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AUSTRALIAN ATOMIC ENERGY COMMISSION
RESEARCH ESTABLISHMENT
LUCAS HEIGHTS

ENVIRONMENTAL SURVEY AT THE AAEC RESEARCH ESTABLISHMENT,
LUCAS HEIGHTS – RESULTS FOR 1972

by

A. DUDAITIS

January 1974

Reprinted May 1979

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ABSTRACT

This report tabulates the results of the environmental survey at Lucas Heights during 1972 and compares them with derived maximum permissible concentrations appropriate to the local environment.

Possible doses to individual members of the local population as a result of Research Establishment operations are less than those due to weapons test fallout and much less than those due to natural radiation background.



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1. INTRODUCTION

This report gives results obtained from samples collected for the environmental survey programme at Lucas Heights during 1972. The rationale for the programme and synopsis of results for the period 1965 - 1970 have been reported by Watson (1972).

2. SAMPLING PROGRAMME

The Woronora estuary receives treated low level aqueous waste from the Research Establishment. Table 1 gives details of collection and preparation of samples taken from the estuary for the environmental survey programme. Figure 1 gives the location of estuary sampling stations.

Table 2 gives details of terrestrial samples and their preparation and Figure 2 gives the location of terrestrial sampling stations.

3. TABULATION OF RESULTS

Tables 3 to 7 refer to samples collected from the Woronora estuary and Table 8 refers to milk samples from the terrestrial environment. These samples show no trace of radioactivity from airborne waste arising from the Research Establishment. Table 9 refers to samples taken from the closed solid waste burial ground (Station T 1, one mile from the Research Establishment).

4. DISCUSSION OF RESULTS

4.1 Woronora Estuary

The results for estuarine water, oysters, fish and beach sand are summarised in Table 12 where the average results for the period are expressed as fractions of the derived maximum permissible concentrations listed. The results for 1966 to 1971 are included for comparison.

The isotopes detected were the same as were found in previous years. The levels for tritium in water, zinc-65 in oysters and cobalt-60 and caesium-137 in fish were all less than one thousandth of the derived maximum permissible concentrations. Gross alpha and gross beta activities in beach sand samples, attributed to natural activity, were generally the same as in previous years at one thousandth and eight thousandths of the derived maximum permissible concentrations.

Dosimeters placed on the bottom sand at the discharge point showed measurable results (Table 11 and Figure 3) and these levels are attributed to waste discharge operations. Cook and Dudaitis (1970) established that levels of gross alpha and gross beta activity bottom sands at 1.5 miles are not significantly different from those in beach sand samples in areas removed from possible influence by site operation and are attributed to natural activity.

Water samples taken from 3.6 miles above the discharge point showed no significant changes from previous years.

Zostera (Table 7) showed the same activity concentrations as in previous years with cobalt-60 and manganese-54 gamma emitters detected. This activity is attributed to site operations. There are no identifiable human exposure routes for Zostera and hence no derived maximum permissible concentrations.

4.2 Terrestrial Samples Related to Possible Airborne Waste

The radioisotopes found in grass and milk samples (Tables 8, 9, 10) are all attributable to the expected activity from weapons test fallout and from natural activity. (The lower limit of detection of iodine-131 in milk (Table 8) is 0.3 pCi/g fresh weight, at the 95% confidence level.)

There is no indication in these samples of any deposition of airborne waste from the Research Establishment. The figures are comparable to previous years.

4.3 Other Terrestrial Samples

Samples from the closed solid waste burial ground are listed in Table 9. Vegetation taken from the nearest point to the actual buried waste showed the presence of cobalt-60 and short lived mixed fission products. Water from boreholes in the burial ground showed only trace levels of cobalt-60.

Sub-surface water from the burial ground is expected to drain into Mill Creek north of the burial ground (see Figure 2). For this reason a line of five borehole sampling sites (designated A to E) is maintained just outside the northern perimeter of the burial ground. Water samples from these holes contain alpha activity from a near equilibrium (i.e. naturally occurring) uranium series.

5. RADIOLOGICAL SIGNIFICANCE OF THE RESULTS

The results have been used to calculate the maximum potential doses to individual members of the local population from ingestion of oysters, fish or milk, or by the other exposure pathways which were taken into account in setting discharge limits. These are given in Table 13.

Maximum whole-body doses from the ingestion of tritium and zinc-65, attributable to operations at the Research Establishment, are 0.02 and 0.05 millirem per year respectively. The total annual dose for a hypothetical individual who consumes 70 g each of local oysters and fish, and swims daily at the discharge point, is 0.14 millirem. This is less than one three-thousandth of the maximum permissible dose limits for members of the public (ICRP 1966).

The traces of activity reported in other samples give no exposure to man. The activity in milk is attributable to fallout and the beach sand activity is natural. For comparison, whole-body dose from natural background radiation, internal and external, is of the order of 100 millirem per year.

6. SUMMARY

During 1972 no radioactivity attributable to aerial dispersion from the Research Establishment was detected in the environment.

In the Woronora estuary a number of radioisotopes were detected other than those that occur naturally or in weapons test fallout, or in quantities in excess of natural or fallout concentrations. These are attributed to low level liquid effluent discharges in the estuary. Those found were tritium (as water), cobalt-60 (in fish, *Zostera* and beach sand 0.8 miles away from the discharge point), caesium-137 (in fish) and zinc-65 (in oysters).

At the solid waste burial ground, cobalt-60 attributed to buried waste has been detected in vegetation taken near the buried material and in the borehole nearest to the buried material.

Levels of activity attributable to Research Establishment operations were similar to those of previous years and generally of the order of, or less than, one thousandth of the appropriate derived maximum permissible concentrations.

Estimates of possible doses to individual members of the public from Research Establishment operations give results less than those due to weapons test fallout and much less than natural radiation background.

7. ACKNOWLEDGEMENTS

The author wishes to acknowledge the assistance received from members of Health and Safety Division and Chemical Technology Division in the collection, processing and chemical and radiochemical analysis of samples.

8. REFERENCES

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ENVIRONMENTAL SURVEY RESULTS

(1972)

TABLES 1 - 13

NOTE: Upper limits shown in Tables 3 - 12 are at the 95 per cent confidence level of the counting statistics. Where an upper limit is given for an average this is the upper limit of the average of all results. Dashes indicate that no activity was detected and blank spaces that no measurement was made.

TABLE 1

DETAILS OF COLLECTION AND PREPARATION OF ESTUARINE SAMPLES

Sample	Stations	Collection Frequency	Collection Details	Special Steps in Preparation
Oysters	E4.4, E5.8 Control	Quarterly	Obtained from commercial leases	Opened by commercial openers. Drained on sieve for 5 minutes. Ashed
Fish	E0.8, E4.0	Quarterly	Caught by seine net	Whole fish ashed
Beach Sand	E0.8, E3.7	Six Monthly	Taken by scoop from top 2 in. in the intertidal region	Fraction between 60 and 120 mesh B.S.S. removed after ashing
Estuary Water	E3.6	Weekly	From surface by bucket	Distilled for tritium
Zostera	E1.0, E1.5 E2.9, E4.4 E5.8	Quarterly	Pulled from bottom by rake or hand.	Ashed

TABLE 2

DETAILS OF COLLECTION AND PREPARATION OF TERRESTRIAL SAMPLES

Sample	Stations	Collection Frequency	Collection Details	Special Steps in Preparation
Milk	T3.1	Monthly	Obtained from bulk milk supplies	Gamma spectrometry of whole milk for iodine-131
Vegetation	T1	Six Monthly	Cut by hand clippers	Whole unwashed vegetation is ashed
Ground Water	T1	Six Monthly	Boreholes pumped out, allowed to refill, sample taken from bottom	The water is passed through 200 ml of Amberlite IRC 120 resin, which is then ashed
Creek Water	TO T2	Six Monthly Six Monthly	Taken in bucket	As for ground water (Distilled for tritium)

TABLE 3

WORONORA SAMPLES – OYSTER FLESH, 1972

Station	Date 1972	Radioactivity, pCi/g Fresh Weight			K (ppm)
		Gross Alpha	Gross Beta (less ⁴⁰ K)	⁶⁵ Zn	
E4.4	3.3	0.32	0.12	0.20	2700 2800
	23.6	0.25	0.24	0.37	
	Average	0.29	0.18	0.29	
E5.8	16.2	0.24	0.16	–	3600 2400 3500
	6.6	0.44	0.27	trace	
	6.10	0.17	< 0.56	trace	
	Average	0.28	< 0.33	–	
Hawkesbury River (H.R.)	16.2	0.24	0.49	–	3100 2600 3600
	14.6	0.15	0.32	–	
	9.10	0.30	0.25	–	
	Average	0.23	0.35		
Oyster Shell Composite	16.2–9.10	< 0.88	0.35	–	300
			Derived m.p.c.	1000	
E4.4	Fraction of m.p.c.			3 x 10 ⁻⁴	
E5.8	" " "			–	
H.R.	" " "			–	
Oyster Shell Composite	" " "			–	

TABLE 4

WORONORA SAMPLES - WHOLE FISH, 1972

Station	Date 1972	Radioactivity, pCi/g Fresh Weight				K (ppm)
		Gross Alpha	Gross Beta (less ^{40}K)	^{137}Cs	^{60}Co	
E0.8 Mullet	22.3	0.67	0.16	trace	0.16	3200
"	23.8	0.07	0.82	-	trace	3200
Bream	22.3	0.15	0.65	0.08	0.25	3300
"	30.11	0.18	0.49	0.07	0.28	3600
Herring	"	0.11	0.09	-	-	3600
Average		0.24	0.44	0.03	0.14	
E4.0 Mullet	17.5	0.62	0.66	-	-	2900
"	29.8	0.23	0.05	-	-	3300
"	23.11	0.43	0.13	-	-	3400
Blackfish	17.5	0.46	0.49	-	-	2900
"	29.8	0.43	0.30	-	-	3300
"	23.11	0.44	0.21	-	-	3100
Herring	17.5	0.07	0.21	-	-	2800
Eel	21.8	0.05	< 0.55	trace	-	3400
Average		0.34	< 0.33	-	-	
Derived m.p.c.				200	500	
E0.8	Fraction of m.p.c.			2×10^{-4}	3×10^{-4}	
E4.0				-	-	

TABLE 5

WORONORA SAMPLES – BEACH SAND, 1972

Station	Date 1972	Radioactivity, pCi/g Fresh Weight				K (ppm)
		Gross Alpha	Gross Beta (less ⁴⁰ K)	⁶⁰ Co	²³² Th + dtrs	
E0.8	22.3	2.5	1.0	–	–	200
	21.7	3.8	1.6	0.38	trace	
Average		3.2	1.3	0.19		
E3.7	22.3	2.9	2.2	–	–	400
	21.7	4.0	2.2	–	–	
Average		3.5	2.2	–	–	
Derived m.p.c.		3000	2500	500		
Average fraction of m.p.c.		0.001	0.0008	<0.0004	–	

TABLE 6

WORONORA SAMPLES – TRITIUM IN SURFACE WATER AT STATION E3.6, 1972

Date	Tritium (pCi/ml)	Date	Tritium (pCi/ml)
4. 2.72	1	4. 8.72	1
11. 2	1	11. 8	5
18. 2	3	18. 8	8
25. 2	2	25. 8	4
3. 3	2	1. 9	1
10. 3	1	8. 9	1
17. 3	1	15. 9	5
24. 3	1	22. 9	3
30. 3	1	29. 9	2
7. 4	1	6.10	2
14. 4	1	13.10	3
24. 4	6	20.10	1
28. 4	6	27.10	1
5. 5	5	3.11	1
12. 5	4	10.11	1
19. 5	2	17.11	1
26. 5	2	24.11	1
2. 6	4	1.12	1
9. 6	2	7.12	2
16. 6	3	15.12	5
23. 6	2	22.12	2
30. 6	1	29.12	3
7. 7	1		
14. 7	1	Average 2	
21. 7	3	Derived m.p.c. = 3×10^4 pCi/ml	
28. 7	1	Average fraction of m.p.c. = 7×10^{-5}	

TABLE 7

WORONORA SAMPLES - ZOSTERA, 1972

Station	Date 1972	Radioactivity (pCi/g Fresh Weight)					
		Gross Alpha	Gross Beta (less ⁴⁰ K)	Gamma Emitters			
				0.5 MeV	⁹⁵ Zr + ⁹⁵ Nb	⁵⁴ Mn	⁶⁰ Co
E1.0	1. 2	1.3	3.1	0.2	0.3	—	2.8
	26. 4	0.9	1.6	—	—	—	5.4
	21. 7	0.6	1.8	—	—	—	3.9
	6.11	1.6	2.1	—	—	0.4	2.5
	Average	1.1	2.2	—	—	—	3.7
E1.5	1. 2	3.0	1.6	0.1	0.4	—	1.5
	26. 4	2.3	1.2	—	—	—	4.3
	21. 7	2.0	0.8	—	—	—	2.9
	6.11	1.1	0.6	—	—	0.2	1.6
	Average	2.1	1.1	—	—	—	2.6
E2.9	1. 2	1.2	1.3	0.1	0.2	—	0.4
	26. 4	0.7	0.9	—	trace	—	0.9
	21. 7	1.2	1.0	—	—	—	0.7
	6.11	1.0	1.1	—	—	—	0.4
	Average	1.0	1.1	—	—	—	0.6
E4.4	1. 2	1.5	1.8	0.1	0.3	—	0.3
	27. 4	0.6	1.2	—	trace	—	0.4
	22. 8	0.8	0.9	—	—	—	0.4
	6.11	1.6	1.8	—	—	—	0.1
	Average	1.1	1.4	—	—	—	0.3
E5.8	1. 2	1.2	1.2	0.1	0.2	—	0.1
	27. 4	0.1	0.6	—	trace	—	trace
	22. 8	0.7	1.2	—	—	—	0.1
	6.11	1.0	1.0	—	—	—	0.1
	Average	0.8	1.0	—	—	—	< 0.1

TABLE 8

TERRESTRIAL SAMPLES - MILK, 1972

Station	Date 1972	Radioactivity (pCi/g Fresh Weight)	
		¹³⁷ Cs	¹³¹ I
T3 (Menai)	24. 1	0.03	trace
	16. 2	0.03	trace
	14. 3	0.04	trace
	14. 4	0.04	-
	19. 5	0.02	-
	16. 6	0.04	-
	18. 7	0.04	trace
	18. 8	0.01	-
	25. 9	0.02	-
	25.10	0.01	-
	15.11	0.01	-
	19.12	0.01	-
	Average		0.03

Note: Minimum detectable level for iodine-131 in milk is
0.3 pCi/g fresh weight (0.3 nCi/litre)

TABLE 9

TERRESTRIAL SAMPLES – SOLID WASTE BURIAL GROUND, 1972

Location	Sample	Date 1972	Radioactivity (pCi/g Fresh Weight)			K (ppm)
			Gross Alpha	Gross Beta ^(a)	Gamma Emitters	
Near Trench No. 59	Acacia	1.3	8.4	0.2	0.5 0.5 MeV 2.4 ⁹⁵ Zr + ⁹⁵ Nb	2600
	"	28.8	3.3	0.4	0.2 0.5 MeV 0.1 ¹³⁷ Cs 0.3 ⁹⁵ Zr + ⁹⁵ Nb	3300
Near Trench No. 70	Acacia	1.3	34.4	0.1	0.3 0.5 MeV 1.2 ⁹⁵ Zr + ⁹⁵ Nb 1.5 ⁶⁰ Co	3300
	"	28.8	32.3	0.3	0.1 0.5 MeV 0.1 ⁹⁵ Zr + ⁹⁵ Nb 1.1 ⁶⁰ Co	3300
	Grass	1.3	41.1	1.0	0.9 0.5 MeV 5.2 ⁹⁵ Zr + ⁹⁵ Nb 6.6 ⁶⁰ Co	4400
	"	28.8	28.7	1.2	1.0 0.5 MeV 0.7 ⁹⁵ Zr + ⁹⁵ Nb 7.3 ⁶⁰ Co	3000

(a) including ⁴⁰K for water results; excluding it for vegetation

(continued)

TABLE 9 (continued)

TERRESTRIAL SAMPLES – SOLID WASTE BURIAL GROUND, 1972

Location	Sample	Date 1972	Radioactivity (pCi/litre)		
			Gross Alpha	Gross Beta ^(a)	Gamma Emitters
Bore Hole 1	Ground Water	1.3	1.1	5.2	—
" " 2	" "	"	0.4	3.1	—
" " 3	" "	"	2.2	5.7	—
" " 4	" "	"	< 1.5	2.2	—
" " 5	" "	"	1.8	2.4	—
" " 6	" "	"	0.5	4.0	—
" " 10	" "	"	11.2	13.3	trace ²³⁸ U series
" " OS1	" "	"	1.6	4.3	—
" " OS2	" "	"	0.6	5.4	—
" " OS3	" "	"	1.1	73.0	0.3 0.5 MeV trace ⁶⁰ Co
" " A	" "	"	2.7	4.6	—
" " B	" "	"	2.3	7.6	—
" " C	" "	"	6.7	6.2	—
" " D	" "	"	11.0	19.6	trace ²³⁸ U series
" " E	" "	"	4.8	11.1	—
" " 1	" "	28.8	1.8	2.8	—
" " 2	" "	"	0.9	2.4	—
" " 3	" "	"	0.9	2.4	—
" " 4	" "	"	< 1.4	1.4	—
" " 5	" "	"	0.7	1.2	—
" " 6	" "	"	1.9	1.8	—
" " 10	" "	"	12.8	11.2	trace ²³⁸ U series
" " OS1	" "	"	0.9	2.1	—
" " OS2	" "	"	1.6	3.4	—
" " OS3	" "	"	5.2	75.5	4.6 0.5 MeV 0.9 ⁶⁰ Co
" " A	" "	"	1.7	7.8	—
" " B	" "	"	9.3	4.6	—
" " C	" "	"	1.8	2.9	—
" " D	" "	"	4.7	9.9	trace ²³⁸ U series
" " E	" "	"	3.3	10.4	—

(a) including ⁴⁰K for water results; excluding it for vegetation

TABLE 10

TERRESTRIAL SAMPLES - MISCELLANEOUS, 1972

Station	Sample	Date 1972	Radioactivity (pCi/g Fresh Weight)				K (ppm)
			Gross Alpha	Gross Beta (less ⁴⁰ K)	³ H (pCi/ml)	Gamma Emitters	
R.E. Storm- water Outlet near South Gate	Sand	2.5	111.4	66.6		29.0 ¹³⁷ Cs 42.6 ⁶⁰ Co trace ²³² Th + dtrs	1200
	"	25.9	161.1	140.7		41.8 ¹³⁷ Cs 50.4 ⁶⁰ Co trace ²³² Th + dtrs	1300
	Water	2.5			110.1		
	"	25.9			38.1		
R.E. Storm- water Outlet near South Gate, 60 ft away from it	Sand	2.5	67.1	40.2		11.4 ¹³⁷ Cs 14.6 ⁶⁰ Co trace ²³² Th + dtrs	1100
	"	25.9	169.9	200.4		46.5 ¹³⁷ Cs 71.1 ⁶⁰ Co trace ²³² Th + dtrs	2200
	Grass	2.5	6.7	6.8		trace 0.5 MeV 2.4 ¹³⁷ Cs 0.3 ⁹⁵ Zr + ⁹⁵ Nb 3.5 ⁶⁰ Co	3300
	"	25.9	0.4	2.6		0.1 0.5 MeV 0.8 ¹³⁷ Cs 0.2 ⁵⁴ Mn 1.3 ⁶⁰ Co trace ²³² Th + dtrs	5200
	Sand	2.5	2.9	2.0		-	300
R.E. Storm- water Outlet near South Gate, 1250 ft away from it	"	7.12	17.0	2.3		-	300
	Water	2.5			7.4		
	"	7.12			11.0		
Junction Mill Crk & Barden Crk	Sand	14.9	16.8	2.8			400
	Water	14.9			< 1.0		

(continued)

TABLE 10 (continued)

TERRESTRIAL SAMPLES - MISCELLANEOUS, 1972

Station	Sample	Date 1972	Radioactivity (pCi/g Fresh Weight)				K (ppm)
			Gross Alpha	Gross Beta (less ⁴⁰ K)	³ H (pCi/ml)	Gamma Emitters	
Stormwater Outlet outside R.E. safety fence: opp. Strassman Crs.	Sand	8.2	15.6	54.0		1.0 0.5 MeV 1.3 ¹³⁷ Cs 5.5 ⁹⁵ Zr + ⁹⁵ Nb 10.1 ⁶⁰ Co trace ²³² Th + dtrs	1200
	"	10.5	11.2	12.8		trace ¹³⁷ Cs trace ⁹⁵ Zr + ⁹⁵ Nb 6.1 ⁶⁰ Co trace ²³² Th + dtrs	780
	"	6.10	15.0	13.0		1.6 ¹³⁷ Cs 5.1 ⁶⁰ Co trace ²³² Th + dtrs	600
Opp. Bldg. 23	"	8.2	20.6	61.0		116.7 ⁶⁰ Co trace ²³² Th + dtrs	700
	"	10.5	15.6	34.5		57.4 ⁶⁰ Co trace ²³² Th + dtrs	1000
	"	6.10	22.3	27.4		trace ¹³⁷ Cs 15.5 ⁶⁰ Co trace ²³² Th + dtrs	700
	Water	8.2			5.3		
Opp. Fermi St.	"	10.5			44.2		
	"	6.10			5.4		
	Sand	10.5	10.0	8.1		trace ¹³⁷ Cs trace ⁹⁵ Zr + ⁹⁵ Nb trace ²³² Th + dtrs	900
	"	6.10	21.2	29.1		0.9 ¹³⁷ Cs 1.3 ⁹⁵ Zr + ⁹⁵ Nb 1.4 ⁶⁰ Co	900
	Water	10.5			19.2		
"	6.10			2.6			

TABLE 11

RESULTS OF 'LiF- TEFLON DOSIMETERS' RADIATION DOSE
READINGS ON BED OF WORONORA ESTUARY AT THE
DISCHARGE POINT

Location of Dosimeters (Fig. 3)		Dose in rems from 23. 9.71 to 19. 9.72
No.	1	0.07
	2	0.13
	3	0.24
	4	
	5	0.12
	6	0.07
	8	0.08
	9	
	10	0.16
	11	0.08
	12	0.11

Note: Blank spaces indicate dosimeters have been vandalised during the period.

TABLE 12

**WORONORA SAMPLES: ANNUAL AVERAGES EXPRESSED AS FRACTIONS
OF THE DERIVED MAXIMUM PERMISSIBLE CONCENTRATIONS (a)**

Sample	Radioisotope and m.p.c.	Fractions of m.p.c.						
		1966	1967	1968	1969	1970	1971	1972
Water	³ H, 30 nCi/ml							
E0		2x10 ⁻⁴	8x10 ⁻⁴	7x10 ⁻⁴	2x10 ⁻⁴	5x10 ⁻⁴		
E1.5		4x10 ⁻⁴	3x10 ⁻⁴	4x10 ⁻⁴	1x10 ⁻⁴	4x10 ⁻⁴		
E3.6				1x10 ⁻⁴	7x10 ⁻⁵	2x10 ⁻⁴	7x10 ⁻⁵	7 x 10 ⁻⁵
E5.0				7x10 ⁻⁵	3x10 ⁻⁵	1x10 ⁻⁴		
Oyster Flesh	⁶⁵ Zn, 1000pCi/g							
E4.4		2x10 ⁻⁴	1x10 ⁻⁴	1x10 ⁻⁴	5x10 ⁻⁵	2x10 ⁻⁴	3x10 ⁻⁴	3x10 ⁻⁴
E5.8		2x10 ⁻⁵	—	—	4x10 ⁻⁵	8x10 ⁻⁵	1x10 ⁻⁴	—
Hawkesbury		—	—	—	—	—	—	—
	⁹⁰ Sr, 1 pCi/g							
E4.4		<1x10 ⁻³	<2x10 ⁻³	<2x10 ⁻³	<2x10 ⁻³	<3x10 ⁻³		
E5.8		<2x10 ⁻³	<2x10 ⁻³	<1x10 ⁻³	<2x10 ⁻³	<1x10 ⁻³		
Hawkesbury		<1x10 ⁻³	<1x10 ⁻³	<2x10 ⁻³	<2x10 ⁻³	<1x10 ⁻³		
Fish (Average of all samples)	⁶⁰ Co, 500 pCi/g	2x10 ⁻⁴	1x10 ⁻⁴	4x10 ⁻⁴	2x10 ⁻⁴	—	—	3x10 ⁻⁴
	⁹⁰ Sr, 1 pCi/g	9x10 ⁻³	8x10 ⁻³	8x10 ⁻³	7x10 ⁻³	<6x10 ⁻³	—	—
	¹³⁷ Cs, 200 pCi/g	—	5x10 ⁻⁵	2x10 ⁻⁴	3x10 ⁻⁵	—	—	2x10 ⁻⁴
Beach Sand (Average of all samples)	Gross Alpha 3000 pCi/g	2x10 ⁻³	1x10 ⁻³	2x10 ⁻³	3x10 ⁻³	3x10 ⁻³	3x10 ⁻³	1x10 ⁻³
	Gross Beta 2500 pCi/g	5x10 ⁻⁴	5x10 ⁻⁴	8x10 ⁻⁴	<1x10 ⁻³	1x10 ⁻³	4x10 ⁻⁴	8x10 ⁻⁴

(a) Derived maximum permissible concentrations are taken from Fry (1966)

TABLE 13**POSSIBLE DOSES TO MEMBERS OF THE LOCAL POPULATION AS A
RESULT OF EXPOSURE TO MEASURED CONCENTRATIONS**

Sample	Isotope	Exposure Route	Possible Annual Dose (mrem)	Critical Organ
Oyster Flesh	Tritium	Ingestion	0.01	Whole Body
	Zinc-65	"	0.05	" "
Fish	Tritium	"	0.01	" "
	Caesium-137	"	0.02	" "
	Cobalt-60	"	0.003	" "
	"	"	0.04	Lower Large Intestine
Milk	Caesium-137	"	0.24	Whole Body
Estuary Water	Tritium	Daily Swimming at Discharge Point	0.01	" "
Beach Sand	Gross Beta Activity	Regular Contact	2.2	Skin

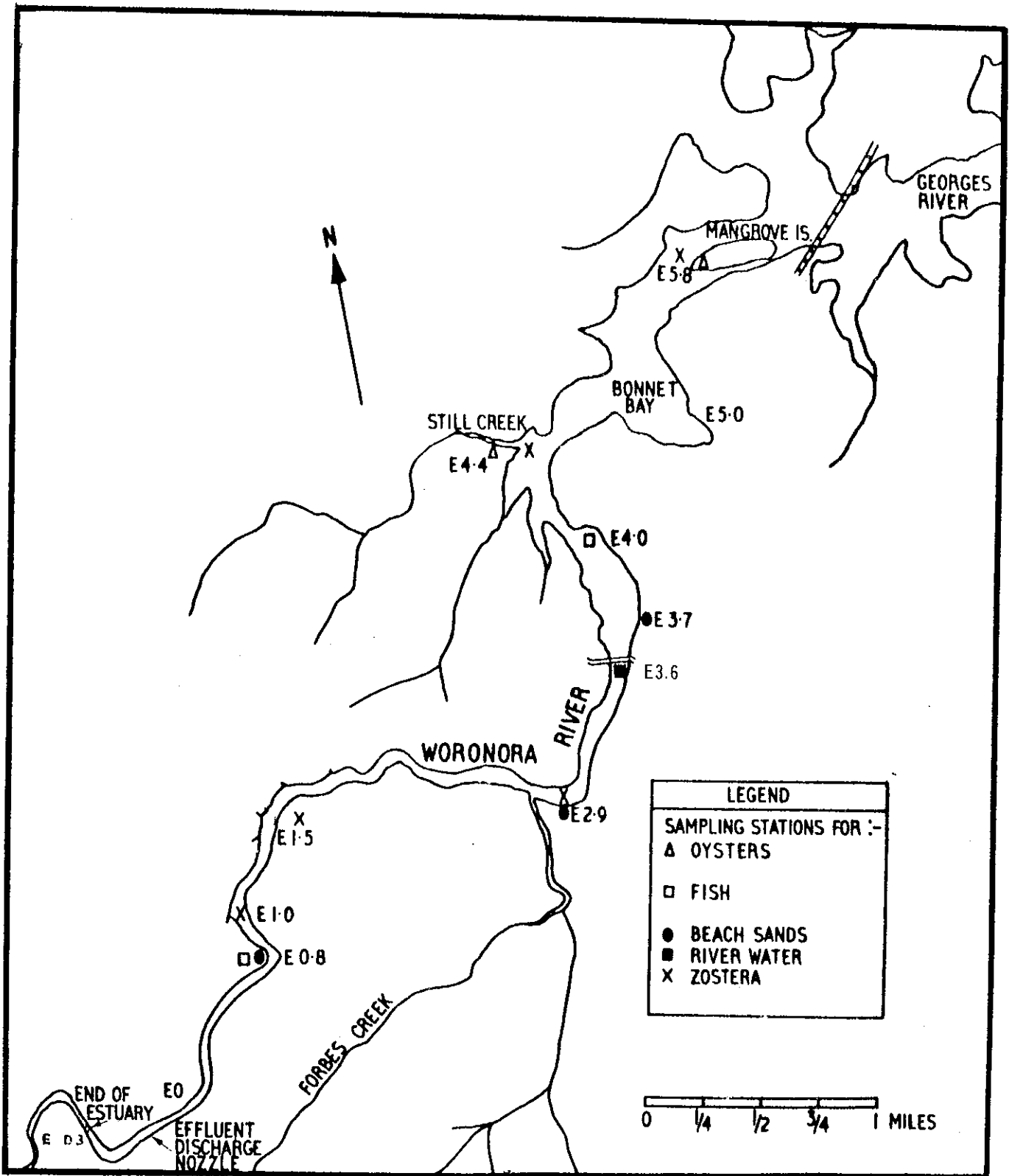


FIGURE 1. WORONORA ESTUARY SAMPLING STATIONS (1972)

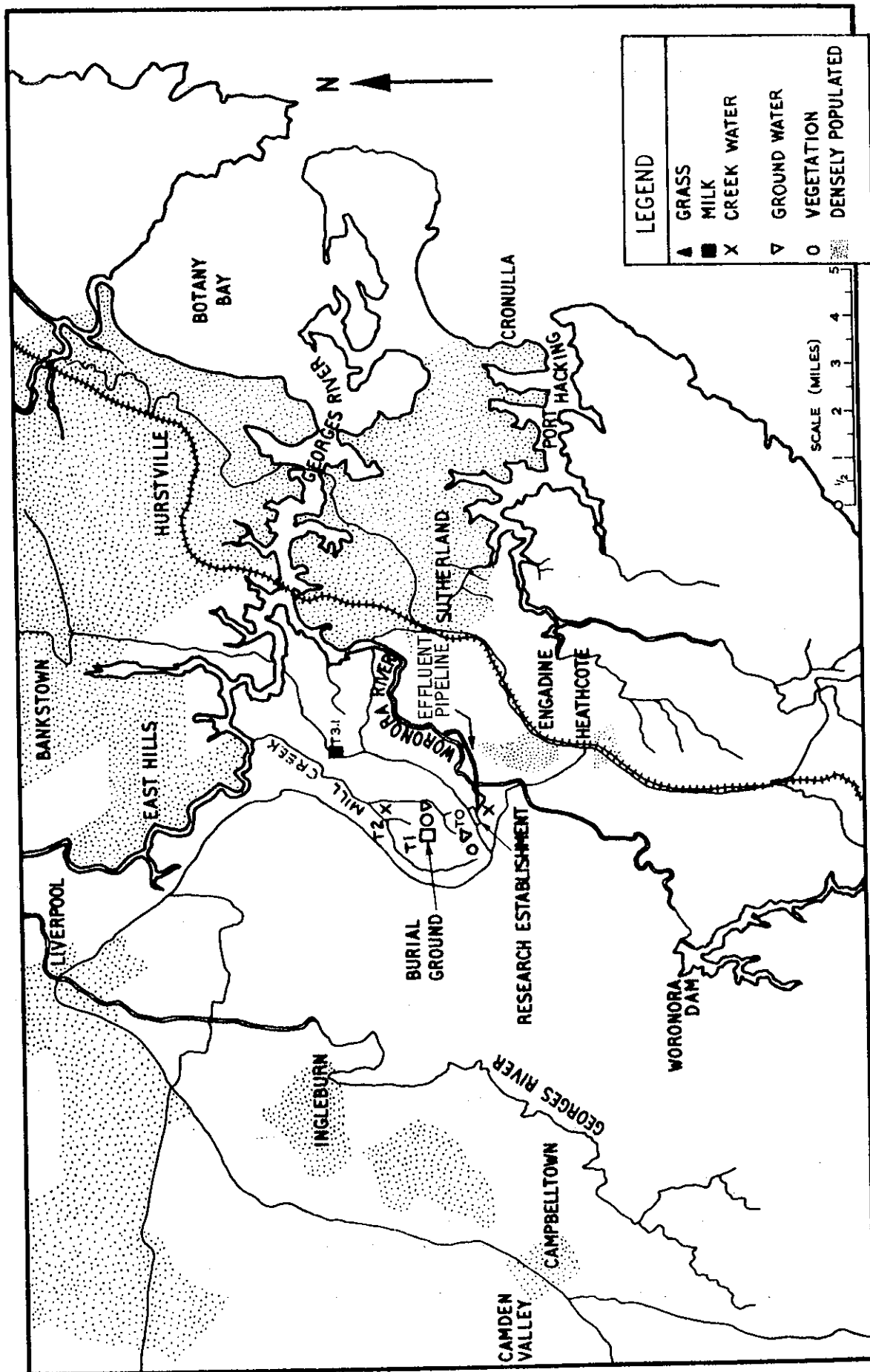


FIGURE 2. TERRESTRIAL SAMPLING STATIONS (1972)

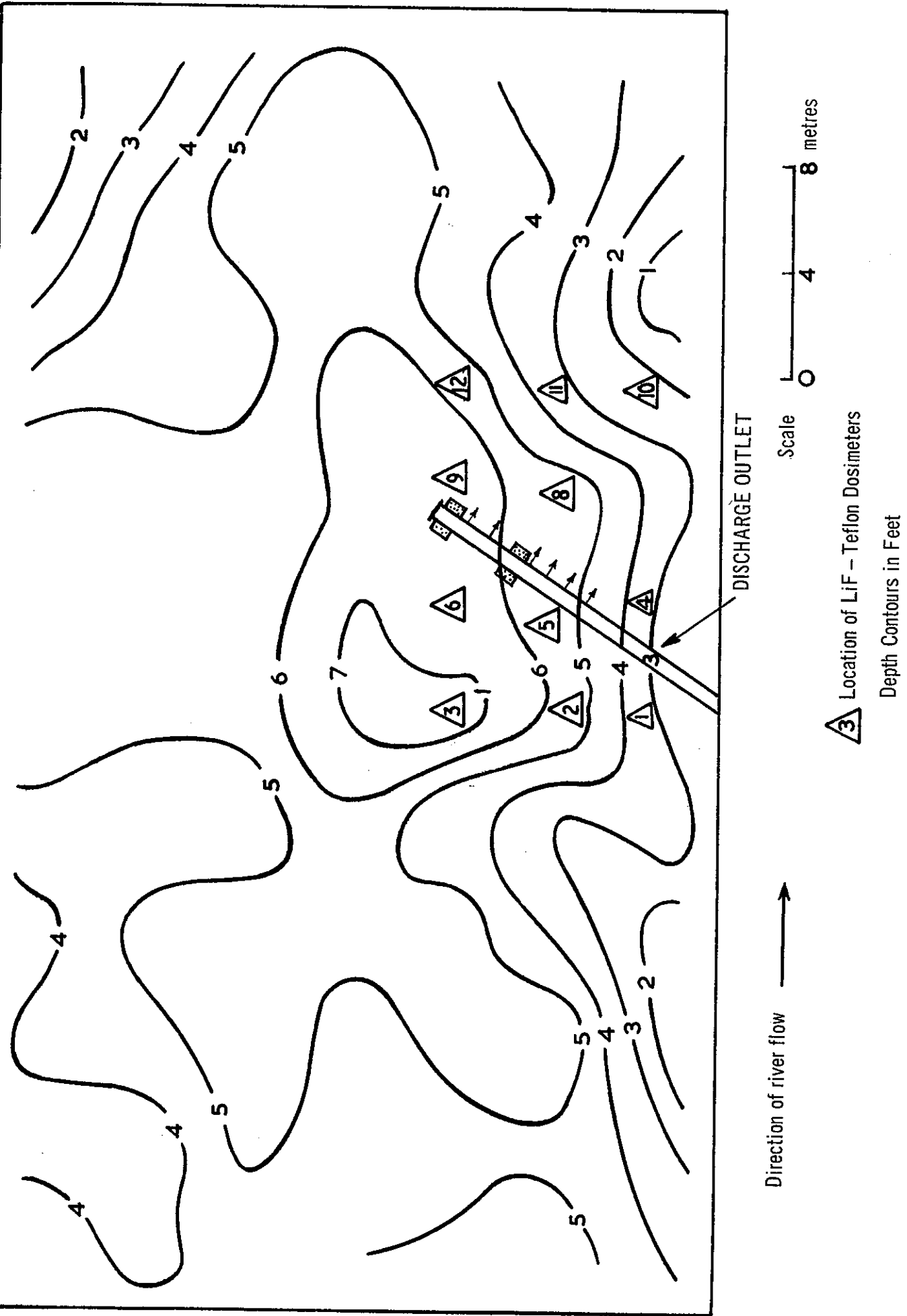


FIGURE 3. LOCATION OF LiF - TEFLON DOSIMETERS ON BED OF WORONORA ESTUARY AT THE DISCHARGE POINT

