Sellafield Ltd

Best Available Techniques Justification of a Specific Tritium Limit for Calder Landfill Extension Segregated Area Disposals

Ref: Waste/Tech/838

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1 Introduction

Sellafield has a number of items where the radioactivity is dominated by tritium which will need to be disposed in the coming years. Sellafield has a disposal facility, the Calder Landfill Extension Segregate Area (CLESA), on the Sellafield site. The ability to dispose of some of these items in CLESA rather than utilising other waste management options could bring a number of benefits.

This Best Available Techniques (BAT) justification demonstrates that the environmental permit for CLESA should be varied to allow it to accept radioactive waste material with higher levels of tritium, and specific tritium limits are herein proposed. This paper does not attempt to demonstrate BAT waste routing for any specific items of waste. Were CLESA to be granted a higher disposal limit for tritium, CLESA would be included as an option within Sellafield Limited's process for waste routing where BAT would be considered for specific waste items.

2 Potential Radiological Impacts

The first point within this BAT justification is to demonstrate that the radiological impacts from disposal of high tritium wastes at CLESA would be acceptable. This is demonstrated for both the operational phase of the facility and the post closure phase. The operational phase consideration (up to approximately 12 years) is based on data in the Operational Radiological Safety Assessment (ORSA) (2), while the post closure consideration (generally 100 to 300 years) is based on data in the Post Closure Radiological Safety Assessment (PCRSA) (3).

A Technical Note (1) has been produced to assess the impacts of higher tritium disposals that builds on the ORSA (2), and the PCRSA (3), both of which informed the revised permit limits in the permit variation notice issued on 1/12/17 (4). The following sub-sections summarise the relevant parts of that technical note and builds further assessment taking into account the ORSA and PCRSA. It is worth noting that the Technical Note uses different tritium levels for different assessments which are either driven by existing perceived constraints such as the tritium discharge limit for the Factory Sewer, or are nominal figures used to illustrate the impact of such levels. This variance is therefore carried through to this paper.

2.1 Operational Phase

2.1.1 Liquid Effluent

CLESA leachate currently discharges from the Factory Sewer (FS), via the Sewage Treatment Works. As was demonstrated in the ORSA (2) the dose impact of tritium discharges at the current FS limit (68 GBq/y) is insignificant (9.76E-13 Sv/y).

The technical note identifies a range of tritium inventories that would result in discharges from CLESA being equal to 60.9 GBq/y (FS limit minus other, non-CLESA, tritium discharges). These inventories were based on:

a) scaled maximum leachate discharge analytical results;
b) scaled mean leachate discharge analytical results;
c) scaled leachate model output.

The inventories identified by these calculations are: 1.9 TBq (derived from scaled max); 11 TBq (derived from scaled mean); and 2.9 TBq (derived from scaled model). Defining which of these figures is most appropriate would then give a potential limiting total inventory for tritium.

It is worth noting that the intention is to divert the leachate discharge to the Calder Interceptor Sewer (CIS), which currently has the same tritium discharge limit as the FS. However the tritium contribution from non-CLESA sources to the CIS is currently slightly lower than from non-CLESA sources to the FS, therefore the assessment referred to within this document is conservative since CLESA could nominally discharge more than the 60.9 GBq/y, hence the inventories identified to reach discharge limits would be slightly higher than those identified above. The current discharges via the FS include run-off from the CLESA hard standing areas. This makes up approximately 10% of the effluent and will contain some tritium. This effluent will continue to discharge via the FS, thus reducing the amount of tritium discharging via the CIS, and adding further conservatism to the above calculations.

Additionally, the site limit for tritium is much higher than the FS or CIS limit at 1.8E+07 GBq/y, and the purpose of permitting radioactive discharges from the CIS was to allow additional future discharges with scope to increase the (plant) limits. Therefore future increases in discharges will be acceptable as long as they are supported by an agreed BAT justification.

2.1.2 Aerial Discharges

A nominal total tritium inventory of 20 TBq was assumed (1) to assess potential aerial discharge, and the resultant gaseous release flux estimated to be 0.43 GBq/y. It is noted that this could be an underestimate, because it does not include direct release from unsaturated high tritium wastes, but it shows that the discharges are likely to be small.

Applying the Long Term Aerial Discharge Release Ratio (LADDR, Infant)(5) to the discharge gives a dose of 4.16E-11 Sv/y (4.16E-05 µSv/y), which is trivial, (see Appendix 1, Table 1).

When compared with the site limit for tritium discharges to air of 1.1E+09 MBq/yr (1.1E+06 GBq/y) from authorised outlets (excluding open ponds and other outlets), the estimated tritium discharge of 4.3E+2 MBq/y (0.43 GBq/y) is very low.

2.1.3 Operator Dose

The ORSA calculated an operator dose of 1.4E+00 mSv/y (from all nuclides at an average activity of 50 Bq/g), which is well within the target of 5.0E+00 mSv/y average and 1.0E+01 mSv/y individual maximum for new plants (6). Significantly increased tritium levels have minimal effect on the calculated dose because of the very low radiotoxicity of tritium. By way of illustration, adopting a tritium concentration of 1.0E+05 Bq/g and calculating the dose from this, then adding that to the ORSA dose gives a dose of 1.52E+00 mSv/y. This is slightly pessimistic since it double counts the tritium component of the ORSA calculation, (see Appendix 1, Tables 2.1 to 2.4).

Actual doses to CLESA operators are recorded as being very low. In 2017 the most exposed operator received a dose of <0.1 mSv (7), and it is assumed that a significant proportion of this dose was received from working in controlled areas other than CLESA. This low actual dose reinforces the pessimistic nature of the calculation above.

It is worth noting that the dose to operators comes from inhalation of dust and gas, and ingestion of dust. Anything that controls such exposure further than assumed in the ORSA would reduce the dose further.

2.2 Post Closure Phase

In line with the PCRSA (3) the technical note assesses the most limiting scenarios, and demonstrates that impacts from nominal tritium concentrations and inventories are well within the inventory fractions and hence target doses/risks. The target doses and risks are specified in regulatory guidance (8). The following sub-headings identify the scenario and whether it is relevant to activity concentration or total activity.

For each scenario, the PCRSA identified the radiological capacity for each nuclide. This capacity is the level at which the target dose or risk quotient, as defined in regulatory guidance (4), would be reached for that nuclide alone, based on either concentration or total activity as appropriate for the scenario. This was calculated by:

- Calculating the dose or risk per unit inventory or activity concentrations as appropriate.
- Dividing the regulatory dose or risk guidance level by the above.

The most limiting radiological capacity was identified i.e. the lowest capacity identified from the different scenarios.

To accommodate a range of nuclides and their individual capacities, fractions for each nuclide were identified:

$$\sum_{n} \frac{I_n}{L_n}$$

I_n is the activity or concentration of each radionuclide (Bq or Bq/g)

L_n is the radionuclide capacity of each radionuclide (Bq)

$_n$ is each radionuclide

The fractional calculations for all the individual radionuclides are then summed to give a Sum of Fractions (SoF).

For radiological capacities expressed as site limits (rather than concentration limits), it is useful to take into account existing disposals and express the radiological capacity as the unused total site activity limit:

$$\sum_{n} \frac{I_n}{L_n - E_n}$$

I_n is the activity of each radionuclide that may be disposed in the future (Bq)

L_n is the radionuclide capacity of each radionuclide (Bq)

E_n is the activity of the existing disposals of each radionuclide (Bq)

$_n$ is each radionuclide

The fractional calculations for all the individual radionuclides are then summed to give a SoF.

It is then possible to increase individual nuclide fractions while keeping the Sum of Fractions below 1, which ensures that the target doses are not reached even with contribution from all the nuclides.

2.2.1 Borehole Intrusion and Consignment Activity Limit

In the PCRSA two scenarios were identified relevant to disposal concentrations: borehole intrusion and smallholder/occupant. The technical note identifies that *"…the argument that Site Occupant and Smallholder intrusion events are too cautious as a basis to set disposal limits was based on disposal limits of 200 Bq/g. For disposal limits >200 Bq/g, this argument should be reviewed, and consideration given to whether disposal limits >200 Bq/g should only be applied to the main body of the site, and not the shallowest disposals"*. Therefore the Technical Note assumed higher tritium wastes would only be emplaced within the main body of CLESA and not the top 4 metres. Thus the smallholder/occupant scenario was deemed not relevant, and the data from the borehole intrusion scenario is used.

A nominal 5.0E+03 Bq/g tritium concentration is used for the waste in the technical note. It is shown that with this nominal 5.0E+03 Bq/g the tritium component of the waste within CLESA is still a small fraction, and does not significantly increase the total waste fraction, the total Sum of Fractions being only 1.47E-03 i.e. less than 0.15% of the potential radiological capacity.

The PCRSA identified that for this scenario the tritium capacity is 1.6E+11 Bq/g. This is the maximum activity in a waste load rather than the average. Were waste items to contain only tritium then this concentration could be applied as the limit if emplacement were to be in the bulk area of CLESA and not in the top 4m. Since it is unlikely that waste will only contain tritium and no other radionuclides the tritium capacity figure cannot be used by itself. To take account of other radionuclides a Sum of Fractions calculation would need to be conducted to ensure that the waste does not breach the total radiological capacity (Bq/g) i.e. SoF = <1.

2.2.2 Site Occupant and Smallholder and Consignment Activity Level

Although the Site Occupant & Smallholder scenario was not suitable for limit setting since it was deemed too cautious, should Sellafield Limited want to emplace high tritium wastes in the top 4m of CLESA, then calculating potential consignment limits based on this scenario's capacity is required. Under this scenario the tritium capacity is stated as 1.0E+05 Bq/g. This is the maximum activity in a waste load rather than the average. Were waste items to contain only tritium then this concentration could be applied as the limit if emplacement were to be in the top 4m of CLESA. Since it is unlikely that waste will only contain tritium and no other radionuclides the tritium capacity figure cannot be used by itself. To take account of other radionuclides a Sum of Fractions calculation will need to be conducted to ensure that the waste does not breach the total radiological capacity (Bq/g) i.e. SoF = <1.

2.2.3 Hot Spots

The technical note assumed there would be no activity concentrations above the current 4.0E+04 Bq/g beta hot spot limit (4). However, it noted *"…that given the short half-life of H-3, and its low radiotoxicity, the updated PCRSA results show that hotspots with more than 40,000 Bq/g H-3 could be acceptable. For hotspots with very high H-3 activities, the updated PCRSA would need to be reviewed to consider if additional assessments are needed*".

As noted in the sections 2.2.1 and 2.2.2 the capacities identified in the PCRSA are the maximum activities that achieve acceptable impact. These are therefore effectively the hot spot limits.

2.2.4 Beach Seeps and Total Activity Limit

The technical note assesses the two scenarios identified in the PCRSA as important for total inventory – coastal erosion and beach seeps. The assessment shows that tritium inventory is more constraining in the beech seeps scenario. It assumes a nominal 20 TBq tritium inventory and shows that the tritium fraction is still small, taking up only 1.4% of the total radiological capacity. However since this inventory is significantly higher than levels identified for other constraints e.g. liquid effluent (section 2.1.1) it does not need to be considered further.

3 Potential Tritium Limits Discussion

3.1.1 Scenario Selection and Emplacement Implications

As noted above (2.2.1 and 2.2.2), using the Borehole Intrusion scenario would potentially give very high tritium disposal limits, but would need to be applied to the main body of CLESA only. Applying the Site Occupant and Smallholder scenario would allow more confident use of the whole CLESA volume including the top 4 metres, especially noting this scenario was considered cautious since the slope of the site will be less attractive for siting a house than it would be for sites where the capped surface would be largely flat. It would be possible to have two tritium limits – one for the top 4m of disposals and one for disposal below the top 4m. In both cases these limits would be the maximum activity concentration (thus accommodating hot spots) rather than mean activity concentration.

3.1.2 Other Nuclides and Sum of Fractions

The tritium capacities could not be used as limits without consideration for other radionuclides. In order to accommodate other nuclides a Sum of Fractions calculation would be required to ensure the total radiological capacity was not breached.

3.1.3 Waste-water Interaction

It is noted that a key factor in tritium discharges is the level of waste-water interaction. A commitment to prevent or minimise this (until the site is capped) would assist in allowing a higher tritium limit, with impacts being much less than assessed. Examples could include simply covering waste items with tarpaulin once positioned in CLESA, to coating waste items in Decothane (and allowing to cure) prior to emplacement in CLESA. This would significantly reduce or even stop any water reaching the tritium in a waste item, thereby minimising or avoiding tritium discharges for a significant period of time from that waste item. Such covering/wrapping is standard practice and is a requirement of the CLESA Conditions for Acceptance (CFA) for wastes above 37Bq/g.

3.1.4 Discharge Limits

Although aerial discharges are assessed as being well within the site’s tritium discharge limits, for leachate the current FS/CIS plant tritium liquid discharge limit could potentially be approached with a tritium inventory much smaller than could be demonstrated as acceptable for other criteria. However, it has been demonstrated that the dose impact at the (current plant) discharge limit is insignificant, so there could be grounds for discussion regarding increasing the limit in line with principles agreed between Sellafield Limited and the EA. This may not be required, noting that the Major Permit Review application proposes removing plant limits and replacing these with notification levels (in support of site limits) to better facilitate the application of BAT and high hazard risk reduction at Sellafield.

Noting pessimisms in the assessments, and the potential to minimise waste-water interaction, it is possible that a tritium inventory even above the higher end of the range (11 TBq) assessed against the FS/CIS tritium discharge limit, would not result in leachate tritium levels approaching the current discharge limit. However, if the leachate discharges were approaching the current limit, (as identified by routine discharge monitoring/sampling), Sellafield Limited would engage with the Environment Agency to increase the limit in line with the agreed principles. Alternatively the plant limit might have been removed as part of the Major Permit Review, in which case agreement of a suitable notification level would be required.

3.1.5 Article 37

Article 37 of the Euratom Treaty is about the actual or potential impacts of operations on EU member states. In relation to A37, the currently declared maximum radiological inventory (all nuclides) is 6.77 TBq (9).

To introduce a specific tritium limit but keep to the 6.77TBq inventory would require a Rationale Statement to be provided to the Department for Business, Energy & Industrial Strategy (BEIS) to confirm that a full Article 37 Submission was not required. Once this was confirmed the Environment Agency would be able to revise the Permit.

With 6.77TBq as a constraint, Sellafield Limited would need to ensure it does not emplace too much high tritium waste to the detriment of other wastes.

3.1.6 Suggested Tritium Limits

When considering concentration limits and total inventory, it has been shown that there is significant headroom from a radiological capacity perspective such that these criteria would not be limiting (capacities in Table 34, reference 3). However consideration needs to be given to the scenario used and whether or not SL would want to emplace high tritium wastes in the main body of CLESA only or to the whole waste volume. One approach would be to use the Site Occupant and Smallholder scenario and apply a limit to the whole site. Alternatively both scenarios (Site Occupant and Smallholder, and Borehole Intruder) could be employed depending on where in CLESA any specific disposal would be made.

Since wastes are unlikely to contain only tritium other radionuclides would need to be taken into account. Applying a Sum of Fractions calculation would accommodate these nuclides.

It is shown that operator doses would not be a limiting factor for tritium concentration levels much higher than currently permitted i.e. 200 Bq/g mean.

The FS/CIS current liquid effluent tritium discharge limit could present more of a constraint, however a number of factors mean that leachate discharges are not particularly constraining: waste-water interaction would be minimised; pessimisms mean that total tritium levels towards the higher end of the assessed range are considered unlikely to challenge the discharge limit; impacts are negligible so there should be scope for increasing the CIS tritium limit (or setting appropriate notification level should the limit be removed).

Since the declared position in relation to Article 37 consideration is a total inventory of no more than 6.77 TBq, and the time taken to change that position, assuming a full A37 Submission would be required, would be well over one year then this becomes a limiting factor for total tritium inventory.

Taking these points into account it is suggested that two limits are adopted:

- For disposals in the top 4m of CLESA - a maximum tritium concentration limit of 1.0E+05 Bq/g and SoF = <1
- For disposals below the top 4m of CLESA - a maximum tritium concentration limit of 1.6E+11 Bq/g and SoF = <1

In both cases any other nuclides must comply with the existing limits (200 Bq/g mean).

No total tritium inventory limit would be required within the Permit since Sellafield Limited is bound by the 6.77 TBq total inventory limit declared in relation to Article 37. This ensures Sellafield Limited takes into account the available radiological capacity for all wastes and does not emplace too much high tritium wastes to the exclusion of other wastes.

Although not currently proposed, should Sellafield Limited decide to pursue a higher tritium inventory the Article 37 process would need to be followed and a decision made at that point regarding what total tritium inventory limit should apply.

4 Potential Environmental Differentiators

Although not a comparative study of waste routing options for a specific waste item, it is possible to identify, at a high level, some environmental advantages and disadvantages of using CLESA compared with other disposal options.

4.1 Transport

The transportation of anything has environmental impacts, and the further the distance the greater those impacts are likely to be. Such impacts would include: carbon dioxide emissions contributing to global warming; particulate emissions from exhaust fumes and wear from tyres and brakes reducing the local air quality; resource use (fuel, oil). Although there would be some transport impacts from moving waste from one part of Sellafield to CLESA, this would clearly be much lower than transporting the same wastes to locations tens or hundreds of miles away.

Additionally, the likelihood of an accident during transportation is increased the more miles are driven. Keeping such movements on the Sellafield site would minimise this risk.

4.2 Hazard Reduction

The potential cost savings associated with disposal at CLESA vs other routes, means that these funds could be used for other hazard reduction activities at Sellafield, resulting in the potential for other associated environmental benefits.

4.3 Impacts from different disposal sites

The potential impact from other disposal sites would depend on a number of factors, including their construction, and distance from the sea or rivers. Such factors would influence the impact assessment scenarios and the potential radiological capacities of the sites. Although it could be argued that a site further from the sea such as King’s Cliffe, for example, would have a lower impact (lack of coastal erosion), the very low radiotoxicity of tritium and the fact that any limits applied to CLESA would be well within the radiological capacity suggest that such impact differences from actual disposals are likely to be inconsequential.

4.4 Impacts from other waste management options

This section considers some other options for dealing with tritium contaminated wastes. However, since CLESA only accepts certain types of material the focus is on concrete and spoil/soil and to a lesser extent organic material. The National Strategic BAT for Soil, Concrete, Rubble, and Granular Material Low Level Waste, (10), and Upstream Optioneering – ILW/LLW Opportunities and The Management of Tritiated Wastes (11) have been taken as guides to potential management techniques.

4.4.1 Decay Storage

With a short half-life (12.32 years), decay storage could be an attractive option with disposal to landfill (or other treatment) at a later date. However, for some waste items it would still take many years for the average activity to get down to the 200Bq/g disposal limit at CLESA. Decay storage would have some negative impacts:

- Requires space for storage inside a building, or weather cover / coating to prevent effluent creation. The building, or cover / coating, would require long term maintenance with associated environmental impacts (use of natural resources, use of energy);
- Alternatively, were an item stored exposed to the weather, liquid effluent would be generated from rainfall washing off the item, and this would need to be disposed of appropriately. Again there would be a range of environmental impacts associated with this (use of energy, use of resources etc.).
- Potential construction impacts if new structure is required to provide shelter.

4.4.2 Enhanced Characterisation

Enhanced characterisation could be useful in demonstrating that a waste item, or part thereof, could be classified at a lower level than initially thought and be disposed of via a more suitable route (potentially including options set out below). This would be most beneficial where the waste could be classified as Out of Scope, however there would need to be sufficient information from the initial characterisation to give confidence that the item was borderline in terms of classification. Enhanced characterisation can have a number of drawbacks:

- Transport to the characterising site, with associated impacts (where such characterisation could not be done on site);
- Secondary wastes generated during characterisation;
- Conventional and radiological safety risks, albeit low.

4.4.3 Mechanical Decontamination

Mechanical decontamination is deemed suitable for surface contamination, so likely to be of limited use for many tritium contaminated items since tritium is very mobile. There are a number of drawbacks with this approach:

- Waste disposal still required;
- Generation of dusts released to air, or requiring abatement;
- Other secondary wastes to manage/dispose of;
- Conventional and radiological safety risks.

4.4.4 Chemical Decontamination

Depending on the material, chemical decontamination might be more successful than mechanical decontamination. However there are a number of negatives:

- Certain chemical agents might not be suitable for disposal at waste sites;
- Generation of secondary wastes requiring management and disposal;
- Environmental, conventional and radiological safety risks;
- Need to ensure contamination is not transferred to a different material that is more costly to manage.

4.4.5 Thermal Detritiation

Thermal detritiation involves heating the waste form in a stream of air or other gas, in the range of 400-1000^{0}C. The tritium is released mainly as tritiated water (HTO). The benefit of this approach is that the waste items could then be reclassified as a lower category of waste, potentially making it suitable for re-use. However there are a number of drawbacks:

- All/most tritium released, if successful. Compared with very gradual release from CLESA, (allowing some decay before release), total release to the environment is higher from thermal detritiation. This is a minor drawback since to discharge the tritium would require demonstration that the impact was sufficiently low and that the discharge was from a permitted discharge point;
- Energy use for furnace/other heating means – CO^2 emissions;
- Processing to enable successful detritiation – for a furnace or in-situ heating processes large blocks would need to be size reduced, however size reduction for disposal at CLESA might be required so the scale of this negative for thermal detritiation might be small;
- Remaining waste – potentially still needs to be disposed at landfill.

4.4.6 Incineration

Incineration provides a potential route to the disposal of organic wastes in which the wastes are reduced to ash. Non-volatile radionuclides remain in the ash whilst radionuclides in volatile form, such as tritium are released as a gas. Concrete can be incinerated. Although the remaining waste following incineration is likely to be of a much reduced volume, the drawbacks with this method are similar to those for thermal detritiation:

- All/most tritium released, if successful. Compared with very gradual release from CLESA, (allowing some decay before release) total release to the environment is higher with incineration. This is a minor drawback since to discharge the tritium would require demonstration that the impact was sufficiently low and that the discharge was from a permitted discharge point;
- Energy use for the incinerator – CO^2 emissions;
- Processing to enable successful detritiation – for an incinerator large blocks would need to be size reduced, however size reduction for disposal at CLESA might be required so the scale of this negative for incineration might be small;
- Emissions of other gaseous substances;
- Potential secondary waste from gaseous abatement techniques.

For both thermal detritiation and incineration, it might be possible to capture the tritium rather than release it to the environment. This tritium could then potentially be reused. However, capturing and transporting the tritium would have associated environmental impacts.

5 Other Considerations

5.1 Cost

There are potentially significant cost savings in disposing of some high tritium waste items to CLESA when compared with other options. By way of illustration, a tritium mortuary (concrete block with steel tubes) was sent from Sellafield to a waste processing site for enhanced characterisation. Following the characterisation an optioneering process was started to define the most appropriate (BAT) waste route.

The financial costs for this example (including transport, additional characterisation, and eventual disposal, but not Sellafield Limited staff time) could exceed £1.5M, depending on waste route.

The costs associated with disposal at CLESA would include transport costs back to Sellafield, costs arising from storage at Sellafield while new tritium limits are sought and implemented, costs associated with modifying the wheel-wash to allow entry for such a large item, and other operational costs. These are likely to be a small percentage of the alternative routes. There are no chargeable costs (per tonne or per m^3) to dispose of waste at CLESA. In this example it possible that savings of over £1M could be achieved.

5.2 Proximity Principle

The proximity principle highlights a need to treat and/or dispose of wastes in reasonable proximity to their point of generation. The principle works to minimise the environmental impact, societal impact, and cost of waste transport. It does not preclude treatment/disposal at sites other than the closest and does not override health and environmental impact considerations. Therefore, assuming there were no overriding health or environmental impacts, CLESA being permitted to take wastes with higher tritium content would potentially assist the disposal of some wastes to align with the proximity principle.

5.3 Waste Capacity

The ability to dispose of additional wastes at CLESA, in this case higher tritium waste, will potentially reduce the burden on LLWR. However care would need to be taken to ensure the operational life of CLESA was not significantly shortened to the detriment of other required disposals. Further, by disposing at CLESA there is a reduction in work being placed in the wider waste management market, and although this would be marginal from a waste volume perspective, it could be significant in terms of financial benefit to the market.

6 Conclusions

A higher tritium disposal limit at CLESA has been demonstrated to have acceptable radiological impact both in the operational and post closure phases. Alternative waste management options have been demonstrated to have negative impacts as well as positive impacts. Potential cost savings from disposal of tritium contaminated items at CLESA could provide the opportunity to undertake other hazard reduction tasks, and be sufficiently large as to demonstrate that other options nominally higher up the preferred hierarchy, are disproportionately costly.

It is considered therefore that the ability of CLESA to receive tritium contaminated wastes at the proposed levels represents BAT.

The application of BAT for any waste item would need to be demonstrated, either via Sellafield Limited's normal waste routing process or by specific BAT justification if required.

It is suggested that maximum tritium disposal limits per consignment are permitted for CLESA disposals of:

- For disposals in the top 4m of CLESA - a maximum tritium concentration limit of 1.0E+05 Bq/g and SoF = <1
- For disposals below the top 4m of CLESA - a maximum tritium concentration limit of 1.6E+11 Bq/g and SoF = <1

In both cases any other nuclides must comply with the existing permit limits (200 Bq/g mean).

A total tritium inventory limit does not need to be specified in the permit since it is in Sellafield Limited's interest to keep the total tritium inventory well below the total 6.77TBq radiological inventory for CLESA, to allow sufficient capacity for other permitted wastes.

7 Recommendations

1. Apply to the Environment Agency to vary the permit to include specific tritium limits (maximum per consignment) of:

   - For disposals in the top 4m of CLESA - 1.0E+05 Bq/g and Sum of Fractions = <1

   - For disposals below the top 4m of CLESA - 1.6E+11 Bq/g and Sum of Fractions = <1

   In both cases any other nuclides must comply with the existing limits.

8 References

1. CLESA: Higher Disposal Limit for H-3, Technical Note 60551744/MARP004, [redacted] 2017
2. CLESA Operational Radiological Safety Assessment (including the Period of Authorisation), [redacted] Quintessa / AECOM, July 2017
3. CLESA PCRSA Review Report, 60493376/MARP003, [redacted] 2017
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7. Personal communication with Remediation Radiation Protection Advisor, 11/09/18
8. Near-surface Disposal Facilities on Land for Solid Radioactive Wastes Guidance on Requirements for Authorisation, February 2009, Environment Agency / Scottish Environment Protection Agency / Northern Ireland Environment Agency
9. Article 37 – Rationale Statement for changes to the current specified waste type for disposals to the Calder Landfill Extension Segregated Area (CLESA), Issue 2, January 2017, [redacted].
10. NWP-REP-120 – Issue 1 – May 2016, National Strategic BAT for Soil, Concrete, Rubble, and Granular Material Low Level Waste, [redacted]
11. RWMD/04/065 / 201139-AA-0003/001 Issue 2, Upstream Optioneering – ILW/LLW Opportunities. The management of tritiated wastes. [redacted] June 2014

9 Distribution

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10 Appendix 1 Calculation Tables

Table 1 Dose from Aerial Discharges at Assumed Tritium Inventory of 20 TBq (section2.1.2)

Discharge GBq/y	TBq	LADDR (Infant) (Ground level release) (HTO)	Dose (Sv)	Dose (µSv)
4.30E-01	4.30E-04	9.67E-08	4.16E-11	4.16E-05

Table 2.1 Inhalation of Dust Operator Dose (section 2.1.3)

B (m^3/h)	T_{inh} (h)	m (g/m^3)	A_i (Bq/g)	$H_{inh,i}$ (Sv/Bq)	E_{inh} (Sv)	E_{inh} (mSv)
1.2	2000	1.00E-03	1.00E+05	4.51E-11	1.08E-05	1.08E-02

$E_{inh} = BT_{inh}mA_iH_{inh,i}$

Where

E_{inh} (Sv) is the annual committed effective dose;

B (m3 h^{-1}) is the breathing rate of the individual;

T_{inh} (h) is the number of hours in a year that the individual is exposed;

m (g m^{-3}) is the dust loading in the air that the individual inhales;

A_i (Bq g^{-1}) is the activity concentration, of radionuclide i, in the material that the individual inhales;

$H_{inh,i}$ (Sv Bq^{-1}) is the committed effective dose per unit intake, of radionuclide i, by inhalation.

Table 2.2 Ingestion of Dust (section 2.1.3)

M (g/h)	T_{ing} (h)	A_i (Bq/g)	$H_{ing,i}$ (Sv/Bq)	E_{ing} (Sv)	E_{ing} (mSv)
0.0125	2000	1.00E+05	4.19E-11	1.05E-04	1.05E-01

$E_{ing} = MT_{ing}A_iH_{ing,i}$

Where

E_{ing} (Sv) is the annual committed effective dose from inadvertent ingestion of dust;

M (g h^{-1}) is the rate of inadvertent ingestion of dust;

T_{ing} (h) is the number of hours in a year that the individual is exposed;

A_i (Bq g^{-1}) is the activity concentration, of radionuclide i, in the material that the individual ingests;

$H_{ing,i}$ (Sv Bq^{-1}) is the committed effective dose per unit intake, of radionuclide i, by ingestion.

Table 2.3 Inhalation of Gas (section 2.1.3)

ORSA dose Sv	Assumed conc. Bq/g ORSA, Table 11	Max conc. Bq/g)Assumed here	Scaling Ratio	Result Sv	mSv
3.57E-11	9.22E-01	1.00E+05	1.08E+05	3.87E-06	3.87E-03

Table 2.4 Total Dose at Assumed Tritium Disposal Concentration (section 2.1.3)

Dust Inhalation Dose mSv	Dust Ingestion Dose mSv	Gas Inhalation mSv	Total mSv	ORSA dose, Table 36, mSv	New Total mSv (1)	New Total µSv (1)
1.08E-02	1.05E-01	3.87E-03	1.19E-01	1.40E+00	1.52E+00	1.52E+03