

## 7 RADIOLOGICAL MONITORING (OPERATION PHASE MONITORING)

### Responsible Person

- 7.1 The Contractor shall nominate a Responsible Person (RP) for the Employer's approval, to be responsible for implementing environmental monitoring and audit, ensuring access at all times to monitoring equipment, maintenance of the equipment and its accurate and continued operation. This person shall be responsible for processing, storage, retrieval and reporting of environmental monitoring data and for reporting of instances of non-compliance of the Environmental Performance Requirements.

### Operation Phase Monitoring and Audit

- 7.2 Since the LRWF is not expected to release radioactivity in significant quantity except possibly a higher level of radon or other radioactive gas from the waste; or leakage of contaminated water from the delay tank of the facility, so there is no need to install a network of radiation monitoring stations or equipment in the vicinity of the LRWF. Only grab samples and in-situ measurements would be sufficient to establish the baseline and to monitor the long-term effect to the environment. The terms of reference and requirements for the operation phase monitoring and audit will include the following:
- (i) An environmental radiation baseline will be established prior to commencement of the operation. Sampling and measurement will be done by a suitably accredited laboratory subject to the Employer's approval.
  - (ii) For baseline monitoring, the following measurements will be done at locations shown in Figure 7.1.
    - a. Ambient gamma dose rate at 1 m above ground will be measured by a compensated GM counter at 20 locations around the LRWF.
    - b. 8 samples of seawater at two depths, and 10 samples each of airborne particulates, surface soil, seabed sediment at low water, vegetations and marine organisms at the vicinity of the LRWF will be collected. All collected samples will be radioassayed by an HPGe gamma spectrometer. Water and biological samples will be further measured for gross alpha and beta radioactivity after appropriate sample treatment process.
  - (iii) During the first six months of the operation, monthly monitoring will be done as follows and at locations shown in Figure 7.2.
    - a. Ambient gamma dose rate at 1 m above ground at the same 20 locations around the LRWF.
    - b. 5 airborne particulate samples, 8 seawater samples at 2 water depths; 3 samples each of surface soil, seabed sediment, vegetations and marine organisms will be collected and assayed just like for the baseline monitoring.
  - (iv) Subsequent monitoring will be commissioned at 12 monthly intervals should the initial EM&A indicate no potential problems. Yearly monitoring will be conducted in the same manner like the monthly monitoring.

- (v) The period/frequency of monitoring of any environmental parameter listed in the Environmental Performance Requirements may be revised as recommended by the independent auditor upon the findings of the environmental audits.
- (vi) The Contractor shall commission independent environmental compliance audits of the LRWF. Appointment of the independent auditors shall be subject to the Employer's approval. Unless otherwise agreed to by the Employer the independent auditor shall preferably be a suitably accredited organization.
- (vii) The environmental compliance audit will include the following:
  - a. All the monitoring results.
  - b. Monthly and yearly monitoring and audit reports to ensure compliance with appropriate environmental standards and pollution control objectives.
  - c. Retrieval and interpretation of data and information throughout the Operation of the LRWF in order to ensure that no long-term deterioration in environmental quality occurs adjacent to the site and/or the LRWF.
  - d. Whether the standard of environmental protection is sufficient to meet current regulatory constraints and that the systems are in place to respond to future regulatory demands.
  - e. Whether cost-effective systems of environmental protection are in use.
  - f. The effectiveness of the environmental database for internal management awareness and decisions to be made in relation to LRWF modifications, new plans etc.
  - g. Records of all complaints received, notifications of summons and successful prosecutions for breaching the relevant legislations during the operation and management of the Facility.
  - h. Recommendations of improvements to the system and its operation.

### **Reporting for Radiological Monitoring**

- 7.3 The RP will submit the monthly and yearly monitoring and audit (EM&A) reports for radiological monitoring to the Employer. The first monthly EM&A report (Operation Phase) for radiological monitoring shall consider the findings of visits made to the LRWF and data obtained during the establishment of the radiation baseline and shall be submitted to the Employer prior to operation of the Facility and not later than 20 days after the completion of the radiological baseline monitoring. Subsequent monthly and yearly reports (Operation Phase) will be submitted not later than 20 days after the completion of the monitoring.
- 7.4 The format and content of the report, and the representation of the monitoring data will be in a format to the satisfaction of the Employer and include, but not be limited to the following:
- (i) Up to half a page executive summary;
  - (ii) Drawings showing locations of the monitoring and sampling sites;

- (iii) Monitoring results (in both hard and diskette copies) together with the following information:
  - a. Monitoring, sampling and measurement methodology.
  - b. Name of laboratory and types of equipment used and calibration details.
  - c. Parameters monitored.
  - d. Any factors which might have affected the monitoring results.
  
- (iv) Report on elevated radiation background.
  - a. Report on monitoring results that have exceeded three times the baseline standard deviation. Suggest possible causes and mitigation actions.
  - b. Review of the reasons for and the implications of the elevated background.
  - c. A description of the actions taken in the event of an elevated background reporting and any follow-up procedures related to similar earlier events
  
- (v) Report on non-compliance.
  - a. Record of all non-compliance of the environmental performance requirements (Trigger Levels).
  - b. Review of the reasons for and the implications of non-compliance including review of contamination sources and working procedures.
  - c. A description of the actions taken in the event of non-compliance and deficiency reporting and any follow-up procedures related to earlier non-compliance.
  
- (vi) Result of the environmental compliance audits as detailed in Section 7.2 (vii) above.

**Non-Compliance**

7.5 The Trigger Levels for non-compliance with the Environmental Performance Requirements during the Operation are shown in Table 7.1.

**Table 7.1 Trigger Levels for Non-compliance**

<b>Environmental Performance Requirements</b>	<b>Trigger Levels</b>
Dose for radiation workers	1.67 mSv per month
Dose rate at areas other than restricted areas	1 µSv per hour
Liquid effluent discharge	10 ALI per month
Airborne effluent discharge	10 ALI per month

## **Radiological Monitoring Procedures**

- 7.6 Since the LRWF is not expected to release radioactivity in significant quantity except possibly a higher level of radon or other radioactive gas from the waste; or leakage of contaminated water from the delay tank of the facility, so that majority of the samples should contain radioactivities close to or below the detection limits of general laboratory equipment. Furthermore, according to the inventory of wastes, all the strontium sources are sealed and tritium wastes aren't in vast quantities, so there is no need to carry out complex radiochemical analysis of these two elements. In view of the above, the principal detection method used here for all samples is the high-resolution germanium gamma-spectrometry (HPGe) for identification of gamma emitters. Water and biological samples are further assayed for alpha and beta emissions by a proportional counter after volume reduction by evaporation and ashing respectively.

### Ambient Gamma Dose Rate

- 7.7 The ambient gamma dose rate at 1 m above ground will be measured directly by a portable compensated GM counter. The dose rate due to cosmic ray at the LRWF can be determined by measuring the gamma dose rate on a boat at a distance away from the shore.

### Air

- 7.8 Airborne particulate samples are collected passively on dry cloth samplers hung in temporary shelters around the LRWF. After collection for 1 month, the filters are compressed to provide a standard counting geometry and then measured by the HPGe. Collected radon progenies would be allowed to decay before the measurement.

### Grass

- 7.9 Grass from a considerable area will be collected to ensure that the sample is representative. About 2 kg of grass per sampling site should be collected in a high-density polythene container. Care should be taken to avoid contamination with soil. Slopes on which abnormal runoff may occur should be avoided. The vegetation should be held in the hand while being cut and it should be cut to a height of 3 cm from the ground. After collection, the grass samples will be dried in a microwave oven, weighted and then measured by the HPGe, after which they will be ashed for alpha and beta counting.

### Soil

- 7.10 Soil samples will be collected after the surface grass has been cut. Soil column up to a depth of 10 cm will be extracted with a coring tool. About 2 kg of soil per sampling site will be collected in a high-density polythene container. Inside the laboratory, the soil samples will be allowed to dry for several days. The vegetation and organic debris will be removed before weighing the dried soil. Stones will be collected, weighted and discarded but their mass has to be accounted for. The radionuclide contents are then measured by the HPGe.

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### Sea Sediment

- 7.11 Sediment samples will be collected at low water and at discharge point of the delay tank. 2 kg of sediment will be collected at each sampling site. Inside the laboratory, the vegetation and organic debris will be removed, then rinsed with fresh water, let dried, weighted and then measured by the HPGe.

### Water

- 7.12 Seawater at two levels will be collected by a water sampler and then transferred to polythene bottles. The volume of each water sample is 1 L and 2 parallel samples will be collected at each sampling location. In the laboratory, the sampling bottles will be radioassayed directly by the HPGe as soon as possible. Simultaneously, the parallel water samples will be evaporated on flat planchets by using infra-red heating lamps. The residues are then measured for alpha and beta activities.

### Coastal Organisms

- 7.13 Fish and other coastal organisms up to about 5 kg will be collected. In the laboratory, the shells of the coastal organisms will be removed and the remaining fresh rinsed with fresh water and then dried. For fish, the bones can be separated after heating for an hour at 150°C. All the removed fresh will then be dried together in a microwave oven, weighted and then measured by the HPGe. The fresh is then ashed for measurement of their alpha and beta activities.