PRIORITY AREA
ENVIRONMENTAL SECURITY

ASSESSMENT METHODOLOGIES FOR SOIL/GROUNDWATER CONTAMINATION AT FORMER MILITARY BASES IN LITHUANIA,

PART TWO: A DEMONSTRATION OF RADIOLOGICAL DECOMMISSIONING FOR THE LITHUANIAN MILITARY BASE «PAJUOSTE»

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SCIENTIFIC AFFAIRS DIVISION

NGU Report 96.147

Assessment Methodologies for
Soil/Groundwater Contamination at Former
Military Bases in Lithuania.
Part two: A demonstration of Radiological
Decommissioning for the Lithuanian Military
Base: Pajuoste.

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REPORT

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Title:
Assessment Methodologies for Soil/Groundwater Contamination at Former Military Bases in Lithuania.
Part two: A Demonstration of Radiological Decommissioning for the Lithuanian Military Base: Pajuoste

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Summary:
An international team consisting of scientists from the Geological Survey of Lithuania, the Geological Survey of Norway, the Canadian Department of National Defence and the Norwegian Defence Research Establishment were awarded a NATO Scientific Affairs Division Grant for the development of a methodology for investigation of soil/groundwater contamination at former military sites in Lithuania. The results of part two of this study concerning radiological aspects are presented in this report.

During the period 17 August to 23 September 1994 the Canadian Department of National Defence (DND) participated in examine groundwater contamination at the Lithuanian Military Base "Pajuoste". Part of this demonstration involved the analysis of groundwater samples for radiological contamination. Since the most probable pathway for radiological contamination is from surface leachate, it was first necessary to survey the surface area of the base, for the presence of radioactive contaminants. Therefore, the radiological decommissioning portion of the Canadian demonstration project included both a survey of surface conditions (land and buildings), and an analysis of environmental samples (soil and water).

For those sites surveyed at Pajuoste, during the demonstration project, it is unlikely that radiological contamination will have any adverse impact on human health and safety. Results of the demonstration revealed that background radiation levels in environmental samples (soil and water) were roughly equivalent to those found in Canada.

The readings taken off base (e.g. at the Air Maintenance Depot) revealed the presence of surface and sub-surface contamination levels, in excess of the limits authorized in Canada. Until such time as all radioactive contamination has been remediated to more acceptable levels, it is recommended that:

A barrier be erected around the contaminated area; and
Access to the contaminated area be strictly controlled by local authorities.

Keywords: Hydrogeology	Military bases	Landfill
Contamination	Groundwater	Radiological investigation
Decommissioning	Methodologies	

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Demonstration Project Overview

Recap of Events

During the period 17 August to 23 September 1994 the Canadian Department of National Defence (DND) participated in a NATO/NACC CCMS pilot study project, to examine groundwater contamination at the Lithuanian Military Base "Pajuoste". Part of this demonstration involved the analysis of groundwater samples for radiological contamination. Since the most probable pathway for radiological contamination is from surface leachate, it was first necessary to survey the surface area of the base, for the presence of radioactive contaminants. Therefore, the radiological decommissioning portion of the Canadian demonstration project included both a survey of surface conditions (land and buildings), and an analysis of environmental samples (soil and water). Radiological survey protocols and data, coupled with laboratory results and analyses, form the basis of this part of the report.

Description of Phases One and Two Work

The Canadian model used for demonstrating radiological decommissioning, consisted of a two phased approach. Phase One involved investigating and prioritizing possible sites where radiological contamination could be located. Phase One activities included:

- Analyzing satellite photographs and Geographical Information System (GIS) data;
- Identifying areas on base where hazardous material may have been used, stored, handled or disposed; stressed vegetation was visible; and Phase 2 survey work (surveying and sampling) should be conducted;
- Obtaining inputs from Lithuanian and Norwegian subject matter experts during their visit to Canada (25 August - 02 September 1994);
- Coordinating site specific information from base personnel;
- Selecting and prioritizing sites for subsequent Phase 2 survey work; and
- Developing a demonstration Phase 2 survey protocol.

Phase Two of the demonstration project involved the following on-site survey activities:

- Characterizing background radiation levels at Pajuoste;
- Surveying an Air Maintenance Depot, located South West of the City of Panevezys;
- Surveying prioritized sites in accordance with the demonstration survey protocol developed in Phase One; and
- Verifying the capability of the survey equipment to detect sub-surface radiological contamination.

Summary of Demonstration Project Results

Results of the demonstration revealed that background radiation levels in environmental samples (soil and water) were roughly equivalent to those found in Canada. However, background radiation levels measured with the General Purpose Survey Meter (GPSM) were approximately twice those normally experienced in Canada.

During the survey of the Air Maintenance Depot (located South West of the City of

Panevezys), levels of radioactivity, well above Canadian permissible limits, were detected. However, no radioactivity, significantly over background was detected at any of the sites surveyed at Pajuoste.

Although no significant levels of radiological contamination were found in environmental samples, or on the base at Pajuoste, the Canadian survey team was unable to render any conclusions regarding the effectiveness of the survey equipment for detecting radioactive contaminants, buried beneath the soil. In order to gain a better insight into the variation between radioactivity measured on the surface versus the depth of radioactive contamination beneath the soil, a separate computer simulation was performed on return to Canada. In this simulation, a number of known radioactive components were buried at various depths beneath the soil. Next, using the Canadian radiological survey instrumentation suite, a number of readings were taken at different depths beneath the soil. Finally, using a detection limit of twice the Canadian background, the following observations were rendered:

- Low level radioactive waste buried within the first 15 cm of the soil, could be readily detected;
- High level radioactive waste buried within 2.5 m of the surface, could be readily detected; and
- Low level radioactive waste buried at depths exceeding 15 cm, would not be easily detected.

These results rendered a reasonable level of confidence that the Canadian radiological survey instrumentation was sensitive enough to detect radiological contaminants buried within the first 15 cm of the soil.

Demonstration results, have been summarized in Part 3.0 of the report.

Demonstration Project Conclusions and Recommendations

For those sites surveyed at Pajuoste, during the demonstration project, it is unlikely that radiological contamination will have any adverse impact on human health and safety.

The readings taken off base (ie. at the Air Maintenance Depot) revealed the presence of surface and sub-surface contamination levels, in excess of the limits authorized in Canada. Until such time as all radioactive contamination has been remediated to more acceptable levels, it is recommended that:

- A barrier be erected around the contaminated area; and
- Access to the contaminated area be strictly controlled by local authorities.

1.0 INTRODUCTION

1.1 Background

As part of the NATO/NACC CCMS pilot project, a joint study was convened to analyze groundwater contamination at the Lithuanian Military Base "Pajuoste". Part of this demonstration involved the analysis of groundwater samples for radiological contamination. Since the most probable pathway for radiological contamination is from surface leachate, it was necessary to survey the surface of the base (land and buildings) and to collect environmental samples (soil and water), from locations both on and off the base.

The radiological decommissioning program adopted for this demonstration was a modified version of that used by the Canadian Department of National Defence (DND). It involved a two phased approach:

Phase 1 Identification and prioritization all sites suspected of being contaminated with radioactive material, and the quantification of survey requirements for phase 2 work.

Phase 2 Location, identification and quantification of radiological contamination and the recommendation of alternatives for remediating those locations identified as containing radiological contamination.

The modified two phased approach was demonstrated during the period 17 Aug - 02 Sep 94 and 20 - 21 Sep 94, respectively.

The Canadian Radiological Survey team consisted of the following personnel:

1. Capt(N) R. Starchuk (DND's - Director General Nuclear Safety (DGNS));
2. Bob Novitsky (Radiological Surveyor, NOTRA Environmental Services Inc.); and
3. Stephen Burns (Radiological Surveyor, NOTRA Environmental Services Inc.).

2.0 PHASE 1 SURVEY WORK

2.1 Pre-Visit Research

Prior to visiting Pajuoste and in order to gain a better appreciation of the past and present operations involving the management of radioactive isotopes on the base, the following pre-visit research activities were conducted:

1. Remote Sensing Analysis (which included the use of 20 meter Spot Image satellite photographs and a Spans based Geographical Information System (GIS) to produce digital elevation models); and
2. Discussions with Lithuanian and Norwegian Subject Matter Experts.

2.2 Remote Sensing Analysis

Through the use of remote sensing techniques, specific environmental information was obtained, analyzed and interpreted for the base. It should be noted that such information was obtained prior to any visit being made to Pajuoste. Remote sensing information included:

1. Identification of areas on base where hazardous materials may have been handled, transported, stored, used or disposed;
2. Identification of areas on the base that indicated the presence of stressed vegetation (indicative of areas where environmental damage may have occurred);
3. Identification of areas on base where background and environmental samples could be taken;
4. Identification of areas on base where Phase 2 survey work (sampling) could be conducted; and
5. Provision to the survey team of a current and scaled photographic representation of the base.

Annex A contains two Spot Image satellite photographs and two GIS digital elevation models of Pajuoste.

Through the use of remote sensing, ten (10) sites were selected. These sites have been identified in Annex B.

2.3 Discussions with Lithuanian and Norwegian Subject Matter Experts

During seminars sponsored by the Canadian Department of National Defence (25 August - 02 September 1994 inclusive), Lithuanian and Norwegian subject matter experts provided information and maps of the base. These inputs were further used to substantiate the selection of the ten (10) survey sites, identified in Annex B.

Additionally, during this same period, Lithuanian and Norwegian subject matter experts visited Atomic Energy of Canada Limited (AECL's) Chalk River Laboratories, to discuss Canadian experiences related to remediation of radioactive leachate in groundwater.

2.4 Coordinating Site Specific Information

On Tuesday, the 20th of September 1994, the survey team arrived at Pajuoste. A thorough tour of the base was provided and a familiarization meeting was conducted by the Base Commander (Captain Algis Arlauskas, Lithuanian Air Force). The following information was obtained:

1. Locations on the base where local authorities suspected that radioactive materials may have been handled, transported, stored, used and/or disposed; and
2. Locations on the base where potential environmental problem areas may exist (ie. old landfill sites and dumps).

2.5 Site Selection

Radiological survey sites were selected and prioritized based on the information received from the following:

1. Remote Sensing Analysis (conducted during the period 17 - 23 Aug 1994);
2. Discussions with Lithuanian and Norwegian Subject Matter Experts 25 Aug and 02 Sep 94); and
3. Discussions with the Base Commander (Captain Algis Arlauskas, Lithuanian Air Force) (conducted on 20 Sep 94).

Based on the above, fifteen (15) sites were selected for Phase 2 survey work.

The site labelling technique adopted by the survey team, to code its survey sites and sampling locations, consisted of the following alphanumeric identifier:

"PA - 01 - 02"

Where:

PA = the identifier for Pajuoste;
01 = the site number as assigned by the project team;
02 = number of the environmental sample or the swipe number taken in that particular building/survey site (used for Phase 2 work).

The fifteen (15) sites selected for Phase 2 survey work included:

SITE #	DESCRIPTION
PA - 01	Background Site for Environmental Samples
PA - 02	Environmental Site
PA - 03	Environmental Site
PA - 04	Environmental Site
PA - 05	Chemical Storage
PA - 06	Lab - Objective Monitoring
PA - 07	Trainer Hanger
PA - 08	Antenna Tower
PA - 09	Guard House
PA - 10	Bomb Storage
PA - 11	Air Armament Storage
PA - 12	Dump Site/Landfill
PA - 13	Snow Plow Area
PA - 14	Radiac Lab
PA - 15	Radar Site

These sites have been superimposed on the Spot Image photograph contained in Annex C.

2.6 Radiological Survey Protocol

A modified Phase 2 radiological survey protocol was developed specifically for this demonstration project (Annex D, refers).

3.0 PHASE 2 RESULTS AND DISCUSSION

3.1 Equipment

The equipment used to perform the radiological survey included:

1. An Eberline, General Purpose Survey Meter (GPSM) for measuring radiation field intensities in msv/hr; and
2. An EG & G Berthold, Area Contamination Monitor (ACM), for measuring activities per square centimetre (in Bq/cm^2) for fixed and removable (loose) contamination.

3.2 Background Characterization

Background characterization results for the GPSM and ACM, are tabularized in Annex E.

In accordance with the survey protocol, background characterization measurements were also taken at an Easterly location, off-base and up-stream from Pajuoste (Annex C, site PA - 01, refers). Soil and water samples were sent to the Royal Military College of Canada (RMC) for gamma spectroscopy and liquid scintillation analyses.

RMC results indicated the presence of radioactive material, at activity levels below background (Annex F, refers).

3.3 Air Maintenance Depot Survey

On request of the Base Commander, the survey team travelled South West of the city of Panevezys, to survey an area of suspected radiological contamination. The survey team was advised, by local authorities, that radioactive materials were suspected of being buried in an area of approximately 100 m^2 (Annex G, Photo #1 refers). This area was surveyed and the subsequent results confirmed that radiological contamination did in fact exist at this site. Survey results revealed:

1. A maximum GPSM reading of 0.8 msv/hr at 50 cm, from the surface;
2. A maximum ACM (beta/gamma) reading of 12.4 Bq/cm^2 at 0.5 cm, from the surface; and
3. A maximum ACM (alpha) reading of 0.05 Bq/cm^2 at 0.5 cm, from the surface.

These readings indicated the presence of radiological contamination at levels in excess of those limits authorized in Canada (Annex D, Phase 2 radiological survey protocol, refers).

Prior to departure from the site, and for the benefit of local authorities, the survey team developed an iso dose schematic of the contaminated area, and left it in the custody of local authorities.

3.4 GPSM, ACM and Swipe Survey Results - Pajuoste

Results - Pajuoste

Survey results for Pajuoste, are tabularized in Annex E. Additionally, photos from survey sites PA - 02, 07 and 12, numbered 2, 3 and 4 respectively, are contained in Annex G.

The five (5) swipes taken from survey sites PA - 10 - 01 to 05 were sent to Chalk River Laboratories (in Canada) for liquid scintillation analysis. Analytical results (for beta/gamma and alpha) were below the detectable limit of the equipment (Annex H, refers).

Discussion

GPSM, ACM and swipe results revealed no sources of fixed or loose radiological contamination (in excess of the limits prescribed by the survey protocol), for beta/gamma or alpha emitting radionuclides.

3.5 Environmental Sample Survey Results - Pajuoste

Results

Four (4) environmental water samples (Annex C, survey sites PA - 02, 03, 04 and 12, refer) and three (3) environmental soil samples (Annex C, survey sites PA - 02, 03 and 04, refer), were collected by the survey team. Soil and water samples were sent to the Royal Military College of Canada (RMC) for both gamma spectroscopy and liquid scintillation analyses (Annex F, refers).

Discussion

RMC results indicated the presence of radioactive materials, at levels at or below background. The radioactive substances derive from the families of uranium (U - 238), thorium (Th - 232) and potassium (K - 40), all of which occur naturally in minute concentrations, as part of the mineral constituents in most water and soils. In addition, cesium (Cs - 137), a by-product of nuclear testing in the atmosphere, was also present in trace amounts.

3.6 DGNS Equipment Verification

Results

While on base, radiological survey equipment was calibrated daily. The accuracy of the equipment was confirmed through the use of calibrated, standard sources. The survey team were therefore confident of the validity and accuracy of their survey results.

Although no serious surface radiological contamination was detected at Pajuoste, the survey team was unable to render any conclusions regarding the effectiveness of the survey equipment for detecting radioactive contaminants buried beneath the soil. On return to Canada, computer simulations were conducted in order to determine a relationship between radioactivity and depth of radioactive sources beneath the soil. In these simulations, a number of radioactive aircraft dials (of varying activities) were buried at depths ranging from 0.1 to 1.0 meter beneath the soil. Using the

Canadian radiological survey instrumentation and a detection limit of twice the Canadian background, a number of readings were taken. A correlation was subsequently made between radioactivity and depth of radioactive sources beneath the soil. The results of this study are contained in Annex I.

Discussion

Based on an analysis of the results contained in Annex I, the following observations were rendered:

1. Low level radioactive waste buried within the first 15 cm of the soil, could be readily detected;
2. High level radioactive waste buried within 2.5 m of the surface, could be readily detected; and
3. Low level radioactive waste buried at depths exceeding 15 cm, would not be easily detected.

These results rendered a reasonable level of confidence that the Canadian radiological survey instrumentation was sensitive enough to detect radiological contamination buried within the first 15 cm of the soil.

4.0 CONCLUSIONS

Based on the results obtained, the following conclusions are rendered:

1. Background environmental samples for water and soil revealed no abnormalities.

2. Field intensity background readings established using the GPSM, were approximately twice the Canadian level.

3. Beta/gamma and alpha background readings established using the ACM, revealed no abnormalities.

4. Radioactivity (in excess of the limits prescribed in Annex D), was detected in a grassy area, at an Air Maintenance Depot, South West of the city of Panevezys (Part 3.3, refers).

5. Based on a radiological survey of fifteen (15) sites at Pajuoste, no radioactivity significantly over background was detected. Therefore, for those sites surveyed, it is unlikely that radiological contamination will have any adverse impact on human health and safety.

6. The GPSM is capable of detecting low level radioactive waste buried within the first 15 cm of the soil, and high level waste buried within the first 2.5 m of the soil. However, low level radioactive waste buried at depths below 15 cm, cannot be detected with any degree of certainty.

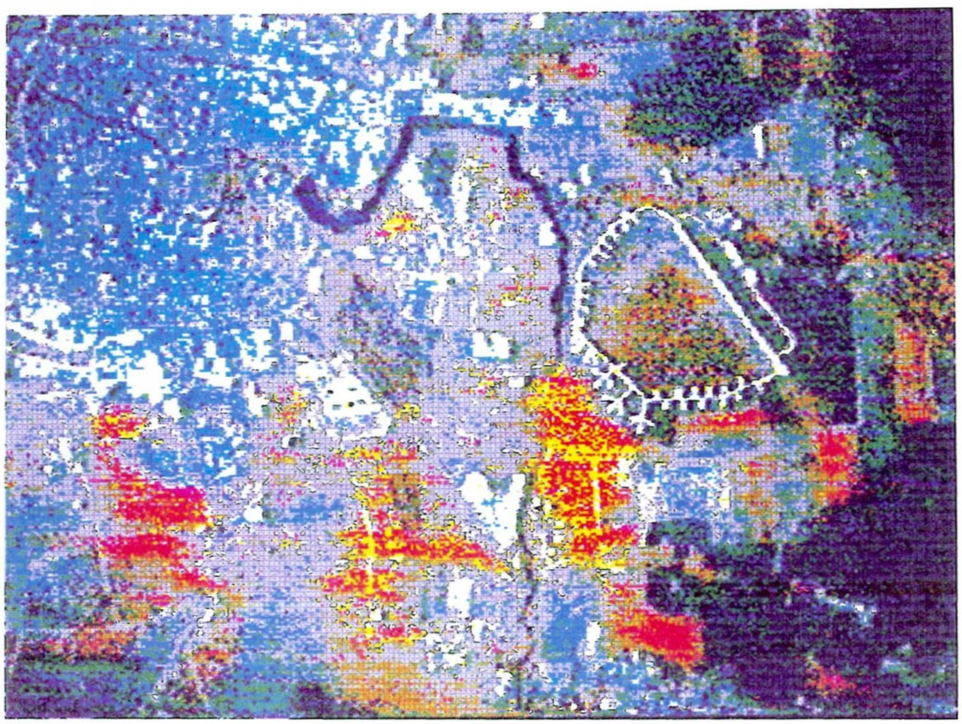
5.0 RECOMMENDATION

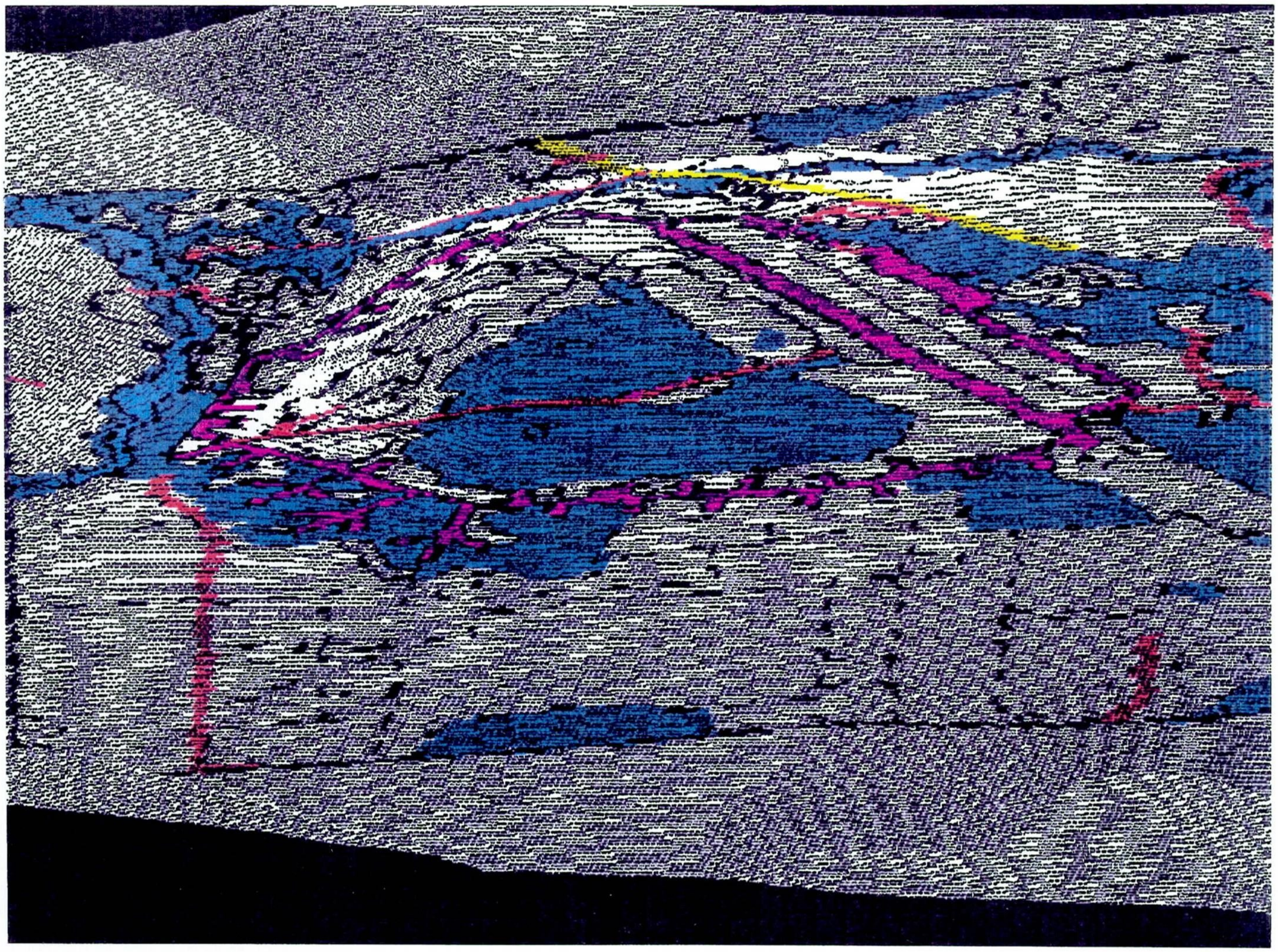
1. Until such time as the radiological contamination identified in Parts 3.3 and 4.4 is safely removed, it is recommended that:

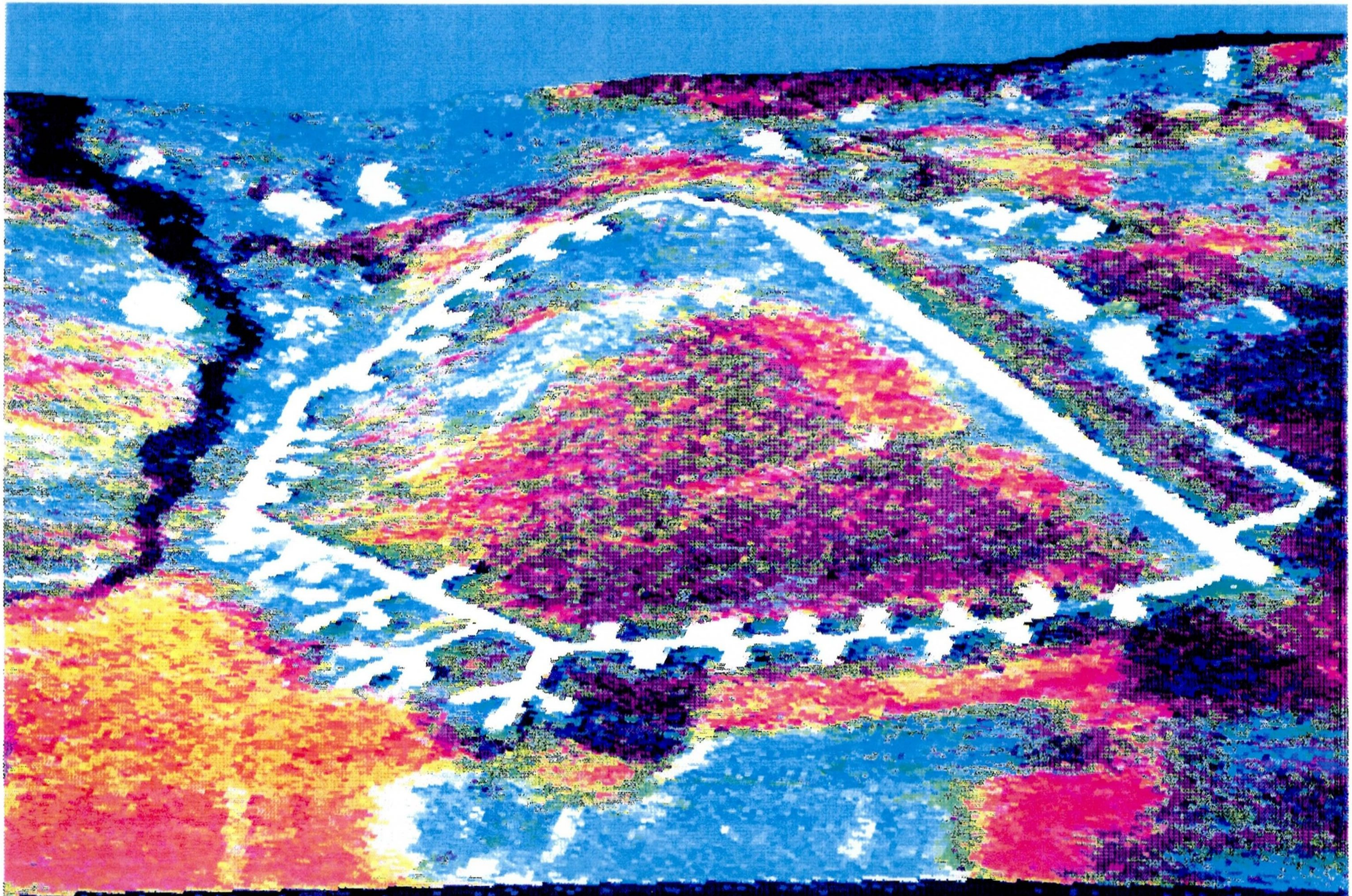
    1. A barrier (ie. fence) be erected around the contaminated area; and
    2. Access to the contaminated area be strictly controlled by local authorities.

ANNEX A

Satellite Images of Pajuoste



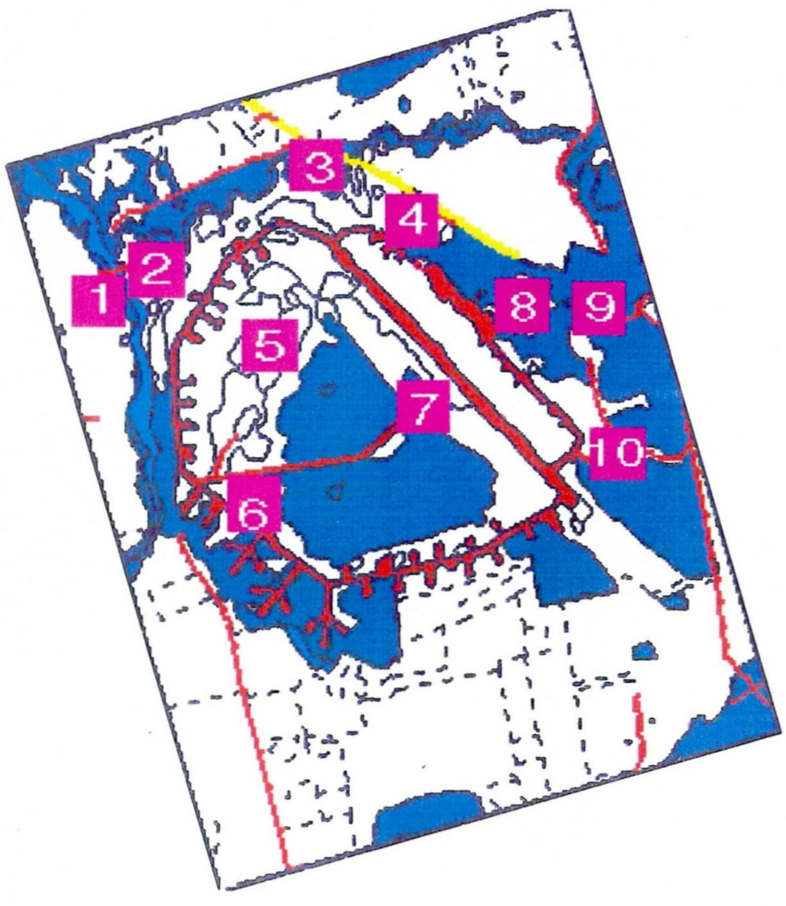




SPOT 20 METER MULTISPECTAL IMAGE ON A DIGITAL ELEVATION MODEL. LOOKING NORTH.

ANNEX B

Sites Identified By Remote Sensing


1
2
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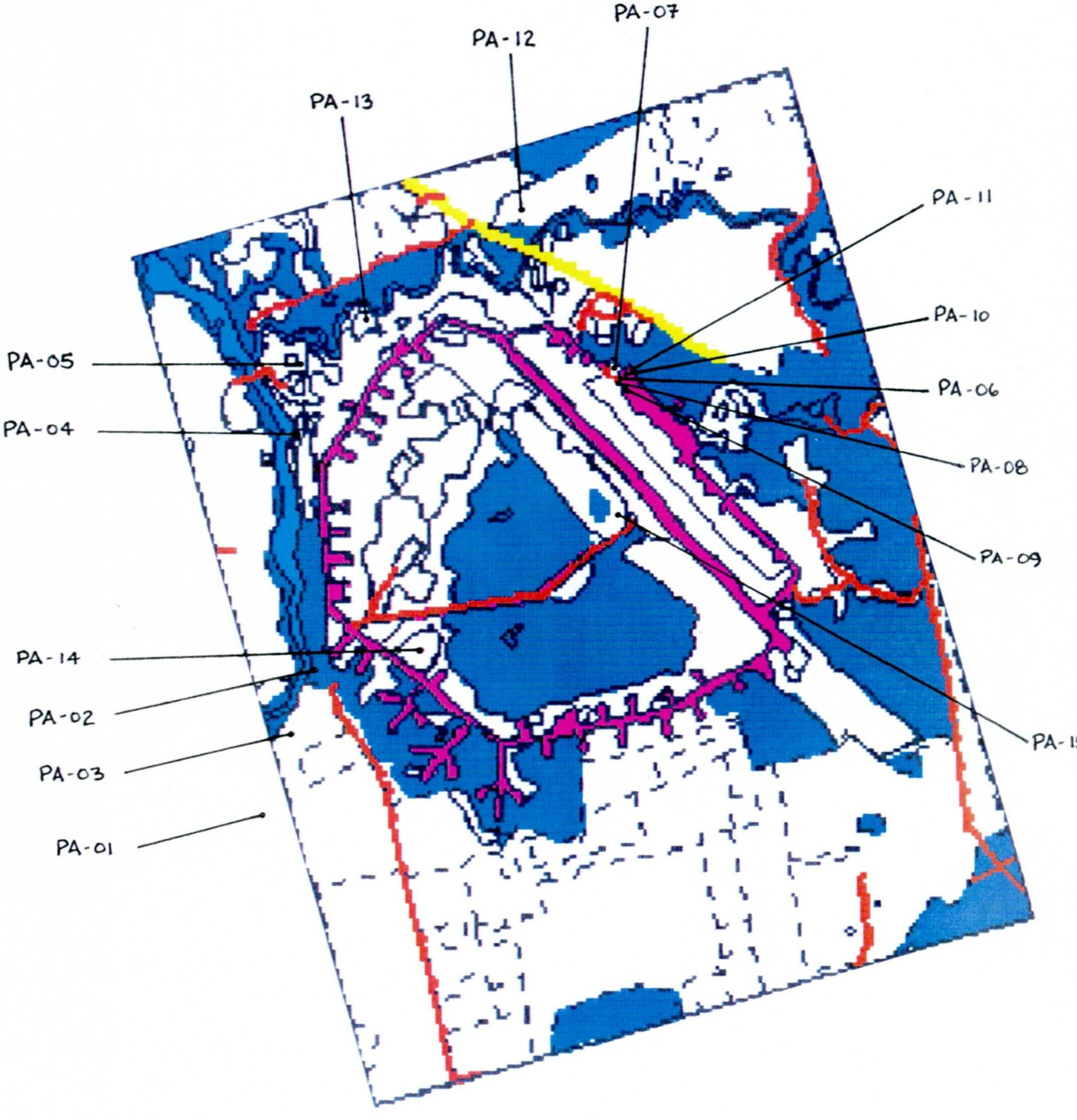
10

ANNEX C

Satellite Imagery - Phase 2 Survey Sites


PA-07
PA-12
PA-13
PA-11
PA-10
PA-05
PA-06
PA-04
PA-08
PA-09
PA-14
PA-02
PA-15
PA-03
PA-01

ANNEX D

Modified Radiological Survey Protocol

Radiological Decommissioning Demonstration

Phase 2 Survey Protocol

1.0 Terminology

For purposes of clarity and consistency, specific terminology associated with this protocol are defined in Appendix 1.

2.0 NOTRA Base Survey Plan

.1 General

In order to maintain rigour in identifying candidate sites for radiological survey, the NOTRA project team undertook to develop a consistent site selection criteria, that would also facilitate prioritization of recommended survey sites. In addition to the development of a site selection criteria, the project team developed a site listing format that would facilitate cross referencing of survey location to a current site plan; incorporate the use of a unique site numbering system that could be readily interpreted and distinguished from sites associated with other bases, and used in identifying subsequent swipe samples; provide references used in the site selection process; and describe the site more fully, if required.

.2 NOTRA Code for Site Identification

The site labelling technique adopted by the project team, to code its proposed survey sites and sampling locations consisted of the following alphanumeric identifier:

"XX-01-02-03-04"

where:

XX : the identifier for CF Bases, (ie. "S" for CFB Summerside and "P" for CFB Portage La Prairie;
01 : the specific site location or building to be surveyed;
02 : room number or location within a building being surveyed;
03 : number of environmental sample or swipe number taken in that particular building/survey site; and
04 : for further delineation (ie. detailed surveys, date, etc.) to be used as required.

.3 Criteria Used to Select Survey Sites

For purposes of consistency and rigour, the project team developed a site selection criteria that it employed in prioritizing the sites recommended for radiological survey.

The site selection matrix, illustrated in the following table, was based on assigning survey priorities (high, medium or low) to sites, based on the best available information on the likely nature of the site and type of component/items that existed on that site. More specifically, the nature of the site was analyzed from four usage conditions. These included:

.1 Sites where new or refurbished materiel were stored for issue to user groups (ie. Base Supply storage facilities);
.2 Sites where materiel was used, expended or consumed on a regular basis (ie. areas where first or second line maintenance would normally occur);
.3 Sites where materiel would be stored prior to disposal (ie. items stored in return stores facilities); and
.4 Sites where disposed materiel would be deposited for long term disposal (ie. land disposal areas).

Additionally, each site was analyzed from the point of view of suspected materiel usage in that site. That is, based on the results of the investigations to date, the project team categorized materiel status into three groups. These included:

.1 Materiel known to contain radioactive isotopes (ie. vehicle dials, compasses, wrist watches, aiming post markers etc.);
.2 Materiel known to be hazardous in nature, that require special handling and storage, which may also be stored with unspecified materiel containing radioactive isotopes; and
.3 Materiel not likely containing any radioactive isotopes (ie. consumables such as paper, food, and clothing).

Survey priorities 1, 2 and 3 were defined as follow:

.1 Priority 1: Sites where it is very likely that components/items containing radioisotopes may have been used, maintained or disposed of;
.2 Priority 2: Sites where it is less likely that components/items containing radioisotopes may have been used, maintained or disposed of; and
.3 Priority 3: Sites where it is unlikely that components/items containing radioisotopes may have been used, maintained or disposed of.

Detailed surveys will only be conducted when and where gross survey results indicate radiation levels in excess of the "limits prescribed by NOTRA" (Appendix 1 refers).

.4 Principal Radioisotopes

The most likely radioisotopes to be detected in base radiological decommissioning include:

.1 Radium 226 and 228;
.2 Thorium 232;
.3 Uranium 238;
.4 Strontium 90;
.5 Promethium 147;
.6 Americium 241; and
.7 Tritium.

.5 Regulatory "Walk Away" Criteria

With regard to selection of instrumentation, the following constraints ("Walk Away" Criteria) have been imposed:

.1 The dose rate due to fixed contamination must not exceed 0.5 μSv/hr. at a distance of 0.5 metres from any surface.
.2 Levels of loose alpha radioactive contamination must not exceed 0.05 Bq/cm^2, averaged over an area not exceeding 100 square centimetres;
.3 Levels of loose beta and gamma radioactive contamination must not exceed 0.5 Bq/cm^2 averaged over an area not exceeding 100 square centimetres; and
.4 Environmental Contamination Limits (only on an "as required basis").

NOTRA will assess environmental radiation contamination by invoking the set of permissible radioactive discharge limits frequently imposed by the AECB as licence conditions on its licensees.

Maximum permissible discharge limits are based upon the concept of "Scheduled Quantity" (S.Q.) which is radionuclide specific and based upon the detrimental health risk potential (relative radiotoxicity) of that radionuclide, as predicted by dosimetric modelling. Schedule I, Part I of the Atomic Energy Control Regulations, specifies the S.Q.s for the radionuclides (defined in Part 2.4 above) to be:

Radionuclide	Scheduled Quantity
Ra - 226	0.1 microcurie (3.7 kBq)
Ra - 228	0.1 microcurie (3.7 kBq)
Th - 232	0.1 microcurie (3.7 kBq)
U - 238	0.1 microcurie (3.7 kBq)
Sr - 90	0.1 microcurie (3.7 kBq)
Pm - 147	10 microcurie (0.37MBq)
Am - 241	0.1 microcurie (3.7 kBq)
H - 3	1000 microcurie (37 MBq)

Environmental discharge limits normally imposed by AECB as a license condition on the radioisotope licensee are:

.1 Solids to Landfill 1 S.Q./kg. for waste material of homogeneous distribution.

.2 Liquids to Sewer 0.01 S.Q./litre (averaged over 1 year).

.6 Survey Assumptions

The following radiological assumptions were used to assist the NOTRA Project Team in recommending the specific survey equipment kit for the radiological decommissioning program:

.1 The energy emitted for the radioisotopes considered in Part 2.4 occurs in an energy range of 0 keV to 5 MeV;

.2 This radiological decommissioning will survey for alpha, beta and gamma emissions, as specified by AECB's "Walk Away" criteria;

.3 The gamma emitting radioactive isotopes considered in this decommissioning will be surveyed by gamma spectroscopy in the energy range of 40 keV to 2 MeV;

.4 Alpha and beta emitters will be analyzed in an energy range from 18 keV to 5 MeV;

.5 Tritium will treated as a special case, beta emitter with a maximum energy of 18 KeV. Tritium surveys will be performed by swipe analysis and followed by a quantification in the Portable Swipe Analyzer and by liquid scintillation analysis in a laboratory;

.6 Radiological decommissioning will be conducted using gross and detailed surveys. Sampling plans and protocols have been described in Parts Three and Four of this submission respectively;

.7 Gross surveys will be conducted in accordance with the radiological decommissioning contamination limits as prescribed by NOTRA (Appendix 1 refers). Detailed surveys will be conducted in accordance with the radiological decommissioning contamination limits specified by the AECB (Appendix 1 refers).

.7 Categories of Radiological Survey Instrumentation

In order to satisfy the radiological decommissioning requirements specified by DGNS, NOTRA considers that the following broadly defined categories of radiological survey instrumentation, will be required:

.1 An Eberline, General Purpose Survey Meter (GPSM) for measuring radiation field intensities;

.2 An EG & G Berthold, Area Contamination Monitor (ACM) for measuring activities per square centimetre for fixed and removable (loose) contamination;

.3 A FAG, portable swipe analyzer (FHT-900-A-14) for measuring gross beta and alpha emissions for removable (loose) radiological contamination;

.4 A FAG Bearing, Swipe Counting System (FHT 1100 and FHT-770-S) for measuring alpha, beta and gamma emissions for removable (loose) radiological contamination;

.5 An EG & G Labserco, Gamma Spectroscopy System (GSS), using a Sodium Iodide (NaI) detector, for identifying gamma emitting radioisotopes during the conduct of the gross and detailed surveys; and

.6 An ultraviolet survey light (spanning the 365 nanometre wave length) for indicating the presence of florescent paint containing tritium or other radioisotopes.

.8 Background Characterization

The NOTRA project team will normally identify two off base sites for conducting background measurements. Each off base site is normally located near the perimeter of the base, in non-cultivated, natural growth areas.

Background characterization will be scheduled to commence during the first day of the survey program. The nuclear physicist will assemble and set-to-work the gamma spectroscopy system in a heated counting room, located either on the base or in the hotel room. Concurrently with this activity, the other members of the survey team will visit each of the two background sites, record GPSM readings and collect environmental samples for subsequent analysis in the counting room.

Each background site will be divided into a 10 metre by 10 metre grid, containing 100 cells of dimension 1 metre by 1 metre per cell. At the centre of the grid, a background reading will be taken using a GPSM and an environmental soil sample will be taken and analyzed for gamma emitters (identification purposes only) using a gamma spectroscopy system. Water samples will also be taken, at positions upstream from the base. The water samples will also be analyzed using gamma spectroscopy.

Alpha and beta/gamma background characterization, using the ACM and Swipe Counter will be conducted indoors.

.9 Gross Survey Plan

Gross Surveys will be conducted both inside buildings and out-of-doors. The objective of the gross survey is to survey very large areas of a building or area, quickly and systematically, and to locate areas of elevated radiation.

10 Gross Surveys (Inside).

NOTRA's gross survey plan will deviate depending on the priority of the site selected for survey. Radiological surveys will be most rigorous for priority 1 sites and then become progressively less rigorous for priority 2 and 3 sites. The surface of each survey site will be divided into a grid of 100 cells. Additionally, priority 1, 2 and 3 sites will be divided into at least 13 cells, 8 cells and 5 cells respectively, for further survey work. This further subdivision represents 1/8th, 1/13th and 1/20th of the total surface area for priority 1, 2 and 3 sites respectively. The gross survey plan for sites located indoors is summarized in the following table:

SURVEY METHOD / INSTRUMENTATION	PRIORITY 1 SITES	PRIORITY 2 SITES	PRIORITY 3 SITES
GPSM for field intensities.	All cells.	All cells.	All cells.
ACM for measuring activity/cm^2 on surfaces for fixed and loose contamination.	13 cells	8 cells.	5 cells.
Swipes for measuring loose contamination (including tritium)	13 cells.	8 cells.	5 cells.
Gamma Spectroscopy.	0 cells.	0 cells.	0 cells.
Environmental Samples for soil & water.	N/A	N/A	N/A

Throughout the conduct of the gross survey (inside), if readings (corrected for background) should be measured in excess of the "limits prescribed by NOTRA", then a detailed survey must be performed. Additionally, the site must be treated as a Priority 1 site regardless of its original survey priority.

.11 <u>Gross Survey (Out-of-Doors)</u>.

Grids consisting of 100 cells will be marked off for all out-of-door gross survey sites. In view of the nature of the surfaces involved and in light of the relatively low temperatures that will be encountered out-of-doors, it is not considered practical to differentiate between fixed and loose contamination or to survey specifically for the presence of alpha contamination. Out-of-door sampling will therefore focus on identifying and quantifying surface and subsurface gamma emitting radionuclides. This approach was confirmed in consultation with AECB and the Low Level Radioactive Waste Management office in Ottawa. The NOTRA project team therefore proposes to follow the following gross survey plan for all out-of-door sites:

.1 Survey all 100 cells in each site using a GPSM;
.2 Using a soil auger (approximately 1½ inch diameter) take the following environmental soil samples:

  .1 13 samples for Priority 1 sites;
  .2 8 samples for Priority 2 sites; and
  .3 5 samples for Priority 3 sites.

Soil samples will normally be taken to a depth of 6 inches. Remove the samples to the counting room and, using a gamma spectroscopy system, identify and quantify the gamma emitting radioisotopes and determine which gamma radioisotopes are present above background.

.3 Laboratory analysis will be required for those samples that indicate activities above the AECB "Walk Away" criteria, and for which radioisotopes cannot be identified and quantified in the field.

.12 Detailed Survey Plan

A detailed survey will be performed only when survey instrumentation readings in excess of the "limits prescribed by NOTRA" have been measured during the conduct of the gross survey. As is the case with gross surveys, detailed surveys may be required to be conducted both in side buildings and out-of-doors. Additionally the manner in which detailed surveys will be performed inside and out-of-doors, will vary slightly; however in both cases a survey grid will be located directly over the position where elevated radiation levels were detected in the gross survey. Each detailed survey grid will measure 1 metre by 1 metre, and consist of 100 cells, measuring 10 centimetres by 10 centimetres.

The requirements for the conduct of detailed surveys are summarized in the following table:

SURVEY METHOD / INSTRUMENTATION	NO. OF CELLS IN THE SURVEY GRID
GPSM for dose rate intensities. .1 Inside .2 Out-of-doors	 100 100
ACM for measuring activity/cm^2 on surfaces for fixed and loose contamination. .1 Inside .2 Out-of-doors	 13 0
Swipes for measuring loose contamination (including tritium). .1 Inside .2 Out-of-doors	 13 0
Gamma Spectroscopy. .1 Indoors (in the designated counting room) .2 Out-of-doors (in the designated counting room)	 Note 1 13
Environmental Samples for soil & water. .1 Indoors .2 Out-of-doors	 N/A 13

Note 1: Analyze only for swipe(s) with loose contamination detected in excess of the AECB "Walk Away" criteria.

3.0 Phase 2 - Radiological Survey Protocol

Background Survey Protocol

1.0 Outdoor sites must be identified for background measurements. The outdoor sites are normally located on the perimeter of the base, in non-cultivated, natural growth areas. The indoor site is normally located in an office or boardroom area.

Outdoor Sites

General Purpose Survey Meter (GPSM)

2.0 Prior to arrival on site, check the GPSM in accordance with manufacturer's instructions (i.e. battery installed, high voltage adjustment, dead time setting, meter-to-detector connection).

Arrival on Site

3.0 Perform a response check to confirm the instrument is still responding to specifications and no change has occurred due to transportation to site. The response check is to be performed by taking twenty (20) readings, using the standard source. Each reading shall have a duration of 10 seconds. The chi square test is to be applied to confirm the response. Establish a 10 metre by 10 metre grid on the location and mark the centre of the grid.

4.0 Suspend the GPSM detector at 0.1 metre (10 cm) above this location and note the reading. Next suspend the GPSM detector at 0.5 metre above the ground at the same location and note the reading.

5.0 Record both measured results on a radiation background form.

Environmental Sampling

6.0 Using a portable soil auger, take one soil sample from the same location selected for the GPSM measurements. The volume of the bulk soil sample is approximately 1½ inches in diameter by 6 inches deep (approximately 1 Kg). Insert soil sample into a plastic sample bag, homogenise the soil sample and identify soil sample on sample bag for further analysis.

7.0 Take water samples from sites XXX and XXX. The following protocol is to be used in obtaining the water sample:

.1 take a two litre, glass sample bottle, flush it with river water thoroughly;
.2 submerge the sample bottle into the water and allow it to fill;

.3 seal the sample bottle under water; and

.4 check the sample bottle to ensure that it is sealed properly for subsequent transport to the counting room.

8.0 Take the water and the soil samples (as applicable) inside to the designated counting room.

Gamma Spectroscopy System

9.0 Set-up and calibrate the Gamma Spectroscopy System in accordance with manufacturer's instruction.

Soil Samples

10.0 Place each soil sample in a Marinelli beaker and place the beaker on top of the gamma detector. Count for at least 30 minutes.

11.0 Using the selected software program identify the radioisotopes present.

Water Sample

12.0 Repeat Steps 10.0 and 11.0 for the water sample.

13.0 Repeat Steps 2.0 to 12.0 for the four remaining off base background sites.

Indoor Sites

Area Contamination Monitor

14.0 Prior to arrival on site check the ACM in accordance with manufacturer's instructions (ie. battery installed, charged gas cartridge, alarm threshold, detector properly installed).

Arrival on Site

15.0 On arrival inside the building, perform a response check to confirm that the instrument is still responding to specifications and that no change has occurred due to transportation to the site. The response check is to be performed in accordance with manufacturer's specifications.

16.0 In accordance with the detailed survey plan (Part 2.1 refers), randomly select a 1 metre by 1 metre survey grid; divide the grid into 100 in number 10 cm by 10 cm cells; and randomly select 13 in number cells.

17.0 Using the ACM with the gamma/beta detector installed, and at a fixed geometry of 0.5 cm form the surface, count for 200 seconds in each of the 13 randomly selected cells. After counting in each cell, remove the ACM from the surface and record the results on a radiation background form. Select the cell with the lowest activity and with the instrument in the background mode, count for 200 seconds.

18.0 Repeat step 17.0 using the ACM with the alpha/beta detector installed.

Swipe Counter and Portable Swipe Analyzer Systems

19.0 In the indoor counting room check the Swipe Counter and Portable Swipe Analyzer Systems in accordance with manufacturer's instructions.

Arrival on Site

20.0 On arrival inside the designated indoor site selected for background characterization, and in accordance with the detailed survey plan, randomly select three in number, 1 metre by 1 metre cells in the survey grid. Divide each 1 metre by 1 metre cell into a grid consisting of one hundred, 10 cm by 10 cm cells.

21.0 Randomly select 13 in number 10 cm by 10 cm cells in each of the three 1 metre by 1 metre cells and perform swipe tests in all 39 cells (3 one metre X one metre cells X 13 = 39).

22.0 Place each swipe (5 cm diameter filter paper) in a zip lock bag and seal it.

23.0 Mark the bag with NOTRA's prescribed and unique identification number. Care is to be exercised not to write over top of the filter paper or in any way compress the filter, so as to minimize the possibility of transferring any radionuclides onto the surface of the bag.

24.0 Do not touch the area of the filter in contact with the test surface. It is good practice to use disposable surgical gloves and remove and dispose of the old pair if cross contamination of samples is suspected.

25.0 Swipe test blanks are to be obtained in an uncontaminated area before and after actual swipes are obtained. These are obtained by taking a filter paper and placing each in a separate storage bag. Pre-test blanks are to be carried with the actual swipe test samples. Pre and post-test blanks should agree within ± 10% of each other during counting.

26.0 Return the swipe tests to the designated counting room and analyze for alpha and gross beta in the Swipe Counter and Portable Swipe Analyzer Systems (Appendix 2 refers).

Data Compilation

19.0 Using a normal distribution, calculate the mean and the standard deviation for measurements recorded by the GPSM, Swipe Counter System, Portable Swipe Analyzer and the Gamma Spectroscopy System.

20.0 Record the mean environmental background value for the GPSM, Swipe Counter and Portable Swipe Analyzer Systems. This value will be used for the background subtraction for all on-base surveys using the GPSM, Swipe Counter and Portable Swipe Analyzer Systems.

21.0 Select the most representative background spectrum based on the average values measured on pre-selected regions of interest.

Gross Survey Protocol

1.0 Enter the building and record the site location on a radiation survey report form and record previously determined background readings.

2.0 Using a building floor plan, divide the building surface areas (ie. floors and walls) into survey grids of 100 cells of equal area.

3.0 Turn on the GPSM and perform a response check in accordance with manufacturer's instructions.

4.0 With the GPSM probe at a height of 0.1 metre (10 cm) above the surface, commence the survey at a scan rate of approximately 1 metre/second. Survey all accessible surfaces in the entire 100 cells of the survey grid. All accessible surfaces include:

1. walls
2. floors
3. windows
4. corners and cracks
5. radiator surfaces
6. ducting/pipe surfaces
7. furnishings such as desks, chairs & contents

5.0 Record any readings in excess of background and mark the area using tape, chalk or permeant marker.

6.0 Fix the GPSM detector 0.5 metre above the marked area(s) and record the reading(s). If the reading(s) is greater than 0.5 microsieverts/hour advise the survey team leader and establish a 0.5 microsieverts/hour isodose boundary. Mark off the boundary in tape and treat the area as a restricted access area, requiring personal dosimeters. This location will require a detailed survey to be conducted. Treat the area as a restricted access area.

7.0 If no readings in excess of background are detected, record "No Detectable Contamination" on the survey report form.

8.0 In accordance with the Survey Plan, and based on the best intelligence available (gained from the familiarization visit); the experience of the survey team; and random selection respectfully, select at least 13, 8 or 5 cells (depending on the priority of each site) and survey for the presence of surface contamination.

9.0 In each of the cells selected in Step 8.0, prepare to survey using an Area Contamination Monitor (ACM) for alpha and beta/gamma detection respectively. Turn on the ACM and perform a response check in accordance with manufacturer's instructions.

10.0 With the alpha detector installed, use the ACM at a fixed distance (i.e. 0.5 cm) from the surface, commence a contamination survey at a fixed scan rate (i.e. 10 cm/second) of all accessible surfaces within each of the cells selected in Step 8.0.

11.0 Record any background corrected readings in excess of 0.05 Bq/cm^2 for alpha and mark the area using tape, chalk or permanent marker. Advise the survey team leader that an area of significant contamination has been detected. Record on the survey report form and on the floor plan, indicating the location, where a detailed survey is required. Treat the area as a restricted access area.

12.0 If no detectable alpha contamination is found, repeat Steps 9.0 through 11.0 using a beta/gamma detector and record any background corrected readings in excess of 0.5 Bq/cm^2. Mark the area using tape, chalk or permanent marker and advise the survey team leader that an area of significant contamination has been detected. Record on the survey report form and on the floor plan, indicating the location, where a detailed survey is required. Treat the area as a restricted access area.

13.0 If no detectable contamination is found, record "No Detectable Contamination" on the survey report form, and swipe test for priority 1, 2 and 3 sites. The swipe testing is performed as follows:

.1 Perform 1 swipe test at the centre of each cell selected in Step 8.0 above. Swipe tests will also be performed at the exhaust fan intake(s) and at the openings of floor drains (as applicable).
.2 Wipe the open area of at least 1 metre by 1 metre, using filter paper appropriately moistened with glycerol. Use moderate pressure on the swipe.
.3 Hold the filter paper in such a manner that only a small portion of the total filter contacts the surface being tested.
.4 Place the filter paper in a zip lock bag and seal it.
.5 Mark the bag with NOTRA's prescribed and unique identification number. Care is to be exercised not to write over top of the filter paper or in any way compress the filter, so as to minimize the possibility of transferring any radionuclides onto the surface of the bag.
.6 Do not touch the area of the filter in contact with the test surface. It is good practice to use disposable surgical gloves and remove and dispose of the old pair if cross contamination of samples is suspected.
.7 Swipe test blanks are to be obtained in an uncontaminated area before and after actual swipes are obtained. These are obtained by taking a filter paper and placing each in a separate storage bag. Pre-test blanks are to be carried with the actual swipe test samples. Pre and post-test blanks should agree within ± 10% of each other during counting.

14.0 Send swipes to the counting room for further analysis (Appendix 2 refers).

Outside

1.0 For predetermined survey sites located outside - record each site location on a radiation survey report form and record the previously determined background readings.

2.0 Using a site plan of the base, divide the site into a survey grid of 100 cells of equal area.

3.0 Turn on the GPSM and perform a response check in accordance with the manufacture's instructions.

4.0 With the GPSM probe at a height of 0.1 metre (10 cm) off the ground surface, commence the survey at a scan rate of approximately 1.0 metre/second. Survey all applicable ground surfaces, this includes:

1. depressions
2. foundations
3. flood plains
4. fissures

Note areas where permeant reservoirs of water exist (i.e. lakes, ponds) and take liquid samples as appropriate. Natural water run-off areas could serve as a collection source for radionuclides. Mark and label the sample jars for subsequent analysis.

5.0 Record any readings in the excess of background and mark the area using marked survey stakes.

6.0 Fix the GPSM detector 0.5 metre above the marked area and record the reading. If the reading is greater than 0.5 microsieverts/hour advise the survey team leader and establish a 0.5 microsieverts/hour isodose boundary. Mark off the boundary with flagging tape or fluorescent survey spray paint and treat the area as a restricted access area, requiring personal dosimeters. A detailed survey must be performed in this area.

7.0 If no measurements are made that exceed the readings specified in step 6.0, enter "No Detectable Contamination" on the survey report form and using the portable soil auger, take environmental soil samples (13 for priority 1 sites, 8 for priority 2 sites and 5 for priority 3 sites). Additionally take 2 litre water samples as applicable. The selection of the specific locations within the grid for environmental sampling is to be the location giving the highest reading in step 4.0. Place the soil samples (approximately 1 Kg) in plastic sample bags and place any water samples in 2 litre sample jars. Homogenise the soil samples and identify the sample bags and/or sample jars for subsequent analysis. The same water sampling protocol used for taking background water samples is to be used for this gross survey protocol.

8.0 In the designated counting room, activate the Gamma Spectroscopy System and perform a response check in accordance with the manufacturer's instructions.

9.0 For purposes of identifying radioisotope contamination only, drape the sample bag around the detector of the Gamma Spectroscopy System. For water samples, empty sample contents into a Marinelli beaker and place the beaker over the Gamma Spectroscopy System detector.

10.0 Count for 30 minutes.

11.0 Using the Gamma Spectroscopy System Software routine, perform a background strip of the recorded spectrum.

12.0 Use the Gamma Spectroscopy System Software identification routine, to identify possible radioisotope contaminants in the sample. Record the results on the radiation survey report form. Only those samples indicating activities above the AECB "Walk Away" criteria are to be specified for subsequent laboratory analysis.

13.0 Send the soil and/or water samples (identified in Part 12) to the laboratory to quantify radioisotopes of interest. Only reputable laboratories, having suitable germanium detectors, will be selected to perform the analysis. Chemical separation or concentration will not be required.

14.0 Gross survey results for indoor and outdoor sites (corrected for background), including swipe analysis are recorded in the format contained in Appendix 3.

Detailed Survey Protocol

Inside

A detailed survey inside will be performed only when readings are measured in excess of the "limits prescribed by NOTRA". The survey team will take appropriate safety precautions and will therefore wear protective clothing such as gloves, booties and coveralls. Additionally, the survey team will take the appropriate safety precautions with respect to eliminating the spread of loose contamination. NOTRA's detailed survey plan is described below:

1.0 In accordance with the Survey Plan establish a grid of 1 metre x 1 metre (consisting of 100 cells of 10 cm x 10 cm) centred on the marked area identified in Steps 6.0 or 11.0 of the Gross Survey (Inside). Turn on the GPSM and perform a response check in accordance with manufacturer's instructions. With the GPSM probe at a height of 0.1 metre (10 cm) above the surface, survey all 100 cells of the survey grid and record the results. In accordance with manufacturer's instructions, perform ACM response checks for the alpha and for the beta/gamma detectors. Using the ACM at a fixed distance (i.e. 0.5 cm) from the surface, commence a contamination survey for alpha and for beta/gamma of all surfaces identified in steps 2.0 and 3.0 below. Record background corrected readings in excess of 0.05 Bq/cm^2 (for alpha) and 0.5 Bq/cm^2 (for beta/gamma). Mark the area using tape, chalk or permanent marker.

2.0 Swipe test in each of eight, 10 cm x 10 cm cells immediately adjacent to the marked area. (Swipe procedure defined above).

3.0 Additionally swipe test in four randomly selected cells in the 1 metre x 1 metre survey grid as well as inside the in the marked cell (described in step 2.0).

4.0 Place each swipe in its own plastic zip lock bag, identify the sample and send to the counting room for further analysis.

5.0 Set up the Swipe Counter and perform a response check in accordance with manufacturer's instructions.

6.0 Affix swipes in the prearranged reproducible geometry.

7.0 Analyze each swipe in accordance with the Swipe Counter and Portable Swipe Analyzer Systems protocol (Appendix 2 refers).

8.0 Detailed survey results (corrected for background), including swipe analysis are recorded in the format contained in Appendix 3.

9.0 Select the swipe(s) with loose contamination detected in excess of the AECB "Walk Away" criteria and place directly on top of the Gamma Spectroscopy System detector.

10.0 Count each swipe for at least 30 minutes.

11.0 Continue following Steps 11.0 and 12.0 in the Gross Survey Protocol (Outside).

Outside

A detailed survey out-of-doors will be performed only when readings are measured in excess of the AECB "Walk Away" criteria.

1.0 In accordance with the Survey Plan (Part 2.1 refers) establish a grid of 1 metre x 1 metre (consisting of 100 cells of 10 cm x 10 cm) centred on the marked area identified in Step 6.0 of the Gross Survey (Outside).

2.0 Using the portable soil auger, take 13 bulk soil samples - 8 in number immediately adjacent to the marked cell identified in step 1.0 above, 4 in number at randomly selected cells in the 1 metre x 1 metre survey grid, and 1 in number inside the in the marked cell described in step 1.0 above.

3.0 Place soil samples in plastic sample bags. Homogenise the samples and identify the sample bags for subsequent analysis.

4.0 In the designated counting room, activate the Gamma Spectroscopy System and perform a response check in accordance with the manufacturer's instructions.

5.0 For purposes of identifying radioisotope contamination only, drape each sample bag around the detector of the Gamma Spectroscopy System.

6.0 Count each bulk soil sample for 30 at least minutes.

7.0 Using the Gamma Spectroscopy System Software routine, perform a background strip of the recorded spectrum.

8.0 Use the Gamma Spectroscopy System Software identification routine, to identify possible radioisotope contaminants in the sample. Record the results in the remarks section of the radiation survey results form (Appendix 3 refers).

9.0 Send the soil and/or water sample to the laboratory to quantify the radioisotopes of interest.

Appendix 1

Terminology

"Limits Prescribed by NOTRA":

The NOTRA Survey Team has been trained to respond to specific radiological contamination, detected during the conduct of the field survey activities associated with the gross survey protocol. These survey limits have been established for the specific equipment used in the field, by members of the NOTRA Survey Team, and have been designed to closely resemble the AECB "Walk Away" criteria. The limits prescribed by NOTRA for the detection of fixed and loose contamination, during the conduct of the gross survey, are described as follow:

.1 GPSM:Dose rates (corrected for background) measured using the GPSM, must not exceed 0.5 μSv/hr, at a distance of 0.5 metres from any surface.

.2 ACM:Levels of Beta contamination (corrected for background) must not exceed 0.5 Bq/cm^2 when averaged over an area estimated to be approximately 100 cm^2. Levels of Alpha contamination (corrected for background) must not exceed 0.05 Bq/cm^2 when averaged over an area estimated to be approximately 100 cm^2.

.3 UV:Dials, gauges sealed components, decals and other items which fluoresce under ultraviolet inspection are to be first checked with the GPSM and ACM for the presence of Alpha, Beta and/or Gamma contamination. These readings are first recorded and then the component(s) is clearly tagged, identified, removed, appropriately bagged and transported for swipe testing and subsequent analysis.

AECB "Walk Away" Criteria:

The dose rate due to fixed contamination must not exceed 0.5 μSv/hr. at a distance of 0.5 metres from any surface. Levels of loose alpha radioactive contamination must not exceed 0.05 Bq/cm^2, averaged over an area not exceeding 100 square centimetres. Levels of loose beta and gamma radioactive contamination must not exceed 0.5 Bq/cm^2 averaged over an area not exceeding 100 square centimetres.

"Gross Beta" Contamination:

The term Gross Beta contamination is used in the Swipe Counter/Portable Swipe Analyzer protocol contained in Appendices 2 and 3 for CF Bases and HMC Ships, respectively. The Portable Swipe Analyzer (FHT-900-A-14) is capable of detecting Beta emissions from swipe samples at energy levels from approximately 18 keV, to 5 MeV. The Portable Swipe Analyzer is therefore capable of detecting both tritium and non-tritium beta emitters - hence NOTRA has adopted the terminology "Gross Beta" to describe these emissions.

Gross Beta measurements are only performed in NOTRA's on site, secure, ventilated and temperature controlled counting room.

Beta Contamination:

The Swipe Counter (FHT-770-S) is capable of measuring Beta emissions from swipe samples above the 100 keV energy level. The Swipe Counter is therefore not capable of detecting the weaker beta emissions originating from tritium. NOTRA uses the terminology "Beta" contamination to refer to non-tritium emitters, and hence differentiates between radiological contamination that does not include tritium and that which does (ie. Gross Beta contamination, described above).

Beta measurements taken using the Swipe Counter (FHT-770-S) are only performed in NOTRA's on site, secure, ventilated and temperature controlled counting room.

Alpha Contamination:

Loose Alpha contamination (from swipe samples) is measured in NOTRA's on site, secure, ventilated and temperature controlled counting room. Both the Swipe Counter (FHT-770-S) and the Portable Swipe Analyzer (FHT-900-A-14) are capable of measuring loose alpha contamination contained on swipe samples.

Alpha measurements taken using the Swipe Counter (FHT-770-S) and Portable Swipe Analyzer (FHT-900-A-14) are only performed in NOTRA's on site, secure, ventilated and temperature controlled counting room.

APPENDIX 2

APPENDIX 2

PROCEDURE FOR ANALYZING LOOSE ALPHA & BETA (INCLUDING TRITIUM)CONTAMINATION

EQUIPMENT

1.0 Equipment used by NOTRA's Nuclear Specialist, to measure loose alpha and beta (including tritium) contamination includes the following:

.1 A Swipe Counter System. Consisting of a Digital Ratemeter (FHT 1100), a Manual Sample Changer c/w 15 mm of lead shielding (FHT-770-S) and an internal detector for measuring alpha and beta emissions (non-tritium with energies greater than 100 KeV); and

.2 A Portable Swipe Analyzer (FHT-900-A-14). Consisting of a Manual Sample Changer and 10 cm lead shielded chamber assembly; and an internal windowless detector, capable of measuring alpha and gross beta emissions including tritium with energies at the 18 KeV level.

2.0 The portable swipe analyzer is assembled separately; however it is electronically connected to the Swipe Counter System.

3.0 Both detectors are Flow-Type Proportional Counter Tubes, consisting of different counting geometries and working in conjunction an Argon-Methane (90/10) gas purge system.

4.0 Using the Portable Swipe Analyzer system the following counting efficiencies can be realized:

.1 Alpha: 80%;

.2 Beta (non-tritium): Using the Pm 147 as the Standard Source, a beta counting efficiency of 46% can be achieved; and

.3 Beta (tritium): A beta efficiency of 3% can be achieved using a background of 0.133 cps. This efficiency should be confirmed prior to use in the field, through the use of a certified standard source for tritium.

SYSTEM SET-UP AND CALIBRATION

5.0 In a secure, well ventilated and temperature controlled counting room, unpack, set-up, clean and calibrate the equipment in accordance with manufacturer's instructions.

6.0 On initial set-up, ensure that both detectors are purged/flushed (with Argon-Methane gas) for at least 60 minutes. On a daily basis, detectors should be purged and flushed for at least 20 minutes prior to switching on the system for use.

7.0 During initial set-up, program the FHT 1100 to respond to both Manual Sample Changers - the FHT-770-S and the FHT-900-A-14.

8.0 Perform daily equipment response checks to ensure that all system components are operating within manufacturer's specifications, and that no damage has occurred during transport to the site or during unpacking. The response check is made using standard sources and the chi square test.

9.0 All swipe samples to be analyzed are to be placed in clean, aluminum planchets, prior to counting. Aluminum planchets will ensure that a reproducible counting geometry is maintained throughout the analysis.

10.0 At the beginning of each survey day, perform a background check using a clean, blank swipe, mounted in a clean, aluminum planchet. Perform counting operations in the alpha and alpha/beta positions for each detector. Counting times are to be 30 and 600 seconds in the alpha and alpha/beta positions for each detector. Calculate the mean and standard deviation for all readings. Record the values and subtract them from swipe sample readings (taken in the field), to correct for background.

ANALYSIS OF LOOSE CONTAMINATION

Gross Survey Samples

11.0 Affix individual swipes, taken in the field, to their own clean, aluminum planchet.

12.0 Place each planchet/swipe assembly in the FHT-900-A-14 counter. Ensure the system switch is in the alpha/beta counting position.

13.0 Perform a 30 second screening count.

14.0 Note the reading and subtract the background value from the reading.

15.0 Estimate gross beta contamination in Bq/cm^2. For values that are less than 0.5 Bq/cm^2, record the result and place the swipe in its own zip lock bag for storage and archiving.

16.0 For results equal to or greater than 0.5 Bq/cm^2, record the value and initiate a 600 second count.

17.0 Record the value for the 600 second count and subtract the background from this reading.

18.0 Estimate gross beta contamination in Bq/cm^2. If the result is less than 0.5 Bq/cm^2 record "No Detectable Contamination" and place the swipe in its zip lock bag for storage and archiving.

19.0 If the contamination level is equal or greater than 0.5 Bq/cm^2, record the value and advise the survey team leader that possible contamination has been identified, that a detailed survey will be required and that the detailed survey protocol must be invoked.

20.0 Place the FHT-900-A-14 system switch in the alpha counting position.

21.0 Count the swipe sample for 30 seconds, and subtract the background reading for alpha.

22.0 Estimate the value for alpha contamination in Bq/cm^2.

23.0 Record the value. For those swipes identified in step 19.0, place the swipes in their own zip lock bags, ensure that they are properly identified and send to the laboratory for liquid scintillation analysis.

Detailed Survey Samples

22.0 Repeat steps 11.0 to 20.0 for all swipe samples taken during the detailed survey. It should be stressed that, as stated in the survey protocol, all swipes taken during the conduct of a detailed survey, are taken over a 100 cm^2 area; hence all readings (corrected for background, in units of Bq/cm^2) can be readily compared with those values specified in the AECB "Walk Away" Criteria.

23.0 Count the swipe sample for 600 seconds and subtract the background reading for alpha.

24.0 Calculate the alpha contamination in Bq/cm^2.

25.0 Record the value and compare with the AECB "Walk Away" Criteria.

26.0 Place each swipe in the Swipe Counter(FHT-770-S) and set the system switch to the alpha/beta position.

27.0 Count each swipe for 600 seconds and subtract the background reading.

28.0 Calculate the beta contamination (non-tritium) in Bq/cm^2.

29.0 Record the value for beta (non-tritium) contamination and compare it with the AECB "Walk Away" Criteria.

30.0 To establish the nature of the contamination for each swipe, compare the values (corrected for background) for alpha, beta and gross beta contamination. Tritium contamination is estimated by subtracting the gross beta results (measured in the portable analyzer - FHT-900-A-14), from the beta results (non-tritium), measured in the Manual Sample Changer - FHT-770-S.

31.0 Replace all swipe samples in their own zip lock bags, ensure that each bag is properly identified and send swipe samples to the laboratory for liquid scintillation analysis.

32.0 Advise the survey team leader to post warning signs/rad haz tape around all contaminated sites.

ANNEX E

Pajuoste Survey Results

LITHUANIAN MILITARY BASE "PAJUOSTE"
RADIOLOGICAL SURVEY RESULTS

LOCATION: Lithuanian Military Base "Pajuoste"	FIELD INSTRUMENTS:	SURVEY TEAM:
PERIOD: 20 - 21 September 1994	Dose Rate Meter - GPSM (Eberline 6150 ADT/AD4) Background (uSv/hr): 0.13 Area Contaminatioin Monitor - ACM (Berthold LB 122) Beta/Gamma Background: 19.5 cps Alpha Background: 0.000 cps	Technical Authority - Capt(N) Bob Starchuk Project Manager - Bob Novitsky Technician - Stephen Burns

DGNS #	LOCATION/AREA DESCRIPTION	ACM		GPSM	CHALK RIVER SWIPE RESULTS		WALK AWAY CRITERIA EXCEEDED ?	REMARKS
		α Bq/cm2	B,γ Bq/cm2	(uSv/hr at 50cm)	α Bq/cm2	B,γ Bq/cm2		
PA - 01	Background Environmental Samples	N/A	N/A	0.13	N/A	N/A	NO	Soil & Water Samples taken
PA - 02	Environmental Sample	N/A	N/A	0.12	N/A	N/A	NO	Soil & Water Samples taken
PA - 03	Environmental Sample	N/A	N/A	0.13	N/A	N/A	NO	Soil & Water Samples taken
PA - 04	Environmental Sample	N/A	N/A	0.11	N/A	N/A	NO	Soil & Water Samples taken
PA - 05	Chemical Storage	0.005	0	0.15	N/A	N/A	NO	
PA - 06	Lab - Objective Monitoring	0	0.01	0.01	N/A	N/A	NO	
PA - 07	Trainer Hanger - No Roof	0	0.3	0.2	N/A	N/A	NO	
PA - 08	Antenna Tower	0	0	0.12	N/A	N/A	NO	
PA - 09	Gaurd House - Behind Maint. Shops	0	0	0.13	N/A	N/A	NO	
PA - 10 - 01	Bomb Storage	0	0.07	0.12	Not Detectable	Not Detectable	NO	
PA - 10 - 02	Bomb Storage	0.004	0.1	0.1	Not Detectable	Not Detectable	NO	
PA - 10 - 03	Bomb Storage	0.003	0.09	0.11	Not Detectable	Not Detectable	NO	
PA - 10 - 04	Bomb Storage	0.003	0.07	0.13	Not Detectable	Not Detectable	NO	
PA - 10 - 05	Bomb Storage	0.002	0.07	0.12	Not Detectable	Not Detectable	NO	
PA - 11	Air Armament Storage	0	0.32	0.16	N/A	N/A	NO	
PA - 12	Dump Site/Landfill	N/A	N/A	0.08	N/A	N/A	NO	Water Sample taken
PA - 13	Snow Plow Area	0	0.01	0.12	N/A	N/A	NO	
PA - 14	Radiac Lab	0	0	0.1	N/A	N/A	NO	
PA - 15	Radar Site	0	0.02	0.16	N/A	N/A	NO	

N/A - Not Applicable

ANNEX F

RMC Report

Studies of Radioactivity in Soil and Water Samples from Lithuania

RMC

STUDIES OF RADIOACTIVITY IN SOIL AND WATER SAMPLES FROM LITHUANIA

M. Farahani, E.A. Somers, R.D. Weir and L.S. Wright

Nuclear Science and Engineering Series: Part 12, 32pp, 1994.
Royal Military College of Canada
Collège Militaire Royale du Canada, Kingston, ON.
RMC-CCE-NSE-94-12

Department of Chemistry and Chemical Engineering
Département de Chimie et de Génie Chimique

Royal Military College of Canada • Collège militaire royal du Canada

6740-2 (Chem/Chem Eng)

18 November 1994

DNSC/LCol H. Higuchi
National Defence Headquarters
MGen George R. Pearkes Building
Ottawa, ON K1A 0K2 FAX: 613-992-5537

SOIL AND WATER SAMPLES FROM LITHUANIA

References: A. 1548-1 (DNSC 2) to Weir 21 Oct 94
B. Delivery Poland to Weir 25 Oct 94

1. Your request at Reference A for a detailed analysis of soil and water samples brought to Canada as a result of a DGNS visit to Lithuania has been completed. There were five soil samples and four water samples obtained at Reference B via Queen's University.

2. Additional soil and water samples were obtained from the grounds of RMC and Lake Ontario waters in order to offer reference and comparison values.

3. The findings by both gamma-ray spectroscopy and by liquid scintillation analyses show the presence of radioactive materials but at levels at or below background. The radioactive substances derive from the families of uranium U-238, thorium Th-232 and potassium K-40, all of which occur naturally in minute concentrations as part of the mineral constituents in most water and soils. In addition, caesium Cs-137 is also present in trace amounts and is a by-product of atmospheric testing.

R.D. Weir

R.D. Weir
Professor and Head
Dept. of Chem. & Chem. Eng.
Tel: 613-541-6612
FAX: 613-542-9489

Enclosure: Report

Kingston
Ontario
K7K 5L0

1. Samples & Sample Preparation

The water and soil samples from Lithuania were received at RMC 25 October 94 and are listed below:

Water Samples	Soil Samples
PA01	PA01
PA02	PA02
PA03	PA03
PA04	PA04
PA12	

The soil samples were placed in sterilized beakers and dried for 100 hours at 75-80 °C. These samples were then finely ground with mortar and pestle to minimize self-absorption of emissions. Fifty grams of each sample was placed in a Petri dish and wrapped with a thin film for gamma-ray spectrometry. A thin layer of each soil sample on a filter paper was also prepared for liquid scintillation analyses. Similar soil samples from RMC grounds were also prepared as references.

One hundred mL of each water sample was placed in a sterilized beaker and covered for gamma-ray spectrometry. Water samples were also prepared for liquid scintillation analyses. One mL of each sample was placed in a vial with 20 mL of ULTIMA GOLD scintillation cocktail resulting in clear and homogeneous solutions. Similar water samples from Lake Ontario were also prepared as references.

The following results detail the analyses of radioactive activity in the above samples with gamma-ray spectroscopy and liquid scintillation counting.

2. Gamma-ray Spectroscopy

Soil and water samples were placed on top of the detector assembly of the gamma-ray spectrometer. The results of a 6.0-hour count (live time = 21600.00 seconds) using a germanium detector are presented in **APPENDIX I** (p 1-22). These spectra depict gross count (designated **G**) and net count (i.e., background subtracted : designated **N**) with the same scale for the ease of comparison. A background spectrum acquired over a 6.0-hour period is also included in **APPENDIX I** (p 23). Where necessary, the components of these spectra have been numbered and identified in **APPENDIX I** (p 24). These spectra confirm the presence of *naturally occurring radioactive substances* belonging to two families. One family has *U-238* as the parent substance, and after 14 transformations reaches a stable end-product, *Pb-206*. Figure 1 (**APPENDIX I**, p 25) shows the members and transformations of the uranium series, which includes *Ra-226* and its decay products. *Th-232* is the parent substance of the second family with *Pb-208* as the stable end-product. Figure 2 (**APPENDIX I**, p 26) shows the members and transformations of the thorium series. This series includes *Ac-228* and its decay products. Potassium, *K-40* (# 14; 1460.83 keV) is also a naturally occurring radioactive species found in the earth's crust. Cesium, *Cs-137* (# 10; 661.62 keV) is a by-product of atmospheric testing.

When the net spectra are considered, all water samples, including the Lake Ontario reference, display background level activities. The net activities of the soil samples are marginal, and compare closely with the RMC ground soil reference.

3. Liquid Scintillation Analyses

All the soil and water samples and references were subjected to a Protocol 1 count. This protocol is utilized for detection of tritium in association with other isotopes. The counter settings for Protocol 1 are as follows.

Count Time : 15 minutes
Data Mode : DPM
Nuclide : 3H93335
Quench Set : 3H
Background Subtract : Yes (first vial : cocktail only)
Region A : 0 - 2000 keV
Region B : 18.6 - 2000 keV
Quench Indicator : tSIE
Luminescence Correction : OFF
Luminescence Indicator : ON
Activity : Bq . sample^{-1}

The results appear in **APPENDIX II** and are indicative of background level activity for all the samples and references.

4. Summary of Findings

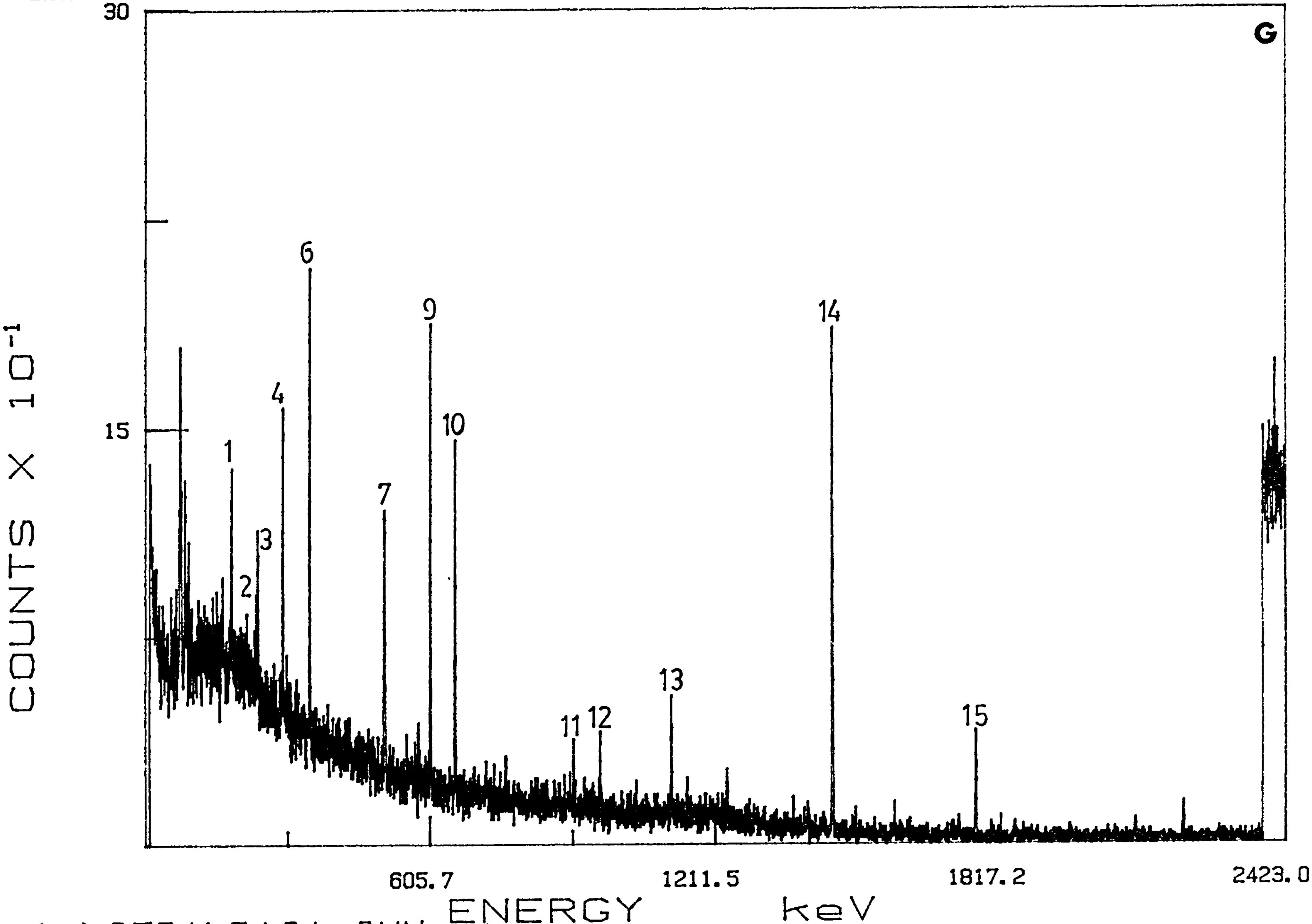
1. Gamma-ray spectroscopy showed the presence of naturally occurring radioactive substances belonging to *U-238* and *Th-232* families in addition to *K-40*. These substances and their decay products are naturally present, in minute concentrations, as part of the mineral constituents in most waters and soils. *Cs-137* is a by-product of atmospheric testing and is present as trace amounts. The activities were at or near background level for all the samples.

2. Liquid scintillation analyses confirmed background level activity for all the samples.

APPENDICES

APPENDIX I
6740-2 (Chem/Chem Eng) 1/26
19 November 1994

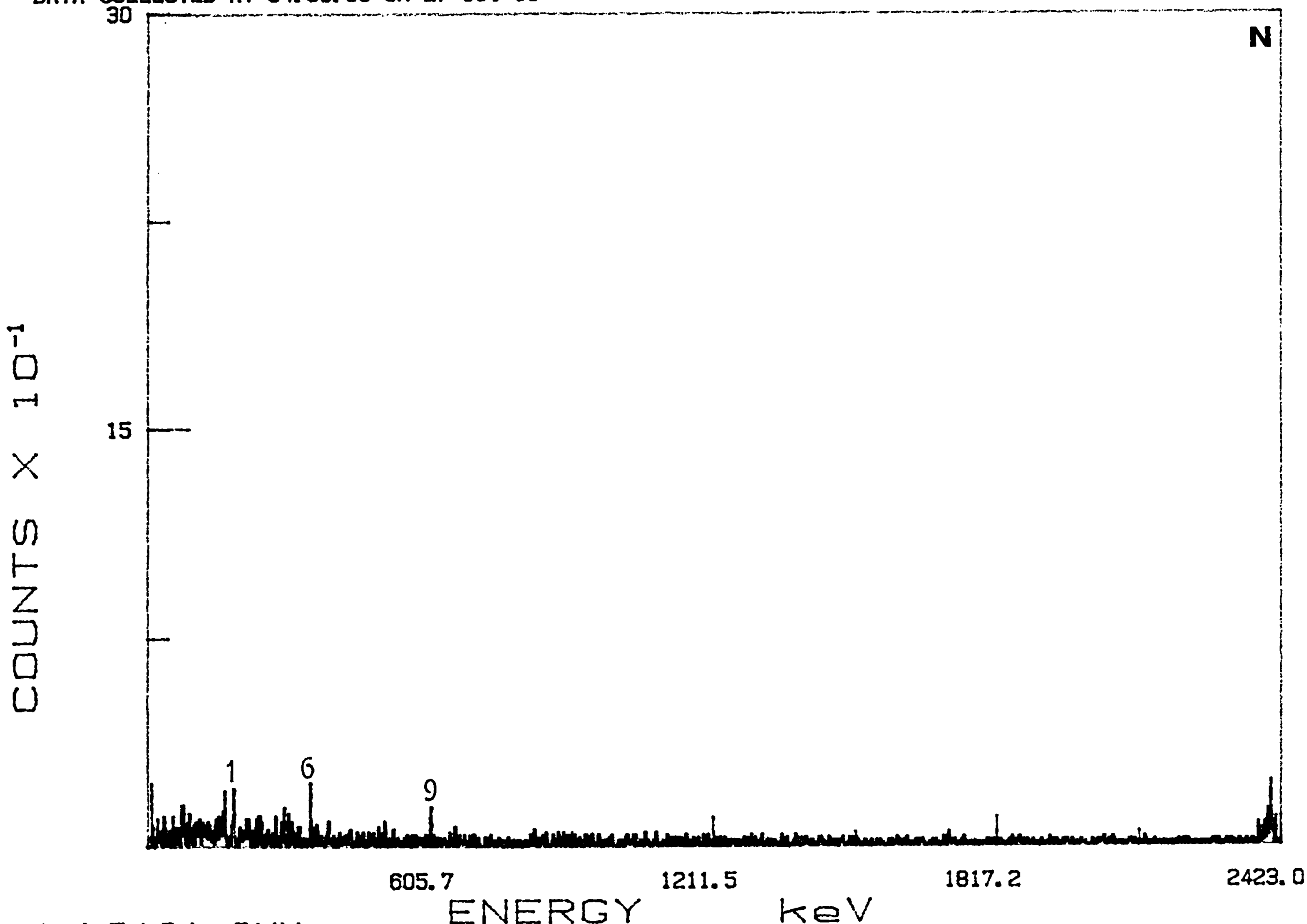
TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21608.96 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 04:08:00 ON 27-Oct-19



A:\GER1\PA01.CHN SAMPLE: Water sample from Lithuania 94300 (RMC)/PA01 (DGNS)

APPENDIX I
6740-2 (Chem/Chem Eng) 2/26
19 November 1994

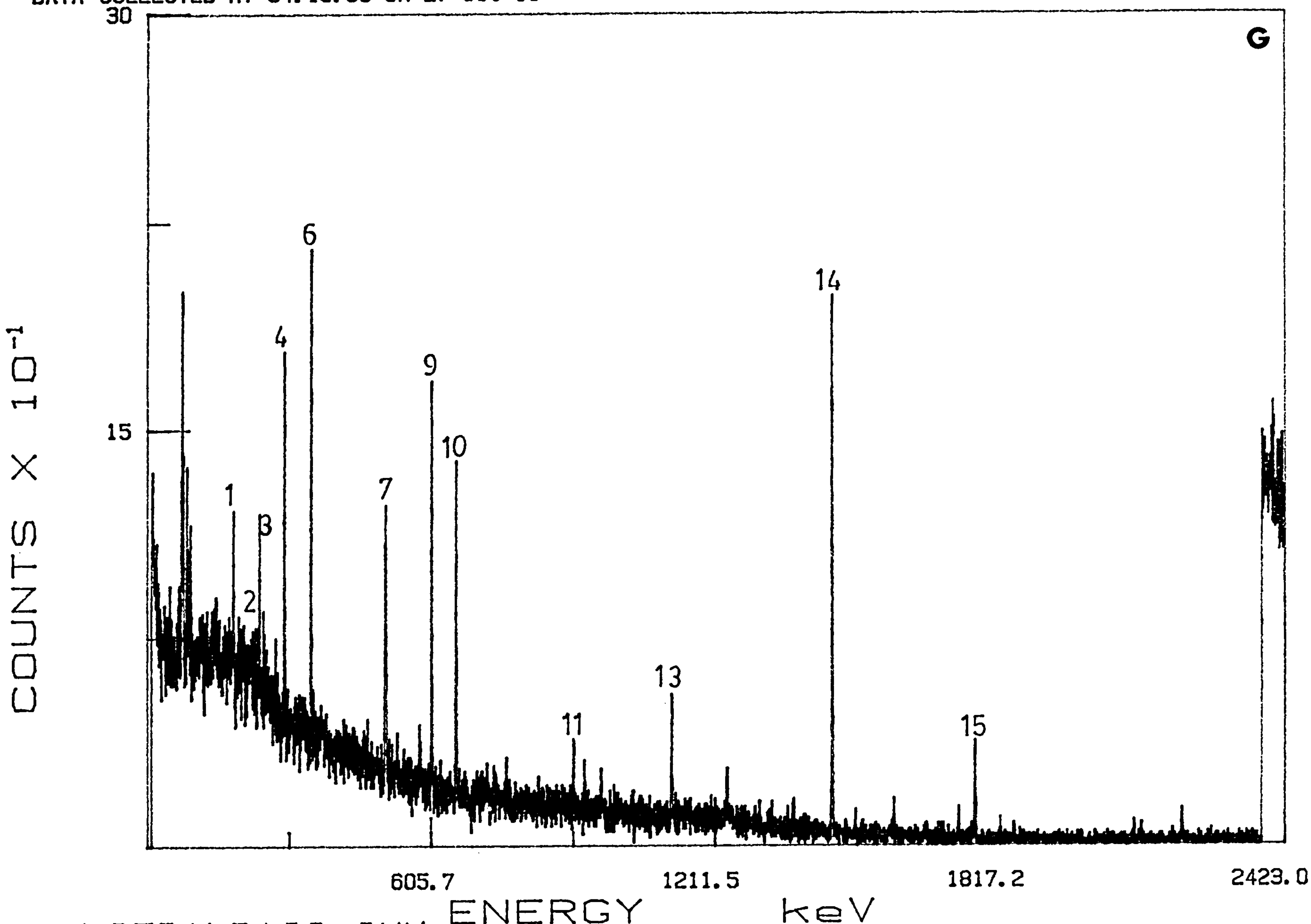
TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21608.96 SECONDS. LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 04:08:00 ON 27-Oct-19



A:\PA01.CHN SAMPLE: Water sample from Lithuania 94300(RMC)/PA01(DGNS)-94308BKG

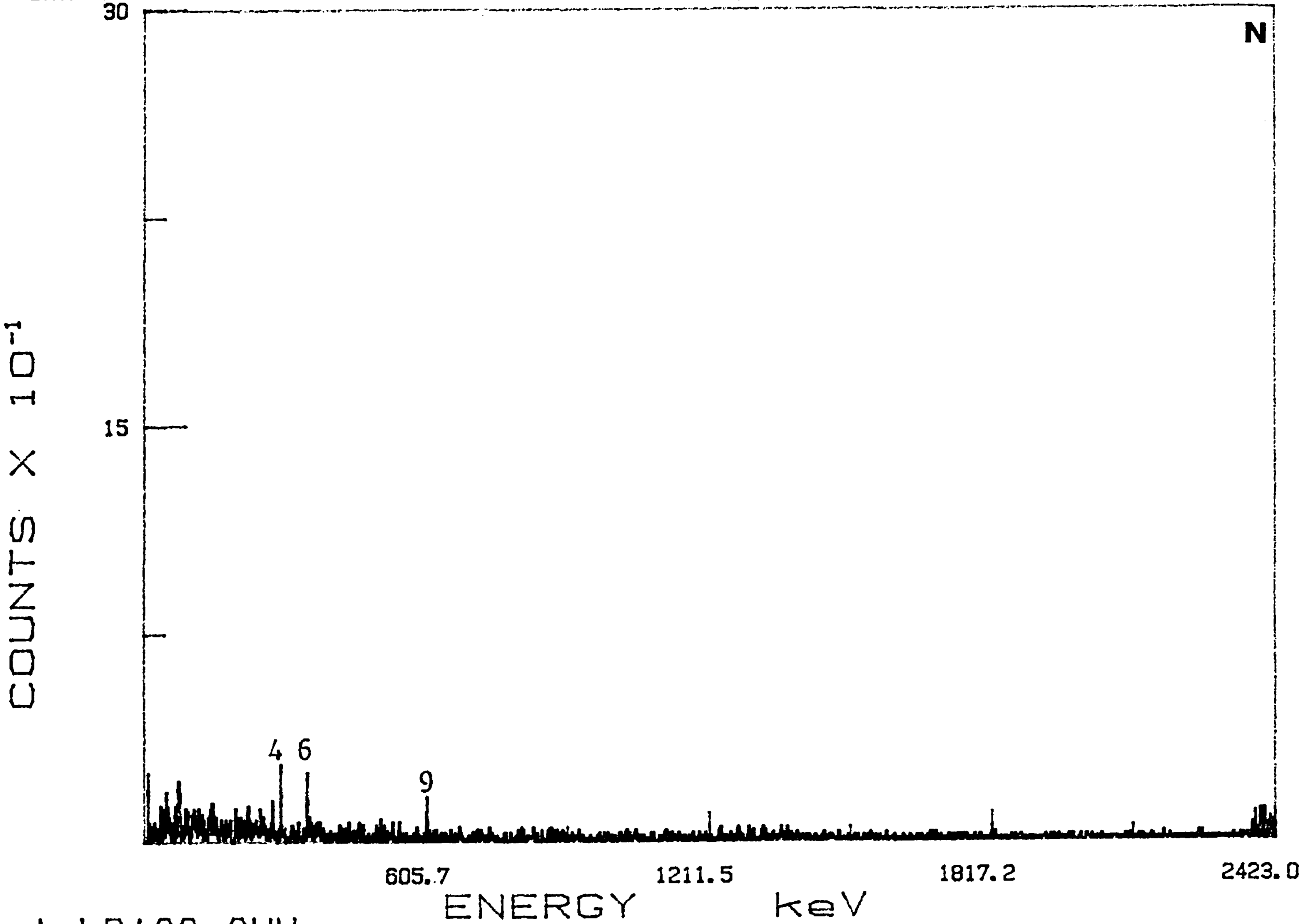
APPENDIX I
6740-2 (Chem/Chem Eng) 3/26
19 November 1994

TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21609.00 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 04:15:00 ON 27-Oct-19



A:\GER1\PA02.CHN SAMPLE: Water sample from Lithuania 94300 (RMC)/PA02 (DGNS)

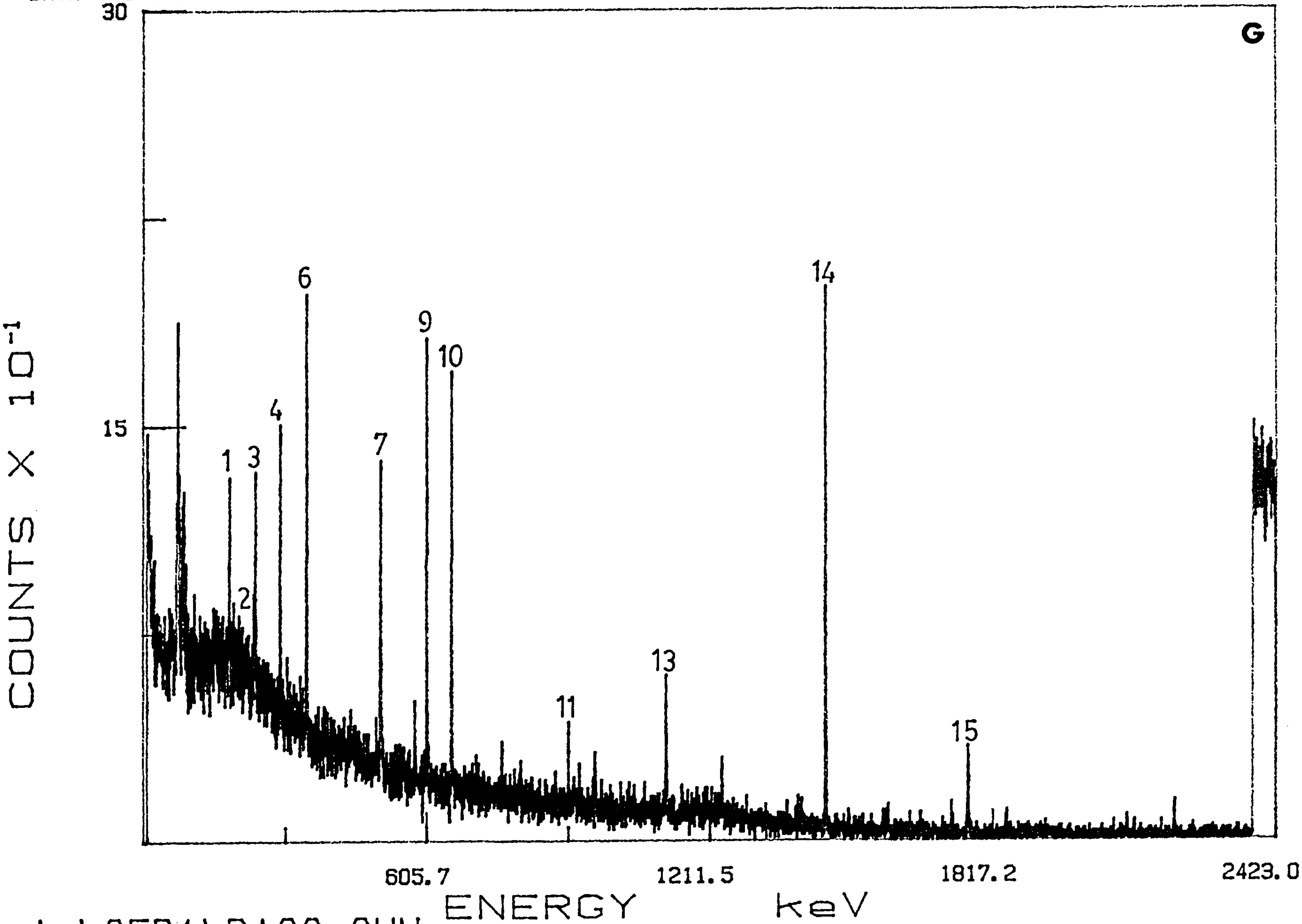
TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21609.00 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 04:15:00 ON 27-Oct-19



A:\PA02.CHN SAMPLE: Water sample from Lithuania 94300(RMC)/PA02(DGNS)-94308BKG

TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21609.04 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 4 :08:47 ON 28-Oct-199

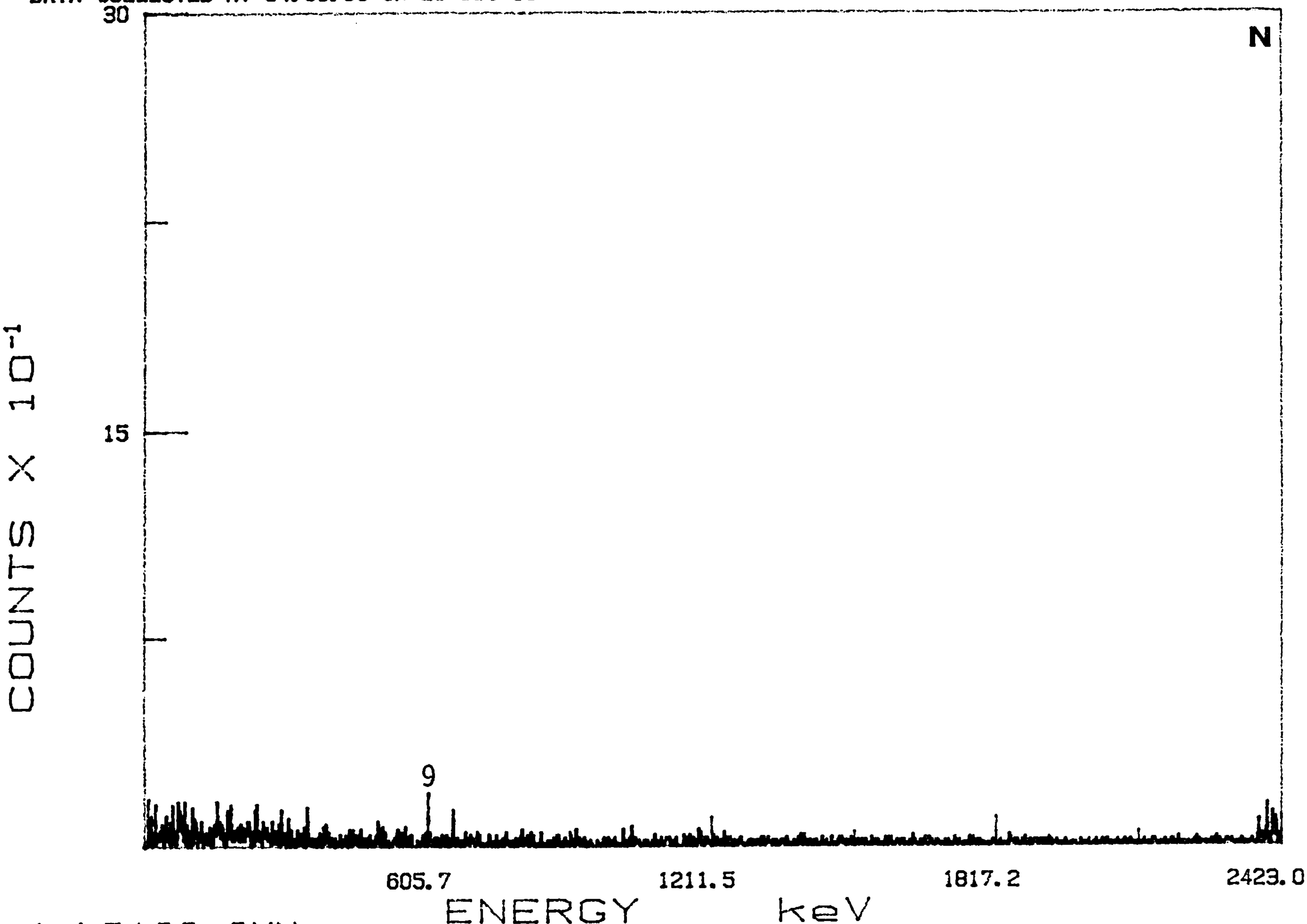
APPENDIX I
6740-2 (Chem/Chem Eng) 5/26
19 November 1994



A:\GER1\PA03.CHN SAMPLE: Water sample from Lithuania 94301 (RMC)/PA03 (DGNS)

TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21609.04 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 04:08:00 ON 28-Oct-19

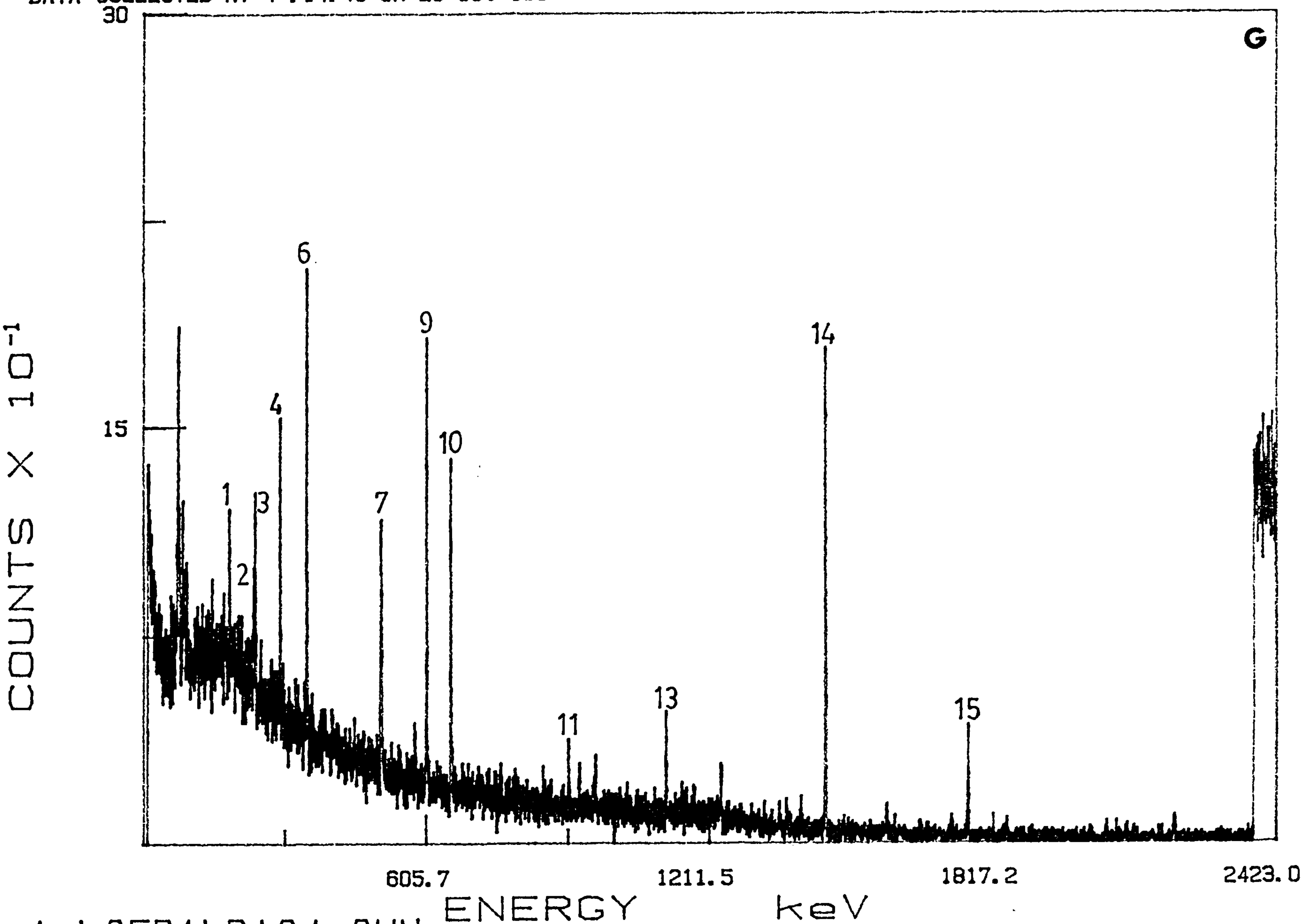
APPENDIX I
6740-2 (Chem/Chem Eng) 6/26
19 November 1994



A:\PA03.CHN SAMPLE: Water sample from Lithuania 94301 (RMC)/PA03 (DGNS)-94308BKG

TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21609.00 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 4 : 14: 40 ON 28-Oct-199

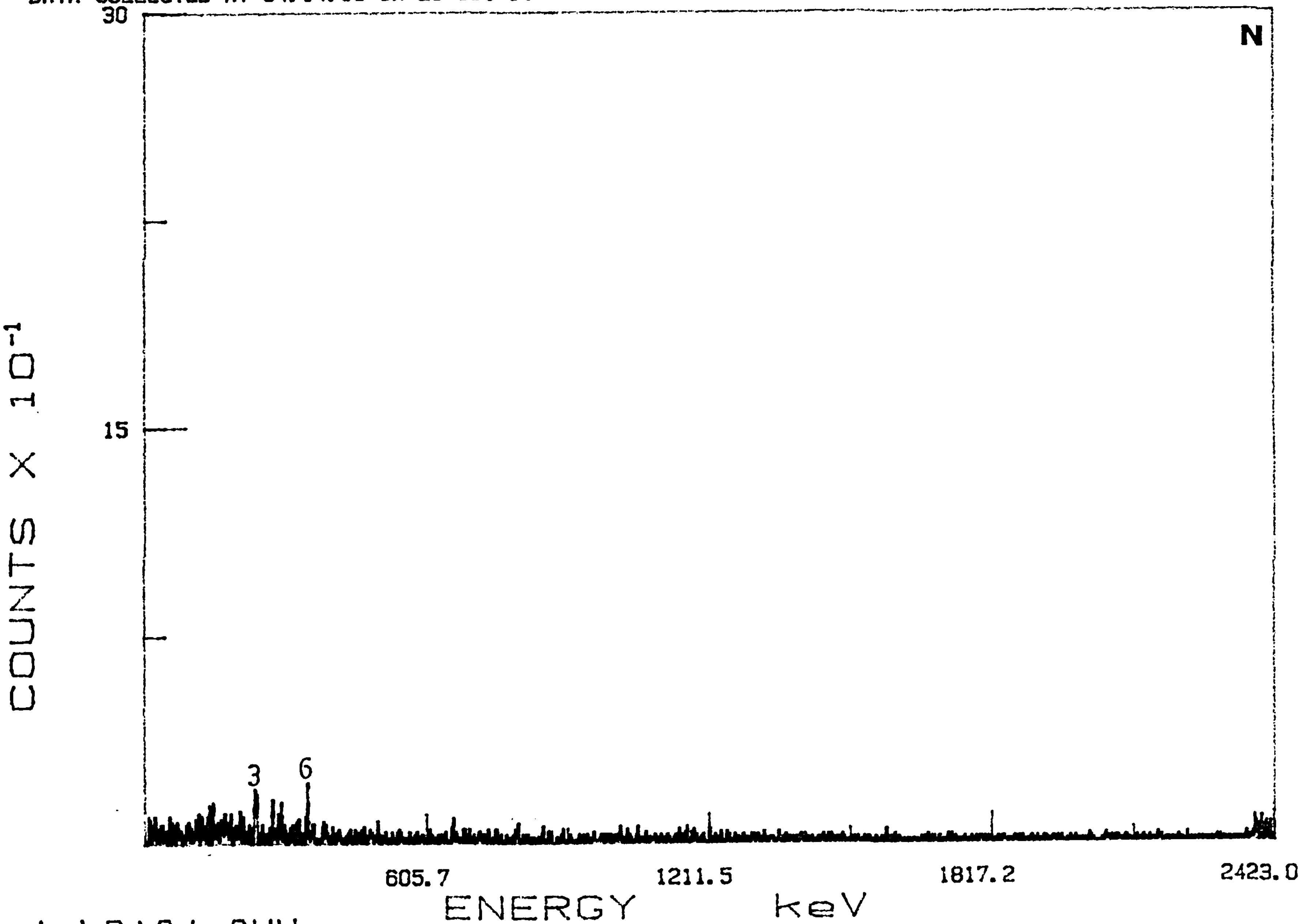
APPENDIX I
6740-2 (Chem/Chem Eng) 7/26
19 November 1994



A: \GER1\PA04. CHN SAMPLE: Water sample from Lithuania 94301 (RMC) /PA04 (DGNS)

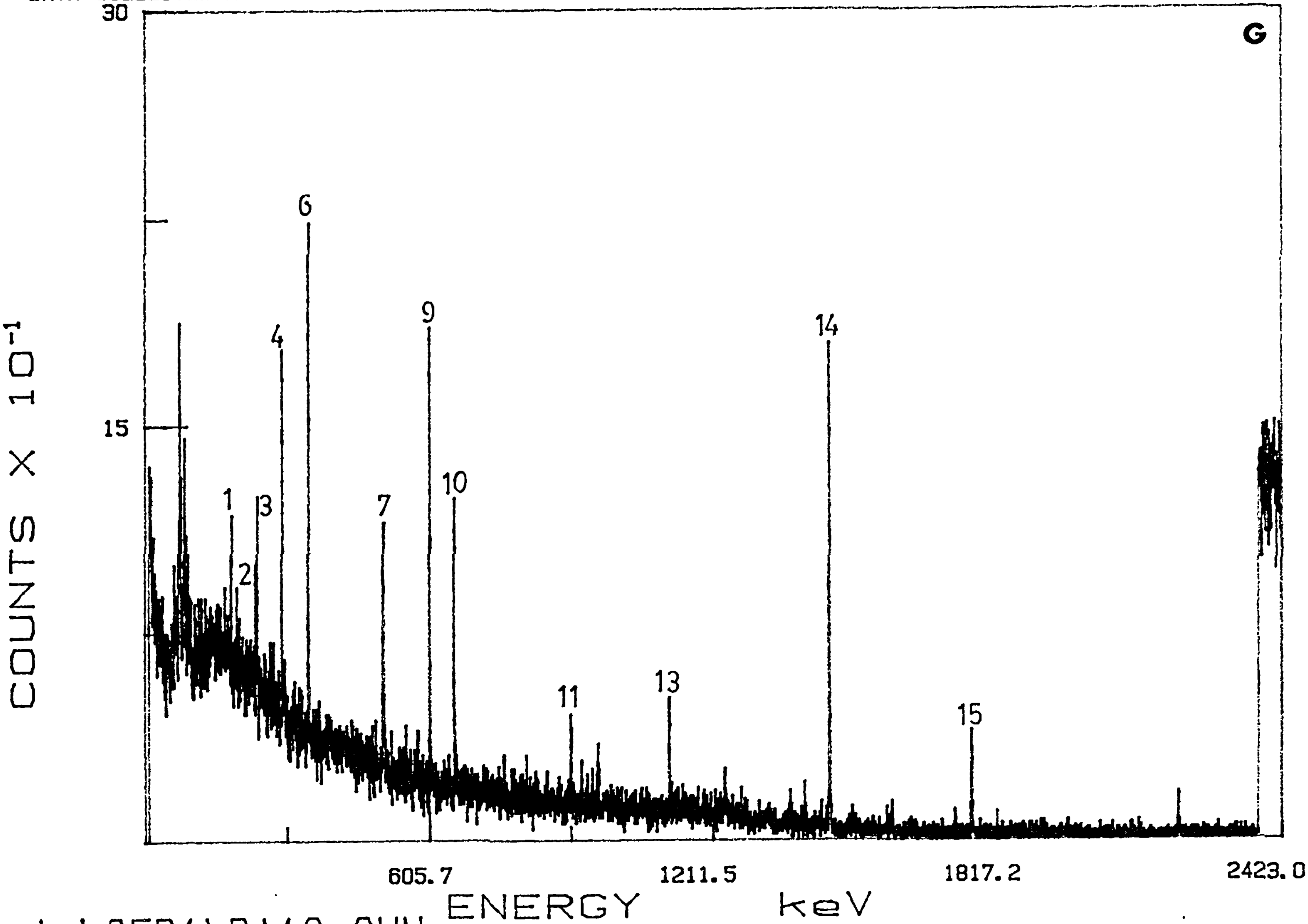
APPENDIX I
6740-2 (Chem/Chem Eng) 8/26
19 November 1994

TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21609.00 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 04:14:00 ON 28-Oct-19



A:\PA04.CHN SAMPLE: Water sample from Lithuania 94301 (RMC)/PA04 (DGNS)-94308BKG

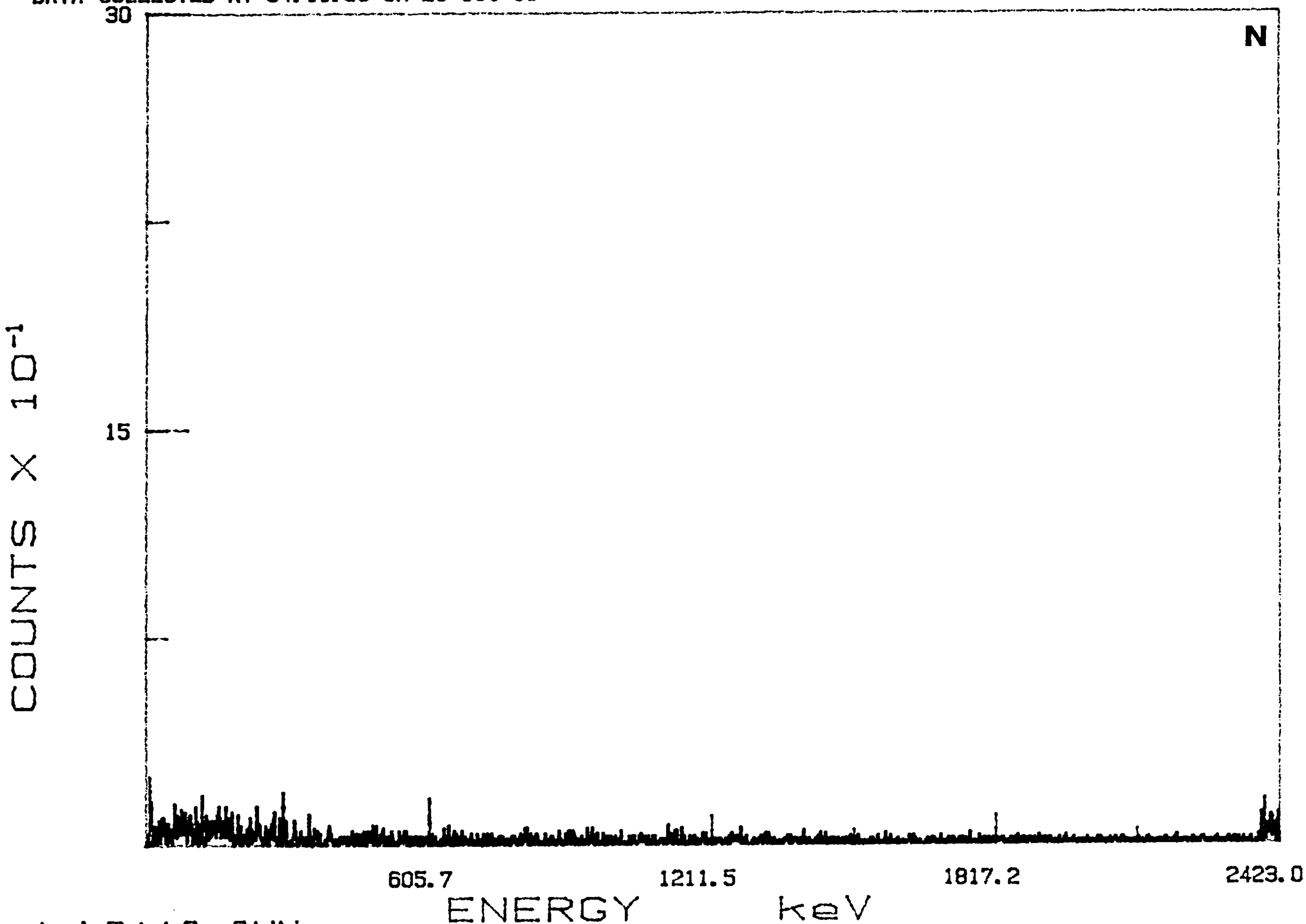
TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21608.84 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 4 : 11: 13 ON 26-Oct-199



A: \GER1\PA12. CHN SAMPLE: Water sample from Lithuania 94299 (RMC) /PA12 (DGNS)

APPENDIX I
6740-2 (Chem/Chem Eng) 10/26
19 November 1994

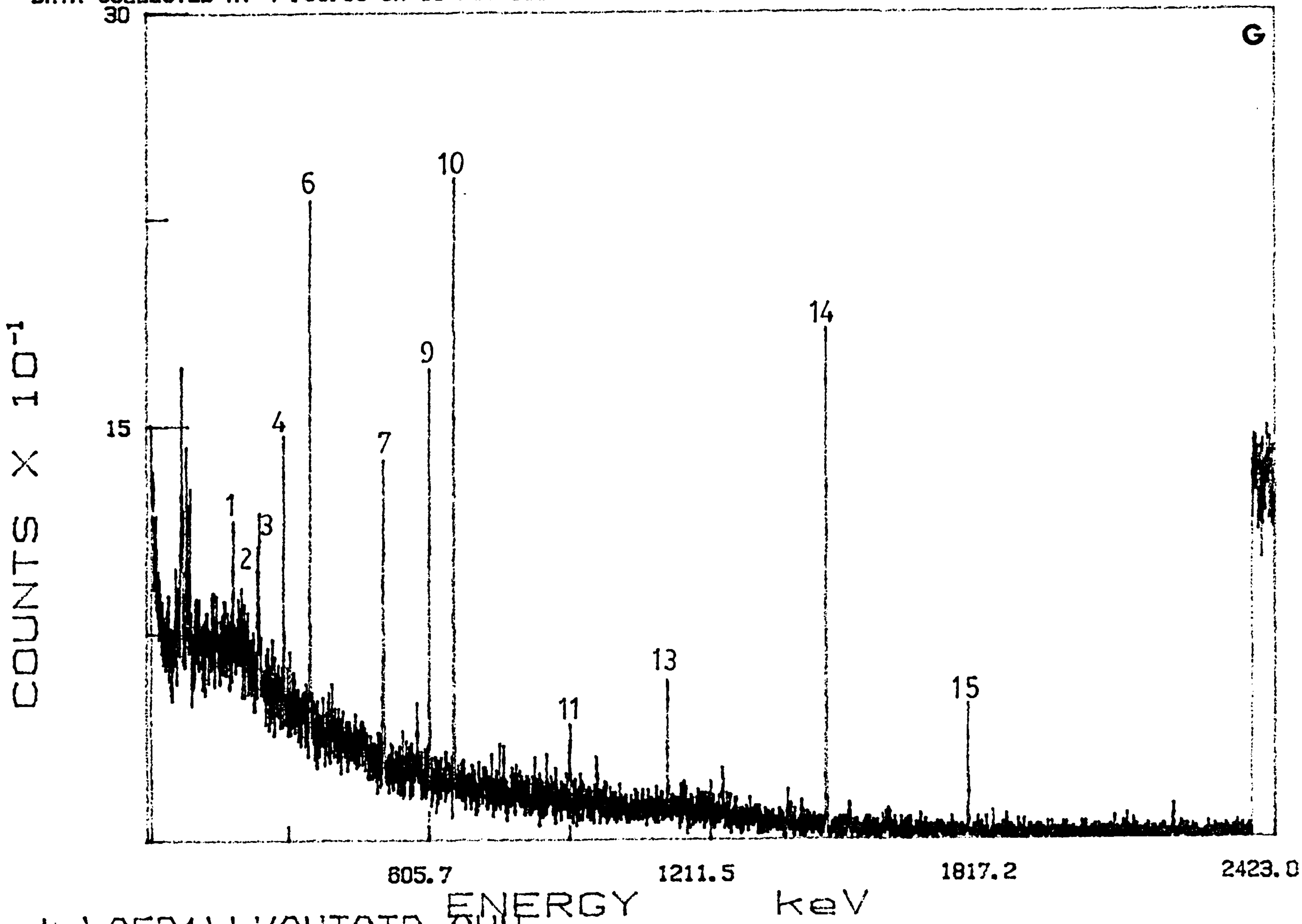
TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21608.84 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 04:11:00 ON 26-Oct-19



A:\PA12.CHN SAMPLE: Water sample from Lithuania 94299(RMC)/PA12(DGNS)-94308BKG

APPENDIX I
6740-2 (Chem/Chem Eng) 11/26
19 November 1994

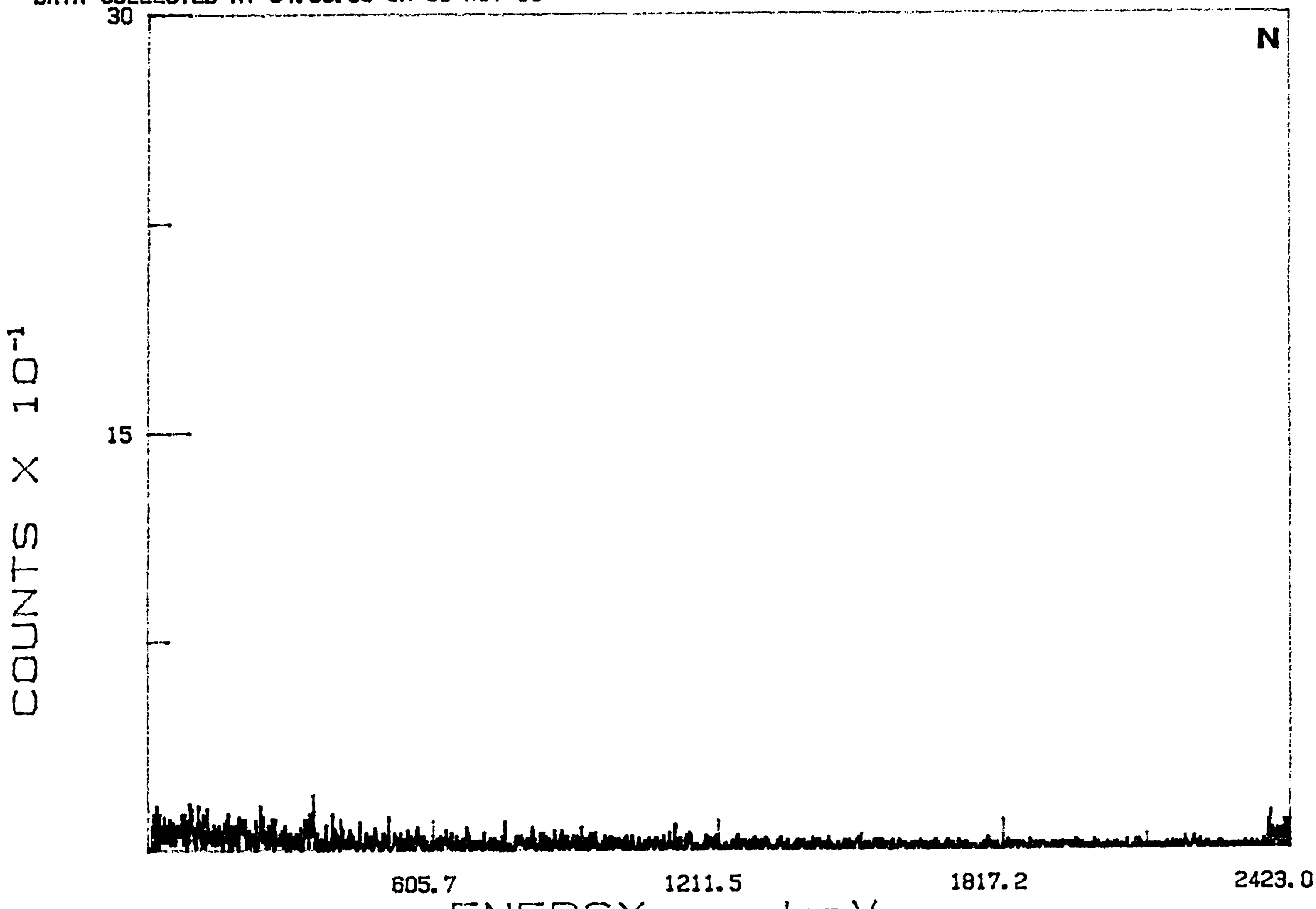
TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21608.96 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 4 :08:35 ON 08-Nov-199



A:\GER1\LKONTC5R.CHN SAMPLE: Lake Ontario water

APPENDIX I
6740-2 (Chem/Chem Eng) 12/26
19 November 1994

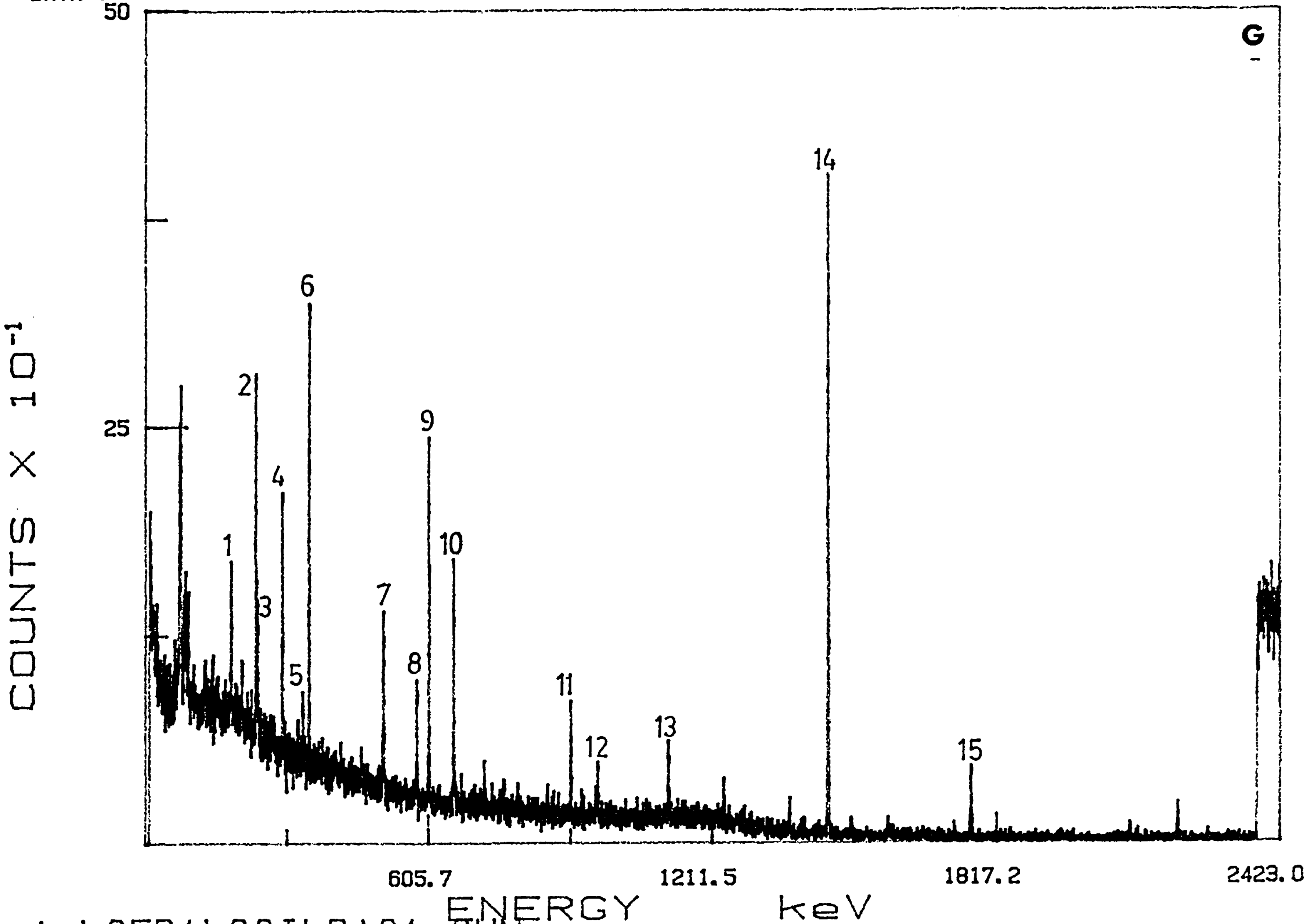
TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21609.96 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 04:08:00 ON 08-Nov-19



A:\LKONTCTR.CHN SAMPLE: Lake Ontario water - 94313BKG

APPENDIX I
6740-2 (Chem/Chem Eng) 13/26
19 November 1994

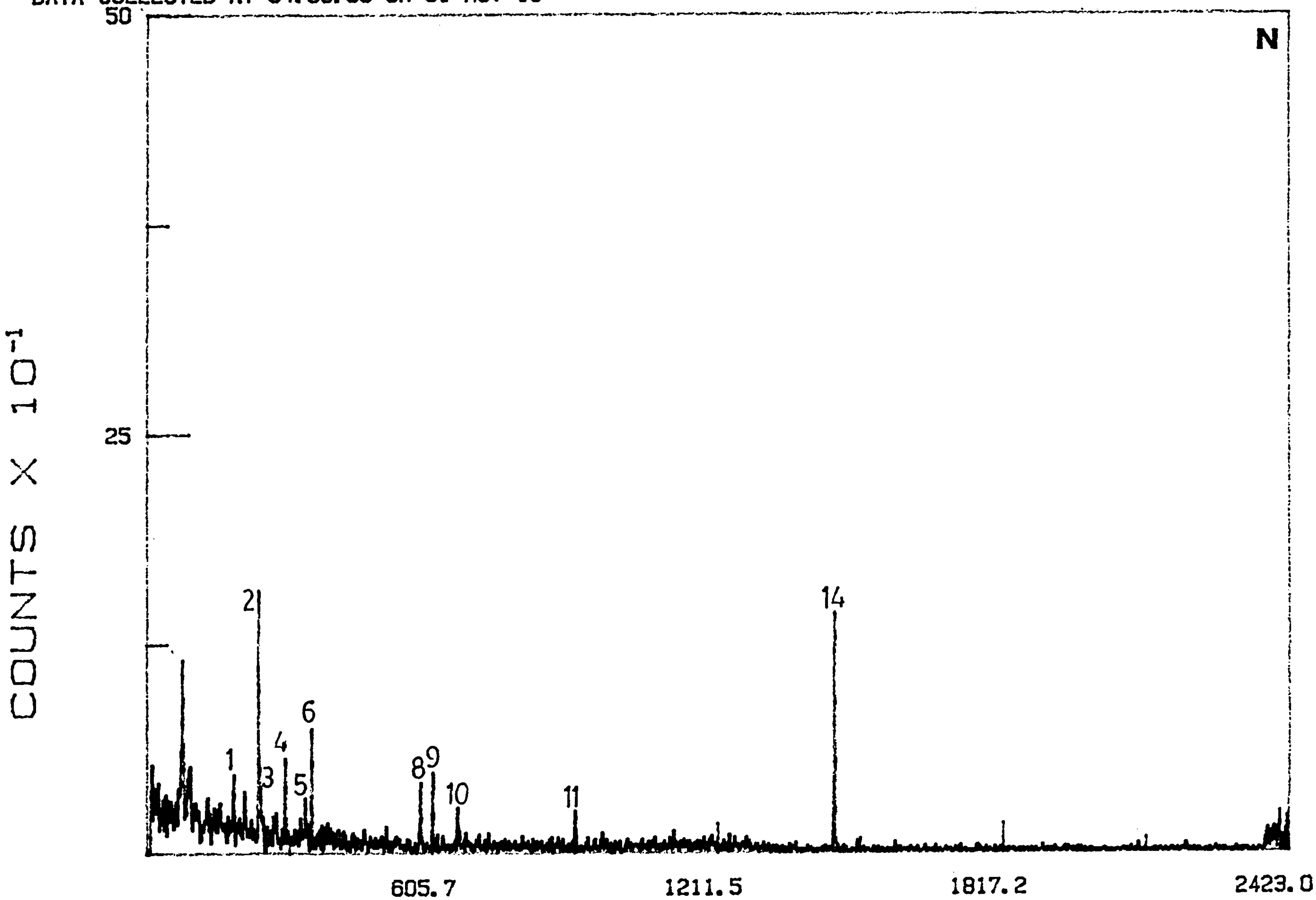
TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21610.36 SECONDS. LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 4 :08:03 ON 01-Nov-199



A:\GER1\SOILPA01.CHN: Soil sample from Lithuania 94305(RMC)/PA01(DGNS)

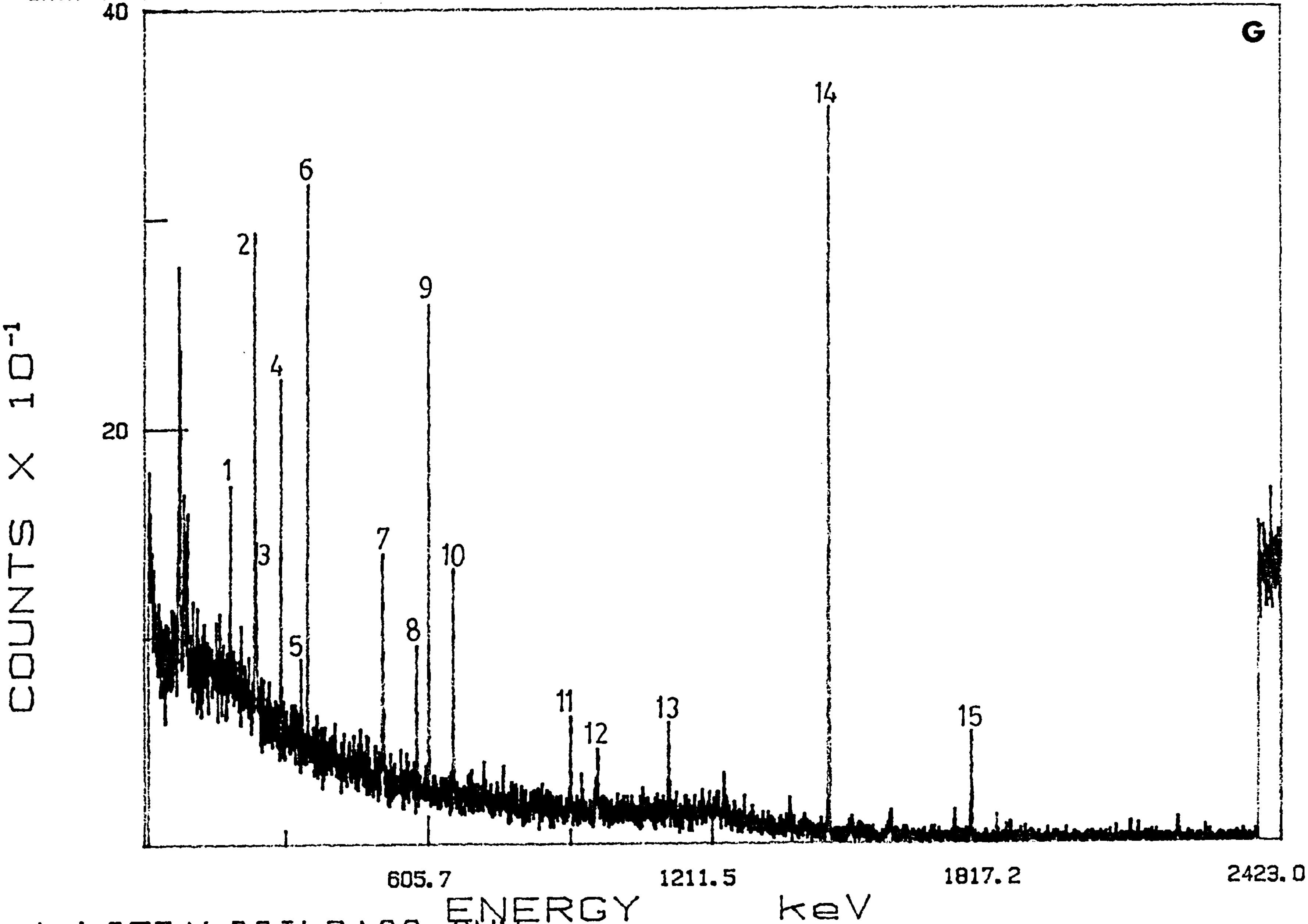
APPENDIX I
6740-2 (Chem/Chem Eng) 14/26
19 November 1994

TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21610.36 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 04:08:00 ON 01-Nov-19



A:\SOILPA01.CHNSAMPLE: Soil sample from Lithuania 94305(RMC)/PA01(DGNS)-94308BKG

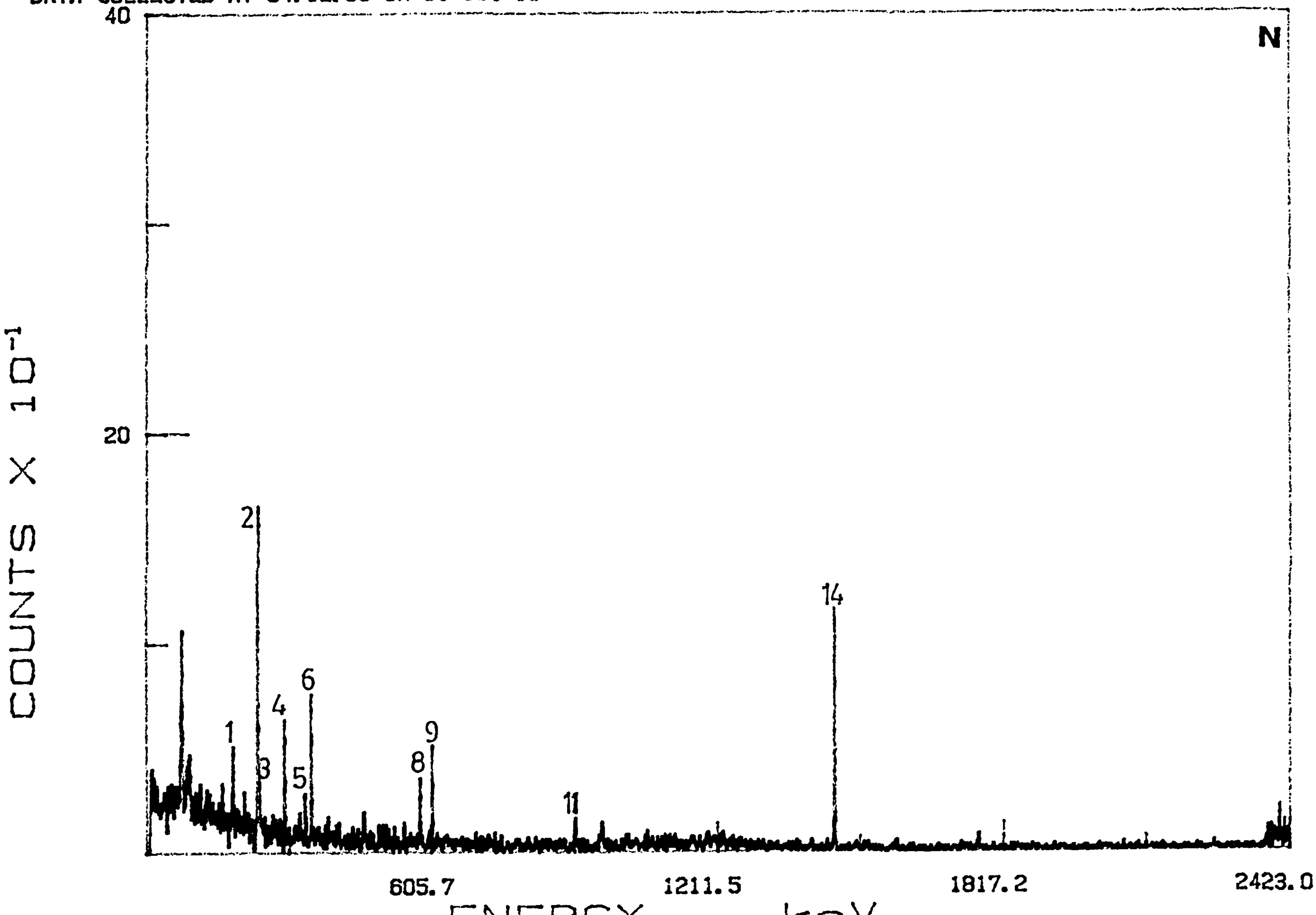
TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21609.86 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 4 : 12: 15 ON 31-Oct-199



A:\GER1\SOILPA02.CHN: Soil sample from Lithuania 94304 (RMC) /PA02 (DGNS)

APPENDIX I
6740-2 (Chem/Chem Eng) 16/26
19 November 1994

TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21609.86 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 04:12:00 ON 31-Oct-19



A:\SOILPA02.CHN SAMPLE: Soil sample from Lithuania 94304(RMC)/PA02(DGNS)-94308BKG

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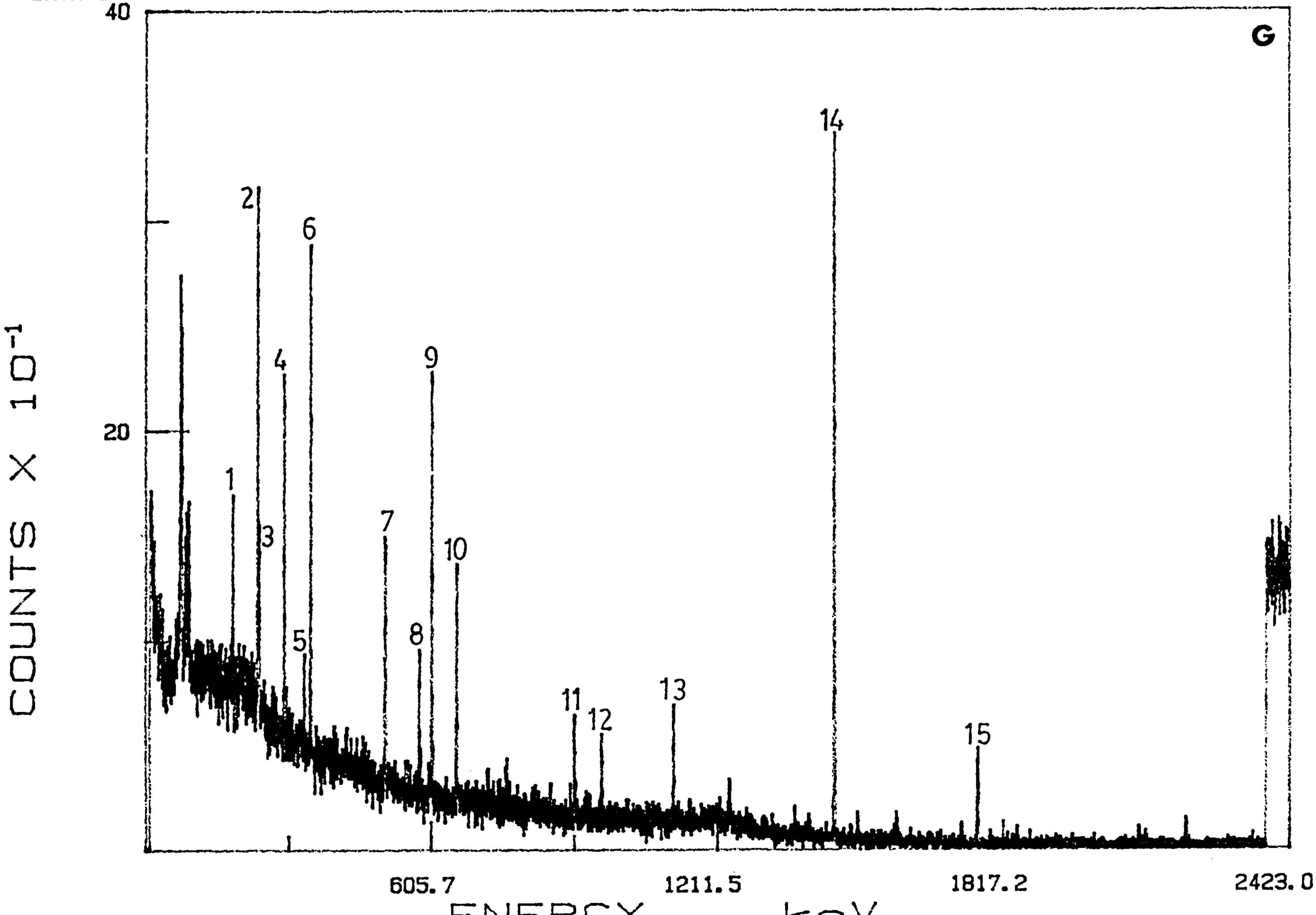
TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21609.88 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 4 :16:05 ON 01-Nov-199

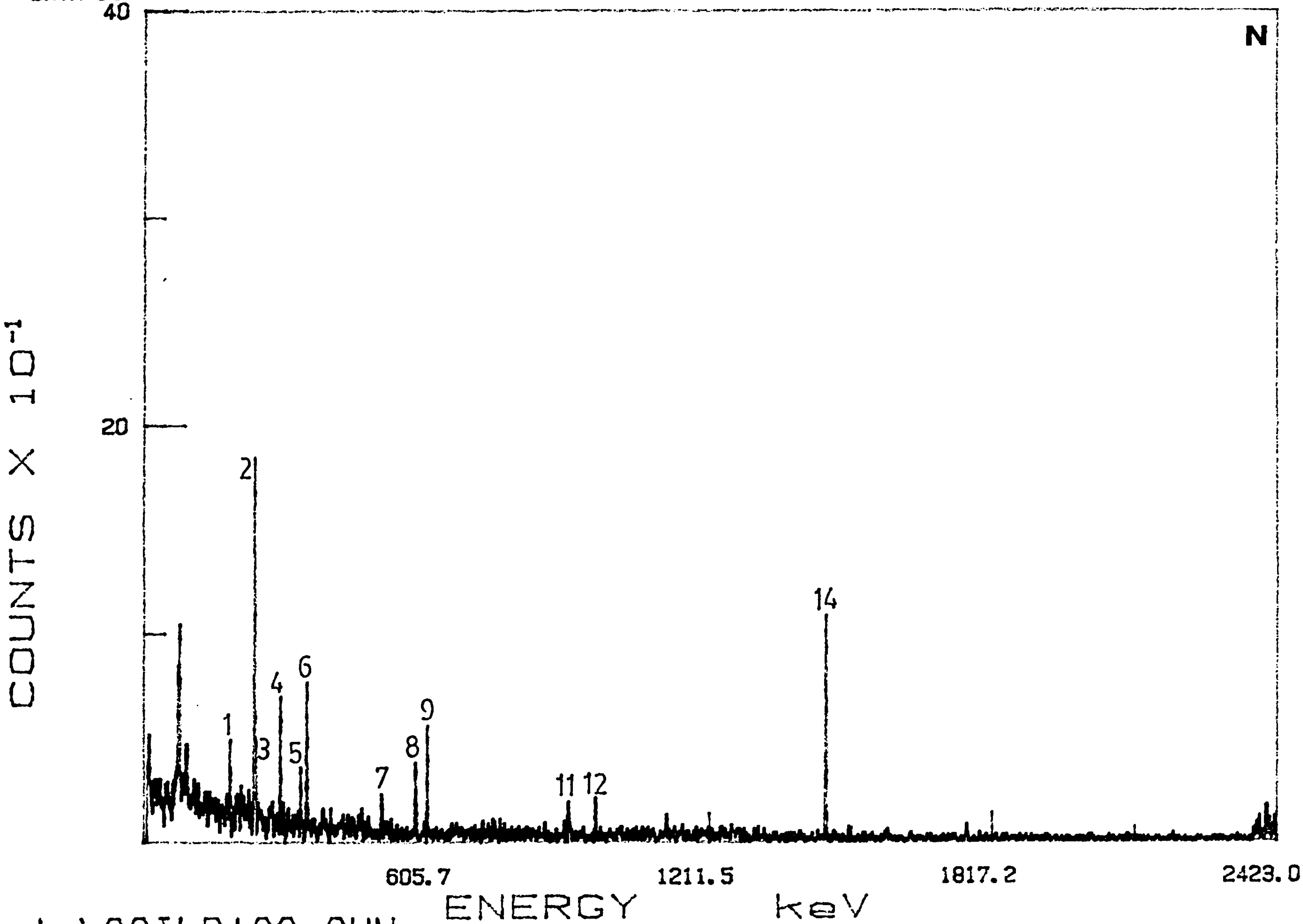
APPENDIX I
6740-2 (Chem/Chem Eng) 17/26
19 November 1994



A:\GER1\SOILPA03.CHN SAMPLE: Soil sample from Lithuania 94305(RMC)/PA03(DGNS)

TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21609.88 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 04:16:00 ON 01-Nov-19

APPENDIX I
6740-2 (Chem/Chem Eng) 18/26
19 November 1994



A:\SOILPA03.CHN SAMPLE: Soil sample from Lithuania 94305(RMC)/PA03(DGNS)-94308BKG

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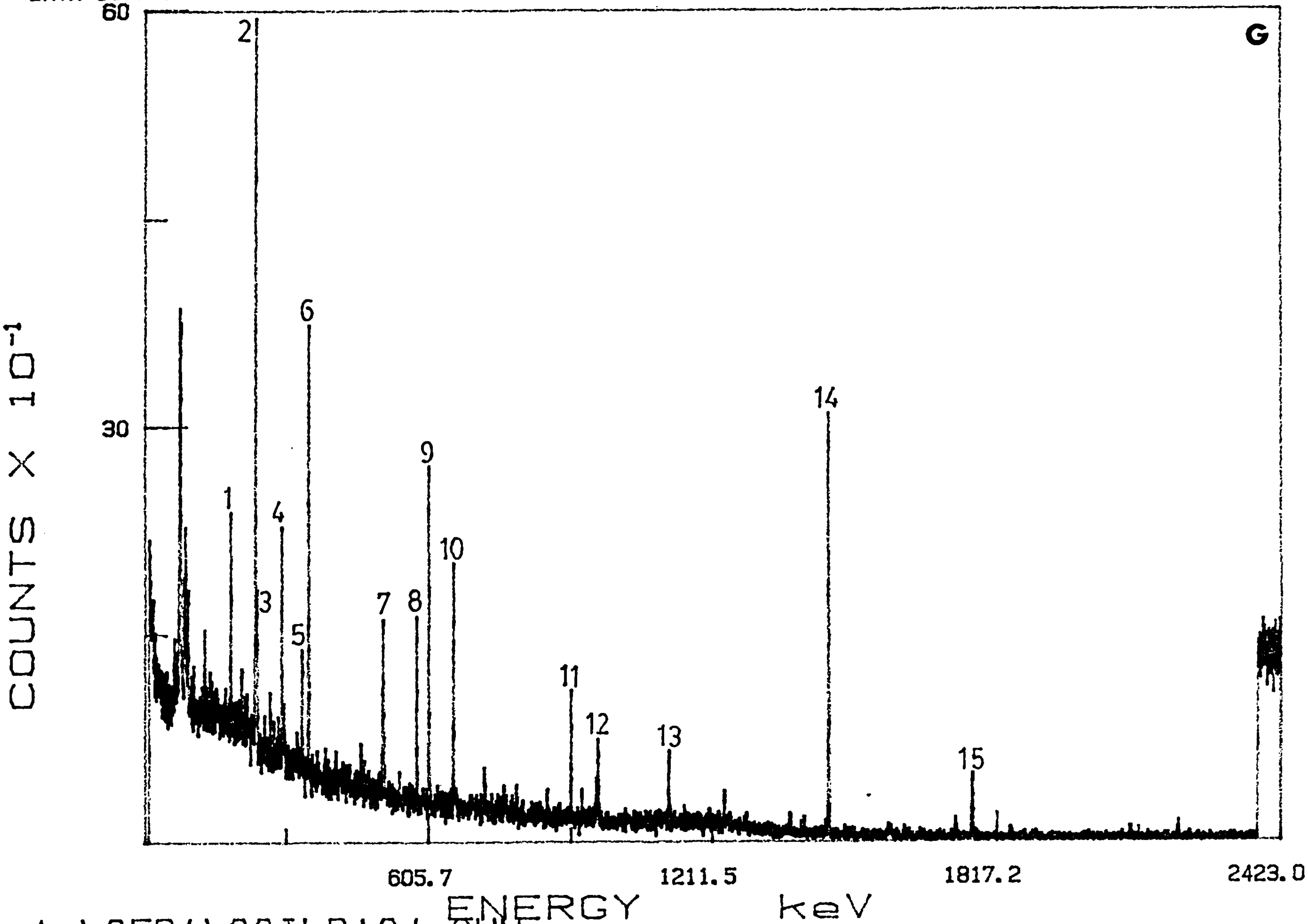
APPENDIX I
6740-2 (Chem/Chem Eng) 19/26
19 November 1994

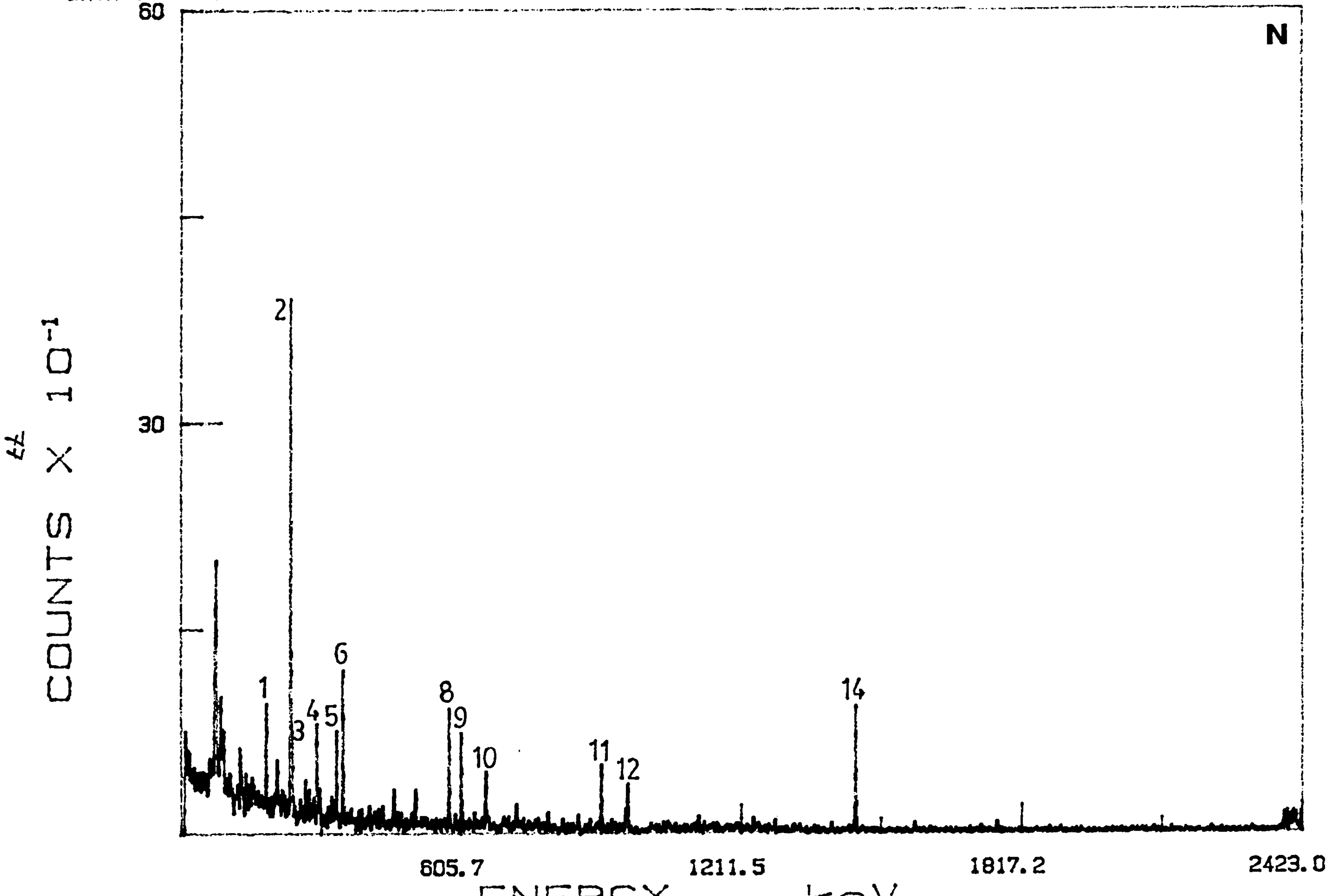
TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21610.26 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 4 :08:58 ON 02-Nov-199



A: \GER1\SOILPA04.CHN: Soil sample from Lithuania 94306(RMC)/PA04(DGNS)

TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21610.26 SECONDS. LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 04:08:00 ON 02-Nov-19

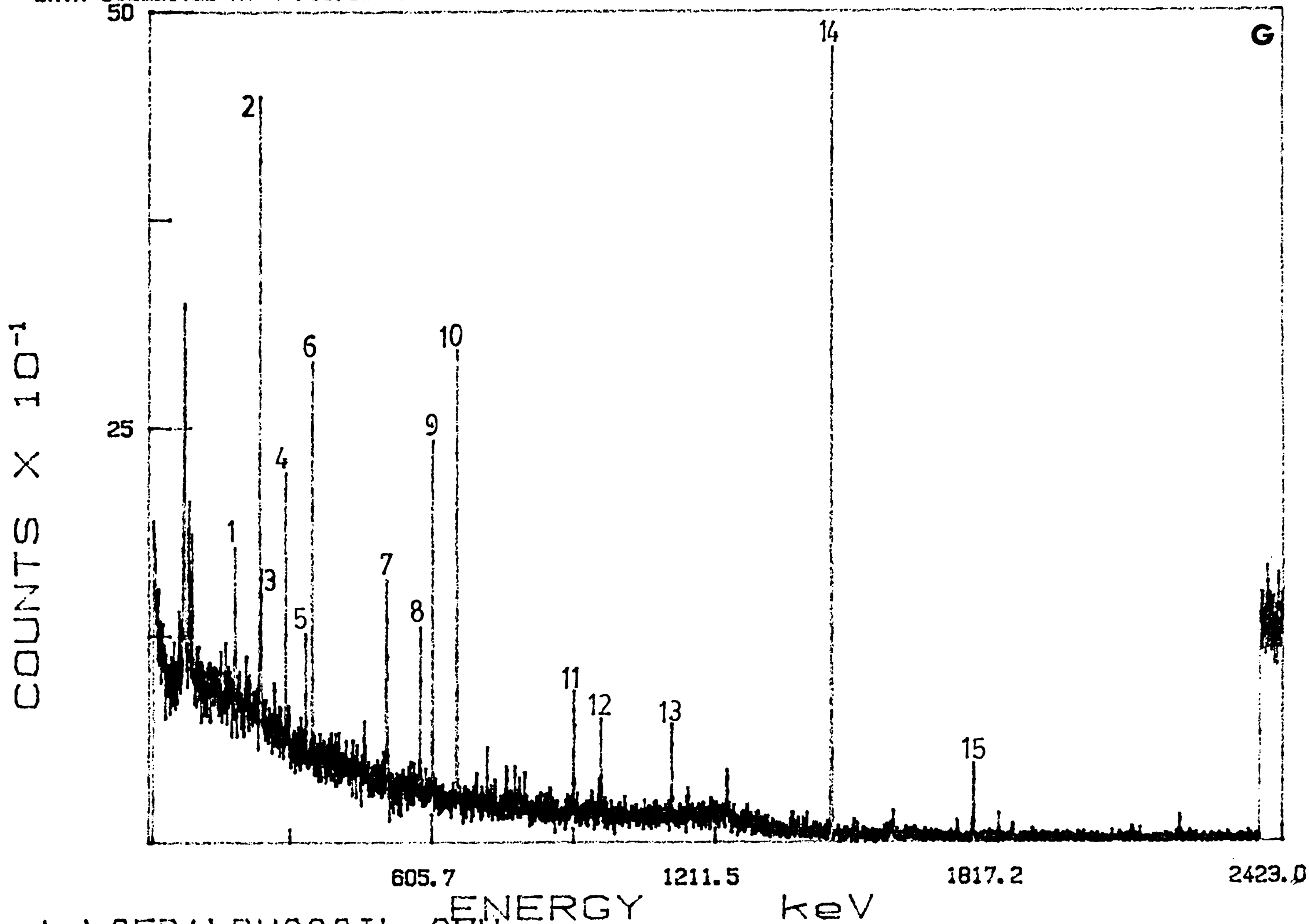
APPENDIX I
6740-2 (Chem/Chem Eng) 20/26
19 November 1994



A:\SOILPA04.CHN SAMPLE: Soil sample from Lithuania 94306(RMC)/PA04(DGNS)-94308BKG

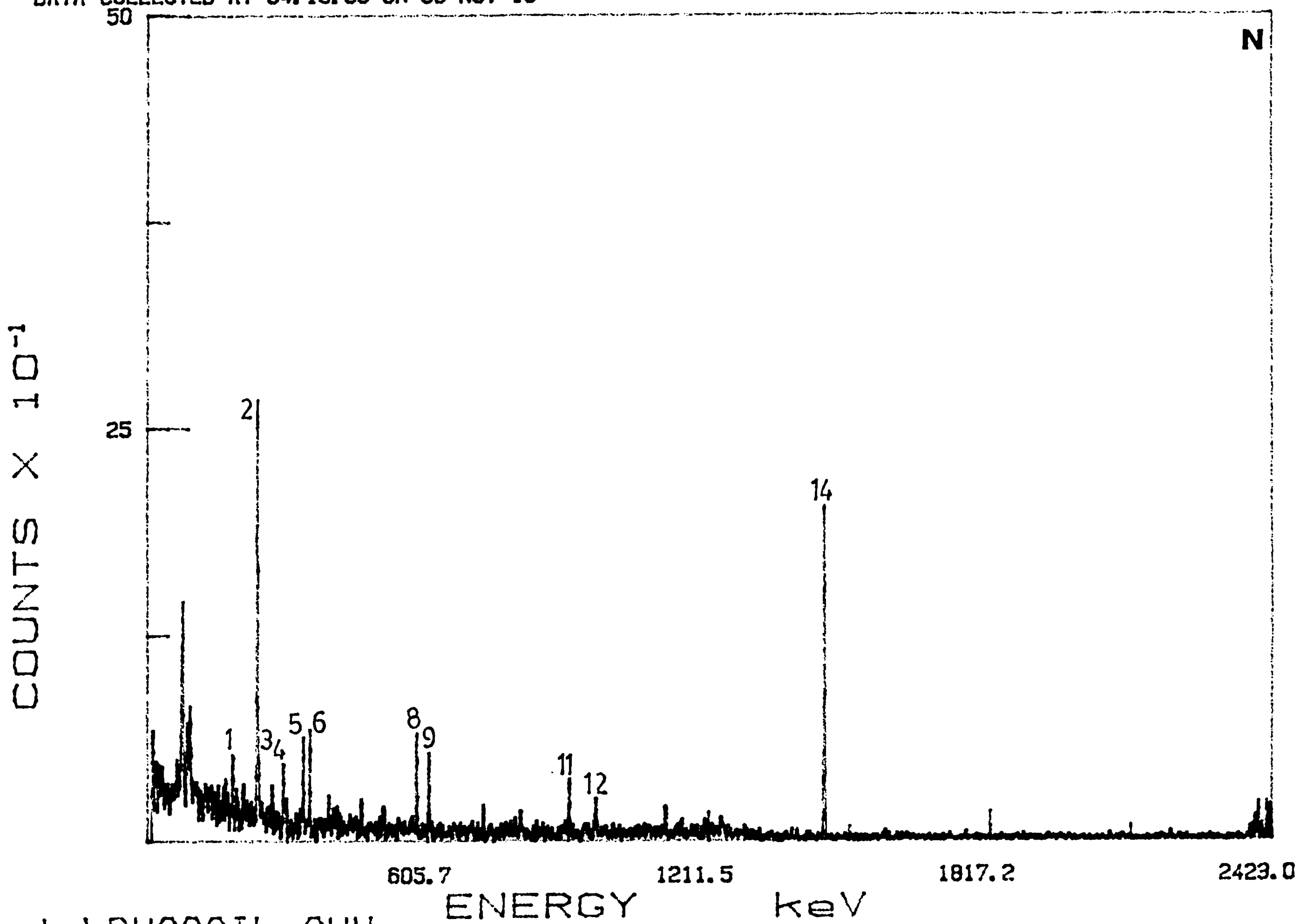
APPENDIX I
6740-2 (Chem/Chem Eng) 21/26
19 November 1994

TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21610.40 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 4 : 16: 08 ON 08-Nov-199



A:\GER1\RMCSOILSAMPLE: Soil from RMC grounds

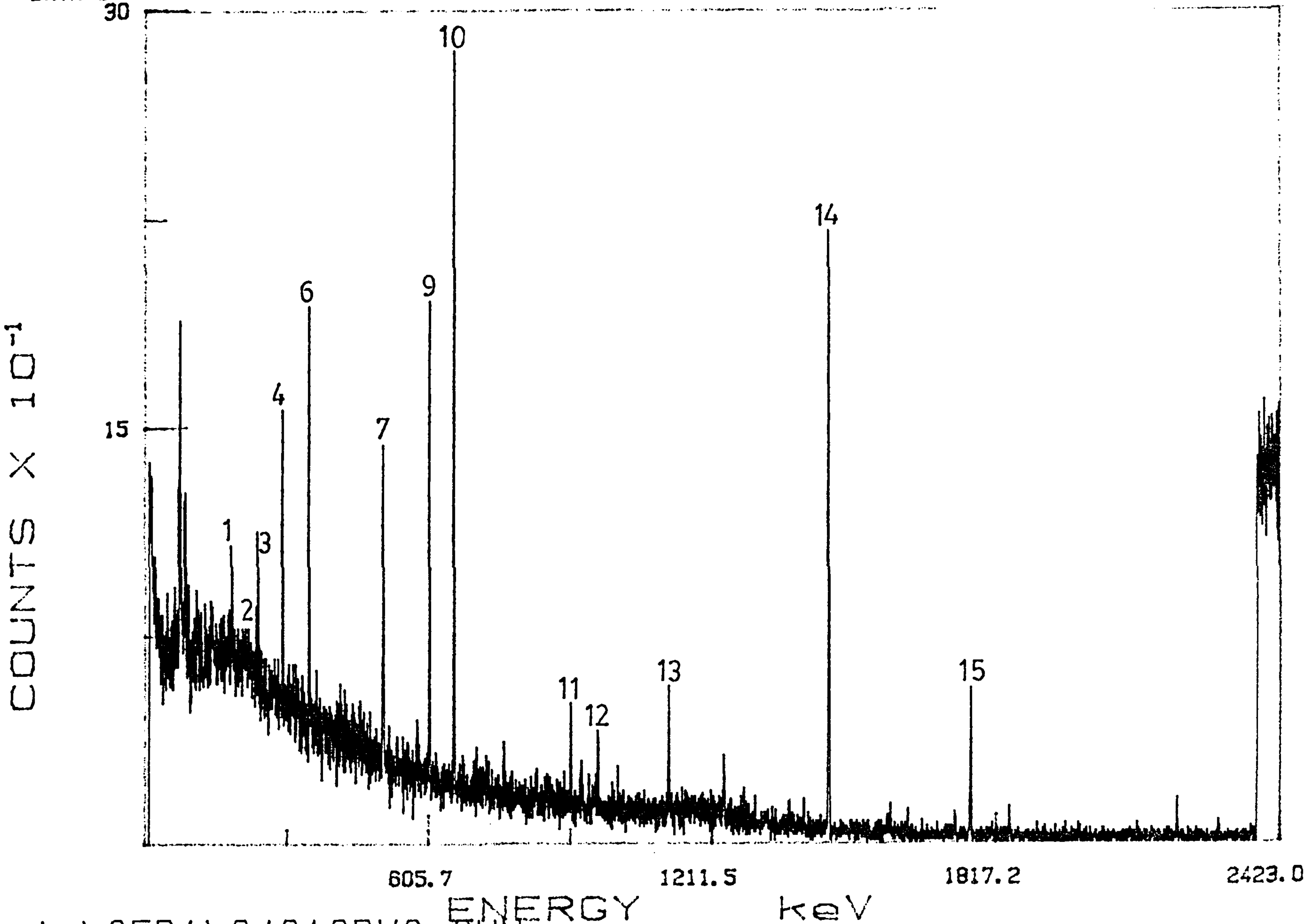
TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21610.40 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 04:16:00 ON 08-Nov-19



A:\RMCSOIL.CHN SAMPLE: Soil from RMC grounds - 94313BKG

APPENDIX I
6740-2 (Chem/Chem Eng) 23/26
19 November 1994

TYPE = -1 MCA # 01 SEGMENT # 01 SEQUENCE # 0
REALTIME = 21609.98 SECONDS, LIVETIME = 21600.00 SECONDS
DATA COLLECTED AT 4 : 09: 46 ON 09-Nov-199



A:\GER1\94313BKG.CHN: Background acquired over a 6-hour period

08

Radionuclide & Gamma-ray Energies

APPENDIX I
6740-2(Chem/Chem Eng) 24/26
19 November 1994

Peak	*Radionuclide*	*KeV*
1	*Ra-226*	*186.10*
2	*Pb-212*	*238.63*
3	*Pb-214*	*241.98*
4	*Pb-214*	*295.21*
5	*Ac-228*	*338.32*
6	*Pb-214*	*351.92*
7	*Tl-208*	*510.77*
8	*Tl-208*	*583.19*
9	*Bi-214*	*609.31*
10	*Cs-137*	*661.62*
11	*Ac-228*	*911.21*
12	*Ac-228*	*968.97*
13	*Bi-214*	*1120.29*
14	*K-40*	*1460.83*
15	*Bi-214*	*1764.49*

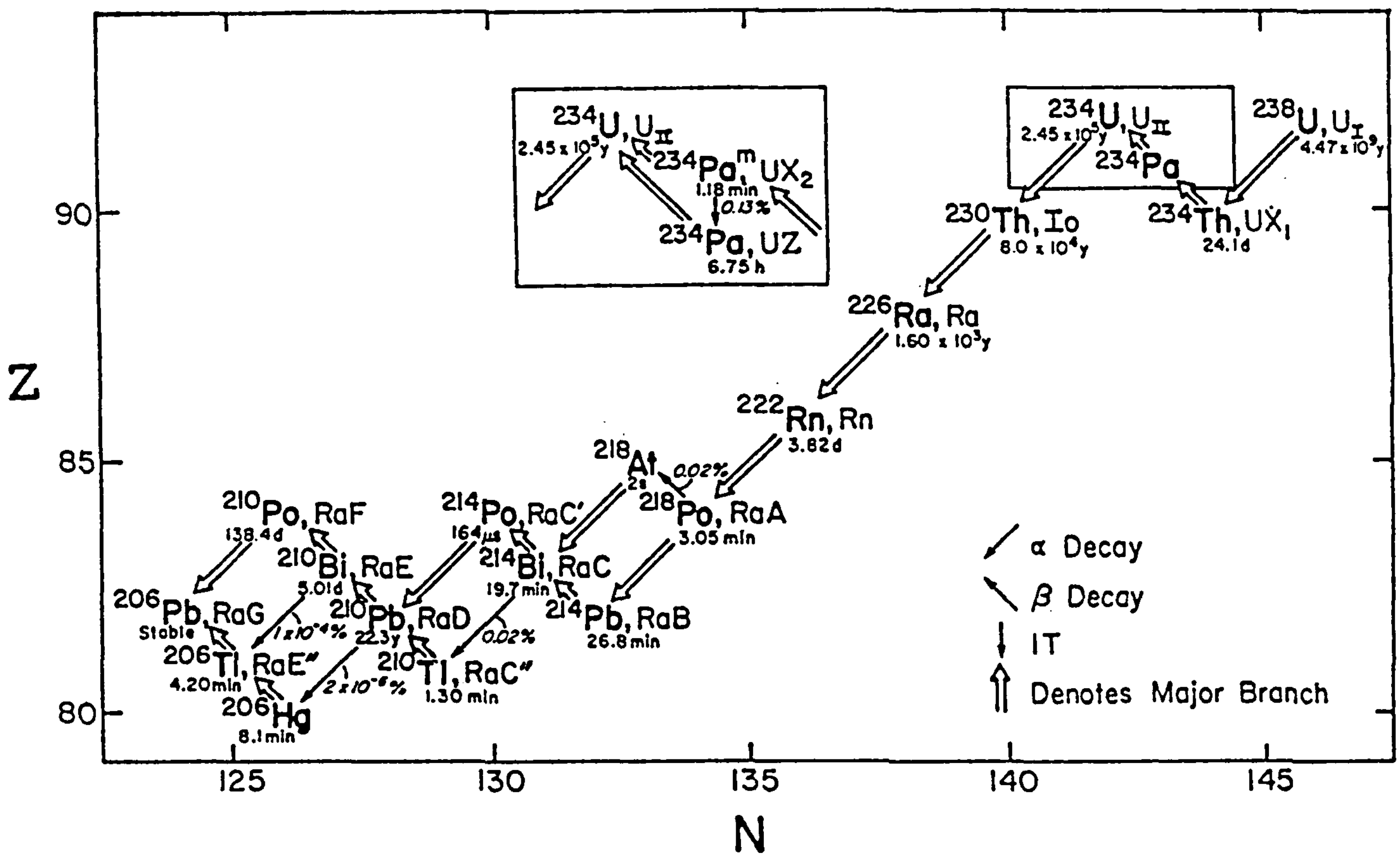


Figure 1. Uranium Series (Friedlander, G., Kennedy, J. W., Macias, E. S. and Miller, J. M., In: *Nuclear and Radiochemistry*, Wiley, New York (1981)).

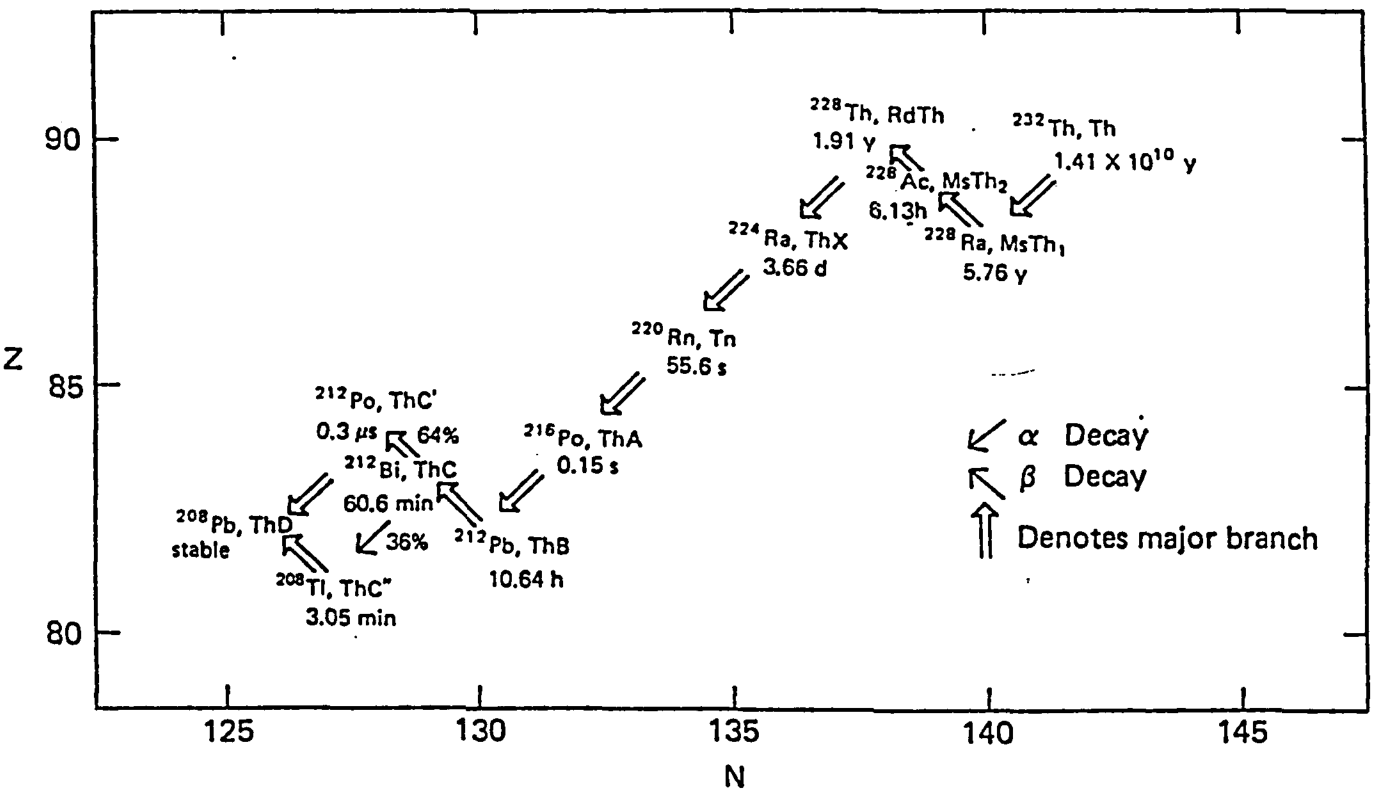


Figure 2. Thorium Series (Friedlander, G., Kennedy, J. W., Macias, E. S. and Miller, J. M., In: *Nuclear and Radiochemistry*, Wiley, New York (1981)).

Liquid Scintillation Analyses

APPENDIX II
6740-2(Chem/Chem Eng) 1/1
19 November 1994

Sample	CPM(Net)	Bq . Sample^{-1}
<u>Soil</u>		
PA01	3.5	0.13
PA02	1.9	0.07
PA03	22.1	0.85
PA04	6.9	0.37
Background	29.8	0.00
<u>Water</u>		
PA01	0.0	0.00
PA02	0.0	0.00
PA03	0.6	0.02
PA04	0.0	0.00
PA12	0.0	0.00
Background	32.9	0.00
<u>Reference</u>		
RMC Soil	28.2	1.11
Lake Ontario water	0.7	0.02
Background	30.6	0.00

ANNEX G

Photos From Selected Survey Sites

Photo #1: Air Maintenance Depot Site, located South West of the City of Panevezys.

Photo #2: Site # PA - 02, Environmental Site

Photo #3: Site # PA - 07, Trainer Hanger

Photo #4: Site # PA - 12, Dump Site/Landfill

ANNEX H

Chalk River Laboratories Swipe Test Report

January 16 1995

SURFACE CONTAMINATION SWIPE TEST

DNSC

SAMPLER INFORMATION

UNIT/UIC 2267 TELEPHONE 992-1499

UNIT RADSO MWO RICHARD

DATE SAMPLED 94/09/21

ANALYST INFORMATION

NAME(S) MARIE DONCASTER

FACILITY Bioassay Laboratory, Health Physics Branch
Chalk River Laboratories

MEASURING DATE 12 OCT 1994

DATE RECEIVED 94/09/30

BATCH # 102

Background (cpm)
Alpha 2.76
Beta 8.56

SWIPE # (ID)	LOCATION	ISOTOPE(S)	Swipe test results (Bq/ cm²)		FOLLOW-UP REQUIRED		REMARKS
			Beta	Alpha	Beta	Alpha	
1	PA-10-01	UNKNOWN	N.D.	N.D.	-	-	
2	PA-10-02	UNKNOWN	N.D.	N.D.	-	-	
3	PA-10-03	UNKNOWN	N.D.	N.D.	-	-	
4	PA-10-04	UNKNOWN	N.D.	N.D.	-	-	
5	PA-10-05	UNKNOWN	N.D.	N.D.	-	-	

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N.D. Not Detectable
E.B. Does not match with specified isotope

ANNEX I

DGNS - Source Detection Report

<u>SOURCE DETECTION</u>

Several cases have been compiled using Microshield 3.13[1], an analytical tool to aid in the evaluation of the dose from shielded and unshielded radioactive sources. For the case study, the following assumptions were made:

a.	activity of one aircraft indicator	5.0 µCi
b.	activity of 1000 aircraft indicators	5.0 mCi
c.	point source	
d.	sandy soil density	2.0 g/cc
e.	GPSM distance above surface	0.5 m
f.	air density	0.00122 g/cc
g.	Ra-226 source in equilibrium with daughters	
h.	Background dose rate	0.06 µSv/hr

Several scenarios were compiled. These included the 1000 aircraft indicators (5.0 µCi Ra-226) buried 1.0 m, and 0.5 m beneath the sandy soil. Table 1 provides the results of the scenarios.

Depth cm	Activity (photons/sec)	Dose point flux $MeV/cm^2/sec$	Dose rate (µSv/hr)
50	3.815e+08	65.8	1.14
55	3.815e+08	38.0	0.65
57	3.815e+08	30.5	0.52
58	3.815e+08	27.4	0.47
60	3.815e+08	22.0	0.38
70	3.815e+08	7.52	0.13
80	3.815e+08	2.61	0.04
100	3.815e+08	0.33	0.005
85	7.626e+08	3.09	0.05

Table 1 - Results for Sources at depth

The results at Table 1 demonstrate that if aircraft indicators with an initial activity of 5.0 µCi Ra-226 are buried at a depth greater than 0.60 m, the resulting dose rate of approximately 0.44 µSv/hr (dose from buried material + background) does not exceed the AECB "walk-away" criteria of 0.5 µSV/hr for fixed contamination, measured at a distance of 0.5 m from any source.

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The detection limit for the Eberline general purpose survey meter (GPSM) is dependant on the background readings. The background dose rate for most sites in Canada is approximatly 0.06 μSv/hr. For practical purposes a crude detection limit of 2.0 times background will provide some measure of confidence in the detection of a source accounting for the detectors time constant and calibration energy. Table 2 provides the results of cases considering the burial of one aircraft indicator at various depths below the surface. The GPSM would indicate a reading of approximately 2 times background for one indicator buried at 0.15 m. Therefore, if the dose rate reading on the GPSM did not exceed 2 times background, a single indicator (5.0 μCi Ra-226) was not buried in the first 0.15 m of soil, or 1000 indicators (5.0 mCi Ra-226) were buried at greater than 0.8 m (ref Table 1).

Depth cm	Activity (photons/sec)	Dose point flux $MeV/cm^2/sec$	Dose rate (γSv/hr)
1	3.815e+05	10.82	0.202
5	3.815e+05	9.484	0.178
10	3.815e+05	6.085	0.113
15	3.815e+05	3.547	0.065
20	3.815e+05	2.003	0.037
100	3.815e+05	0.328	0.005

Table 2 - Results for one indicator

The attached graph of Indicators vs dectection depth provides a curve representing approximately the depth at which the twice background level (0.12 μSv/hr) would be recorded given the number of indicators buried.

As presented in Table 1, if 5.0 mCi Ra-226 (1000 indicators) was buried in a shallow disposal site 1.0 m in depth, the resulting additional dose rate above background would be 0.005 μSv/hr, which would be extremely difficult to discriminate. If the disposal site was 2.5 m deep, a source activity of 10,000 Ci would provide a dose rate of 0.053 μSv/hr above background and the GPSM would indicate approximately a twice background measurement.

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DNSSA 2
22/11/94

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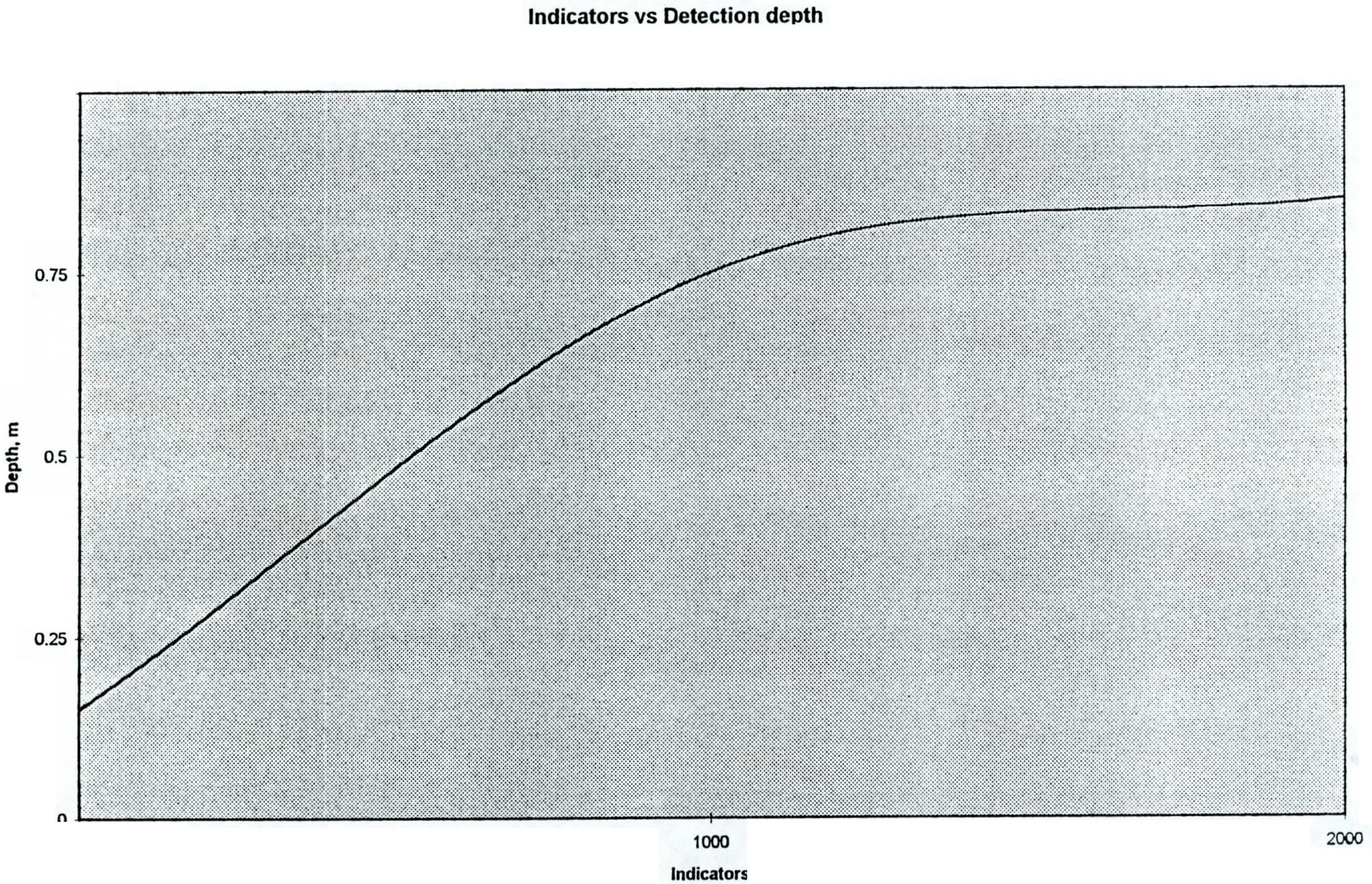
Indicators vs Detection depth
0.75
0.5
0.25
0
Depth, m
1000
2000
Indicators

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