

ATAL Engineering Limited
13/F, Island Place Tower
No. 510 King's Road
North Point
Hong Kong

Level 5, Festival Walk
80 Tat Chee Avenue
Kowloon Tong, Kowloon
Hong Kong

t +852 2528 3031
d +852 2268 3208
f +852 2268 3950

sam.tsoi@arup.com
www.arup.com

For the attention of Mr Ray Leung

14 December 2017

Dear Mr Leung

**Low Level Radioactive Waste Storage Facility at Siu A Chau
Independent Environmental Checker Services
Environmental Monitoring and Audit Report No. 2 (Operation Phase)**

We refer to your ET's email submission dated 12 October 2017 on the draft submission and 14 December 2017 on the final submission for the subject report and advise below our comments.

We have checked the report and do not have further comments and hereby enclosed the captioned report for your onward submission.

If you require any further information, please do not hesitate to contact the undersigned or our Mr Martin Yu at 2268 3206.

Yours sincerely



Sam Tsoi
Director

Encl.

ATAL ENGINEERING LIMITED


Contract No. EP/SP/75/14

**Low Level Radioactive Waste Storage Facility
Follow-On Contract**

**Environmental Monitoring and Audit Report No. 2
(Operation Phase)**

Version 1.0

August 2017

Certified By 

(Environmental Team Leader)

REMARKS:

The information supplied and contained within this report is, to the best of our knowledge, correct at the time of printing.

The Environmental Team Leader accepts no responsibility for changes made to this report by third parties.

Dr. John K.C. Leung

E-mail: jkcleung@hku.hk

TABLE OF CONTENTS

EXECUTIVE SUMMARY	1
1. INTRODUCTION.....	2
BACKGROUND	2
PURPOSE OF THE REPORT	2
2. MONITORING RESULTS.....	3
AMBIENT γ DOSE RATES	5
SOIL	7
GRASS	9
SEA WATER.....	10
MARINE ORGANISMS.....	11
AIRBORNE PARTICULATES	13
3. REPORT ON ELEVATED ENVIRONMENTAL RADIATION BACKGROUND	14
4. REPORT ON NON-COMPLIANCE	15
DOSE FOR RADIATION WORKERS	15
DOSE RATES AT UN-CONTROLLED AREAS.....	15
LIQUID EFFLUENT DISCHARGE	15
AIRBORNE EFFLUENT DISCHARGE	15
5. RECORD OF ENVIRONMENTAL COMPLAINTS.....	16
APPENDIX 1	17
LIMIT LEVEL AND ACTION LEVEL	17
INVESTIGATION LEVEL	17

LIST OF TABLES

Table 2.1(a)	Ambient γ Dose Rates at 1 m above Ground
Table 2.1(b)	Comparison of Ambient γ Dose Rates with Previous Results
Table 2.2(a)	Activity Concentration of Some Major Radionuclides in Soil Samples
Table 2.2(b)	Comparison of Activities in Soil with Updated Previous Results
Table 2.3(a)	Activity Concentration of Some Major Radionuclides in Sand Samples
Table 2.3(b)	Comparison of Activities in Sand with Updated Previous Results
Table 2.4(a)	Activity Concentration of Gross α and β Emitters in Grass Samples
Table 2.4(b)	Comparison of α/β Activities in Grass Samples with Previous Results
Table 2.5(a)	Activity Concentration of Gross α/β Emitters in Sea Water Samples
Table 2.5(b)	Comparison of α/β Activities in Sea Water Samples with Previous Results
Table 2.6(a)	Activity Concentration of Gross α/β Emitters in Fish Samples
Table 2.6(b)	Comparison of α/β Activities in Fish Samples with Previous Results
Table 2.7(a)	Activity Concentration of Gross α/β Emitters in Sea Snail Samples
Table 2.7(b)	Comparison of α/β Activities in Sea Snails with Previous Results
Table 2.8(a)	Net Gross α/β Counts in Airborne Particulate Samples
Table 2.8(b)	Comparison of α/β in Airborne Particulate Samples with Previous Samples
Table A1.1	Limit Levels for Non-compliance and Action Levels
Table A1.2	Investigation Levels for Environmental Samples

LIST OF FIGURES

Fig. 2.1	Locations of the Sampling Sites
----------	---------------------------------

EXECUTIVE SUMMARY

This is the second Environmental Monitoring & Audit (EM&A) Report for the new Low Level Radioactive Waste Storage Facility Follow-On Contract.

The samples were collected on August 1, 2017. The first batch of ambient γ dose-rate data was found to be not reliable when compared to previous data and therefore was discarded. The measurement was repeated on August 10, 2017 and the results are more consistent.

It is noted that the upgrading Works have disturbed the soil surface at some γ dose-rate measurement points, notably locations H, I, J and O. Since the landscape and surface soil contents of these locations have been changed, new γ dose-rate baseline were established for these 4 locations during this visit. Each baseline was determined by taking γ dose-rates at 5 randomly chosen spots within a circle of radius 0.5 m centred at each newly selected location. Corresponding new Investigation Levels for these 4 new locations were determined and given in **Table 2.1(a)** and **Table A1.2**.

The Th-228 activity in Soil Sample A exceeded the Investigation Level (IL) again by a small margin (220 Bq kg^{-1} vs 218 Bq kg^{-1}). Following the recommendation of last year's EM&A Report (i.e. EM&A Report No.1 (Operation Phase)), an investigation has been carried out. Repeated soil samples were collected at Locations A and C on October and December 2016. Both October and December Th-228 activities in Location A (227 and 233 Bq kg^{-1} respectively) still exceeded the IL while those in Location C dropped to below the IL. In general if contamination were coming from the operation of the Facility, other isotopes with significant amount would have been observed, which was not our situation. Additionally, in December 2016 Belgoprocess as Radiation Protection Advisor performed an annual radiation audit and no abnormal issues were found. It was therefore concluded that this exceedance was not related to operation of the Facility. The possible cause of exceedance in Soil Sample A may be that after more than 10 years of taking soil samples from the same location, deeper soil layer that has a different Th-228 content have been reached. Further review of the cause is being carried out by taking a few more samples from around Location A. The findings will be reported in the next EM&A report. If the exceedance persists and it is proven not related to the Facility's operation, then no mitigation measures would be required but instead a review of IL is suggested.

No other exceedance of IL was observed.

1. INTRODUCTION

Background

- 1.1 Various industrial, educational and medical facilities in Hong Kong have, for a number of years, used radioactive materials and generated radioactive waste. Most of the existing waste arisings were stored in disused air raid tunnels close to Queen's Road East in Wan Chai. Other arisings were stored temporarily (although in some cases for several years) at the point of use in educational institutions or hospitals.
- 1.2 A consultancy study in 1995 concluded that Siu A Chau was a suitable location for a purpose-built storage facility to which all waste will be transported, placed in stainless steel drums and stored.
- 1.3 In July 2003 ATAL-Belgoprocess Joint Venture Limited (ABJV) was awarded a contract to design, construct, and operate the Low Level Radioactive Waste Storage Facility at Siu A Chau (LLRWSF) for 10 years. Thereafter, the ABJV will transfer the waste management skills for this Facility to Hong Kong.
- 1.4 The LLRWSF was designed to have a storage vault that can initially store 260 drums of waste, each drum of 275 litres net capacity. The building also contains facilities for waste reception and repackaging waste, and administering the process. A jetty was built to provide marine access to the Facility.
- 1.5 The Facility is equipped with various radiation monitors inside the building specially installed for detecting all possible leakage of effluents from the building.
- 1.6 However, it is possible that minute activities may escape from detection and enter the biosphere, or an unexpected incidence would have resulted in a significant release of radionuclide from the Facility. It is one of the objectives of this environmental monitoring scheme to monitor whether in the long-term, the operation of the Facility will cause deterioration to the environment.
- 1.7 In 2015, ATAL was awarded the contract (Low Level Radioactive Waste Storage Facility Follow-On Contract) to operate the LLRWSF for another 10 years starting from January 19, 2016.

Purpose of the Report

- 1.8 This is EM&A Report No. 2 (Operation Phase) for the Follow-On Contract. This report covers the monitoring period from September 20, 2016 to the date of sampling which was August 1, 2017.
- 1.9 The requirements of the operation phase monitoring and audit; monitoring scheme and monitoring equipment and procedures have been fully described in the EM&A Manual (Part 2). Please refer to that manual for reference.
- 1.10 This report also covers the monitoring of personnel doses, the non-active areas of the Facility and the liquid and gaseous effluents.

2. MONITORING RESULTS

- 2.1 The sampling scheme remained unchanged. 15 in-situ ambient γ dose rates were measured. 3 soil samples; 3 sand samples; 3 grass samples; 8 seawater samples from 4 locations at two depths; sea snails; a few fish and 3 airborne particulate samples were collected and analysed as in previous monitoring. **Figure 2.1** shows the locations for taking various samples.
- 2.2 Ambient γ dose rates were taken at exactly the same locations and would give a true picture of the variation of the radiation environment if there were any.
- 2.3 Soil and grass samples were collected at more or less the same place as for the baseline. Since we need fresh surface soils that would have stored information of fallout since the commencement of the operation, the sampling sites shifted a little bit every time.
- 2.4 The uncertainties of the measurement results are given as standard deviation (SD) or standard uncertainty (SU). SD is given for individual sample and is calculated according to the number of counts recorded and assuming a normal distribution for the counts. SU is reported for each group of samples and it takes into account of the variance between samples. Please refer to the First EM&A Report (Operation Phase) (Oct 2005) for details.

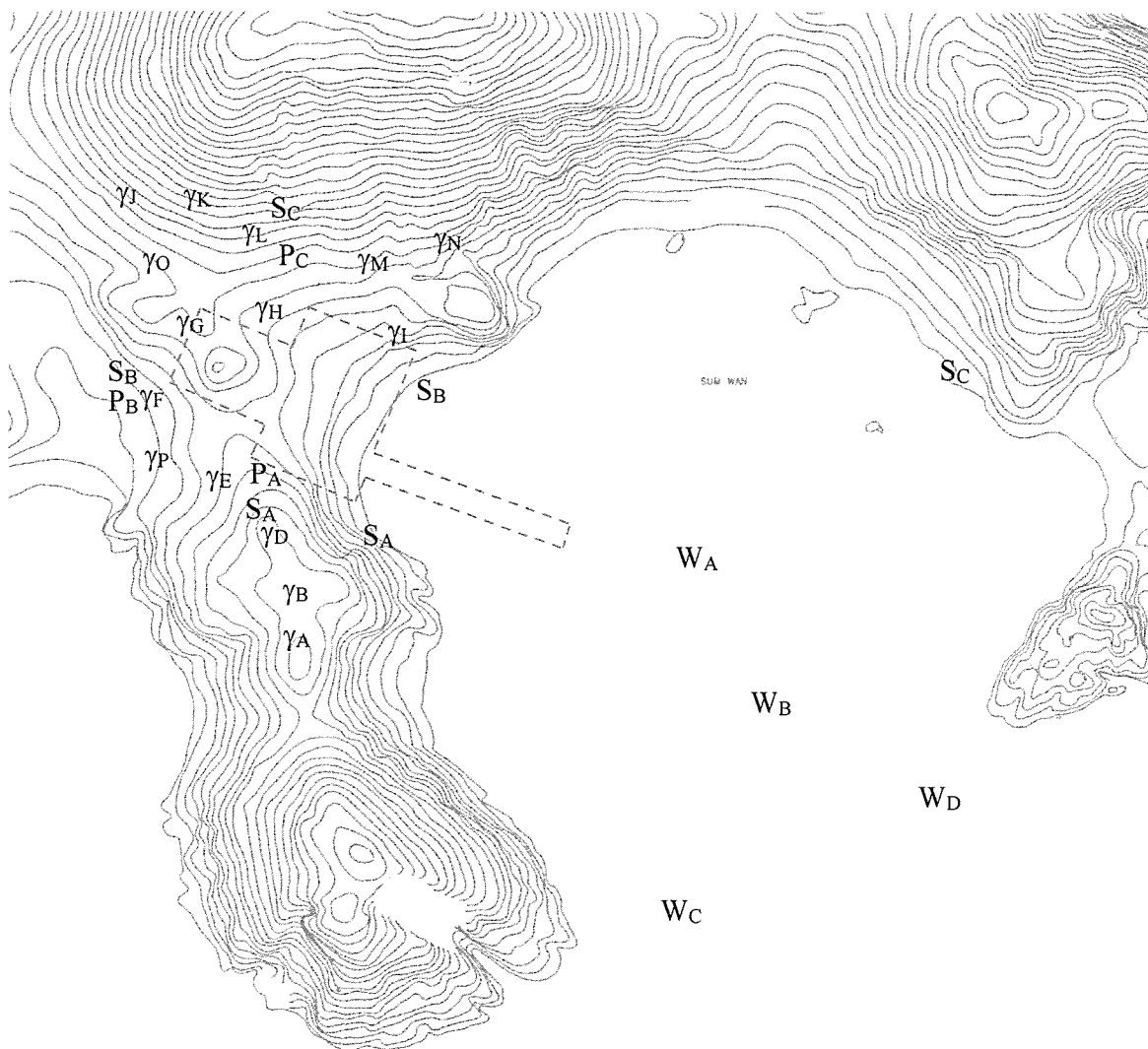


Fig. 2.1 Locations of the Sampling Sites

(γ : Ambient gamma dose rate; S: Soil or Sand; W: Water; P: Air particulates)
(Grass sampling sites are the same as soil sampling sites)

Ambient γ Dose Rates

- 2.5 The measurement results are given in the last column in **Table 2.1(a)**. The last five years of results are given for comparison. **Table 2.1(b)** shows the mean γ dose rates of all the past results. It is noted that the overall average value has remained similar during the monitoring period.
- 2.6 It is noted that the upgrading Works have disturbed the soil surface at some γ dose-rate measurement points, notably locations H, I, J and O. Since the landscape and surface soil contents of these locations have been changed, new γ dose-rate baseline were established for these 4 locations during this visit. Each baseline was determined by taking γ dose-rates at 5 randomly chosen locations within a circle of radius 0.5 m centred at each newly selected location. Corresponding new Investigation Levels for these 4 new locations were determined and given in **Table 2.1(a)** & **Table A1.2**.

Table 2.1(a) Ambient γ Dose Rates at 1 m above Ground

Location	ILs	Net γ Dose Rate ($\mu\text{Sv h}^{-1}$)					
		Baseline (2005)	2012	2013	2014	2015	2016
A	0.17	0.14	0.14	0.15	0.17	0.16	0.14
B	0.19	0.15	0.18	0.17	0.19	0.17	0.16
D	0.21	0.16	0.19	0.18	0.21	0.20	0.18
E	0.23	0.18	0.14	0.16	0.16	0.16	0.15
F	0.22	0.17	0.19	0.21	0.21	0.19	0.18
G	0.21	0.16	0.21	0.19	0.20	0.19	0.18
H	0.25	0.20	0.23	0.22	0.25	0.21	--
I	0.26	--	0.20	0.22	0.20	0.24	--
J	0.18	0.14	0.18	0.17	0.19	0.18	--
K	0.26	0.21	0.20	0.19	0.22	0.22	0.18
L	0.24	0.19	0.19	0.18	0.20	0.22	0.21
M	0.25	0.20	0.25	0.22	0.24	0.20	0.21
N	0.23	0.18	0.19	0.21	0.17	0.19	0.19
O	0.18	--	0.16	0.17	0.15	0.15	--
P	0.23	--	0.21	0.18	0.22	0.23	0.18

Location	ILs	Net γ Dose Rate ± 1 SD ($\mu\text{Sv h}^{-1}$)
		2017
A	0.17	0.15 \pm 0.02
B	0.19	0.17 \pm 0.02
D	0.21	0.21 \pm 0.02
E	0.23	0.13 \pm 0.02
F	0.22	0.18 \pm 0.02
G	0.21	0.14 \pm 0.02
H	0.21*	0.15 \pm 0.02
I	0.34*	0.18 \pm 0.02
J	0.20*	0.17 \pm 0.02
K	0.26	0.16 \pm 0.02
L	0.24	0.15 \pm 0.02

Location	ILs	Net γ Dose Rate ± 1 SD ($\mu\text{Sv h}^{-1}$)
		2017
M	0.25	0.18 \pm 0.02
N	0.23	0.15 \pm 0.02
O	0.21*	0.15 \pm 0.02
P	0.23	0.18 \pm 0.02

-- Not measured

* New ILs for Locations H, I, J and O

Table 2.1(b) Comparison of Ambient γ Dose Rates with Previous Results

EM&A Report No.	Mean Net γ Dose Rate ($\mu\text{Sv h}^{-1}$)	SU
1 (Baseline) (2005)	0.18	0.026
10 (2006)	0.19	0.029
11 (2007)	0.20	0.025
12 (2008)	0.18	0.031
13 (2009)	0.19	0.028
14 (2010)	0.18	0.027
15 (2011)	0.19	0.026
16 (2012)	0.19	0.030
17 (2013)	0.19	0.023
18 (2014)	0.20	0.028
19 (2015)	0.19	0.027
1 (2016)	0.18	0.022
2 (2017)	0.16	0.021

- 2.7 The overall mean ambient γ dose-rate for this year is slightly lower than those in previous years because of changes in Locations H, I, J & O.

Soil

- 2.8 Soil samples were collected at 3 locations, all from the undisturbed areas. These locations correspond to the passive air sampler locations which aim to detect dispersion of effluent leakages, if any, in the prevailing wind directions. The measurement results are given in **Table 2.2(a) & (b)**.

Table 2.2(a) Activity Concentration of Some Major Radionuclides in Soil Samples (ILs for ^{226}Ra , ^{228}Th & ^{40}K are respectively 155, 218 & 2544 Bq kg⁻¹)

Location	Collection Date	Activity Concentration (Bq kg ⁻¹)					
		^{226}Ra	SD	^{228}Th	SD	^{40}K	SD
A	1 Aug 17	108	0.8	220	1.0	1187	4.7
B	1 Aug 17	106	1.3	143	1.4	1070	7.9
C	1 Aug 17	62.0	1.2	132	1.5	377	5.5

Table 2.2(b) Comparison of Activities in Soil Samples for the past years

EM&A Report No.	Mean Activity Concentration (Bq kg ⁻¹)		
	^{226}Ra	^{228}Th	^{40}K
1 (Baseline)	85	136	1030
10 (2006)	86.2	166	846
11 (2007)	89.8	181	821
12 (2008)	109	168	860
13 (2009)	100	197	805
14 (2010)	99.8	178	1064
15 (2011)	83.1	89.3	857
16 (2012)	76.3	108	782
17 (2013)	89.9	115	1140
18 (2014)	102	109	931
19 (2015)	107	126	1015
1 (2016)	101	213	704
2 (2017)	91.8	165	878

- 2.9 Th-228 in sample A has slightly exceeded the IL.

Sand

2.10 The measurement results are shown in Table 2.3(a) & (b).

**Table 2.3(a) Activity Concentration of Some Major Radionuclides in Sand Samples
(ILs for ^{226}Ra , ^{228}Th & ^{40}K are respectively 54, 65 & 1520 Bq kg⁻¹)**

Location	Collection Date	Activity Concentration (Bq kg ⁻¹)					
		^{226}Ra	SD	^{228}Th	SD	^{40}K	SD
A	1 Oct 17	30.2	0.8	30.0	0.9	479	5.9
B	1 Oct 17	28.1	0.6	24.2	0.6	294	3.7
C	1 Oct 17	25.3	0.7	34.4	0.9	646	6.3

Table 2.3(b) Comparison of Activities in Sand Samples for the past years

EM&A Report No.	Mean Activity Concentration (Bq kg ⁻¹)		
	^{226}Ra	^{228}Th	^{40}K
1 (Baseline)	31.9	36.7	979
10 (2006)	31.2	31.4	640
11 (2007)	28.9	31.6	674
12 (2008)	30.6	28.0	649
13 (2009)	32.4	29.4	532
14 (2010)	24.3	21.2	511
15 (2011)	28.7	18.5	562
16 (2012)	32.6	23.6	464
17 (2013)	35.5	23.8	501
18 (2014)	25.3	14.6	537
19 (2015)	28.9	27.0	443
1 (2016)	26.5	25.3	433
2 (2017)	27.9	29.5	473

2.11 No exceedance of Investigation Level is observed.

Grass

2.12 Grass samples were collected in locations near to the soil samples. The measurement results are given in **Table 2.4(a) & (b)**. The γ -spectra are identical to the background of the γ spectrometer and do not reveal the presence of any significant γ -emitting radionuclides, hence they are not reported here.

Table 2.4(a) Activity Concentration of Gross α and β Emitters in Grass Samples
(ILs for α and β activities are respectively 0.22 & 0.43 Bq g⁻¹)

Location	Collection Date	α Activity* (Bq g ⁻¹)	SD (Bq g ⁻¹)	β Activity* (Bq g ⁻¹)	SD (Bq g ⁻¹)
A	1 Oct 17	0.005	0.001	0.169	0.003
B	1 Oct 17	0.003	0.001	0.117	0.004
C	1 Oct 17	0.011	0.001	0.186	0.003

* Bq g⁻¹ refers to dry mass of grass

Table 2.4(b) Comparison of α/β Activities in Grass with Previous Results

EM&A Report No.	Mean α Activity (Bq g ⁻¹)	SU (Bq g ⁻¹)	Mean β Activity (Bq g ⁻¹)	SU (Bq g ⁻¹)
1 (Baseline)	0.083	0.044	0.33	0.03
10 (2006)	0.051	0.008	0.40	0.07
11 (2007)	0.030	0.022	0.27	0.06
12 (2008)	0.012	0.020	0.17	0.04
13 (2009)	0.014	0.016	0.10	0.03
14 (2010)	0.038	0.027	0.21	0.04
15 (2011)	0.021	0.019	0.15	0.03
16 (2012)	0.022	0.022	0.10	0.03
17 (2013)	0.026	0.015	0.27	0.06
18 (2014)	0.036	0.017	0.23	0.05
19 (2015)	0.019	0.002	0.27	0.03
1 (2016)	0.008	0.006	0.24	0.03
2 (2017)	0.006	0.004	0.16	0.04

2.13 No exceedance of Investigation Level is observed.

Sea Water

- 2.14 Approximately the same 4 locations were chosen to collect the water samples at 2 depths. The measurement results are given in **Table 2.5(a) & (b)**.
- 2.15 Similar to grass samples, the γ spectra are not reported. There is no sign of presence of γ emitters.
- 2.16 No exceedance of Investigation Level is observed.

Table 2-5(a) Activity Concentration of Gross α/β Emitters in Sea Water Samples (ILs for α and β activities are respectively 1.52 & 9.3 Bq L⁻¹)

Location	Collection Date	Water Depth (m)	α Activity (Bq L ⁻¹)	SD (Bq L ⁻¹)	β Activity (Bq L ⁻¹)	SD (Bq L ⁻¹)
A	1 Aug 17	1	0.00 [#]	0.19	2.14	0.59
		3.5	0.00 [#]	0.15	0.00 [#]	0.47
B	1 Aug 17	1	0.00 [#]	0.21	0.00 [#]	0.62
		6.5	0.00 [#]	0.16	4.80	0.49
C	1 Aug 17	1	0.00 [#]	0.22	0.00 [#]	0.62
		7.5	0.00 [#]	0.17	3.33	0.49
D	1 Aug 17	1	0.00 [#]	0.15	0.00 [#]	0.43
		5	0.00 [#]	0.19	5.48	0.61

[#] Below minimum detectable activity of 0.32 Bq L⁻¹ for α and 0.90 Bq L⁻¹ for β .

Table 2.5(b) Comparison of α/β Activities in Sea Water with Previous Results

EM&A Report No.	Mean α Activity (Bq L ⁻¹)	SU (Bq L ⁻¹)	Mean β Activity (Bq L ⁻¹)	SU (Bq L ⁻¹)
1 (Baseline)	0.77	0.25	7.20	0.70
10 (2006)	0.70	0.35	8.35	2.19
11 (2007)	0.00	0.00	2.35	0.21
12 (2008)	0.00	0.00	4.08	0.42
13 (2009)	0.32	0.29	5.44	1.27
14 (2010)	0.00	0.00	4.80	0.41
15 (2011)	0.14	0.21	2.88	1.39
16 (2012)	0.03	0.07	3.74	0.96
17 (2013)	0.00	0.00	2.76	1.14
18 (2014)	1.01	0.57	4.91	1.43
19 (2015)	0.00	0.00	6.34	2.08
1 (2016)	0.00	0.00	2.66	2.63
2 (2017)	0.00	0.00	1.97	2.32

Marine Organisms

- 2.17 Fishes were caught along the jetty and sea snails were collected randomly along the shores.
- 2.18 The measurement results are given in **Table 2.6(a) & (b)** and **Table 2.7(a) & (b)** for the gross α/β activities in fish and sea snails respectively.

**Table 2.6(a) Activity Concentration of Gross α/β Emitters in Fish Samples
 (ILs for α and β activities are respectively 0.021 & 0.076 Bq g⁻¹)**

Sample	Collection Date	α Activity* (Bq g ⁻¹)	SD (Bq g ⁻¹)	β Activity* (Bq g ⁻¹)	SD (Bq g ⁻¹)
1	1 Aug 17	0.000 [#]	0.001	0.054	0.003
2	1 Aug 17	0.000 [#]	0.001	0.043	0.002
3	1 Aug 17	0.000 [#]	0.001	0.067	0.003

* Bq g⁻¹ refers to wet mass of fish flesh.

[#] Below minimum detectable α activity of 0.001 Bq g⁻¹.

Table 2.6(b) Comparison of α/β Activities in Fish Samples with Previous Results

EM&A Report No.	Mean α Activity (Bq g ⁻¹)	SU (Bq g ⁻¹)	Mean β Activity (Bq g ⁻¹)	SU (Bq g ⁻¹)
1 (Baseline) (2005)	0.0093	0.004	0.068	0.003
10 (2006)	0.0060	0.005	0.078	0.007
11 (2007)	0.0003	0.001	0.055	0.012
12 (2008)	0.0000	0.000	0.067	0.003
13 (2009)	0.0075	0.002	0.079	0.000
14 (2010)	0.0030	0.003	0.111	0.023
15 (2011)	0.0032	0.001	0.040	0.001
16 (2012)	0.0000	0.000	0.027	0.004
17 (2013)	0.0000	0.000	0.040	0.000
18 (2014)	0.0083	0.007	0.072	0.011
19 (2015)	0.0100	0.006	0.035	0.015
1 (2016)	0.0077	0.008	0.014	0.005
2 (2017)	0.0000	0.000	0.055	0.012

- 2.19 No exceedance in Investigation Level is observed.

Table 2.7(a) Activity Concentration of Gross α/β Emitters in Sea Snail Samples
(ILs for α and β activities are respectively 0.048 & 0.076 Bq g⁻¹)

Sample	Collection Date	α Activity* (Bq g ⁻¹)	SD (Bq g ⁻¹)	β Activity* (Bq g ⁻¹)	SD (Bq g ⁻¹)
1	1 Aug 17	0.001	0.000	0.017	0.002
2	1 Aug 17	0.000 [#]	0.000	0.015	0.002
3	1 Aug 17	0.000 [#]	0.000	0.018	0.002

* Bq g⁻¹ refers to wet mass of sea snail flesh.[#] Below minimum detectable α activity of 0.001 Bq g⁻¹.**Table 2.7(b) Comparison of α/β Activities in Sea Snails with Previous Results**

EM&A Report No.	Mean α Activity (Bq g ⁻¹)	SU (Bq g ⁻¹)	Mean β Activity (Bq g ⁻¹)	SU (Bq g ⁻¹)
1 (Baseline) (2005)	0.029	0.006	0.064	0.004
10 (2006)	0.010	0.009	0.045	0.005
11 (2007)	0.000	0.001	0.043	0.002
12 (2008)	0.000	0.000	0.024	0.002
13 (2009)	0.003	0.003	0.035	0.004
14 (2010)	0.005	0.000	0.034	0.002
15 (2011)	0.002	0.001	0.048	0.001
16 (2012)	0.000	0.000	0.014	0.001
17 (2013)	0.001	0.000	0.082	0.024
18 (2014)	0.011	0.003	0.050	0.008
19 (2015)	0.006	0.005	0.045	0.023
1 (2016)	0.001	0.001	0.025	0.016
2 (2017)	0.003	0.001	0.017	0.002

2.20 No exceedance in Investigation Level is observed.

Airborne Particulates

2.21 The measurement results are given in **Table 2.8(a) & 2.8(b)**.

Table 2.8(a) Net Gross α/β Activities in Airborne Particulate Samples (ILs are not defined)

Location	Collection Date	α Activity (Bq per 1000 cm ²)	SD	β Activity (Bq per 1000 cm ²)	SD
Blank		0.28	0.01	10.3	0.05
A1	1 Aug 17	0.05	0.03	0.41	0.09
A2	1 Aug 17	0.00 [#]	0.02	0.33	0.07
B1	1 Aug 17	0.01 [#]	0.02	0.23	0.08
B2	1 Aug 17	0.02 [#]	0.03	0.28	0.09
C1	1 Aug 17	0.04	0.02	0.40	0.07
C2	1 Aug 17	0.04	0.02	0.15	0.09

[#] Below minimum detectable activity of 0.033 Bq per 1000 cm² for α and 0.14 Bq per 1000 cm² for β .

Table 2.8(b) Comparison of α/β in Airborne Particulate Samples with Previous Results (Units in Bq per 1000 cm²)

EM&A Report No.	A		B		C	
	α	β	α	β	α	β
1 (Baseline) (2005)	0.00	0.00	0.00	0.00	0.00	0.13
10 (2006)	0.07	0.21	0.02	0.11	0.00	0.00
11 (2007)	0.08	0.11	0.02	0.00	0.00	0.19
12 (2008)	0.06	0.66	0.09	0.59	0.04	0.30
13 (2009)	0.22	0.39	0.06	0.33	0.18	0.19
14 (2010)	0.21	1.75	0.00	0.67	0.00	0.38
15 (2011)	--	--	--	--	--	--
16 (2012)	--	--	--	--	--	--
17 (2013)	0.00	0.07	0.00	0.06	0.00	0.07
18 (2014)	0.11	0.64	0.19	0.51	0.07	0.46
19 (2015)	0.00	0.44	0.00	0.10	0.09	0.56
1 (2016)	0.00	0.46	0.00	0.34	0.00	0.17
2 (2017)	0.03	0.37	0.01	0.26	0.04	0.27

2.22 All activities are normal.

3. REPORT ON ELEVATED ENVIRONMENTAL RADIATION BACKGROUND

- 3.1 The Investigation Levels for environmental samples have been established and they are given in Appendix 1. The relevant action plan is given in the First EM&A Report (Operation Phase) (Oct 2005).
- 3.2 The Th-228 activity in Soil Sample A exceeded the Investigation Level (IL) again by a small margin (220 Bq kg^{-1} vs 218 Bq kg^{-1}). Following the recommendation of last year's EM&A Report (i.e. EM&A Report No.1 (Operation Phase)), an investigation has been carried out. Repeated soil samples were collected at Locations A and C on October and December 2016. Both October and December Th-228 activities in Location A (227 and 233 Bq kg^{-1} respectively) still exceeded the IL while those in Location C dropped to below the IL. In general if contamination were coming from the operation of the Facility, other isotopes with significant amount would have been observed, which was not our situation. Additionally, in December 2016 Belgoprocess as Radiation Protection Advisor performed an annual radiation audit and no abnormal issues were found. It was therefore concluded that this exceedance was not related to operation of the Facility. The possible cause of exceedance in Soil Sample A may be that after more than 10 years of taking soil samples from the same location, deeper soil layer that has a different Th-228 content have been reached. Further review of the cause is being carried out by taking a few more samples from around Location A. The findings will be reported in the next EM&A report. If the exceedance persists and it is proven not related to the Facility's operation, then no mitigation measures would be required but instead a review of IL is suggested.

4. REPORT ON NON-COMPLIANCE

4.1 The Action Level and Limit Level (A/L Levels) for non-compliance have been established and they are given in Appendix 1 for easy reference. The relevant Event and Action Plan have been developed. Please refer to the First EM&A Report (Operation Phase) (Oct 2005) for details.

Dose for Radiation Workers

4.2 There was no record of exceeding the A/L Levels as recorded by TLDs.

Dose Rates at Un-controlled Areas

4.3 No exceedance of the A/L Levels was observed.

Liquid Effluent Discharge

4.4 There was no liquid effluent discharged during the monitoring period.

Airborne Effluent Discharge

4.5 The average total radon released during the monitoring period was estimated to be 4.86×10^8 Bq/month, which is below the A/L Levels.

4.6 The discharged α and β activities were also below the A/L Levels.

4.7 The total airborne effluent discharge was below the A/L Levels.

5. RECORD OF ENVIRONMENTAL COMPLAINTS

5.1 No environmental complaint was received during the period.

APPENDIX 1**Limit Level and Action Level**

The Limit Levels for non-compliance with the Environmental Performance Requirements during the Operation are shown in **Table A1-1**.

Table A1.1 Limit Levels for Non-compliance and Action Levels

Environmental Performance Requirements	Limit Levels	Action Levels (3/10 th of Limit Levels)
Dose for radiation workers	1.67 mSv per month	0.5 mSv per month
Dose rate at un-controlled areas	1 μ Sv per hour	0.3 μ Sv per hour
Liquid effluent discharge	10 ALI per month	3 ALI per month
Airborne effluent discharge	10 ALI per month	3 ALI per month

Investigation Level

With the help of all the internal monitoring, it is unlikely that the effluents will cause any observable increase in the radiation levels in the vicinity of the Facility under normal operation. It is also not anticipated that any significant quantity of the radioactive wastes would be released to the environment under even the most severe natural disasters. Nevertheless when the environmental samples are found to have radioactivities higher than the normal fluctuation of the established baseline levels, some investigation has to be initiated. The levels that trigger the investigation are called investigation levels and they are given in **Table A1.2**.

Table A1.2 Investigation Levels for Environmental Samples

Environmental Samples		Investigation Levels	
Net Ambient γ dose rate (μ Sv h ⁻¹)	A	0.17	3 \times SD of individual baseline dose rate
	B	0.19	
	D	0.21	
	E	0.23	
	F	0.22	
	G	0.21	
	H	0.21	
	I	0.34	
	J	0.20	
	K	0.26	
	L	0.24	
	M	0.25	
	N	0.23	
O	0.21		
P	0.23		
Soil (Bq kg ⁻¹)	²²⁶ Ra	155	3 \times SU of baseline samples
	²²⁸ Th	218	
	⁴⁰ K	2544	
	¹³⁷ Cs	2.31	

	Other γ emitters		Occurrence in any quantities
Sand (Bq kg ⁻¹)	²²⁶ Ra	54.4	3 × SU of baseline samples
	²²⁸ Th	64.8	
	⁴⁰ K	1520	
	Other γ emitters		Occurrence in any quantities
Grass (Bq g ⁻¹)	Gross α	0.22	3 × SU of baseline samples
	Gross β	0.43	
	γ emitters not found in baseline		Occurrence in any quantities
Sea water (Bq L ⁻¹)	Gross α	1.52	3 × SU of baseline samples
	Gross β	9.3	
	γ emitters not found in baseline		Occurrence in any quantities
Fish (Bq g ⁻¹)	Gross α	0.021	3 × SU of baseline samples
	Gross β	0.076	
Sea snails (Bq g ⁻¹)	Gross α	0.048	3 × SU of baseline samples
	Gross β	0.076	
Airborne particulates (Bq per 1000 cm ²)	Gross α		Occurrence in any quantities
	Gross β		

- SD is the standard deviation of a single sample.
- SU is standard uncertainty of the sample group.