. Pre-pads source test, one thorium source below pack.
4. Stabilization on thorium taken off.
5. Pads test carried out in order: background, potassium (six minutes recording each).
6. Re-stabilize on thorium.
7. Stabilization on thorium taken off.
8. Pads test carried out in order: uranium, thorium, and background (six minutes recording each).
9. Stabilization on thorium put on.
10. Post-pads source test, one thorium source below pack

Table 3: Stripping Ratios

Stripping Ratios	
Thorium into Uranium (Alpha)	0.2307
Thorium into Potassium (Beta)	0.3704
Uranium into Potassium (Gamma)	0.6878
Uranium into Thorium (A)	0.0353
Potassium into Thorium (B)	0.0000
Potassium into Uranium (G)	0.0076

Attenuation Coefficients

The exponential height attenuation coefficients for the spectrometer were calculated using the data acquired during a pre-survey test flight over the GSC test range at Breckenridge, Quebec on April 28th, 2004. The calibration flights were carried out from approximately 50 m to 250 m mean terrain clearance at 25 m intervals. A series of background measurements were made at the same altitudes over the Ottawa River to determine the background due to cosmic radiation, radon decay products in the air and the radioactivity of the aircraft and equipment. Results of this test are given in *Table 4*.

Table 4: Spectrometer Calibration Test Data

Spectrometer Calibration Test Data				
Altitude at STP (m)	**Total counts (cps)**	**Potassium (cps)**	**Uranium (cps)**	**Thorium (cps)**
58.94	2460.8	307.229	22.928	71.076
86.05	2011.9	236.122	18.197	58.706
114.58	1632.9	180.728	14.629	47.542
141.92	1346.7	143.152	11.519	37.848
170.37	1105.6	112.176	9.258	32.581
198.75	908.2	87.765	7.891	25.902
228.60	738.5	68.653	n/a	22.26
260.23	603.8	53.271	4.891	17.691

After correction for background and stripping, the variation in count rate with effective height was used to determine the attenuation coefficients shown in *Table 5*.

Table 5: Attenuation Coefficients

Attenuation Coefficients	
Total	-0.006991
Potassium	-0.008674
Uranium	-0.006000
Thorium	-0.006886

This test was then repeated on May 28, 2004, using the daily test line flown north of the Mid-Valley Airport in Weslaco, Texas. Lines were flown consecutively at 50 ft. intervals from 150 ft. to 700 ft. and 100 ft. intervals from 700 ft. to 2000 ft. This data set was then adjusted using the attenuation coefficients calculated from the Ottawa test to verify their effectiveness.

It was determined that the attenuation coefficient for the Uranium window calculated from the Ottawa test was inaccurate. An alternate Uranium coefficient was calculated using the full survey stripped uranium window data set. The stripped uranium grid was quantized into altitude windows and the mean count rate for each altitude bin determined. A linear regression was performed between the mean count rate value for each bin and the mean altitude for that bin. A linear equation was developed and the slope of 0.006 was used to correct for uranium attenuation. Applying the same method to the other windows resulted in equivalent coefficients to those from during the Ottawa test data.

Spectrometer System Sensitivity

Sensitivities were determined during the pre-survey test flight over the GSC test range at Breckenridge, Quebec on April 28th, 2004. The test flight served to determine system sensitivities through comparison of airborne data with data acquired on the ground, as well as to determine the variation of the window counts with aircraft altitude (attenuation coefficients, see above).

The ground measurements were made with an Exploranium portable gamma ray spectrometer. Measurements were acquired at 32 different sites along the 10 km length of the calibration range. Measurements were also made with the portable spectrometer on the Ottawa River to determine background radiation due to cosmic radiation, radon decay products in the air and any radioactivity of the equipment. The background was subtracted from the ground measurements and the ground concentrations of potassium, uranium and thorium were determined by calibration of the portable spectrometer using the GSC calibration pads located at Ottawa Airport.

The sensitivities of the airborne system to potassium, equivalent uranium, and equivalent thorium were calculated by dividing the average count rates corrected to an effective height of 150 m above ground by the ground concentrations of the test range. Results are presented in *Table 6*.

Table 6: System Sensitivities

System Sensitivities			
	Average counts at 150 m (cps)	**Ground Concentrations**	**SGL Sensitivities**
Potassium	133.825	1.8450 %	72.5340 cps / %
Equivalent Uranium	10.840	1.4590 ppm	7.4297 cps / ppm
Equivalent Thorium	37.476	7.7030 ppm	4.8651 cps / ppm

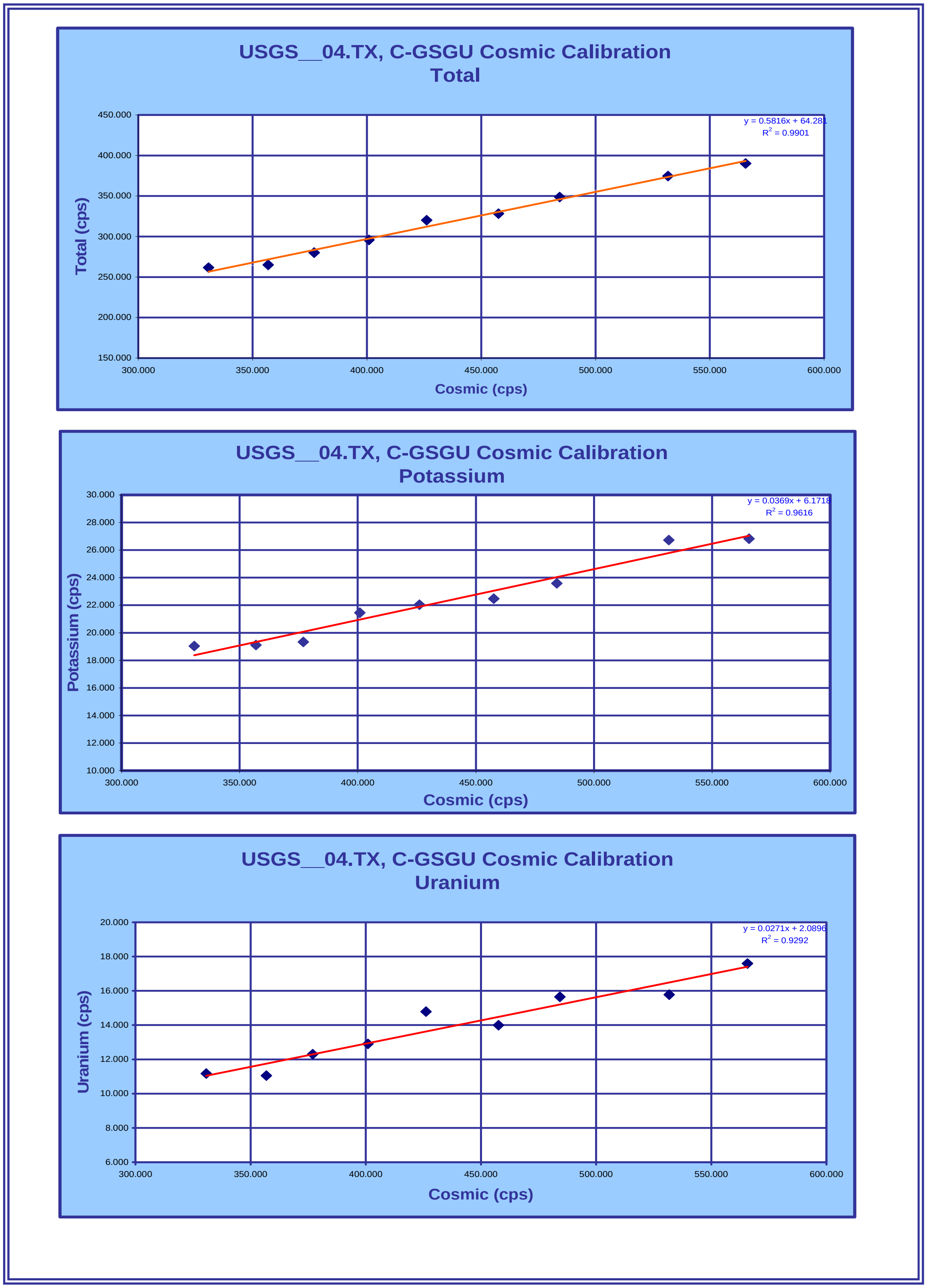
Cosmic and Aircraft Background

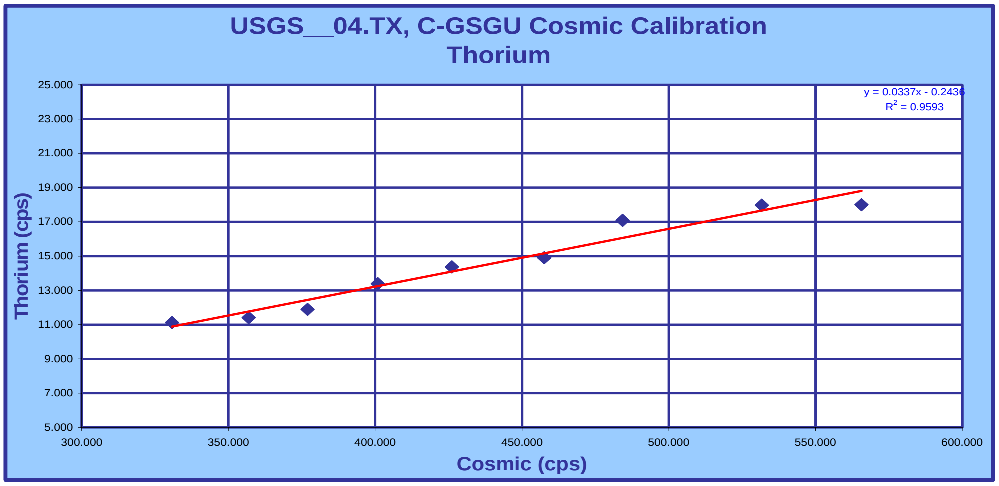
A cosmic and aircraft background test was performed for the spectrometer on May 22nd, 2004 using the daily test line north of the Mid-Valley airport in Weslaco, Texas. The test flights consisted of flying at heights of 4000 ft to 8000 ft above sea level at 500 ft intervals, recording data for a few minutes at each level. Coefficients are determined by linear regression of cosmic counts versus each spectral window as described in the IAEA Report 323 (1991). Graphs of cosmic counts versus each spectral window are given in *Figure 2*. *Table 7* lists the computed cosmic and aircraft background coefficients.

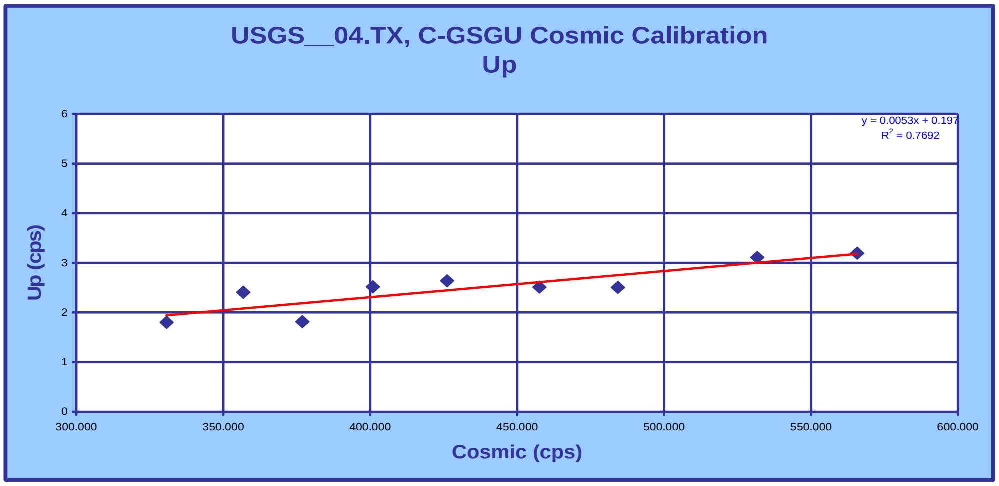
Table 7: Cosmic Coefficients

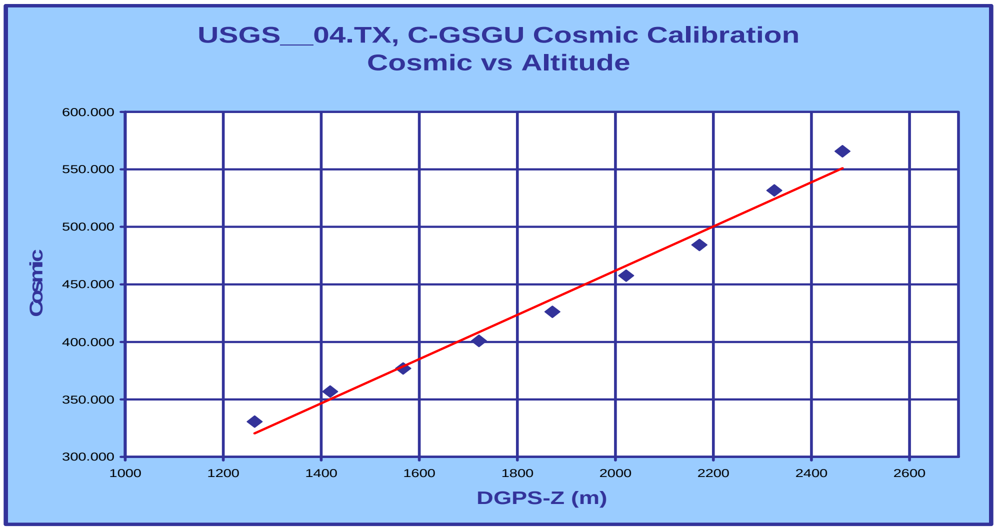
Cosmic Coefficients		
	Cosmic Coefficient	**Aircraft Background**
Total	0.5816	64.27
Potassium	0.0369	6.17
Uranium	0.0271	2.09
Thorium	0.0337	0.00
Upward	0.0053	0.20

Figure 2: Cosmic Counts vs. Each Spectral Window




USGS__04.TX, C-GSGU Cosmic Calibration
Thorium
y = 0.0337x - 0.2436
R2 = 0.9593
Thorium (cps)
Cosmic (cps)


USGS__04.TX, C-GSGU Cosmic Calibration
Up
y = 0.0053x + 0.197
R2 = 0.7692
Up (cps)
Cosmic (cps)


USGS__04.TX, C-GSGU Cosmic Calibration
Cosmic vs Altitude
Cosmic
DGPS-Z (m)

Radon Corrections

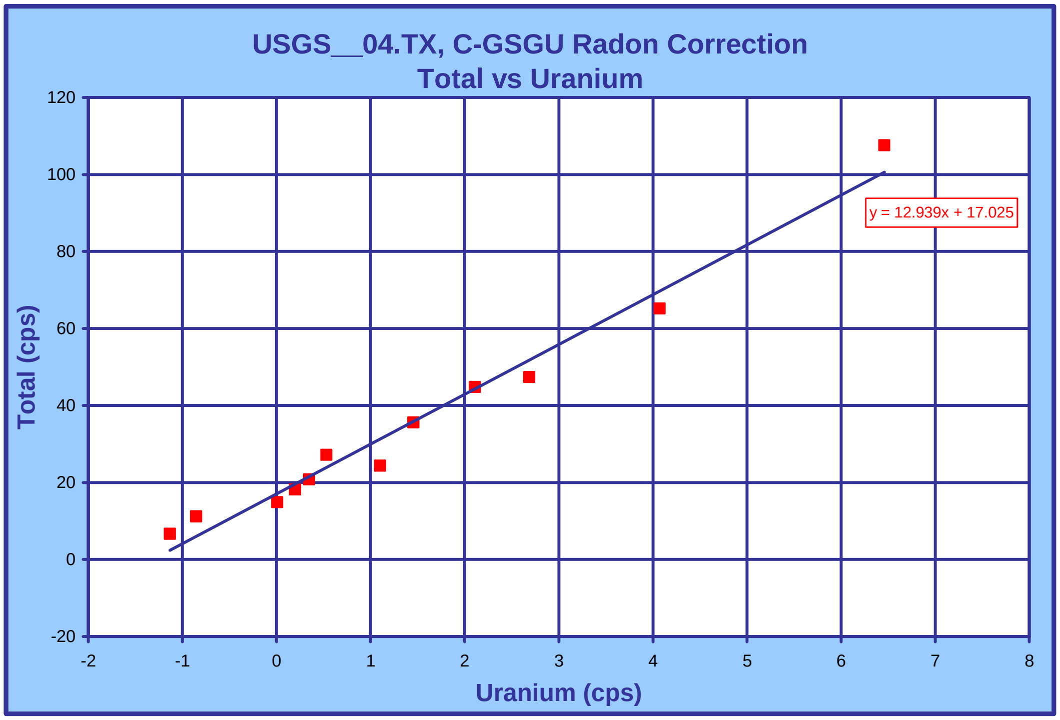
Radon background was monitored through the use of upward facing detectors. Coefficients relating the count rate in the uranium window from the upward detectors to the count rate in the potassium, uranium, thorium and total count windows from the downward facing detectors were determined using several water test lines flown over the Gulf of Mexico near Padre Island, Texas.

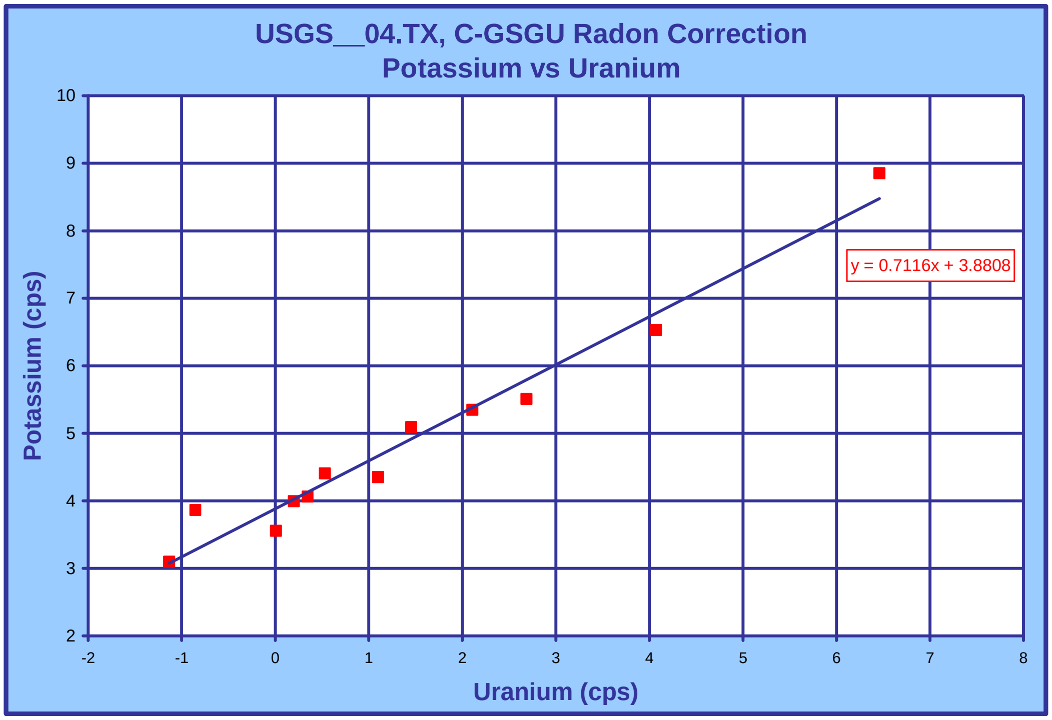
The cosmic and background corrected data from each of the Up, Thorium, Potassium and Total windows are plotted against the counts in the Uranium window for each water line flown. Linear regressions of these plots provide the radon coefficients to be used in the radiometric data processing. The coefficients determined from the plots in *Figure 3* for this survey are presented in *Table 8*.

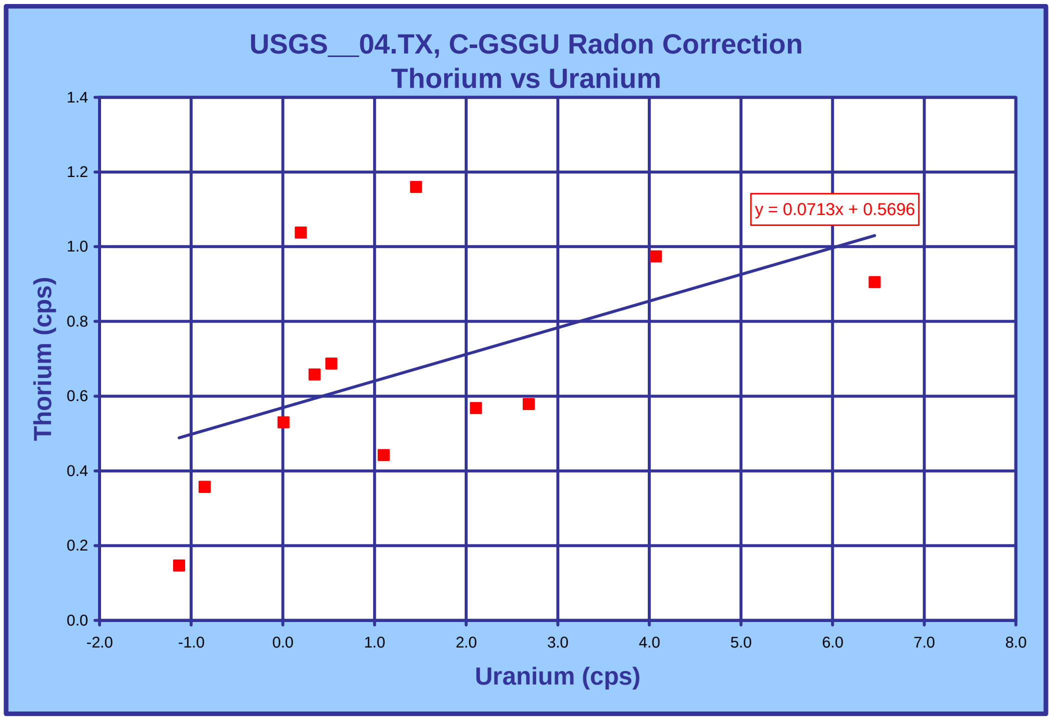
Table 8: Radon Correction Coefficients

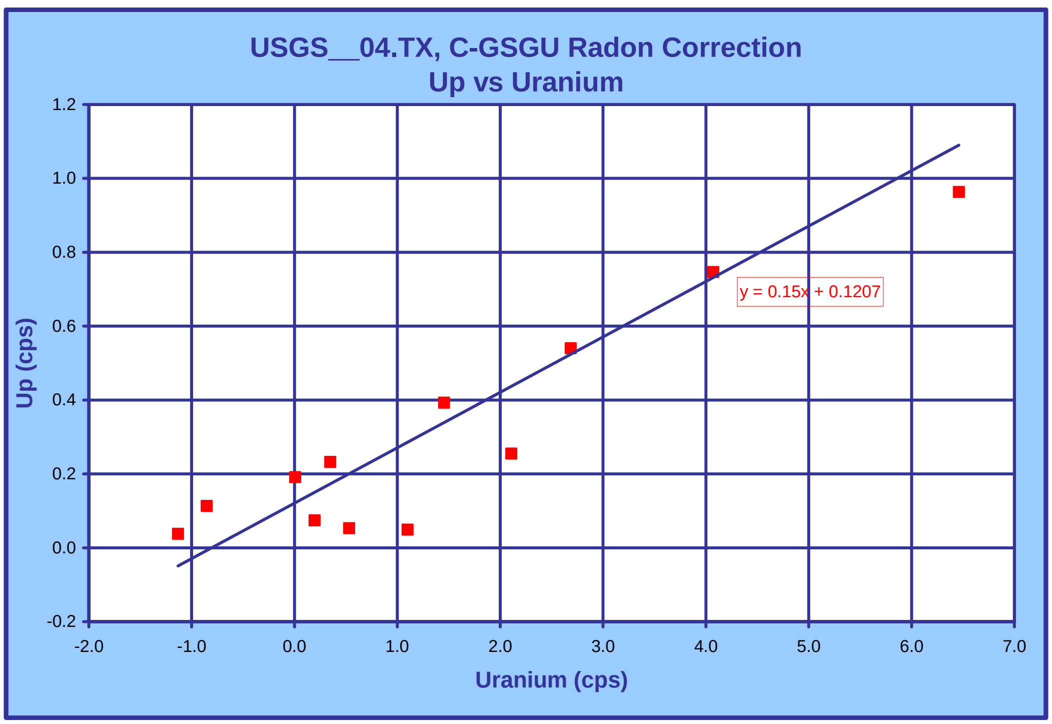
Correction Coefficients	
Constants	**Values**
$I_r = A_I U_r + B_I$	$12.939\ U_r + 17.025$
$K_r = A_K U_r + B_K$	$0.7116\ U_r + 3.8808$
$T_r = A_T U_r + B_T$	$0.0713\ U_r + 0.5696$
$u_r = A_u U_r + B_u$	$0.1500\ U_r + 0.1207$

Figure 3: Radon Correction






USGS__04.TX, C-GSGU Radon Correction
Thorium vs Uranium
Thorium (cps)
Uranium (cps)
y = 0.0713x + 0.5696
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
-2.0
-1.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0


USGS__04.TX, C-GSGU Radon Correction
Up vs Uranium
Up (cps)
Uranium (cps)
y = 0.15x + 0.1207
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
-2.0
-1.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0

Ground Component Coefficients

The ground component coefficients are used to quantify the response of the upward looking detector to radiation from the ground. The IAEA Report 323 describes a technique that involves computing two separate coefficients based on the counts in the uranium and thorium windows. More recent studies (Grasty and Hovgaard, 1996) have suggested that in view of the high correlation between the uranium and thorium windows, it is better to assume that the upward response originating from the ground can be correlated to either counts in the thorium window or to counts in the uranium window. For this survey a coefficient a2 (thorium) only was determined and it was assumed that there was no contribution from uranium (a1 = 0). The ground component coefficients used for this project are listed in *Table 9*.

Table 9: Ground Component Coefficients

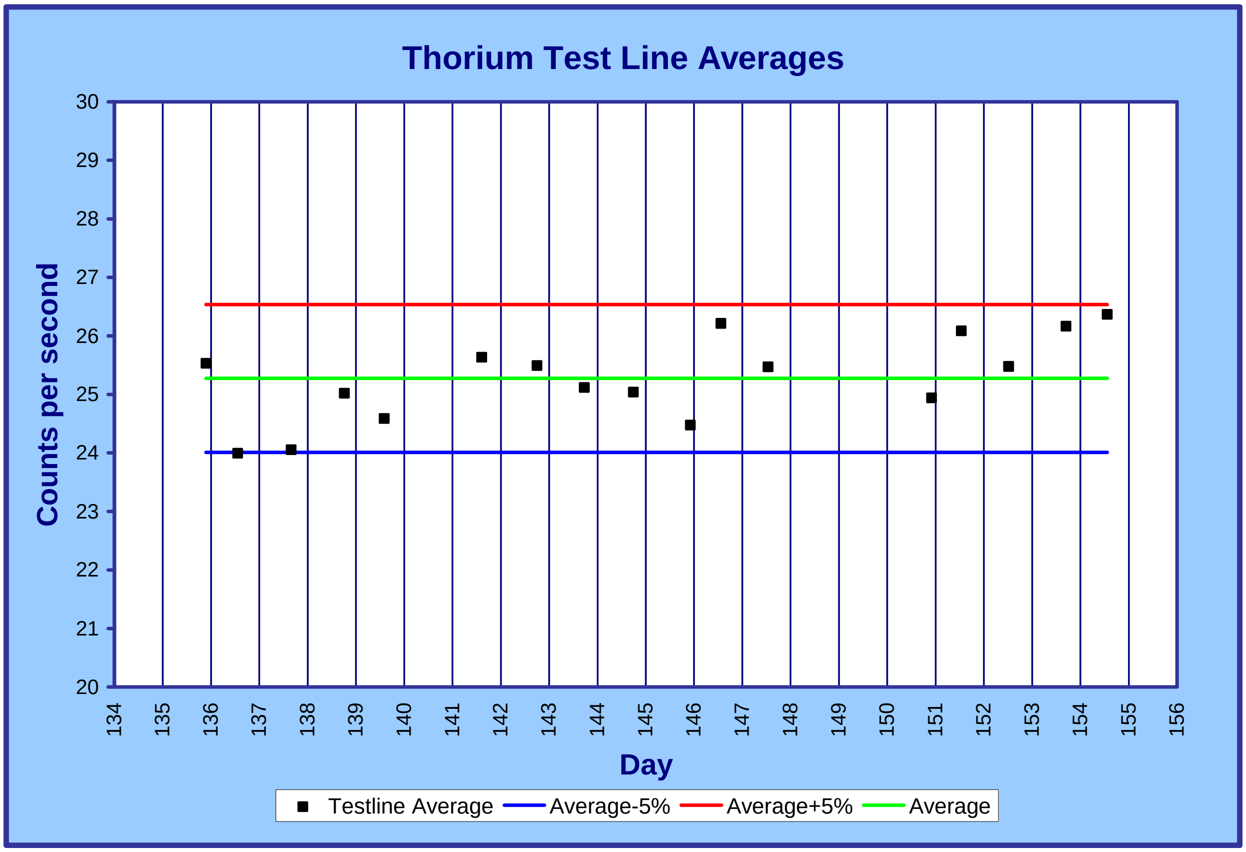
Ground Component Coefficients	
A1 (uranium)	A2 (thorium)
0.0000	0.0656

Spectrometer Data Test Line

High and low altitude spectrometer test lines were flown at 2000 feet (610 m) and 500 feet (150 m) above ground level on most production flights from 002 to 023 using a 4 Km segment of the line C115 between lines T1172 and T1192. High altitude test lines were given line numbers 7002 – 7023, whilst low altitude test lines were given line numbers 8002 – 8023. Test lines flown in the morning were given line extension .01, while test lines flown at the end of the day were given line extension .02.

Corrected thorium data for the test lines were within +/-5% of the average (*Figure 4*) therefore no correction for changes in ground conditions was considered necessary.

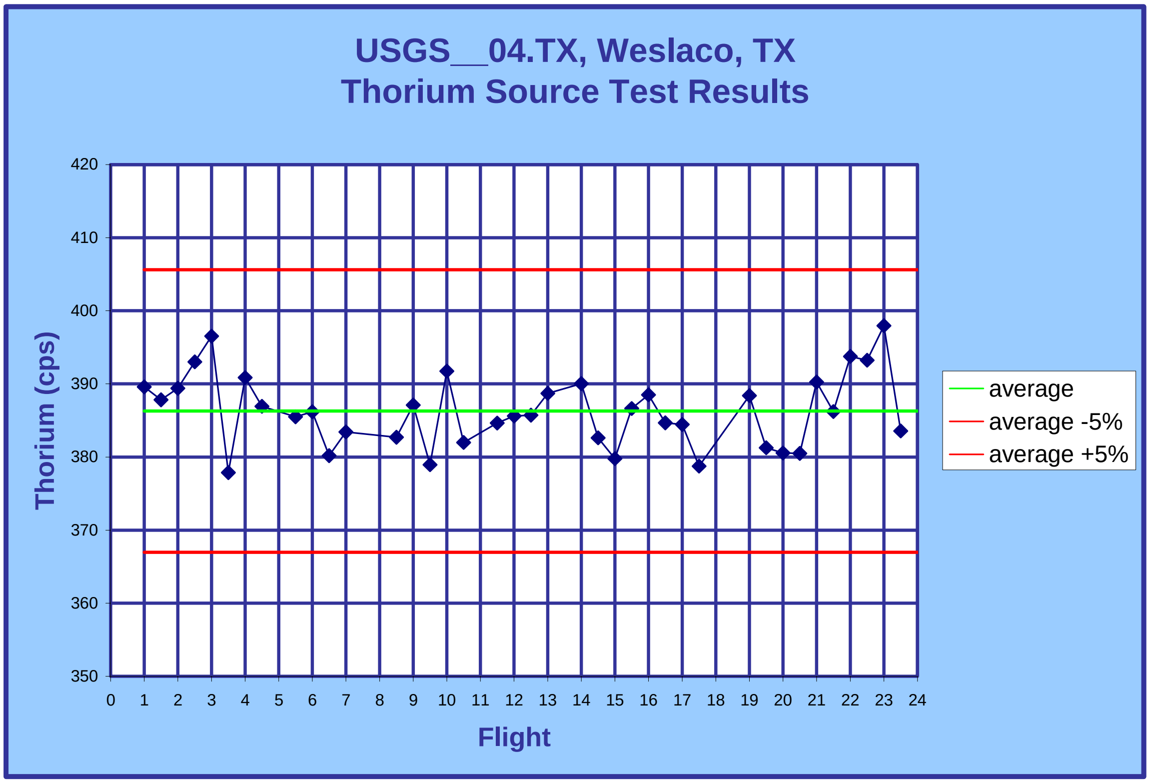
Figure 4: Test Line Averages



Source Tests

Thorium source tests were performed at the start and end of each production day. A source was positioned beneath each crystal pack. Uranium, thorium, and background windows were averaged and recorded for 240 seconds during each test. Recorded data was dead time and background corrected before the statistics were compiled. Thorium source test results were well within +/-5% of the mean value (*Figure 5*) which indicates that the system was operating correctly.

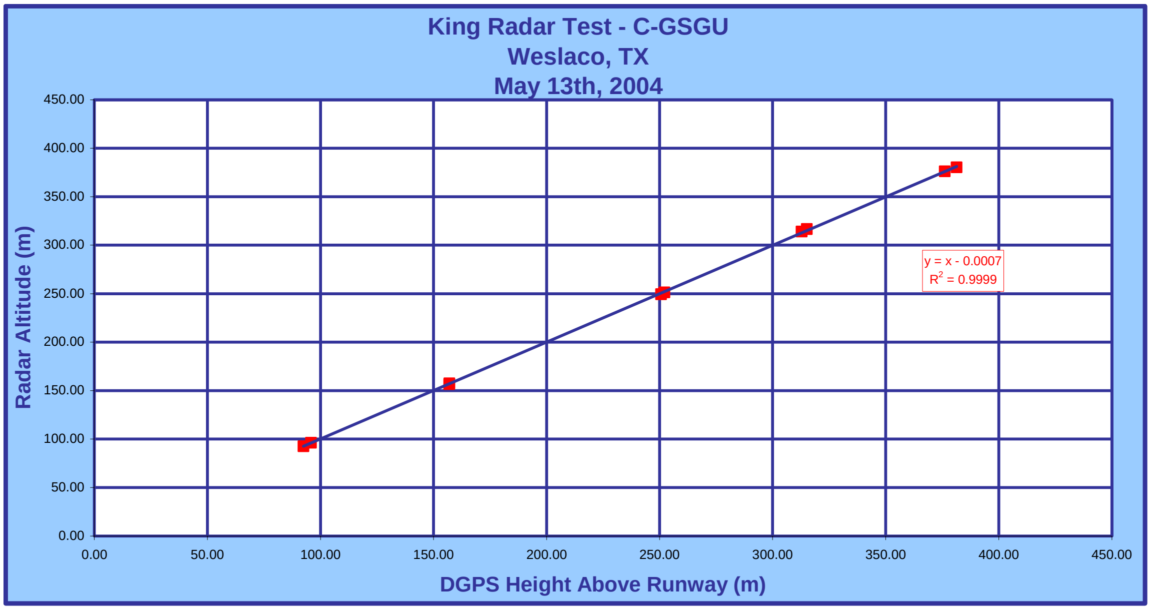
Figure 5: Source Tests



Radar Altimeter Calibration

The King radar altimeter was calibrated by flying at different altitudes over the runway at the Mid-Valley Airport in Weslaco, Texas on May 13th, 2004. By plotting the radar readings against the differentially corrected GPS heights, and calculating a linear regression on the data, we determine a slope of 0.9647 and an intercept of 2.7586. We then use these calculated values to calibrate the radar altimeter readings. *Figure 6* shows the corrected data with slope 1.00 and intercept 0.0007.

Figure 6: Radar Altimeter Test



VI. FIELD OPERATIONS

Operations were conducted from the Mid-Valley Airport in Weslaco, Texas. The field office was established at the Best Western Palm Aire Hotel in the same city. A combined magnetic/GPS ground station was set up in a plastic storage shed in the field east of the airport runway, north of all the hangars. The GPS antenna was located 100 ft north of the storage shed and the magnetometer was located 200 ft northwest of the shed. The position of the ground station was determined precisely by applying a differential correction with respect to the CORS (Continuously Operating Reference Stations) in Corpus Christi (TXCC), Laredo (TXLR), and Pharr (TXPR) using data from Julian days 134 and 135 of year 2004.

The average coordinates of the ground station with respect to WGS-84 are:

Mid-Valley Airport Ground Station	Latitude:	N26:10:51.72318
	Longitude:	W97:58:25.51574
	Elevation:	-2.7074 m

The Mid-Valley Airport ground station was used to apply post-mission differential corrections to the GPS position of the aircraft for all flights.

The weather during the survey was generally hazy and warm. A few early morning flights had to be aborted due to poor visibility associated with rising fog generated by the rapidly increasing temperatures. Mid-afternoon flights were generally avoided due to high levels of turbulence; evening flights were thus preferred and utilised to maximise production. Please refer to the Weekly Reports in Appendix VII for a description of the weather each day. The survey was successfully completed in twenty-three flights. To adhere to the technical specifications of this project, a few lines were reflown; a list of these reflights is provided below.

Line Number	Flight	Reflight	Segment	New Line Number	Reason
T1260.00	001	004	Complete	T1260.01	Radar Altimeter
T1261.00	001	004	Complete	T1261.01	Radar Altimeter
T1262.00	001	004	Complete	T1262.01	Radar Altimeter
T1264.00	001	004	Start – C106	T1264.01	Radar Altimeter
T1265.00	001	004	Start – C106	T2265.01	Radar Altimeter
C0117.00	021	023	Complete	C0117.01	Line Interception

Field Personnel

The following technical personnel participated in field operations:

Party Chief:	Adam Jones
Geophysicist:	André Merizzi
Pilots:	François Genest, Bill Hutton
Aircraft Engineer:	James Pattingale

VII. DIGITAL DATA COMPILATION

All preliminary data compilation such as editing and filtering was performed in the field. Preliminary processing for on-site quality control was performed as each flight was completed. Final data processing was performed at SGL head office in Ottawa.

Radiometric Data

Please refer to *Figure 7* for a summary of the spectrometer data compilation process.

Spectral Component Analysis

Raw 256 channel spectrometer data is analysed using the noise adjusted singular value decomposition method (NASVD; J. Hovgaard and R L. Grasty paper 98, Geophysics and Geochemistry at the Millennium, Proceedings of the 4th Decennial International Conference on Mineral Exploration, 1997). NASVD is similar to principal component analysis in that it identifies the spectral shapes or "components" that comprise the recorded data. However, data must be normalized with respect to count rate since channels with low count rates will have naturally higher statistical variation than those with high count rates. If this is not done, components will describe variation dominated by changes in single channels. Normalization is achieved by dividing each measured spectra by the square root of the best fit of the mean spectra (known as component zero). The NASVD method then determines the components in order of significance with respect to the amount of variance in the data they describe. Each component is a spectrum with 256 channels and there are in theory as many components as there are channels (i.e. 256). Variation in the signal is accounted for by the first components to be identified, whereas variation due to noise is accounted for by the higher order components. Inspection of the components allows us to determine which components describe the signal, so that noise components may be discarded. Spectra are then reconstructed from the signal only components, and the count rates in the standard windows are recalculated.

For this survey, signal from the downward looking crystals is contained within the first seven components, so that components 8 and higher are discarded. Relevant components are illustrated in *Figure 8*.

Figure 7: Spectrometer Data Processing

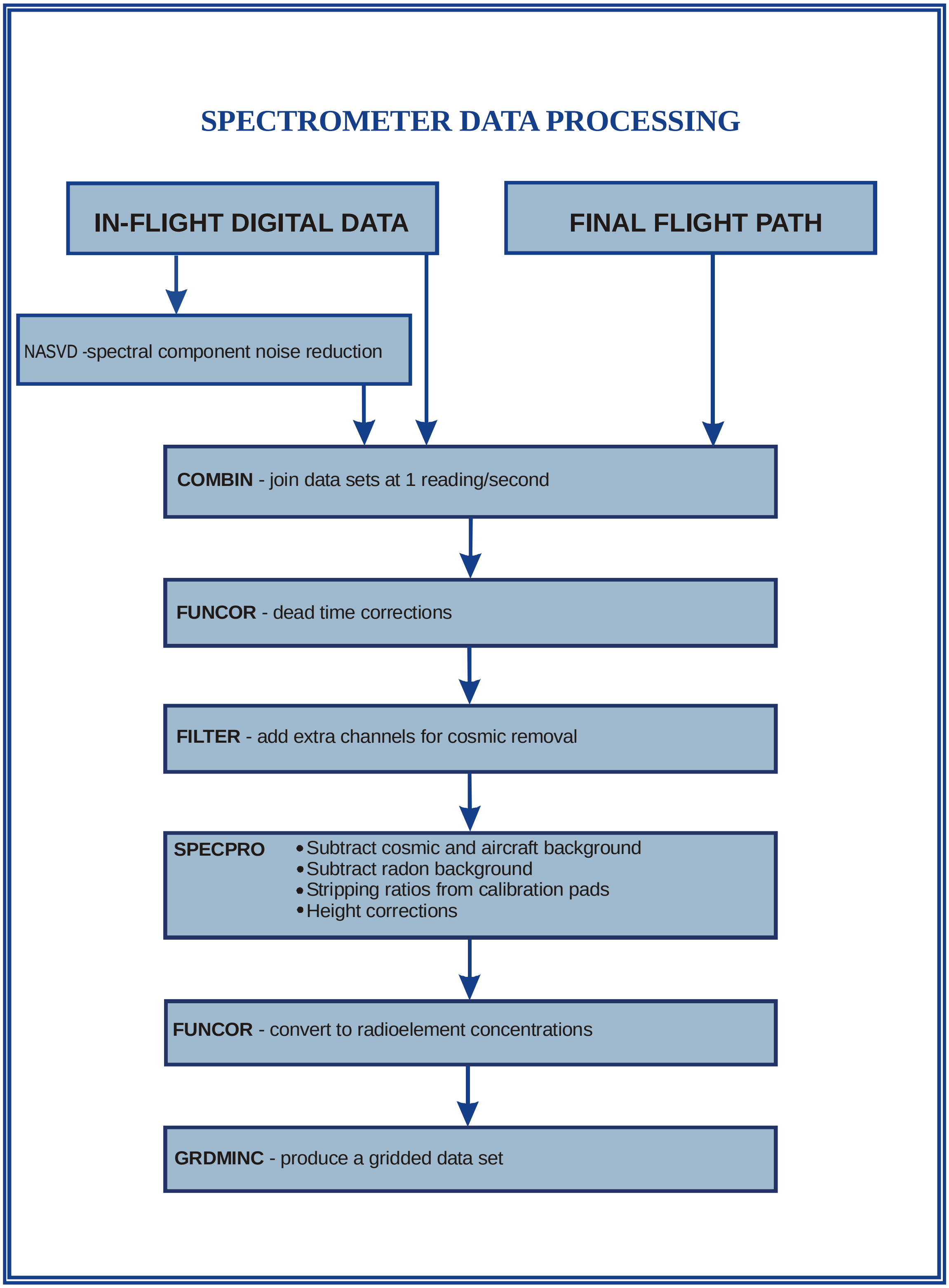
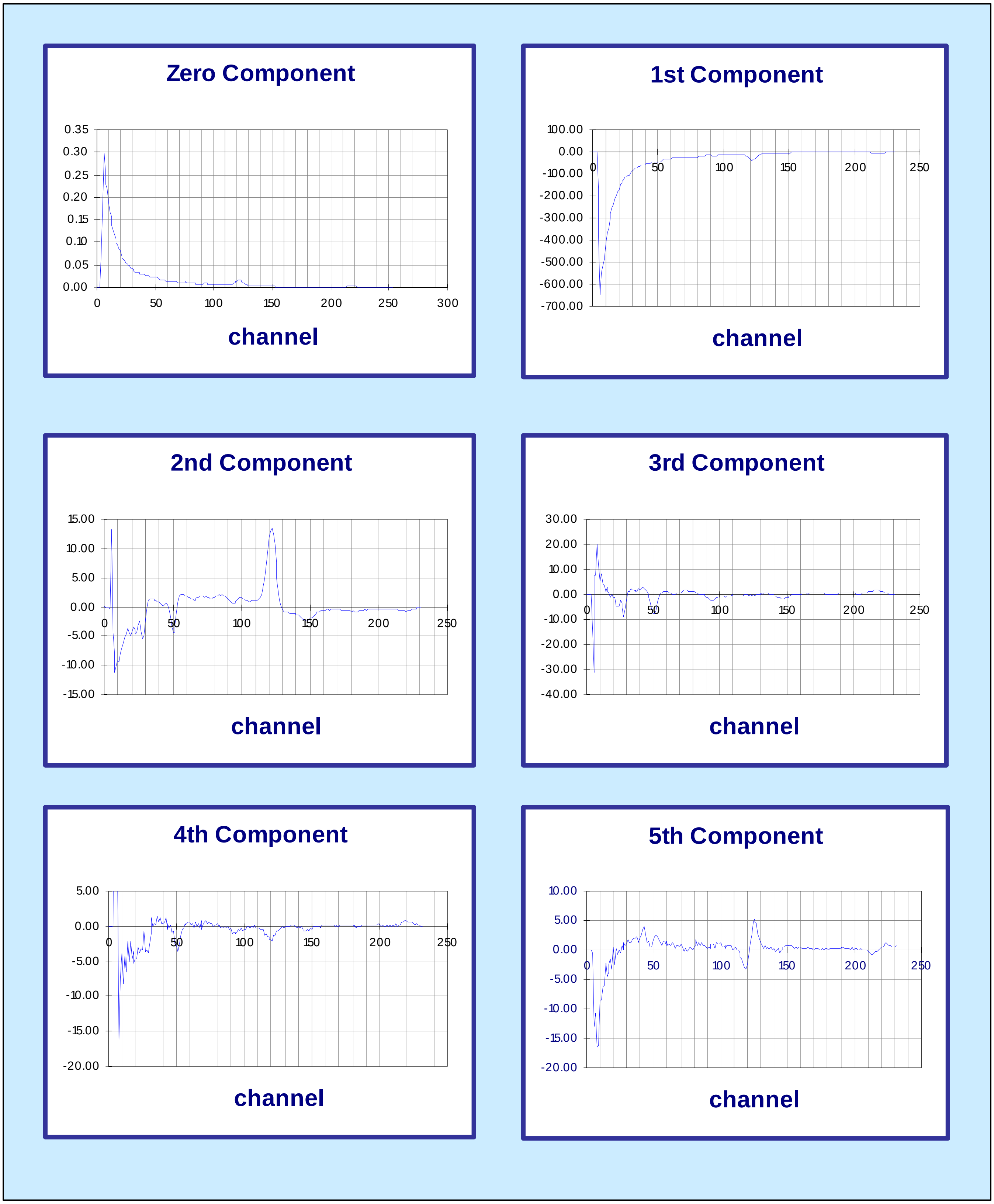
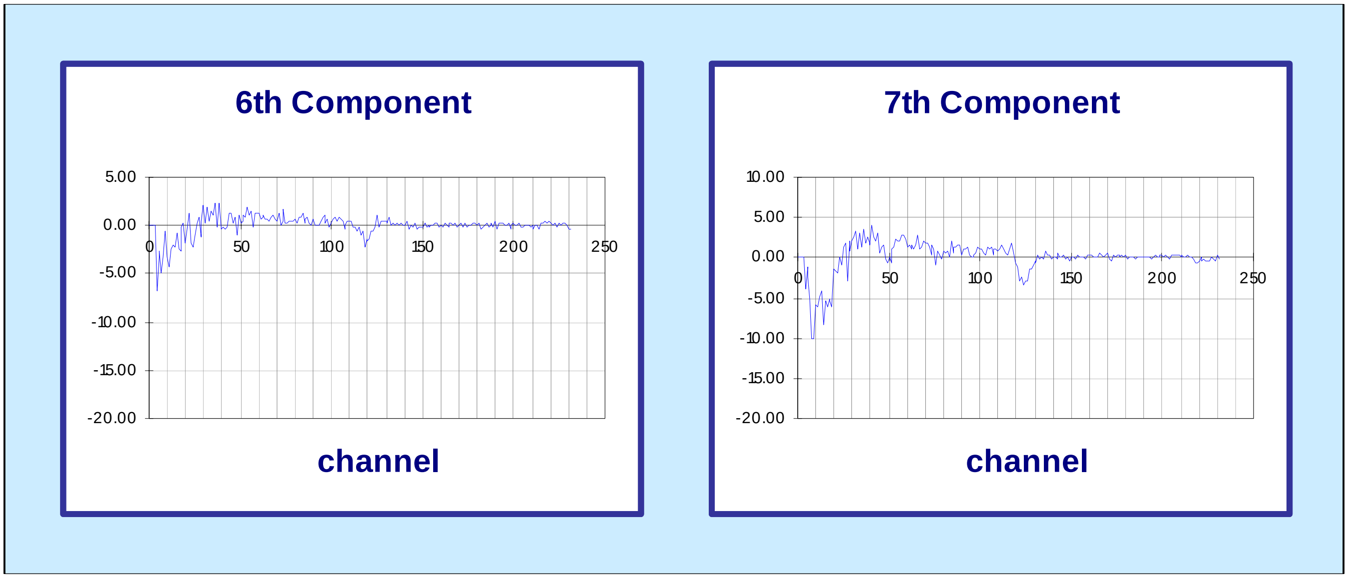


Figure 8: Components





Standard Radiometric Data Processing

Spectrometer data is corrected as documented in the Geological Survey of Canada Open File No.109 and the IAEA report "Airborne gamma-ray spectrometer surveying; Technical Report Series No. 323 (International Atomic Energy Agency, Vienna).

The gamma-ray spectrometer processing parameters are described in *Table 10*.

Table 10: Spectrometer Processing Parameters – Texas, USA

Spectrometer Processing Parameters – Texas, USA			
USGS__04.TX, SPECTROMETER GR-820 SN.8250, 12 DOWN & 2 UP, USED FOR ALL FLIGHTS			
WINDOW	COSMIC STRIPPING (B)	AIRCRAFT (A)	COUNT= A+ B *COSMIC
Total Potassium Uranium Thorium Upward	0.5816 0.0369 0.0271 0.0337 0.0053	64.27 6.17 2.09 0.00 0.20	
RADON COMPONENT	A	B	U_r=Uranium component due to radon
Total (I_r) Potassium (K_r) Thorium (T_r) UP (u_r)	12.9390 0.7116 0.0713 0.1500	17.0250 3.8808 0.5696 0.1207	$I_r=A_i*U_r+B_i$ $K_r=A_k*U_r+B_k$ $T_r=A_t*U_r+B_t$ $u_r=A_u*U_r+B_u$
GROUND COMPONENT	A1	A2	$U_g=A1*U_g+A2*T_g$
UP (u_g)	0.0000	0.0656	
STRIPPING RATIOS (GR820)	INCREASE IN HEIGHT (per metre)	INCREASE IN HEIGHT (per metre)	
alpha beta gamma a b g	0.2307 0.3704 0.6878 0.0353 0.0000 0.0076	0.00049 0.00065 0.00069	
ATTENUATION COEFFICIENTS			
Total Potassium Uranium Thorium	-0.006991 -0.008674 -0.006000 -0.006886		
SENSITIVITIES		C = N / S	
Potassium Uranium Thorium	72.5340 cps per % 7.4297 eU ppm 4.8651 eTh ppm	N – Count S – Sensitivity C - Concentrations	

Before gridding the following corrections are applied to the spectrometer data in the order shown:

1. Dead time correction

   The system live time is recorded by the spectrometer and represents the time that the system was available to accept incoming gamma radiation pulses. Live time is reduced, and dead time increased, as count rates increase and the time taken by the spectrometer to process measured pulses increases. The dead-time correction is applied to each window in both the upward and downward looking detector data, except the cosmic channel data that is processed by separate circuitry in the GR820 spectrometer, using the following equation:

$$N = n / t$$

where: N = the corrected count rate in each channel
n = the raw count recorded in each second
t = the recorded live time (fraction of a second).

2. Calculation of effective height above ground level (AGL)

   A 21-point low pass filter *Figure 9* is applied to 4Hz radar altimeter data, and a 131-point low pass filter (*Figure 10*) is applied to 4Hz barometric altimeter data. The barometric altimeter data is then converted to equivalent pressure, and used with the digitally recorded temperature to convert the radar altimeter data to effective height at standard pressure and temperature (STP) as follows:

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

   where: h_e = the effective height
   h = the observed radar altitude in metres
   T = the observed air temperature in degrees Centigrade, and
   P = the observed barometric pressure in millibars.

3. Height Adaptive Filter

   By convention, data collected at terrain clearance greater than 300m is considered unreliable due to the low count rates and consequent low signal to noise ratio. The maximum terrain clearance was determined to be 318 m based on the calculated effective height. In order to extend the range of useable data, a filter is applied to data flown at higher altitudes. While reducing resolution, this procedure increases the signal to noise ratio to acceptable levels. The degree of filtering applied depends on the clearance as follows:

Clearance	Filter
below 150m:	None
150m to 200m :	3 point average on 1 Hz data
above 200m:	9 point average on 1 Hz data

4. Removal of cosmic radiation and aircraft background radiation

   A low pass filter with a cosine tapered ramp between 15 and 25 points is applied to 1Hz Cosmic data to reduce statistical noise. Cosmic radiation and aircraft background radiation are removed from each spectral window using the cosmic coefficients and aircraft background radiation values determined from test flight data using the following equation:

   N = a + bC

   where: N = the combined cosmic and aircraft background in each spectral window,
   a = the aircraft background in the window,
   b = the cosmic stripping factor for the window, and
   C = the cosmic channel count.

5. Radon background corrections

   A low pass filter with a cosine tapered ramp between 3 and 8 points is applied to 1Hz downward uranium, downward thorium and upward uranium count data for the purposes of the radon correction only. The upward uranium count channel is then filtered with a further 15-point filter to smooth it further before the radon correction. The radon component in the uranium window is calculated using the radon coefficients determined from test flight data and ground coefficients determined from the survey data using the following equation:

$$U_r = \frac{u - a_1 U - a_2 T + a_2 b_T - b_u}{a_u - a_1 - a_2 a_T}$$

where: U_r = the radon background measured in the downward uranium window,
u = the filtered observed count in the upward uranium window,
U = the filtered observed count in the downward uranium window,
T = the filtered observed count in the downward thorium window,
a_1 and a_2 = the ground coefficients,
a_u and b_u = the radon coefficients for uranium,
a_T and b_T = the radon coefficients for thorium.

The radon counts in the total count, potassium and thorium downward windows are then calculated from U_r using the following equations:

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

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, and a and b are the radon calibration coefficients.

Figure 9: 21 Point Filter

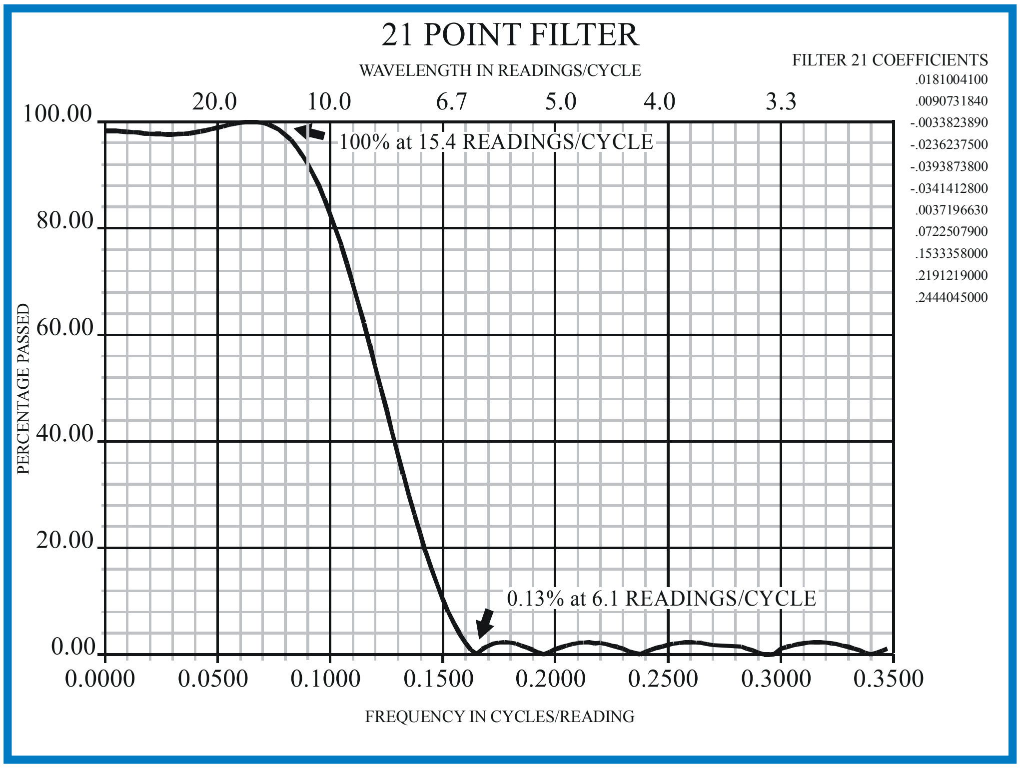
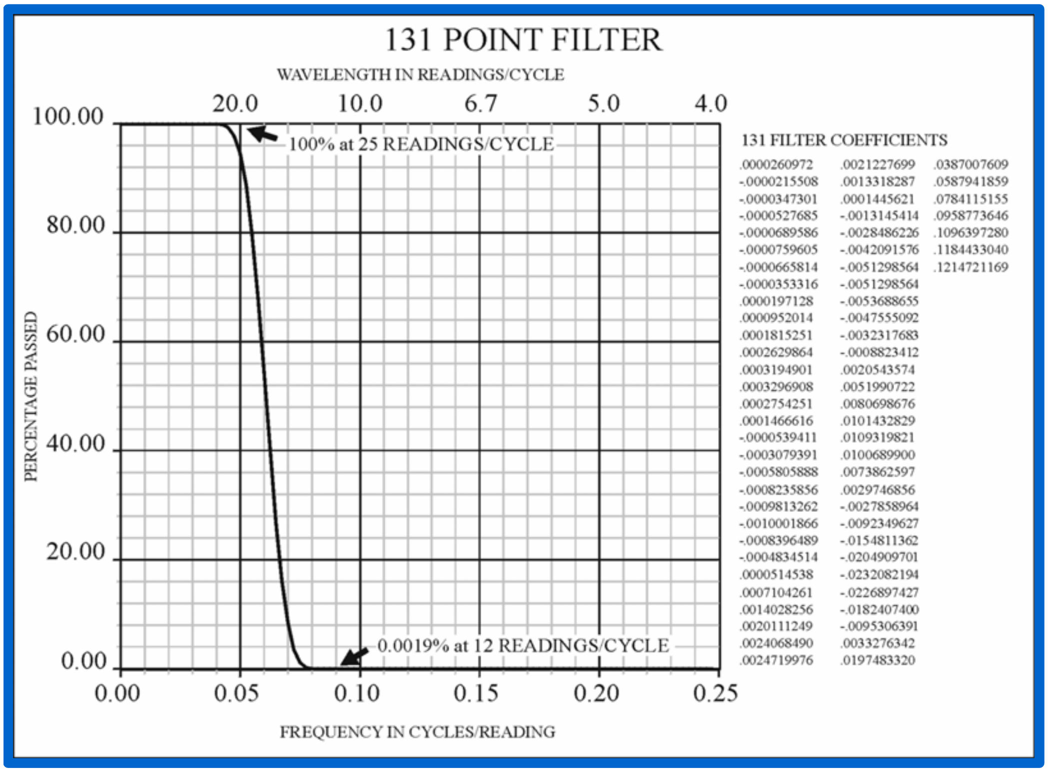


Figure 10: 131 Point Filter



6. Stripping

The stripping ratios for the spectrometer system are determined experimentally. The stripped count rates for the potassium, uranium and thorium downward windows are calculated using the following equations:

$$N_K = \frac{n_{Th}(\alpha\gamma - \beta) + n_U(\alpha\beta - \gamma) + n_K(1 - a\alpha)}{A}$$

$$N_U = \frac{n_{Th}(g\beta - \alpha) + n_U(1 - b\beta) + n_K(b\alpha - g)}{A}$$

$$N_{Th} = \frac{n_{Th}(1 - g\gamma) + n_U(b\gamma - a) + n_K(ag - b)}{A}$$

where A has the value:

$$A = 1 - g\gamma - a(\gamma - gb) - b(\beta - \alpha\gamma)$$

and where

n_K, n_U and n_{Th} = the unstripped potassium, uranium and thorium downward windows counts,

N_K, N_U and N_{Th} = the stripped potassium, uranium and thorium downward windows counts,

α, β, and γ = the forward stripping ratios, and
a, b and g = the reverse stripping ratios.

α, β, and γ are adjusted for effective height (as calculated above) by standard factors given in *Table 5*.

7. Altitude attenuation correction

   This correction normalizes the data to a constant terrain clearance of 150 m above ground level (AGL) at standard temperature and pressure (STP). Attenuation coefficients for each of the downward windows are determined from test flights. The measured count rate is related to the actual count rate at the nominal survey altitude by the equation:

$$N_s = N_m(e^{\mu(h_o - h)})$$

where: N_s = the count rate normalized to the nominal survey altitude, h_o,
N = the background corrected, stripped count rate at effective height h,
μ = the attenuation coefficient for that window,
h_o = the nominal survey altitude, and
h = the effective height.

   The effective height is determined in step 2) "Calculation of effective height above ground level (AGL)".

8. Correction for effects of precipitation

   The survey test line averages for thorium were consistent throughout the duration of the survey (within +/- 5%). No correction for effects of precipitation was deemed necessary.

9. Conversion to radio element concentration

   Sensitivities are determined experimentally from test flight data. The units of the count rates in each spectral window are converted to "Apparent Radio Element Concentrations" using the following equation:

C = N / S

where: C = the concentration of the element(s)

N = the count rate for the window after correction for dead time, background, stripping and attenuation
S = the broad source sensitivity for the window.

Potassium concentration is expressed as a percentage and equivalent uranium and thorium as parts per million of the accepted standards. Uranium and thorium are described as "equivalent" since their presence is inferred from gamma-ray radiation from daughter elements (^{214}Bi for uranium, ^{208}Tl for thorium).

10. Data gridding

A minimum curvature gridding algorithm is considered most appropriate in order to preserve detail in the data. The method generates a 2-dimensional grid, equally incremented in x and y, from randomly placed data points. The algorithm (I.C. Briggs, 1974, Geophysics, v 39, no. 1) produces a smooth grid by iteratively solving a set of difference equations that minimize the total second horizontal derivative and attempt to honour input data. Spectrometer data within cells are combined with a cosine weighting function before the minimum curvature surface is fitted.

For the survey block, radiometric data are interpolated to a 50 m grid cell size appropriate for survey lines spaced at 200 m. Control lines and test lines are not included in the grids.

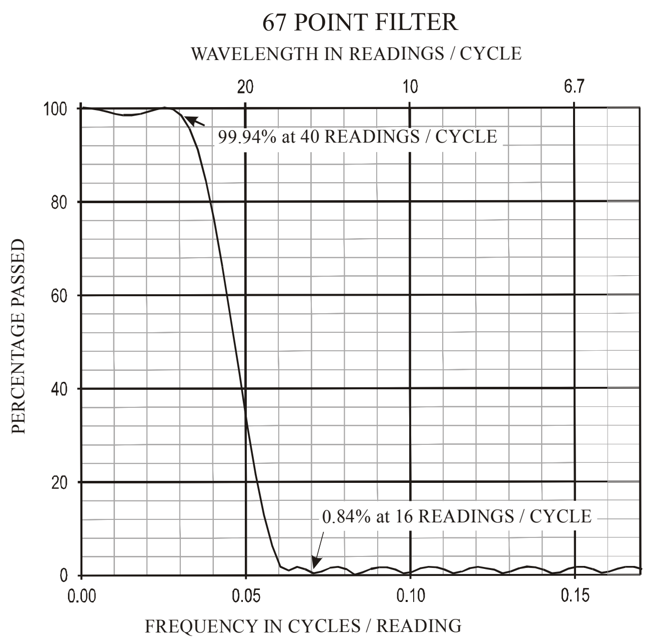
11. Magnetometer Data

The airborne magnetometer data, recorded at 10 Hz, were plotted and checked for spikes and noise. Ground magnetometer data was inspected for cultural interference and edited where necessary; specifically, various spikes were edited for flight 17, during which an airport lawnmower was operating close to the ground magnetic sensor. All ground station magnetometer data was then filtered using a 67-point low pass filter, (*Figure 11*.) Ground station magnetometer data were IGRF corrected using the fixed ground station location and the recorded date for each flight. Please refer to *Figure 12* for a summary of the magnetometer data compilation process.

The airborne magnetometer data were corrected for diurnal variations by subtracting the filtered and IGRF corrected ground station data and adding back the average residual ground station value (-110.67 nT). The average ground station value was calculated from all the ground station data used to correct the airborne data, ensuring that the ground station corrections did not bias the airborne data set. The airborne magnetometer data was

IGRF corrected, using the location, altitude and date of each point. The IGRF was calculated using the IGRF 2000 model.

Figure 11: 67-Point Filter



FILTER 67 COEFFICIENTS
-.0073813819
.0017786870
.0022008393
.0028708524
.0036799926
.0044552023
.0050366484
.0052816825
.0050482578
.0042355750
.0028043608
.0007561474
.0018169265
-.0047570802
-.0078405226
-.010776499
-.013235446
-.014878507
-.015358825
-.014386294
-.011729066
-.0072475690
-.0009241524
.0071362499
.016706382
.027417007
.038819272
.050368667
.061476381
.071564890
.080079578
.086310541
.090552829
.091944844

As part of the levelling procedure, intersections between control and traverse lines were determined. The program extracts the magnetic, altitude, and x and y values of the traverse and control lines at each intersection point. Each control line was adjusted by a specific constant magnetic value to minimize the intersection differences, which were calculated using the following equation:

$\sum|i - a|$ summed over all traverse lines

where, i = individual intersection difference

a = average intersection difference for that traverse line.

The influence of anomalous intersections was avoided by calculating local average corrections and applying a threshold to the intersection correction values.

Adjusted control lines were further corrected locally to minimize the difference between individual corrections and the average correction for the line. Traverse line levelling was carried out by a program that interpolates and extrapolates levelling values for each point, based on the two closest levelling values.

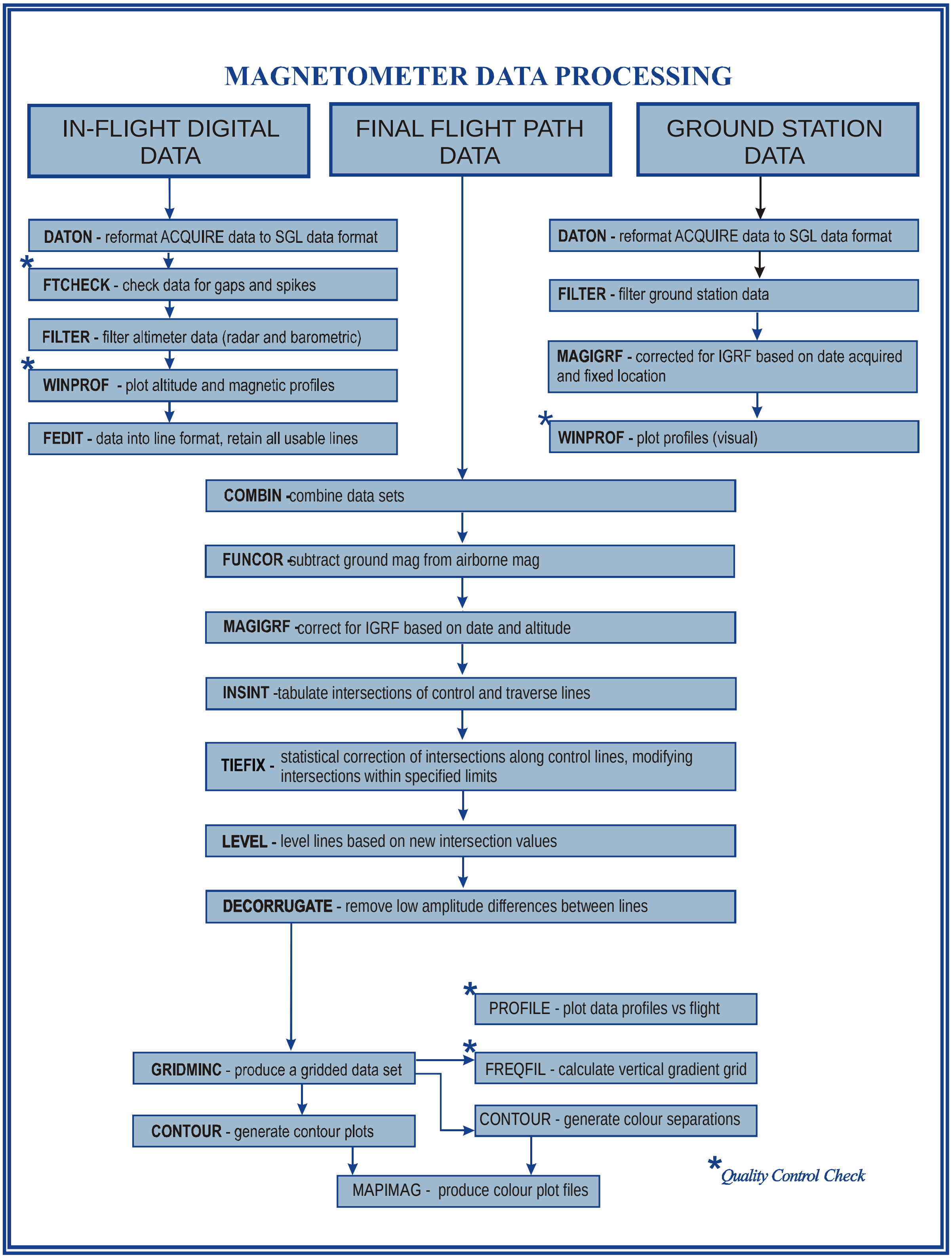
After the traverse lines were levelled, the control lines were matched to them, allowing the use of all data in the final products.

The levelling procedure was checked by inspection of the total magnetic intensity (TMI) and the first vertical derivative of the total magnetic intensity (FVD). Levelling statistics were also examined to ensure that steep correction gradients were minimized.

The magnetic data were gridded using a minimum curvature algorithm to create a two-dimensional grid equally incremented in X and Y directions. The algorithm produces a smooth grid by iteratively solving a set of difference equations minimizing the total second horizontal derivative, while attempting to honour the input data (Briggs, I.C, 1974, Geophysics, v 39, no. 1).

For the survey block, magnetic data are interpolated to a 50 m grid cell size appropriate for survey lines spaced at 200 m.

Figure 12: Magnetometer Data Processing



Radar Altimeter Data

The terrain clearance measured by the radar altimeter in metres was recorded at 4 Hz. The data were filtered to remove high frequency noise using a 21-point filter (see *Figure 9*). The final data were plotted and inspected for quality.

Positional Data

The navigation positional data is re-formatted and recalculated in differential GPS (DGPS) mode. SGL's GPS data processing package, GPSoft2 was used to calculate DGPS positions from raw range data obtained from the moving (airborne) and stationary (ground) receivers. The ground station GPS receiver positions are themselves differentially corrected with respect to the IGS reference stations. This technique provides a final receiver location with an accuracy of +/- 0.2m. The GPS data from all flights was processed using phase-smoothed code and automatic fixing of the cycle slips.

The general data flow of GPSoft is illustrated in *Figure 13*.

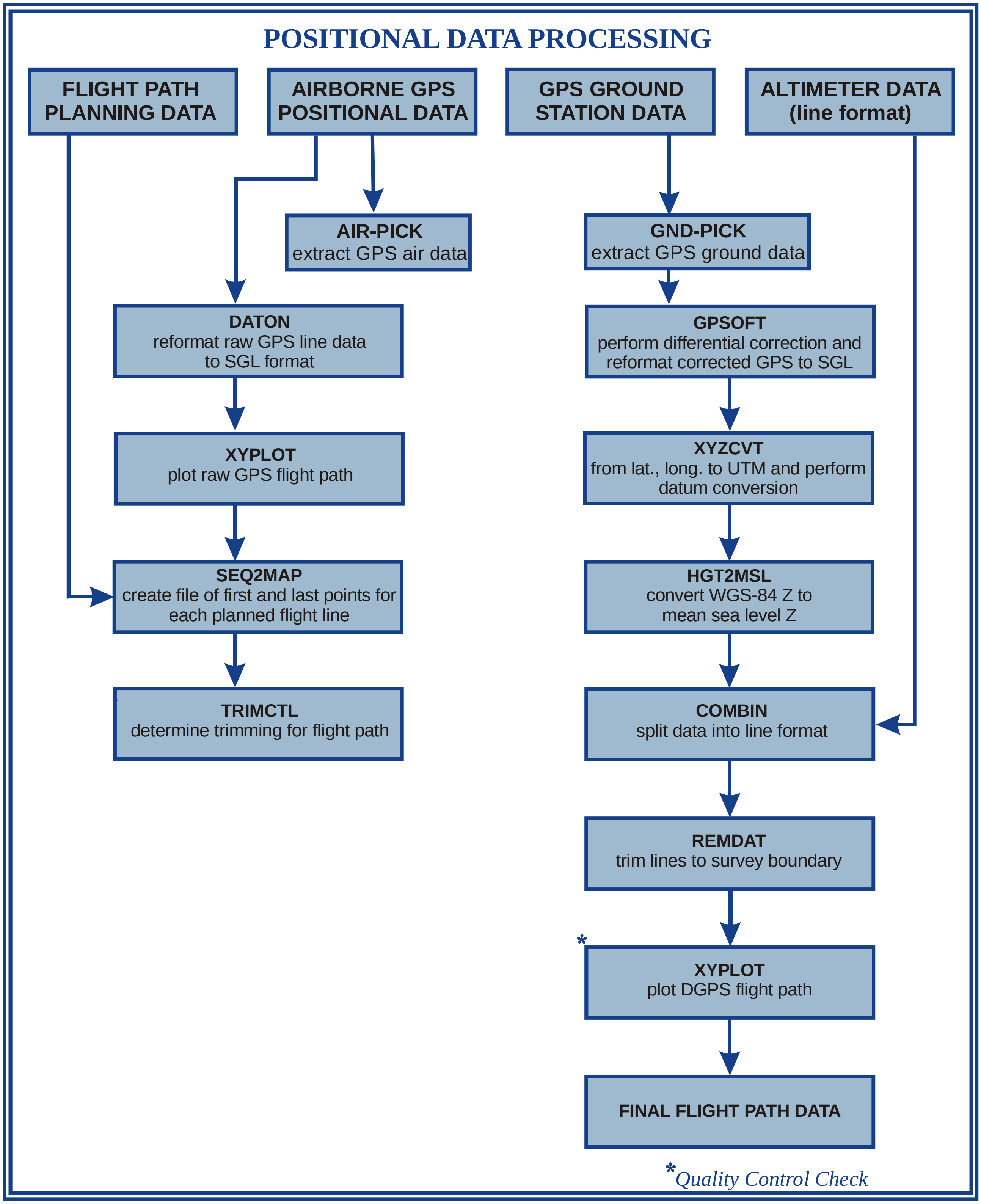
Positional data (X, Y, Z) were recorded in the WGS-84 datum. All processing was performed using data in the WGS-84 datum, but positional data is also provided in the NAD-27 USA west datum. Positional data is provided both in geographic latitude and longitude, and as x,y locations in the UTM projection zone 14 North.

Parameters for each datum used are:

WGS-84	
Ellipsoid:	GRS-80
Semi-major axis:	6378137.0
1/flattening:	298.257
NAD-27-USA-West	
Ellipsoid:	Clarke-1866
Semi-major axis:	6378206.4
1/flattening:	294.979

Transformation from WGS-84 to NAD-27-USA-West is achieved by ellipsoid x, y, z shifts of 8m, -159 m and -175 m respectively. No ellipsoid rotations are involved.

Figure 13: Positional Data Processing



VIII. FINAL PRODUCTS

Digital Data

Digital data is provided as a set of two compact disks (CDs) as follows:
Note: Disk 1 was redelivered after the data was reviewed and re-processed.

Disk 1:Radiometrics – Re-delivered September 27, 2004

spcd256.xyz (Geosoft ASCII format - 256 channel downward detector spectra, data presented with a single header preceding each line).

spcu256.xyz (Geosoft ASCII format - 256 channel upward detector spectra, data presented with a single header preceding each line).

spc_trav.xyz (Geosoft ASCII line data – traverse line data)
spc_ctrl.xyz (Geosoft ASCII line data – control line data)
spc_test.xyz (Geosoft ASCII line data – test line data)

Note: Fully processed data (total counts and equivalent concentrations) are not provided for daily high altitude test lines. Raw data only are presented.

Tot.gxf (GXF format grid – total radiometric counts in cps)
Pot.gxf (GXF format grid – potassium in per cent)
Ura.gxf (GXF format grid – equivalent uranium in ppm)
Tho.gxf (GXF format grid – equivalent thorium in ppm)

Disk 2:Magnetics – Delivered September 1, 2004

mag-tx04.xyz (Geosoft ASCII line data)
tmi.gxf (GXF format grid - total magnetic intensity)
fvd.gxf (GXF format grid - first vertical derivative of the total magnetic intensity in nT/m)
ra-gxf (GXF format grid – radar altimeter)

Tables 11, 12 and *13* describe the located line data delivered in ASCII format. All data are organized by line.

Table 11: Magnetic Data

Name	Description	Format	Units
LINE#	line number (line and segment number)	A7	LLLLSS
LONG	longitude WGS-84	F11.4	degrees
LAT	latitude WGS-84	F9.4	degrees
UTMX	UTM X, WGS-84, zone 14N	F9.1	Meters
UTMY	UTM Y, WGS-84, zone 14N	F10.1	Meters
UTMX_N27	UTM X, NAD-27-USA-west, zone 14N	F9.1	Meters
UTMX_N27	UTM Y, NAD-27-USA-west, zone 14N	F10.1	Meters
FID	fiducial time - seconds after midnight UTC	F9.2	seconds
DATE	year, month, day	A10	'YYYYMMDD'
TIME	hour, minutes, seconds	A13	'HH:MM:SS.SS'
ALT_R	radar altimeter	F7.1	Meters
ALT_B	barometric altimeter	F6.1	Meters
ALT_G	DGPS altitude (MSL)	F7.1	Meters
GND_IG_C	IGRF corrected ground station	F8.2	nT
RAW_MAG	raw magnetic total field	F9.2	nT
MAG-GND	diurnal corrected mag	F9.2	nT
MAG-IG	diurnal & IGRF corrected mag	F8.2	nT
MAG_LEV	final levelled mag	F8.2	nT

Table 12: Radiometric Data (SPC_*.xyz)

Name	Description	Format	Units
LINE	Line No.	A7	n/a
LONG	Longitude WGS-84	F13.7	degrees
LAT	Latitude WGS-84	F12.7	degrees
UTMX WGS-84	UTM X WGS-84 zone 14N	F9.1	meters
UTMY WGS-84	UTM Y WGS-84 zone 14N	F11.1	meters
UTMX NAD-27	UTM X NAD-27-USA-west, zone 14N	F9.1	meters
UTMY NAD-27	UTM Y NAD-27-USA-west, zone 14N	F11.1	meters
FID	Fiducial time - seconds after midnight UTC	I6	seconds
DATE	Date	A9	YYYYMMDD
TIME	Time	A12	HH:MM:SS.SS
EFF	Effective height	F7.1	meters
TEMP	Temperature	F6.1	degrees Celsius
LIVE	Live time	F6.1	Per cent
COSMIC RAW	Raw cosmic window	I6	counts/second
TOT RAW	Raw total window counts	I6	counts/second
K RAW	Raw potassium window counts	I6	counts/second
U RAW	Raw uranium window counts	I6	counts/second
Th RAW	Raw thorium window counts	I6	counts/second
UP RAW	Raw upward Window counts	I6	counts/second
TOT	Corrected total counts	I6	counts/second
K	Corrected potassium concentration	F8.2	Per cent
U	Corrected uranium concentration	F8.2	Ppm
Th	Corrected thorium concentration	F8.2	Ppm
UP	Corrected upward counts	F8.2	counts/second
RA	Radar Altimeter	F7.1	Metres
BA	Barometric Altimeter	F7.1	Metres

Table 13: 256 Channel Spectrometer Data (SPC*256.xyz)

Name	Description	Format	Units
Time	seconds after midnight UTC	F10.2	0.01 sec
UTMX	UTM X WGS-84	F10.1	meters
UTMY	UTM Y WGS-84	F10.1	meters
STIME	Sample time	I4	0.001 sec
CH	256 channel data	I4	counts

IX. PROJECT SUMMARY

SURVEY LOCATION		
Survey Title:	Airborne Magnetic/Spectrometer Survey – USGS__04.TX, Texas	
Survey Location:	Rio Grande Valley, Weslaco Area	
Survey Duration:	May 12 – June 2, 2004	
Client:	United States Geological Survey	
Address:	Box 25046, Denver Federal Center Denver, CO 80225 USA	
Client Contacts:	Pat Hill, Procurement and Contracts Phone: 303 236-1343 Fax: 303 236-1425 E-mail: pathill@usgs.gov Anne McCafferty, Technical Authority Phone : 303 236-1397 E-mail : anne@usgs.gov	
Field Office Location:	Best Western Palm Aire Hotel 415 S. International Blvd. Weslaco, Texas 78956 956 969-2411	
Airport Used:	Mid-Valley Airport in Weslaco, Texas	
SURVEY SPECIFICATIONS		
Magnetic field (IGRF 2000 model):		
Total Field:	46 329 nT	
Inclination:	55.5	
Declination:	5.7	
Horizontal/Vertical Datum		
Raw Recorded Data:	WGS-84	
Delivered Data:	WGS-84/NAD-27-USA-West	
Line Direction:	Traverse: 090	Control: 000
Line Spacing:	Traverse: 200 m	Control: 2000 m
Total lkm Flown:	11 069 km	
Survey Speed:	110 knots	
Survey Altitude:	150 m	
Survey Flight Numbers:	001-023	
SURVEY AIRCRAFT AND EQUIPMENT		
Aircraft Used:	C-GSGU Cessna Grand Caravan	
Radar Altimeter:	King Radar KRA 10A	

Barometric Sensor:	Sander BA 012
Magnetometer (Air):	Geometrics G-822A Cesium
Magnetometer (Local Ground):	Geometrics G-822A Cesium
GPS Receiver (Air):	NovAtel Millennium, 12 channels
DGPS Receiver (Air):	Omnistar 3100LM
GPS Receiver (Local Ground):	NovAtel Millennium, 12 channels
Spectrometer:	Exploranium GR-820 Three crystal detector packs GPX-1024/256 (12 down-looking and 2 upward-looking crystals)
FIELD PERSONNEL	
Geophysicist/Party Chief:	Adam Jones
Data Processor/Geophysicist:	André Merizzi
Aircraft Maintenance Engineer:	Jamie Pattingale
Pilots:	François Genest, Bill Hutton

FLIGHT DETAILS

REFLIGHTS

Line No.	Flight	Re-flight Line No.	Re-flight Flight No.	Reason for Re-flight
T1260.00	001	T1260.01	004	Radar Altimeter not functioning
T1261.00	001	T1261.01	004	Radar Altimeter not functioning
T1262.00	001	T1262.01	004	Radar Altimeter not functioning
T1264.00	001	T1264.01	004	Radar Altimeter not functioning
T1265.00	001	T2265.01	004	Radar Altimeter not functioning
C0117.00	021	C0117.01	023	Line Interception out of spec

PROBLEMS AND SOLUTIONS

The survey was successfully completed in twenty-three flights with minimal difficulties. The few problems encountered during the survey were solved quickly and did not interfere significantly with production. A list of these issues follows.

The Rio Grande Valley area is considerably built up in the south, and has several antennae, some of which reaching 1200 feet, scattered within the survey boundary. Certain flight lines were thus diverted to avoid collisions with these obstacles. Respecting the FAA regulations imposed for this project, survey flying over urban areas was conducted at 1000 feet, which explains the various vertical deviations scattered throughout the block.

The TRT radar installed in the aircraft generated a series of drop-outs in the first production flight data. The King radar was thus used in its stead for the rest of the survey; the affected lines of flight 1 were reflown during flight 4.

During flight 17, the field in which the ground station was installed was mowed. The repeated passage of the lawnmower generated a number of spikes in the ground magnetic data. Due to the relatively calm nature of the diurnal magnetic activity in the area, a few simple manual edits sufficed to remedy this problem.

DATA PROCESSING				
PROCESSING FILE LOCATION:				
PROCESSING	COMPUTER	DIRECTORY	DONE	COMPILED BY
Field Processing	P4-39 P4-40	D:\USGS__04.TX E:\USGS__04.TX	X	Adam Jones André Merizzi
Altimeter Data	P4-40	E:\USGS__04.TX\ALT	X	Kevin Charles
DGPS Data	P4-40	E:\USGS__04.TX\DGPS	X	Kevin Charles
Ground Mag Data	AMD-4	G:\USGS__04.TX\GND	X	Chris van Galder
Air Mag Data	AMD-4 P4-65	G:\USGS__04.TX\MAG	X	Chris van Galder Dragos Bologa Jennifer Dennis
Spectrometer Data	P4-53	E:\USGS__04.TX\SPEC256	X	Bernard Desmons Stefan Elieff Bill Peck

MAJOR PROCESSING ITEMS	
MASTER CORNER FILE:	Tex.mcf
UTM ZONE:	14N
IGRF REMOVED:	Yes
INSINT:	Yes
TIEFIX:	Yes
ADJUSTCTL:	Yes
CTL FILE TO ADJUST INTERSECTIONS:	Faint1.ctl
SHORT FIX:	Yes
MOVINT:	Yes
MAXIMUM INT. DEVIATION:5.0	
MIN GRADIENT TO CORRECT:0.2	MAX DEVIATION FROM AVERAGE: 5.0
DECORRUGATION FILTER: No	FREQUENCY CORRECTIONS: No
DECORRUGATION CORRECTION LIMITS: N/A	CORRECTIONS FILTERED: No

FINAL PRODUCTS	
MAPS	Two mylar copies of contoured magnetic field
DIGITAL LINE DATA	RADIOMETRICS *spcd256.xyz* (256 channel downward detector spectra, data presented with a single header preceding each line). *spcu256.xyz* (256 channel upward detector spectra, data presented with a single header preceding each line). *spc_trav.xyz* (traverse line data) *spc_ctrl.xyz* (control line data) *spc_test.xyz* (test line data) MAGNETICS *mag-tx04.xyz*
GRIDS	RADIOMETRICS *Tot.gxf* (GXF format grid – total radiometric counts in cps) *Pot.gxf* (GXF format grid – potassium in per cent) *Ura.gxf* (GXF format grid – equivalent uranium in ppm) *Tho.gxf* (GXF format grid – equivalent thorium in ppm) MAGNETICS *tmi.gxf* (GXF format grid - total magnetic intensity) *fvd.gxf* (GXF format grid - first vertical derivative of the total magnetic intensity in nT/m) *ra-gxf* (GXF format grid – radar altimeter)