***Response to the Environment Agency's Questions on Radioactive Substances Act 1993 - Application for authorisation submitted by Sita (Lancashire) Limited in respect of Clifton Marsh Landfill Site***

**Reference no: CD0235** **date: 2nd May 2010**

**Schedule: additional information and clarification sought**

**General**

1. Please check all your application documents for where you may have inadvertently implied that your arrangements apply only to very low level waste, and provide the necessary corrections and clarification regarding the broader low level waste category. [Particular examples include sections 6.1.1 and 6.3 of your Management, Operational and Safety Systems].

Answer – the application is for VLLW and LLW up to 200 Bq $g^{-1}$

**Action Complete** – the application documents (Environmental Safety Case and Radiological Risk Assessment have been altered to ensure that this is stated every time the types of waste proposed to be taken on site are referenced.

2. Please confirm that you are content for us to regard references 89290 / IN / RA / 001, Issue 3 of the Baseline monitoring proposal, and the 2009 Hazard Assessment, as constituting part of the application.

Answer - Yes this is correct

**Action Complete**.

3. Provide legible versions of the drawings in Appendices 1 and 2 in the Environmental Safety Case (received electronically).

Answer – Nuvia has supplied these drawings to Colin Hardman via E-Mail on 11th November 2009.

**Action Complete**.

**Environmental Safety Case**

4. Provide a statement that explains what you mean by "the site" in different contexts within the application, and reconcile those parts of the application that say that the site has received radioactive waste "since 1986" and "since 1974".

Answer – for the purposes of this application, the site means the Clifton Marsh landfill site. However, in accordance with Requirement R5 of the GRA which requires that the site related dose constraint applies to the aggregate exposure from a number of sources with contiguous boundaries at a single location, the source term inventory for the Radiological Risk Assessment has been taken to include both historic disposals at the Clifton Marsh and the adjacent Grange Farm landfill site. Radioactive waste disposals to the Clifton Marsh landfill site commenced in 1986. Prior to this, radioactive waste disposals were made to the adjacent Grange Farm landfill during the period 1974 to 1986.

**Action Complete** – the application documents have been altered to ensure there is no confusion over this point. For all references to the radioactive waste inventory, it has been explicitly stated that disposals to the Grange Farm site during the period 1974 to 1986 have been included in the radioactive waste inventory along with those to the Clifton Marsh site from 1986 to the present day. All other references to the site, unless explicitly stated otherwise, refer to the Clifton Marsh landfill site.

5. For the purposes of assessment, you have assumed that all the radioactive disposals since 1974 were made in those parts of the landfill to the East of the sewage treatment works. For each different assessment scenario, how would the total potential impact of all disposals differ if you had assumed a portion of that waste to have been buried West of the sewage treatment works? Justify your answer.

Answer – It is considered that the inclusion of the inventory of waste buried to the west of the sewage treatment works (i.e. at Grange Farm) in the Radiological Risk Assessment for Clifton Marsh is a conservative approach for all basecase scenarios, since this effectively increases the radionuclide concentration across the site and hence increases radionuclide concentration in the leachate for those radionuclides that are not solubility limited.

Clearly where localised activity determines the dose impact rather than average activity, if a higher activity concentration of waste was deposited to the West of the sewage works than has been assumed throughout the whole site to the East of the sewage works, then this could result in a higher dose impact than currently modelled. However, there is no inventory data upon which to base such a model and the sensitivity studies that have already been completed for the current assessment modelling effectively assesses the consequences of a higher activity concentration on site for those potentially affected scenarios.

For the operational scenarios, since workers on the Clifton Marsh site and sewage workers should not be exposed to radiation via pathways from the Grange Farm site in the scenarios considered (waste fire should not occur at Grange Farm, no leachate is pumped from Grange Farm to the sewage works, dust from Grange Farm waste will not be inhaled), inclusion of radionuclides disposed of at Grange Farm within the Clifton Marsh inventory is a conservative approach.. In summary if it was assumed that a proportion of the waste had been buried to the West of the sewage works, the impacts to site workers and sewage workers would be lower than currently indicated through the risk assessment modelling.

The human intrusion, erosion and bathtubbing scenarios have all been based on average activity concentration across the site. Similarly to the operational scenarios, if a proportion of the waste were assumed to be buried to the west of the sewage treatment works, the radionuclide concentration on the Clifton Marsh site for these scenarios would be lowered, therefore resulting in lower dose impacts.

In the post closure groundwater scenario, the impact of assuming a proportion of the waste is disposed to the West of the sewage works will depend on the hydrogeological model and the uptake pathways associated with the different disposal areas. Assuming the same groundwater discharge location and pathways, there should be insignificant difference in the dose impact from splitting the inventory or considering it as a single entity.

**Action Complete** – The EA has accepted this answer (see correspondence 08/02/2010 “views on Nuvia’s draft letter of 27 January 2010) and Nuvia has provided a statement in the Radiological Risk Assessment report (section 4.2) and the ESC (section 7.1) to highlight this assumption.

6. In the third paragraph of section 2.1.2, you assert that the amounts of radioactive waste are relatively small, in order to justify adopting a simplified assessment approach for certain scenarios. You do not say what you are comparing the amounts with. Provide a more detailed justification, and clarify which scenarios you mean.

Answer – the assertion that the amounts of radioactive waste to be disposed at the Clifton Marsh landfill in the future are relatively small refers to the percentage of radioactive waste received in comparison to the percentage of non-radioactive waste received.

It is estimated that the amount of radioactive waste received to date at the Clifton Marsh landfill is 3% of the sites' total waste volumetric disposal inventory received at the site. An example calculation has been carried out for waste received in 2007.

In 2007 the volume of VLLW and low activity LLW disposed at Clifton Marsh was 8369 $m^3$. This value equates to 3% of the total volume of waste disposed at the site for that year (see Calculation 1 below).

**Calculation 1 - % of VLLW and Low Level LLW disposed at Clifton Marsh in 2007**

| | | |
|---|---|---|
| **Total volume ($m^3$) of waste disposed at Clifton Marsh (2007)** | Tonnage / Density = Volume<br><br>284486.30 / 1.1 = 258623.909 | **Tonnage supplied by Ian Thomson (Operations Manager for Clifton Marsh), density as used in the conceptual model** |
| **Total volume ($m^3$) of disposals from Capenhurst (2007)** | 1677.25 | **As stated in the Annual Total column on the Monthly return for wastes disposed of by controlled burial at Clifton Marsh Landfill Site (December 2007)** |
| **Total volume ($m^3$) of disposals from Springfields (2007)** | 6692.054 | **As calculated below, all data was taken from the BNFL Springfields Works Clifton Marsh Disposal Summary Report (January – December 2007)** |
| **Total volume of VLLW and low level LLW disposed at Clifton Marsh (2007)** | 1677.25 + 6692.054 =<br>8369.30364 | **Calculated** |
| **% of VLLW and low level LLW disposed of at Clifton Marsh (2007)** | (8369.30364 / 258623.909) x 100 = 3.23609 | **Calculated** |

| | Mass of Springfield disposals 2007 (kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Decommissioning waste** | **General Waste** | **Graphite** | **Process Waste** | **Process Waste (Historical)** | **TOTAL (kg)** | **TOTAL (tonnes)** | **TOTAL Volume (m3) – Calculated using a density of 1.1 te / m3** |
| January | 2130160 | 84040 | 9120 | 90280 | 0 | 2313600 | 2313.6 | 2103.273 |
| February | 368740 | 126180 | 109940 | 9980 | 0 | 614840 | 614.84 | 558.9455 |
| March | 134320 | 193820 | 14240 | 60260 | 45140 | 447780 | 447.78 | 407.0727 |
| April | 119660 | 115380 | 4880 | 21840 | 10660 | 272420 | 272.42 | 247.6545 |
| May | 569600 | 139060 | 9440 | 46960 | 10420 | 775480 | 775.48 | 704.9818 |
| June | 115220 | 14640 | 164440 | 10640 | 0 | 304940 | 304.94 | 277.2182 |
| July | 15820 | 106400 | 9880 | 121640 | 10200 | 263940 | 263.94 | 239.9455 |
| August | 16120 | 179940 | 8910 | 86848 | 9621 | 301439 | 301.439 | 274.0355 |
| September | 30280 | 173600 | 9660 | 81720 | 9180 | 304440 | 304.44 | 276.7636 |
| October | 1400 | 168240 | 9340 | 108520 | 19720 | 307220 | 307.22 | 279.2909 |
| November | 295280 | 400460 | 3440 | 56560 | 0 | 755740 | 755.74 | 687.0364 |
| December | 140560 | 532920 | 6440 | 19500 | 0 | 699420 | 699.42 | 635.8364 |
| | | | | | | 7361259 | 7361.259 | 6692.054 |

NB the Capenhurst disposals have not been broken down but amount to approximately 1677 m3 as noted in the table above.

**Action Complete** – the statement in the ESC (section 2.1.2) has been amended to reflect this approach and is considered to be proportionate to the amounts of radioactive waste being accepted at the site (i.e. <10% of the total volume of waste disposed of at the site and 200 Bq/g specific activity).

7. Can you confirm that Phase 3 was filled between 1999 and 2002?

Answer – SITA have confirmed that Phase 3 was operational for landfilling from August 1993 to May 2003.
**Action Complete** – statement to confirm this has been added to Radiological Risk Assessment (Section 3.1) and the ESC (Section 3.1) documents.

8. It is unclear which parts of section 3.2.2 and 3.2.3 apply to Phases 1 – 3; please clarify and, where information is not given for some of the phases, provide it.

Answer – sections 3.2.2 and 3.2.3 of both the Radiological Risk Assessment and the ESC have been amended in order to clarify which parts apply to each disposal phase.
**Action Complete**

9. If authorised, you will be required to demonstrate that you have sufficient access to experts who can advise you as to compliance with the conditions in the authorisation. Provide details of who these qualified experts will be, together with sufficient details for us to reach a view on their suitability and competence relevant to radioactive waste disposals.

Answer –
Technical Manager - B Thaker
Operations Manager - I Thomson
RPA Services – The appointed RPA is Serco Ltd
RPS - I Thomson / Designated Deputy
SMLO - To be Appointed
DGSA - T Brooke
PPC - S Westerman
Leachate and Gas Monitoring – Contracted out to VT Plc
**Action Complete**

10. Which elements of the Site Induction Training cover the requirements of Environmental Legislation, including those for which the Environment Agency is the designated regulator?

Answer – Both the RPS Training and the Site Induction Training will include a Module on the relevant requirements of the authorisation i.e. RSA 93 / EPR 2010. Additionally, Sita's Environmental Policy. and related Quality Environment Management Policy and Procedure, training in respect of ISO 9001, ISO 14001 and ISO 18001 is provided and recorded on each employees Training Matrix. This is reviewed annually and refreshed throughout the year through Toolbox Talks, Bespoke Exercises, etc.
**Action Complete** .

11. What self-auditing will Sita carry out in respect of compliance with a radioactive substances authorisation ?

Answer –
Annual review of MAC and Ops Statement
Annual review of Staff Competency Training
Compliance auditing of Consignors arrangements
Annual site monitoring of Leachate and Gas (H3, C14 and Radon)
Annual Emergency Exercise Demonstration
**Action Complete**

12. Operating procedures appear to be split between Section 6.2 of the Environmental Safety Case and Section 4 of your Materials Acceptance Criteria and Operational Statement. This needs clarifying. Also, explain which are existing instructions and which are proposed new ones. If existing, outline how you will modify them to cater for the new regulatory regime.

Answer – Section 6.2 of the Environmental Safety Case has been removed. The Materials Acceptance Criteria and Operational Statement will cover all operating procedure on site.
Action outstanding – SITA will provide updated Mac and Operating Procedures.

13. Clarify the minimum number of surface radiation and contamination surveys you will carry out for consignments of each type of package.

**Answer –**

**Level 1 Inspection**

A pre-arrival check of the consignment, involving an inspection of documentation to ensure that the consignment meets the Material Acceptance Criteria (MAC), the Carriage of Dangerous Goods Act and that SITA will not exceed their Authorisation limits (both Annual and Lifetime).

**Level 2 Inspection**

A Level 2 inspection consists of a visual inspection of all packages upon arrival at Clifton Marsh. In addition, the measurement of the beta/gamma dose rate in contact and at 1m and the measurement of loose surface contamination will be performed on a randomly selected proportion (e.g. 1 in 10) of the packages to provide reassurance.

**Level 3 Inspection**

For a small number of consignments SITA will request that representative samples are taken and that these samples are analysed to verify that the waste is compliant.
Sampling will be performed at the customer's site and may be observed by SITA.
**Action Complete**

14. Describe the training requirements for staff carrying out "level 1" and "level 2" inspections. Will "level 2" inspections be carried out periodically to maintain staff training levels ?

Answer – See Q13 above.

Level 1 - Only designated personnel such as the Technical Manager, SMLO, DGSA or Site Manager will undertake the Level 1 checks. Internal training of the Waste Consignment Process from receipt of documentation to acceptance and disposal at the Clifton Marsh Landfill Site will be provided by the Technical Manager through development of a bespoke Training Course. Each attendee will require to prove competence of understanding by an internally developed Test Paper. Upon satisfactory prove of competence the attendee will be appointed to carry out the Level 1 Inspections.

Level 2: - The appointed RPA will develop a course to train site personnel to carry out Level 2 Inspections. The Training Course will require the Site Personnel to demonstrate a level of competency after which they will be formally appointed to carry out Level 2 Inspections.

Assurance checks will be carried out periodically to for both Level 1 and 2 appointments to ensure competency.
**Action Complete.**

15. Confirm that the requirement to quarantine damaged drums applies to other types of container as well as drums.

Answer – All packages will be checked for damage and if found to be damaged they will be quarantined and an investigation initiated
**Action Complete**

16. What is the maximum period quarantined waste may be held before dispatch back to the originating site?

Answer – 30 days

**Action Complete**

17. On page 37, you refer to independent checks by the RPS (presumably to protect against accidental disposal rather than despatch). Are these the "level 1 inspections" referred to elsewhere, or are they additional, independent checks?

Answer – See Q13 for meaning of Level 1, 2 and 3.inspections. The RPS assurance checks are merely independent internal audits that will be carried out periodically to ensure appointed personnel are competent to continue performing the designated checks within their competency level of appointment.

**Action Complete.**

18. Regarding Section 6.2.4 (and noting that RIFE-14 has been published), please provide some meaningful summary analysis of the available environmental monitoring data. Also clarify whether the Health Protection Agency monitoring data is available publicly.

Answer – A summary report of the available monitoring data has been produced (Report on the Historic Radiological Monitoring Data at the Clifton Marsh Landfill Site, Higgins, 2009) and is submitted with this response. It has also been referred to in section 6.2.4 of the Environmental Safety Case. Results from the HPA gamma surveys and leachate lagoon sampling are available from SITA if required by EA.

**Action Complete**

19. State when the results of the initial Baseline Monitoring will be provided to the Environment Agency.

Answer – July 2010.

**Action Complete**

20. Provide simply-worded summaries of -

(i) how you have selected the radionuclide groupings against which to apply for disposal limits; and

(ii) the process you have gone through to derive the limits in Table 3 (this should possibly be renumbered as table 8). Include an explanation of where you have used real data, and justify use of approximations or estimates

Answer –

i) In order to simplify the WAC for waste consignors and for SITA, the radionuclides have been grouped and the most limiting annual disposal limit (which has been calculated as described in part ii below) for any radionuclide in that group has been applied to each specific group.

The radionuclide groupings against which disposal limits have been applied have been derived from a combination of the radionuclide type e.g. alpha or beta, the calculated annual disposal limit for each radionuclide and the output from a risk assessment modelled scenario using the maximum theoretical inventory. In general, where several radionuclides having similar properties – decay type or isotopes of the same element - or being part of the same decay chain and are calculated to have maximum annual disposal limits within one or two orders of magnitude of each other then they have been grouped. This grouping has also been undertaken in order to fully optimise the site (i.e. to avoid unnecessarily restrictions on disposals of certain radionuclides) and to ensure the risk assessment is not compromised (i.e. to restrict the annual disposal limit of certain radionuclides where necessary. e.g. disposals of Ce-144, Fe-55, Ni-63 and Pu-241 have a suggested annual disposal limit that is two orders of magnitude higher than the "other beta" category so as not to unnecessarily restrict disposals of these radionuclides whilst simultaneously ensuring the dose criteria are met under the risk assessment. In addition, the disposal limit for Ra-226 is an order to magnitude below that for "other alpha" since disposals of Ra-226 are limited by the radiological impacts modelled in the risk assessment.

A final step has been taken to optimise this grouping. This has involved an iterative approach to assess the effect of gradual increase of the maximum inventory for certain radionuclides in order to allow them to be assigned to a group. Since the maximum inventory has been calculated by assuming a simple linear extrapolation to the peak doses, a re-run of the risk assessment model using this optimised maximum inventory will not necessarily mean that the dose criteria are reached, due to other effects such as decay and in-growth being taken into account. The limits shown in Table 38 of the risk assessment report have been derived through this iterative approach and have been used to calculate the full potential inventory for the site which has been input to the risk assessment models to ensure that the dose criteria are not exceeded.

ii) In order to calculate the remaining radiological capacity for the Clifton Marsh site and thereby the Site Lifetime Activity Limit and to set annual disposal limits for each radionuclide, the peak dose from each radionuclide to any PEG from the operational and post closure pathways that are normally expected to occur as well as the human intrusion and bathtubbing pathways have been extracted from the basecase model runs. These peak doses and the corresponding radionuclide inventory have then been used to calculate the maximum potential inventory for that radionuclide, based on a maximum allowable dose of 2.00E-05 Sv $yr^{-1}$ or 1.00E-03 Sv $yr^{-1}$ as applicable, per radionuclide (i.e. pro-rating for the inventory used in the modelling and the peak dose up to the screening criteria dose).

Since there could be significant dose contributions from more than one radionuclide at any one time, it should be noted that this calculation gives a theoretical maximum inventory for each radionuclide assuming a dose is received from that individual radionuclide only.

The remaining capacity of the Clifton Marsh landfill site for each radionuclide has then been calculated by subtracting the existing inventory of the Grange Farm site and the Clifton Marsh landfill from this maximum inventory.

Given a further operational period of 11 years for the remaining waste disposals to the Clifton Marsh landfill site, the maximum annual disposal limit for each radionuclide has then been calculated by dividing the remaining site capacity for each radionuclide by 11. . See also notes on maximum inventory modeling in part 1 above.
**Action Complete** – these statements have been added to the ESC section 8.2.1 and section 10.6 of the radiological risk assessment report.

21. You have chosen thorium as one of the radionuclide groupings for assessing site capacity and possible annual limits on disposal. Explain how you have assessed the impact of thorium arising after disposal of uranium radionuclides; i.e. should the capacity for thorium be reduced to include an allowance for in-growth.

Answer – the risk assessment model calculates in-growth of radionuclides therefore each radionuclide specified in the inventory is considered to be head of chain. The site capacity calculations described in the application documents are based on peak doses from each radionuclide in the model inventory over the model time length. Since the inventory input to the model (which represents the potential inventory to the site) will be subject to in-growth, the peak doses output by the model are therefore due to the combined impact of head of chain and daughter radionuclides. Therefore the calculated capacity of the site for each radionuclide already takes into account that its overall inventory may be added to via in-growth from its parent or may be depleted due to decay.

**Action Complete** – the above statement has been incorporated into section 10.6 of the Radiological Risk Assessment for clarity.

**Material Acceptance Criteria and Operational Statement**

22. The structure of Section 1 is somewhat confusing, with several of the criteria split between two or more sub-sections. There is also a tendency to refer to some of the independent safeguards (such as those applied at consigning sites and those attributable to transport legislation) as if they were your own criteria. Provide a re-written section, preferably giving the criteria in a logical, chronological sequence (i.e. those applying before waste leaves the consignor's site [including assay and level 2 inspection], those applying to the transfer stage, and those applying upon arrival at your site).

Answer – SITA is amending the MAC and operating statement.
Action outstanding - SITA will provide an up to date MAC and operating statement.

23. We note that several other aspects of section 1 need clarifying –

(i) The reference to natural background levels of radiation (2.6 millisieverts / year) is not quite right – you may wish to consult text given in the latest RIFE (Radioactivity in Food and the Environment) Report, RIFE -14, sections 1.1.2 and 1.2.6).

(ii) The reference to an authorisation limit of 7.5 µSv/hour is confusing; is this a transport limit or a Sita criterion?

Answer –
i) Extract from RIFE 14 "An additional comparison can be made with doses from natural radioactivity. The UK average is 2.2 mSv per year, with a range across counties from 1.5 mSv per year to 7 mSv per year (Watson et al., 2005).

The average annual dose from naturally-occurring radiation was found to be 2.2mSv and approx 50% this was from radon exposure indoors. The average annual dose from artificial radiation was 0.42mSv, mainly derived from medical procedures, such as x-rays. The overall average annual dose was 2.7mSv."

ii) This limit is incorrect and should be 5 µSv/hr which corresponds to UK Transport Regulations "The radiation level at any point on the external surface of an excepted package must therefore not exceed 5 µSv/h"
**Action Complete**

24. In Section 4, why does the first row of the table apparently only apply to "NORM" consignments ?

Answer – This is merely a typographical error. SITA will amend in final MAC and operating procedures document.
**Action Complete**

25. Provide details of the main information you will require to be present on paperwork, checked at Reception when a consignment arrives at site.

Answer – These details will be incorporated into the Materials Acceptance Criteria which will be submitted by 31st May 2010.
Action outstanding.

26. Confirm that you will write Operating Instructions for Leachate Monitoring, Surface Water Monitoring and Groundwater Monitoring.

Answer – This is correct, these instructions will be submitted with the final application documents.
**Action Complete**

**Radiological Assessment – General questions**

27. Confirm and justify the assumption that there was no significant content of Ra-226 in wastes disposed during the period 1974 to 2009.

Answer – Since radium is a decay product of U-238, it is will be found in all uranium bearing ores. It is believed that prior to 1974, the Uranium ores that were imported for use at Springfields contained high levels of impurities and would have been likely to have contained elevated levels of Ra-226. Towards the late sixties and early seventies, there was a shift towards using purer ores that would only have contained Ra-226 in secular equilibrium with its parent radionuclides.
**Action Complete**

28. Provide modelling output for the scenario: 'Erosion of the waste mass (phases 1, 2 and 3) as a result of the failure of the River Ribble bank' (during the operational period, not certain to occur).

Answer – It is thought that inundation or erosion f the site is not likely to occur on the timescales of the operational period (sea level rise is predicted at les than 1 m over the next century) however, an assessment has been undertaken and described in section 7.2.3 of the Radiological Risk Assessment.
**Action Complete**

29. Regarding the human intrusion and erosion calculations, please clarify and justify the assumptions you have made about solubility limits and $K_d$ values. In particular, when making conservative assumptions about radionuclides transferring to leachate and groundwater, demonstrate that you are not being unduly optimistic over what remains in the bulk solid waste.

Answer – In both the intrusion and erosion calculations the report states that no leaching of the waste occurs (page 52). Therefore, no activity is transferred to leachate and groundwater, and the approach is inherently cautious as to how much activity remains in the waste.

No sorption has been assumed in the wastes for the groundwater pathway, so solubility limitation has been used as a surrogate for sorption. Sorption has been included in the models where it would increase doses due to inhalation of resuspended material (inhalation of dust by site workers, the waste fire scenario – inhalation of particles in smoke plume, the human intrusion scenario – inhalation of dust and the erosion scenario – inhalation of dust).

The Radiological Risk Assessment section 5.2 and section 7.2.1 has been updated to ensure that there is clarification on this point.
**Action Complete**

30. How have you assessed the impact of possible groundwater ingress into the cells?

Answer – the model assumes that the waste cells are located below the water table. Whilst the flow through the wastes could be assumed to be the same as the general groundwater flow, the wastes and degraded cap are treated as having negligible resistance to flow (the whole of the infiltration is taken to percolate the wastes). In contrast, the fraction of infiltration entering the groundwater system in surrounding areas will be substantially lower. Therefore, the cautious assumption made as to infiltration means that there is a high local flux of water. This will flow downward into the waste and the flow lines will then become diverted sub-horizontally so that the flow merges with the general groundwater flow over a significant distance below the water table. To be more specific, it would be necessary to construct a realistic hydrogeological model of the system. The general groundwater

flow is currently used in the groundwater transport calculation, as this represents the situation after sub-horizontal deflection and merging has occurred.
**Action Complete** – The EA has accepted this answer (see correspondence 08/02/2010 "Views on Nuvia's draft letter of 27 January 2010). No changes to application documents have been made.

31. Provide evidence to support using solubility limits (and $K_d$s) appropriate to reducing conditions in the near field.

Answer - The model uses infiltrating meteoric water as the driver for advective flow through the waste and geosphere. This water will be oxic when it infiltrates into the cap. Although much of the oxygen may be consumed by microbial processes in the overlying soil zone and experimental evidence suggests that the oxicanoxic transition can occur within distances of about 0.1 to 0.2 m in homogeneous soils, there is the possibility of preferential flow paths resulting in oxygenated water reaching the wastes (or alternatively sulphate and nitrate concentrations being such that fully reducing conditions do not occur). A fuller answer to this question has been provided in a report by Mike Thorne (Thorne, 2010d) which discusses why it is thought appropriate to adopt reducing conditions in the wastes, as well as evaluating the most appropriate parameter values to use. A short commentary on solubility limits for Tc, Th and U forms part of this report and also helps to answer this question as these are the only elements for which relatively low solubility limits arise.
**Action Complete** - The EA has endorsed this approach – see correspondence 08/02/2010 "Views on Nuvia's draft letter of 27 January 2010. Mike Thorne's report is also provided with this response. A short comment has been added to the Radiological Risk Assessment (section 5.2) to reference this report.

32. Provide further clarification of the sensitivity of the overall assessment results (for all scenarios) to assumed $K_d$ values.

Answer – This question has been addressed in conjunction with the other questions on Kds and solubility and additional modelling has been performed to ensure that the sensitivity studies performed adequately account for uncertainties in the Kd values used. These sensitivity studies are described in section 10.5.4 of the Radiological Risk Assessment report.
**Action Complete**

33. Justify the assumption that no exposure pathways associated with Savick Brook will exist in the post-closure period.

Figure 1 of the Radiological Risk Assessment report indicates that at worst only a limited length of the Savick Brook could become contaminated. The Hydrogeological Risk Assessment for Phase 1, 2 and 3 also states that the predominant groundwater discharge is to the River Ribble.
Furthermore, because a spatially dispersed release will occur, there is no reason why radionuclide concentrations in environmental media adjacent to Savick Brook will be significantly higher than concentrations along the general frontage of the River Ribble.

However, question 34 addresses the possibility that PEGs associated with the Savick Brook may be impacted should an exposure pathway to the Savick Brook develop in the post closure period of the site.
**Action Complete** – a statement to re-iterate the hydrogeological model has been added to section 4.3 of the Radiological Risk Assessment and section 3.4 of the Environmental Safety Case.

34. Provide a supplementary assessment, for reassurance, for potential impact upon canal boat users and walkers.

Answer – SITA understands that the assessment requested here is for receptors on the Savick Brook. If this is indeed the case, PEGs on Savick Brook could be included into the sensitivity study in which 50% of the groundwater is discharged to the Savick Brook
**Action Complete** – a houseboat dweller PEG associated with the Savick Brook has been added to the sensitivity assessment described above.

35. Clarify, for each exposure scenario, whether the impact is considered to depend primarily on the total disposed activity of each radionuclide through the whole landfill or on localised activity concentration. If the latter, provide an illustration of the scale (volume / activity) above which the local concentration is more limiting than the average throughout the whole landfill. Explain further how these conclusions are taken into account in deriving proposed future limitations on disposals.

Answer –.the following table outlines the scenarios considered in the risk assessment model and whether their impact is considered to depend primarily on the total disposed activity of each radionuclide through the whole landfill or on localised activity concentrations.

<table>
<tr><th colspan="3">Operational Exposure Pathway</th><th>Scenario Dependence as Modelled</th></tr>
<tr><td colspan="4">Exposure pathways normally expected to occur</td></tr>
<tr><td colspan="3">SITA worker - Inhalation of contaminated dust</td><td>Site average radionuclide concentration</td></tr>
<tr><td rowspan="5">PEGs leachate discharge to sewage works</td><td colspan="2">Public – Angler</td><td rowspan="5">Site average radionuclide concentration</td></tr>
<tr><td colspan="2">Public – Farming</td></tr>
<tr><td rowspan="3">Workers – Sewage treatment</td><td>External irradiation</td></tr>
<tr><td>Inhalation</td></tr>
<tr><td>Ingestion</td></tr>
<tr><td colspan="4">Exposure pathways not certain to occur</td></tr>
<tr><td rowspan="2">PEGs leachate spillage</td><td colspan="2">Drinking water from Savick Brook</td><td rowspan="2">Site average radionuclide concentration</td></tr>
<tr><td colspan="2">Consumption of fish from Savick Brook</td></tr>
<tr><td rowspan="6">Waste fire</td><td rowspan="2">Smoke inhalation</td><td>Workers</td><td rowspan="6">Site average radionuclide concentration</td></tr>
<tr><td>Public</td></tr>
<tr><td rowspan="2">Irradiation in smoke plume</td><td>Workers</td></tr>
<tr><td>Public</td></tr>
<tr><td colspan="2">Irradiation due to dust on ground</td></tr>
<tr><td colspan="2">Ingestion of crops contaminated with dust</td></tr>
<tr><th colspan="3">Post Closure Exposure Pathway</th><th>Scenario Dependence</th></tr>
<tr><td rowspan="5">Post Closure Groundwater pathway</td><td colspan="2">Wildfowler</td><td rowspan="5">Site average radionuclide concentration</td></tr>
<tr><td colspan="2">Fisherman</td></tr>
<tr><td colspan="2">Houseboat dweller</td></tr>
<tr><td colspan="2">Seafood consumer</td></tr>
<tr><td colspan="2">Child drinking from river Ribble</td></tr>
<tr><td rowspan="2">Human intrusion scenario</td><td colspan="2">Ingestion of offal – site resident</td><td rowspan="2">Localised radionuclide concentration</td></tr>
<tr><td colspan="2">Gas Pathway</td></tr>
<tr><td rowspan="5">Bathtubbing</td><td colspan="2">External irradiation – working on contaminated soil</td><td rowspan="5">Site average radionuclide concentration</td></tr>
<tr><td colspan="2">Inhalation of dust</td></tr>
<tr><td colspan="2">Ingestion of soil</td></tr>
<tr><td colspan="2">Ingestion of vegetables</td></tr>
<tr><td colspan="2">Ingestion of beef</td></tr>
</table>

<table>
<tr><td rowspan="3"></td><td colspan="2">Ingestion of mutton</td><td rowspan="3"></td></tr>
<tr><td colspan="2">Ingestion of cow liver</td></tr>
<tr><td colspan="2">Ingestion of milk</td></tr>
<tr><td rowspan="6">Dose to public adult due to coastal erosion scenario</td><td rowspan="3">River bank</td><td>External irradiation</td><td rowspan="3">Localised radionuclide concentration</td></tr>
<tr><td>Inhalation of dust</td></tr>
<tr><td>Ingestion of exposed waste</td></tr>
<tr><td rowspan="3">Waste block</td><td>External irradiation</td><td rowspan="3">Localised radionuclide concentration</td></tr>
<tr><td>Inhalation of Dust</td></tr>
<tr><td>Ingestion of exposed waste</td></tr>
</table>

This is summarised in section 8.1 of the Radiological Risk Assessment which addresses the issue of waste heterogeneity.

The issue of spatial scale can be considered by pathway. It is not a major issue for the groundwater pathway or bathtubbing, as the impact is determined by the overall flux of activity. Although there could be some variations in concentrations spatially within the discharge area, it is not possible to represent these without a detailed hydrogeological model of the facility and surrounding area. Furthermore, movements of individuals who are characteristic of the exposed groups will tend to average out these spatial variations. For the gas pathway, rather different considerations arise. In this case, the house could be constructed over an area of the facility where release rates of radioactive gases were higher than average. However, there is no reason why such areas should be selected preferentially; therefore, the expectation value of radiological impact is properly calculated by using the spatially averaged release rate. This is in line with ICRP recommendations on handling potential exposures when levels of exposure are not anticipated to be in excess of dose limits.

In the case of intrusion, similar arguments apply as in the case of the gas pathway, but it may be useful to quantify the degree of spatial averaging intrinsic to the calculations. For excavation and subsequent occupancy, the relevant area is 400 $m^2$ (say 20 m by 20 m), so heterogeneities on spatial scales smaller than this are not relevant. For the erosion pathway, the main concern would be exposure to blocks of waste material. However, exposures would likely be to multiple blocks, so heterogeneity may be less important than if exposure was to a single block.

In all cases, there is a need to determine the degree to which it is acceptable to compute the expectation value of radiological impact. To my knowledge, there is no clear UK guidance on this topic. For future disposals, my view is that heterogeneities should not be so large that there is a substantial risk of exceeding dose constraints to members of the public (0.3 mSv/y), i.e. a factor of 15 higher than the target value of 0.02 mSv/y.

EA feedback on this response raised two additional questions:

1 Are there any materials or items that might be distinguishable and attract special attention if/when the waste mass is disturbed? If so then what if calculations may be needed to represent some selective handling or use of specific material or items

2 Does the assessment meet all the criteria if the suggested concentration limit of 200Bq/g applies to quantities of 10te and above?

1 will be responded to in the assessment to look at isolated packages of higher activity wastes – question 36

2 a repeat assessment will be performed to look at 10 te waste consignments containing 200Bq/g – question 36

**Action Complete**

36. In the same context, explain your choice of 200 Bq/g as an upper bound on activity concentration.

Answer – The authorisation currently held by Springfields Fuels Ltd for radioactive waste disposals to Clifton Marsh stipulates total radionuclide concentration limits of 100 - 250 Bq/g for wastes consigned to the site. It was agreed upon commencing the work towards this application that the nature of the Clifton Marsh landfill, current practices on site and stakeholder expectations would not allow for a new authorisation held by the site to significantly exceed these limits. This was anticipated to require significant additional engineering of the site, an extensive detailed risk assessment (given the location of the site) and publication to stakeholders of significant changes to the radioactivity of the wastes currently received on site. A decision was therefore taken to keep the specific activity of waste accepted on site to the lower end of low level waste activity limits.
A scoping calculation has been performed to assess the risks of filling the site with radioactive waste of average concentration of 200 Bq/g. The results of this assessment are given in section 10.5.1 of the Radiological Risk Assessment. Further studies have also been undertaken to assess the risks of disposal of higher specific activity packages. These sensitivity studies are also documented in section 10.5.1 of the Radiological Risk Assessment.

**Action Complete**

37. Please clarify the "maximum inventory" used to test whether disposals of nuclides in all eight of the proposed groups at the proposed group limits would exceed the Environment Agency's dose or risk criteria. Did the inventory include only eight radionuclides – the most limiting in each group, at the activity limit for that group – or was the activity in each group assumed to be distributed among the radionuclides in the group ?

Answer –the "maximum inventory" used in the risk assessment was the maximum allowable site capacity for each individual radionuclide in the inventory. There was no grouping or averaging involved.

**Action Complete** – a statement to this effect has been added to section 10.6 of the Radiological Risk Assessment and section 8.2.1 of the Environmental Safety Case

38. Explain which radionuclides can be included within "other alpha" and "other beta", and which cannot. How much flexibility there would be, if any, in your Acceptance Criteria for receipt of wastes containing radionuclides not included specifically in the radiological risk assessment?

Answer – the grouping of the radionuclide inventory considered in the risk assessment model is shown in Table 38 of the Radiological Risk Assessment.

Since the radiological capacity of the site has been calculated using the estimated peak doses from the operational and post-closure pathways that are normally expected to occur and the human intrusion and bathtubbing pathways (Eden, 2009) in order to expand the WAC to radionuclides not explicitly covered in the assessment, how the radiological impacts of additional radionuclides for these pathways would compare with the radiological impacts of those radionuclides that have already been assessed needs to be considered. This could be addressed by extending the assessment to include these additional radionuclides. However, as the additional radionuclides are unspecified and there are more than 100 different radionuclides listed in the UK National Radioactive Waste Inventory, this is not considered the most appropriate option. Rather, general arguments are proposed that group radionuclides into categories. This means that additional radionuclides can be assigned Acceptance Criteria by analogy with those that have been studied in detail in the assessment.

Combining the list of radionuclides considered in the UK National Radioactive Waste Inventory (the same as those included in the RWMD assessment model for the biosphere (Thorne, 2007)), those radionuclides considered in the EA's initial Safety Assessment Methodology (EA, 2006a; 2006b) , along with those radionuclides already assessed for the Clifton Marsh RSA 93 Authorisation application, an exercise has been undertaken by Mike Thorne (2010c and 2010f) to categorise these radionuclides in order to determine their impacts at various stages of the site's lifetime.

Radionuclides have been grouped as follows:

- Excluded radionuclides - those with half lives of less than 10 days would not be expected to be present in their own right (they might be present at close to secular equilibrium with their ancestors, but this would be addressed by setting appropriate Acceptance Criteria for those ancestors). Also, there should be very little of the noble gases present;
- relatively short-lived (half lives of no more than a few years), so only operational constraints on their disposal apply;
- longer lived, but data relevant to both operational and post-closure assessments are available;
- unlikely to be of any significance due to operational releases, but have been identified in other studies as being of potential post-closure significance in radioactive waste repositories;
- higher actinides (yellow) are unlikely to be of operational significance relative to the actinides included in the assessment, but could be of significance post-closure;
- other radionuclides judged unlikely to be of significance either operationally or post-closure.

Thorne (2010c) has worked up a method to assign surrogate radionuclides to each radionuclide which have not already been assessed in the risk assessment model, in order to allow their classification in the radionuclide categories for the Waste Acceptance Criteria. The full details of this methodology are given in Thorne (2010c) however; it is broadly based on the following:

- operational phase - SITA worker exposure– radionuclide classification based on inhalation dose co-efficient;
- operational phase – sewage workers, angler and farming family exposure – radionuclide classification based on DPUR;
- post closure phase – radionuclide classification based on RWMD model biosphere factors for natural groundwater discharge and well abstraction for irrigation (Thorne, 2007

For each type of classification, a rank-ordered list of radionuclide dose coefficients or DPURs has been drawn up and examined for each additional radionuclide for its first, second and third nearest neighbours from the radionuclides already included in the assessment. Rankings both below and above the additional radionuclide are considered. Where two radionuclides included in the assessment have equal differences in rank above and below the additional radionuclide, the one with the larger dose factor is given preference.

The nearest-neighbour radionuclides differ substantially from pathway to pathway. This means that surrogate radionuclides have initially been assigned on a pathway-by-pathway basis.

Thorne (2010f) has then gone further to assign a shortened list of new radionuclides to surrogates to enable them to be classified within a group specified in the proposed Waste Acceptance Criteria for Clifton Marsh.

This is documented in section 10.6 of the Radiological Risk Assessment and section 8.2 of the Environmental Safety Case.

**Action Complete**

39. Use of the term "Other Beta" to refer to Ac-227 might be considered slightly misleading. It is strictly accurate that Ac-227 itself decays predominantly by beta decay, and it may be appropriate to group Ac-227 with certain pure beta–gamma emitters, but a significant part of the radiological hazard associated with Ac-227 is due to its alpha-emitting progeny.

Answer – the impacts of Ac-227 decay products have already been assessed in the risk assessment model.

**Action Complete**

40. We would like you to consider the following scenarios (as not certain to occur):

- Aircraft impact as a result of the proximity of the site to the Warton Airfield and its location under the main flight path.

- Pipeline explosion (ICI, British Gas and Shell): A number of pipes containing highly flammable liquids pass through between Phases 2 and 3. These pipelines could be compromised resulting in a significant explosion (it should be noted that the consequences of a pipeline explosion would be very similar to an aircraft impact).

If an aircraft impact were explicitly treated as giving rise to a crater exposing undiluted waste in the crater, but with degradation giving rise to contaminated soil in the vicinity, the resultant calculations are very similar to those adopted for intrusive excavation with a mix of pathways relating to the intruder and subsequent householder.

Alternatively, it could be reasonably argued that the probability of aircraft impact is low and that the consequences are bounded by those assessed for excavation (which is considerably more likely to occur). Demonstration that the excavation is bounding would be done by comparing the volume and area of the excavation with the crater size at Lockerbie, for which data and photographs from the 2002 LLWR assessment are available.

It is anticipated that the degree of disturbance by a pipeline explosion would be very small compared with that due to impact of the engine of a commercial airliner.

A report has been produced by Mike Thorne (Thorne, 2010a) to look at the impacts to the waste mass from both of these scenarios. It has been concluded that the radiological impacts of aircraft crash and pipeline explosion on the site are bounded by those assessed for human intrusion. In addition an aircraft crash is considered to be associated with a much lower probability of occurrence than house construction.

This report has been referred to and referenced in a new section in the Radiological Risk Assessment (Section 7.2.4) and in section 7.2 of the Environmental Safety Case. The report is also submitted with these responses.

**Action Complete**

41. You should consider assessing dust exposure from loose waste / dropped waste (refer also to Section 6.1.2).

Answer – It is considered that management control will mitigate the risks from loose or dropped waste since the operating procedures specifically ensure that waste is emplaced by operatives who are located inside air conditioned truck cabs and the disposal area is classified as restricted access. In addition, emergency procedures are in place for any spillage of waste prior to delivery at the waste disposal area. However, the calculation in section 6.1.2 of the Radiological Risk Assessment has been adapted to represent potential exposure due to inhalation of resuspended dust from loose waste or a drum spillage. The specific activity of radionuclides in the waste have been taken to be 200 Bq/g in the basecase and sensitivity analyses have been performed on this specific activity in section 8.1.

**Action Complete**

42. We disagree with the waste density values used for the GOLDSIM model. The values used are based on CLESA site at Sellafield. The CLESA site takes construction and demolition wastes with small quantities of organic materials. However, Clifton Marsh has taken large amounts of sewerage sludge and MSW. We note that the input parameters used for the model come from a number of sources, not all of them specific to Clifton Marsh. We would like to see a greater usage of site specific values and in particular common values from the site Hydrogeological Risk Assessment.

Answer – It is proposed that the waste density value be altered to 1.22 kg/m3 which is a value proposed by SITA. It is believed that site specific values have been used wherever possible (noting that there is a lack of information on site specific radionuclide behaviour) and values used in the Radiological Risk Assessment undertaken by BNFL in 2002 have also been used for many of the parameters. However an additional cross check of the Hydrogeological Risk Assessment has been performed and sections 3.3 and 3.4 of the Radiological Risk Assessment and Environmental Safety Case have been amended accordingly. In particular, it should be noted that in addition to altering the value used for the density of the waste mass, the pathlength to the River Ribble, the hydraulic conductivity and gradient (see also question 57) of the alluvial deposits and the cross sectional area of discharge of the landfill to reflect values given in the Hydrogeological Risk Assessment rather than those in the Radiological Risk Assessment undertaken by BNFL in 2002. These changes have also been documented in section 5.3 of the Radiological Risk Assessment.

**Action Complete**

43. For Phases 1, 2 and 3, a large amount of sewerage sludge was co-disposed with MSW and LLW. This configuration differs significantly from other sites. Provide assurance that the model's approach can accommodate this issue, including any sewerage sludge containing radionuclides discharged previously from Clifton Marsh as leachate.

Answer – the effect of the sewage sludge and MSW on the mobility and migration of radionuclides from the waste along with any effect on the evolution of the waste form has not been assessed since it is assumed that radionuclides are instantaneously solubilised and released from the waste form into the underlying aquifer – no account of barriers to migration has been taken.

The potential radionuclide content of the sewerage sludge and MSW is not known however, it is recognised that the sewage sludge may provide a source of radionuclides which are additional to those calculated in the inventory. There is insufficient information available to accurately characterise the radionuclide content of the sewage sludge, however it is noted that is possible that these radionuclides could migrate directly from the basal layer of the sewage sludge into the landfill. There is also the possibility that the sewage sludge might actually remove radionuclides from leachate as it migrates through the base of the landfill, by sorption or other processes. As noted, there is insufficient information on the behaviour of radionuclides in the sewage sludge however it might be argued that in effect, the release of additional radionuclides from the sludge is balanced by attenuation of radionuclides in leachate as they pass through it. Therefore omitting radionuclides possibly derived from the sludge is unlikely to affect the accuracy of the assessment. A paragraph to reflect this has been added to section 5.2 of the Radiological Risk Assessment.

**Action Complete**

44. Provide more details on the present likelihood of Phase 4 flooding and the Savick Brook flood defences being breached by normal flood events.

Answer – A report on the likelihood of flooding events at the site along with the likely extent and impact of flooding is being prepared by SITA (2010). This will be submitted with the final application documents.

**Action Complete**.

45. What is the possibility of increased radioactive contamination of the groundwater within the annulus between the Phase 4 lining system and the perimeter cut off wall. This groundwater is outside of the cell, but may not be able to dissipate as per the model and as such may become contaminated if the basal lining system fails.

Answer – If the groundwater does not dissipate, it does not give rise to a radiological impact. If it dissipates, it will either be by bathtubbing (already addressed) or transfer by leakage to the regional groundwater.

**Action Complete** – The EA has accepted this answer (see correspondence 08/02/2010 "views on Nuvia's draft letter of 27 January 2010).

46. We note that the final restoration design of the site, a domed land raise shape, can be vulnerable to surface water erosion. If erosion removes the top soil and compromises the capping FML then the waste may be exposed. Consider this alongside the intrusion scenario.

Answer – it is considered that this scenario results in impacts that are essentially the same as the impacts resulting from the coastal erosion scenario modelled – i.e. exposure of the waste and subsequent dose uptake by receptors due to external irradiation, inhalation of resuspended dust and inadvertent ingestion of the mixed waste mass and blocks of higher activity waste.

It has been noted in section 7.2.1 of the Radiological Risk Assessment that the human intrusion PEG could be impacted by pathways associated with erosion of the top soil of the site. Since the exposure pathways are considered to be analogous to those considered in the erosion scenarios in section 7.2.4, this PEG and exposure pathway has also be noted in that section.

**Action Complete**

47. Provide an assessment of spray / aerosol pathways from the two leachate collection lagoons (refer to Section 6.1.3), due to aeration, agitation and wind action.

Answer – an assessment has been undertaken to investigate the impacts of aerosol pathways from the leachate lagoons due to aeration, agitation and wind action. This assessment has been documented in section 6.1.2 of the Radiological Risk Assessment.

**Action Complete**

48. Describe arrangement for removing sludge from the leachate lagoons, including considerations of radioactive content and appropriate disposal route for the sludge.

Answer – The intention is initially to pump out the lagoon water.  This will be followed by pumping out the sludge into a bespoke tank designed to retain sludge and discharge water via an in-built filter. The sludge will then be allowed to dry.  The dried sludge will then be analysed for radioactive content and disposed off within the landfill.

An Operating Procedure for the above process will be generated.

**Action Complete**

49. Provide data if possible on the radioactive content if any of the landfill leachate discharged to the River Ribble after treatment. What contribution does this make to dose impact for the receptors considered in your assessment?

Answer – Nuvia and SITA are not aware of any radioactive monitoring currently being undertaken by United Utilities. Any monitoring data would not directly affect the results of the Radiological Risk Assessment model since monitoring data are not directly used in the model. Site is currently undertaking the additional monitoring that has been requested by EA as part of the Baseline Monitoring Programme.
Action outstanding – Baseline Monitoring data will be presented in July 2010.

50. We understand that phase 1, 2 and 4 leachate is pumped to the leachate treatment lagoons via a pipe that runs adjacent to a small surface water drain (where flow is significantly smaller than that in Savick Brook). You should model leakage from this pipe and assess the consequences as for a leachate spillage on site.

Answer – Phase 1, 2, 3 and 4 leachate is pumped to the leachate lagoons via a pipe that is buried approximately one metre underneath the access road. The pipe is located in a silt bund that is 3- 4 m deep underneath the access road.

It is believed that if the leachate pipes were to burst and leak, the leakage would either travel vertically downwards into the silt bund or rather more unlikely, overtop the access road and spread over the road and down into the surface water drain on the other side of the road.

The bathtubbing scenario that has been documented in the Radiological Risk Assessment assumes that 1,000$m^3$ of leachate spills onto the top of the landfill contaminating a 100,000$m^2$ growing area.

If the figures for the volumes of leachate collected on the Clifton Marsh landfill per day for 2009 are taken (approx 91$m^3$/d) and it is assumed that the leachate pipe broke and went unnoticed for a month then 2730 $m^3$ of leachate would be spilt. If the spill was concentrated into a 10m2 area at a depth of 0.25, the peak doses would still be below the EA's screening criterion (peak dose due to external irradiation from Ra-226 of 2.47E-04 Sv/yr, peak dose due to ingestion of cow liver from cows grazing on the contaminated land is 3.27E-04 Sv/yr from Pb-210 and peak dose from ingestion of milk is 4.81E-04 Sv/yr due to H-3).

It should also be noted that there are management controls in place via visual inspection of the ditch and monthly sampling of the discharge to the River Ribble where any increase in flow rate due to a ruptured drain pipe would be detected. Any detection of leak would be followed up by an investigation to detect point of leak followed by repair and test.
**Action Complete –** a statement has been added to the Radiological Risk Assessment Section 7.2.2 detailing this additional assessment**.**

51. You have not mentioned the authorised surface water extractions for agricultural spray irrigation from the Ribble, close to the site and immediately downstream. Determine whether these are valid receptors, and if so, provide an appropriate assessment.

Answer – it is considered that the "bathtubbing" scenario assesses the same pathways as would be assessed through an agricultural spray pathway, but given that the bathtubbing scenario involves leachate generated from the site rather than leachate diluted by river water, the bathtubbing scenario is far more conservative than the agricultural spray scenario. It is therefore proposed not to repeat this type of scenario assessment.
**Action Complete** – a section has been added to the Radiological Risk Assessment (section 6.1.4) and a paragraph to the ESC (section 7.2) which concludes that receptors to a spray irrigation pathway have been adequately assessed using the "bathtubbing" scenario. The EA has accepted this answer (see correspondence 08/02/2010 "views on Nuvia's draft letter of 27 January 2010)

**Radiological Assessment – Questions on specific sections of the document**

52. On page 15, either justify your classification of the erosion and bathtubbing scenarios as "not certain to occur" or treat them as "expected to occur".

Answer –guidance provided by the EA entitled "Environment Agency Expectation for content of a radiological assessment supporting an application for disposal of radioactive waste at an established landfill site adopting a simplified approach" written by J. Titley 4th Dec 2008 indicates on page 3 that the bathtubbing and coastal erosion scenarios are considered not certain to occur. The human intrusion scenario is also grouped into this category. This guidance has been followed in the first instance.

It is considered that only by detailed hydrogeological and geomorphological modelling could the likelihood of these scenarios be investigated more quantitatively. In addition, if detailed hydrogeological modelling were performed, this would likely be in the context of cap design studies, with final capping designed to limit infiltration and prevent bathtubbing for an extended period.

A report has however been produced by Mike Thorne (Thorne 2010g) which assesses the likelihood of inundation of the Clifton Marsh landfill site due to breach of the banks of the River Ribble. The findings of this report are underpinned by model predictions of climate change and consequent sea level rise which themselves are inherently uncertain.

**Action Complete**

53. We believe some text needs correcting; confirm that all of the basal footprint of Phase 4 is located below the groundwater table.

Answer –yes this is correct.

**Action Complete** – this statement has been corrected in the Radiological Risk Assessment.

54. A figure of 100 years is given for the degradation of the basal BES lining system and the LLDPE capping FML. These values are significantly below the current expected lifespan of both a BES and LLDPE. Please clarify why these values where used. As a minimum we would like to see realistic performance life spans for these materials.

Answer – neither a cap nor liner were modelled in the Radiological Risk Assessment, therefore these quoted values have no impact on the risk assessment results. However, the corresponding text has been corrected.

**Action Complete** – statement in the application document has been changed to indicate that the lifetime of the cap and liner is in the region of 1000 years.

55. On page 20, you refer to a boulder clay layer resting on the middle sands. Clarify how continuous this layer is underneath the landfill phases and how effective a barrier it is likely to represent on top of the other engineering barriers.

Most of the strata appear to be laterally continuous beneath Phase 4 of the landfill. However, Strata IV and V (peaty, silty clay, and sand and gravel respectively) have been found to be absent in several boreholes to the north of the Phase 4 boundary, and appear to pinch out approximately 750 m to the north of the existing landfill. Stratum IV is very thin with an area interpreted from borehole logs to be a post glacial channel that runs from the north towards the south through the northern boundary of Phase 1. Strata IV and V have also been shown to be absent within some boreholes located within the area of Phase III and in Cell 2 of Phase 4. Therefore in general Strata IV and V appear to be less consistent towards the western part of the Clifton Marsh landfill.

The thickness of the glacial clay or upper boulder clay (Strata VI) has been proven by exploratory boreholes. A maximum thickness of this layer has been found to be 23 - 24 m in boreholes located in the area of Phase 4. A lesser thickness of this glacial clay has been found beneath Phase 3 of the landfill (approx 6.6 m).

The alluvial aquitard is not completely continuous under Phase 4, in addition, Strata IV may be less prevalent toward the western parts of the site (Phases 2 and 3) therefore some leakage may occur between Strata III and V in these areas. However there is evidence to indicate that Strata II and V are essentially hydraulically isolated in the area adjacent to Phase 4 which means it could be reasonable to assume that Strata IV is a relatively effective aquitard. In addition, there is no evidence to suggest that there is any significant hydraulic connection between the Sherwood Sandstone and the alluvial aquifers (Strata III and V).

Statements to this effect have been added to the Radiological Risk Assessment and Environmental Safety Case (Section 3.3. and 3.4).
**Action Complete**

56. In Section 5.2 (Source Term parameterisation) –

(i) We have noted various published reference effective infiltration values, such as 359 mm/year (for vegetated surfaces) and 406mm/year for (un-vegetated soil). Explain why you have used 500 mm/year;

Answer –the value of 500 mm/year was used in the Radiological Risk Assessment undertaken by BNFL in 2002. In addition, studies of effective infiltration rates for LLWR near the village of Drigg have been taken into account (Thorne, 2008a). For the LLWR, long-term annual average precipitation in temperate conditions were predicted to be 0.753 to 1.069 m $y^{-1}$, which compared well with individual annual values at the LLWR site ranging from 0.892 to 1.413 m $y^{-1}$. Comparing the locations of the LLWR and Clifton Marsh, similar values of annual precipitation would be expected to occur at both sites.

For greenhouse-warmed conditions, ranges of 0.896 to 1.212 m $y^{-1}$ were estimated for moderate warming and 0.775 to 1.091 m $y^{-1}$ for more extreme warming (Thorne, 2008b).

Estimates of actual evapotranspiration were 0.5 m $y^{-1}$ in temperate conditions, 0.598 m $y^{-1}$ in moderately warmed conditions and 0.683 m $y^{-1}$ in more extreme warmed conditions (Thorne, 2008b).

Thus, by difference, the HER is 0.253 to 0.569 m $y^{-1}$ in temperate conditions, 0.298 to 0.614 m $y^{-1}$ in moderately warmed conditions and 0.092 to 0.408 m $y^{-1}$ in more extreme warmed conditions. These values are for a cover of shrub land vegetation. Values for grass cover of the cap would be about 0.1 m $y^{-1}$ larger.
**Action Complete**

(ii) Justify your assumption that flow is advective rather than diffusive;

Answer – Transport is in an alluvial aquifer and there is a significant head gradient. Therefore, advective flow is predicted. Diffusive transport only dominates where water is essentially static in geological media. This could happen if perched water built up within the bentonite slurry walls, but this case is taken into account in the bathtubbing scenario. As diffusive transport is much slower than advective transport, consideration of advective transport is cautious.

A statement has been added to section 5.2 of the Radiological Risk Assessment to this effect.
**Action Complete**

(iii) What is the original source of BNFL and NEXIA solubility limit data?

Answer – The original source of the Nexia solutions solubility data is Nexia Solutions, 2006. Sellafield Conceptual Model Database. Users Guide. Version 1.2, BNFL Report 1654 and Quantisci 1999, Assessment of the consequences if the presence if toxic elements in some common radioactive wastestreams. Report produced for the European Commission Ref. EUR 18211.
It has not been possible to obtain a reference for the original source of the BNFL solubility limit data.
**Action Complete**

57. In Section 5.3 (Geosphere Pathways) –

(i) Justify using a 500 metre path length rather than a shorter path length of, say, 100 metres;

Answer – This pathlength has been altered to reflect information given in the Hydrogeological Risk Assessment for Phases 1, 2 and 3 rather than the parameters used in the Radiological Risk Assessment undertaken by BNFL in 2002. The pathlength for the basecase scenario has been taken to be 165 m and sensitivity studies have been performed to assess the impacts of decreasing this pathlength to 30 m which is considered to be the minimum pathlength from the waste mass to the River Ribble based on the current site state.
**Action Complete -** This has been updated in the Radiological Risk Assessment Section 5.3 and in the models.

(ii) Does the hydraulic gradient of 0.003 quoted from BNFL 2002 reflect the geometry of the site and the receptor?

Answer – It seems likely that the hydraulic gradient of 0.003 is the regional gradient of the alluvial aquifer. From Figure 1 of the Radiological Risk Assessment, it will be seen that the capped wastes rise above the local topography. As the cap is assumed not to provide any significant degree of hydrological protection in the long term (greater than 1000 years), some degree of mounding of groundwater is likely to occur over the waste area. This will increase the hydraulic gradient between the landfill site and the discharge location. As the depth of disposals is given as 6 m, it seems plausible to envisage the groundwater level as elevated by a few metres within the wastes. If the increase in water table height were 5 m and this additional height was lost over 500 m of downstream pathway, the increase in hydraulic gradient would be 5/500 = 0.01. Thus, the overall hydraulic gradient would become 0.013 and the flow through the aquifer would become 1.11 $10^6$ $m^3$ $y^{-1}$. This would be sufficient to account for both the flow in the aquifer due to the regional gradient (2.55 $10^5$ $m^3$ $y^{-1}$) and the infiltration through the wastes (7.325 $10^5$ $m^3$ $y^{-1}$).

**Action Complete -** A statement has been added to the Radiological Risk Assessment (section 5.3) to this effect and the models have been updated accordingly

(iii) Expand on why you have chosen 10% of path length for dispersion;

Answer – a value of 10% of pathlength for diffusion is recommended by GoldSim technologies as a good first approximation for one-dimensional transport through a relatively homogenous aquifer. A dispersion of 10% of pathlength has also been used in the Hydrogeological Risk Assessment for Phases 1, 2 and 3.

**Action Complete -** The Radiological Risk Assessment report Section 5.3 has been annotated to reflect this.

(iv) How applicable are the applied sorption coefficients to the Clifton Marsh materials?

Answer –The sorption coefficients used are based on the most recent review undertaken by the IAEA and now reported in IAEA-TECDOC-1616. That review makes distinctions by aspects such as soil texture, cation exchange capacity and other geochemical factors.

That review and other relevant literature were taken into consideration for the LLWR and were again examined when determining values for use at Clifton Marsh. The materials present at Clifton Marsh fall within the range of materials that have been studied experimentally, so it is realistic to use the recommended values. Ranges and distributions of values were provided for the LLWR and these ranges and distributions could be used to determine the degree to which uncertainties in values applicable to Clifton Marsh materials would affect the results obtained.

See also response to question 31.

**Action Complete**

58. In Section 6.2.1, state what assumptions you have made about differing levels of radionuclides present in leachate from Phases 1, 2, 3 and 4.

Answer – in the risk assessment model, no distinction has been drawn between the different phases of the site since the available inventory data is not broken down into phases. There has therefore been no assumption drawn about differing levels of radionuclides present in leachate from Phases 1, 2, 3 and 4.

**Action Complete –** a statement to this effect has been added to the Radiological Risk Assessment report Section 6.2.1

59. The text at the top of page 65 makes it unclear how the tables in Section 10 have been derived. Provide additional text, or resubmit the tables with an extra column showing the radionuclide source term to which the calculated dose in each row corresponds.

Answer – it is acknowledged that clarification is required as to whether the stated doses are from the existing landfill site inventory or 100 MBq inventories of potential new radionuclides to be disposed of at the site. The tables will be adjusted accordingly to indicate the inventory used in each model assessment

**Action Complete**

60. The statement at the top of page 96 needs to be clarified. It states that “The dose criteria for a simplified assessment are exceeded by an order of magnitude … but would fall below the dose criteria in requirement R6 of the GRA”. The dose criteria for simplified assessments are 20 µSv/y for scenarios considered certain to occur and 1 mSv/y for those considered not certain to occur. The criterion in requirement R6 is a risk guidance level of $10^{-6}$ $y^{-1}$, which is the risk associated with a dose of about 20 µSv/y. Requirement R7 of the GRA specifies that a dose guidance level in the range 3–20 mSv/y should be applied to doses from human intrusion scenarios only. It is therefore not apparent to us how the criteria for simplified assessment can be exceeded by an order of magnitude while the criteria in the GDA are met.

Answer – the application documents were written prior to the final issue of the GRA being published and therefore some references to the GRA may have originally referred to the draft GRA for

consultation and may not have been updated to refer to the final issue. In the draft GRA for consultation, requirement 6 stated that the dose constraints during the period of authorisation are 0.3 mSV/yr for a source related constraint and 0.5 mSv/yr for a site related dose constraint. This requirement is now requirement R5 in the final issue of the GRA, 2009. Therefore the site related dose constraint for the period of authorisation is over one order of magnitude greater than the screening criterion of 0.02 mSv/yr for a simplified assessment. Dose constraints for the human intrusion scenario are given in Requirement R7 of the final issue of the GRA as between 3-20mSv/yr and in Requirement R8 of the draft for consultation of the GRA and 3-30mSV/yr. If the upper bound to these limits is considered, then this is over one order of magnitude greater than the dose criterion set for a simplified assessment which is 1mSv/yr.
**Action Complete** – The statement in Section 10.6 of the Radiological Risk Assessment and section 8.2.1 of the ESC have been clarified and all corresponding references updated to reflect the numbering of requirements in the final issue of the GRA, 2009

61. Please check the dose coefficients for intakes in Tables 45 and 46 of the radiological risk assessment report. All tabulated values include the in growth of radioactive progeny after intake of the parent. In cases, such as this, where the environmental transport of short-lived progeny is not modelled explicitly, it is also necessary to adjust dose coefficients to allow for the fact that the parent is likely to be in secular equilibrium with its short-lived progeny before intake, and therefore that a person who ingests or inhales 1 Bq of the parent will probably also ingest or inhale 1 Bq of each of the short-lived progeny at the same time. The values for adults in Tables 45 and 46 appear to include this correction, but those for children and infants appear not to. (We note that the potential error is not large – a factor of two at the very most – but we expect applicants to understand and apply correctly the fundamental basis for their modelling).

Answer: The dose coefficients in tables 45 and 46 for infants and children have been updated to include contributions from short-lived progeny in secular equilibrium. In addition, dose coefficients in tables 49 and 50 have been updated following amendments to SNIFFER as communicated by the EA. All of these changes have been propagated through the models and calculations
**Action Complete**

## References

SITA, 2010, Report on Clifton Marsh Flooding Scenarios.

Thorne, M C, 2008a, LLWR Lifetime Project: Estimates of Cap Infiltration and Erosion, Nexia Solutions (07) 1234, Issue 1.

Thorne 2010a: External Memorandum – Aircraft Crashes and Explosions, Mike Thorne correspondence.

Thorne 2010c External Memorandum - Other Radionuclides, Mike Thorne correspondence

Thorne 2010d Memo to Nuvia Ltd, Commentary on applicability of solubility limits and Kds reflecting Reducing Conditions in the Near Field

Thorne 2010f Memo to Nuvia Ltd, Classification of Additional Radionuclides, Mike Thorne correspondence

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**Reference no: CD0235** **Date:**

**Radioactive Substances Act 1993 - Application for authorisation submitted by Sita (Lancashire) Limited in respect of Clifton Marsh Landfill Site**

## The Data Protection Act 1998

We, the Environment Agency, will process the information you provide so that we can:

- deal with your application;
- make sure you keep to the conditions of the licence, permit or registration;
- process renewals; and
- keep the public registers up to date.

We may also process or release the information to:

- offer you documents or services relating to environmental matters;
- consult the public, public organisations and other organisations (for example, the Health and Safety Executive, local authorities, the emergency services, the Department for Environment, Food and Rural Affairs) on environmental issues;
- carry out research and development work on environmental issues;
- provide information from the public register to anyone who asks;
- prevent anyone from breaking environmental law, investigate cases where environmental law may have been broken, and take any action that is needed;
- assess whether customers are satisfied with our service, and to improve our service; and
- respond to requests for information under the Freedom of Information Act 2000 and the Environmental Information Regulations 2004 (if the Data Protection Act allows). We may pass the information on to our agents or representatives to do these things for us.

## Confidentiality and national security

We will normally put all the information in your application on a public register of environmental information. However, we may not include certain information in the public register if this is in the interests of national security, or because the information is confidential.

You can ask for information to be made confidential by enclosing a letter with your application giving your reasons. If we agree with your request, we will tell you and not include the information in the public register. If we do not agree with your request, we will let you know how to appeal against our decision, or you can withdraw your application.

You can tell the Secretary of State that you believe including information on a public register would not be in the interests of national security. You must enclose a letter with your application telling us that you have told the Secretary of State and you must still include the information in your application. We will not include the information in the public register unless the Secretary of State decides that it should be included.

Your application includes the Environment Agency’s request for information dated 17 December 2009 and your attached response.

**Tick the box if you wish to claim confidentiality for your application**

Please treat the information in my application as confidential. √

**Tick the box if you wish to claim national security for your application**

I believe that including my information in the public register would not be in the interests of national security.

**Declaration**

If you knowingly or carelessly make a statement that is false or misleading to help you get an environmental permit (for yourself or anyone else), you may be committing an offence under the Environmental Permitting (England and Wales) Regulations 2010.

A relevant person should make the declaration.

I declare that the information in this application is true to the best of my knowledge and belief. I understand that this application may be refused or approval withdrawn if I give false or incomplete information.

If you deliberately make a statement that is false or misleading in order to obtain approval you may be liable to prosecution.

Tick this box to confirm that you understand and agree with the declaration above √

Name:

| | |
|---|---|
| Title | Mr |
| First name | Bhavesh |
| Last name | Thaker |
| Position in Organisation | Technical Manager (UK Nuclear) |

Today's Date 7th May 2010