

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

For the attention of Mr Dicky Siu

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

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Dear Mr Siu

Low Level Radioactive Waste Storage Facility at Siu A Chau
Independent Environmental Checker Services
Environmental Monitoring and Audit Report No. 4 (Operation Phase)

We refer to your ET's email dated 17 January 2020 on the revised final submission for the subject report.

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

If you require any further information, please do not hesitate to contact the undersigned or our Dr Kin Lo at 2268 3256.

Yours sincerely



Sam Tsoi
Independent Environmental Checker

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. 4
(Operation Phase)**

Version 1

October 2019

Prepared and Submitted By



(Environmental Team Leader
and Responsible Person)

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: jkleung@hku.hk

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EXECUTIVE SUMMARY

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

A cleaning work was carried out on the northern shore of the jetty to remove debris that have been accumulated over the shoreline on December 2018. It is believed that the work has brought a lot of soil from the ground into the sea which was then mixed with sand along the shoreline. This was reflected by the higher than normal radionuclide contents measured in the Sand B sample collected on August this year. A repeated sand sample was therefore taken at a location further away from the shore during a low tide period on October, which was measured to have normal radionuclide contents. Since the sand along the shoreline has been contaminated by soil, it is suggested to collect Sand B sample at locations further away from the shore to prevent exceedance of IL in the future.

Other than the above, radionuclide contents in all other samples remain normal.

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. 4 (Operation Phase) for the Follow-On Contract. This report covers the monitoring period from August 20, 2018 to the date of sampling which was August 20, 2019.
- 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 reports on any non-compliance of personnel doses, dose-rates on 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.

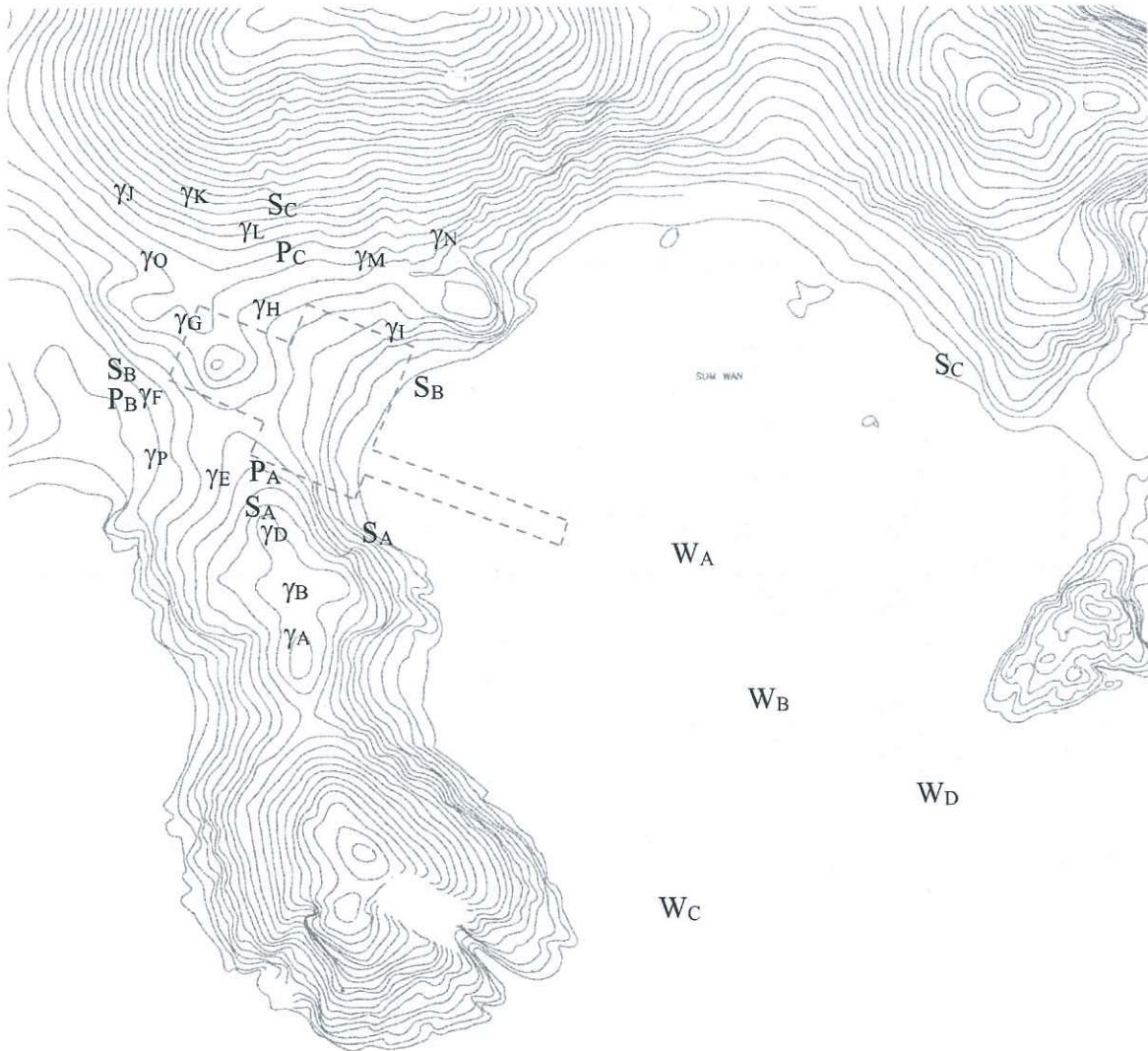


Fig. 2.1 Locations of the Sampling Sites

(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. It is noted that the overall average value has remained similar during the monitoring period.

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) | 2014 | 2015 | 2016 | 2017 | 2018 |
| A | 0.17 | 0.14 | 0.17 | 0.16 | 0.14 | 0.15 | 0.13 |
| B | 0.19 | 0.15 | 0.19 | 0.17 | 0.16 | 0.17 | 0.18 |
| D | 0.21 | 0.16 | 0.21 | 0.20 | 0.18 | 0.21 | 0.19 |
| E | 0.23 | 0.18 | 0.16 | 0.16 | 0.15 | 0.13 | 0.14 |
| F | 0.22 | 0.17 | 0.21 | 0.19 | 0.18 | 0.18 | 0.14 |
| G | 0.21 | 0.16 | 0.20 | 0.19 | 0.18 | 0.14 | 0.19 |
| H | 0.25 | 0.20 | 0.25 | 0.21 | -- | 0.15 | 0.19 |
| I | 0.26 | -- | 0.20 | 0.24 | -- | 0.18 | 0.18 |
| J | 0.18 | 0.14 | 0.19 | 0.18 | -- | 0.17 | 0.14 |
| K | 0.26 | 0.21 | 0.22 | 0.22 | 0.18 | 0.16 | 0.22 |
| L | 0.24 | 0.19 | 0.20 | 0.22 | 0.21 | 0.15 | 0.18 |
| M | 0.25 | 0.20 | 0.24 | 0.20 | 0.21 | 0.18 | 0.20 |
| N | 0.23 | 0.18 | 0.17 | 0.19 | 0.19 | 0.15 | 0.16 |
| O | 0.18 | -- | 0.15 | 0.15 | -- | 0.15 | 0.13 |
| P | 0.23 | -- | 0.22 | 0.23 | 0.18 | 0.18 | 0.20 |

-- Not measured

| Location | ILs | Net γ Dose Rate \pm 1 SD ($\mu\text{Sv h}^{-1}$) |
|----------|------|---|
| | | 2019 |
| A | 0.17 | 0.15 \pm 0.03 |
| B | 0.19 | 0.13 \pm 0.03 |
| D | 0.21 | 0.17 \pm 0.03 |
| E | 0.23 | 0.23 \pm 0.04 |
| F | 0.22 | 0.18 \pm 0.04 |
| G | 0.21 | 0.16 \pm 0.03 |
| H | 0.21 | 0.15 \pm 0.03 |
| I | 0.34 | 0.18 \pm 0.03 |
| J | 0.20 | 0.12 \pm 0.03 |
| K | 0.26 | 0.13 \pm 0.03 |
| L | 0.24 | 0.22 \pm 0.04 |
| M | 0.25 | 0.17 \pm 0.03 |
| N | 0.23 | 0.17 \pm 0.03 |
| O | 0.21 | 0.18 \pm 0.03 |
| P | 0.23 | 0.18 \pm 0.03 |

Table 2.1(b) Comparison of Ambient γ Dose Rates for last 5 years

| EM&A Report No. | Mean Net γ Dose Rate ($\mu\text{Sv h}^{-1}$) | SU |
|----------------------------|--|-----------|
| Baseline (2005) | 0.18 | 0.026 |
| 18 (2014) | 0.20 | 0.028 |
| 19 (2015) | 0.19 | 0.027 |
| 1 (2016) | 0.18 | 0.022 |
| 2 (2017) | 0.16 | 0.021 |
| 3 (2018) | 0.17 | 0.028 |
| 4 (2019) | 0.17 | 0.031 |

2.6 There is no exceedance of IL.

Soil

2.7 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 ²²⁶Ra, ²²⁸Th, ⁴⁰K and ¹³⁷Cs are respectively 155, 218, 2544 & 2.31 Bq kg⁻¹)

| Location | Collection Date | Activity Concentration (Bq kg ⁻¹) | | | | | | | |
|----------|-----------------|---|-----|-------------------|-----|-----------------|------|-------------------|-----|
| | | ²²⁶ Ra | SD | ²²⁸ Th | SD | ⁴⁰ K | SD | ¹³⁷ Cs | SD |
| A | 20 Aug 19 | 110 | 2.9 | 260 | 3.1 | 1152 | 10.1 | 0.0* | 0.2 |
| | 25 Oct 19 | 81.4 | 1.6 | 199 | 1.7 | 1189 | 6.1 | 0.0 [#] | 0.2 |
| B | 20 Aug 19 | 122 | 2.7 | 163 | 2.7 | 1001 | 9.5 | 0.0* | 0.2 |
| C | 20 Aug 19 | 73.0 | 2.7 | 188 | 2.7 | 284 | 6.1 | 0.0* | 0.2 |

* Below minimum detectable activity of 0.86 Bq kg⁻¹

[#] Below minimum detectable activity of 0.32 Bq kg⁻¹

Table 2.2(b) Comparison of Activities in Soil Samples for last 5 years

| EM&A Report No. | Mean Activity Concentration (Bq kg ⁻¹) | | |
|-----------------|--|-------------------|-----------------|
| | ²²⁶ Ra | ²²⁸ Th | ⁴⁰ K |
| Baseline (2005) | 85 | 136 | 1030 |
| 18 (2014) | 102 | 109 | 931 |
| 19 (2015) | 107 | 126 | 1015 |
| 1 (2016) | 101 | 213 | 704 |
| 2 (2017) | 91.8 | 165 | 878 |
| 3 (2018) | 82.8 | 179 | 774 |
| 4 (2019) | 92.2 | 184 | 825 |

2.8 Soil A collected on August 20 was found to have a high ²²⁸Th content that exceeded its IL. This sample was confirmed to have been erroneously collected from the high ²²⁸Th content area near Soil A sampling site (see EM&A Report No. 3), hence it has to be discarded. A new Soil A sample was re-collected on October 25, which shows normal ²²⁸Th activity.

Sand

2.9 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 | 20 Aug 19 | 35.0 | 1.2 | 34.3 | 1.3 | 603 | 6.0 |
| B | 20 Aug 19 | 56.4 | 1.3 | 45.1 | 1.5 | 533 | 5.9 |
| | 25 Oct 19 | 34.1 | 0.3 | 31.9 | 0.4 | 453 | 1.6 |
| C | 20 Aug 19 | 16.7 | 1.1 | 18.6 | 1.1 | 499 | 5.5 |

Table 2.3(b) Comparison of Activities in Sand Samples for last 5 years

| EM&A Report No. | Mean Activity Concentration (Bq kg ⁻¹) | | |
|-----------------|--|-------------------|-----------------|
| | ^{226}Ra | ^{228}Th | ^{40}K |
| Baseline (2005) | 31.9 | 36.7 | 979 |
| 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 |
| 3 (2018) | 30.9 | 32.6 | 526 |
| 4 (2019) | 28.6 | 28.3 | 518 |

2.10 Sand B showed an exceedance in IL, hence an investigation was carried out. The average activity concentrations of ^{226}Ra , ^{228}Th and ^{40}K for Sand B in the past 3 years were respectively 32, 26 and 309 Bq kg⁻¹ and their variations were small. It was therefore believed that the surge in radioactivities in all 3 radionuclides was due to contamination of the sea sand by soil from land as a result of recent shoreline works.

2.11 A new Sand B was collected on October 25 from sand further away from the shore during low tide. The result now shows no exceedance.

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 | 20 Aug 19 | 0.006 | 0.001 | 0.105 | 0.003 |
| B | 20 Aug 19 | 0.007 | 0.001 | 0.132 | 0.003 |
| C | 20 Aug 19 | 0.029 | 0.001 | 0.271 | 0.003 |

* Bq g⁻¹ refers to dry mass of grass

Table 2.4(b) Comparison of α/β Activities in Grass for last 5 years

| EM&A Report No. | Mean α Activity (Bq g ⁻¹) | SU (Bq g ⁻¹) | Mean β Activity (Bq g ⁻¹) | SU (Bq g ⁻¹) |
|-----------------|--|--------------------------|---|--------------------------|
| Baseline (2005) | 0.083 | 0.044 | 0.33 | 0.03 |
| 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 |
| 3 (2018) | 0.013 | 0.003 | 0.21 | 0.06 |
| 4 (2019) | 0.014 | 0.013 | 0.17 | 0.09 |

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 | 20 Aug 19 | 1 | 0.00 [#] | 0.14 | 3.24 | 0.42 |
| | | 3.5 | 0.02 [#] | 0.15 | 3.80 | 0.42 |
| B | 20 Aug 19 | 1 | 0.00 [#] | 0.14 | 4.44 | 0.42 |
| | | 6.5 | 0.00 [#] | 0.14 | 0.38 [#] | 0.42 |
| C | 20 Aug 19 | 1 | 0.00 [#] | 0.14 | 0.00 [#] | 0.41 |
| | | 7.5 | 0.00 [#] | 0.14 | 1.42 | 0.42 |
| D | 20 Aug 19 | 1 | 0.00 [#] | 0.14 | 3.24 | 0.42 |
| | | 5 | 0.00 [#] | 0.14 | 3.24 | 0.42 |

[#] Below minimum detectable activity of 0.31 Bq L⁻¹ for α and 0.88 Bq L⁻¹ for β .

Table 2.5(b) Comparison of α/β Activities in Sea Water for last 5 years

| EM&A Report No. | Mean α Activity (Bq L ⁻¹) | SU (Bq L ⁻¹) | Mean β Activity (Bq L ⁻¹) | SU (Bq L ⁻¹) |
|-----------------|--|--------------------------|---|--------------------------|
| Baseline (2005) | 0.77 | 0.25 | 7.20 | 0.70 |
| 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 |
| 3 (2018) | 0.00 | 0.00 | 1.01 | 0.98 |
| 4 (2019) | 0.00 | 0.01 | 2.47 | 1.65 |

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 | 20 Aug 19 | 0.000 [#] | 0.001 | 0.023 | 0.002 |
| 2 | 20 Aug 19 | 0.000 [#] | 0.001 | 0.023 | 0.002 |
| 3 | 20 Aug 19 | 0.000 [#] | 0.001 | 0.040 | 0.002 |

* 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 for last 5 years

| EM&A Report No. | Mean α Activity (Bq g ⁻¹) | SU (Bq g ⁻¹) | Mean β Activity (Bq g ⁻¹) | SU (Bq g ⁻¹) |
|-----------------|--|--------------------------|---|--------------------------|
| Baseline (2005) | 0.0093 | 0.004 | 0.068 | 0.003 |
| 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 |
| 3 (2018) | 0.0000 | 0.000 | 0.032 | 0.032 |
| 4 (2019) | 0.0000 | 0.000 | 0.029 | 0.010 |

- 2.19 There is no exceedance of IL.

**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 | 20 Aug 19 | 0.000 [#] | 0.000 | 0.040 | 0.002 |
| 2 | 20 Aug 19 | 0.009 | 0.001 | 0.040 | 0.002 |
| 3 | 20 Aug 19 | 0.006 | 0.001 | 0.044 | 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 for past 5 years**

| EM&A Report No. | Mean α Activity (Bq g ⁻¹) | SU (Bq g ⁻¹) | Mean β Activity (Bq g ⁻¹) | SU (Bq g ⁻¹) |
|-----------------|---|-----------------------------|--|-----------------------------|
| Baseline (2005) | 0.029 | 0.006 | 0.064 | 0.004 |
| 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 |
| 3 (2018) | 0.002 | 0.002 | 0.048 | 0.012 |
| 4 (2019) | 0.005 | 0.005 | 0.041 | 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 | | 0.27 | 0.01 | 10.2 | 0.05 |
| A1 | 20 Aug 19 | 0.04 | 0.02 | 0.45 | 0.07 |
| A2 | 20 Aug 19 | 0.05 | 0.02 | 0.28 | 0.07 |
| B1 | 20 Aug 19 | 0.07 | 0.02 | 0.72 | 0.07 |
| B2 | 20 Aug 19 | 0.04 | 0.02 | 0.42 | 0.07 |
| C1 | 20 Aug 19 | 0.05 | 0.02 | 0.11 | 0.07 |
| C2 | 20 Aug 19 | 0.02 | 0.02 | 0.26 | 0.07 |

**Table 2.8(b) Comparison of α/β in Airborne Particulate Samples for last 5 years
(Units in Bq per 1000 cm²)**

| EM&A Report No. | A | | B | | C | |
|-----------------|----------|---------|----------|---------|----------|---------|
| | α | β | α | β | α | β |
| Baseline (2005) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 |
| 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 |
| 3 (2018) | 0.11 | 1.33 | 0.13 | 0.59 | 0.13 | 1.25 |
| 4 (2019) | 0.04 | 0.36 | 0.05 | 0.57 | 0.04 | 0.18 |

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 Soil A collected on August 20 was found to have a high ^{228}Th content that exceeded its IL. This sample was confirmed to have been erroneously collected from the high ^{228}Th content area near Soil A sampling site (see EM&A Report No. 3), hence it has to be discarded. A new Soil A sample was re-collected on October 25, which shows normal ^{228}Th activity.
- 3.3 Sand B showed an exceedance in IL, hence an investigation was carried out. The average activity concentrations of ^{226}Ra , ^{228}Th and ^{40}K for Sand B in the past 3 years were respectively 32, 26 and 309 Bq kg⁻¹ and their variations were small. It was therefore believed that the surge in radioactivities in all 3 radionuclides was due to contamination of the sea sand by soil from land as a result of recent shoreline works. A new Sand B was collected on October 25 from sand further away from the shore during low tide. The result now shows no exceedance.
- 3.4 Overall, there is no elevation in environmental radiation background level.

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 4.72×10^8 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 (3/10th of Limit Levels) |
|---|---------------------|--|
| Dose for radiation workers | 1.67 mSv per month | 0.5 mSv per month |
| Dose rate at un-controlled areas | 1 µSv per hour | 0.3 µSv 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 ($\mu\text{Sv h}^{-1}$) | 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.