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GammaLog Playback 1.0 - mobile gamma ray
spectrometry software

REPORT

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Title:
 GammaLog Playback 1.0 - mobile gamma ray spectrometry software

Authors:
 R.J.Watson, M.A.Smethurst*

 *present address: Avalonia Geophysics, University of Exeter
 Cornwall Campus, Tremough, UK

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 Statens Strålevern - NGU

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Summary:

The Geological Survey of Norway (NGU) operates a mobile gamma ray spectrometer system which can be used in nuclear emergency situations to determine the location and type of orphan sources, or the extent and type of fallout contamination. The system consists of a 20 litre (16 litre downward and 4 litre upward looking) RSX-5 NaI detector and spectrometer, and can be mounted in fixed wing aircraft, helicopters, or vans/cars as appropriate. NGU has developed its own data acquisition and analysis software for this system. GammaLog (Smethurst 2005) controls the acquisition, display, and storage of data from the spectrometer, and performs real-time data analysis including estimation of dose rates and fallout concentrations, and separation of geological and anthropogenic components of the signal. The latter is particularly important where the geological radioisotope signal varies strongly from one place to another, and makes it easier to locate and identify anthropogenic sources which might otherwise be difficult to separate from the geological background signal.

A modifed version of GammaLog has been developed, GammaLog Playback, which allows the replay of previously acquired GammaLog datasets, while performing similar processing and display as the GammaLog acquisition software. This allows datasets to be reviewed and compared in the field or during post-survey analysis to help plan subsequent measurement strategies.

Keywords:	Radiometrics (Radiometri)	Nuclear emergencies (Atomberedskap)
		Gamma ray spectrometry (Gammaspektrometri)
		Software manual

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1. INTRODUCTION

The Geological Survey of Norway (NGU) operates a mobile gamma ray spectrometer system which can be used in nuclear emergency situations to determine the location and type of orphan sources, or the extent and type of fallout contamination. The system consists of a 20 litre (16 litre downward and 4 litre upward looking) RSX-5 NaI detector and spectrometer (Radiation Solutions Inc., Ontario, Canada), and can be mounted in fixed wing aircraft, helicopters, or vans/cars as appropriate. NGU has developed its own data acquisition and analysis software for this system. GammaLog (Smethurst 2005) controls the acquisition, display, and storage of data from the spectrometer, and performs real-time data analysis including estimation of dose rates and fallout concentrations, and separation of geological and anthropogenic components of the signal. The latter is particularly important where the geological radioisotope signal varies strongly from one place to another, and makes it easier to locate and identify anthropogenic sources which might otherwise be difficult to separate from the geological background signal.

A modifed version of GammaLog has been developed, GammaLog Playback, which allows the replay of previously acquired GammaLog datasets, while performing the same processing and display as the live GammaLog software. This allows datasets to be reviewed in the field to help plan subsequent measurement strategies, or for post-survey analysis to review or compare previously collected datasets.

GammaLog Playback processes the raw data contained in GammaLog binary files. This means that during playback, different processing settings can be applied from those which were used during collection. A user could for example use different calibration settings, or use part of a dataset as a background and subtract this from other parts of the dataset, even if this background subtraction had not been performed during acquisition. The processing state used during acquisition is also recorded in the binary file on a record-by-record basis, and so GammaLog Playback is able to recreate the same processing options that were used during acquisition if the user wishes.

The RSX-5 syxtem records data in 1024 channels between 0 and 3 MeV, and can export real-time data in 256, 512 or 1024 channel formats. GammaLog reads and records the 256 channel form of this data, and GammaLog Playback reads data-files in this same 256 channel format.

2. DESIGN

GammaLog was developed using LabView (LabView 7.1, National Instruments Corporation, Texas, USA) software development platform. LabView is primarily aimed at data-acquisition, providing tools for interfacing with common types of hardware, but also includes sophisticated display and analysis tools. GammaLog Playback has no requirement for hardware data acquisition, but it was decided to develop GammaLog Playback using the same LabView software platform. This would :

- allow re-use of software components from GammaLog

- enable the user-interface to have a similar look and feel to the GammaLog interface, making its operation easier for users already familiar with GammaLog

- allow sharing of any future modifications to GammaLog or GammaLog Playback software components

- assist any future implementation of a combined live/replay version of GammaLog.

3. BASIC OPERATION

The user interface (Figure 1) consists of two panels: a control panel (including playback-related controls), and a display panel (including spectral, waterfall, chart, dose rate and map displays).
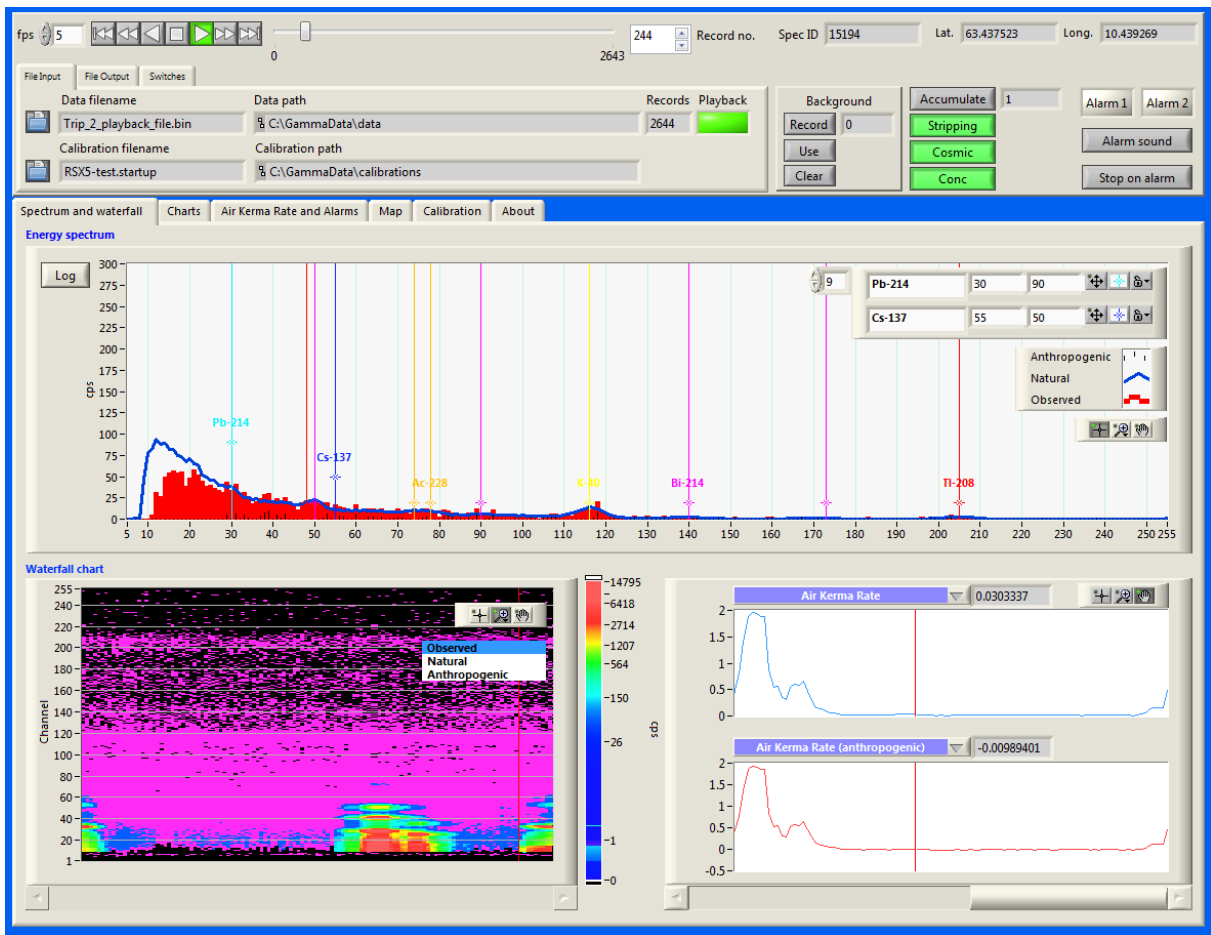

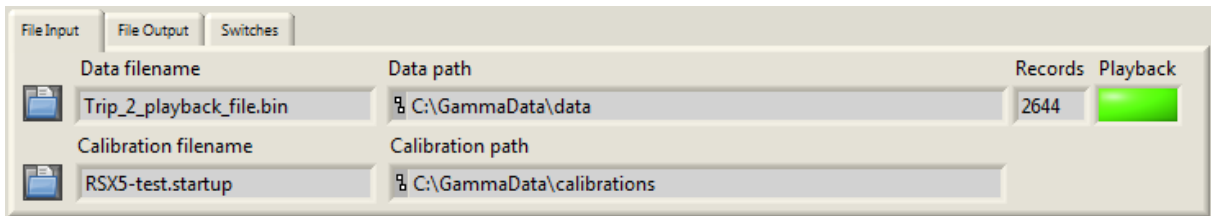**Figure 1: GammaLog Playback user interface.**

Figure 2: File input controls

To begin visualising the contents of a data-set, first use the file input controls (Figure 2) to load data and calibration files:

1. Select the "open data file" icon (to the left of the "Data filename" indicator) and select a suitable binary ('.bin') data file (APPENDIX A).
2. Select the "open calibration file" icon (to the left of the "Calibration filename" indicator) and select a suitable calibration ('.startup') file (APPENDIX B).

Once a data file and calibration file are loaded, GammaLog Playback displays the contents of the first record in the file in the various indicators, charts and graphs. To view other records in the file, use the playback controls (Figure 3) at the top of the control panel.
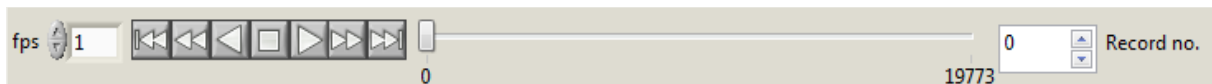

Figure 3: Playback controls

To play through the dataset, select the [play] icon and adjust the speed of playback through the frames-per-second [fps] control. To jump to other records in the file, use the slider, or enter a record number directly in the [Record no.] control. As new records are loaded, the spectrum, waterfall and chart displays update. Data records in the binary GammaLog format data files are normally recorded once per second, and so setting frames-per-second to 1 would result in a playback at the same rate as the original live acquisition.

4. USER INTERFACE

The user interface is divided into a Control panel (4.1) and a Display panel (4.2).

4.1 Control panel

4.1.1 Playback controls

The playback controls are shown in Figure 3: Playback controls and consist of:

a. FPS (frames per second) control. This controls the approximate rate of playback through a dataset.
b. Jump to start. This sets the display to record number 0.
c. Step backwards. This decrements the record number by 1.
d. Play backwards: This plays through a file in reverse order, at a rate determined by the FPS control.
e. Stop. This stops playback.
f. Play forwards. This plays through a file at a rate determined by the FPS control.
g. Step forwards. This increments the record number by 1.
h. Jump to end. This sets the display to the last record in the file.
i. Record-number-slider: The slider can be dragged to move backwards and forwards through a dataset
j. Record-number control. A record number can be entered directly in this box, and can be incremented/decremented with the arrow controls.
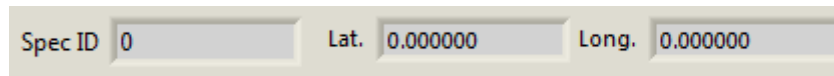
4.1.2 ID and GPS indicators

Figure 4: ID and GPS indicators

Here the spectrum ID, latitude, and longitude of the record are displayed. The spectrum ID is a unique identifier of the record in the file, but is not necessarily the same as the record number.
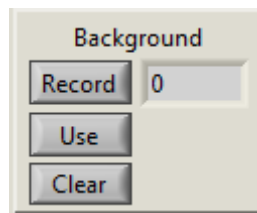
4.1.3 Background controls

Figure 5: Background controls

The background controls (Figure 5) allow the use of a sequence of records as a background which is subtracted from the record on display. This can be used to record the geological background in a location and have it subtracted from subsequent records, or to remove a background signal from a contaminated vehicle, and can also be used during calibrations to remove the environmental background from a calibration source dataset. To begin recording a background, press the [Record] button. This begins background accumulation, and the number of accumulated records is displayed. Pressing [Record] again stops the background acquisition.   To apply the background, press [Use]. This will subtract the averaged (counts per second) background spectrum from the displayed spectrum. Pressing [Clear] resets the background. A background can be based on records from different parts of a data-set by pressing [Record] multiple times at different parts of the dataset.

4.1.4 Processing controls
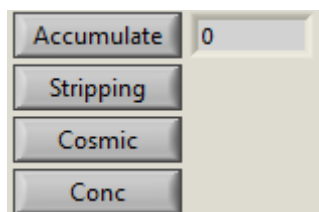
Figure 6: Processing controls

The processing controls (Figure 6) consist of Accumulate, Stripping, Cosmic and Concentration controls.

When the [Accumulate] button is pressed, an accumulated, time-averaged (cps) spectrum is displayed. The number of accumulated spectra is indicated in the numerical display. Pressing [Accumulate] again switches off accumulation, and resets the counter to zero.

The records in a GammaLog binary file represent spectra accumulated over a measurement period of one second. It can sometimes be beneficial to compound successive measurements

over a longer period to obtain a more accurate spectrum, usually when the measurement system is stationary, or during calibration procedures.

Note that raw (non-accumulated) data are exported to binary format regardless of the state of the [Accumulate] button.

When [Stripping] is pressed, a window-stripping procedure is applied to the counts displayed in the K-40, U-238, Th-232 and Cs-137 charts. The channel windows and stripping ratios used in the stripping procedure are defined in the '.cal' calibration file (APPENDIX C), and can be adjusted in the Calibration tab (4.2.5). Note that stripping ratios and sensitivities appropriate to the survey elevation should be used.

When [Cosmic] is pressed, a cosmic background is subtracted from the displayed spectrum, and from subsequent derived quantities (such as counts per second and concentrations) in the charts. The cosmic background is based on the unit spectrum contained in the cosmic calibration file (loaded along with other calibration files), and the number of counts in channel 255.

When [Conc] is pressed, window counts are converted into ground concentrations using the sensitivity conversion factors in the calibration file. Sensitivity conversion factors can be viewed and adjusted in the Calibration controls (4.2.5). Chart displays are updated to show concentrations (in % K-40, ppm U-238, ppm Th-232 and Bq/m^2 Cs-137) instead of cps.

The [Conc] button can only be pressed when [Stripping] is already activated.

4.1.5 Alarm indicators and controls

Figure 7: Alarm indicators and controls
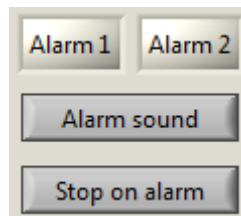
The alarm controls indicate when either of the two alarm conditions have been met. The alarm conditions are set in the Air Kerma Rates and Alarms tab (4.2.3) in the display panel. The [Alarm 1] and [Alarm 2] LEDS will flash if their alarm conditions are met. The user can also enable an alarm sound [Alarm sound], and can set playback to pause whenever an alarm is triggered [Stop on alarm].
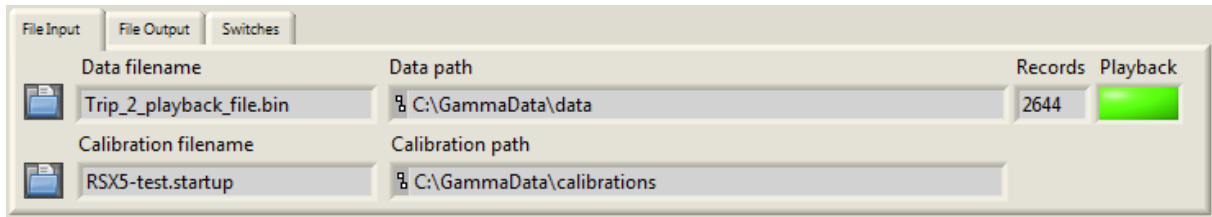
4.1.6 File input controls

Figure 8: File input controls

The file input controls (Figure 8) allow selection of data and calibration files. To load a binary data file ('.bin', APPENDIX A) select the "open data file" icon (to the left of the "Data filename" indicator). To load calibration data ('.startup', APPENDIX B) select the "open calibration file" icon (to the left of the "Calibration filename" indicator). The filename and paths of the loaded files are displayed in the indicators, along with the number of records in the binary data file. The playback LED indicates that the loaded file was generated by GammaLog Playback software (see 4.1.7).

4.1.7 File output controls
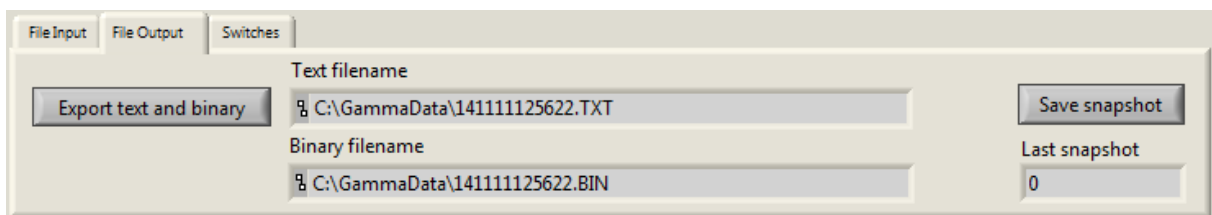
Figure 9: File output controls

During playback the user can export data in one of several formats: binary log format, text log format, and snapshot format. To enable binary and text output, select the [Export text and binary] button. The output paths are indicated in the panel. Note that the output path is not configurable in the interface, and is specified in the '.setup' calibration file (APPENDIX B). The output filenames are not editable but are automatically named at creation time with a name derived from a time-stamp.

Binary and text files contain multiple records and are normally exported on a continuous basis, once per session. However the export can be switched on and off during a playback session. One could for example exclude parts of an imported binary file which were not of interest. For each input binary file, one binary output and one text file are created, with new records continually appended to the file while the [Export text and binary] switch is active.

If a user loads a new input binary file during a session, new binary and text output files will be created.

GammaLog binary formats have changed slightly over the years as new features have been added to the software; on import, GammaLog Playback detects which binary format has been used and reads the data appropriately. On export, only the binary format described in APPENDIX A is supported.

A snapshot file (APPENDIX D) contains the full spectrum data for the currently displayed record. To create a snapshot, press the [Save snapshot] button. The record number of the last exported snapshot is displayed in the numerical indicator under the button.

4.1.8 Switch controls

Figure 10: Switch controls

During acquisition, the state of GammaLog controls is recorded in the binary file through a set of binary switches, and these are displayed in the Switches tab (Figure 10). These indicate for example whether or not stripping was activated, if the accumulate function was active, or if a background was being recorded and/or used. Details of the switches can be found in APPENDIX E.

The processing applied to GammaLog Playback is independent of the recorded switch states, and is determined by the controls detailed in Processing controls (4.1.4) The user may however elect to override these controls and have the processing determined by the state of the original acquired data. To do this press the [Use binary file switches] button.

GammaLog Playback can be set to pause playback whenever the state of the binary switches has changed. Such a switch change might for example indicate that something of interest occurred at that point in the original acquisition. This behaviour is enabled by the [Stop on switch change] button.

4.2 Display panel

4.2.1 Spectrum and waterfall tab
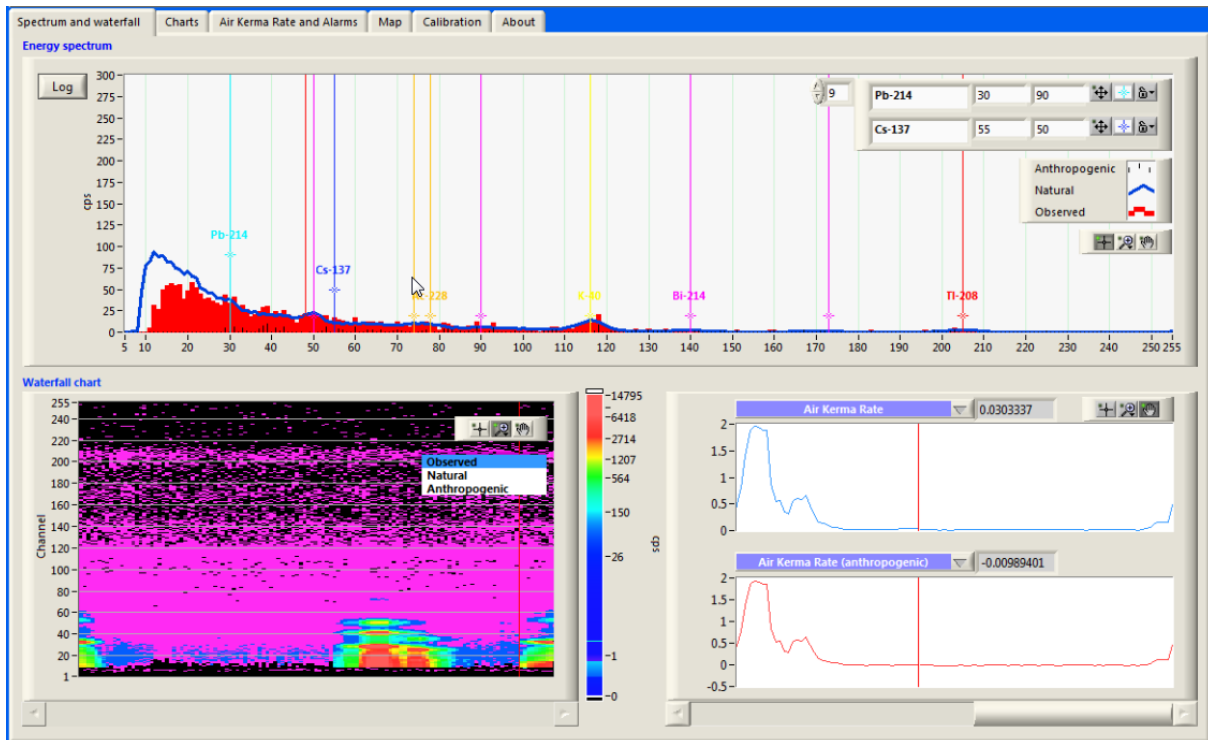
Figure 11: Spectrum and waterfall tab. The Energy Spectrum displays counts against channel for the current record; in the charts in the lower half of the figure, the horizontal axis represents record-number, and the chart windows continually scroll to the left as new records are displayed.

The spectrum and waterfall tab (Figure 11) displays the current record and recent records in three formats:

a. 256 channel spectrum.
A 256-channel spectrum, indicating the raw (red bars), modelled geogenic (blue line) and modelled anthropogenic (black bars) components. The modelled spectra are obtained by summing the stripped counts in each of the K-40, U-238 and Th-232 windows and using these in combination with the unit spectra loaded from the calibration files to estimate the geological component of the signal. See Calibration (4.2.5) for information about the window channels and stripping ratios. This geological component is represented by the blue line; after subtracting the geological model from the raw spectrum, the residual component is indicated by the black bars and can be regarded as the anthropogenic component of the signal.

Figure 12: Separation of anthropogenic signal from natural background component

Figure 12 illustrates the use of geological background modelling to assist in the identification of an anthropogenic nuclide (Cs-137). The Cs-137 signal around channel 55 is weak and not easily visible in the unprocessed (red) spectrum. The geological model (blue line) fits the red signal well over much of the spectrum, (indicating that most of the signal originates from geological background) but there are noticeable deviations - represented by the black lines - at low chan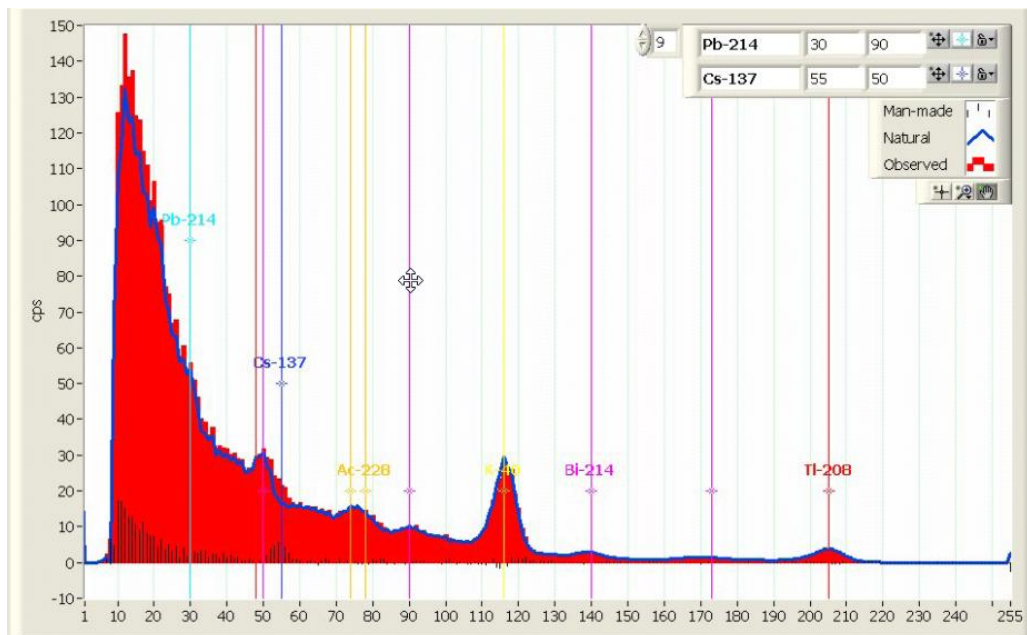nel numbers (where the modelled geological signal is less reliable) but also around channel 55, where the Cs-137 contribution can be clearly seen.

b. Waterfall chart.
    The waterfall chart scrolls continually from right to left as new records are fetched from the binary file. Record-number (time) is represented on the horizontal axis and channel number on the vertical axis. Channel intensity is indicated by the colour scale. This facilitates understanding of time-dependent changes of the spectra. In the waterfall chart in the lower left of Figure 11 we can see signals corresponding to three sets of sources. From the chart it is clear that the central source actually consists of two separate but closely spaced sources, and that they are of different radio-isotopic composition.

    The intensity displayed in the waterfall chart can be set to reflect the observed (raw), natural, or anthropogenic components.

c. Charts. Two time-dependent charts are displayed on the front panel. Each of these can be set to display one of a variety of processed quantities: Air Kerma rate (total), Air Kerma rate (anthropogenic), Total counts, K-counts, U-counts, Th-counts and Cs-counts.   Record-number (time) is represented on the horizontal axis and the chart continually moves from right to left as new records are fetched from the binary file. If the [Conc] button on the control panel is selected, the K, U, Th and Cs-count displays change to concentration displays.

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4.2.2 Charts tab

Figure 13: Charts tab, with record-number on the horizontal axis.

Here four time-dependent charts are displayed. They can be configured in the same way as those on the Spectrum and waterfall (4.2.1) tab. To the upper right of Figure 13 one can see a spike in the Total Counts chart which is not reflected in any of the K, U, or Th charts, suggesting that the system has passed an anthropogenic source at that point.
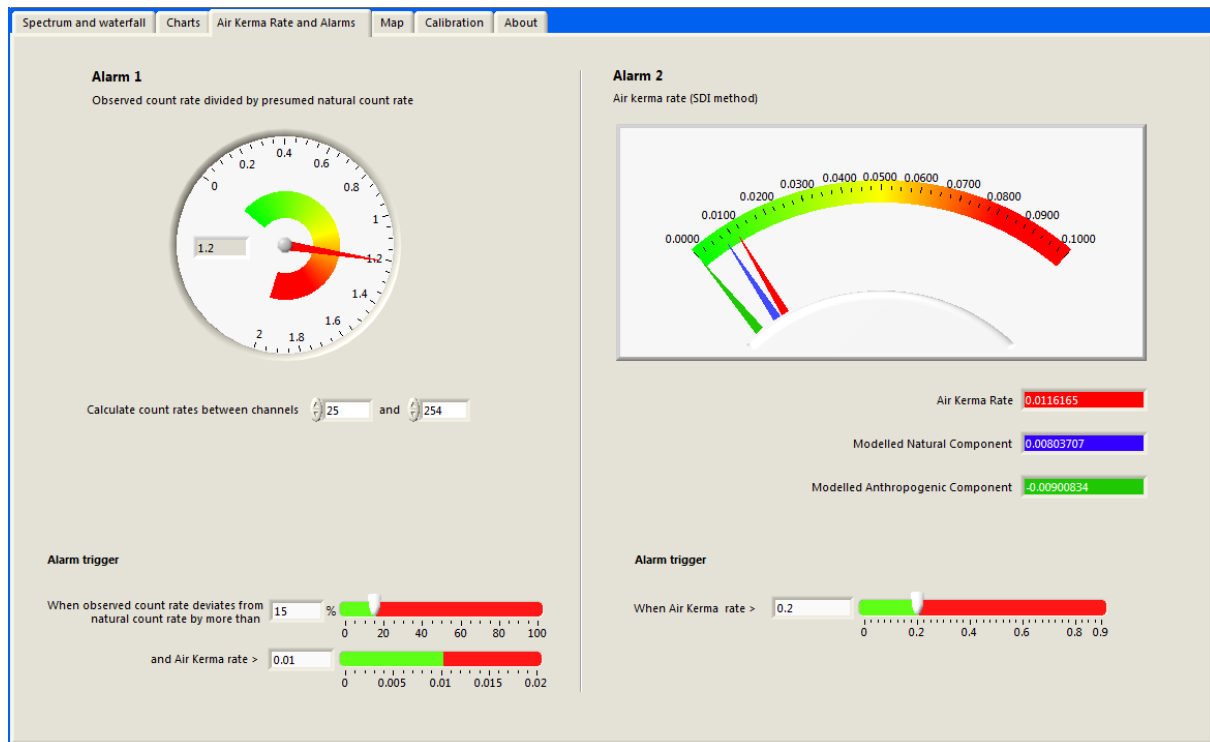
4.2.3 Air Kerma Rate and Alarms tab

Figure 14: Air kerma rate and Alarms tab

The dial on the left of Figure 14 shows the ratio of observed to natural count rates, and can be used to help identify the presence of anthropogenic sources. A ratio of around 1 suggests that the natural model is a good explanation for the observed spectrum, and that there is little or no anthropogenic signal. A ratio greater than 1 implies the presence of anthropogenic sources. The channels over which the ratio is calculated can be adjusted in the spin boxes below the dial display; this allows a more sensitive test to be applied by tuning the channel range to that expected for specific nuclides.

The display on the right shows the estimated air kerma rate calculated using the SDI (spectral dose index) method (Bargholz and Korsbech, 1997, and see also 4.2.5.4). Calibration values used in this calculation are specified in the '.cal' calibration file (APPENDIX C) and are adjustable in real time via the Calibration controls (4.2.5). Three forms of air kerma rate are shown: the total rate (obtained from the background-corrected observed spectrum) in red, the natural rate (based on the modelled natural spectrum) in blue and the anthropogenic rate (based on the difference between the observed and natural spectra) in green. The units of air kerma rate will depend on the calibration factors that the user provides via the calibration file; those illustrated here are in units of µGy/h.

Two alarm conditions can be set based on these calculations. Alarm 1 is based on both the channel ratio and air kerma rate values; Alarm 2 is based on the air kerma rate alone. The alarm thresholds can be adjusted via the sliders and spinboxes at the bottom of the panel.

When an alarm condition is triggered, the corresponding alarm LED (4.1.5) on the control panel will flash. Playback can be set to automatically pause when an alarm is triggered using the [Stop on Alarm] switch on the control panel.

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4.2.4 Map tab
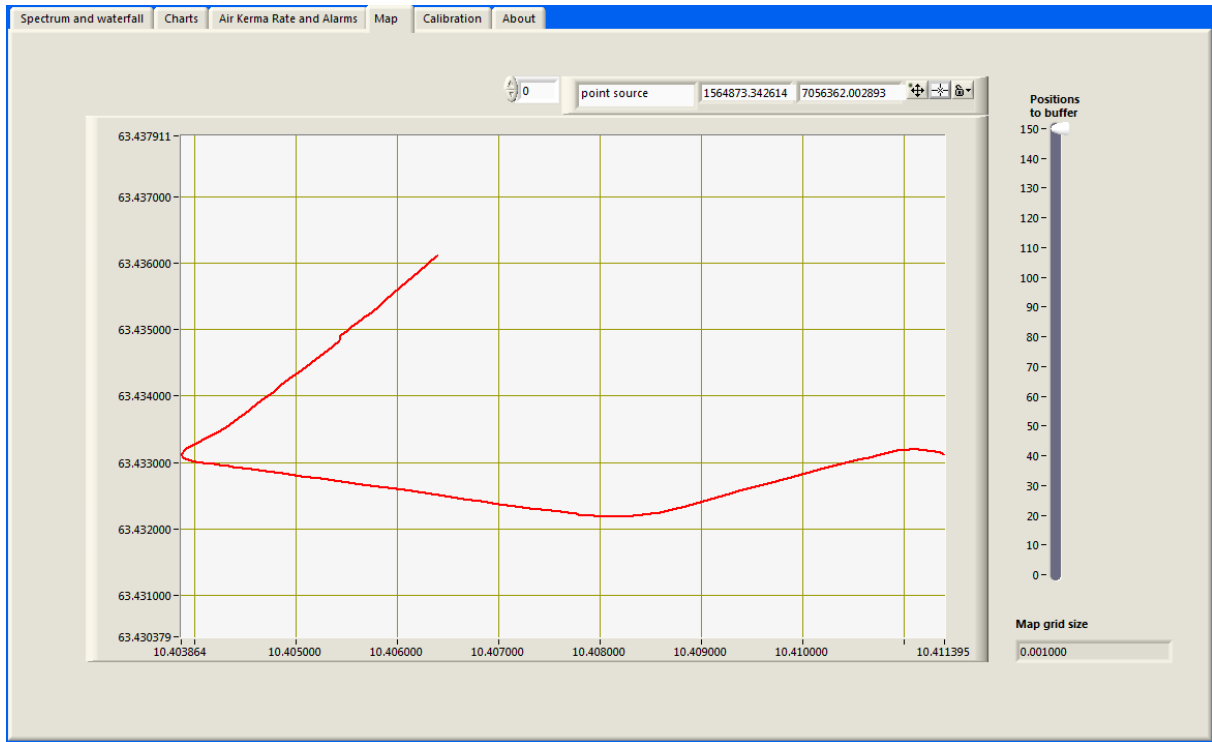
Figure 15: Map tab

The map tab (Figure 15) displays a simple representation of the GPS track. The user can adjust how many previous track points are buffered and displayed via the slider on the right hand side. The cursor control above the map lets the user place reference marks on the map to indicate positions of interest (for example, estimated point source locations). It is not currently possible to display background map images behind the GPS track.

4.2.5 Calibration control

The calibration tabs display, and allow control of, various calibration factors including window channels, stripping factors, sensitivities and air kerma rate conversion factors. These calibration factors are read from a '.cal' calibration file (APPENDIX C) and can be adjusted in real time.

4.2.5.1 Windows tab
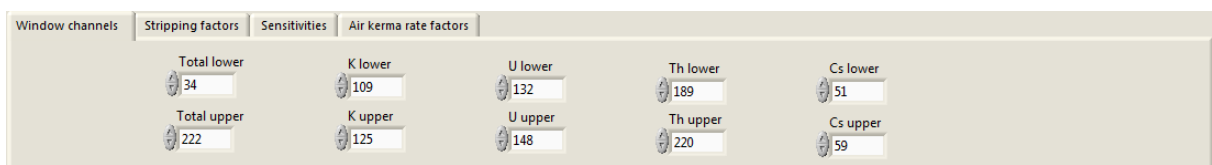
Figure 16: Windows tab

The windows tab lets the user adjust the channel ranges for K-40, U-238, Th-232, C-137 and total counts used in the stripped count rate (4.1.4), sensitivity (4.1.4) and air kerma rate (4.2.3) calculations.

4.2.5.2 Stripping tab

Window channels	Stripping factors	Sensitivities	Air kerma rate factors

Alpha (U/Th)	Beta (K/Th)	Gamma (K/U)	a (Th/U)	b (Th/K)	g (U/K)	CsK (Cs/K)	CsU (Cs/U)	CsTh (Cs/Th)
0.3830	0.6270	1.0228	0.0738	0.0000	0.0000	1.5076	2.1875	0.3157
1.0000	4.2973	4.2973	1.0000	0.2327	0.2327	0.9748	4.1892	4.1892

Figure 17: Stripping tab

The stripping factors are used to correct Cs, K, U and Th windows for the influence of compton scattering from each of the K, U and Th windows. These can be adjusted in real time. Below the spinboxes are displayed the "live" ratios. During calibration sessions these can be used to estimate stripping ratios.

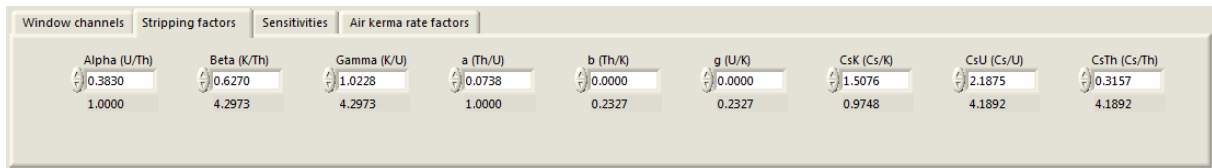### 4.2.5.3 Sensitivities tab

Window channels	Stripping factors	Sensitivities	Air kerma rate factors

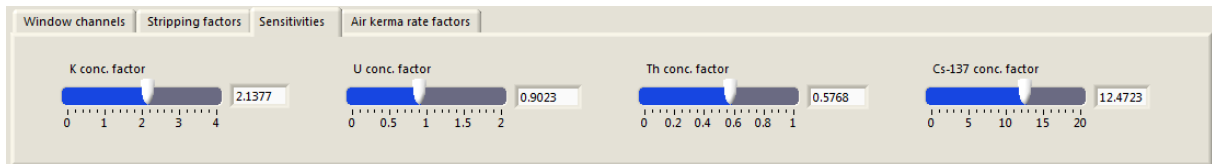| K conc. factor	U conc. factor	Th conc. factor	Cs-137 conc. factor
2.1377	0.9023	0.5768	12.4723

Figure 18: Sensitivities tab

The sensitivities tab displays, and allows the control of, the sensitivity factors used in the conversion of window count rates to ground concentrations in units of % K-40, ppm U-238, ppm Th-232 and Bq/m^2 Cs-137. See also Processing controls (4.1.4)

4.2.5.4 Air kerma rate tab

Window channels	Stripping factors	Sensitivities	Air kerma rate factors

SDI from channel 1

SDI to channel 254

Air kerma rate factor 4.496E-7

Air kerma rate offset -0.0183
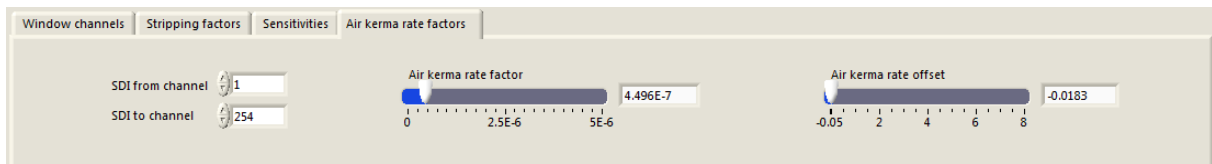
Figure 19: Air kerma rate tab

The air kerma rate factors determine how the air kerma rate is obtained from the spectral data. The air kerma rate is derived using an SDI (Spectral Dose Index) method (Bargholz and Korsbech 1997) where a channel-weighted sum of the spectrum is converted to an air kerma rate by multiplying by an air kerma rate factor, and adding an air kerma rate offset. Bargholz and Korsbech showed that the SDI is proportional to the Air Kerma Rate, but observed that better results were obtained by omitting the lower channels (below 350 keV, here corresponding roughly to channel 30). The channel range over which the air kerma rate is calculated is therefore specified in the calibration files and can be adjusted in real time using the [SDI from channel] and [SDI to channel] controls.

5. INSTALLATION

GammaLog Playback is available for Windows 7 as a compressed zip file in the form GammaLogPlayback<version>.zip. To install GammaLog Playback, unzip the file and run (double click) the setup.exe file. This will start an installation process which allows the user

to select the install location. After installation the application can be started through the computer's Start menu. GammaLog Playback should also run on Windows XP and Windows Vista.

6. ORPEX

As part of the NKS ORPEX mobile gamma ray spectrometry exercise (Dowdall 2011), a simplified version of GammaLog Playback called GammaLog Playback Orpex was developed and distributed to participants. This simplified version, along with ORPEX data sets, will be made available from the NKS website (www.nks.org). GammaLog Playback Orpex is similar to the software described in this report, but with somewhat simplified capabilities: the calibration values are not configurable, and are hard-coded to suit the ORPEX exercise files; stripping is always performed; and there are no background-subtraction, switch-control, or file-export capabilities.

7. REFERENCES

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IAEA 1991: Airborne Gamma Ray Spectrometer Surveying. Technical reports series No. 323, International Atomic Energy Agency, Vienna.

Smethurst M.A., Mogaard J.O., Koziel J. (2005) A mobile gamma ray spectrometer system for nuclear hazard mapping: GAMMALOG v 3.0. NGU Report 2005.026

APPENDIX A
BINARY DATA FILE FORMAT

The binary log file is one of the three data products of the GammaLog acquisition software. The file contains all measurements made, including full spectrum data from NaI and HpGe spectrometers. This means that the file can be used, if necessary, to retrieve the lowest level of data and re-process it.

GammaLog Playback reads these binary log files, and can generate new binary log files (for example, to create a new file representing an interesting subset of the originally imported dataset). Note that the binary file also has provision for storage of HpGe spectra. GammaLog Playback does not currently support the display of HpGe spectra.

Binary files are generated by GammaLog and GammaLog Playback as follows:

- One file per mission

- File name: DDMMYYHHMMSS.BIN (Year, Month, Hour, Day, Minute, Second)

- File path: specified in the '.startup' configuration file (APPENDIX B)

- Data types stored in the file:

  - Instrument settings
  - Geographic positions
  - Full gamma ray spectra from the two spectrometers (NaI and HpGe)
  - Ground clearances from the radar altimeter
- Format: structured binary. Purpose written software is required to read this file. Figure 20 shows a screenshot from LabView software illustrating the format of the file.

GammaLog Playback exports binary data whenever the [Export text and binary] control (4.1.7) is active. One binary output file will be generated per input file. On loading a new binary data input file, a new binary output filename will be generated based on a new time-stamp.
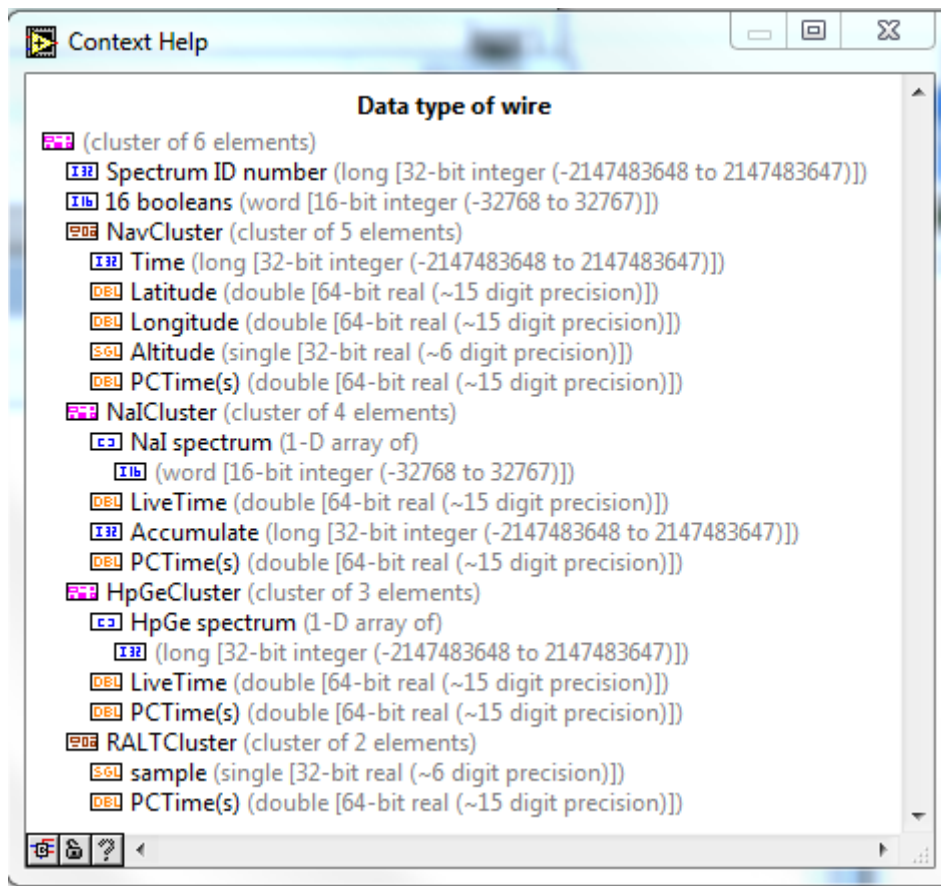
Figure 20: Screenshot from LabView illustrating the data format of the binary log file.

APPENDIX B
STARTUP FILE FORMAT

To load calibration data into GammaLog Playback, the user selects an ASCII '.startup' file (4.1.6). This file contains the names of configuration files that describe the characteristics of the measuring system that was used to acquire the data. An example '.startup' file is listed below:

C:\StartUp\VISA_PPS.HW /	Hardware configuration
C:\StartUp\GR-820_CAR.CAL /	Spectrometer calibration (NaI)
C:\StartUp\bolange-k.SPE /	K-40 unit spectrum (NaI)
C:\StartUp\bolange-u.SPE /	U-238 unit spectrum (NaI)
C:\StartUp\bolange-th.SPE /	Th-232 unit spectrum (NaI)
C:\StartUp\Cosmic3_edited.SPE /	Cosmic unit spectrum (NaI)
C:\GammaData /	File path for binary data output
C:\GammaData /	File path for text data output

File names are on the left and comments are to the right of the "/" symbol. Any other text can be added to the file after the last line shown above. Note that GammaLog Playback does not attempt to read a hardware configuration file, but the line is retained in the above format for compatibility with GammaLog acquisition software '.startup' files.

The configuration files used by GammaLog Payback are:

Calibration	Type '.cal'	(APPENDIX C)
Snapshot (K-40 unit NaI spectrum)	Type '.spe'	(APPENDIX D)
Snapshot (U-238 unit NaI spectrum)	Type '.spe'	(APPENDIX D)
Snapshot (Th-232 unit NaI spectrum)	Type '.spe'	(APPENDIX D)
Snapshot (cosmic unit NaI spectrum)	Type '.spe'	(APPENDIX D)

The last two lines of the '.startup' file determine where binary and ASCII data products are generated. Binary log files (APPENDIX A) are written to the first file path. ASCII log files (APPENDIX E) and ASCII Snapshot files (APPENDIX D) are written to the second file path.

'.cal' files can be created using a text editor. Snapshot '.spe' files are created using GammaLog Playback's [Save snapshot] button (4.1.7) and can be edited in a text editor if necessary.

APPENDIX C
CALIBRATION FILE FORMAT

GammaLog Playback reads this file through its name appearing in line 2 of the user specified '.startup' file (APPENDIX A). The calibration file contains values used in real time processing of NaI spectra to produce dose rate estimates and radionuclide concentrations. All of the values in the calibration file can be adjusted in real-time using the Calibration controls (4.2.5). An example calibration file is listed below:

```
0.3830        / Alpha stripping ratio (Th pad: counts U per count Th)
0.6270        / Beta stripping ratio (Th pad: counts K per count Th)
1.0228        / Gamma stripping ratio (U pad: counts K per count U)
0.0738        / a stripping ratio (U pad: counts Th per count U)
0.0000        / b stripping ratio (K pad: counts Th per count K)
0.0000        / g stripping ratio (K pad: counts U per count K)
1.5076        / Th/Cs stripping ratio (Th pad: counts Cs per count Th)
2.1875        / U/Cs stripping ratio (U pad: counts Cs per count U)
0.3157        / K/Cs stripping ratio (K pad: counts Cs per count K)
2.1377        / K-40 calibration factor (Unit = cps * factor)
0.9023        / U-238 calibration factor (Unit = cps * factor)
0.5768        / Th-232 calibration factor (Unit = cps * factor)
12.4723       / Cs-137 calibration factor (Unit = cps * factor)
0.44960E-6    / Air kerma rate factor (Unit = SDI * factor + offset)
-0.01830E+0   / Air kerma rate offset (Unit = SDI * factor + offset)
1             / Start channel for SDI calculation
254           / End channel for SDI calculation
34            / Total counts lower channel
222           / Total counts upper channel
109           / K window lower channel
125           / K window upper channel
132           / U window lower channel
148           / U window upper channel
189           / Th window lower channel
220           / Th window upper channel
51            / Cs window lower channel
59            / Cs window upper channel
```

Calibration values are to the left of the "/" character and comments to the right. Comments may follow the last line in the file.

Lines 1 to 9 are the stripping factors for determining pure quantities (in counts per second) of K-40, U-238 (or Ra-226), Th-232 and Cs-137 (IAEA, 1991). These factors should be appropriate for the nominal survey elevation (see Processing controls, 4.1.4)

Lines 10 to 13 are factors that convert pure quantities (in counts per second) of K-40, U-238 (or Ra-226), Th-232 and Cs-137 to standard units of activity/concentration at ground level assuming constant ground clearance and standard temperature and pressure (see Processing controls, 4.1.4).

Lines 16 and 17 determine the range of spectrum channels used to calculate spectral

dose index (SDI).

Lines 14 and 15 determine the conversion of SDI to air kerma rate at ground level assuming constant ground clearance and standard temperature and pressure.

Lines 18 to 27 determine the lower and upper channel numbers used for Total counts, K-40, U-238, Th-232 and Cs-137 processing.

APPENDIX D
SNAPSHOT FILE FORMAT

Snapshot files are required by GammaLog Playback as calibration input files, and are specified by name in the '.startup' file (APPENDIX A). Snapshot files are also created by GammaLog Playback as one of its three data output files (4.1.7).

A Snapshot file contains full spectrum data for a single measurement at a particular location and for that reason lends itself to being used as the source of pure nuclide spectra (unit spectra) for use in full NaI-spectrum modelling in real-time (Processing controls, 4.1.4).

The system operator creates an ASCII Snapshot file at any time and place using the [Save snapshot] button on the File output display panel (4.1.7). The file can be made to contain an average spectrum produced over many seconds or hours by first pressing the [Accumulate] switch (4.1.4) to start averaging measurements, and then some time later pressing the [Save snapshot] switch. The average spectrum is written to the Snapshot file. The Snapshot files containing unit spectra listed in APPENDIX B were produced using large calibration pads, background subtraction controls and [Accumulate] and [Save snapshot] switches.

GammaLog Playback creates Snapshot files as follows:
- File name: YYMMDDHHMMSS. (Year, Month, Day, Hour, Minute, Second)

- File path: specified in the '.startup' configuration file (APPENDIX B)

- Data types:

    - Geographic position
    - Ground clearance from the radar altimeter
    - Raw and processed radionuclide and dose-rate data from the NaI device
    - Three full gamma ray spectra from the NaI spectrometer - 'observed', 'natural' and 'man-made'. (The first spectrum is used when GammaLog Playback reads a Snapshot file for unit spectrum data, APPENDIX B)
- A full gamma ray spectrum from the HpGe spectrometer corrected for livetime/deadtime . Note that GammaLog Playback does not display HpGe spectra.

Format: Tab delimited text suitable for standard spreadsheet software packages.

The layout of a Snapshot file is given below:

Line	Content (TAB delimited)
1	Unique spectrum ID , Number of NaI spectra accumulated
2	GPS latitude, GPS longitude, GPS altitude, Radar altimeter elevation
3	8 live-time corrected NaI window values. Cosmic and background corrected if switches [Cosmic] and [Use] are "on". Compounded if switch [Accumulate] is "on" (4.1.4)

4	8 processed NaI window values, followed by 3 air kerma rates. NaI window values are as above, but also processed according to switches [Strip] and [Conc] (4.1.4). Units depend on calibration values (4.2.5). Some of the processed values may be in error in presence of anthropogenic sources. Air kerma rates are: total air kerma rate; "Natural" air kerma rate; "Anthropogenic" air kerma rate (4.2.3). Units depend on calibration values (4.2.5).
5	256 channel NaI spectrum corrected for live time and background (4.1.4), and coloured red in the Spectrum (NaI) display (4.2.1).
6	256 channel NaI model "natural" spectrum based on real-time processing of U-238, Th-232 and K-40 windows (4.2.5), and coloured blue in the Spectrum (NaI) display (4.2.1).
7	The difference between the NaI spectra in lines 5 and 6, constituting an anthropogenic spectrum (i.e. what cannot be readily explained by naturally occurring radionuclides), and coloured black in the Spectrum (NaI) display (4.2.1).
8	1024 channel HpGe spectrum corrected for live time. (Not displayed in GammaLog Playback).

When a snapshot file is used as the source of pure nuclide spectra, the first spectrum in the file, line 5, is taken to be the characteristic spectrum for the pure radionuclide. GammaLog Playback translates this spectrum into a unit spectrum immediately after reading it by dividing the channel values by the window total appropriate for the radionuclide (lines 18-27, APPENDIX C).

APPENDIX E
TEXT LOG FILE FORMAT

The ASCII text log file is one of the three data products of the GammaLog Playback program. The file contains all measurements made, in 'raw' and processed forms, and full spectrum data.

GammaLog Playback creates ASCII text log files as follows:

- File name: YYMMDDHHMMSS.TXT (Year, Month, Day, Hour, Minute, Second)

- File path: specified in the '.startup' configuration file (APPENDIX B).

- Data types stored in the file:
    - Instrument settings
    - Geographic positions
    - Ground clearance from the radar altimeter
    - Raw and processed radionuclide and dose-rate data from the NaI device

- Format: Tab delimited text suitable for import to many software packages.

The ASCII file is in a simple table format with a single row header. Column headings are explained below:

Heading	Meaning	Units	Example value
ID	Unique spectrum ID	N/A	1432
Snap [Save snapshot]	Status of real-time processing switches that determine the processing level for headings marked *. The states of these are also stored in the binary log file in variable "16 switches" (APPENDIX A)	1/0 (on/off)	0
Rec [Record]		1/0 (on/off)	1
Zero [Zero]		1/0 (on/off)	0
Strip [Strip]		1/0 (on/off)	1
Use [Use]		1/0 (on/off)	1
Conc [Conc]		1/0 (on/off)	1
Cos [Cosmic]		1/0 (on/off)	1
NaIRecorded	Whether or not an NaI spectrum is present	1/0	1
HpGeRecorded	Whether or not an HpGe spectrum is present	1/0	1
FromPlayback	Whether or not the binary input file was generated from GammaLog Playback. A value of 0 indicates that the file was created by GammaLog; a value of 1 indicates that the file was created by GammaLog Playback	1/0	0
B11-B16	Unused binary switches	1/0	0
GPSTime	Time for last navigational fix	HHMMSS	102405
GPSPCTime	PC time at which the GPS signal was recorded	Seconds	3384937308.843
GPSLat	GPS navigation	Degrees, WGS-1984	61.132814
GPSLong			123.649454
GPSAlt		Metres above WGS-1984	923.6
ALTPCTime	PC time at which altimeter signal was recorded	Seconds	3384937308.843
ALTElevation	Radar altimeter	Metres above ground	60.8

BTC	Live-time corrected NaI window values. Cosmic and background corrected if switches [Cosmic] and [Use] are on. Compounded if switch [Accumulate] is on.	cps total count window	614.2
BK		K-40 cps	35.5
BU		U-238 cps	451.8
BTh		Th-232 cps	24.6
BCs		Cs-137 cps	850.3
BW6		user-defined window	
BW7		user-defined window	
BW8		user-defined window	
PTC	Processed NaI window values. As above, but also processed according to switches [Strip] and [Conc]. Units depend on calibration values. Some of the processed values may be in error in presence of anthropogenic sources.	Cps total count window	614.2
PK*		K-40 cps or %	7.5
PU*		U-238 cps or ppm	11.3
PTh*		Th-232 cps or ppm	4.7
PCs*		Cs-137 cps or Bq/m^2	55.3
PW6		User-defined window	
PW7		User-defined window	
PW8		User-defined window	
AKR*	Total dose rate/air kerma rate (AKR) (4.2.3). This is split into natural (AKRNat) and anthropogenic (AKRAnt) doses. This allocation may be in error in the presence of some anthropogenic radionuclides.	Air kerma rate, total. Units depend on calibration values.	0.02708
AKRNat*		Air kerma rate, naturally occurring nuclides. Units depend on calibration values.	0.00919
AKRAnt*		Air kerma rate, anthropogenic nuclides. Units depend on	0.01024

			calibration values.	
NaIChannels	Number of channels in the NaI spectrum	n/a	256
NaIPCTime	PC time at which the NaI spectrum was recorded	Seconds	3384937308.843
NaIAccumulate	The number of accumulated spectra in the NaI spectrum.	n/a	1
NaILiveTime	The NaI spectrum live time	Seconds	0.999
NAI0-NAIx, where x = [NaIChannels]	The content of each of the channels in the raw NaI spectrum. There will be [NaIChannels] entries. If no NaI spectrum was recorded, [NaIChannels] will be zero and no spectrum channels will be recorded to file.	counts per second	105
HpGeChannels	Number of channels in the HpGe spectrum	n/a	1024
HpGe0-HpGex, where x = [HpGeChannels]	The content of each of the channels in the raw HpGe spectrum. There will be [HpGeChannels] entries. If no HpGe spectrum was recorded, [HpGeChannels] will be zero and no spectrum channels will be recorded to file.	counts per second	105

* processed values that depend on the settings of switches and calibration values