ANSTO/E661

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# AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION

## LUCAS HEIGHTS RESEARCH LABORATORIES

**ANSTO TRITIUM LIST NO. 1**

**1985 - 1986**

by

G.E. CALF

R.C. STOKES

AUGUST 1987

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ABSTRACT

Details are given of the concentration of the environmental radioisotope, tritium, in monthly precipitation samples taken during the period 1985-1986, at eleven stations throughout Australia. Tritium levels in Australian rainfall have been estimated for seventeen years and published first as reports of the Australian Atomic Energy Commission and now of the Australian Nuclear Science and Technology Organisation.

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The following descriptors have been selected from the INIS Thesaurus to describe the subject content of this report for information retrieval purposes. For further details please refer to IAEA-INIS-12 (INIS: Manual for Indexing) and IAEA-INIS-13 (INIS: Thesaurus) published in Vienna by the International Atomic Energy Agency.

AUSTRALIA; RADIATION MONITORING; RADIOACTIVITY; RAIN; RAIN WATER; TRITIUM

**EDITORIAL NOTE**

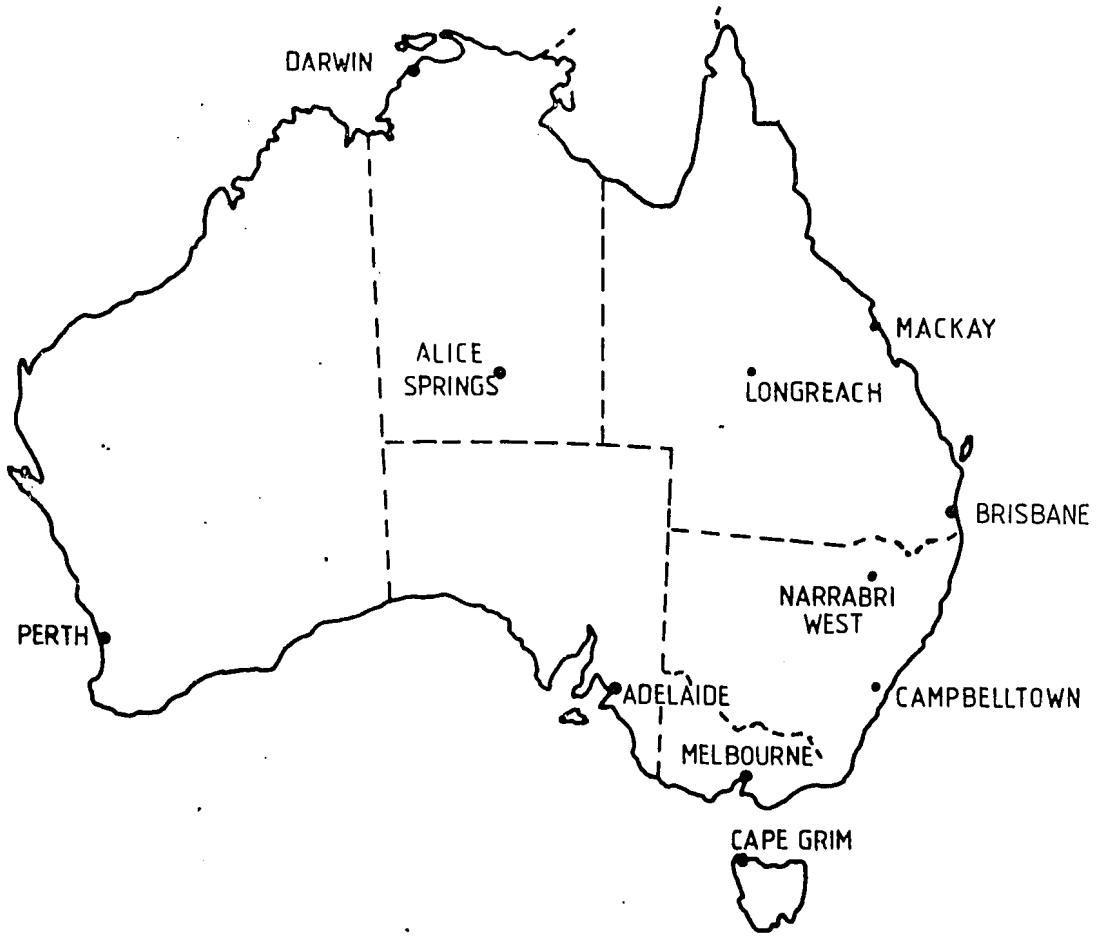
From 27 April 1987, the Australian Atomic Energy Commission (AAEC) is replaced by Australian Nuclear Science and Technology Organisation (ANSTO). Serial numbers for reports with an issue date after April 1987 have the prefix ANSTO with no change of the symbol (E, M, S or C) or numbering sequence.

CONTENTS

## 1. INTRODUCTION

From 1970 to 1982, monthly precipitation samples were collected for the Australian Atomic Energy Commission (AAEC) from 16 stations in Australia. Previous publications include data from 1970 to 1974 [Calf *et al.* 1976], 1975 to 1976 [Calf *et al.* 1977], 1977 to 1978 [Calf and Stokes 1979], 1979 to 1980 [Calf and Stokes 1981], 1981 to 1982 [Calf and Stokes 1983], and 1983 to 1984 [Calf and Stokes 1985].

In 1983, sampling was discontinued at Clarendale, Bundaberg, Charleville and Toowoomba in Queensland and Ryde in New South Wales, and Cape Grim was substituted for Hobart in Tasmania. Since 1983, monthly precipitation samples have been collected from 11 stations in Australia, as shown below.




In 1985, the Minister for Resources and Energy, Senator the Hon. Gareth Evans, QC, introduced legislation into the Senate to repeal the bulk of the Atomic Energy Act and to create the Australian Nuclear Science and Technology Organisation (ANSTO) as the successor to the AAEC. In 1987, the transition of the AAEC to ANSTO was completed. ANSTO will continue to report on the results of the tritium sampling program.

## 2. STATION DATA

Basic information, including latitude, longitude and elevation, are given for each location for which the tritium activity is reported.

## 3. SAMPLE ANALYSIS

Samples are composites from the total precipitation at a station during one calendar month and were assayed using methods reported by Calf *et al.* [1975]. The tritium concentration, given in tritium units (TU), has been corrected for decay to the last day of the sampling month. One TU is defined as one atom of

tritium per $10^{18}$ atoms of hydrogen and is equivalent to 118 mBq (3.19 pCi) per litre of water if a half-life of 12.43 years is assumed. All results have an estimated standard deviation of 8.5 per cent or 0.4 TU, whichever is the larger.

## 4. RESULTS

Yearly weighted means for tritium, weighted by the total amount of precipitation, have been calculated according to the formula

$$\text{Weighted mean} = \frac{\sum(\text{monthly precipitation x monthly tritium concentration})}{\sum(\text{monthly precipitation})}$$

The figures in parenthesis represent the percentage of the total precipitation for which tritium data are available to calculate the weighted means.

Tritium levels in Australian rainfall have been estimated for 17 years. The results show that the tritium concentration in rainfall is still decreasing at most monitoring stations.

## 5. ACKNOWLEDGEMENTS

We are pleased to acknowledge the assistance of the Department of Science's Bureau of Meteorology, the Water Resources Commission of New South Wales and the Water Resources Commission of Queensland in collecting the samples and relaying the relevant monthly precipitation values.

## 6. REFERENCES

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*TABLES 1-11*
*MONTHLY TRITIUM PRECIPITATION DATA*

The following reference symbols apply to all tables in this set:

(a) Precipitation in mm.

(b) TU = tritium unit.

**TABLE 1**
**ADELAIDE**

Station: 023034

Latitude: 34 57S Longitude: 138 32E
Elevation: 6.0 m

| Year | Month | Precipitation[a] | Type | T.U.[b] |
|---|---|---|---|---|
| 1985 | 01 | 1 | rain | |
| | 02 | 2 | | |
| | 03 | 39 | | 5.5 |
| | 04 | 29 | | 4.7 |
| | 05 | 58 | | 6.0 |
| | 06 | 37 | | 3.7 |
| | 07 | 34 | | 4.7 |
| | 08 | 63 | | 7.7 |
| | 09 | 37 | | 4.9 |
| | 10 | 38 | | 5.3 |
| | 11 | 10 | | 7.0 |
| | 12 | 31 | | 6.7 |
| | Sum | 379 | | |
| | Weighted Mean | | | 5.7 (99.2%) |
| 1986 | 01 | 11 | rain | 9.5 |
| | 02 | 1 | | |
| | 03 | 0 | | |
| | 04 | 43 | | 3.7 |
| | 05 | 44 | | 4.3 |
| | 06 | 35 | | 4.6 |
| | 07 | 118 | | 4.7 |
| | 08 | 85 | | 6.0 |
| | 09 | 51 | | 8.0 |
| | 10 | 51 | | 6.0 |
| | 11 | 15 | | 4.4 |
| | 12 | 28 | | 3.4 |
| | Sum | 482 | | |
| | Weighted Mean | | | 5.3 (99.8%) |

**TABLE 2**
**ALICE SPRINGS**

Station: 015590

Latitude: 23 49S Longitude: 133 54E
Elevation: 545.0 m

| Year | Month | Precipitation[a] | Type | T.U.[b] |
|---|---|---|---|---|
| 1985 | 01 | 0 | rain | |
| | 02 | 17 | | 4.5 |
| | 03 | 25 | | 3.1 |
| | 04 | 1 | | |
| | 05 | 1 | | 7.3 |
| | 06 | 17 | | |
| | 07 | 1 | | |
| | 08 | 3 | | 12.8 |
| | 09 | 0 | | |
| | 10 | 31 | | 6.6 |
| | 11 | 22 | | 4.5 |
| | 12 | 3 | | 3.1 |
| | Sum | 121 | | |
| | Weighted Mean | | | 5.0 (84.3%) |
| 1986 | 01 | 13 | rain | 7.3 |
| | 02 | 0 | | |
| | 03 | 0 | | |
| | 04 | 0 | | |
| | 05 | 8 | | 5.3 |
| | 06 | 81 | | 4.5 |
| | 07 | 144 | | 3.7 |
| | 08 | 13 | | 5.6 |
| | 09 | 0 | | |
| | 10 | 37 | | 5.4 |
| | 11 | 78 | | 7.2 |
| | 12 | 20 | | 7.2 |
| | Sum | 394 | | |
| | Weighted Mean | | | 5.1 (100.0%) |

**TABLE 3**
**BRISBANE**

Station: 040214

Latitude: 27 28S Longitude: 153 02E
Elevation: 38.0 m

| Year | Month | Precipitation[a] | Type | T.U.[b] |
|---|---|---|---|---|
| 1985 | 01 | 168 | rain | 5.2 |
| | 02 | 69 | | 3.4 |
| | 03 | 187 | | 2.7 |
| | 04 | 109 | | 3.0 |
| | 05 | 66 | | 3.4 |
| | 06 | 41 | | 4.5 |
| | 07 | 149 | | 3.4 |
| | 08 | 46 | | 5.1 |
| | 09 | 49 | | 7.1 |
| | 10 | 127 | | 3.8 |
| | 11 | 44 | | 3.4 |
| | 12 | 87 | | 5.6 |
| | Sum | 1142 | | |
| | Weighted Mean | | | 4.0 (100.0%) |
| 1986 | 01 | 28 | rain | 4.7 |
| | 02 | 49 | | 3.8 |
| | 03 | 61 | | 3.6 |
| | 04 | 55 | | 3.6 |
| | 05 | 69 | | 4.2 |
| | 06 | 4 | | 3.5 |
| | 07 | 38 | | 4.2 |
| | 08 | 41 | | 4.0 |
| | 09 | 26 | | 4.7 |
| | 10 | 133 | | 4.9 |
| | 11 | 137 | | 4.9 |
| | 12 | 138 | | 4.1 |
| | Sum | 779 | | |
| | Weighted Mean | | | 4.3 (100.0%) |

## TABLE 4
## CAMPBELLTOWN

Station: 068160

Latitude: 34 4S Longitude: 150 52E

Elevation: 115.0 m

| Year | Month | Precipitation[a] | Type | T.U.[b] |
|---|---|---|---|---|
| 1985 | 01 | 11 | rain | 6.4 |
| | 02 | 29 | | 3.0 |
| | 03 | 33 | | 4.6 |
| | 04 | 54 | | 4.1 |
| | 05 | 100 | | 4.1 |
| | 06 | 89 | | 2.6 |
| | 07 | 31 | | 3.1 |
| | 08 | 23 | | 12.8 |
| | 09 | * | | 6.8 |
| | 10 | * | | 4.1 |
| | 11 | * | | |
| | 12 | * | | 7.9 |
| | Sum | | | |
| | Weighted Mean | | | |
| 1986 | 01 | * | rain | 5.0 |
| | 02 | * | | 7.2 |
| | 03 | * | | 5.0 |
| | 04 | * | | 3.2 |
| | 05 | * | | 4.7 |
| | 06 | * | | 4.2 |
| | 07 | * | | |
| | 08 | * | | 4.2 |
| | 09 | 38 | | 5.0 |
| | 10 | 65 | | 6.0 |
| | 11 | 106 | | 7.8 |
| | 12 | 14 | | 5.1 |
| | Sum | | | |
| | Weighted Mean | | | |

* Rainfall figures for these months not available.

**TABLE 5**
**CAPE GRIM**

Station: 52000101

Latitude: 40 68S Longitude: 144.69E
Elevation: 94.0 m

| Year | Month | Precipitation[a] | Type | T.U.[b] |
|---|---|---|---|---|
| 1985 | 01 | 31 | rain | 4.7 |
| | 02 | 7 | | 3.7 |
| | 03 | 24 | | 3.9 |
| | 04 | 78 | | 3.0 |
| | 05 | 90 | | 3.6 |
| | 06 | 121 | | 3.2 |
| | 07 | 89 | | 3.4 |
| | 08 | 61 | | 6.5 |
| | 09 | 18 | | 4.6 |
| | 10 | 66 | | 5.2 |
| | 11 | 100 | | 5.9 |
| | 12 | 91 | | 4.1 |
| | Sum | 776 | | |
| | Weighted Mean | | | 4.3 (100.0%) |
| 1986 | 01 | 20 | rain | 4.6 |
| | 02 | 21 | | 3.1 |
| | 03 | 23 | | 4.3 |
| | 04 | 83 | | 3.2 |
| | 05 | 108 | | 3.5 |
| | 06 | 85 | | 2.6 |
| | 07 | 117 | | 4.0 |
| | 08 | 41 | | 5.1 |
| | 09 | 76 | | 4.8 |
| | 10 | 107 | | 5.4 |
| | 11 | 14 | | 5.1 |
| | 12 | 86 | | 6.9 |
| | Sum | 781 | | |
| | Weighted Mean | | | 4.4 (100.0%) |

**TABLE 6**
**DARWIN**

Station: 014015

Latitude: 12 25S Longitude: 130 52E
Elevation: 31.0 m

| Year | Month | Precipitation[a] | Type | T.U.[b] |
|---|---|---|---|---|
| 1985 | 01 | 281 | rain | 3.9 |
| | 02 | 300 | | 3.2 |
| | 03 | 229 | | 3.8 |
| | 04 | 190 | | 2.1 |
| | 05 | 0 | | |
| | 06 | 0 | | |
| | 07 | 0 | | |
| | 08 | 0 | | |
| | 09 | 1 | | |
| | 10 | 82 | | 3.0 |
| | 11 | 58 | | 3.9 |
| | 12 | 92 | | 3.0 |
| | Sum | 1233 | | |
| | Weighted Mean | | | 3.3 (99.9%) |
| 1986 | 01 | 660 | rain | 3.8 |
| | 02 | 267 | | 4.1 |
| | 03 | 283 | | 3.2 |
| | 04 | 100 | | 2.6 |
| | 05 | 15 | | 3.2 |
| | 06 | 3 | | 3.7 |
| | 07 | 5 | | 2.0 |
| | 08 | 11 | | 3.5 |
| | 09 | 6 | | 3.5 |
| | 10 | 170 | | 3.4 |
| | 11 | 103 | | |
| | 12 | 115 | | 3.6 |
| | Sum | 1738 | | |
| | Weighted Mean | | | 3.6 (94.1%) |

**TABLE 7**
**LONGREACH**

Station: 036031

Latitude: 23 26S Longitude: 144 17E
Elevation: 192.0 m

| Year | Month | Precipitation[a] | Type | T.U.[b] |
|---|---|---|---|---|
| 1985 | 01 | 20 | rain | 6.8 |
| | 02 | 15 | | 4.1 |
| | 03 | 1 | | |
| | 04 | 10 | | 5.1 |
| | 05 | 1 | | |
| | 06 | 51 | | 4.8 |
| | 07 | 16 | | |
| | 08 | 21 | | 5.6 |
| | 09 | 1 | | |
| | 10 | 56 | | 4.8 |
| | 11 | 57 | | 4.7 |
| | 12 | 24 | | 5.9 |
| | Sum | 273 | | |
| | Weighted Mean | | | 5.1 (93.0%) |
| 1986 | 01 | 36 | rain | 4.5 |
| | 02 | 113 | | 3.6 |
| | 03 | 0 | | |
| | 04 | 7 | | |
| | 05 | 12 | | 3.4 |
| | 06 | 14 | | 6.1 |
| | 07 | 45 | | 4.5 |
| | 08 | 41 | | 4.4 |
| | 09 | 1 | | |
| | 10 | 37 | | 6.1 |
| | 11 | 25 | | 5.0 |
| | 12 | 90 | | 4.8 |
| | Sum | 421 | | |
| | Weighted Mean | | | 4.5 (98.1%) |

**TABLE 8**
**MACKAY**

Station: 033119

Latitude: 21 7S Longitude: 149 13E
Elevation: 6.0 m

| Year | Month | Precipitation[a] | Type | T.U.[b] |
|---|---|---|---|---|
| 1985 | 01 | 15 | rain | 2.2 |
| | 02 | 303 | | 1.4 |
| | 03 | 406 | | 1.6 |
| | 04 | 63 | | 3.7 |
| | 05 | 138 | | 4.3 |
| | 06 | 59 | | 2.9 |
| | 07 | 66 | | 4.0 |
| | 08 | 16 | | 3.5 |
| | 09 | 6 | | 3.9 |
| | 10 | 152 | | 3.6 |
| | 11 | 338 | | 3.6 |
| | 12 | 64 | | 3.4 |
| | Sum | 1626 | | |
| | Weighted Mean | | | 2.7 (100.0%) |
| 1986 | 01 | 330 | rain | 2.5 |
| | 02 | 249 | | 2.7 |
| | 03 | 390 | | 2.2 |
| | 04 | 184 | | 2.7 |
| | 05 | 101 | | 2.0 |
| | 06 | 92 | | 2.7 |
| | 07 | 30 | | 3.2 |
| | 08 | 42 | | 3.2 |
| | 09 | 15 | | 2.8 |
| | 10 | 67 | | 3.9 |
| | 11 | 20 | | 2.7 |
| | 12 | 65 | | 2.6 |
| | Sum | 1585 | | |
| | Weighted Mean | | | 2.6 (100.0%) |

**TABLE 9**
**MELBOURNE**

Station: 086071

Latitude: 37 49S Longitude: 144 58E
Elevation: 34.7 m

| Year | Month | Precipitation[a] | Type | T.U.[b] |
|---|---|---|---|---|
| 1985 | 01 | 17 | rain | 5.7 |
| | 02 | 6 | | |
| | 03 | 49 | | 5.8 |
| | 04 | 62 | | 4.4 |
| | 05 | 54 | | 5.0 |
| | 06 | 63 | | 4.2 |
| | 07 | 38 | | 7.1 |
| | 08 | 81 | | 7.2 |
| | 09 | 42 | | 6.9 |
| | 10 | 53 | | 8.4 |
| | 11 | 77 | | 7.8 |
| | 12 | 137 | | 7.2 |
| | Sum | 679 | | |
| | Weighted Mean | | | 6.5 (99.1%) |
| 1986 | 01 | 22 | rain | 4.0 |
| | 02 | 16 | | 5.8 |
| | 03 | 17 | | 5.2 |
| | 04 | 16 | | 5.1 |
| | 05 | 74 | | 5.3 |
| | 06 | 28 | | 4.1 |
| | 07 | 77 | | 5.4 |
| | 08 | 48 | | |
| | 09 | 27 | | |
| | 10 | 54 | | |
| | 11 | 38 | | |
| | 12 | 70 | | 6.0 |
| | Sum | 487 | | |
| | Weighted Mean | | | 5.3 (65.7%) |

**TABLE 10**
**NARRABRI WEST**

Station: 053030

Latitude: 30 20S Longitude: 149 45E
Elevation: 212.0 m

| Year | Month | Precipitation[a] | Type | T.U.[b] |
|---|---|---|---|---|
| 1985 | 01 | 21 | rain | |
| | 02 | 24 | | |
| | 03 | * | | |
| | 04 | 19 | | |
| | 05 | 14 | | |
| | 06 | 13 | | |
| | 07 | 44 | | 4.8 |
| | 08 | 98 | | |
| | 09 | 27 | | 9.8 |
| | 10 | 75 | | 7.5 |
| | 11 | 40 | | 6.2 |
| | 12 | 103 | | 6.8 |
| | Sum | | | |
| | Weighted Mean | | | |
| 1986 | 01 | 72 | rain | 5.9 |
| | 02 | * | | |
| | 03 | 3 | | |
| | 04 | 18 | | |
| | 05 | 38 | | 3.4 |
| | 06 | * | | |
| | 07 | 108 | | 3.8 |
| | 08 | 21 | | 6.3 |
| | 09 | 100 | | 6.9 |
| | 10 | 30 | | |
| | 11 | 43 | | 5.8 |
| | 12 | 32 | | 6.0 |
| | Sum | | | |
| | Weighted Mean | | | |

* Rainfall figures for these months not available

**TABLE 11**
**PERTH**

Station: 009021

Latitude: 31 56S Longitude: 115 58E
Elevation: 20.0 m

| Year | Month | Precipitation[a] | Type | T.U.[b] |
|---|---|---|---|---|
| 1985 | 01 | 1 | rain | |
| | 02 | 2 | | |
| | 03 | 4 | | |
| | 04 | 47 | | 4.5 |
| | 05 | 75 | | 6.9 |
| | 06 | 82 | | 3.5 |
| | 07 | 154 | | 3.7 |
| | 08 | 145 | | 4.0 |
| | 09 | 54 | | 5.1 |
| | 10 | 23 | | 4.6 |
| | 11 | 25 | | |
| | 12 | 8 | | 5.2 |
| | Sum | 620 | | |
| | Weighted Mean | | | 4.4 (94.8%) |
| 1986 | 01 | 3 | rain | |
| | 02 | 93 | | 4.1 |
| | 03 | 29 | | 3.8 |
| | 04 | 1 | | 6.8 |
| | 05 | 152 | | 3.3 |
| | 06 | 193 | | 5.0 |
| | 07 | 198 | | 5.0 |
| | 08 | 119 | | 4.2 |
| | 09 | 52 | | 4.3 |
| | 10 | 41 | | 4.4 |
| | 11 | 20 | | 4.1 |
| | 12 | 0 | | |
| | Sum | 901 | | |
| | Weighted Mean | | | 4.4 (99.7%) |