May 2000

Environmental Radioactivity Intercomparison Exercise 2000

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ABSTRACT

The results of the eighth NPL Environmental Radioactivity Intercomparison Exercise are reported. The level of metrological performance observed was generally lower than that observed in the previous exercise. The measurements of both α/β- and β/γ-emitting samples at approximately 2 Bq g^{-1} per nuclide yielded data which indicated problems with the quantification of Type B uncertainties. The quality of measurements of nuclides used in γ-ray detector calibration was surprisingly low, and there are still problems with measurements of ^{90}Sr and nuclides which exhibit cascade summing. The quality of data for the plutonium nuclides has improved, and usage of traceable standards and reliable nuclear data remains high.

ISSN 1369-6793

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1. INTRODUCTION

This environmental radioactivity intercomparison was the eighth such exercise[1-8] to have been conducted by NPL. Five samples were available for analysis:

i) a high-level mixture of α- and pure β-emitting radionuclides (@ ~ 2 Bq g^{-1} per radionuclide (apart from ^{3}H, which was @ ~ 20 Bq g^{-1}), in dilute nitric acid);
ii) a low-level mixture of α-and pure β-emitting radionuclides (@ ~ 2.5 Bq kg^{-1} per radionuclide (with ^{3}H @ ~ 25 Bq kg^{-1}), in dilute nitric acid);
iii) a high-level mixture of γ-emitting radionuclides (~ 2.5 Bq g^{-1}, in dilute hydrochloric acid);
iv) an intermediate-level mixture of γ-emitting radionuclides (~ 25 Bq kg^{-1}, in dilute hydrochloric acid);
v) a low-level mixture of γ-emitting radionuclides (~ 2.5 Bq kg^{-1}, in dilute hydrochloric acid).

In earlier exercises[1-6], the mixing of individual radionuclides in the participants' samples had been performed at the last possible stage in the preparation regime. This allowed radiometric validation to be performed at every dilution stage; traceability was, therefore, maintained. A consequence of this was that the activity ratio varied from sample to sample. Although this might be regarded as the optimum approach for an intercomparison (i.e. to maintain traceability and to eliminate any possibility of informal comparison before submission of results), the measurement community, prior to the last exercise[7] , had expressed a preference for a source preparation regime which would provide identical samples to all participants. To that end, the source preparation regime for the last exercise was somewhat different to that used previously, with individual radionuclide standard solutions being firstly mixed and then diluted prior to dispensing samples to individual participant bottles. The same regime has been adopted in this exercise.

2. ORGANISATION

2.1 PARTICIPANTS

A total of 32 participants took part in this exercise. The majority of the samples taken were of the γ-emitting mixtures, with 19 participants taking the high-level mixture, 24 taking the intermediate-level mixture and 16 taking the low-level mixture. Uptake of the α/β-emitting mixtures was 19 for the high-level mixture and 12 for the low-level mixture.

The participants came from a wide cross-section of the UK measurement community and a full list is given in Appendix 1.

2.2 SAMPLES

The samples were given the following identifiers:

i) high-level α-emitting and pure β-emitting radionuclide mixture - ABHxx/99
ii) low-level α-emitting and pure β-emitting radionuclide mixture - ABLxx/99
iii) high-level γ-emitting radionuclide mixture - BGHxx/99
iv) intermediate-level γ-emitting radionuclide mixture - BGMxx/99

v) low-level γ-emitting radionuclide mixture - BGLxx/99

Tables 1 - 10 show the principal radionuclides and their impurities for the five sample mixtures.

All the radionuclides used in this exercise are released by the nuclear industry in the course of normal operations. The following criteria were looked for when choosing the radionuclides:

(i) that the half-lives were > 50 days;
(ii) that no obscure species were selected (i.e. all could reasonably be found in the environment or in effluent);
(iii) that the α/β-emitter samples contained no radionuclides conventionally used as chemical yield tracers;
(iv) that all the radionuclides were measurable by well-established techniques.

For the first time, both ^{55}Fe and ^{63}Ni were included in the exercise. Disposal of these nuclides to the environment (either as effluent or to solid waste sites) is expected to increase as more and more of the older nuclear power stations in the UK are decommissioned. Both of these nuclides are formed in neutron-irradiated steel components within a reactor's bio-shield. Although the dose delivered by these nuclides is low, the low energy of their emissions means that essentially all the energy of decay is deposited in close proximity to the decaying atom. This is of particular concern if such nuclides are ingested.

A list of radionuclides present in the α/β-emitting mixture was provided to reduce the amount of analytical effort required by participants. A composition list was not provided for the γ-emitting mixtures since the analytical techniques normally used allow for the straightforward identification of the radionuclides present.

However the following list of possible γ-emitters was provided for the participants:

^{7}Be, ^{22}Na, ^{46}Sc, ^{54}Mn, ^{56}Co, ^{57}Co, ^{58}Co, ^{60}Co, ^{65}Zn, ^{85}Sr, ^{88}Y, ^{95}Zr, ^{95}Nb, ^{106}Ru/^{106}Rh, ^{109}Cd, ^{110m}Ag, ^{113}Sn, ^{124}Sb, ^{125}Sb, ^{133}Ba, ^{134}Cs, ^{137}Cs, ^{139}Ce, ^{144}Ce, ^{153}Gd, ^{154}Eu, ^{155}Eu, ^{160}Tb, ^{170}Tm, ^{203}Hg and ^{207}Bi.

3. CALIBRATION

3.1 ABSOLUTE CALIBRATION

An absolute standard of radioactivity is one that has been measured directly without reference to any other standard of activity; the activity has been determined from count-rate data alone, without reference to any supplementary data determined from previous experiments. A primary standard is the highest level standard in any hierarchical measurement system. In most cases, primary standards are also absolute standards.

In the case of radioactivity standards, absolute standards are generally derived using the 4π-proportional counter-γ-coincidence counting technique for α/γ and β/γ emitting radionuclides[9]. Those radionuclides decaying by pure α- or pure β-emission are determined by a variation of this technique.

3.2 SECONDARY STANDARDISATION

Absolute calibrations are labour intensive and require a high-level of operator expertise; this makes them very expensive. Also a limit is placed on the lowest amount of activity that can be measured without the associated uncertainties becoming unacceptably high.

A more robust and routine method of calibration is therefore needed. This is achieved using an absolutely calibrated solution to calibrate a secondary standard instrument. In the case of α/γ or β/γ emitters and some high energy pure β-emitters, this is usually a well-type ionisation chamber that responds only to the γ-rays emitted (in the case of high-energy pure β-emitters, the ionisation chamber measures the Bremsstrahlung radiation). Other γ-ray detectors (NaI(Tl) or hyperpure Germanium detectors) can be used but they do not have the long term stability that is associated with ionisation chambers. For pure α-emitters and pure β-emitters, there are no suitable secondary standard instruments that have sufficient long term stability; however, liquid scintillation counters can be used, albeit with counting efficiencies which are dependent on such factors as particle energy, spectral shape, chemical format, etc.

4. SOURCE PREPARATION

4.1 PROCUREMENT

The individual radionuclides were obtained from a number of suppliers and were calibrated in different laboratories. Table 11 shows the suppliers, the laboratories responsible for the calibrations and the traceability of the measurements. In all but one case, NPL was the calibrating laboratory.

4.2 PURITY

Each nuclide was checked for impurities either by α-spectrosopy, γ-spectroscopy or by reference to the original calibration certificate; the impurity levels are shown in Tables 2, 4, 6, 8 and 10.

4.3 ACTIVITY CONFIRMATION

The activity concentrations of the original individual radionuclide solutions were determined either from the calibration certificates or from measurement at NPL, using either absolute methods or secondary standard instruments as described above.

4.4 PREPARATION

For both the γ-emitting and the α/β-emitting mixtures, the stock solutions of the individual radionuclides were prepared by gravimetric dilution of standardised solutions. By counting sources made at each dilution stage and comparing count-rates, the overall (gravimetrically-determined) dilution factors were confirmed.

For the γ-emitting radionuclides, the radiometric dilution factors were determined using a NaI(Tl) crystal; for the α-emitters and pure β-emitters, the measurements were done by liquid scintillation counting.

4.4.1 The α-emitters and pure β-emitters

The stock solutions (approximately 20 ml each) of all the nuclides, with the exception of ^{238}U, were combined and diluted to make 7 litres. This was used to make:

a) 50 x 100 ml samples @ 2 Bq g^{-1} per nuclide (except for ^{3}H, which was present at 20 Bq g^{-1});
b) 1 x dilution bottle (100 ml diluted to 3 litres).

An aliquot of bottle 'b' (870 ml) was then spiked with ^{238}U (480 ml), and carrier, to approximately 25 litres; this solution was then used to generate:

c) 50 x 500 ml samples @ 2.5 Bq kg^{-1} per nuclide (^{3}H present at 25 Bq kg^{-1}).

The diluent used was 1 M nitric acid containing iron, nickel, strontium and yttrium carriers, at concentrations of approximately 50 μg/g each. The aqueous matrix acts as a carrier for tritium; there are no suitable carriers for americium, curium, plutonium or uranium.

The radiometric dilution factors were determined by counting the ^{241}Am component of the mixture, at the various activity levels involved, using a hyperpure Germanium γ-ray spectrometer.

4.4.2 The γ-emitters

The stock solutions of the individual radionuclides (approximately 2- 14 ml each) were combined and diluted to make approximately 11 litres. This was used to generate:

a) 85 x 100 ml samples @ 2.5 Bq g^{-1} per nuclide;
b) 1 x dilution bottle (475 ml diluted to 47.5 litres).

Solution (b) was then used to generate:

c) 85 x 500 ml @ 25 Bq kg^{-1} per nuclide;
d) 1 x dilution bottle (4.4 litres diluted to 44 litres).

Finally, solution (d) then generated 85 x 500 ml @ 2.5 Bq kg^{-1}.

As for the α/β-emitting mixtures above, the dilutions were confirmed from measurements of radiometric dilution factors using a hyperpure Ge γ-ray spectrometer. Radiometric factors were determined for all the nuclides present. The diluent used throughout was 2.5 M hydrochloric acid containing antimony, barium, caesium, cobalt, europium, tellurium and zinc carriers at concentrations of 50 μg g^{-1}.

To further validate the overall gravimetric dilution factors, selected samples of the three types were assayed by γ-ray spectrometry.

5 TREATMENT OF DATA

5.1 NUMERICAL DATA

Data reporting forms were prepared and distributed with the samples. The data returned were used in conjunction with NPL data to calculate two main parameters. First, the deviation from the NPL value was calculated as a percentage:

$$\text{Deviation (\%)} = \left(\frac{\text{Analyst's result - NPL value}}{\text{NPL value}} \right) \times 100$$

The value of the u-statistic[10] was also calculated:

$$\text{u-statistic} = \frac{\text{(Analyst's result - NPL result)}}{\sqrt{(\text{Analyst's uncertainty}^2 + \text{NPL uncertainty}^2)}}$$

The uncertainty to be used is the standard uncertainty (i.e. with $k = 1$).

This statistic is compared with values in the t-statistic tables[11] and assessed in accordance with the criteria in Table 12.

Note that, throughout this report, the term 'discrepant' refers to data yielding a u-statistic of more than 3.29.

5.2 UNCERTAINTIES

Uncertainties for the NPL data have all been estimated in accordance with the internationally-accepted protocols[12,13]. Unless otherwise stated, all the uncertainties in this report are stated as standard uncertainties with a coverage factor of $k = 1$.

5.3 NUCLEAR DECAY DATA

The data used by the participants are discussed later; the data[14-20] used by NPL for this work are given in Table 13. In each case, the γ-ray emission probabilities, P_γ, are only given if they exceed 1%; the uncertainties on these values are quoted at the 1σ level, as are all other uncertainties quoted within this report.

5.4 PRESENTATION

The results of u-tests are summarised in Tables 14 -16.

The participants' results for the radionuclides included in the samples by NPL are tabulated in Tables 17 - 58 and are plotted in Figures 1 - 84. Other radionuclides reported by the participants are given in Table 59.

5.5 CONFIDENTIALITY

As is usual in these exercises, the relationship between the participants and the results remains confidential to NPL.

6 RESULTS FOR α-EMITTERS AND PURE β-EMITTERS

6.1 General comments

In total, 16 data sets were returned for the higher-level samples and 11 were returned for the lower-level samples. Only two laboratories carried out a complete analysis of the former, and no laboratory measured all nine nuclides in the latter. All participants used radiochemical analyses to isolate the individual nuclides, inevitably a more complex procedure than for the γ-emitters. Feedback from the user community had indicated an interest in analyses at higher activity levels than in the previous exercises, and this seems to be reflected in the greater number of measurements at the higher level in this exercise (nominally 2 Bq/g per nuclide, with tritium being nominally 20 Bq/g). A variety of nuclear data sources were cited; it was notable that many laboratories referred to the new version of the Radiochemical Manual[21].

6.2 ^{3}H

The results for this nuclide are given in Tables 17 and 24 and are plotted in Figures 1, 2, 15 and 16.

All the participants who reported their separation method had isolated the ^{3}H by some form of distillation. Nearly everyone used distillation based on boiling and condensing, with two laboratories using low temperature distillation. There appears to be no significant difference in the results obtained from the two methods. The standards reported were nearly all traceable to national primary standards.

Three discrepant results were reported for this nuclide at the higher activity level (nominally 20 Bq/g), and it is interesting to note that they are from the subset of four results with the lowest reported uncertainties; moreover, one uncertainty was slightly lower than that quoted by NPL. It should be noted that the starting material used by NPL was a standard obtained from Amersham International, and that the uncertainty quoted by NPL is derived from (quadrature) summation of the uncertainty quoted by the supplier and the additional uncertainties arising from source preparation. Any reported uncertainty will exceed the corresponding NPL value if a comprehensive uncertainty budget has been compiled by the analyst.

All the results submitted for the lower-level sample (nominally 25 Bq kg^{-1}) agreed well with the NPL value. Fewer laboratories (five) submitted results for this activity level than in the last exercise, there being an apparent preference for the higher level samples available this year.

6.3 ^{55}Fe

See Table 25 and Figures 17 and 18. Only two participants reported data for this nuclide at the higher level (2 Bq g^{-1}), with no results at all being returned for the lower-level sample (2.5 Bq kg^{-1}). Both initially extracted the iron into ether: one then precipitated it as the oxine prior to X-ray counting whilst the other back-extracted the iron into aqueous solution prior to liquid scintillation counting. The second laboratory used an Amersham International internal standard.

Both reported values agreed well with the NPL value although, with so little data returned, it is impossible to draw any conclusions concerning metrological proficiency within the UK as a whole.

6.4 ^{63}Ni

See Table 26 and Figures 19 and 20. As for ^{55}Fe above, only two laboratories reported data for the higher-level sample (2 Bq g^{-1}) and none at all analysed the lower-level sample for this nuclide. One laboratory used ether extraction followed by chromatographic separation whilst the other used ion exchange and extraction chromatography. Both used liquid scintillation counting. Both results agreed with NPL although, again, one cannot draw any kinds of general conclusions from such a small data set.

6.5 ^{90}Sr

See Tables 18 and 27, and Figures 3, 4, 21 and 22. A variety of analysis schemes were adopted for this nuclide but most involved the basic principle of allowing the yttrium to ingrow into purified strontium and then separating and counting the yttrium. Ion exchange, extraction chromatography and solvent extraction were all used as extraction methods. Liquid scintillation counting, Cerenkov counting and proportional counting were used as assay techniques. Standards from both NPL and Amersham International were used.

Measurement performance for the lower-level samples (2.5 Bq kg^{-1}) was similar to the previous exercise (where a similar activity concentration was offered); one laboratory of the four reporting data quoted a result which was probably discrepant, although this was most likely due to the very low uncertainty they quoted. As with tritium, more analysts opted to assay this nuclide at the higher level (2 Bq g^{-1}). It is surprising that four of the twelve results were discrepant (and another probably so). One would reasonably expect good results across the community for this nuclide, and the reasons for this outcome are not clear: the subset of discrepant results is not biased either way, with two having large positive deviations and the other two large negative deviations.

6.6 ^{238}U

See Table 19 and Figures 5 and 6. This was the only nuclide included in the lower-level mixture (2.5 Bq kg^{-1}) but not at the higher level; this was due to a lack of standardised material at NPL when the sources were produced.

Ten results were returned for this nuclide, and all agreed well with NPL: performance was similar to the last exercise where, again, similar activity levels were offered. Most participants used ion exchange or extraction chromatography to isolate this nuclide, although two used solvent extraction. In all but one case, the activity was determined by α-spectrometry. Most laboratories used a ^{232}U yield tracer (from NPL, NIST or AEA Technology) whilst one used ^{236}U from AEA Technology.

6.7 ^{238}Pu/^{239}Pu

See Tables 20, 21, 28 and 29, and Figures 7, 8, 9, 10, 23, 24, 25 and 26.

In previous exercises, doubts had been raised concerning the activity concentrations quoted by NPL for these nuclides, which in turn had raised questions about the activity concentrations of the starting materials used by NPL in preparing the samples. Measurements made at NPL indicated that the supplier had quoted values which were higher than the actual values. This made it very difficult for NPL to draw conclusions as to metrological proficiency in exercises up to that point.

Since the last exercise, NPL has developed primary standards for both nuclides, and this now ensures that the NPL values have a sound footing. Nearly all participants used ion exchange to separate the nuclides from the mixture. The majority of analysts used a ^{242}Pu tracer (from NPL, Amersham International, AEA Technology or elsewhere) with four using ^{236}Pu and another using ^{239}Pu.

At the lower activity level (2.5 Bq kg^{-1}), ten laboratories reported data, with only one one (^{238}Pu) result being possibly discrepant. Again, this is a slightly better performance than in the previous exercise. At the higher level (2 Bq g^{-1}), sixteen laboratories returned data. Two reported discrepant results for both nuclides and another two discrepant data for ^{238}Pu only: of the first two laboratories, one used a ^{236}Pu tracer of unstated origin, which may be significant. It is again interesting to note the greater participation at the higher level. It should also be noted that the results for both nuclides still exhibit a low bias. A nuclide ratio (^{238}Pu ÷ ^{239}Pu) of (1.035 ± 0.021) is observed at the lower level, in agreement with the NPL value of (1.016 ± 0.010); at the higher level this rises to (1.138 ± 0.104). It is interesting to note that, if one excludes two particular values which deviate from the NPL value by more than 20 %, the ratio then agrees well with the NPL value.

6.8 ^{241}Am

See Tables 22 and 30, and Figures 11, 12, 27 and 28. Eleven laboratories returned results for this nuclide at the higher activity level (2 Bq g^{-1}): six used α-spectrometry, three used γ-spectrometry and two used both techniques. At the lower level (2.5 Bq kg^{-1}), nine laboratories reported data: six used α-spectrometry, two used γ-spectrometry and one used both methods. Standards used for γ-spectrometry were from Amersham International (QCY48) whereas ^{243}Am, from a variety of sources (NPL, Amersham International, AEA Technology, IMER and others), was used as a tracer in the α-spectrometric methods. The level of performance was similar to the previous exercise, with only two of the 26 reported results being discrepant.

The results have been coded in the tables and graphs to indicate which analytical method had been used.

6.9 ^{244}Cm

See Tables 23 and 31, and Figures 13, 14, 29 and 30. This nuclide has recently been standardised at NPL and the starting material came from this batch of material. Six laboratories assayed this nuclide. All used ion exchange followed by α-spectrometry, and employed ^{243}Am tracer from various sources (as given for ^{241}Am above). Two discrepant results were reported at the higher level (2 Bq/g). Again, there are few data here from which to draw conclusions.

7 RESULTS FOR γ-EMITTERS

7.1 General comments

As in previous exercises, the bulk of reported data were from analyses of γ-emitters. As for the α- and β-emitters above, a higher activity level (2.5 Bq g^{-1} per nuclide) was offered in this exercise (in addition to samples at 25 Bq kg^{-1} per nuclide and 2.5 Bq kg^{-1} per nuclide) and uptake was again high. Approximately one third of participants carried out a dilution (in water, hydrochloric acid or nitric acid) prior to counting, and everyone used a semiconductor detector, with p-type and n-type detectors being used in equal numbers. The vast majority of participants used commercially-available data-handling software, with two using 'in-house' systems. A wide variety of recognised nuclear data sources were cited, with NPL and IAEA being predominant. The standards used were, almost without exception, of the mixed radionuclide type, with two analysts having used single nuclide standards.

7.2 ^{57}Co

The results for this nuclide are given in Tables 32, 41 and 50, and are plotted in Figures 31, 32, 49, 50, 67 and 68.

This is used as a calibration nuclide. It is interesting to compare the results obtained for the 2.5 Bq kg^{-1} and 25 Bq kg^{-1} samples with those obtained in the previous exercise[7,8] for similar activity levels. At the lower of these levels, a similar distribution of data was observed and the amount of discrepant data is approximately the same (around 5 %). At the intermediate level (25 Bq kg^{-1}), there are clearly more discrepant data (some 17 % of the total) from a smaller number of results, whereas at the high level (2 Bq/g) the proportion of discrepant data rises to 32 %. An examination of the uncertainties quoted for the latter set of results is revealing: of the eight laboratories reporting discrepant data, seven had quoted uncertainties less than the corresponding NPL value, suggesting that incomplete evaluation of Type B uncertainties is at least part of the problem. Given that this is a calibration nuclide, it is of concern that only 66 % of the reported results are clearly in agreement with the NPL value.

7.3 ^{60}Co

See Tables 33, 42 and 51, and Figures 33, 34, 51, 52, 69 and 70. This nuclide, too, is used by NPL in its mixed radionuclide standard for detector calibration; it is also an activation product. The proportion of discrepant data obtained at each of the three activity levels is similar to that obtained for ^{57}Co, and again performance is less good at the 25 Bq kg^{-1} level than in the last exercise, although the distribution at the 2.5 Bq kg^{-1} level is narrower than in the last exercise, and the bias at this level appears smaller. Again, the proportion of unambiguously correct data is surprisingly low (70 %) for a calibration nuclide.

7.4 ^{65}Zn

See Tables 34, 43 and 52, and Figures 35, 36, 53, 54, 71 and 72. This is a positron emitter and therefore gives rise to photons at 511 keV as a result of positron annihilation. It was included in the previous intercomparison and the level of performance is much the same as then, although, some 25 % of the highest-level results are discrepant, again probably due, at least in part, to underestimation of uncertainties. The distribution of data at the lowest level is narrower than in 1998, and the bias smaller.

7.5 ^{124}Sb

See Tables 35, 44 and 53, and Figures 37, 38, 55, 56, 73 and 74. This nuclide is formed by activation of ^{123}Sb (which is present in reactor shielding or as a fission product). The results of u-tests suggest a higher level of proficiency than for the above nuclides, although there appears to be a larger spread at the 2.5 Bq kg^{-1} level.

7.6 ^{125}Sb

See Tables 36, 45 and 54, and Figures 39, 40, 57, 58, 75 and 76. This is a fission product and is prevalent in waste effluent streams. Although there is still a noticeable positive bias at the lowest level (2.5 Bq/kg), a much narrower distribution is evident than in the previous exercise and very few discrepant data were reported at any of the levels. This nuclide requires a summing correction, and these data suggest that this may have been widely applied.

7.7 ^{134}Cs

See Tables 37, 46 and 55, and Figures 41, 42, 59, 60, 77 and 78. This nuclide occurs in nuclear waste and is present in various ecosystems. Measurements are complicated by cascade summing (more so than for ^{125}Sb), and the results clearly demonstrate that corrections are not being applied. This is perhaps surprising given that this nuclide has been included in most previous exercises and that the need for such corrections has been emphasised. The problem is particularly prominent at the 2 Bq g^{-1} level, where almost half the data submitted were discrepant.

7.8 ^{137}Cs

See Tables 38, 47 and 56, and Figures 43, 44, 61, 62, 79 and 80. This is a fission product and is also used as a calibration radionuclide. It occurs widely in the environment. Again, the levels of discrepant data are high, particularly for a nuclide for which one would expect a higher success rate: only 71 % of the submitted data are unambiguously correct. As in the last exercise, there is a slight positive bias at all levels, and the reasons for this are not clear.

7.9 ^{154}Eu

See Tables 39, 48 and 57, and Figures 45, 46, 63, 64, 81 and 82. This nuclide is formed by neutron activation of stable europium. It emits γ-rays across all energy regions of the γ spectrum. It is possible to misidentify this nuclide as any of a number of other nuclides, such as ^{152}Eu, ^{56}Co, ^{124}Sb, ^{108}Ag, ^{95}Zr and ^{22}Na. Although few discrepant data were reported, there is a clear low bias at the two highest activity levels, again suggesting that cascade summing corrections have not been applied.

7.10 ^{155}Eu

See Tables 40, 49 and 58, and Figures 47, 48, 65, 66, 83 and 84. This is another fission product, albeit with a low fission yield. Measurement of this nuclide is complicated by the fact that it emits (low energy) γ-rays in an energy range where the rate of change of detector efficiency with energy is large. This is evident from the spread of the data, although observed distributions are narrower than in the previous exercise. The proportion of discrepant data is low (9 % overall).

8 DISCUSSION

8.1 α-EMITTERS

The α-emitting component of the two available mixtures was very similar to that used in the last exercise, and it is interesting to compare the results obtained for the low-level mixture with the results from 1998, when very similar activity levels were offered. The level of participation is very similar and the data are, generally, slightly better, with only one discrepant result being reported. Also interesting is the greater interest in measurements at the higher activity level, and, more importantly, the higher proportions of discrepant data reported at this level. Possibly this reflects the fact that, at the higher activity levels, the Type A component of the overall uncertainty will be smaller than at the lower level, and this will mean that the Type B component will account for a larger proportion of the overall uncertainty - thus, any underestimation of the Type B component will become clearer.

In previous exercises, doubts were raised over the activities quoted by NPL for ^{238}Pu and ^{239}Pu, owing to possible problems with the starting material for these nuclides. The recent standardisation of these nuclides by NPL has now resolved this issue: the ^{244}Cm component was also derived from material standardised at NPL.

8.2 β-EMITTERS

There are three points to note about these sets of results.

(i) There was a clear preference for analysing the higher activity level offered (20 Bq g^{-1} tritium and 2 Bq g^{-1} each of the other nuclides) and a distinct lack of data offered for the lower level.
(ii) Very few data were returned for ^{55}Fe and ^{63}Ni (with no data at all being offered at the lower level) making it impossible to draw any conclusions as to national proficiency at this level. The overall return of data for these two nuclides is both surprising and disappointing: as was stated earlier, these nuclides were specifically included in this intercomparison in response to a perceived demand from the user community; this was reflected in the setting of a specific milestone in the current NPL NMS-PU programme.
(iii) There was a very large spread on the data for ^{90}Sr, a nuclide for which one would now reasonably expect a high level of performance.

8.3 γ-EMITTERS

This is the first exercise to include γ-mixtures at three activity levels (2.5 Bq g^{-1}, 25 Bq kg^{-1} and 2.5 Bq kg^{-1}). The results demonstrate several points:

(i) The two lowest activity levels are similar to those offered in the last exercise and it is interesting to note that the proportion of discrepant data obtained this year is similar for the lower of these levels (2.5 Bq/kg) but clearly greater for the higher level (25 Bq/kg). Data for the highest level (2 Bq/g) show still larger proportions of discrepant data, with 59 % of the reported data falling in this category. This is clearly a result of the underestimation of uncertainties, and this issue must be addressed more closely.
(ii) It appears that corrections for cascade summing are not being made in many cases.
(iii) The radionuclides used in detector calibration (^{57}Co, ^{60}Co and ^{137}Cs) are still causing significant problems in that the proportions of unambiguously correct results are 66 %, 70 % and 71 % respectively.

8.4 GENERAL COMMENTS

8.4.1 Nuclear Decay Data

The participants used a variety of data sources to obtain their nuclear data, with the majority of participants using data from internationally recognised sources. Since the previous NPL environmental intercomparison, the new version of the Radiochemical Manual has become available, and it is encouraging to see the wide usage of this as a data source. A number of participants used data supplied with detector systems which they had modified using the recommended values from IAEA or NPL: this practice is to be encouraged. A small number of participants are using manufacturers data, which is acceptable practice provided that the user checks the provenance of the data and makes adjustments as necessary.

The number of laboratories using data which are not recommended (or are of unknown origin) is now very small. This is clearly poor practice and one cannot overemphasise the importance of using data from recently recommended data sets: if there is any doubt as to the reliability of the data, an expert body such as NPL should be consulted.

8.4.2 Standards

Virtually all the participants used γ-emitting standards of the mixed radionuclide type for the γ assays, with two laboratories using single nuclide standards. For the α/β assays, the standards and chemical yield tracers had been obtained mostly from NPL, Amersham International or AEA Technology, although some other calibration sources were used, with a significant minority being of unknown origin. In most cases, however, the tracers/standards were traceable to national standards.

9 CONCLUSIONS

On the positive side, the results for the plutonium radionuclides are better now that they are based on newly-standardised material. The usage of traceable standards and reliable nuclear data is still high, and citation of the Radiochemical Manual as a data source is now common.

The results of this exercise are mixed. Whilst the results for some nuclides are reasonable, many are not. The main problem area seems to be underestimation of uncertainties, Type B uncertainties in particular. This is evident from the higher levels of discrepant data reported at the higher activity levels, where the Type A contribution represents a smaller proportion of the overall uncertainty. Also of concern is the apparent paucity of cascade summing corrections for certain nuclides, an area which has been regularly covered in previous exercises and workshops. The results of the ^{90}Sr measurements have a surprisingly large spread, and the proportions of ambiguous data reported for the nuclides used in γ-detector calibrations remains high. The amount of data returned for the β-emitting nuclides (at 25 and 2.5 Bq kg^{-1}) was disappointing, given that the indications were that the user community would welcome the opportunity to make such measurements.

In conclusion, one can say that:

(i) there remains considerable scope for improvement in metrological performance, particularly for the calibration radionuclides;
(ii) specific areas for improvement, once again, include uncertainty budgets and cascade summing corrections;
(iii) measurement capabilities in non-aqueous matrices should be assessed once the problems with the aqueous solutions are resolved;
(iv) feedback from the measurement community needs to be clearer to ensure that future intercomparisons are relevant and are actually addressing users' needs.

10 ACKNOWLEDGEMENTS

The authors acknowledge the financial support of the National Measurement System Policy Unit of the United Kingdom Department of Trade and Industry. The participants are thanked for the time and effort they have put into this exercise.

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Table 1- ABHxx/99 - principal radionuclides.

Radionuclide	Decay mode	Activity concentration @ 1200 GMT 1/10/99 (Bq g^{-1})	Standard uncertainty (k = 1) (Bq g^{-1})
^{3}H	β^-	20.21	0.21
^{55}Fe	e.c.	2.011	0.046
^{63}Ni	β^-	2.043	0.016
^{90}Sr	β^-	1.780	0.026
^{238}Pu	α	1.9506	0.0066
^{239}Pu	α	1.921	0.016
^{241}Am	α/γ	2.0347	0.0085
^{244}Cm	α	1.8689	0.0060

Table 2 - ABHxx/99 - impurities.

Radionuclide	Decay mode	Activity concentration @ 1200 GMT 1/10/99 (Bq g^{-1})	Standard uncertainty (k = 1) (Bq g^{-1})
^{241}Pu	β^-	< 0.04	-
^{243}Cm	α/γ	< 0.0002	-
^{245}Cm	α/γ	< 0.0002	-
unspecified α-emitters	α	< 0.002	-

Table 3- ABLxx/99 - principal radionuclides.

Radionuclide	Decay mode	Activity concentration @ 1200 GMT 1/10/99 (Bq kg^{-1})	Standard uncertainty (k = 1) (Bq kg^{-1})
^{3}H	β^-	25.10	0.26
^{55}Fe	e.c.	2.497	0.057
^{63}Ni	β^-	2.537	0.020
^{90}Sr	β^-	2.211	0.033
^{238}U	α	2.436	0.058
^{238}Pu	α	2.4220	0.0099
^{239}Pu	α	2.385	0.021
^{241}Am	α/γ	2.526	0.012
^{244}Cm	α	2.3206	0.0091

Table 4 - ABLxx/99 - impurities.

Radionuclide	Decay mode	Activity concentration @ 1200 GMT 1/10/99 (Bq kg^{-1})	Standard uncertainty (k = 1) (Bq kg^{-1})
^{241}Pu	β^-	< 0.05	-
^{243}Cm	α/γ	< 0.0003	-
^{245}Cm	α/γ	< 0.0003	-
unspecified α-emitters	α	< 0.002	-

Table 5 - Principal radionuclides - BGHxxx/99

Radionuclide	Decay mode	Activity concentration @ 1200 GMT 1/10/99 (Bq g^{-1})	Standard uncertainty (k = 1) (Bq g^{-1})
^{57}Co	e.c./γ	2.480	0.018
^{60}Co	β^-/γ	2.421	0.009
^{65}Zn	e.c., β^+/γ	2.721	0.054
^{124}Sb	β^-/γ	2.558	0.025
^{125}Sb	β^-/γ	2.431	0.073
^{134}Cs	β^-/γ	2.583	0.027
^{137}Cs	$\beta^-,\beta^-/\gamma$	2.414	0.018
^{154}Eu	β^-/γ	2.531	0.029
^{155}Eu	β^-/γ	2.467	0.033

Table 6 - BGHxxx/99 impurities

Radionuclide	Decay mode	Activity concentration @1200 GMT 1/10/99 (Bq g^{-1})	Standard uncertainty (k = 1) (Bq kg^{-1})
^{152}Eu	β^-/γ	0.126	0.013

Table 7 - Principal radionuclides - BGMxxx/99

Radionuclide	Decay mode	Activity concentration @ 1200 GMT 1/10/99 (Bq kg^{-1})	Standard uncertainty (k = 1) (Bq kg^{-1})
^{57}Co	e.c.*/γ	24.84	0.37
^{60}Co	β/γ	24.25	0.33
^{65}Zn	β^+/γ	27.26	0.64
^{124}Sb	β/γ	25.63	0.42
^{125}Sb	β/γ	24.36	0.80
^{134}Cs	β/γ	25.87	0.43
^{137}Cs	β,β/γ	24.18	0.36
^{154}Eu	β/γ	25.36	0.44
^{155}Eu	β/γ	24.71	0.46

Table 8 - BGMxxx/99 - impurities

Radionuclide	Decay mode	Activity concentration @1200 GMT 1/10/99 (Bq kg^{-1})	Standard uncertainty (k = 1) (Bq kg^{-1})
^{152}Eu	β/γ	1.27	0.13

Table 9 - Principal radionuclides - BGLxxx/99

Radionuclide	Decay mode	Activity concentration @ 1200 GMT 1/10/99 (Bq kg^{-1})	Standard uncertainty (k = 1) (Bq kg^{-1})
^{57}Co	e.c.*/γ	2.476	0.036
^{60}Co	β^-/γ	2.418	0.032
^{65}Zn	e.c., β^+/γ	2.717	0.064
^{124}Sb	β^-/γ	2.555	0.042
^{125}Sb	β^-/γ	2.428	0.079
^{134}Cs	β^-/γ	2.579	0.043
^{137}Cs	β^-,β^-/γ	2.411	0.036
^{154}Eu	β^-/γ	2.528	0.044
^{155}Eu	β^-/γ	2.463	0.046

Table 10 - BGLxxx/99 - impurities

Radionuclide	Decay mode	Activity concentration @1200 GMT 1/10/99 (Bq kg^{-1})	Standard uncertainty (k = 1) (Bq kg^{-1})
^{152}Eu	β/γ	0.13	0.02

Table 11 - Radionuclide provenance

Radionuclide	Origin	Calibrating Laboratory	Traceability
^{238}U	ORNL, USA	NPL	French Primary Standard/LNHB
^{238}Pu	TENEX, Russia	NPL	UK Primary Standard/NPL
^{239}Pu	TENEX, Russia	NPL	UK Primary Standard/NPL
^{241}Am	NA, UK	NPL	UK Primary Standard/NPL
^{244}Cm	TENEX, Russia	NPL	UK Primary Standard/NPL
^{3}H	NA, UK	NA	US Primary Standard/NIST
^{55}Fe	NA, UK	NPL	UK Primary Standard/NPL
^{63}Ni	NA, UK	NA	UK Primary Standard/NPL
^{90}Sr	NA, UK	NPL	UK Primary Standard/NPL
^{57}Co	NA, UK	NPL	UK Primary Standard/NPL
^{60}Co	NA, UK	NPL	UK Primary Standard/NPL
^{65}Zn	NA, UK	NPL	UK Primary Standard/NPL
^{124}Sb	NA, UK	NPL	UK Primary Standard/NPL
^{125}Sb	NA, UK	NPL	UK Primary Standard/NPL
^{134}Cs	NA, UK	NPL	UK Primary Standard/NPL
^{137}Cs	NA, UK	NPL	UK Primary Standard/NPL
^{154}Eu	NPL, UK	NPL	UK Primary Standard/NPL
^{155}Eu	IIR, Czech Republic	NPL	UK Primary Standard/NPL

IIR: Inspektorát pro Ionizující Záreni, Czech Republic
LNHB: Laboratoire Nationale D'Henri Becquerel, France
NA: Nycomed-Amersham, UK
NIST: National Institute of Standards and Technology, USA
ORNL: Oak Ridge National Laboratory, USA
TENEX: TENEX All-Union Foreign Economic Association Techsnabexport,

Russia

Table 12- Criteria for u-tests

Value	Conclusion
u < 1.64	The values do not differ significantly
1.64 < u < 1.96	The values probably do not differ significantly but more data are required to confirm this
1.96 < u < 2.58	One cannot say whether there is a significant difference without further data
2.58 < u < 3.29	The values probably differ significantly but more data are required to confirm this
3.29 < u	The values differ significantly

Table 13 - Nuclear decay data

Nuclide	Half life (days)	Eγ (keV)	Pγ (%)	Reference
^{3}H	4504 ± 8	-	-	[19]
^{55}Fe	999 ± 8	-	-	[15]
^{57}Co	271.79 ± 0.09	14.4	9.16 ± 0.15	[15]
		122.1	85.60 ± 0.17	[15]
		136.5	10.68 ± 0.08	[15]
^{60}Co	1925.5 ± 0.5	1173.2	99.857 ± 0.022	[15]
		1332.5	99.983 ± 0.006	[15]
^{63}Ni	36525 ± 731	-	-	[19]
^{65}Zn	244.26 ± 0.26	1115.5	50.6 ± 0.24	[15]
^{90}Sr	10460 ± 60	-	-	[16]
^{125m}Te	57.40 ± 0.15	35.5	6.67 ± 0.20	[17]
^{124}Sb	60.24 ± 0.09	602.7	97.80 ± 0.10	[16]
		645.9	7.40 ± 0.07	[16]
		709.3	1.400 ± 0.020	[16]
		713.8	2.340 ± 0.030	[16]
		722.8	10.97 ± 0.12	[16]
		968.2	1.92 ± 0.04	[16]
		1045.1	1.860 ± 0.020	[16]

Nuclide	Half life (days)	Eγ (keV)	Pγ (%)	Reference
^{124}Sb	60.24 ± 0.09	1325.5	1.55 ± 0.05	[16]
		1355.2	1.06 ± 0.05	[16]
		1368.2	2.60 ± 0.08	[16]
		1436.6	1.22 ± 0.07	[16]
		1691.0	48.4 ± 0.6	[16]
		2091.0	5.57 ± 0.06	[16]
^{125}Sb	1007.7 ± 0.6	176.3	6.85 ± 0.07	[15]
		380.5	1.518 ± 0.016	[15]
		427.9	29.7 ± 0.3	[15]
		463.4	10.48 ± 0.11	[15]
		600.6	17.73 ± 0.18	[15]
		606.7	5.00 ± 0.05	[15]
		636.0	11.21 ± 0.12	[15]
^{134}Cs	754.28 ± 0.22	475.4	1.49 ± 0.02	[15]
		563.2	8.36 ± 0.03	[15]
		569.3	15.39 ± 0.06	[15]
		604.7	97.63 ± 0.06	[15]
		795.9	85.4 ± 0.3	[15]
		801.9	8.69 ± 0.03	[15]
		1168.0	1.792 ± 0.007	[15]
		1365.2	3.016 ± 0.011	[15]
^{137}Cs	11020 ± 60	661.7	85.1 ± 0.2	[15]
^{154}Eu	3136.8 ± 2.9	123.1	41.2 ± 0.5	[15]
		247.9	6.95 ± 0.09	[15]
		591.8	4.99 ± 0.06	[15]
		692.4	1.80 ± 0.03	[15]
		723.3	20.2 ± 0.2	[15]
		756.8	4.58 ± 0.06	[15]
		873.2	12.24 ± 0.15	[15]

		996.3	10.48 ± 0.13	[15]
Nuclide	Half life (days)	Eγ (keV)	Pγ (%)	Reference
^{154}Eu	3136.8 ± 2.9	1004.7	18.2 ± 0.2	[15]
		1274.4	35.0 ± 0.4	[15]
^{155}Eu	1770 ± 50	60.0	1.13 ± 0.05	[15]/[17]
		86.5	30.7 ± 0.7	[17]
		105.3	21.2± 0.5`	[17]
^{238}U	(1.632 x 0.002) x 10^6	-	-	[17]
^{238}Pu	(3.20 ± 0.02) x 10^4	-	-	[20]
^{239}Pu	(8.807 ± 0.015) x 10^6	-	-	[16]
^{241}Am	(1.5785 ± 0.0024) x 10^5	59.5	36.0 ± 0.4	[15]
^{244}Cm	6611 ± 18	-	-	[20]

Table 14 - results of u-tests for α-emitters

NUCLIDE	LIMITS	NUMBER OF RESULTS HIGH LEVEL	NUMBER OF RESULTS LOW LEVEL
^{238}U	< 1.64	n/a	9
	1.64 - 1.96		1
	1.96 - 2.58		
	2.58 - 3.29		
	> 3.29		
^{238}Pu	< 1.64	13	8
	1.64 - 1.96		
	1.96 - 2.58		1
	2.58 - 3.29		1
	> 3.29	2	
^{239}Pu	< 1.64	11	9
	1.64 - 1.96	1	
	1.96 - 2.58		1
	2.58 - 3.29		
	> 3.29	4	
^{241}Am	< 1.64	9	10
	1.64 - 1.96	3	
	1.96 - 2.58	2	
	2.58 - 3.29		
	> 3.29	1	1
^{244}Cm	< 1.64	2	3
	1.64 - 1.96		
	1.96 - 2.58		
	2.58 - 3.29		
	> 3.29	2	

Table 15 - Results of u-tests for β-emitters

NUCLIDE	LIMITS	NUMBER OF RESULTS HIGH LEVEL	NUMBER OF RESULTS LOW LEVEL
^{3}H	< 1.64	5	4
	1.64 - 1.96		
	1.96 - 2.58	1	1
	2.58 - 3.29		
	> 3.29	3	
^{55}Fe	< 1.64	2	
	1.64 - 1.96		
	1.96 - 2.58		
	2.58 - 3.29		
	> 3.29		
^{63}Ni	< 1.64	2	
	1.64 - 1.96		
	1.96 - 2.58		
	2.58 - 3.29		
	> 3.29		
^{90}Sr	< 1.64	3	3
	1.64 - 1.96	3	
	1.96 - 2.58	1	
	2.58 - 3.29	1	1
	> 3.29	4	

Table 16 - Results of u-tests for β/γ-emitters

NUCLIDE	LIMITS	NUMBER OF RESULTS HIGH LEVEL	NUMBER OF RESULTS INTERMEDIATE LEVEL	NUMBER OF RESULTS LOW LEVEL
^{57}Co	< 1.64	14	16	13
	1.64 - 1.96	1		
	1.96 - 2.58	2	3	1
	2.58 - 3.29		1	1
	> 3.29	8	4	
	* maximum			1
^{60}Co	< 1.64	15	18	13
	1.64 - 1.96	1	1	1
	1.96 - 2.58		2	2
	2.58 - 3.29			1
	> 3.29	9	3	
	* maximum			
^{65}Zn	< 1.64	10	19	12
	1.64 - 1.96	2	1	
	1.96 - 2.58	4	3	
	2.58 - 3.29	2		2
	> 3.29	6	1	
	* maximum			1
^{8124}Sb	< 1.64	19	19	10
	1.64 - 1.96			
	1.96 - 2.58	1	2	1
	2.58 - 3.29	1		1
	> 3.29	3	1	
	* maximum			3
^{125}Sb	< 1.64	22	20	12
	1.64 - 1.96	2	1	
	1.96 - 2.58		3	1
	2.58 - 3.29	1		
	> 3.29			
	* maximum			1
^{134}Cs	< 1.64	9	15	12
	1.64 - 1.96			1
	1.96 - 2.58		5	3
	2.58 - 3.29	5		1
	> 3.29	11	4	
	* maximum			
^{137}Cs	< 1.64	13	18	16
	1.64 - 1.96	1		
	1.96 - 2.58	1		
	2.58 - 3.29	3	3	
	> 3.29	7	3	1
	* maximum			
^{154}Eu	< 1.64	12	15	11
	1.64 - 1.96	2	2	
	1.96 - 2.58	7	4	1
	2.58 - 3.29			1
	> 3.29	4	3	
	* maximum			1
^{155}Eu	< 1.64	18	19	11
	1.64 - 1.96			
	1.96 - 2.58	2	2	1
	2.58 - 3.29	2	2	
	> 3.29	3	1	2

	* maximum			1

* Number of results quoted as maximum values

Table 17 - Results for ^{3}H (Low Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{3}H Bq kg^{-1}	± Bq kg^{-1}	^{3}H Bq kg^{-1}	± Bq kg^{-1}		
ABL03/99	28.2	3.1	25.10	0.26	-1.00	12.35
ABL05/99	25.9	1	25.10	0.26	-0.77	3.19
ABL11/99	26	3	25.10	0.26	-0.30	3.59
ABL12/99	28.4	3	25.10	0.26	-1.10	13.15
ABL13/99	27.94	1.15	25.10	0.26	-2.41	11.31

Table 18 - Results for ^{90}Sr (Low Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{90}Sr Bq kg^{-1}	± Bq kg^{-1}	^{90}Sr Bq kg^{-1}	± Bq kg^{-1}		
ABL03/99	2.23	0.09	2.211	0.033	-0.20	0.86
ABL06/99	2.1	0.47	2.211	0.033	0.24	-5.02
ABL07/99	2.1	0.00541	2.211	0.033	3.32	-5.02
ABL12/99	2.11	0.45	2.211	0.033	0.22	-4.57

Table 19 - Results for ^{238}U (Low Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{238}U Bq kg^{-1}	± Bq kg^{-1}	^{238}U Bq kg^{-1}	± Bq kg^{-1}		
ABL03/99	2.26	0.07	2.436	0.058	1.94	-7.22
ABL03/99	2.44	0.13	2.436	0.058	0.03	0.16
ABL04/99	2.4	0.07	2.436	0.058	0.40	-1.48
ABL08/99	2.37	0.03	2.436	0.058	1.01	-2.71
ABL10/99	2.16	0.35	2.436	0.058	0.78	-11.33
ABL12/99	2.43	0.13	2.436	0.058	0.04	-0.25
ABL13/99	2.388	0.099	2.436	0.058	0.42	-1.97
ABL11/99	2.27	0.22	2.436	0.058	0.73	-6.81
ABL11/99	2.16	0.21	2.436	0.058	1.27	-11.33
ABL11/99	2.39	0.23	2.436	0.058	0.19	-1.89

Table 20 - Results for ^{238}Pu (Low Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{238}Pu Bq kg^{-1}	± Bq kg^{-1}	^{238}Pu Bq kg^{-1}	± Bq kg^{-1}		
ABL03/99	2.33	0.13	2.4220	0.0099	0.71	-3.80
ABL04/99	2.24	0.06	2.4220	0.0099	2.99	-7.51
ABL06/99	2.4	0.12	2.4220	0.0099	0.18	-0.91
ABL07/99	1.738	0.5827	2.4220	0.0099	1.17	-28.24
ABL08/99	2.52	0.19	2.4220	0.0099	-0.52	4.05
ABL11/99	2.26	0.12	2.4220	0.0099	1.35	-6.69
ABL11/99	2.18	0.11	2.4220	0.0099	2.19	-9.99
ABL11/99	2.27	0.12	2.4220	0.0099	1.26	-6.28
ABL12/99	2.4	0.18	2.4220	0.0099	0.12	-0.91
ABL13/99	2.35	0.09	2.4220	0.0099	0.80	-2.97

Table 21 - Results for ^{239}Pu (Low Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{239}Pu Bq kg^{-1}	± Bq kg^{-1}	^{239}Pu Bq kg^{-1}	± Bq kg^{-1}		
ABL03/99	2.26	0.14	2.385	0.021	0.88	-5.24
ABL04/99	2.22	0.07	2.385	0.021	2.26	-6.92
ABL06/99	2.42	0.12	2.385	0.021	-0.29	1.47
ABL07/99	1.713	0.5827	2.385	0.021	1.15	-28.18
ABL08/99	2.17	0.17	2.385	0.021	1.26	-9.01
ABL11/99	2.3	0.12	2.385	0.021	0.70	-3.56
ABL11/99	2.24	0.11	2.385	0.021	1.29	-6.08
ABL11/99	2.26	0.11	2.385	0.021	1.12	-5.24
ABL12/99	2.24	0.17	2.385	0.021	0.85	-6.08
ABL13/99	2.32	0.13	2.385	0.021	0.49	-2.73

Table 22 - Results for ^{241}Am (Low Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{241}Am Bq kg^{-1}	± Bq kg^{-1}	^{241}Am Bq kg^{-1}	± Bq kg^{-1}		
ABL03/99 (α)	2.36	0.14	2.526	0.012	1.18	-6.57
ABL04/99 (α)	2.51	0.12	2.526	0.012	0.13	-0.63
ABL04/99 (α)	2.45	0.08	2.526	0.012	0.94	-3.01
ABL06/99 (γ)	2.05	0.37	2.526	0.012	1.29	-18.84
ABL06/99 (α)	1.87	0.12	2.526	0.012	5.44	-25.97
ABL07/99 (α)	2.507	0.516	2.526	0.012	0.04	-0.75
ABL08/99 (α)	2.52	0.05	2.526	0.012	0.12	-0.24
ABL11/99 (γ)	1.9	0.5	2.526	0.012	1.25	-24.78
ABL12/99 (α)	2.42	0.16	2.526	0.012	0.66	-4.20
ABL13/99 (α)	2.5	0.08	2.526	0.012	0.32	-1.03
ABL14/99 (γ)	2.74	0.2	2.526	0.012	-1.07	8.47

Table 23 - Results for ^{224}Cm (Low Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{224}Cm Bq kg^{-1}	± Bq kg^{-1}	^{224}Cm Bq kg^{-1}	± Bq kg^{-1}		
ABL03/99	2.3	0.25	2.3206	0.0091	0.08	-0.89
ABL07/99	1.922	0.689	2.3206	0.0091	0.58	-17.18
ABL13/99	2.17	0.1	2.3206	0.0091	1.50	-6.49

Table 24 - Results for ^{3}H (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{3}H Bq g^{-1}	± Bq g^{-1}	^{3}H Bq g^{-1}	± Bq g^{-1}		
ABH02/99	21.32	1.2	20.21	0.21	-0.91	5.49
ABH04/99	19.44	0.86	20.21	0.21	0.87	-3.81
ABH05/99	23.14	0.23	20.21	0.21	-9.41	14.50
ABH06/99	20.2	0.6	20.21	0.21	0.02	-0.05
ABH07/99	19.68	1	20.21	0.21	0.52	-2.62
ABH12/99	19.58	0.22	20.21	0.21	2.07	-3.12
ABH14/99	18.2	0.3	20.21	0.21	5.49	-9.95
ABH15/99	17.6	0.19	20.21	0.21	9.22	-12.91
ABH19/99	19.47	0.88	20.21	0.21	0.82	-3.66

Table 25 - Results for ^{55}Fe (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{55}Fe Bq g^{-1}	± Bq g^{-1}	^{55}Fe Bq g^{-1}	± Bq g^{-1}		
ABH04/99	2.05	0.12	2.011	0.046	-0.30	1.94
ABH06/99	2.04	0.19	2.011	0.046	-0.15	1.44

Table 26 - Results for ^{63}Ni (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{63}Ni Bq g^{-1}	± Bq g^{-1}	^{63}Ni Bq g^{-1}	± Bq g^{-1}		
ABH04/99	1.97	0.23	2.043	0.016	0.32	-3.57
ABH06/99	1.9	0.09	2.043	0.016	1.56	-7.00

Table 27 - Results for ^{90}Sr (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{90}Sr Bq g^{-1}	± Bq g^{-1}	^{90}Sr Bq g^{-1}	± Bq g^{-1}		
ABH02/99	1.66	0.06	1.780	0.026	1.84	-6.74
ABH03/99	1.6	0.09	1.780	0.026	1.92	-10.11
ABH03/99	1.69	0.04	1.780	0.026	1.89	-5.06
ABH04/99	1.626	0.056	1.780	0.026	2.49	-8.65
ABH06/99	1.49	0.03	1.780	0.026	7.30	-16.29
ABH08/99	1.38	0.117	1.780	0.026	3.34	-22.47
ABH11/99	1.64	0.15	1.780	0.026	0.92	-7.87
ABH11/99	1.75	0.16	1.780	0.026	0.19	-1.69
ABH12/99	1.92	0.046	1.780	0.026	-2.65	7.87
ABH14/99	1.7	0.12	1.780	0.026	0.65	-4.49
ABH15/99	2.47	0.08	1.780	0.026	-8.20	38.76
ABH19/99	3.38	0.16	1.780	0.026	-9.87	89.89

Table 28 - Results for ^{238}Pu (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{238}Pu Bq g^{-1}	± Bq g^{-1}	^{238}Pu Bq g^{-1}	± Bq g^{-1}		
ABH02/99	1.87	0.05	1.9506	0.0066	1.60	-4.13
ABH04/99	1.9	0.058	1.9506	0.0066	0.87	-2.59
ABH06/99	1.98	0.04	1.9506	0.0066	-0.73	1.51
ABH06/99	1.93	0.07	1.9506	0.0066	0.29	-1.06
ABH08/99	0.9116	0.124	1.9506	0.0066	8.37	-53.27
ABH09/99	1.87	0.08	1.9506	0.0066	1.00	-4.13
ABH11/99	1.97	0.1	1.9506	0.0066	-0.19	0.99
ABH11/99	1.8	0.1	1.9506	0.0066	1.50	-7.72
ABH11/99	1.79	0.1	1.9506	0.0066	1.60	-8.23
ABH12/99	1.75	0.39	1.9506	0.0066	0.51	-10.28
ABH14/99	1.69	0.07	1.9506	0.0066	3.71	-13.36
ABH15/99	1.8	0.12	1.9506	0.0066	1.25	-7.72
ABH16/99	1.979	0.045	1.9506	0.0066	-0.62	1.46
ABH19/99	1.79	0.1	1.9506	0.0066	1.60	-8.23
ABH20/99	1.91	0.03	1.9506	0.0066	1.32	-2.08

Table 29 - Results for ^{239}Pu (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{239}Pu Bq g^{-1}	± Bq g^{-1}	^{239}Pu Bq g^{-1}	± Bq g^{-1}		
ABH02/99	1.87	0.05	1.921	0.016	0.97	-2.65
ABH02/99	2.1	0.1	1.921	0.016	-1.77	9.32
ABH04/99	1.83	0.056	1.921	0.016	1.56	-4.74
ABH06/99	1.85	0.04	1.921	0.016	1.65	-3.70
ABH06/99	1.99	0.07	1.921	0.016	-0.96	3.59
ABH08/99	0.8616	0.116	1.921	0.016	9.05	-55.15
ABH09/99	1.82	0.06	1.921	0.016	1.63	-5.26
ABH11/99	1.98	0.1	1.921	0.016	-0.58	3.07
ABH11/99	1.83	0.1	1.921	0.016	0.90	-4.74
ABH11/99	1.81	0.1	1.921	0.016	1.10	-5.78
ABH12/99	1.688	0.04	1.921	0.016	5.41	-12.13
ABH14/99	1.35	0.08	1.921	0.016	7.00	-29.72
ABH15/99	1.79	0.12	1.921	0.016	1.08	-6.82
ABH16/99	1.972	0.044	1.921	0.016	-1.09	2.65
ABH19/99	1.81	0.1	1.921	0.016	1.10	-5.78
ABH20/99	0.81	0.01	1.921	0.016	58.88	-57.83

Table 30 - Results for ^{241}Am (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{241}Am Bq g^{-1}	± Bq g^{-1}	^{241}Am Bq g^{-1}	± Bq g^{-1}		
ABH02/99	2.12	0.1	2.0347	0.0085	-0.85	4.19
ABH02/99 (γ)	2.06	0.06	2.0347	0.0085	-0.42	1.24
ABH02/99 (α)	2.09	0.14	2.0347	0.0085	-0.39	2.72
ABH04/99 (α)	2.142	0.061	2.0347	0.0085	-1.74	5.27
ABH06/99 (α)	1.91	0.02	2.0347	0.0085	5.74	-6.13
ABH06/99 (α)	1.99	0.09	2.0347	0.0085	0.49	-2.20
ABH09/99 (α)	1.97	0.36	2.0347	0.0085	0.18	-3.18
ABH10/99 (γ)	2.32	0.3	2.0347	0.0085	-0.95	14.02
ABH11/99 (γ)	2.2	0.2	2.0347	0.0085	-0.83	8.12
ABH12/99 (α)	1.814	0.12	2.0347	0.0085	1.83	-10.85
ABH14/99 (α)	1.97	0.08	2.0347	0.0085	0.80	-3.18
ABH14/99 (γ)	2	0.05	2.0347	0.0085	0.68	-1.71
ABH15/99 (α)	1.86	0.08	2.0347	0.0085	2.17	-8.59
ABH16/99 (α)	1.946	0.044	2.0347	0.0085	1.98	-4.36
ABH19/99 (γ)	2.11	0.04	2.0347	0.0085	-1.84	3.70

Table 31 - Results for ^{244}Cm (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{244}Cm Bq g^{-1}	± Bq g^{-1}	^{244}Cm Bq g^{-1}	± Bq g^{-1}		
ABH04/99	1.925	0.056	1.8689	0.0060	-1.00	3.00
ABH15/99	1.55	0.06	1.8689	0.0060	5.29	-17.06
ABH06/99	1.78	0.02	1.8689	0.0060	4.26	-4.76
ABH06/99	2	0.1	1.8689	0.0060	-1.31	7.01

Table 32 - Results for ^{57}Co (Low Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{57}Co Bq kg^{-1}	± Bq kg^{-1}	^{57}Co Bq kg^{-1}	± Bq kg^{-1}		
BGL03/99	2.46	0.43	2.476	0.036	0.04	-0.65
BGL04/99	2.24	0.21	2.476	0.036	1.11	-9.53
BGL05/99	2.6	0.3	2.476	0.036	-0.41	5.01
BGL06/99	1.77	0.241	2.476	0.036	2.90	-28.51
BGL07/99	2.75	0.13	2.476	0.036	-2.03	11.07
BGL08/99	2.69	0.14	2.476	0.036	-1.48	8.64
BGL10/99	2.394	0.177	2.476	0.036	0.45	-3.31
BGL11/99	2.022	0.333	2.476	0.036	1.36	-18.34
BGL12/99	2.8	0.6	2.476	0.036	-0.54	13.09
BGL13/99	2.6	0.3	2.476	0.036	-0.41	5.01
BGL14/99	2.5	0.2	2.476	0.036	-0.12	0.97
BGL17/99	2.46	0.76	2.476	0.036	0.02	-0.65
BGL18/99	<5	-	2.476	0.036	#######	#######
BGL19/99	2.53	0.17	2.476	0.036	-0.31	2.18
BGL20/99	2.5	0.1	2.476	0.036	-0.23	0.97
BGL21/99	2.7	0.3	2.476	0.036	-0.74	9.05

Table 33 - Results for ^{60}Co (Low Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{60}Co Bq kg^{-1}	± Bq kg^{-1}	^{60}Co Bq kg^{-1}	± Bq kg^{-1}		
BGL03/99	2.48	0.23	2.418	0.032	-0.27	2.56
BGL04/99	2.77	0.12	2.418	0.032	-2.83	14.56
BGL05/99	2.4	0.2	2.418	0.032	0.09	-0.74
BGL06/99	2.47	0.272	2.418	0.032	-0.19	2.15
BGL07/99	2.17	0.11	2.418	0.032	2.16	-10.26
BGL08/99	2.43	0.12	2.418	0.032	-0.10	0.50
BGL10/99	1.837	0.391	2.418	0.032	1.48	-24.03
BGL11/99	2.121	0.198	2.418	0.032	1.48	-12.28
BGL12/99	3.1	0.4	2.418	0.032	-1.70	28.21
BGL13/99	2.6	0.3	2.418	0.032	-0.60	7.53
BGL14/99	2.9	0.3	2.418	0.032	-1.60	19.93
BGL17/99	2.7	0.27	2.418	0.032	-1.04	11.66
BGL18/99	1.9	0.4	2.418	0.032	1.29	-21.42
BGL19/99	2.75	0.14	2.418	0.032	-2.31	13.73
BGL20/99	2.3	0.2	2.418	0.032	0.58	-4.88
BGL21/99	2.4	0.2	2.418	0.032	0.09	-0.74
BGL22/99	3.06	0.666	2.418	0.032	-0.96	26.55

Table 34 - Results for ^{65}Zn (Low Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{65}Zn Bq kg^{-1}	± Bq kg^{-1}	^{65}Zn Bq kg^{-1}	± Bq kg^{-1}		
BGL03/99	3	0.5	2.717	0.064	-0.56	10.42
BGL04/99	3.41	0.23	2.717	0.064	-2.90	25.51
BGL05/99	3.3	0.2	2.717	0.064	-2.78	21.46
BGL06/99	2.52	0.49	2.717	0.064	0.40	-7.25
BGL07/99	2.98	0.42	2.717	0.064	-0.62	9.68
BGL08/99	2.68	0.39	2.717	0.064	0.09	-1.36
BGL10/99	2.274	0.907	2.717	0.064	0.49	-16.30
BGL11/99	2.409	0.225	2.717	0.064	1.32	-11.34
BGL13/99	2.7	0.5	2.717	0.064	0.03	-0.63
BGL14/99	3	0.4	2.717	0.064	-0.70	10.42
BGL17/99	2.68	0.4	2.717	0.064	0.09	-1.36
BGL18/99	<5	-	2.717	0.064	#######	#######
BGL19/99	2.51	0.19	2.717	0.064	1.03	-7.62
BGL20/99	3.4	0.7	2.717	0.064	-0.97	25.14
BGL21/99	3.0	0.6	2.717	0.064	-0.47	10.42

Table 35 - Results for ^{124}Sb (Low Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{124}Sb Bq kg^{-1}	± Bq kg^{-1}	^{124}Sb Bq kg^{-1}	± Bq kg^{-1}		
BGL03/99	3.52	0.65	2.555	0.042	-1.48	37.77
BGL04/99	3.9	0.66	2.555	0.042	-2.03	52.64
BGL05/99	2.8	0.3	2.555	0.042	-0.81	9.59
BGL06/99	5.2	2.125	2.555	0.042	-1.24	103.52
BGL07/99	2.76	0.55	2.555	0.042	-0.37	8.02
BGL08/99	<3.0	0	2.555	0.042	#######	#######
BGL10/99	5.348	0.918	2.555	0.042	-3.04	109.32
BGL11/99	2.882	0.776	2.555	0.042	-0.42	12.80
BGL13/99	3.6	1.4	2.555	0.042	-0.75	40.90
BGL14/99	5.4	2.4	2.555	0.042	-1.19	111.35
BGL17/99	1.6	0.82	2.555	0.042	1.16	-37.38
BGL18/99	<20	-	2.555	0.042	#######	#######
BGL19/99	2.4	0.19	2.555	0.042	0.80	-6.07
BGL20/99	<3.1	--	2.555	0.042	#######	#######
BGL21/99	2.5	0.6	2.555	0.042	0.09	-2.15

Table 36 - Results for ^{125}Sb (Low Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{125}Sb Bq kg^{-1}	± Bq kg^{-1}	^{125}Sb Bq kg^{-1}	± Bq kg^{-1}		
BGL03/99	2.71	0.35	2.428	0.079	-0.79	11.61
BGL04/99	2.87	0.29	2.428	0.079	-1.47	18.20
BGL05/99	2.5	0.2	2.428	0.079	-0.33	2.97
BGL06/99	3.89	0.712	2.428	0.079	-2.04	60.21
BGL07/99	2.7	0.27	2.428	0.079	-0.97	11.20
BGL08/99	2.02	0.34	2.428	0.079	1.17	-16.80
BGL11/99	2.054	0.215	2.428	0.079	1.63	-15.40
BGL13/99	3	0.6	2.428	0.079	-0.95	23.56
BGL14/99	3.2	0.5	2.428	0.079	-1.53	31.80
BGL17/99	3.13	0.83	2.428	0.079	-0.84	28.91
BGL18/99	<4	-	2.428	0.079	#######	#######
BGL19/99	2.6	0.18	2.428	0.079	-0.87	7.08
BGL20/99	2.8	0.5	2.428	0.079	-0.73	15.32
BGL21/99	2.3	0.6	2.428	0.079	0.21	-5.27

Table 37 - Results for ^{134}Cs (Low Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{134}Cs Bq kg^{-1}	± Bq kg^{-1}	^{134}Cs Bq kg^{-1}	± Bq kg^{-1}		
BGL03/99	2.77	0.27	2.411	0.036	-0.32	2.86
BGL04/99	2.44	0.12	2.411	0.036	0.96	-4.60
BGL05/99	2.6	0.2	2.411	0.036	0.10	-0.46
BGL06/99	2.8	0.229	2.411	0.036	-0.52	7.42
BGL07/99	2.29	0.12	2.411	0.036	-14.27	172.92
BGL08/99	2.24	0.17	2.411	0.036	-0.58	3.69
BGL10/99	2.152	0.341	2.411	0.036	-0.09	1.12
BGL11/99	2.21	0.137	2.411	0.036	1.52	-20.16
BGL12/99	2.8	0.4	2.411	0.036	-1.57	32.73
BGL13/99	2.5	0.2	2.411	0.036	-0.63	7.84
BGL14/99	2.8	0.3	2.411	0.036	-0.96	11.99
BGL17/99	2.37	0.62	2.411	0.036	-0.55	9.08
BGL18/99	2.2	0.5	2.411	0.036	-0.70	20.28
BGL19/99	2.26	0.1	2.411	0.036	-1.30	9.91
BGL20/99	2.3	0.1	2.411	0.036	0.10	-0.46
BGL21/99	2.4	0.3	2.411	0.036	-0.44	3.69
BGL22/99	1.74	0.598	2.411	0.036	0.58	-13.31

Table 38 - Results for ^{137}Cs (Low Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{137}Cs Bq kg^{-1}	± Bq kg^{-1}	^{137}Cs Bq kg^{-1}	± Bq kg^{-1}		
BGL03/99	2.48	0.21	2.411	0.036	-0.32	2.86
BGL04/99	2.3	0.11	2.411	0.036	0.96	-4.60
BGL05/99	2.4	0.1	2.411	0.036	0.10	-0.46
BGL06/99	2.59	0.344	2.411	0.036	-0.52	7.42
BGL07/99	6.58	0.29	2.411	0.036	-14.27	172.92
BGL08/99	2.5	0.15	2.411	0.036	-0.58	3.69
BGL10/99	2.438	0.303	2.411	0.036	-0.09	1.12
BGL11/99	1.925	0.317	2.411	0.036	1.52	-20.16
BGL12/99	3.2	0.5	2.411	0.036	-1.57	32.73
BGL13/99	2.6	0.3	2.411	0.036	-0.63	7.84
BGL14/99	2.7	0.3	2.411	0.036	-0.96	11.99
BGL17/99	2.63	0.4	2.411	0.036	-0.55	9.08
BGL18/99	2.9	0.7	2.411	0.036	-0.70	20.28
BGL19/99	2.65	0.18	2.411	0.036	-1.30	9.91
BGL20/99	2.4	0.1	2.411	0.036	0.10	-0.46
BGL21/99	2.5	0.2	2.411	0.036	-0.44	3.69
BGL22/99	2.09	0.548	2.411	0.036	0.58	-13.31

Table 39 - Results for ^{154}Eu (Low Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{154}Eu Bq kg^{-1}	± Bq kg^{-1}	^{154}Eu Bq kg^{-1}	± Bq kg^{-1}		
BGL03/99	2.62	0.56	2.528	0.044	-0.16	3.64
BGL04/99	2.78	0.28	2.528	0.044	-0.89	9.97
BGL05/99	2.4	0.4	2.528	0.044	0.32	-5.06
BGL06/99	3.44	0.396	2.528	0.044	-2.29	36.08
BGL07/99	2.52	0.15	2.528	0.044	0.05	-0.32
BGL08/99	2.67	0.27	2.528	0.044	-0.52	5.62
BGL11/99	2.35	0.62	2.528	0.044	0.29	-7.04
BGL13/99	3.3	0.7	2.528	0.044	-1.10	30.54
BGL14/99	2.4	0.3	2.528	0.044	0.42	-5.06
BGL17/99	2.34	0.52	2.528	0.044	0.36	-7.44
BGL18/99	<5	-	2.528	0.044	#######	#######
BGL19/99	2.02	0.19	2.528	0.044	2.60	-20.09
BGL20/99	2.9	0.3	2.528	0.044	-1.23	14.72
BGL21/99	2.7	0.4	2.528	0.044	-0.43	6.80

Table 40 - Results for ^{155}Eu (Low Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{155}Eu Bq kg^{-1}	± Bq kg^{-1}	^{155}Eu Bq kg^{-1}	± Bq kg^{-1}		
BGL03/99	2.21	0.46	2.463	0.046	0.55	-10.27
BGL04/99	2.38	0.35	2.463	0.046	0.24	-3.37
BGL05/99	2.6	0.2	2.463	0.046	-0.67	5.56
BGL06/99	3.06	0.611	2.463	0.046	-0.97	24.24
BGL07/99	2.71	0.16	2.463	0.046	-1.48	10.03
BGL08/99	2.47	0.32	2.463	0.046	-0.02	0.28
BGL10/99	3.153	0.652	2.463	0.046	-1.06	28.01
BGL11/99	3.073	0.123	2.463	0.046	-4.65	24.77
BGL13/99	2.9	0.7	2.463	0.046	-0.62	17.74
BGL14/99	2.6	0.5	2.463	0.046	-0.27	5.56
BGL17/99	2.95	0.43	2.463	0.046	-1.13	19.77
BGL18/99	<2	-	2.463	0.046	#######	#######
BGL19/99	3.06	0.28	2.463	0.046	-2.10	24.24
BGL20/99	2.4	0.2	2.463	0.046	0.31	-2.56
BGL21/99	1.3	0.2	2.463	0.046	5.67	-47.22

Table 41 - Results for ^{57}Co (Intermediate Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{57}Co Bq kg^{-1}	± Bq kg^{-1}	^{57}Co Bq kg^{-1}	± Bq kg^{-1}		
BGM03/99	24.9	1.3	24.84	0.37	-0.04	0.24
BGM04/99	25.7	1.4	24.84	0.37	-0.59	3.46
BGM05/99	15.9	1.39	24.84	0.37	6.22	-35.99
BGM06/99	26.61	1.07	24.84	0.37	-1.56	7.13
BGM07/99	24.2	0.3	24.84	0.37	1.34	-2.58
BGM08/99	21.3	3.7	24.84	0.37	0.95	-14.25
BGM10/99	24.9	0.5	24.84	0.37	-0.10	0.24
BGM11/99	37.08	0.61	24.84	0.37	-17.16	49.28
BGM12/99	18.52	1.11	24.84	0.37	5.40	-25.44
BGM13/99	28.5	0.7	24.84	0.37	-4.62	14.73
BGM14/99	27.3	2.4	24.84	0.37	-1.01	9.90
BGM15/99	24.2	1.3	24.84	0.37	0.47	-2.58
BGM17/99	25.95	3.6	24.84	0.37	-0.31	4.47
BGM18/99	23	3	24.84	0.37	0.61	-7.41
BGM19/99	25.8	1.2	24.84	0.37	-0.76	3.86
BGM21/99	21.5	1.5	24.84	0.37	2.16	-13.45
BGM22/99	25.1	0.7	24.84	0.37	-0.33	1.05
BGM24/99	28.4	1.6	24.84	0.37	-2.17	14.33
BGM25/99	24.3	2.1	24.84	0.37	0.25	-2.17
BGM26/99	24.05	0.92	24.84	0.37	0.80	-3.18
BGM27/99	26.3	0.53	24.84	0.37	-2.26	5.88
BGM28/99	22.8	0.6	24.84	0.37	2.89	-8.21
BGM29/99	25.5	1.5	24.84	0.37	-0.43	2.66
BGM31/99	23.58	0.96	24.84	0.37	1.22	-5.07

Table 42 - Results for ^{60}Co (Intermediate Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{60}Co Bq kg^{-1}	± Bq kg^{-1}	^{60}Co Bq kg^{-1}	± Bq kg^{-1}		
BGM03/99	25.2	0.6	24.25	0.33	-1.39	3.92
BGM04/99	23.7	1.3	24.25	0.33	0.41	-2.27
BGM05/99	24.1	1.89	24.25	0.33	0.08	-0.62
BGM06/99	23.38	0.94	24.25	0.33	0.87	-3.59
BGM07/99	23.5	0.3	24.25	0.33	1.68	-3.09
BGM08/99	25.2	3.6	24.25	0.33	-0.26	3.92
BGM10/99	24	0.4	24.25	0.33	0.48	-1.03
BGM11/99	21.37	0.68	24.25	0.33	3.81	-11.88
BGM12/99	21.27	0.51	24.25	0.33	4.91	-12.29
BGM13/99	24.5	0.5	24.25	0.33	-0.42	1.03
BGM14/99	24.1	2.3	24.25	0.33	0.06	-0.62
BGM15/99	24.7	1.4	24.25	0.33	-0.31	1.86
BGM17/99	26.16	3.6	24.25	0.33	-0.53	7.88
BGM18/99	24	2	24.25	0.33	0.12	-1.03
BGM19/99	25.4	0.8	24.25	0.33	-1.33	4.74
BGM21/99	24.91	0.39	24.25	0.33	-1.29	2.72
BGM22/99	24.1	0.4	24.25	0.33	0.29	-0.62
BGM24/99	27.3	1.4	24.25	0.33	-2.12	12.58
BGM25/99	24.9	2	24.25	0.33	-0.32	2.68
BGM26/99	23.97	0.85	24.25	0.33	0.31	-1.15
BGM27/99	25.6	0.49	24.25	0.33	-2.29	5.57
BGM28/99	20.4	0.6	24.25	0.33	5.62	-15.88
BGM29/99	24.5	1	24.25	0.33	-0.24	1.03
BGM31/99	24.6	1.71	24.25	0.33	-0.20	1.44

Table 43 - Results for ^{65}Zn (Intermediate Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{65}Zn Bq kg^{-1}	± Bq kg^{-1}	^{65}Zn Bq kg^{-1}	± Bq kg^{-1}		
BGM03/99	27.3	0.7	27.26	0.64	-0.04	0.15
BGM04/99	28.8	1.6	27.26	0.64	-0.89	5.65
BGM05/99	28.6	2.65	27.26	0.64	-0.49	4.92
BGM06/99	31.4	1.64	27.26	0.64	-2.35	15.19
BGM07/99	28.5	0.9	27.26	0.64	-1.12	4.55
BGM08/99	30	4.2	27.26	0.64	-0.64	10.05
BGM10/99	27.5	1	27.26	0.64	-0.20	0.88
BGM11/99	27.18	1.46	27.26	0.64	0.05	-0.29
BGM12/99	22.77	1.13	27.26	0.64	3.46	-16.47
BGM13/99	28.8	1.7	27.26	0.64	-0.85	5.65
BGM14/99	29	2.4	27.26	0.64	-0.70	6.38
BGM15/99	28.4	2	27.26	0.64	-0.54	4.18
BGM17/99	30.71	4.5	27.26	0.64	-0.76	12.66
BGM18/99	26	3	27.26	0.64	0.41	-4.62
BGM19/99	29.4	1.4	27.26	0.64	-1.39	7.85
BGM21/99	24.61	0.86	27.26	0.64	2.47	-9.72
BGM22/99	26.4	0.5	27.26	0.64	1.06	-3.15
BGM24/99	26.8	6.6	27.26	0.64	0.07	-1.69
BGM25/99	29	3.3	27.26	0.64	-0.52	6.38
BGM26/99	30.92	1.7	27.26	0.64	-2.01	13.43
BGM27/99	29.6	1.4	27.26	0.64	-1.52	8.58
BGM28/99	26.2	1.3	27.26	0.64	0.73	-3.89
BGM29/99	30.6	1.9	27.26	0.64	-1.67	12.25
BGM31/99	31.8	4.38	27.26	0.64	-1.03	16.65

Table 44 - Results for ^{124}Sb (Intermediate Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{124}Sb Bq kg^{-1}	± Bq kg^{-1}	^{124}Sb Bq kg^{-1}	± Bq kg^{-1}		
BGM03/99	29.6	1.9	25.63	0.42	-2.04	15.49
BGM04/99	25.7	1.7	25.63	0.42	-0.04	0.27
BGM05/99	29.3	4.74	25.63	0.42	-0.77	14.32
BGM06/99	19.56	2.7	25.63	0.42	2.22	-23.68
BGM07/99	27.2	1.4	25.63	0.42	-1.07	6.13
BGM08/99	23.4	3.1	25.63	0.42	0.71	-8.70
BGM11/99	37.43	2.62	25.63	0.42	-4.45	46.04
BGM12/99	22.94	2.09	25.63	0.42	1.26	-10.50
BGM13/99	26.2	4.4	25.63	0.42	-0.13	2.22
BGM14/99	28.7	3.9	25.63	0.42	-0.78	11.98
BGM15/99	29.9	3.8	25.63	0.42	-1.12	16.66
BGM17/99	29.68	4.3	25.63	0.42	-0.94	15.80
BGM18/99	26	4	25.63	0.42	-0.09	1.44
BGM19/99	23.9	1	25.63	0.42	1.60	-6.75
BGM21/99	25.9	1.9	25.63	0.42	-0.14	1.05
BGM22/99	25.3	0.9	25.63	0.42	0.33	-1.29
BGM25/99	24.7	3.4	25.63	0.42	0.27	-3.63
BGM26/99	26.44	1.95	25.63	0.42	-0.41	3.16
BGM27/99	25.1	1.6	25.63	0.42	0.32	-2.07
BGM28/99	24.9	1.9	25.63	0.42	0.38	-2.85
BGM29/99	24.2	4.5	25.63	0.42	0.32	-5.58
BGM31/99	23.91	1.82	25.63	0.42	0.92	-6.71

Table 45 - Results for ^{125}Sb (Intermediate Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{125}Sb Bq kg^{-1}	± Bq kg^{-1}	^{125}Sb Bq kg^{-1}	± Bq kg^{-1}		
BGM03/99	26.9	0.8	24.36	0.80	-2.25	10.43
BGM04/99	24.9	1.6	24.36	0.80	-0.30	2.22
BGM05/99	23.8	2.51	24.36	0.80	0.21	-2.30
BGM06/99	26.06	1.41	24.36	0.80	-1.05	6.98
BGM07/99	24	0.9	24.36	0.80	0.30	-1.48
BGM08/99	25.8	4.5	24.36	0.80	-0.32	5.91
BGM10/99	25.5	0.7	24.36	0.80	-1.07	4.68
BGM11/99	23.8	1.43	24.36	0.80	0.34	-2.30
BGM12/99	21.59	0.92	24.36	0.80	2.27	-11.37
BGM13/99	25.2	2.4	24.36	0.80	-0.33	3.45
BGM14/99	27	2.5	24.36	0.80	-1.01	10.84
BGM15/99	24.7	1.8	24.36	0.80	-0.17	1.40
BGM17/99	27.68	3.6	24.36	0.80	-0.90	13.63
BGM18/99	23	3	24.36	0.80	0.44	-5.58
BGM19/99	24.8	1	24.36	0.80	-0.34	1.81
BGM21/99	24.5	0.77	24.36	0.80	-0.13	0.57
BGM22/99	22.6	0.5	24.36	0.80	1.87	-7.22
BGM24/99	27.3	3.6	24.36	0.80	-0.80	12.07
BGM25/99	26.4	2.4	24.36	0.80	-0.81	8.37
BGM26/99	24.25	1.17	24.36	0.80	0.08	-0.45
BGM27/99	25.3	0.76	24.36	0.80	-0.85	3.86
BGM28/99	21.8	0.8	24.36	0.80	2.26	-10.51
BGM29/99	25	2	24.36	0.80	-0.30	2.63
BGM31/99	26.7	2.62	24.36	0.80	-0.85	9.61

Table 46 - Results for ^{134}Cs (Intermediate Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{134}Cs Bq kg^{-1}	± Bq kg^{-1}	^{134}Cs Bq kg^{-1}	± Bq kg^{-1}		
BGM03/99	24.9	0.6	25.87	0.43	1.31	-3.75
BGM04/99	25.1	1.5	25.87	0.43	0.49	-2.98
BGM05/99	25.9	1.86	25.87	0.43	-0.02	0.12
BGM06/99	23.61	0.97	25.87	0.43	2.13	-8.74
BGM07/99	22.3	0.7	25.87	0.43	4.35	-13.80
BGM08/99	27.7	3.4	25.87	0.43	-0.53	7.07
BGM10/99	24.4	0.6	25.87	0.43	1.99	-5.68
BGM11/99	21.35	0.74	25.87	0.43	5.28	-17.47
BGM12/99	21.63	0.54	25.87	0.43	6.14	-16.39
BGM13/99	24.1	0.7	25.87	0.43	2.15	-6.84
BGM14/99	23.5	2.3	25.87	0.43	1.01	-9.16
BGM15/99	25.4	1.5	25.87	0.43	0.30	-1.82
BGM17/99	26.09	3.6	25.87	0.43	-0.06	0.85
BGM18/99	25	2	25.87	0.43	0.43	-3.36
BGM19/99	24.5	0.8	25.87	0.43	1.51	-5.30
BGM21/99	24.66	0.44	25.87	0.43	1.97	-4.68
BGM22/99	26	0.5	25.87	0.43	-0.20	0.50
BGM24/99	27.6	1.3	25.87	0.43	-1.26	6.69
BGM25/99	25.2	2	25.87	0.43	0.33	-2.59
BGM26/99	23.84	0.92	25.87	0.43	2.00	-7.85
BGM27/99	25.4	0.49	25.87	0.43	0.72	-1.82
BGM28/99	20.3	0.6	25.87	0.43	7.55	-21.53
BGM29/99	23.9	1.2	25.87	0.43	1.55	-7.61
BGM31/99	24.89	1.90	25.87	0.43	0.50	-3.79

Table 47 - Results for ^{137}Cs (Intermediate Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{137}Cs Bq kg^{-1}	± Bq kg^{-1}	^{137}Cs Bq kg^{-1}	± Bq kg^{-1}		
BGM03/99	23.8	0.5	24.18	0.36	0.62	-1.57
BGM04/99	24.2	1.3	24.18	0.36	-0.01	0.08
BGM05/99	23.4	1.87	24.18	0.36	0.41	-3.23
BGM06/99	40.81	1.66	24.18	0.36	-9.79	68.78
BGM07/99	24.9	0.4	24.18	0.36	-1.34	2.98
BGM08/99	23.8	2.3	24.18	0.36	0.16	-1.57
BGM10/99	23.8	0.8	24.18	0.36	0.43	-1.57
BGM11/99	22.25	0.61	24.18	0.36	2.72	-7.98
BGM12/99	21.05	0.48	24.18	0.36	5.22	-12.94
BGM13/99	26.1	0.6	24.18	0.36	-2.74	7.94
BGM14/99	25.2	1.4	24.18	0.36	-0.71	4.22
BGM15/99	24	1.4	24.18	0.36	0.12	-0.74
BGM17/99	26.86	3.2	24.18	0.36	-0.83	11.08
BGM18/99	25	2	24.18	0.36	-0.40	3.39
BGM19/99	24.9	0.9	24.18	0.36	-0.74	2.98
BGM21/99	24.58	0.38	24.18	0.36	-0.76	1.65
BGM22/99	24.2	0.4	24.18	0.36	-0.04	0.08
BGM24/99	26.6	2.3	24.18	0.36	-1.04	10.01
BGM25/99	26	2.2	24.18	0.36	-0.82	7.53
BGM26/99	24.52	1	24.18	0.36	-0.32	1.41
BGM27/99	26.4	0.64	24.18	0.36	-3.02	9.18
BGM28/99	20.7	0.6	24.18	0.36	4.97	-14.39
BGM29/99	24.5	1.3	24.18	0.36	-0.24	1.32
BGM31/99	25.1	1.42	24.18	0.36	-0.63	3.80

Table 48 - Results for ^{154}Eu (Intermediate Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{154}Eu Bq kg^{-1}	± Bq kg^{-1}	^{154}Eu Bq kg^{-1}	± Bq kg^{-1}		
BGM03/99	25.5	0.8	25.36	0.44	-0.15	0.55
BGM04/99	28.5	2.3	25.36	0.44	-1.34	12.38
BGM05/99	26.3	2.56	25.36	0.44	-0.36	3.71
BGM06/99	24.73	1.07	25.36	0.44	0.54	-2.48
BGM07/99	23.7	0.8	25.36	0.44	1.82	-6.55
BGM08/99	23.5	4.1	25.36	0.44	0.45	-7.33
BGM10/99	20	0.5	25.36	0.44	8.05	-21.14
BGM11/99	21.03	3.27	25.36	0.44	1.31	-17.07
BGM12/99	19.53	2.27	25.36	0.44	2.52	-22.99
BGM13/99	15.1	1.1	25.36	0.44	8.66	-40.46
BGM14/99	23.3	4.4	25.36	0.44	0.47	-8.12
BGM15/99	26.8	4.8	25.36	0.44	-0.30	5.68
BGM17/99	25.18	3.6	25.36	0.44	0.05	-0.71
BGM18/99	23	3	25.36	0.44	0.78	-9.31
BGM19/99	24.4	0.9	25.36	0.44	0.96	-3.79
BGM21/99	22.8	1.2	25.36	0.44	2.00	-10.09
BGM22/99	23.7	0.5	25.36	0.44	2.49	-6.55
BGM24/99	26.8	2.9	25.36	0.44	-0.49	5.68
BGM25/99	22.4	1.9	25.36	0.44	1.52	-11.67
BGM26/99	24.51	1	25.36	0.44	0.78	-3.35
BGM27/99	24.1	0.54	25.36	0.44	1.81	-4.97
BGM28/99	22.6	0.7	25.36	0.44	3.34	-10.88
BGM29/99	22	1.4	25.36	0.44	2.29	-13.25
BGM31/99	23.79	1.00	25.36	0.44	1.44	-6.19

Table 49 - Results for ^{155}Eu (Intermediate Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{155}Eu Bq kg^{-1}	± Bq kg^{-1}	^{155}Eu Bq kg^{-1}	± Bq kg^{-1}		
BGM03/99	26.2	0.9	24.71	0.46	-1.47	6.03
BGM04/99	26.2	1.7	24.71	0.46	-0.85	6.03
BGM05/99	22.7	2.24	24.71	0.46	0.88	-8.13
BGM06/99	26.03	1.07	24.71	0.46	-1.13	5.34
BGM07/99	24.5	0.9	24.71	0.46	0.21	-0.85
BGM08/99	23.3	2.4	24.71	0.46	0.58	-5.71
BGM10/99	22.4	0.7	24.71	0.46	2.76	-9.35
BGM11/99	22.66	1.26	24.71	0.46	1.53	-8.30
BGM12/99	22.94	0.48	24.71	0.46	2.66	-7.16
BGM13/99	25.7	1	24.71	0.46	-0.90	4.01
BGM14/99	26.9	6.4	24.71	0.46	-0.34	8.86
BGM15/99	25	2.1	24.71	0.46	-0.13	1.17
BGM17/99	28.9	3.6	24.71	0.46	-1.15	16.96
BGM18/99	26	3	24.71	0.46	-0.43	5.22
BGM19/99	26.7	0.9	24.71	0.46	-1.97	8.05
BGM21/99	24.2	0.81	24.71	0.46	0.55	-2.06
BGM22/99	25.3	0.5	24.71	0.46	-0.87	2.39
BGM24/99	25	2.1	24.71	0.46	-0.13	1.17
BGM25/99	26.1	4.3	24.71	0.46	-0.32	5.63
BGM26/99	24.22	1	24.71	0.46	0.45	-1.98
BGM27/99	25.7	3.2	24.71	0.46	-0.31	4.01
BGM28/99	22.2	1	24.71	0.46	2.28	-10.16
BGM29/99	17.7	1.4	24.71	0.46	4.76	-28.37
BGM31/99	26	3.78	24.71	0.46	-0.34	5.22

Table 50 - Results for ^{57}Co (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{57}Co Bq g^{-1}	± Bq g^{-1}	^{57}Co Bq g^{-1}	± Bq g^{-1}		
BGH03/99	2.439	0.1810021	2.480	0.018	0.23	-1.65
BGH04/99	2.69	0.1	2.480	0.018	-2.07	8.47
BGH05/99	2.78	0.18	2.480	0.018	-1.66	12.10
BGH06/99	2.52	0.26	2.480	0.018	-0.15	1.61
BGH07/99(1)	2.45	0.03	2.480	0.018	0.86	-1.21
BGH07/99(2)	2.45	0.03	2.480	0.018	0.86	-1.21
BGH07/99(3)	2.44	0.03	2.480	0.018	1.14	-1.61
BGH08/99	2.778	0.426	2.480	0.018	-0.70	12.02
BGH10/99	4.403	0.005	2.480	0.018	-102.94	77.54
BGH11/99	2.29	0.033	2.480	0.018	5.05	-7.66
BGH12/99	2.332	0.2	2.480	0.018	0.74	-5.97
BGH13/99	2.5	0.2	2.480	0.018	-0.10	0.81
BGH18/99	2.44	0.05	2.480	0.018	0.75	-1.61
BGH19/99	1.77	0.01	2.480	0.018	34.48	-28.63
BGH20/99	2.577	0.015	2.480	0.018	-4.14	3.91
BGH20/99	2.601	0.01	2.480	0.018	-5.88	4.88
BGH20/99	2.573	0.008	2.480	0.018	-4.72	3.75
BGH20/99	2.558	0.007	2.480	0.018	-4.04	3.15
BGH20/99	2.557	0.006	2.480	0.018	-4.06	3.10
BGH20/99	2.522	0.007	2.480	0.018	-2.17	1.69
BGH21/99	2.53	0.07	2.480	0.018	-0.69	2.02
BGH24/99	2.474	0.075	2.480	0.018	0.08	-0.24
BGH25/99	2.4	0.09	2.480	0.018	0.87	-3.23
BGH26/99	2.45	0.05	2.480	0.018	0.56	-1.21
BGH27/99	2.57	0.072	2.480	0.018	-1.21	3.63

Table 51 - Results for ^{60}Co (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{60}Co Bq g^{-1}	± Bq g^{-1}	^{60}Co Bq g^{-1}	± Bq g^{-1}		
BGH03/99	2.4266	0.1801003	2.421	0.009	-0.03	0.23
BGH04/99	2.38	0.09	2.421	0.009	0.45	-1.69
BGH05/99	2.539	0.069	2.421	0.009	-1.70	4.87
BGH06/99	2.29	0.23	2.421	0.009	0.57	-5.41
BGH07/99(1)	2.45	0.03	2.421	0.009	-0.93	1.20
BGH07/99(2)	2.45	0.03	2.421	0.009	-0.93	1.20
BGH07/99(3)	2.43	0.03	2.421	0.009	-0.29	0.37
BGH08/99	2.603	0.487	2.421	0.009	-0.37	7.52
BGH10/99	2.649	0.007	2.421	0.009	-20.00	9.42
BGH11/99	2.402	0.033	2.421	0.009	0.56	-0.78
BGH12/99	2.358	0.2	2.421	0.009	0.31	-2.60
BGH13/99	2.4	0.2	2.421	0.009	0.10	-0.87
BGH18/99	2.22	0.06	2.421	0.009	3.31	-8.30
BGH19/99	2.08	0.01	2.421	0.009	25.35	-14.09
BGH20/99	2.523	0.022	2.421	0.009	-4.29	4.21
BGH20/99	2.516	0.011	2.421	0.009	-6.68	3.92
BGH20/99	2.546	0.009	2.421	0.009	-9.82	5.16
BGH20/99	2.495	0.009	2.421	0.009	-5.81	3.06
BGH20/99	2.538	0.006	2.421	0.009	-10.82	4.83
BGH20/99	2.473	0.007	2.421	0.009	-4.56	2.15
BGH21/99	2.5	0.07	2.421	0.009	-1.12	3.26
BGH24/99	2.444	0.064	2.421	0.009	-0.36	0.95
BGH25/99	2.32	0.08	2.421	0.009	1.25	-4.17
BGH26/99	2.45	0.05	2.421	0.009	-0.57	1.20
BGH27/99	2.5	0.054	2.421	0.009	-1.44	3.26

Table 52 - Results for ^{65}Zn (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{65}Zn Bq g^{-1}	± Bq g^{-1}	^{65}Zn Bq g^{-1}	± Bq g^{-1}		
BGH03/99	2.841	0.2132598	2.721	0.054	-0.55	4.41
BGH04/99	3.01	0.12	2.721	0.054	-2.20	10.62
BGH05/99	2.961	0.098	2.721	0.054	-2.14	8.82
BGH06/99	2.61	0.27	2.721	0.054	0.40	-4.08
BGH07/99(1)	3.06	0.11	2.721	0.054	-2.77	12.46
BGH07/99(2)	2.96	0.1	2.721	0.054	-2.10	8.78
BGH07/99(3)	2.93	0.1	2.721	0.054	-1.84	7.68
BGH08/99	3.053	0.598	2.721	0.054	-0.55	12.20
BGH10/99	3.280	0.018	2.721	0.054	-9.82	20.54
BGH11/99	2.62	0.036	2.721	0.054	1.56	-3.71
BGH12/99	2.787	0.25	2.721	0.054	-0.26	2.43
BGH13/99	2.7	0.2	2.721	0.054	0.10	-0.77
BGH18/99	2.5	0.14	2.721	0.054	1.47	-8.12
BGH20/99	2.97	0.101	2.721	0.054	-2.17	9.15
BGH20/99	3.039	0.037	2.721	0.054	-4.86	11.69
BGH20/99	3.122	0.031	2.721	0.054	-6.44	14.74
BGH20/99	2.92	0.024	2.721	0.054	-3.37	7.31
BGH20/99	3.081	0.016	2.721	0.054	-6.39	13.23
BGH20/99	2.913	0.019	2.721	0.054	-3.35	7.06
BGH21/99	2.7	0.08	2.721	0.054	0.22	-0.77
BGH24/99	2.861	0.089	2.721	0.054	-1.34	5.15
BGH25/99	2.9	0.13	2.721	0.054	-1.27	6.58
BGH26/99	2.87	0.07	2.721	0.054	-1.69	5.48
BGH27/99	3.05	0.085	2.721	0.054	-3.27	12.09

Table 53 - Results for ^{124}Sb (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{124}Sb Bq g^{-1}	± Bq g^{-1}	^{124}Sb Bq g^{-1}	± Bq g^{-1}		
BGH03/99	2.4861	0.2014355	2.558	0.026	0.35	-2.81
BGH04/99	2.08	0.09	2.558	0.026	5.10	-18.69
BGH05/99	2.58	0.23	2.558	0.026	-0.10	0.86
BGH06/99	2.35	0.24	2.558	0.026	0.86	-8.13
BGH07/99(1)	2.7	0.1	2.558	0.026	-1.37	5.55
BGH07/99(2)	2.57	0.09	2.558	0.026	-0.13	0.47
BGH07/99(3)	2.5	0.08	2.558	0.026	0.69	-2.27
BGH08/99	2.693	0.454	2.558	0.026	-0.30	5.28
BGH10/99	2.446	0.018	2.558	0.026	3.54	-4.38
BGH11/99	2.582	0.06	2.558	0.026	-0.37	0.94
BGH12/99	2.841	0.25	2.558	0.026	-1.13	11.06
BGH13/99	2.6	0.2	2.558	0.026	-0.21	1.64
BGH18/99	2.26	0.33	2.558	0.026	0.90	-11.65
BGH20/99	2.57	0.098	2.558	0.026	-0.12	0.47
BGH20/99	2.509	0.037	2.558	0.026	1.08	-1.92
BGH20/99	2.551	0.031	2.558	0.026	0.17	-0.27
BGH20/99	2.492	0.036	2.558	0.026	1.49	-2.58
BGH20/99	2.48	0.021	2.558	0.026	2.33	-3.05
BGH20/99	2.429	0.039	2.558	0.026	2.75	-5.04
BGH21/99	2.48	0.09	2.558	0.026	0.83	-3.05
BGH24/99	0.83	0.048	2.558	0.026	31.65	-67.55
BGH25/99	2.45	0.12	2.558	0.026	0.88	-4.22
BGH26/99	2.5	0.1	2.558	0.026	0.56	-2.27
BGH27/99	2.63	0.758	2.558	0.026	-0.09	2.81

Table 54 - Results for ^{125}Sb (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{125}Sb Bq g^{-1}	± Bq g^{-1}	^{125}Sb Bq g^{-1}	± Bq g^{-1}		
BGH03/99	2.4511	0.1859429	2.431	0.073	-0.10	0.83
BGH04/99	2.52	0.1	2.431	0.073	-0.72	3.66
BGH05/99	2.372	0.089	2.431	0.073	0.51	-2.43
BGH06/99	2.31	0.24	2.431	0.073	0.48	-4.98
BGH07/99(1)	2.37	0.09	2.431	0.073	0.53	-2.51
BGH07/99(2)	2.39	0.09	2.431	0.073	0.35	-1.69
BGH07/99(3)	2.39	0.09	2.431	0.073	0.35	-1.69
BGH08/99	2.595	0.515	2.431	0.073	-0.32	6.75
BGH10/99	2.374	0.013	2.431	0.073	0.77	-2.34
BGH11/99	2.351	0.027	2.431	0.073	1.03	-3.29
BGH12/99	2.388	0.2	2.431	0.073	0.20	-1.77
BGH13/99	2.3	0.2	2.431	0.073	0.62	-5.39
BGH18/99	2.34	0.15	2.431	0.073	0.55	-3.74
BGH19/99	2.3	0.02	2.431	0.073	1.73	-5.39
BGH20/99	2.46	0.071	2.431	0.073	-0.28	1.19
BGH20/99	2.38	0.031	2.431	0.073	0.64	-2.10
BGH20/99	2.576	0.031	2.431	0.073	-1.83	5.96
BGH20/99	2.46	0.029	2.431	0.073	-0.37	1.19
BGH20/99	2.542	0.014	2.431	0.073	-1.49	4.57
BGH20/99	2.34	0.019	2.431	0.073	1.21	-3.74
BGH21/99	2.42	0.07	2.431	0.073	0.11	-0.45
BGH24/99	2.144	0.064	2.431	0.073	2.96	-11.81
BGH25/99	2.39	0.11	2.431	0.073	0.31	-1.69
BGH26/99	2.3	0.08	2.431	0.073	1.21	-5.39
BGH27/99	2.46	0.078	2.431	0.073	-0.27	1.19

Table 55 - Results for ^{134}Cs (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{134}Cs Bq g^{-1}	± Bq g^{-1}	^{134}Cs Bq g^{-1}	± Bq g^{-1}		
BGH03/99	2.3155	0.1722721	2.583	0.027	1.53	-10.36
BGH04/99	2.33	0.09	2.583	0.027	2.69	-9.79
BGH05/99	2.621	0.08	2.583	0.027	-0.45	1.47
BGH06/99	2.24	0.23	2.583	0.027	1.48	-13.28
BGH07/99(1)	2.33	0.08	2.583	0.027	3.00	-9.79
BGH07/99(2)	2.26	0.08	2.583	0.027	3.83	-12.50
BGH07/99(3)	2.3	0.08	2.583	0.027	3.35	-10.96
BGH08/99	2.648	0.473	2.583	0.027	-0.14	2.52
BGH10/99	2.556	0.007	2.583	0.027	0.97	-1.05
BGH11/99	2.48	0.018	2.583	0.027	3.17	-3.99
BGH12/99	2.295	0.2	2.583	0.027	1.43	-11.15
BGH13/99	2.5	0.2	2.583	0.027	0.41	-3.21
BGH18/99	2.24	0.09	2.583	0.027	3.65	-13.28
BGH19/99	1.99	0.01	2.583	0.027	20.60	-22.96
BGH20/99	2.455	0.025	2.583	0.027	3.48	-4.96
BGH20/99	2.404	0.013	2.583	0.027	5.97	-6.93
BGH20/99	2.35	0.01	2.583	0.027	8.09	-9.02
BGH20/99	2.459	0.011	2.583	0.027	4.25	-4.80
BGH20/99	2.366	0.007	2.583	0.027	7.78	-8.40
BGH20/99	2.406	0.009	2.583	0.027	6.22	-6.85
BGH21/99	2.49	0.07	2.583	0.027	1.24	-3.60
BGH24/99	2.343	0.062	2.583	0.027	3.55	-9.29
BGH25/99	2.34	0.09	2.583	0.027	2.59	-9.41
BGH26/99	2.43	0.05	2.583	0.027	2.69	-5.92
BGH27/99	2.45	0.156	2.583	0.027	0.84	-5.15

Table 56 - Results for ^{137}Cs (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{137}Cs Bq g^{-1}	± Bq g^{-1}	^{137}Cs Bq g^{-1}	± Bq g^{-1}		
BGH03/99	2.4156	0.1794217	2.414	0.019	-0.01	0.07
BGH04/99	2.69	0.1	2.414	0.019	-2.71	11.43
BGH05/99	2.585	0.055	2.414	0.019	-2.94	7.08
BGH06/99	2.32	0.24	2.414	0.019	0.39	-3.89
BGH07/99(1)	2.37	0.04	2.414	0.019	0.99	-1.82
BGH07/99(2)	2.42	0.04	2.414	0.019	-0.14	0.25
BGH07/99(3)	2.44	0.03	2.414	0.019	-0.73	1.08
BGH08/99	2.571	0.387	2.414	0.019	-0.41	6.50
BGH10/99	2.64	0.007	2.414	0.019	-11.16	9.36
BGH11/99	2.38	0.015	2.414	0.019	1.40	-1.41
BGH12/99	2.486	0.2	2.414	0.019	-0.36	2.98
BGH13/99	2.4	0.2	2.414	0.019	0.07	-0.58
BGH18/99	2.15	0.06	2.414	0.019	4.19	-10.94
BGH19/99	2.46	0.01	2.414	0.019	-2.14	1.91
BGH20/99	2.521	0.028	2.414	0.019	-3.16	4.43
BGH20/99	2.591	0.015	2.414	0.019	-7.31	7.33
BGH20/99	2.621	0.013	2.414	0.019	-8.99	8.57
BGH20/99	2.534	0.01	2.414	0.019	-5.59	4.97
BGH20/99	2.611	0.007	2.414	0.019	-9.73	8.16
BGH20/99	2.507	0.009	2.414	0.019	-4.42	3.85
BGH21/99	2.39	0.06	2.414	0.019	0.38	-0.99
BGH24/99	2.499	0.071	2.414	0.019	-1.16	3.52
BGH25/99	2.42	0.08	2.414	0.019	-0.07	0.25
BGH26/99	2.44	0.05	2.414	0.019	-0.49	1.08
BGH27/99	2.52	0.056	2.414	0.019	-1.79	4.39

Table 57 - Results for ^{154}Eu (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{154}Eu Bq g^{-1}	± Bq g^{-1}	^{154}Eu Bq g^{-1}	± Bq g^{-1}		
BGH03/99	2.3874	0.1875737	2.531	0.029	0.76	-5.67
BGH04/99	2.36	0.09	2.531	0.029	1.81	-6.76
BGH05/99	2.329	0.089	2.531	0.029	2.16	-7.98
BGH06/99	2.06	0.21	2.531	0.029	2.22	-18.61
BGH07/99(1)	2.56	0.09	2.531	0.029	-0.31	1.15
BGH07/99(2)	2.55	0.09	2.531	0.029	-0.20	0.75
BGH07/99(3)	2.42	0.08	2.531	0.029	1.30	-4.39
BGH08/99	2.593	0.504	2.531	0.029	-0.12	2.45
BGH10/99	2.768	0.027	2.531	0.029	-5.98	9.36
BGH11/99	2.312	0.083	2.531	0.029	2.49	-8.65
BGH12/99	2.271	0.2	2.531	0.029	1.29	-10.27
BGH13/99	2.4	0.2	2.531	0.029	0.65	-5.18
BGH18/99	2.02	0.21	2.531	0.029	2.41	-20.19
BGH19/99	2.17	0.02	2.531	0.029	10.25	-14.26
BGH20/99	2.678	0.059	2.531	0.029	-2.24	5.81
BGH20/99	2.522	0.028	2.531	0.029	0.22	-0.36
BGH20/99	2.461	0.024	2.531	0.029	1.86	-2.77
BGH20/99	2.29	0.03	2.531	0.029	5.78	-9.52
BGH20/99	2.492	0.019	2.531	0.029	1.12	-1.54
BGH20/99	2.463	0.019	2.531	0.029	1.96	-2.69
BGH21/99	2.44	0.06	2.531	0.029	1.37	-3.60
BGH24/99	2.208	0.064	2.531	0.029	4.60	-12.76
BGH25/99	2.34	0.09	2.531	0.029	2.02	-7.55
BGH26/99	2.3	0.06	2.531	0.029	3.47	-9.13
BGH27/99	2.57	0.072	2.531	0.029	-0.50	1.54

Table 58 - Results for ^{155}Eu (High Level)

Sample	Analyst Data		NPL Data		u-test statistic	Deviation (%)
	^{155}Eu Bq g^{-1}	± Bq g^{-1}	^{155}Eu Bq g^{-1}	± Bq g^{-1}		
BGH03/99	2.5747	0.1918101	2.467	0.033	-0.55	4.37
BGH04/99	2.54	0.1	2.467	0.033	-0.69	2.96
BGH05/99	2.73	0.21	2.467	0.033	-1.24	10.66
BGH06/99	2.24	0.23	2.467	0.033	0.98	-9.20
BGH07/99(1)	2.58	0.1	2.467	0.033	-1.07	4.58
BGH07/99(2)	2.54	0.1	2.467	0.033	-0.69	2.96
BGH07/99(3)	2.57	0.11	2.467	0.033	-0.90	4.18
BGH08/99	2.48	0.412	2.467	0.033	-0.03	0.53
BGH10/99	2.879	0.014	2.467	0.033	-11.49	16.70
BGH11/99	2.871	0.014	2.467	0.033	-11.27	16.38
BGH12/99	2.535	0.23	2.467	0.033	-0.29	2.76
BGH13/99	2.9	0.3	2.467	0.033	-1.43	17.55
BGH18/99	2.31	0.06	2.467	0.033	2.29	-6.36
BGH19/99	2.21	0.02	2.467	0.033	6.66	-10.42
BGH20/99	2.585	0.025	2.467	0.033	-2.85	4.78
BGH20/99	2.475	0.014	2.467	0.033	-0.22	0.32
BGH20/99	2.545	0.011	2.467	0.033	-2.24	3.16
BGH20/99	2.525	0.017	2.467	0.033	-1.56	2.35
BGH20/99	2.555	0.009	2.467	0.033	-2.57	3.57
BGH20/99	2.424	0.008	2.467	0.033	1.27	-1.74
BGH21/99	2.45	0.09	2.467	0.033	0.18	-0.69
BGH24/99	2.572	0.076	2.467	0.033	-1.27	4.26
BGH25/99	2.31	0.09	2.467	0.033	1.64	-6.36
BGH26/99	2.51	0.06	2.467	0.033	-0.63	1.74
BGH27/99	2.62	0.116	2.467	0.033	-1.27	6.20

Table 59 - Other reported radionuclides

Sample identifier	Radionuclide	Reported activity concentration	Overall uncertainty
ABL14/99	Gross α	3.5 Bq/l	2 %
ABL14/99	Gross β	6.3 Bq/l	1 %
ABH15/99	Gross β	7.7 Bq/ml	0.12 Bq/ml
BGL12/99	^{46}Sc	not reported	-
BGM10/99	^{95}Zr	11.3 Bq/kg	2.5 Bq/kg
BGM13/99	^{22}Na, ^{46}Sc and ^{40}K	not reported	-
BGH19/99	^{170}Tm	1.8 Bq/g	0.4 Bq/g

APPENDIX 1

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