# New radiation protection guidelines for mining and minerals processing industry in Western Australia

**Nick Tsurikov**

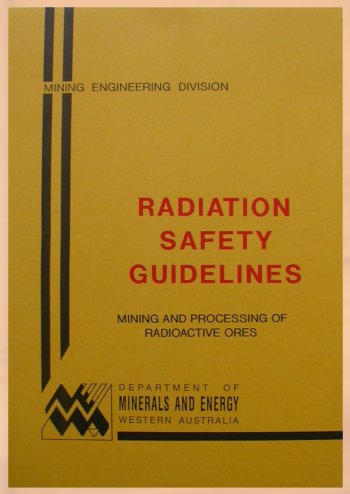
CALYTRIX CONSULTING PTY LTD

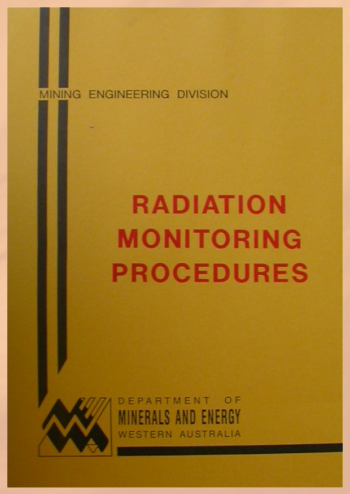
Ivan Fetwadjieff, Stephen Turner

Department of Consumer and Employment Protection
Government of Western Australia
Resources Safety

# History

## 1987 – 1992:

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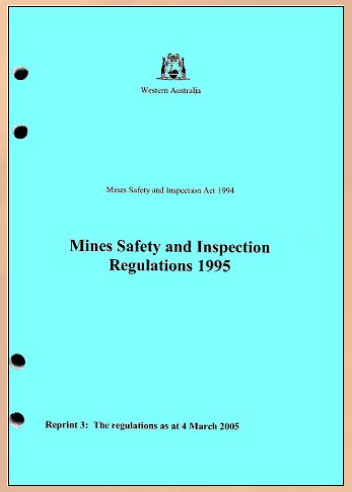


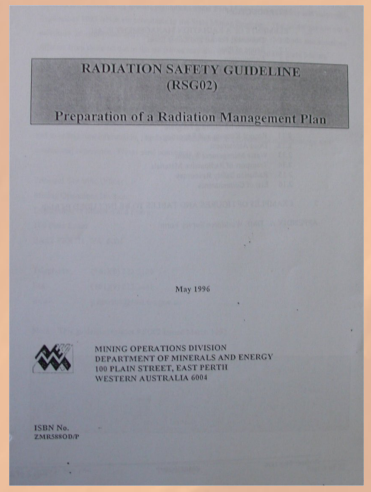


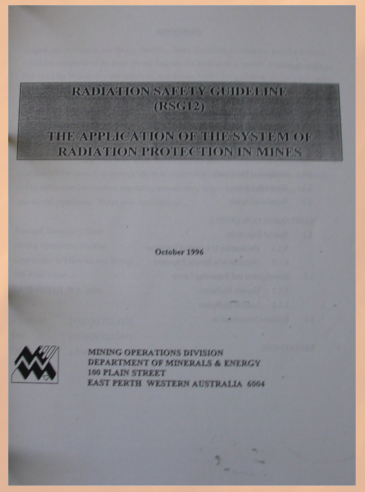


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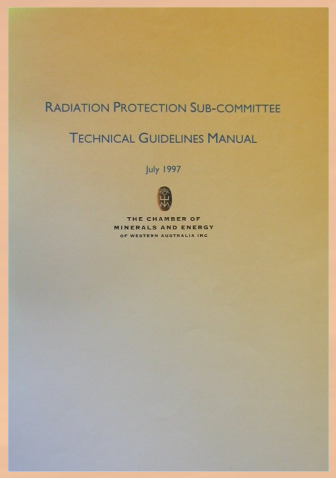


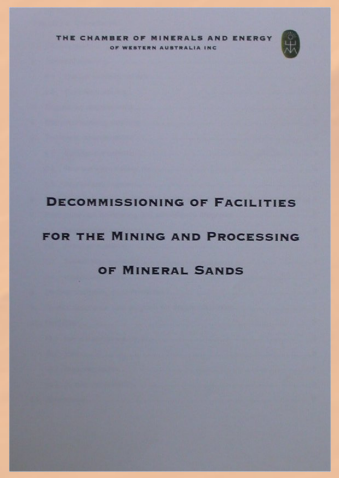


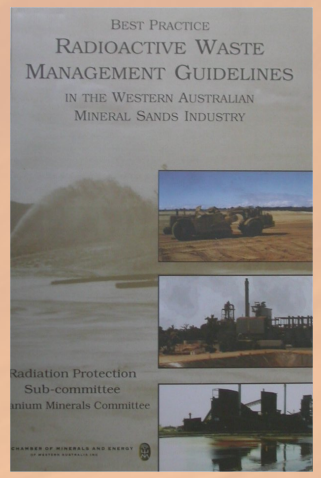

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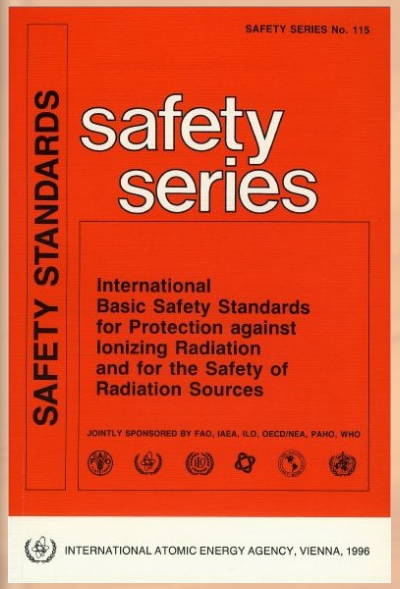
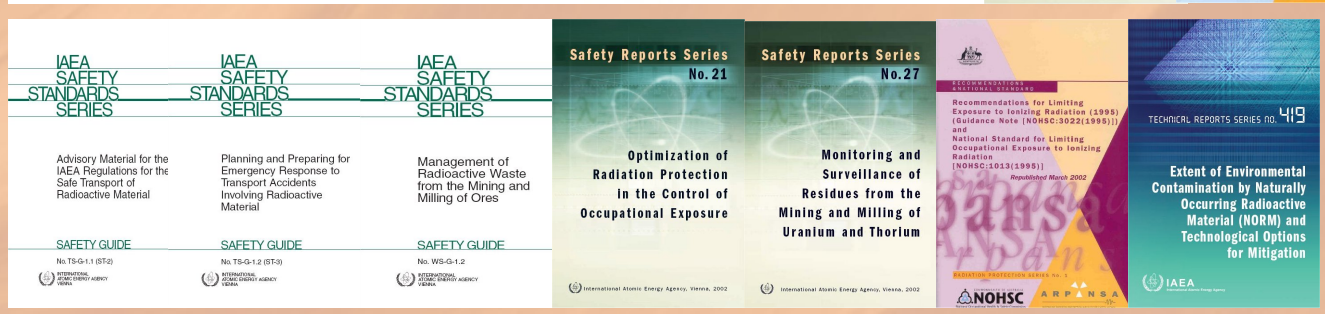
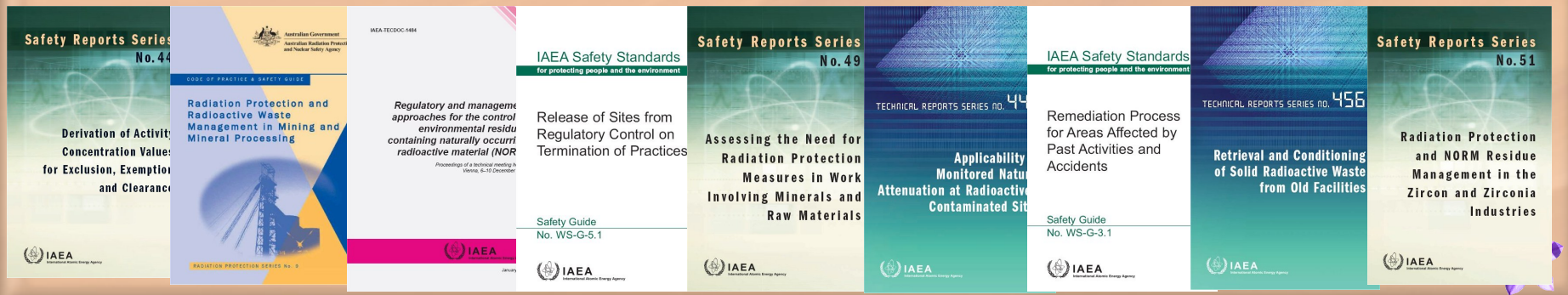

SAFETY SERIES No. 115
SAFETY STANDARDS
safety series
International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources
JOINTLY SPONSORED BY FAO, IAEA, ILO, OECD/NEA, PAHO, WHO
INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1996


IAEA SAFETY STANDARDS SERIES
Occupational Radiation Protection
SAFETY GUIDE
No. RS-G-1.1
IAEA SAFETY STANDARDS SERIES
Assessment of Occupational Exposure Due to Intakes of Radionuclides
SAFETY GUIDE
No. RS-G-1.2
IAEA SAFETY STANDARDS SERIES
Assessment of Occupational Exposure Due to External Sources of Radiation
SAFETY GUIDE
No. RS-G-1.3
Technologically enhanced natural radiation (TENR II)
IAEA SAFETY STANDARDS SERIES
REGULATORY CONTROL OF RADIOACTIVE DISCHARGES TO THE ENVIRONMENT
SAFETY GUIDE
No. WS-G-2.3
Safety Reports Series No.19
Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment
Safe Transport of Radioactive Material


IAEA SAFETY STANDARDS SERIES
Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material
SAFETY GUIDE
No. TS-G-1.1 (ST-2)
IAEA SAFETY STANDARDS SERIES
Planning and Preparing for Emergency Response to Transport Accidents Involving Radioactive Material
SAFETY GUIDE
No. TS-G-1.2 (ST-3)
IAEA SAFETY STANDARDS SERIES
Management of Radioactive Waste from the Mining and Milling of Ores
SAFETY GUIDE
No. WS-G-1.2
Safety Reports Series No. 21
Optimization of Radiation Protection in the Control of Occupational Exposure
Safety Reports Series No.27
Monitoring and Surveillance of Residues from the Mining and Milling of Uranium and Thorium
Recommendations for Limiting Exposure to Ionizing Radiation (1995) (Guidance Note [NOHSC:3022(1995)]) and National Standard for Limiting Occupational Exposure to Ionizing Radiation [NOHSC:1013(1995)]
NOHSC
TECHNICAL REPORTS SERIES NO. 419
Extent of Environmental Contamination by Naturally Occurring Radioactive Material (NORM) and Technological Options for Mitigation


RADIATION PROTECTION
Effluent and dose control from European Union NORM industries: Assessment of current situation and proposa for a harmonised Community approach
Volume 1: Main Report
Issue N° 135
IAEA SAFETY STANDARDS SERIES
Occupational Radiation Protection in the Mining and Processing of Raw Materials
JOINTLY SPONSORED BY IAEA AND ILO
SAFETY GUIDE
No. RS-G-1.6
IAEA SAFETY STANDARDS SERIES
Application of the Concepts of Exclusion, Exemption and Clearance
SAFETY GUIDE
No. RS-G-1.7
Safety Reports Series No.37
Methods for Assessing Occupational Radiation Doses Due to Intakes of Radionuclides
TECHNICAL REPORTS SERIES NO. 424
Remediation of Sites with Dispersed Radioactive Contamination
TECHNICAL REPORTS SERIES NO. 442
Remediation of Sites with Mixed Contamination of Radioactive and Other Hazardous Substances
National Directory for Radiation Protection - Edition 1.0
Naturally occurring radioactive materials (NORM IV)
IAEA Safety Standards for protecting people and the environment
Environmental and Source Monitoring for Purposes of Radiation Protection
Safety Guide
No. RS-G-1.8
IAEA Safety Standards for protecting people and the environment
Regulations for the Safe Transport of Radioactive Material
2005 Edition
Safety Requirements
No. TS-R-1


Safety Reports Series No.44
Derivation of Activity Concentration Values for Exclusion, Exemption and Clearance
Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing
Regulatory and management approaches for the control of environmental residues containing naturally occurring radioactive material (NORM)
IAEA Safety Standards for protecting people and the environment
Release of Sites from Regulatory Control on Termination of Practices
Safety Guide
No. WS-G-5.1
Safety Reports Series No.49
Assessing the Need for Radiation Protection Measures in Work Involving Minerals and Raw Materials
TECHNICAL REPORTS SERIES NO. 44
Applicability of Monitored Natural Attenuation at Radioactive Contaminated Sites
IAEA Safety Standards for protecting people and the environment
Remediation Process for Areas Affected by Past Activities and Accidents
Safety Guide
No. WS-G-3.1
TECHNICAL REPORTS SERIES NO. 456
Retrieval and Conditioning of Solid Radioactive Waste from Old Facilities
Safety Reports Series No.51
Radiation Protection and NORM Residue Management in the Zircon and Zirconia Industries

## *2007 – Joint project – Chamber of Minerals and Energy and the Department of Consumer and Employment Protection of WA*

**System of Radiation Protection in Mines (NORM-1)**

**Radiation Management Plan (NORM-2)**

Exploration (NORM-2.1)

Mining & Processing (NORM-2.2)

**Monitoring NORM (NORM-3)**

Pre-Operational Monitoring (NORM-3.1)

Operational Monitoring (NORM-3.2)

Air Monitoring Strategies (NORM-3.3)

Airborne Radioactivity Sampling (NORM-3.4)

Measurement of Particle Size (NORM-3.5)

**Controlling NORM (NORM-4)**

Dust Control Strategies (NORM-4.1)

Management of Radioactive Waste (NORM-4.2)

Transport of NORM (NORM-4.3)

**Assessing Doses (NORM-5)**

Dose Assessment

**Reporting & Notifying (NORM-6)**

Reporting Requirements

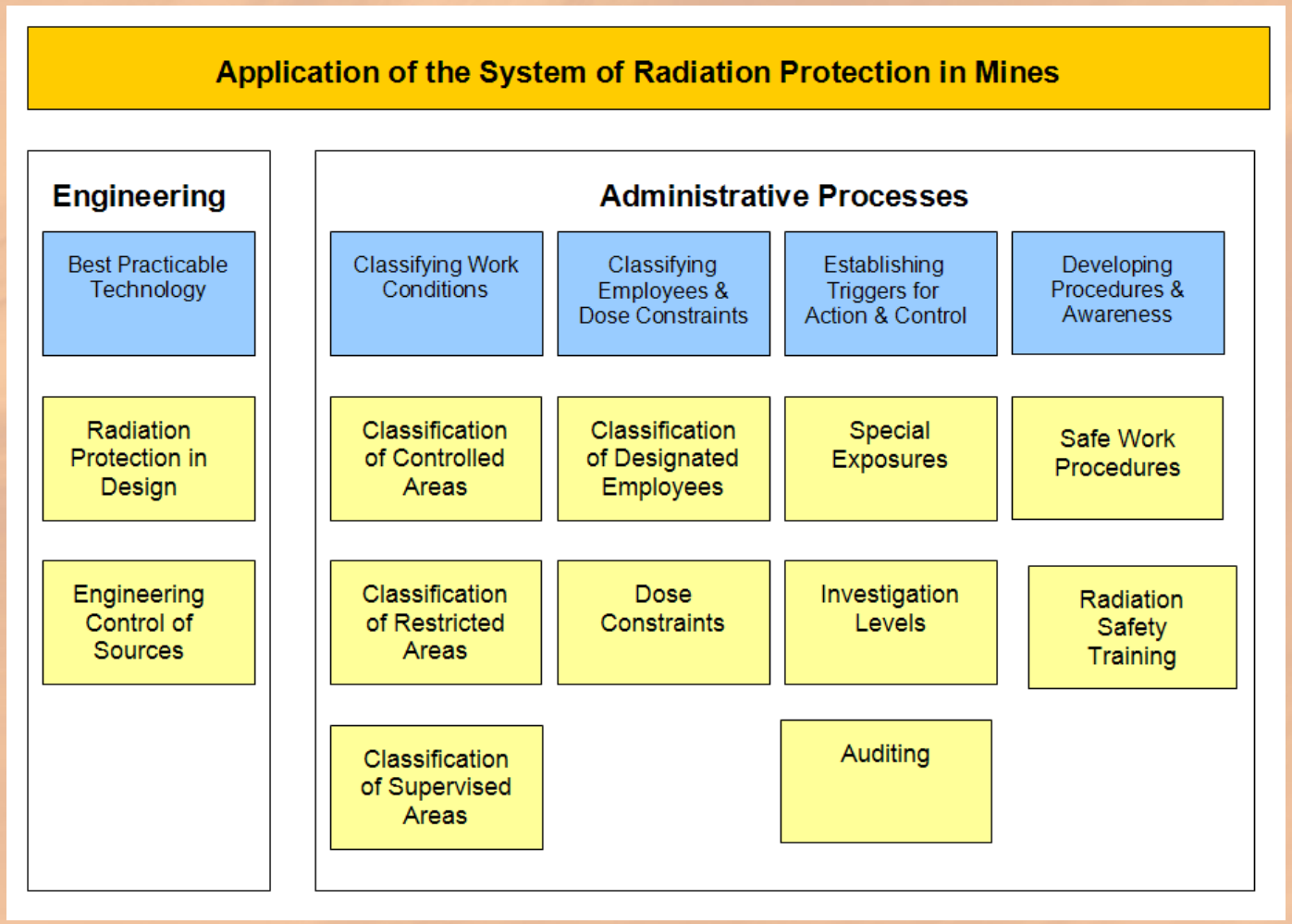
**BOSWELL Assessment & Reporting Database (NORM-7)**

Electronic Data Management System

Review carried out by the Radiation Industry Work Group of the Chamber of Minerals and Energy of Western Australia

DRAFT versions: http://calytrix.biz/radlinks/tenorm

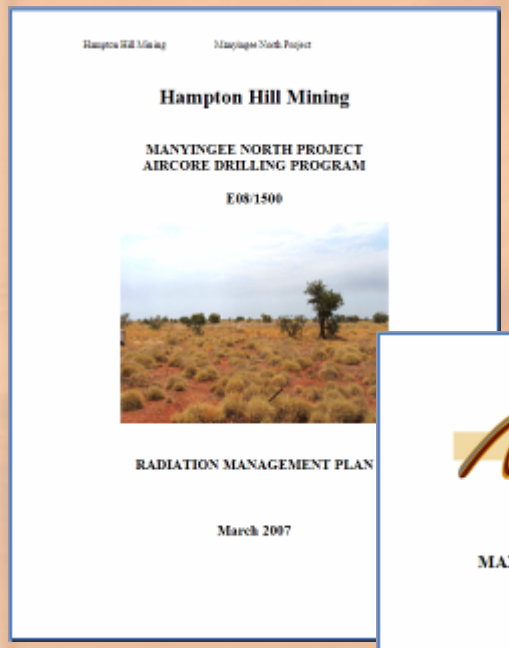
# System of Radiation Protection in Mines (NORM-1)



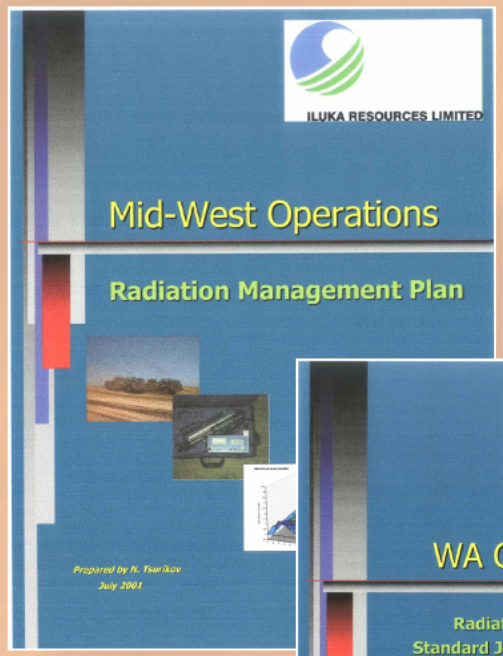
# Radiation Management Plan (NORM-2)

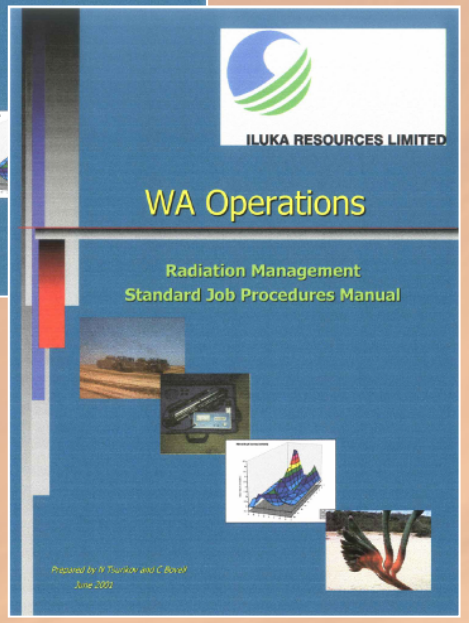
Exploration (NORM-2.1)

Mining & Processing (NORM-2.2)







**Monitoring NORM (NORM-3)**

Pre-Operational Monitoring (NORM-3.1)

Operational Monitoring (NORM-3.2)

Air Monitoring Strategies (NORM-3.3)

Airborne Radioactivity Sampling (NORM-3.4)

Measurement of Particle Size (NORM-3.5)

# *Pre-Operational Monitoring*

**Monitoring NORM (NORM-3)**

Pre-Operational Monitoring (NORM-3.1)

Operational Monitoring (NORM-3.2)

Air Monitoring Strategies (NORM-3.3)

Airborne Radioactivity Sampling (NORM-3.4)

Measurement of Particle Size (NORM-3.5)

# *Operational Monitoring*

**Monitoring NORM (NORM-3)**

Pre-Operational Monitoring (NORM-3.1)

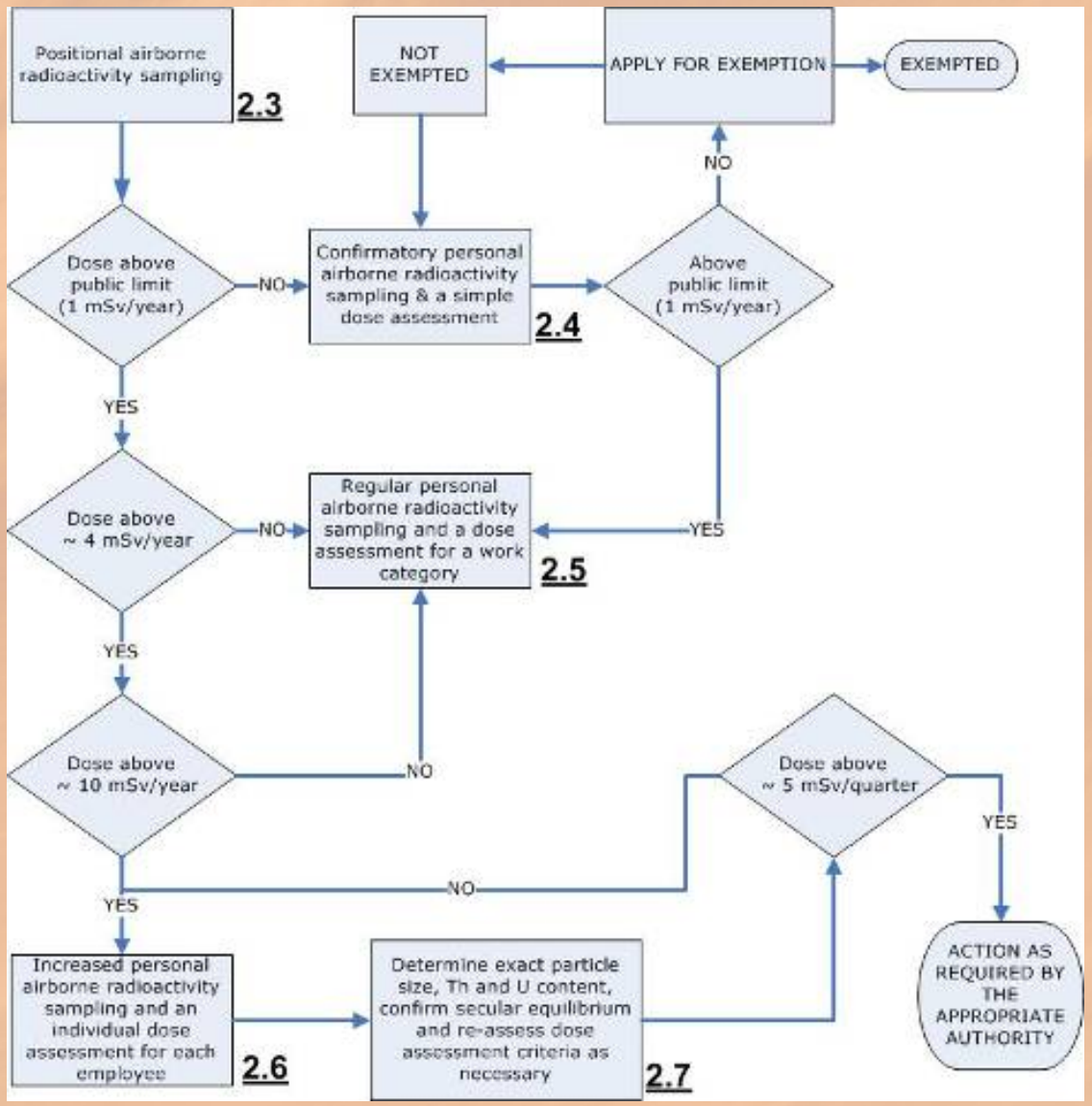
Operational Monitoring (NORM-3.2)

Air Monitoring Strategies (NORM-3.3)

Airborne Radioactivity Sampling (NORM-3.4)

Measurement of Particle Size (NORM-3.5)

# *Air Monitoring Strategies*



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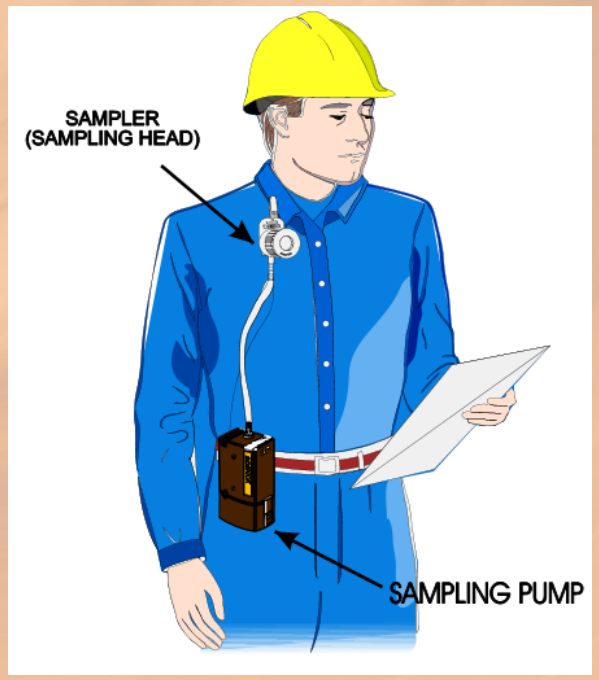
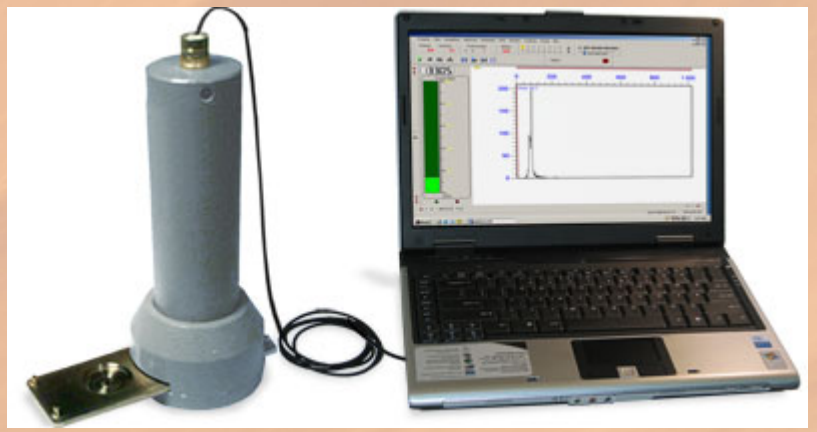
# *Airborne Radioactivity Sampling*



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Measurement of Particle Size (NORM-3.5)

# *Measurement of Particle Size*


Microsoft Excel - NORM-3.1.sample_calculation

File Edit View Insert Format Tools Data Window RExcel Help

Rockwell 12 B I

Reply with Changes... End Review... Import Adobe PDF file

A4 fx Post-weight (mg)

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *SAMPLE No…* | | | | | | | | | |
| 2 | *Stage No.* | 1 | 2 | 3 | 4 | 5 | 6 | 9 | Σ | |
| 3 | *Pre-weight (mg)* | 28.58 | 27.27 | 27.25 | 27.33 | 26.75 | 26.53 | 10.31 | | |
| 4 | *Post-weight (mg)* | 44.05 | 43.94 | 32.12 | 27.77 | 27.01 | 26.67 | 10.47 | | |
| 5 | *Total weight [W] (mg)* | 15.47 | 16.67 | 4.87 | 0.44 | 0.26 | 0.14 | 0.16 | 38.01 | |
| 6 | *Cum.% < size* | 59.30 | 15.44 | 2.63 | 1.47 | 0.79 | 0.42 | 0.00 | | |
| 7 | *Size range (nm)* | 50 - 21.3 | 21.3 - 14.8 | 14.8 - 9.8 | 9.8 - 6.0 | 6.0 - 3.5 | 3.5 - 1.55 | 1.55 - 0.1 | | |
| 8 | *Median [M] (nm)* | 32.6 | 17.75 | 12.04 | 7.67 | 4.58 | 2.33 | 0.39 | | |
| 9 | *ln[M]* | 3.484 | 2.876 | 2.488 | 2.037 | 1.522 | 0.846 | -0.942 | | |
| 10 | *Background count* | 42 | 37 | 42 | 42 | 42 | 42 | 37 | | |
| 11 | *Background time (min)* | 900 | 900 | 900 | 900 | 900 | 900 | 900 | | |
| 12 | *Efficiency* | 0.359 | 0.315 | 0.359 | 0.359 | 0.359 | 0.359 | 0.315 | | |
| 13 | *Count time (min)* | 60 | 60 | 60 | 60 | 100 | 100 | 200 | | |
| 14 | *Min.Detect. Act (mBq)* | 7 | 7 | 7 | 7 | 5 | 5 | 4 | | |
| 15 | *Counts* | 775 | 291 | 162 | 57 | 45 | 19 | 43 | | |
| 16 | *Net counted Activity (mBq)* | 597 | 254 | 123 | 42 | 19 | 7 | 9 | | |
| 17 | *Is net activity <MDL (NO)?* | | | | | | | | | |
| 18 | *Activity [A] (mBq)* | 597 | 254 | 123 | 42 | 19 | 7 | 9 | 1052 | |
| 19 | *Cum.% < size* | 43.18 | 18.99 | 7.28 | 3.29 | 1.51 | 0.87 | 0.00 | | |
| 20 | *{[A]*ln[M]}* | 2081.852 | 731.863 | 306.505 | 85.440 | 28.494 | 5.629 | -8.663 | 3231.120 | |
| 21 | ***AMAD=*** | **21.6** | | | | | | | | |
| 22 | *{[A]*@SQ(ln([N])/LN(AMAD))}* | 101.335 | 9.785 | 42.048 | 44.939 | 45.032 | 32.991 | 148.247 | 424.377 | |
| 23 | ***GSD=*** | **1.9** | | | | | | | | |
| 24 | *{[W]*ln[M]}* | 53.902 | 47.949 | 12.118 | 0.896 | 0.396 | 0.118 | -0.151 | 115.229 | |
| 25 | ***MMAD=*** | **20.7** | | | | | | | | |
| 26 | *{[N]*@SQ(ln([N])/LN(MMAD))}* | 3.171 | 0.401 | 1.438 | 0.435 | 0.593 | 0.669 | 2.526 | 9.232 | |
| 27 | ***GSD=*** | **1.6** | | | | | | | | |
| 28 | | | | | | | | | | |
| 29 | ***NAME*** | ***WORK*** | ***SHIFT*** | *TIME (min)* | *FLOW (lpm)* | ***SAMPLE*** | ***COUNT*** | *Tot mBq/m3* | *Tot mg/m3* | |
| 30 | *J.Smith* | *D.P.O.* | *NGT* | *480* | *2* | *31-Jan* | *11-Feb* | 1095 | 40 | |
| 31 | | | | | | | | | | |
| 32 | ***M.D.L.Stages -*** | ***none*** | | | | | | | | |
| 33 | | | | | | | | | | |
| 34 | | | | | | | | | | |
| 35 | | | | | | | | | | |
| 36 | | | | | | | | | | |
| 37 | | | | | | | | | | |
| 38 | | | | | | | | | | |
| 39 | | | | | | | | | | |
| 40 | | | | | | | | | | |

**MANUALLY ENTERED DATA**

# *Dust control strategies*

**Controlling NORM (NORM-4)**

Dust Control Strategies (NORM-4.1)

Management of Radioactive Waste (NORM-4.2)

Transport of NORM (NORM-4.3)

# *Management of radioactive waste*

**Controlling NORM (NORM-4)**

Dust Control Strategies (NORM-4.1)

Management of Radioactive Waste (NORM-4.2)

Transport of NORM (NORM-4.3)


# Transport of NORM

**Controlling NORM (NORM-4)**

Dust Control Strategies (NORM-4.1)

Management of Radioactive Waste (NORM-4.2)

Transport of NORM (NORM-4.3)


MONAZITE CONCENTRATE – STANDING DECLARATION FOR MULTIPLE TRANSPORT

**ROAD/RAIL/MARINE CONSIGNOR'S DECLARATION FOR DANGEROUS GOODS**
**CLASS 7 RADIOACTIVE MATERIAL**

**TWO COMPLETED AND SIGNED COPIES OF THIS DECLARATION MUST BE PROVIDED TO THE CARRIER**

| CONSIGNOR (SENDER'S NAME AND ADDRESS): | NAME OF TRANSPORTING COMPANY AND CONSIGNMENT No. |
|---|---|
| ILUKA RESOURCES LTD<br>GOULDS ROAD<br>NARNGULU WA 6530 | GIACCI BROS<br><br>CONSIGNOR'S REFERENCE No. |
| CONSIGNEE (RECEIVER'S NAME AND ADDRESS): | MARINE USE ONLY |
| ILUKA RESOURCES LTD<br>BRAND HIGHWAY<br>ENEABBA WA 6518 | PORT OF LOADING .....<br>DATE OF LOADING.....<br>PORT OF DISCHARGE .....<br>VESSEL.....<br>CONTAINER No ..... |

**NATURE AND QUANTITY OF RADIOACTIVE MATERIAL**

**See applicable Codes:** International Atomic Energy Agency — Safety Series No. 6 (IAEA), Maritime Dangerous Goods Code (IMO) and Code of Practice for Safe Transport of Radioactive Material 2001 ("The Transport Code")

| PROPER SHIPPING NAME<br>Refer overleaf | RADIONUCLIDE<br>Name or symbol of principal radioactive content e.g. Iridium-192, Ir-192 or $^{192}$Ir | FORM<br>Physical state: gas, liquid, solid or special form | UNITED NATIONS NUMBER | SUBSIDIARY RISK<br>(if applicable) Classes 1 to 8 |
|---|---|---|---|---|
| RADIOACTIVE MATERIAL LOW SPECIFIC ACTIVITY (LSA-I) | THORIUM-232 | SOLID | 2912 | N/A |

| NUMBER OF PACKAGES | ACTIVITY OF RADIONUCLIDE<br>in Becquerel units (Bq). (Curie units (Ci) may be used) | HAZARD CATEGORY<br>Delete category not applicable | TRANSPORT INDEX<br>Definition: 100 times the maximum radiation dose in millisievert per hour (mSv/h) at 1 metre | PACKAGE CLASSIFICATION<br>Delete classification not applicable | COMPETENT AUTHORITY CERTIFICATE NUMBER(S)<br>required only for Type B containers |
|---|---|---|---|---|---|
| ROAD TRAIN (TWO TRAILERS) | 6.6 GBq | ~~I White~~ or ~~II Yellow~~ or III Yellow | For Yellow hazard categories only<br>7 | ~~Industrial I, II, III~~ or ~~Type A~~ or ~~Type B(U)~~ or ~~Type B(M)~~ | N/A |

**"WARNING"**

FAILURE TO COMPLY IN ALL RESPECTS WITH THE APPLICABLE RADIOACTIVE MATERIALS TRANSPORT REGULATIONS MAY BE IN BREACH OF THE APPLICABLE LAW, SUBJECT TO LEGAL PENALTIES. THIS DECLARATION MUST NOT, IN ANY CIRCUMSTANCES, BE COMPLETED AND/OR SIGNED BY A CONSOLIDATOR, A FORWARDER OR CARGO AGENT.

I HEREBY DECLARE THAT I AM AUTHORISED TO SIGN THIS DECLARATION ON BEHALF OF THE CONSIGNOR AND THAT THE CONTENTS OF THIS CONSIGNMENT ARE FULLY AND ACCURATELY DESCRIBED ABOVE AND ARE CLASSIFIED, PACKED, MARKED AND LABELLED AND ARE, IN ALL RESPECTS, IN THE PROPER CONDITION FOR TRANSPORT ACCORDING TO THE APPLICABLE REGULATIONS BY THE FOLLOWING MODE(S) OF TRANSPORT

NAME OF SIGNATORY: (PLEASE PRINT) NICK ISLAIKOV

POSITION RADIATION SAFETY OFFICER

SIGNATURE (SEE ABOVE WARNING)

DATE 21 NOVEMBER 2003

ADDITIONAL HANDLING INFORMATION (e.g. EmS Number, Schedule Number, Special arrangements, Exclusive use, other information)

RSO EMERGENCY CONTACT 0428880340

SEE REVERSE FOR INFORMATION FOR CARRIERS AND EMERGENCY PROCEDURES

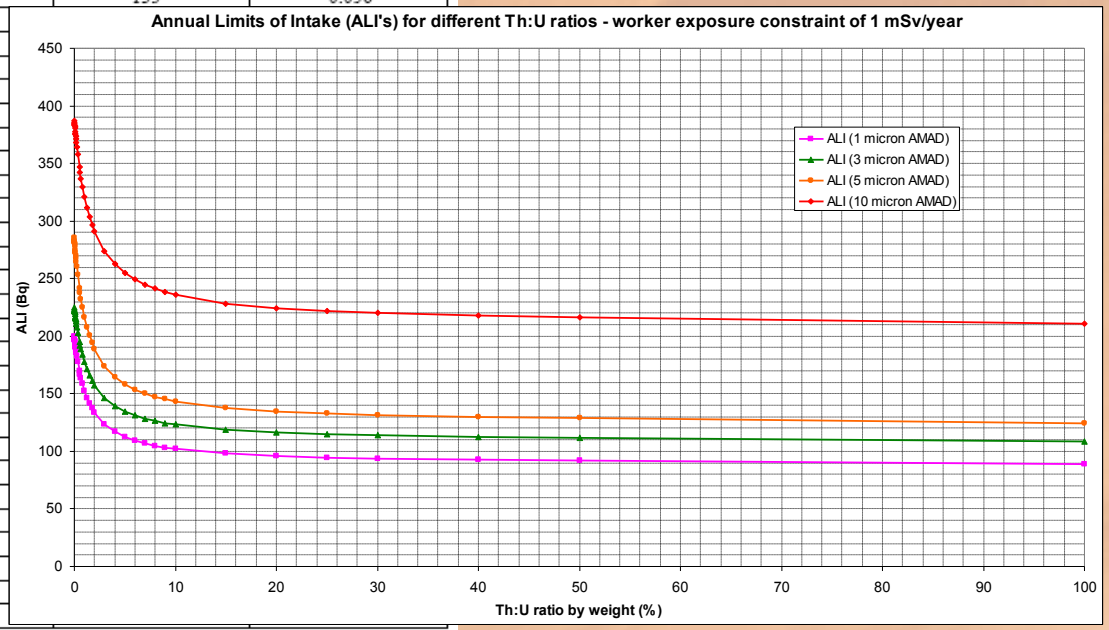
Version Date: 6 May 2002

## Assessing Doses (NORM-5)

Dose Assessment

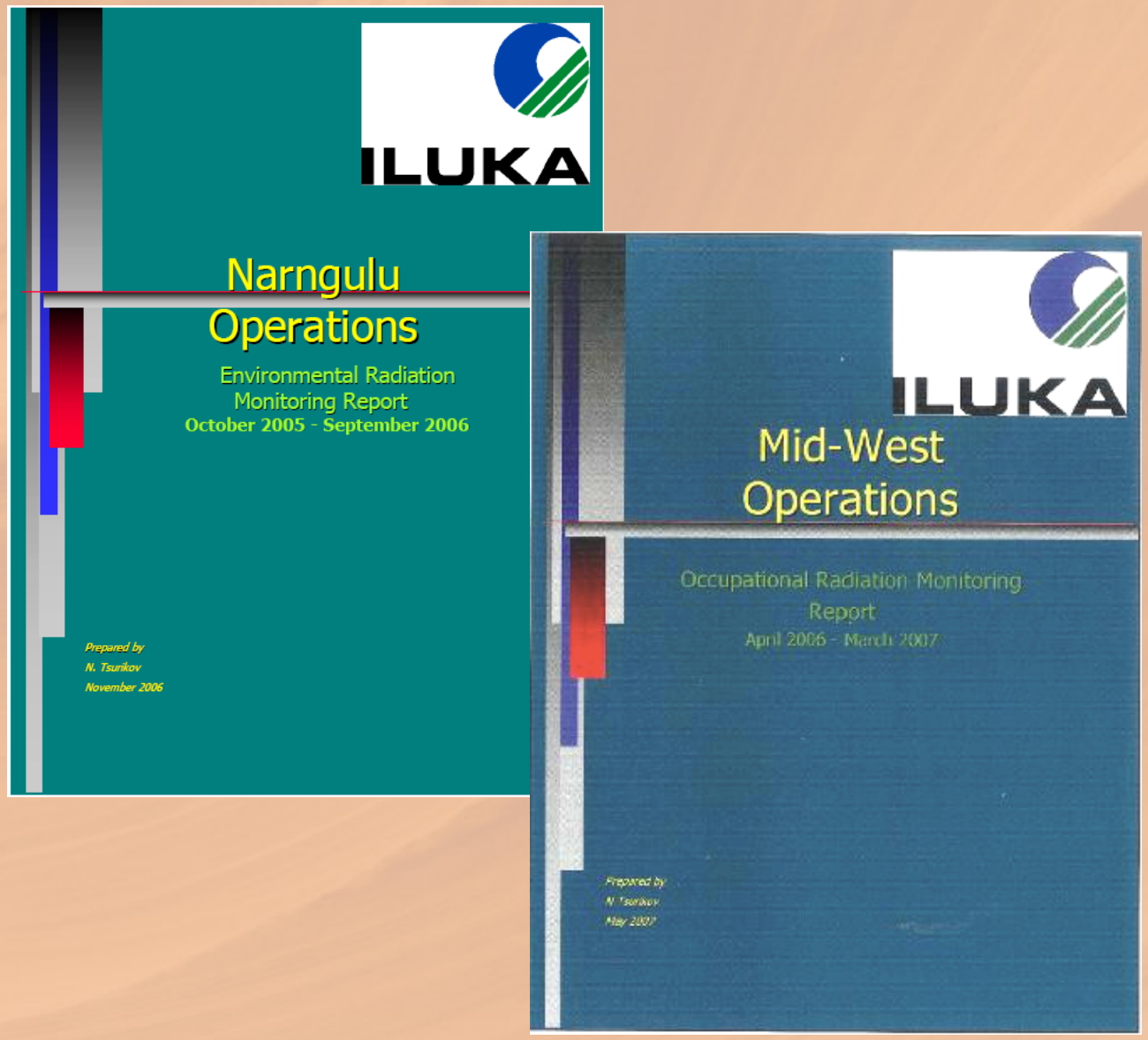
**Table 18 – Dose conversion factors (DCF – mSv/Bq), Annual limits of intake (ALI – Bq/year) and Derived air concentrations (DAC – Bq/m$^3$) for the dust with AMAD = 3 µm containing both thorium and uranium in different ratios, for workers (dose constraint = 1 mSv/year)**

| Th:U weight ratio | Dose conversion factor (mSv/Bq) | Annual limit of intake (Bq/year) | Derived air concentration (Bq/m$^3$) |
|---|---|---|---|
| All thorium | 0.0092 | 108 | 0.045 |
| 50:1 | 0.0090 | 112 | 0.047 |
| 40:1 | 0.0089 | 112 | 0.047 |
| 30:1 | 0.0088 | 114 | 0.047 |
| 25:1 | 0.0087 | 115 | 0.048 |
| 20:1 | 0.0086 | 116 | 0.048 |
| 15:1 | 0.0084 | 119 | 0.049 |
| 10:1 | 0.0081 | 123 | 0.051 |
| 9:1 | 0.0080 | 125 | 0.052 |
| 8:1 | 0.0079 | 126 | 0.053 |
| 7:1 | 0.0078 | 129 | 0.054 |
| 6:1 | 0.0076 | 131 | 0.055 |
| 5:1 | 0.0074 | 135 | 0.056 |
| 4:1 | 0.0072 | | |
| 3:1 | 0.0068 | | |
| 2:1 | 0.0063 | | |
| 1.75:1 | 0.0062 | | |
| 1.5:1 | 0.0060 | | |
| 1.25:1 | 0.0058 | | |
| 1:1 | 0.0056 | | |
| 1:1.25 | 0.0054 | | |
| 1:1.5 | 0.0053 | | |
| 1:1.75 | 0.0052 | | |
| 1:2 | 0.0051 | | |
| 1:3 | 0.0049 | | |
| 1:4 | 0.0048 | | |
| 1:5 | 0.0047 | | |
| 1:6 | 0.0047 | | |
| 1:7 | 0.0047 | | |
| 1:8 | 0.0046 | | |
| 1:9 | 0.0046 | | |
| 1:10 | 0.0046 | | |
| 1:15 | 0.0046 | | |
| 1:20 | 0.0045 | | |
| 1:25 | 0.0045 | | |
| 1:30 | 0.0045 | | |
| 1:40 | 0.0045 | | |
| 1:50 | 0.0045 | | |
| All uranium | 0.0044 | | |



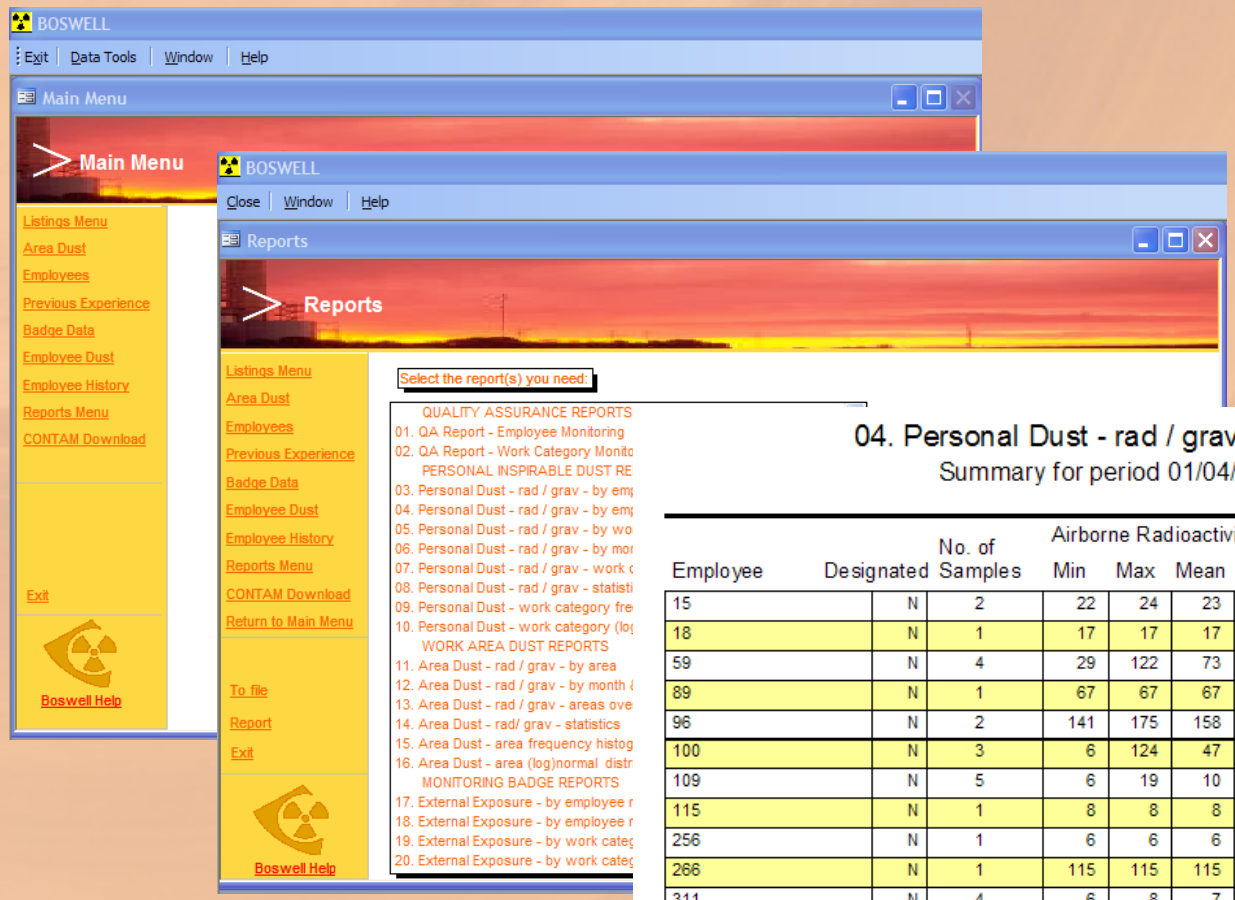
**Reporting & Notifying (NORM-6)**

Reporting Requirements



# BOSWELL
# Assessment & Reporting Database (NORM-7)

Electronic Data Management System




## 04. Personal Dust - rad / grav - by employee number

Summary for period 01/04/2006 to 31/03/2007

| Employee | Designated | No. of Samples | Airborne Radioactivity (mBq/m³) Min | Max | Mean | SDev | UCL | | Dust Concentration in Air (mg/m³) Min | Max | Mean | SDev | UCL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | N | 2 | 22 | 24 | 23 | 1 | | | 0.2 | 0.5 | 0.3 | 0.2 | |
| 18 | N | 1 | 17 | 17 | 17 | | | | 0.2 | 0.2 | 0.2 | | |
| 59 | N | 4 | 29 | 122 | 73 | 45 | 126 | | 0.2 | 0.6 | 0.4 | 0.1 | 0.6 |
| 89 | N | 1 | 67 | 67 | 67 | | | | 4.3 | 4.3 | 4.3 | | |
| 96 | N | 2 | 141 | 175 | 158 | 24 | | | 3.4 | 4.6 | 4.0 | 0.9 | |
| 100 | N | 3 | 6 | 124 | 47 | 66 | 159 | | 0.1 | 8.0 | 2.8 | 4.5 | 10.4 |
| 109 | N | 5 | 6 | 19 | 10 | 5 | 15 | | 0.1 | 0.4 | 0.2 | 0.1 | 0.3 |
| 115 | N | 1 | 8 | 8 | 8 | | | | 0.2 | 0.2 | 0.2 | | |
| 256 | N | 1 | 6 | 6 | 6 | | | | 0.1 | 0.1 | 0.1 | | |
| 266 | N | 1 | 115 | 115 | 115 | | | | 1.6 | 1.6 | 1.6 | | |
| 311 | N | 4 | 6 | 8 | 7 | 1 | 7 | | 0.0 | 0.3 | 0.1 | 0.1 | 0.2 |
| 319 | N | 2 | 16 | 87 | 51 | 50 | | | 0.4 | 4.3 | 2.4 | 2.8 | |
| 352 | N | 1 | 54 | 54 | 54 | | | | 2.1 | 2.1 | 2.1 | | |

Thank you for your attention