	Environmental Safety Case for the Clifton Marsh Landfill Site	Document Ref. 89290/SC/SR/003 Issue: 3 Date: 9/12/2010 Page 1 of 69 Author: Louise Eden
Title: Environmental Safety Case for the Disposal of Very Low and Low Level Radioactive Waste at the Clifton Marsh Landfill Site		

Revision details:

1. Further to comments and questions from the Environment Agency on Issue 1, revisions to the report have been undertaken as detailed in Eden (2010).

2. Minor amendments to text of Issue 2

Signatures	
Author **Louise Eden**	**Date 9/12//2010**
Checked **Jonathan Clark**	**Date 9/12//2010**
Approved **Jonathan Clark**	**Date 9/12//2010**
Document Status	**DAS No** .... **Date** ………………………………………..... **Signature** .... (Not applicable for internal documents)

Registered Office: Nuvia Limited, Kelburn Court, Daten Park, Risley, Warrington WA3 6TW
Registered in England No 2063786
Tel: 01925 858200 Fax: 01925 811866 Email: Info@nuvia.co.uk www.nuvia.co.uk

CONTENTS

EXECUTIVE SUMMARY

This document is an Environmental Safety Case (ESC) which underpins the application for authorisation under the Radioactive Substances Act (RSA) 1993 for the Clifton Marsh site to receive additional radioactive wastes (VLLW and lower activity LLW) onto the site.

The proposals set out in this document are in line with Government Low Level Waste (LLW) Policy (DEFRA, 2007) which outlines a flexible approach to the management of LLW and places greater emphasis on the application of the waste hierarchy prior to final disposal of LLW.

Clifton Marsh is classified as a non-hazardous landfill site and has been operating since the early 1980s for the disposal of domestic, commercial and industrial wastes. The Clifton Marsh landfill site has also accepted low level radioactive waste (LLW) for landfill disposal from the Capenhurst and Springfields Nuclear Decommissioning Authority (NDA) owned sites since 1986. The site is currently operated by SITA UK under an Environmental Permit, reference BK2348, IU Variation LP3132LC. Disposals of VLLW and low level LLW are sanctioned under the RSA 93 authorisations held by the Springfield and Capenhurst sites. The site's environmental impacts have been assessed previously for the environmental permit and under a radiological risk assessment undertaken in 2002 (BNFL, 2002).

This ESC supports the application for authorisation under the RSA 93 by providing a safety assessment giving evidence of the acceptability of the disposal of radioactive waste at the Clifton Marsh site. The ESC is set out in accordance with the requirements and guidance provided by the Environment Agency (EA, 2009).

The radiological risk assessment that underpins this ESC has been undertaken according to a methodology that has been agreed with the EA. This methodology uses a combination of approaches including the SNIFFER model developed by Galson Sciences and the screening methodologies developed by the EA for radionuclide releases during operational procedures, along with a more complex modelling approach using the GoldSim software tool.

The risk assessment is based both on the historically existing radioactive disposal inventory as defined in BNFL (2002) which includes radioactive waste disposals to the Clifton Marsh landfill since 1986 and also radioactive waste disposals to the adjacent Grange Farm site which took place during the period 1974 to 1986 and an estimated potential future disposal inventory which has been based on waste arisings reported in the 2007 UK National Inventory. This future disposal inventory of the Clifton Marsh site will, however, only be defined after commercial agreements between SITA and the waste consignors are concluded.

The results of this assessment have been compared to the regulatory screening criteria as set out by the EA (2009) and are considered to meet requirement R9 of the GRA (Guidance on Requirements for Authorisation) which states that "*The developer/operator should carry out an assessment to investigate the*

radiological effects of a disposal facility on the accessible environment both during the period of authorisation and afterwards with a view to showing that all aspects of the accessible environment are adequately protected".

The proposed waste acceptance criteria for the Clifton Marsh landfill site which will fall under the new authorisation have also been discussed in this report. Annual radioactivity limits for the waste to be accepted on the Clifton Marsh site have been derived from the radiological risk assessment results and the calculated remaining radiological capacity of the site. These limits are shown in the following table:

Radionuclide	***Group for Waste Acceptance Criteria Annual Disposal Limit***	***Proposed Annual Limit (Bq/yr) assuming 11 years of future disposals***
U-232	Uranium (and associated surrogates)	5.00E+11
U-233		
U-234		
U-235		
U-236		
U-238		
I-129		
Th-228	Thorium (and associated surrogates)	1.00E+11
Th-229		
Th-230		
Th-232		
Th-234		
Sn-126		
Nb-94		
Ac-227	Restricted Beta	1.00E+10
C-14		
Cl-36		
Co-60		
Cs-134		
Cs-137		
Ru-106		
Sr-90		
Tc-99		
Zn-65		
Zr-95		
Nb-95		
Ru-103		
Ag-110m		
Sb-125		
Eu-155		

Radionuclide	***Group for Waste Acceptance Criteria Annual Disposal Limit***	***Proposed Annual Limit (Bq/yr) assuming 11 years of future disposals***
Ba-133		
Eu-152		
Eu-154		
Pb-210	Ra-226/Ra-228/Pb-210/Po-210	6.00E+09
Po-210		
Ra-226		
Ra-228		
Ce-144	Other Beta (and associated surrogates)	2.00E+12
Fe-55		
Ni-63		
Pu-241		
Mn-54		
Pm-147		
Am-241	Other Alpha (and associated surrogates)	5.00E+10
Np-237		
Pa-231		
Pu-238		
Pu-239		
Pu-240		
Cm-242		
Ag-108m		
Pu-242		
Am-243		
Cm-243		
Cm-244		
H-3	H-3	1.00E+13

It is anticipated that where the radionuclides are grouped, the sum of the activities of the radionuclides in that group will not exceed the limit for the group.

The annual disposal limit is based on 11 years of future disposals to the Clifton Marsh site. An extension in the site lifetime would therefore lead to a decrease in the acceptable annual disposal limit, in order to observe the calculated site lifetime capacity.

The average activity concentration of any package of radioactive material shall not exceed a total of 200 Bq g^{-1} for all radionuclides, unless explicitly agreed by prior arrangements. This average activity concentration will be applied to each package of waste.

A waste accounting system recording all inputs, activity per package, and providing a recording system for all radioactive materials will be established. This will enable effective inventory management and optimal use of the site's radiological capacity.

The management procedures in place at the Clifton Marsh site which cover waste acceptance, receipt, disposal and health and environmental monitoring have also been outlined and are considered to meet the requirements of the GRA for the developer/operator of a disposal facility to foster and nurture a positive environmental safety culture at all times.

Throughout the programme of work carried out for the authorisation application, SITA UK has undertaken an in-depth, open and honest stakeholder engagement process. This integrated communication process which took place from the planning phase through to the application stage was intended to ensure high quality effective communications with all those stakeholders that are potentially affected by the plans for future VLLW and low activity LLW disposals at Clifton Marsh site. The focus of this communication was to enable stakeholders were able to express their views and opinions on how they would like to shape the engagement processes.

In summary, the measures set out in this ESC are considered to meet the requirements under the GRA (EA, 2009) and provide assurance that the authorisation of the Clifton Marsh site to receive VLLW/LLW waste disposals from a range of consignors will be managed in a safe and effective manner and any radiological impacts will be within the relevant regulatory prescribed criteria.

1 INTRODUCTION & SCOPE

This document is an Environmental Safety Case (ESC) to underpin the application for authorisation under the Radioactive Substances Act (RSA) 1993 for the Clifton Marsh site to receive radioactive wastes (VLLW and lower activity LLW) onto the site.

SITA UK, a subsidiary of Suez Environnement, is a recycling and resource management company that currently owns and operates the Clifton Marsh site. The company delivers environmentally responsible and increasingly innovative solutions for the public, local government, industry and commerce, enabling its customers to reduce their impact on the environment.

SITA UK serves over 12 million people and handles more than 10.6 million tonnes of domestic, commercial and industrial waste through a network of recycling, composting, energy-from-waste and landfill facilities. SITA UK employs over 6,000 staff and has an annual turnover in excess of £844 million.

SITA UK's operations in the North West are handled by SITA Lancashire, which is based in Preston.

This ESC supports the application for authorisation under the RSA 93 by providing a safety assessment giving evidence of the acceptability of the disposal of radioactive waste at the Clifton Marsh site. The ESC is set out in accordance with the requirements and guidance provided by the Environment Agency (EA, 2009) which are summarised in Table 1.

Table 1: List of Requirements from the EA's Guidance (EA, 2009)

Requirement	**Relevant Section of ESC**
R1: Process by agreement	N/A
R2: Dialogue with local communities and others	Section 4
R3: Environmental safety case	Entirety of this document
R4: Environmental safety culture and management system	Documented in SITA's Materials Acceptance Criteria and Operating Procedures
R5: Dose constraints during the period of authorisation	Section 7
R6: Risk guidance level after the period of authorisation	Section 7
R7: Human intrusion after the period of authorisation	Section 7
R8: Optimisation	Section 9
R9: Environmental radioactivity	Documented in SITA's Materials Acceptance Criteria and Operating Procedures and Section 7

R10: Protection against non-radiological hazards	Documented in SITA's Materials Acceptance Criteria and Operating Procedures
R11: Site investigation	Completed prior to this report
R12: Use of site and facility design, construction, operation and closure	Section 3
R13: Waste acceptance criteria	Section 8
R14: Monitoring	Documented in SITA's Materials Acceptance Criteria and Operating Procedures

The programme of work which has been set out to cover all aspects of the application for authorisation has been agreed with the EA and hold points have been incorporated into this programme to allow for review of information by the EA. This complies with Requirement R1 of the GRA which states that "*The developer should follow a process by agreement for developing a disposal facility for solid radioactive waste."*

This document forms the Environmental Safety Case for the Clifton Marsh site as required under R3 of the GRA "*An application under RSA 93 relating to a proposed disposal of solid radioactive waste should be supported by an environmental safety case*."

2 REGULATORY CONTEXT

2.1.1 Government Policy

The proposals set out in this document are in line with new Government Low Level Waste (LLW) policy (DEFRA, 2007) which outlines a flexible approach to the management of LLW and places greater emphasis on the application of the waste hierarchy prior to final disposal of LLW.

The policy recommends the consideration and use of a wide range of waste management solutions in order to optimise capacity at the UK's low level waste repository. These solutions could include minimisation, re-use and recycling of the wastes prior to disposal in an engineered facility either above or below ground. The use of local waste management facilities in this process are encouraged in order to minimise the impacts of long distance transportation of radioactive waste.

The policy discusses various types of disposal facility for LLW and notes that such facilities should be 'fit for purpose'. This means that the degree of engineering required for particular types of waste should be proportional to the risk posed by the wastes such that higher activity low level wastes will continue to require highly engineered facilities such as the UK low Level Waste Repository (LLWR) whilst lower activity low level waste could be disposed of in less engineered facilities that still provide sufficient levels of safety and environmental protection. In particular, the Government's view is that very low level waste (VLLW) disposals to landfill is a viable and an important option for the management of radioactive waste and is proven to be safe under appropriately regulated conditions.

The (NDA) undertook a strategic review which included a baseline inventory of all LLW wastes arising from NDA sites over their project lifetimes (2008 to 2129). The NDA estimated that approximately 3 million m^3 (NDA 2009) of LLW wil be generated during this time from the NDA sites as well as from non-NDA sites such as the British Energy sites, Ministry of Defence sites and non nuclear operations (including healthcare and research). Of this volume it is estimated that 60% will be high volume VLLW. The greatest generation of this waste will be over the period 2008 to 2031. The review also estimated that one of the largest producers of VLLW will be the Springfields site which is situated in very close proximity to Clifton Marsh.
The proposals set out in this document have taken into account the relevant government policy and guidance and are considered to:

- Enable conservation of capacity at the LLWR, in particular reserving capacity for wastes that require disposal in such a highly engineered facility by diverting other waste to Clifton Marsh;
- Conform with regulatory criteria and guidance;
- Make use of a proportional approach to develop the environmental safety case, in consideration of the level of radiological impact anticipated from the radioactive waste disposals at Clifton Marsh.

2.1.2 Regulatory Requirements

The framework for controlling the disposal of radioactive wastes is provided under the Radioactive Substances Act 1993 (RSA 93). In England and Wales, responsibility for granting authorisations for the disposal of such waste types rests with the Environment Agency.

The current regulatory guidance on the requirements for authorisation (GRA) under the RSA 93 (EA, 2009) necessitates that the radiological risks to people and the environment from disposals of solid radioactive waste shall be within nationally recognised safety standards both at the time of operation of the disposal site and in the future. This overriding objective is covered in the GRA by its 5 key principles and 14 requirements as described in Table 1.

As mentioned previously, the GRA outlines that the approach to the safety assessment should be proportionate to the perceived risks. Since it is proposed that the anticipated volumes of VLLW/LLW to be disposed of at Clifton Marsh will only be up to 10% of the site's total volumetric capacity and that the LLW specific activity will be limited to packages of up to 200 Bg g^{-1}, the approach to the radiological risk assessment described here is considered to be proportionate to the perceived risks posed by the anticipated levels of activity..

The radiological risk assessment has as its output an estimated maximum dose to potentially exposed groups (PEGs) associated with the Clifton Marsh site and its surroundings from a series of radionuclides disposed of at both the Clifton Marsh site and the adjacent Grange Farm site.

For a simplified approach, the following dose criteria apply:

Phase	Scenario	Criterion (mSv/yr)
Operational	Normally expected to occur	0.02
	Not certain to occur	1
Post Closure	Normally expected to occur	0.02
	Not certain to occur	1

If these criteria can be met using a simplified approach, then the EA's requirements as laid down in the GRA can be considered to have been satisfied. If the criteria are not met using a simplified approach, then fuller application of the requirements of the GRA (EA, 2009) will be required against the dose criteria defined in the GRA:

- Requirement R5: Dose constraints during the period of authorisation:
  - source-related dose constraint of 0.3 mSv y^{-1}
  - site-related dose constraint of 0.5 mSv y^{-1}
- Requirement R6: Risk guidance level after the period of authorisation:
  - risk guidance level of 10^{-6} per year (i.e. 1 in a million per year) (this is equivalent to a dose of around 20 µSv y^{-1} if the ICRP (1991) dose-risk factor of 0.06 per Sv is assumed).

The term "risk guidance level" indicates the standard of environmental safety that the EA requires. However, the EA does not set an absolute requirement for this level to be met.

The radiological risk assessment is described in full within Section 7.

3 SITE INFORMATION

3.1 Location and History

Clifton Marsh is classified as a non-hazardous landfill site and is located within an extensive area of reclaimed marshland along the northern bank of the River Ribble at Freckleton in Lancashire, approximately 6 km west of Preston town centre.

The facility sits in an area of versatile agricultural land, and is part of the Ribble Estuary Sites of Special Scientific Interest consultation area. The Ribble and Alt Estuaries Special Protection Area (SPA) are located to the south west of the site. The SPA is listed as a Ramsar site under the Ramsar convention for its internationally important wetland status (EU, 1992).

The Preston sewage works, the restored Grange Farm landfill site and the Clifton Marsh farm are adjacent to the site. There are also business premises in close proximity to the site, the Preston West Premier Inn approximately 0.5 miles from the landfill and the Clifton Fields business park approximately 0.5 miles away.

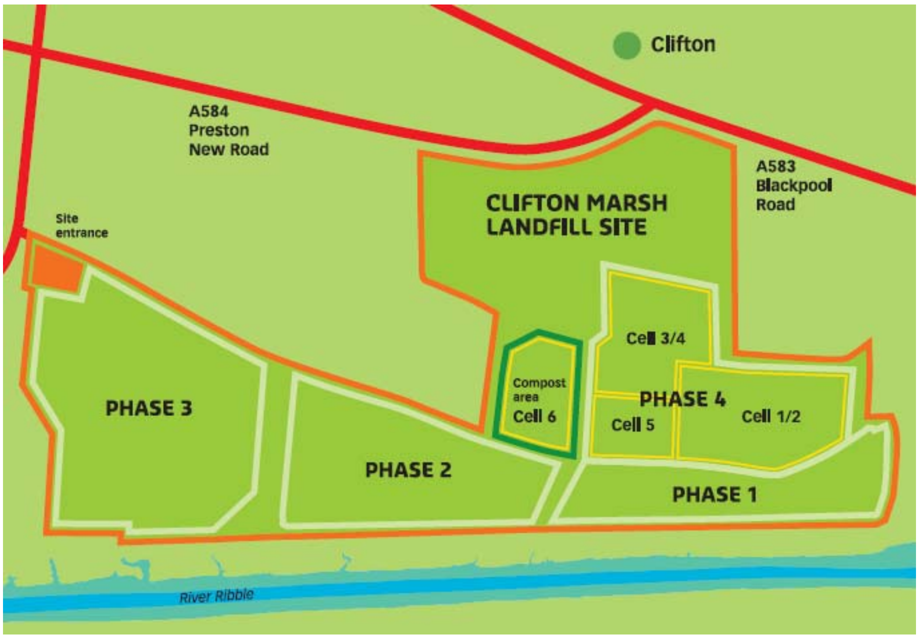
Figure 1: Clifton Marsh Landfill Location

The existing Clifton Marsh landfill has been operating since the early 1980s for the disposal of domestic, commercial and industrial including difficult and hazardous wastes. The Clifton Marsh landfill site has accepted low level radioactive waste (LLW) disposals from the NDA's Capenhurst and Springfields sites since 1986. Further information on these waste disposals is given in the following section. The site is classified as a non-hazardous landfill and is currently operated under an environmental permit. Disposals of VLLW and low level LLW are sanctioned under the RSA 93 authorisations held by the Springfields and Capenhurst sites.

The adjacent Grange Farm site has also historically accepted disposals of radioactive waste. These disposals took place during the period 1974 to 1986 at which point disposals were commenced at the Clifton Marsh landfill site. The impacts from the disposal inventory within the Grange Farm site has been taken into consideration in this radiological risk assessment.

The Clifton Marsh landfill site was developed initially as three operational phases sited adjacent to the River Ribble and development has more recently centred on Phase 4 which occupies approximately 50 hectares (ha) of land to the north of Phase 1. Radioactive waste disposals to the Clifton Marsh landfill site commenced in August 1986 in Phase 1 at the eastern end of the site.

Figure 2: Clifton Marsh Landfill Site Disposal Phases



Disposals to Phase 3 took place during the period August 1993 to May 2003. Disposals to Phase 4 commenced in 2001 and are expected to continue until at least 2019, subject to planning permission.

The entire landfill is classed as a supervised area under the Ionising Radiations Regulations (IRR) 1999.

3.2 Landfill Description

3.2.1 Disposal Phases

Phase 1 occupies a narrow 9.8 ha strip of land at the eastern end of Clifton Marsh and was composed of 9 approximately equal sized cells and encircled by a compacted sand and silt embankment, the latter being about 25 m wide, 4.5 m high with a 4.5 m crest. The waste rests directly on alluvial sands and gravel in cells 3 to 7 whilst silts and silty sands form the main component of strata underlying cells 1, 2, 8 and 9. The first three cells to be developed (1-3) were excavated down to the water table; however, the potential for rapid leachate dispersal associated with this approach was recognised and a policy of maintaining a significant buffer of sediment between the wastes and water table has been operated ever since.

Phase 2 occupies a 19.8 ha strip of land between Phases 1 and 3. It is bounded to the east and west by surface water drainage channels or trenches containing the Springfields Fuels Limited, ICI, Shell and British Gas pipeline easements. The Phase contained 12 cells with a combination of dry and wet (sewage sludge) waste. The embankment on the northern edge was constructed of silts and sands with a 1 m thick internal clay liner. The southern and eastern perimeter was composed of compacted clay and was keyed into the underlying Alluvium to a depth of 1 m. The waste is underlain by alluvial silts and clays. Excavation into the Alluvium was minimised during the construction of Phase 2 to guarantee a 2 m unsaturated zone thickness between the waste and the water table. Waste filling to Phase 2 was completed in early 1994.

Phase 3 occupies 30.1 ha of ground at the western end of the Clifton Marsh site. The base of the Phase resides at least 2 m above the prevailing water table and a geocomposite lined bund enclosed the cells.

Appendix 1 contains maps of phases 1, 2 and 3.

Before the deposition of solid wastes, Phases 1, 2 and part of 3 were filled with sludge from the nearby sewage treatment works which was pumped into the prepared tipping cells and allowed to settle out over several months. The liquid component was then returned to the sewage treatment works, and the sewage sludge (up to 3 m thick in Phase 1) was covered by dry waste. The later tipping in phase 3 comprised disposal of a pressed cake which was spread across the base of the site in advance of general waste tipping.

Phase 4 covers 59 ha of land to the north of the site. It has been constructed in a cellular manner with each cell's base located beneath the existing water table (Atkins, 2002a).

A leachate pumping system and a fully engineered composite lining system (HDPE, clay or bentonite sand and drainage blanket) is in place at the base of each cell in Phase 4.

Prior to dewatering the cells a low permeability bentonite/cement slurry trench cut off wall has been installed around the perimeter of each cell keyed into the low permeability of Stratum VI (glacial clay). This allows the dewatering process to be simplified and also prevented the movement of leachate during the installation process.

Clifton Marsh also accepts disposals of asbestos in a separate engineered cell along with non biodegradable wastes as stipulated in Schedule 1 Paragraph 14 of the Landfill (England and Wales) Regulations 2002 (as amended).

A 42 inch gas and ethylene line lies between phases 2 and 3 (owned by British Gas and Shell) and two surface water effluent pipelines run from the Springfields site between Phases 1 and 2. There is also a chemical store, treatment facility on site and electricity generating unit on site.

3.2.2 Slurry Trench Cut off Wall, Liner and Cap

The most recently developed phase of the landfill site, Phase 4, has several engineered barriers as key features to prevent contaminant migration from the site.

A slurry trench cut off wall has been installed around each cell in phase four. The wall has been constructed by introducing cement/bentonite slurry into a trench and then extending the trench by excavating through the slurry. The base of the trench has been keyed to an appropriate depth into the boulder clay (Stratum VI). The depth of the cut off wall is dictated by the depth to the surface of Stratum VI (average 12 m). A design permeability criterion of <1 x 10^{-9} m/s is used for the cut-off wall.

Due to the installation of this cut-off wall around phase 4, groundwater flow beneath Phase 1 will be locally restricted, reducing the amount of groundwater under Phase 1 available to dilute the leachate leaking from within it.

In addition, a basal lining system is in place in Phase 4 which extends over the base of each cell and up the side to the crest of the perimeter bunds. The liner consists of compacted clay or Bentonite enriched soil (BES) which is laid as a single 300 mm layer, on top of which is a 2 mm high density polyethylene (HDPE) flexible membrane, then a layer of geotextile protection and finally a 300 mm thick non-calcareous leachate drainage stone. The permeability of the BES layer is <1 x 10^{-10} m/s. This lining system is expected to degrade over 1,000 years following installation.

Phases 1, 2 and 3 do not have any engineered low permeability liner to inhibit the passage of leachate to groundwater. However leachate entry into the aquifier below phases 1, 2 and 3 is partly hindered due to a pseudo ‘liner’ of low permeability consolidated sewage sludges deposited at the base of each phase prior to commencement of disposals.

Once a phase has reached its volumetric capacity it is ‘capped off’ in accordance with the environmental permit. The cap consists of a 1 mm thick welded linear low density polyethylene (LLDPE) Geomembrane layer, above which is 1050 mm of sub-soils and 150 mm of top-soils. There is no assumed permeability for the cap therefore leakage into the landfill is assessed purely on infiltration rates.
Phases 1, 2 and 3 are all now fully covered with a low permeability cap in order to reduce any rainfall infiltration and leachate production. Phase 4 cells will be capped off once they have been filled.

A detailed assessment of effective rainfall at the Clifton Marsh landfill site was undertaken (Atkins, 2002b) which estimates that cap infiltration rate will be 27mm/a (+/- 5mm). An assessment of the infiltration rate upon cap degradation (1000 years from completion of landfilling) has not been completed.

The end state of the Clifton Marsh landfill site is defined in the current planning permission and is a fully capped area restored back to agricultural use.

3.2.3 Leachate and Gas Management

Leachate is removed from Phases 1, 2, 3 and 4 of the landfill site via a pumped system which discharges to the leachate lagoons. In Phase 4, the leachate collection system is constructed over the composite liner which covers the base and side walls of each cell. The leachate drainage blanket is formed from 20 to 40 mm diameter non-calcareous clean granular stone.

The leachate collection pipework system comprises of a network of perforated pipes all of which has been oversized to accommodate the relatively gentle 1:100 fall of the landfill base. The pipework system feeds into a concrete pumping chamber with a 1.0 m sump located at the lowest point of the cell. The leachate level is maintained at 1.0 m or lower relative to the surface of the liner.

Leachate is pumped from the waste disposal cells in all four phases of the site, and transferred via a pipe network to fully lined lagoons on site for aeration to strip dissolved methane. The system comprises of two lagoons for the processing of two separate leachate waste streams. The smaller of the lagoons (B) has a gross capacity of 4,736 m^3 and collects the leachate from the phase 4 operational area. This lagoon is connected by a 100 mm pipe which allows the leachate to "overtop" into the larger lagoon (A). This larger lagoon is used for the treatment of leachate from phases 1, 2 & 3, and has a gross capacity of 12,200 m^3.

The leachate is tested on a monthly basis for non radiological chemicals before being discharged into the adjacent sewage works. The combined treated effluent from the Sewage Works is discharged into the River Ribble under a discharge consent that is managed by United Utilities.

Over the last three years, the total volume of leachate pumped off the Clifton Marsh landfill site has been approximately 245,000 m^3, of which approximately 630 m^3 per day has come from Phases 1 - 3 and 58 m^3 per day from Phase 4.

Under the discharge consent, not more than 1500 m^3 per day of leachate and no more than 18 l per second of leachate from the Clifton Marsh landfill can be discharged to the sewage works.

Gas extraction systems extract gas from phases 1, 2 and 3 of the landfill and transfer it via pipes to four gas engines that generate electricity. There are several gas monitoring wells on the Clifton Marsh landfill site to allow the frequent measurement of carbon dioxide and methane levels. A monitoring programme for measuring the radioactive content of gas discharged from the landfill will be put in place under SITA's RSA 93 authorisation.

The gas management system is operated and maintained by ENER.G Natural Power Limited (ENPL) and it is their responsibility to collect, extract and treat the landfill gas that emerges. A generator which allows the gas to be flared in order to generate electricity for the site was commissioned in April 2004 by ENPL (ENPL 2007).

No gas collection system is in place on phase 4 since the waste mass has not yet been sealed. Gas extraction is not possible around the operational face due to the risk of pulling oxygen into the gas system which could potentially lead to a landfill fire. However the gas extraction equipment will be installed once the site has areas of capping completed.

3.3 Geology

The following information has been taken from the Regulation 15 assessment (under the EC Directive on the Protection of Groundwater against Pollution caused by certain Dangerous Substances 80/68/EEC) for the Phase 4 extension, (Atkins, 2002b)

The shallow geology near the Clifton Marsh landfill has been investigated in detail. Monitoring boreholes have been excavated into the sediments under the site, some of which intersect the underlying glacial deposits and are positioned along the fringes of the landfill. The remainder extend a few metres below the base of the landfill disposed wastes.

The boreholes reveal a variety of alluvial deposits (Strata I-V) which overlie the Boulder Clay (Stratum VI) and Sherwood Sandstone (Stratum VII). Table 2 summarises the geology underlying the site and a diagrammatical representation is shown in Appendix 2.

The alluvial deposits which consist of sands, silts and gravels contain groundwater. The water table is 4m or less below ground. The Sherwood Sandstone also contains groundwater.

Table 2: Geology underlying the Clifton Marsh landfill site

Stratum	***Depth (m bGL)***	***Thickness (m) Mean/Min/Max***	***Description:***	***Location***
I	0.0 – 0.7	0.44 / 0.1 / 1.15	Topsoil and subsoil	
IIa	0.0 – 5.0	4.18 ./ 0.00 / 5.00	Loose fine to coarse occasional gravely sand	Northern Edge of Phase 2
IIb	0.0 – 6.0	1.67 / .14 / 5.80	Loose clayey silty sand and sandy silt	Present under whole site, thinnest to west and NW of Phase 1
III	0.7 – 12.5	5.48 / 2.80 / 8.80	Loose silty fine to medium sand with depth becoming fine to coarse sand with occasional gravel and shells	Present under whole site
IV	5.3 – 14.3	2.09 / 0.00 / 4.80	Soft organic silty clay and clayey silt with some bands of peat/ loose v sandy silt	Present under whole site except north-eastern extremity of Phase 4
V	7.0 – 15.0	2.65 / 0.00 / 7.10	Medium dense to dense fine to coarse gravel	Present under whole site except north-eastern extremity of Phase 4
VIa	13. 7 – 29.8	11.5 / 5.30 / 17.00	Firm to stiff or stiff clay with some gravel – Upper Boulder Clay	Glacial Deposits
VIb	23.3 – 40.5	13.65 / 3.80 / 21.69	Fine sand with occasional sandy clay, coarse sand and gravel – Middle Sands	Glacial Deposits
VII	-	> 190	Fine to medium grained red and grey sandstone with occasional marl bands	Bedrock

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 to 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 (Strata VI) has been proven by exploratory boreholes. Maximum thicknesses for this layer have 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 3of the landfill (approx 6.6 m).

3.4 Hydrology and Hydrogeology

The following information has been taken from Atkins (2002b), Golder Associates (1996) and SITA (2003).

Clifton Marsh landfill is situated on the northern banks of the River Ribble. The Savick Brook enters the tidal River Ribble approximately 100 m to the south east of Phase 4 and the reach adjacent to the landfill is tidal. Extensive tracts of farmland and marsh on both sides of the channel are prone to flooding. There are minor surface water features comprising drainage ditches and flood storage ditches that cross Phase 4 from north to south and east to west. They ultimately discharge to the Savick Brook.

The Sherwood Sandstone has been designated a major aquifer by the Environment Agency. The sandstone is a major source of groundwater abstraction in the region as a whole however, in the region around the Clifton Marsh, the aquifer has not been widely utilised, possibly due to relatively poor groundwater quality through effects of the Ribble Estuary and saline intrusion. The Middle Sands which form a major component of the glacial drift also have good water bearing properties.

The piezometric surface of the Sherwood Sandstone in the area is reported to be approximately 0 m AOD with a gentle fall in the hydraulic gradient to the south of approximately 0.003. These conditions would confine the Sherwood Sandstone beneath the glacial clay. Hydraulic continuity between the Sherwood Sandstone and the groundwater within the overlying drift will therefore be inhibited by the glacial clay, which will act as an aquitard. Downward movement of groundwater from the drift to the Sherwood Sandstone will also be prevented by the upward piezometric potential acting on the base of the glacial clay. Confirmation of the conditions has been provided by the results of the site investigations (SITA, 2003).

The hydrogeological character of the Clifton Marsh area relates primarily to the groundwater contained within the alluvial drift deposits. The base of the aquifer is defined by the surface of the glacial clay. The relative permeable alluvial sands and gravels (Strata III and V) are hydraulically isolated (or partially isolated) by a relatively low permeability clayey aquitard (Strata IV) over much of the site.

The alluvial aquitard is not completely continuous under Phase 4 as described in Section 3.3, 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).

The general direction of groundwater flow in Stratum III (the sands sils and gravels) has been calculated from groundwater monitoring to be towards the south/south east into the River Ribble. The groundwater flow direction within Stratum V indicates that predominant discharge occurs into the River Ribble. The groundwater flow is, however, modified in the vicinity of the existing landfill. The cut-off wall surrounding Phase 4 of the landfill blocks groundwater flow under Phase 1 and through Phase 4, reducing the amount of groundwater under Phases 1 and 4 available to dilute leachate leaking from them. Therefore, groundwater discharging to the Savick Brook should have passed around Phase 4 and at worst only a small length of the Savick Brook could experience contaminated groundwater discharge.

A sensitivity analysis has, however, been undertaken to assess the impact of groundwater discharge to the Savick Brook and covers the possibility of changes to the groundwater pathway over time.

There is a diurnal variation in groundwater level in response to the tidal cycle in both Stratum II and Stratum V.

The hydrogeology of the Clifton Marsh landfill site is shown in Appendix 2.

3.5 Volumetric Site Capacity

The total waste volume disposed of in Phases 1, 2 and 3 has been modelled in SITA drawing reference Clm-WMA-0908-01, Waste Mass Assessment. The total waste volume disposed of in Phase 4 has also been modelled in SITA drawing reference L01/00/113.

Phase 1 has been calculated to have a volume of 949,250 m^3, Phase 2 to have a volume of 1,550,700 m^3 and Phase 3 to have a volume of 2,696,500 m^3. The levels of the base and the top of the waste have been modelled and show that towards the edge of the disposal phases the waste depth is between 5-7 m and toward the middle, the waste depth is between 10-12 m.

The volume of Phase 4 has been calculated to be 3,906,267 m^3. Given a surface area of 590,000 m^2, this gives an average waste depth of 6.6 m.

A conversion factor of 1.1 tonnes of waste per cubic metre has been suggested (SITA correspondence). This gives the total mass of waste in Phase 1 as 1,044,175 te, Phase 2 as 1,705,770 te, Phase 3 as 2,966,150 te and Phase 4 as 4,296,893 te.

Phases 1-3 are completely filled and capped. The current remaining void space in Phase 4 (excluding cap area on cell 1) is 2,534,598 m^3, this is based on the March 2009 quarterly survey.

3.6 Waste disposals on the Clifton Marsh landfill site

The radioactive wastes currently received at the Clifton Marsh landfill from Springfields and Capenhurst are operational, production and decommissioning wastes. The majority of the waste received from Springfields to date is uranic residues that have been generated during the uranium purification residues recovery process. Similarly, the wastes from the Capenhurst site have come from decommissioning of the ex-Uranium Enrichment Gas Diffusion Plant as well as similar wastes from decommissioning of Urenco's E21 Centrifuge Plant..

Other components of the historic wastes and potential future wastes could be building rubble, soil and steel items such as framework, pipework and reinforcement from the dismantling and decommissioning of buildings and process facilities.

The waste inputs to the landfill for 2007 show that approximately 2.5% by weight of the disposals are radioactively contaminated wastes from the Capenhurst and Springfields sites, the majority of which is contained in steel drums or is unpackaged. A very small percentage (0.05%) of the contaminated waste is packed in ISO containers.

Before the radioactive waste is received, a trench (for loose waste) or disposal platform (for packaged waste) is dug in the conventional non radioactive waste that has already been deposited in the operational part of the landfill. The radioactive waste is then placed into the trenches or onto the platform and immediately covered with a 1.5 m layer of non-radioactive waste. This is then subsequently covered with another layer of non-radioactive waste and the location of these burials is recorded for future reference to ensure against uncontrolled excavation into existing deposits of radioactive waste.

It is assumed that this method of disposal will continue for future waste streams unless the risk assessment described in this document shows that the risks posed to potential receptors are greater than the acceptable limits. In this case, scenarios will be developed to assess the options for optimising the radioactive disposal to the Clifton Marsh landfill site and reducing the level of risk associated with them.

Limited information is available to characterise the disposals to the Clifton Marsh landfill site prior to 2001, however a radiological safety assessment undertaken in 2002 for the Clifton Marsh site gives an outline of the estimated radioactivity of both the Clifton Marsh landfill site and the adjacent Grange Farm site (BNFL, 2002).

Springfields is currently authorised to dispose of waste containing radioactivity concentrations around the 100 Bq/g level (0.1 GBq/tonne). This clearly straddles the formally accepted definitions of VLLW and enters into low activity LLW.

It is anticipated that disposals from Capenhurst and Springfields will continue under the new authorisation but that additional very low level waste (VLLW) and low activity low level waste (LLW) streams from other nuclear sites will also be disposed of to the site, subject to the requirements under the authorisation. It is also predicted that 'new' radionuclides could potentially be disposed of at the Clifton Marsh landfill site (see section 7).

Following a recent planning decision, The Clifton Marsh landfill site has planning permission to operate until 2015, therefore radioactive waste disposals would continue until this time subject to the relevant regulatory consents. SITA has applied to Lancashire County Council to extend the planning permission for the site to 2020.

As detailed in the section 3.5, the total capacity of the Clifton Marsh landfill site is approximately 9 million cubic metres. The remaining capacity from 2010 is approximately 2.5 million cubic metres. It is not anticipated that more than about 10 per cent of this total capacity would be made up of radioactive waste. The remaining 90% will be everyday household and commercial waste.

The radioactive wastes from Springfields and Capenhurst have historically taken up about 2 per cent of the waste mass on the Clifton Marsh landfill site. In future if the Springfields site is decommissioned as is currently planned, then the permitted radioactive waste inputs from Springfield's decommissioning could range from 175,000 te to 260,000 te. This waste is expected to comprise mostly of decommissioning materials and is likely to have a density of about 1.5 tonnes per cubic metre and hence the volume used will be between 116,000 to 173,000 cubic metres.

This equates to approximately 10 per cent by weight and 7 per cent by volume of the total remaining waste disposals on the Clifton Marsh landfill site.

3.7 Radioactive Waste Inventory

The radioactive inventory of 15 radionuclides disposed of to the Clifton Marsh landfill site from 1986 to the present day and to the adjacent Grange Farm site during the period 1974 to 1986 is given in BNFL (2002). For the purposes of the radiological risk assessment, the entire radioactive disposals inventory of the landfill has been taken to include disposals to the adjacent Lancashire County Council owned Grange Farm landfill, even though this is not and never has been in SITA's ownership.

Detailed records of Springfields and Capenhurst disposals of uranium, neptunium, technetium, other alpha and other beta are available between 2000 and 2008. This dataset has been broken down into estimates of the activity of constituent radionuclides using the ratios calculated from the historic disposals.

The estimated radionuclide inventory available at the time of writing this report is given in Table 3.

Table 3 Radionuclide inventory of the Clifton Marsh and Grange Farm sites (TBq) (BNFL, 2002)

Radionuclide	Historic Disposals 1974-2000 (TBq)	Future Arisings 2001 - 2011 (TBq)	Calculated Inventory 1974-2009 (TBq)
Am-241	1.30E-05	2.60E-05	3.43E-05
Pu-240	1.30E-05	2.60E-05	3.43E-05
Pu-239	1.30E-05	2.60E-05	3.43E-05
Pu-238	6.60E-07	1.30E-06	1.72E-06
Np-237	1.30E-05	2.60E-05	3.43E-05
U-238	5.00E-01	9.80E-01	1.30E+00
U-236	1.90E-03	3.80E-03	5.01E-03
U-235	3.10E-02	4.40E-02	6.70E-02
U-234	5.80E-01	9.80E-01	1.38E+00
U-232	5.00E-05	1.00E-04	1.32E-04
Th-232	4.60E-03	9.20E-03	1.21E-02
Th-230	9.60E-02	1.90E-01	2.51E-01
Th-228	4.60E-03	9.30E-03	1.22E-02
Tc-99	2.00E-05	4.00E-05	5.27E-05
H-3	0.00E+00	0.00E+00	0.00E+00
Total	1.22E+00	2.22E+00	3.03E+00

An initial assessment was undertaken to determine the likely radionuclide fingerprint of future arising waste streams that could be disposed of to the Clifton Marsh site. The data for this assessment has been taken from the 2007 UK National Radioactive Waste Inventory and considers VLLW and lower activity LLW (up to 200 Bq g^{-1}) waste streams arising from sites in the vicinity of Clifton Marsh. The radionuclides contributing the highest level of activity to the potential future disposals to Clifton Marsh are:
H-3, C-14, Cl-36, Fe-55, Co-60, Ni-63, Sr-90, Ru-106, Cs-134, Cs-137, Ce-144, Ra-226, Th-234, Pu-239, Pu-240, Am-241 and Pu-241.

The radiological risk and capacity assessment as described in section 7 was expanded to include 100 MBq disposal of these potential new radionuclides.

4 STAKEHOLDER ENGAGEMENT

Requirement R2 of the GRA states that:

"*The developer should engage in dialogue with the planning authority, local community, other interested parties and the general public on its developing environmental safety case*."

SITA UK and the communications company DTW have undertaken an in-depth, open and honest stakeholder engagement process. The stakeholder groups approached were (SITA 2008);

- MEPs at the Regional Level;
- MPs at the Regional and district level;
- Lancashire County Council;
- Fylde Borough Council;
- Preston City Council;
- South Ribble Borough Council;
- West Lancashire District Council;
- Parish Councils including Newton-with-Clifton and Freckleton Parish Council;
- Special Interest Groups including Campaign to Protect Rural England, Action Ribble Estuary and the Wildfowlers Association;
- SITA UK Clients including Sellafield Limited, Urenco and Westinghouse;
- Regulators including the EA and NII (Nuclear Installations Inspectorate);
- Industry Bodies including LLW Repository Ltd;
- Government including Department for Business Enterprise & Regulatory Reform, DEFRA, Department for Transport, Government Office North West and the (NDA Nuclear Decommissioning Authority);
- Sita UK employees/consultants including Trade Union Representatives, subcontractors and site staff;
- Site neighbours including Clifton Marsh Farm & Clifton Fields Business Park, Savick Brook Farm, Premier Travel Inn & Gastro Grill and United Utilities Ltd;
- Community representatives including Local religious leaders Head teachers and GPs;
- Various Media groups (local, regional and trade/professional).

The aim of the stakeholder engagement plan is:

"To present a stakeholder engagement programme, which will then be developed and adapted through SITA UK's liaison with stakeholders, which will at all times maintain and build upon SITA UK's corporate

reputation. We will adopt a two-way approach to engagement, listening to what people say and, take account of any feedback as we move forward".

Throughout the programme of work carried out for the authorisation application, SITA UK has undertaken an in-depth, open and honest stakeholder engagement process. This integrated communication process which took place from the planning phase through to the application stage was intended to ensure high quality, effective communications with all potentially affected stakeholders by the plans for future VLLW and low activity LLW disposals at Clifton Marsh site with a focus to enable that stakeholders to express their views and opinions on how they would like to shape the engagement.

The programme included the communication techniques outlined in Table 4:

Table 4 – Communication Techniques for the Stakeholder Engagement Process

Technique	Purpose
Media Audit	To identify key media and journalists and disseminate information to the media to achieve maximum coverage
Press Briefings	To meet reporters and encourage presentation of SITA UK's proposals leading to more informed comment and editorial material in media coverage
News releases	To inform the media about the proposal and stakeholder events
Media Response service	To respond accurately to queries from journalists
Stakeholder meetings/ briefings	To provide county and district councils with the relevant information about SITA UK, its proposals, key SITA UK contacts and processes to listen to feedback
Stakeholder presentation	To supply detailed information to key stakeholders at special events
Clifton Marsh landfill Site visits	To educate and inform the relevant stakeholders and to form positive and open relationships with relevant stakeholders
Events/Exhibitions	To educate and inform relevant stakeholders and facilitate two way communications with stakeholders
Publicity materials, including posters, leaflets, panels	To present information in printed format
Website	To provide up-to-date, changeable information and latest news about SITA UK, its proposal and its services

The main issues raised by the stakeholders included;

- Concern over any changes to radioactivity/tonnage limits on the Clifton Marsh landfill site;
- Concern over long term effects and risks to health;
- Concerns over any increases to local vehicle traffic;
- ‘Importation’ of waste from outside Lancashire;
- Concerns that the waste is being buried in ISO containers.

Technical experts were made available at a public exhibition over two days in Freckleton and one day in Lea Gate, Preston, to answer questions raised by the public and the public were given an honest response to their queries. Assurance was given that the Clifton Marsh landfill site would be subject to stringent internal management controls and Environment Agency regulation and that public health would not be at risk from implementation of the proposals.

Presentations with Q & A sessions were also given to local councillors in Penwortham over two evenings.

The public were advised that levels of traffic travelling to the bClifotn Marsh landfill site are currently declining as the total volume of general waste has declined by about 50% since the implementation of the landfill tax and Lancashire’s County Council’s implementation of waste recycling initiatives.

The public were advised that waste could be imported from outside Lancashire from sites such as Heysham and Trawsfynnydd.

This ESC aims to demonstrate that safety and environmental impacts associated with this proposal will be very low and well within regulatory constraints and requirements. Furthermore, it is understood that disposals will only commence upon approval and issue of an Authorisation under RSA93 from the Environment Agency which will only be granted after satisfactory demonstration that potential radiological impacts as a consequence of future intended operations are within acceptable regulatory limits

5 HAZARD IDENTIFICATION

A HAZOP 1 has been undertaken for the Clifton Marsh site in order to identify the main hazards associated with receipt of waste, waste tipping and covering, the gas and effluent management and post closure period of the site.

The outputs of this HAZOP have been fed into subsequent risk assessment modelling for the site. A full report on the HAZOP 1 process can be found in (Higgins, 2009). The key areas discussed during the HAZOP were:

- Waste receipt/acceptance – including the potential for fire/explosion; the possibility of insufficient or lack of appropriate documentation during waste receipt and the effects of vehicle collision or dropped load;
- Waste tipping and covering - including the potential for a landfill fire, damage to drums / ISOs containing waste, mis-consigned waste, external events and loss of management control;
- Gas management – including gas ignition leading to fire, damage to pipes through operations and drilling into radioactive waste during installation of gas monitoring point;
- Effluent System – including overtopping of leachate lagoon, pipe failure and failure to monitor effluents before discharge to sewage works;
- Criticality and heat generation;
- Post Closure – including human intrusion, failure of containment, uptake of radionuclides in crops, digging of a drinking water well on the Clifton Marsh landfill site and external events (e.g. landfill erosion, seismic events and climate change).

The HAZOP team were able to identify safeguards (either engineered or managerial) for many of the hazards. In some instances the study identified issues that could benefit from further investigation or improvement and these are summarised below:

Table 5: Hazards identified during the HAZOP undertaken for the Clifton Marsh landfill.

Hazard ID	**Hazard**	**Recommendation**	**Action**
1-9	Insufficient or lack of paperwork	On receipt of authorisation under the RSA 93 to accept additional wastes, it is recommended SITA set up a system to monitor waste on entry to the site	This will be covered under the application process for authorisation under RSA 93
2-6	Site equipment punctures drum containing waste during operations leading to damage and possible contamination of equipment	Implement monitoring protocols	Look into the most effective monitoring plan to instate, for example the monitoring of all equipment following the disposal of radioactive material
2-13	Surface Water flooding	SITA are setting up surface water management systems off site	None needed
2-21	Degradation of materials	Further investigation of	To be assessed by risk

Hazard ID	Hazard	Recommendation	Action
	by aerobic / anaerobic microbial degradation	risks needed	assessment modelling and development of the Waste Acceptance Criteria
3-2	Potential for engine lubricants used in the gas management system to become contaminated	It is necessary to ensure contaminated oil is disposed of appropriately	Investigate where used oil is disposed of.
3-8	Possible entrainment of contamination into passive gas	Gas should be monitored for radioactive contaminants – tritium, carbon-14	Investigation into possibility of implementing a regular monitoring system
3-11	Evolution of wastes (in particular putresible material) causing the generation of contaminated gas	Assessment needed	To be assessed during development of the Waste Acceptance Criteria and risk assessment modelling
4-3	Failure of leachate system leading to potential overtopping	SITA UK to implement an interlock system to existing leachate management system	Potential exposure to public and workers to be assessed in risk assessment models.

These recommendations have been addressed in the following sections.

6 MANAGEMENT, OPERATIONAL & SAFETY SYSTEMS

6.1 Management System

Requirement R4 (Environmental Safety Culture and Management System) of the GRA (EA, 2009) states that:

"*The developer/operator of a disposal facility for solid radioactive waste should foster and nurture a positive environmental safety culture at all times and should have a management system, organisational structure and resources sufficient to provide the following functions: (a) planning and control of work; (b) the application of sound science and good engineering practice; (c) provision of information; (d) documentation and record-keeping; (e) quality management.*"

This section outlines SITA's management systems in order to demonstrate that proper management processes and quality management are an integral part of the Organisation's operations.

SITA UK operates an Integrated Management System (IMS) accredited to ISO 9001:2000 for quality management systems and ISO 14001:2004 for environment management. SITA is also in the process of securing OHSAS1801:2007 accreditation for its safety management system.

The scope of the IMS is for "The collection, transport, sorting, separation, treatment and disposal of household, municipal, commercial and industrial waste (including hazardous and difficult waste), transfer stations, materials, recycling facilities, security shredding facilities, composting plants, and household waste recycling facilities."

The scope also includes certification for "The design and development of waste management facilities."

There is a commitment throughout SITA UK that the IMS will continuously evolve and improve through the ongoing review and development process.

The IMS is structured and communicated in 5 tiers:

- Tier 1 The Integrated Policy Statement – SITA's Management Committee sets out the aims of the IMS and defines the Integrated Policy Statement;
- Tier 2 The IMS Policy Manual – This manual introduces the IMS and details scope and content;
- Tier 3 IMS Procedures Manual – This includes procedures that relate to all aspects of the company;
- Tier 4 Divisional and Site Specific Operational Procedures – These procedures relate to specific divisions and operations;
- Tier 5 Records – SITA actively collect data for analysis in order to demonstrate the effectiveness of the IMS.

The system is audited internally at 6 month interval and externally at not less than 12 month intervals.

6.1.1 Personnel and Training

The management structure for the Clifton Marsh site is shown in figure 1.

Figure 1 - Diagrammatical Representation of the Management Structure for the Clifton Marsh Landfill Site

The overall responsibility for the operations at the Clifton Marsh site is delegated by the Managing Director of SITA Holdings UK Limited, who is the head of the Company. The key personnel associated with the operations are outlined below:

MANAGING DIRECTOR -	David Palmer Jones
OPERATIONS DIRECTOR	John Scanlon
GENERAL MANAGER NORTH WEST	John Grainger
AREA MANAGER	Brian Harper

SITE MANAGER (and appointed RPS) -	Ian Thomson
RELIEF RPS	Ray Walker
SITE SUPERVISOR	John Bracken
SITE SUPERVISOR	Derek Haworth
RPA	Serco Ltd

Technical and engineering support is also provided by SITA UK via its regional office in Preston:

Decommissioning Development Manager	Phil Holland
Technical Manager (UK Nuclear)	Bav Thaker
Engineering Manager	Martin Lavery
Environment Support Manager	Steve Westerman
Monitoring Compliance Manager Senior Environment Assistant	Helen Boyd

Engineering support is also provided by SITA UK via its regional office in Preston:

Health and safety supervision and advice is provided by the SITA UK Health and Safety Team and the Regional Advisor based in Preston:

Regional Health and Safety Manager	Kate Brown
Transport and packaging advice	SITA UK DGSA (level 7).
DGSA level 7	Tim McCabe
	Dr Toni Brook (based at Clifton Hazardous Waste Hub).

All Clifton Marsh landfill site management and supervisory staff are trained in "Managing Safely" through the Institution of Occupational Safety and Health (IOSH) Accredited course. The General Manager and the Site Supervisor are also qualified to National Examination Board in Occupational Safety and Health (NEBOSH) level in occupational health and safety.

Further technical and professional development for the technically competent management and other staff employed at the site is demonstrated via various accredited training schemes supplied by industry specialists such as Chartered Institute of Wastes Management (CIWM), Environment and Plastics Industry Council (EPIC), Environmental Services Association (ESA). Ongoing continual professional development training and membership of related Institutions i.e. IMechE, etc is also supported..

As set out in their health and safety protocols and in line with the IRR 99, SITA must appoint a Radiation Protection Supervisor (RPS) who is responsible for the monitoring and supervision of any radioactive waste disposals. A relief RPS must also be appointed. The RPS (and relief RPS) report to the Area Manager and occupy a line management position (e.g. Site Manager). They must be directly involved with the receipt and disposal of radioactive waste

To obtain RPS status staff must attend a certified training course. In addition, all SITA personnel at Clifton Marsh must receive an appropriate level of training to ensure they have a thorough understanding of ionising radiation and are aware of the necessary precautions to adopt to ensure radioactive waste is handled in a safe ans compliant manner. The RPS is responsible for ensuring all procedures and protocols are followed to restrict exposure to ionising radiation.

The RPS duties are:

- To develop and train staff working with Ionising Radiation;
- To ensure that all appropriate staff know what to do in an emergency and to develop emergency contingency plans;
- To ensure that correct procedures are followed in accessing any controlled and supervised areas;
- To ensure safe working arrangements for sub contractors and visitors;
- To complete permits to work for sub contractors working within a radiation disposal area;
- To undertake radiation disposal record keeping;
- Regular inspection and checking of safety devices and recording results;
- Dosimetry procedures – checking staff are wearing dosimetry devices where required and checking the management of these devices is carried out correctly;
- Carrying out routine radiological monitoring and recording results;
- Ensuring all monitoring equipment is calibrated;
- Carrying out risk assessments and setting up Safe Working Procedures (SWPs);
- Reviewing SWPs and other related procedures;
- Controlling movement and disposal of radioactive materials on site; and
- Liaison with a Radiation Protection Adviser (RPA).

The Site Manager / RPS shall appoint a third party specialist to act as Radiation Protection Advisor (RPA). The RPA will be suitably qualified and experienced to advise on all matters of radiological safety and protection.

The RPA will be a suitably qualified and experienced expert hired on a consultancy and call out basis from Nuvia Ltd (or other locally sourced RPA).

All staff and operators working on the Clifton Marsh site will under go the following induction training upon commencement of their employment;

- SITA Health & Safety Induction;
- SITA CD ROM induction;
- Health & Safety induction to site risk assessments;
- Induction to all relevant safe systems of work.

Staff may attend internal SITA training courses as required and endorsed by their manager. All staff are then assessed by an external evaluator and provided with certification for plant operations. Operations at

Clifton Marsh are supervised by a technically competent manager (e.g. the Site Supervisor and Operations Manager) as required under the environmental permit).

All training information (documents and certificates) are kept (for all site staff at Clifton Marsh) within training files in the Site Manager's office. The training files are kept for a minimum of 2 years beyond the termination of employment. All the training records held are manual records.

6.1.2 Audit and Review

Regular management reviews and audits are an important aspect of the Quality Assurance of the site. Currently SGS (Société Générale du Surveillance) carry out the external auditing of the scheme and SITA's internal Quality and Environmental Management Systems (QEMS) team carry out internal auditing function.

These reviews are conducted at not less than 6 monthly intervals to ensure the management system is upheld and the quality system is being appropriately applied. Internal auditing is undertaken routinely at not less than a 6 monthly interval and results are recorded on SITA's Auditing and Compliance Database COMPAS – the Compliance Auditing System which is used as a tool to ensure that all non compliances are identified and addressed within an acceptable timeframe. COMPAS is an electronic system which summarises all internal compliance audits (quality, environment, fleet, health and safety). The system identifies non compliances and prompts a Corrective Action Request (CAR).

6.1.3 Record Keeping and Document Control

A procedure is in place to control the documents that are required by the SITA Integrated Management System and the two International Standards of ISO 14001:2004 and ISO 9001:2000. These documents include the IMS Manual (incorporating the IMS Policy Manual and IMS Procedures Manual) and selected documents that are referenced within the IMS Manual.

The IMS Manual, amendments to the IMS Manual and IMS forms are approved by the QEMS & Compliance Manager / Group Health & Safety Manager / for their adequacy, prior to issuing to the Internal Control and Risk Department for uploading onto the SITA Intranet. The current and up to date version of the IMS Manual and related documents are maintained and made available on the SITA Intranet.

6.2 Operating Procedures

SITA UK have a number of strict policies and procedures (SITA, 2009) which must be adhered to on the Clifton Marsh landfill site to keep the risks due to acceptance and disposal of radioactive waste ALARP (as low as reasonably practicable).

For the purposes of this application, SITA have performed a complete assessment of these policies and procedures and produced a document entitled "Materials Acceptance Criteria and Operating Procedures

2010". This document underpins the authorisation application and is submitted along with this environmental safety case.

The document includes the following:

- Detailed description of procedures for waste acceptance and receipt;
- Detailed description of procedures for waste disposal;
- Procedures for health impact monitoring;
- Procedures for environmental monitoring; and
- Emergency procedures.

6.3 Records / Document Keeping

The documents and records kept at the Clifton Marsh site include:

- Notification of waste consignment documents;
- Delivery / consignment notes;
- Site monitoring records;
- Vehicle / Waste monitoring records;
- Location and dates of disposals; and
- Emergency equipment checks.

All the records relating to radioactive waste disposals are held on file in the site reception office for one year. After this period they are moved to the site archive office and storage for the lifetime of the site. Disposal certificates are scanned and held on file on the SITA UK main server.

6.3.1 Pre-Notification of Waste Consignment Documents

Prior to receiving any radioactive waste onto the site the waste provider must notify the Clifton Marsh Landfill of the amount and type and radioactive content of the waste to be delivered. This must then be formally accepted by the Site Manager. This notification is given in the Radioactive Movements Authorisation Form (89290-SC-SF-001) which is completed by the waste consignor.

Prior to any radioactive waste being accepted at the site for disposal the RPS will inspect and record all the information as outlined below. This will provide a detailed archive of all radioactive waste inputs for each waste stream, package and consignment.

- Waste Stream Characterisation Document (WSCD) for the RSA waste-stream demonstrating compliance with the Waste Acceptance Criteria.

- Written request or waste consignment application (to include activity value for all nuclides with half-lives of more than 3 months. To be received by SITA not less than 14 days prior to date of proposed shipment.
- Radioactive Movements Authorisation: a requirement of the Authorisation and will be approved and signed off by the Landfill site's Technically Competent Manager and RPS not less than 14 days prior to dispatch to site.
- Consignor's Certificate for Transport: Certificate providing full details of consignment load and description of waste.
- Radioactive Materials Transport Monitoring Certificate for dispatch.
- Transport Emergency Action Management Plan – to be produced and held by Haulier/waste producer.
- Waybill: To be signed at Weighbridge to confirm arrival at Site and to be returned by fax to waste producer
- Waste Management Advice Note: For disposal of materials to Site, to be signed by Weighbridge to confirm date and time waste is received and to confirm Weighbridge Ticket Number.

The WSCD generated by the waste consignor shall be examined and approved by SITA and will include the following:

- Waste-stream to be disposed of;
- Brief description of the process generating the waste;
- Estimated annual, total and cumulative arisings of the waste-stream in terms of activity (total Alpha, Beta ,Gamma) volume, mass and lifetime generation timescale;
- Activity concentration of the waste stream;
- The radiological fingerprint and the estimated annual, total and cumulative arisings for the specified activity groupings. All radionuclides present in the RSA material must be stated.
- Physical and chemical composition;
- Non-radiological hazardous components;
- Conditioning and treatment of the waste;
- Containment and Packaging of the waste;
- Method of radioactivity content assessment;
- Means by which the waste is controlled to demonstrate that it is within the relevant activity limits.

6.3.2 Delivery / Consignment Notes

For every waste load the driver must present paperwork which includes the following information to the weighbridge clerk (SITA, 2009);

- the carrier's name and vehicle number;

- the type of waste for disposal;
- where the waste originated,
- the tonnage;
- the number of drums (where applicable) in the load;
- the gamma radiation dose rate of the load measured by the waste consignorI n accordance with Section 7 of the Code;
- any other special information about the load considered of value; and
- the radionuclide fingerprint of the waste;

In addition to providing the information required prior to shipment, the Consignor/waste producer must verbally notify the Site Weighbridge Office of the amount and type of waste to be delivered to the landfill site on the working day prior to the proposed deposit.

All sections of the Delivery Note will be endorsed by the Weighbridge Clerk to confirm the details are correct. One copy of the delivery note will be retained by SITA.
The following paperwork is received by SITA on acceptance of VLLW or low activity LLW onto site;

- Consignor's (Shippers) Certificate for the Transport of Radioactive Materials (89290/SC/SF/002);
- Radioactive Material Transport Monitoring Certificate for Off Site Dispatch (89290/SC/SF/003)
- Waybill Ticket (89290/SC/SF/004) confirming consignment details. This document is to be signed by the driver and the weighbridge operator confirming time and arrival at destination and time. The completed Waybill is then to be faxed (or scanned and e-mailed) back to the waste consignor/customer;
- Waste Management Advice Note for Disposal of Material to Clifton Marsh (89290/SC/SF/005) signed at weighbridge confirming time of arrival, weighbridge ticket number and gross weight of material or package disposed in kg;
- Consignment and Dispatch of Low Level Waste (as LSA-II non-fissile or fissile excepted) off site (89290/SC/SF/006); and
- Estimate of Radioactive Non Combustible Waste Stream (89290/SC/SF/007).

6.3.3 Monitoring Records

All waste consignment monitoring must be recorded by the RPS or relief RPS and held in the site laboratory in the relevant “Waste Monitoring File” (SITA, 2009), along with any vehicle monitoring records.

6.3.4 Location and Dates of Disposal

A plan of the trench area must be kept in the “Trench File” which is held at the supervisor’s office detailing the location and dates of disposal of radioactive waste consignments (SITA, 2009).

A Waste Accounting System recording all inputs, activity per package, and providing a recording system for all radioactive materials will be implemented. This will enable effective inventory management and optimal used of the site's radiological capacity.

6.3.5 Emergency Equipment Checks

The supervisor must check that all emergency equipment is available and is in good repair. These checks must be made at least monthly and recorded in the day book (SITA, 2009).

6.4 Security Arrangements on Site

Security on the Clifton Marsh landfill site is vital to ensure public safety. Access to site is restricted to authorised personnel and fencing around the site prevents public access. This ensures that the public are prevented from interfering with site operations and avoids potential exposure to ionising radiation.

The following security arrangements are in place on the site:

- Security fence surrounding site (6ft) with barbed wire;
- Site surrounded by watercourses and a farm so access from southern perimeter difficult;
- Secured gates which are padlocked ;
- CCTV motion activated cameras;
- Alarm systems linked to monitoring system; and
- Redcare security 4 min response from police.

Following cessation of disposals to the landfill, it is anticipated that a 50 year institutional management period will take place. The operational security arrangements are expected to be retained to prevent public access to the Clifton Marsh landfill site and potential disturbance of the deposited waste mass.

7 RADIOLOGICAL RISK ASSESSMENT

Requirement R9 of the GRA states that "*The developer/operator should carry out an assessment to investigate the radiological effects of a disposal facility on the accessible environment both during the period of authorisation and afterwards with a view to showing that all aspects of the accessible environment are adequately protected*".

A radiological risk assessment has therefore been undertaken for the Clifton Marsh site. The aims of the radiological risk assessment were:

- To carry out a robust assessment of the present day and post closure radioactive impact of historic, current and future radioactive disposals to the Clifton Marsh landfill site (inclusive of the historical radioactive waste inventory within the adjacent Grange Farm site);
- To assess the present day and post closure radiological impact of the historic, current and potential future authorised disposals against the relevant requirements of the regulatory guidance; and
- To calculate the remaining radiological capacity of the Clifton Marsh site, given the regulatory guidance.

The radiological risk assessment has been undertaken according to a methodology that uses a combination of approaches including those developed by SNIFFER (2006), the EA's screening methodology (2006b) and the approach used for a previous site risk assessment developed by BNFL (2002).

The EA's guidance sets limits on the radiation doses that might arise to members of the public for the operational and post closure periods of the disposal site. It also distinguished between scenarios that are normally expected to occur for which a dose criterion of 2.00E-05 Sv yr^{-1} has been set and those that are not certain to occur, for which a dose criterion of 1.00E-03 Sv yr^{-1} has been set.

The risk assessment considers two time periods – the operational period which includes the remaining lifetime of the Clifton Marsh landfill site for disposals (currently estimated to end in 2020) and the site management period (a period of 50 years for site monitoring and surveillance), and the post closure period which is the future lifetime of the site following the withdrawal of institutional control of the site. The impacts from potential exposure pathways during these two time periods have been assessed using conservative (ensuring impacts are not underestimated) assumptions.

A detailed account of the radiological risk assessment can be found in Eden (2010). However a short summary is given in the following sections.

For information, Requirement 10 of the GRA states: *"The developer/ operator of a disposal facility for solid radioactive waste should demonstrate that the disposal system provides adequate protection against non-radiological hazards."*

This ESC does not cover impacts due to non-radiological waste since a hydrogeological risk assessment has been performed (Atkins, 2002b) and submitted to the EA which provides the basis for the Clifton Marsh environmental permit.

7.1 Risk Assessment Model

A conceptual model of the disposal system has been developed in the first stage of the risk assessment process. This includes a description of the general features and characteristics of the Clifton Marsh landfill site system and identifies the potential pathways of radionuclide release and transport through the environment. The existence and relevance of such potential release pathways have also been considered over time.

The performance of the Clifton Marsh landfill has been considered for groundwater and gas pathways and exposure scenarios have been modelled to assess the potential dose to human and non human biota. These exposure scenarios include those that are normally expected to occur during the operational and post closure periods of the site's lifetime and those that are not certain to occur for example human intrusion into the waste mass following closure of the site and any potential changes to the landscape around the site.

The groundwater pathway addresses the movement of radionuclides from the Clifton Marsh landfill disposal site and the adjacent Grange Farm site to the biosphere by transport in flowing groundwater. It is noted that the groundwater conceptual model for Grange Farm may differ from that of the Clifton Marsh landfill however there is no supporting hydrogeological risk assessment for Grange Farm to enable this to be modelled. Therefore the hydrogeological model for Clifton Marsh has been used to model radionuclide migration from this site.

The gas pathway considers the production of gases within the wastes and the migration of these gases from the facility to the surrounding biosphere where exposure may occur via inhalation.

A model has then been developed using the GoldSim software (GoldSim, 2008) in which the disposal system is mathematically modelled. The model has been divided into three areas: the source term (radioactive disposals to Clifton Marsh landfill site and adjacent Grange Farm site), the geosphere pathways from the source term, and the biosphere pathways to the potentially exposed groups. The source term has been based on the radioactive disposals inventory given in BNFL (2002), which includes historic disposals to the Grange Farm site (now closed) and the Clifton Marsh landfill site and a nominal 100 MBq disposal of a suite of additional radionuclides that could be disposed of on the Clifton Marsh landfill site in the future.

7.2 Exposure Pathways

The biosphere pathways to potentially exposed groups have been assessed in accordance with the EA guidance received, along with knowledge of the Clifton Marsh landfill site gained through the HAZOP process.

During the operational period of the modelling the following pathways have been assessed:

***Normally expected to occur*:**

- Exposure to workers and public from **radioactive gases and dust;**

- **Leachate discharge to water courses and sewage works** – including **exposure to** Sewage treatment workers who might receive radiation doses as a result of external irradiation and inadvertent ingestion and inhalation of raw sewage and sewage sludge; exposure to a farming family exposed to sludge used for land conditioning who might receive radiation doses as a result of external irradiation from the conditioned soil, the inadvertent inhalation or ingestion of soil or the ingestion of contaminated crops grown on land conditioned by sludge (these are identified by the Environment Agency as critical exposure pathways); and exposure to an 'angler family' group who are assumed to consume fish and drinking water from the river and spend some time on its banks.

Not certain to occur

- **Leachate spillage -** leakage of the leachate through the bottom of the landfill into groundwater or a nearby surface water body and subsequent ingestion of organisms from the surface water body by the potentially exposed group.

- **Waste fire -** dose to site workers from inhalation of fire smoke and from external irradiation in the smoke plume and the dose to public via external irradiation and ingestion related to soil contaminated by surface deposition from the smoke.

During the post closure period of the model, the following potentially exposed groups and exposure pathways have been assessed:

***Normally expected to occur*:**

- Wildfowlers: occupancy on Ribble floodplain – external irradiation;
- Fisherman: occupancy on Ribble floodplain - external irradiation;
- Agricultural worker: occupancy on Clifton Marsh soil relating to grazing of livestock external irradiation, inhalation and ingestion of radionuclides;
- Houseboat dweller: external irradiation, inhalation of re-suspended dust, inadvertent ingestion of radionuclides from Ribble floodplain sediments and ingestion of radionuclides through consumption of foodstuffs;
- Seafood consumers – inadvertent ingestion of radionuclides through consumption of foodstuffs; and
- Child drinking from river – short exposure time such that inhalation of soil and external irradiation would not deliver significant doses.

For seafood consumers and houseboat dwellers, the dose from each exposure pathway has been summed for that PEG (Potentially Exposed Group). Performing such a summation is considered to be appropriate but may overestimate the total dose to the seafood consumer PEG since an individual is unlikely to consume all three of these foods at high rates.

Not certain to occur:

- **Intrusion into the waste -** this scenario has been established in order to assess the possible dose due to development activity on the Clifton Marsh landfill site following its closure. It has been assumed that at the end of the management period in 2020, a house is built on site and it is subsequently occupied. As a result, the cap is damaged and members of potentially exposed groups (excavator and site resident) receive a dose from the residual inventory on the site (this covers requirement R7 of the GRA – "*The developer/operator of a near-surface disposal facility should assess the potential consequences of human intrusion into the facility after the period of authorisation on the basis that it is likely to occur*."

- **Bathtubbing -** this scenario describes the processes occurring when landfill leachate overflows from the landfill. This could happen during the operational period due to failure in the leachate collection system or during the post closure period where no leachate is being collected, leaving the site susceptible to overflow if leachate accumulates more quickly than it can flow away;

- **Erosion of the landfill** – two scenarios to assess the effect of increases in sea level and changes in the River Ribble flow path resulting in exposure of the disposed waste at the River Ribble banks (River Banks Scenario) and exposure to substantial pieces or blocks of eroded waste on the floodplain (block scenario).

The following scenarios have also been considered as part of the risk assessment:

- 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 between Phases 2 and 3. These pipelines could be compromised resulting in a significant explosion; and
- Exposure due to surface water abstraction from the River Ribble for spray irrigation.

It has been concluded, however, 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. The full rationale behind this conclusion is given in Thorne (2010a).

It is considered that the “bathtubbing” scenario assesses the same pathways that would be assessed through an agricultural spray pathway However, given that the bathtubbing scenario involves leachate generated from the site rather than leachate diluted by river water, the bathtubbing scenario is expected to be more conservative than the agricultural spray scenario. It is therefore considered that potential receptors from an agricultural spray pathway have been assessed using the “bathtubbing scenario”.

The GoldSim model has been set up so that the various individual pathways and total doses for the different PEGs (and age groups, as appropriate) are interrogated and the peak annual dose and time of the peak are output to a results file.

A non-human biota dose assessment has also been performed. This uses outputs from the main radiological risk assessment model (e.g. soil and water compartment concentrations) to assess the scale of potential ecological impacts. The ERICA tool (Beresford *et al.*, 2007) has been used for this assessment. This tool estimates the dose to wildlife in terrestrial, marine and freshwater ecosystems and screens the dose against a maximum limit below which the risk of adverse biological effects to wildlife are considered acceptable. Radionuclide concentrations in each of the three ecosystems have therefore been used to assess the maximum potential dose to wildlife surrounding the Clifton Marsh landfill site.

It is considered that the parameters used in the risk assessment model are cautious (i.e. they should not underestimate the risk) however, it is also considered that they are not unrealistic. The sensitivity of the model to the following parameters has, however, been investigated:

- heterogeneity of the waste – assessment of the risks associated with increasing the specific activity concentration of the radioactive waste material. This will impact on the worker dust inhalation scenario human intrusion and landfill erosion scenarios;
- leachate management – consideration of a scenario in which there is no leachate management during the operational and management periods of the Clifton Marsh landfill site and leachate flows from the wastes to the alluvial deposits from the start of the model run;
- groundwater discharge location - given the uncertainty regarding the hydrogeological model of the Clifton Marsh landfill site and the location of the groundwater discharge point, a sensitivity analysis has been undertaken to examine the effects of groundwater discharge to the Savick Brook and the Clifton Marsh soil; and
- Sorption coefficients - a comparative study has been done to assess the affect of parameterising the model with different sorption coefficients.

7.3 Results

The maximum estimated doses from the risk assessment, along with the relevant exposure pathway and the screening criterion are shown below. These doses are based on the current disposals inventory (BNFL, 2002) and 100 MBq disposals of a suite of future new radionuclides to the Clifton Marsh landfill site. An assessment has been made of the sum of the contributions over all disposed radionuclides (this does not take account of the timing of the peak doses) in addition to individual radionuclide dose impacts.

Table 6: Maximum estimated doses form the radiological risk assessment (Eden 2010)

	Maximum Individual Radionuclide Dose (**Sv yr^{-1})**	***Exposure Pathway***	***Screening Criterion*** **(Sv yr^{-1})**
Operational Phase			
Exposure pathways normally expected to occur	3.39E-05 (Ra-226)	Public – exposure due to deposition of aerosols formed from leachate lagoons	2.00E-05
Exposure pathways not certain to occur	1.08E-02 (Ac-227)	Leachate Spillage – ingestion of fish	1.00E-03
Post-Closure Phase			
Exposure pathways normally expected to occur	1.49E-06 (Pb-210)	Seafood consumers – ingestion of samphire	2.00E-05
Exposure pathways not certain to occur	2.83E-03 (Rn-222)	Human Intrusion –site resident exposure to Rn-222	1.00E-03

This table shows that the estimated peak doses for the scenarios that are considered likely to occur in the post closure scenarios are below the screening criteria. The dose criterion is exceeded for exposure to Ra-226 due to deposition of aerosols formed from the leachate lagoons.

The estimated peak doses for the pathways in the operational scenario that are uncertain to occur are all at least two orders of magnitude below the screening criteria with the exception of the dose from exposure to Ra-228 through consumption of fish following a leachate spillage to the Savick Brook.

The operational pathways have been modelled using parameters that are aimed not to underestimate the radionuclide impacts, as explained in Eden (2010). For example the impacts from leachate discharge to the leachate lagoons or the sewage works are based on radionuclide release from the disposals inventory of the Clifton Marsh landfill site and the adjacent Grange Farm site with no sorption to the waste, therefore these calculations are conservative. It is difficult to parameterise and justify sorption to the waste without experimental analysis however significant sorption would be expected to certain wastes. In addition near field waste form evolution processes such as corrosion, microbial degradation etc will control the release rate of radionuclides into the leachate. Such processes have not been accounted for in this model.

The leachate spillage scenario is considered to have been conservatively modelled since no account has been taken of radionuclide sorption to the wastes. A re-run of the model where sorption coefficients for radionuclides in the wastes have been included gives a peak total dose from all radionuclides of 2.07E-04 Sv yr^{-1} (ingestion of fish pathway) of which 2.32E-05 Sv yr^{-1} is contributed by Ra-228. Future disposals of Ra-228 will be limited to ensure that the potential exposures do not exceed this dose criterion.

For the pathways in the post closure scenario that are considered likely to occur, all the individual doses and sum of the total dose to each PEG are below the dose criterion of 2.00E-05 Sv yr^{-1}. The peak doses are to seafood consumers from ingestion of samphire and marine fish and come from the radionuclide decay chain of Th-230, Ra-226, Pb-210 and Po-210.

All the individual doses and the sum of the total dose to each PEG for the pathways in the post closure scenario that are uncertain to occur, are below the dose criterion of 1.00E-03 Sv yr^{-1}, with the exception of the dose from inhalation of Rn-222 in the human intrusion scenario (2.83E-03 Sv yr^{-1}). This figure is sensitive to parameters such as the volume of the house that has been assumed to be built on the Clifton Marsh landfill site, its ventilation rate and the assumed release rate of Rn-222 through the landfill site. For example, doubling the volume of the house decreases the peak dose to 1.73E-03 Sv yr^{-1}.

No account has been taken for the effect of the foundations and any concrete at the base of the house on the release of Rn-222 into the house. Rn-222 is assumed to enter the house directly through the deposited waste mass which is a very conservative assumption. These results are however, taken into account when determining the remaining radiological capacity of the Clifton Marsh landfill site and setting appropriate waste acceptance criteria for future disposals on the site.

A dose assessment for non-human biota shows that the impacts from radionuclides disposals on the Clifton Marsh landfill site and adjacent Grange Farm site during the post closure period of the site are lower than the screening criteria.

Full results of the risk assessment modelling along with the associated sensitivity studies are given in Eden (2010)

8 DEVELOPMENT OF WASTE ACCEPTANCE CRITERIA

Requirement 13 of the GRA states:

"The developer/operator of a disposal facility for solid radioactive waste should establish waste acceptance criteria consistent with the assumptions made in the environmental safety case and with the requirements for transport and handling, and demonstrate that these can be applied during operations at the facility."

This section addresses this requirement by setting out proposals for limits on the radioactive content of the wastes to be disposed of at the Clifton Marsh landfill site. The controls that are in place on site in order to ensure that wastes received comply with these WAC have been discussed in section 6.2 and are outlined in more detail in SITA, (2009).

Non-radioactive waste disposals to Clifton Marsh are regulated under its Environmental Permit and restricted by Waste Acceptance Criteria (WAC) put in place under this permit. All materials or substances classified as “Hazardous Waste” are excluded and shall not be disposed of at the Clifton Marsh landfill site. Wastes classified as “Hazardous” are considered to display one or more of the properties as detailed in Annex III of EU Directive 91/689/EEC.

It is beyond the scope of this report to discuss in detail the non-radiological waste acceptance criteria in place at Clifton Marsh, however a parallel set of radiological waste acceptance criteria will be put in place under the site’s own authorisation to accept radioactive waste.

These radiological WAC include;

- Maximum annual radiological disposal limits;
- Maximum radionuclide concentrations;
- Waste form limitations; and
- Packaging requirements

It is the consignor’s responsibility to ensure that wastes are compliant with the WAC, however, SITA will monitor compliance with this requirement and assess individual waste streams and review consignment paperwork to ensure consistency with the WAC as outlined in section 6.2.

The steps undertaken prior to consignment of waste at the Clifton Marsh landfill site have been outlined in section 6.2.

The limits set down to regulate annual radiological disposal limits and radionuclide concentrations have been generated using the results of the radiological risk and capacity assessment. These limits therefore ensure that risks to potentially exposed human and non human receptors comply with regulatory prescribed criteria.

8.1 Existing Waste Acceptance Criteria

The current radioactive waste disposals at Clifton Marsh are conducted in accordance with authorisations under the RSA 93 for the Capenhurst and Springfields sites. The annual radioactivity limits for the radionuclides that can be disposed at Clifton Marsh under these authorisations are given in tables 7-9.

Table 7: Annual Disposal Limits for Radioactive Wastes from the Capenhurst Site to Clifton Marsh (EA 2007b)

Radionuclide or Group of Radionuclides	Annual Disposal Limits (GBq)
Uranium	36
Other Alpha Emitting Radionuclides	4
Technetium-99	68
Tritium	136
Other Radionuclides	20

Table 8: Annual Disposal Limits for Non-Decommissioning Radioactive Wastes from the Springfields Site to Clifton Marsh (EA 2006a)

Waste Form	Radionuclide or Group of Radionuclides	Annual Disposal Limits (TBq)	Concentration Limit (Bq/g)
Process Wastes	Uranium	0.060	50
General Wastes	Uranium	0.020	50
	Other Alpha Emitting Radionuclides*	0.001	100
	Other Beta Emitting Radionuclides*	0.005	100
Historic Incinerator Ash	Uranium	0.020	125
Graphite	Uranium	0.020	100
Historic Process Waste	Uranium	0.010	100

*Applicable to Nexia Solutions Limited only

Table 9: Annual Disposal Limits for Decommissioning Radioactive Wastes from the Springfields Site to Clifton Marsh (EA 2006a)

Waste Form	Radionuclide or Group of Radionuclides	Annual Disposal Limits (TBq)	Concentration Limit (Bq/g)
Decommissioning Waste	Uranium	0.200	100
	Neptunium-237	0.010	10
	Technetium-99	0.010	10
	Other Trans-uranic Radionuclides	0.010	10
	Other Beta Emitting Radionuclides	0.001	100

Any radioactive waste disposed of on the site will have to comply with the WAC under the PPC permit at Clifton Marsh. Disposal of the following waste forms are prohibited on site:

- Hazardous wastes
- Chemical substances from research and development or testing which are not identified and / or are new and whose effects on man and / or the environment are unknown
- Any waste in liquid form (including waste waters but excluding sludge)
- Whole used tyres – apart from those used as engineering material, bicycle tyres and tyres with an outside diameter of more than 1,400mm
- Shredded tyres – apart from bicycle tyres and tyres with an outside diameter of more than 1,400mm, except where their use as an engineering material constitutes recovery; and
- Infectious or other clinical and related wastes

Further limiting factors include;

- Any waste which is chemically unstable or potentially explosive
- Any waste which is spontaneously reactive with air or water or potentially with any other deposited waste
- Any waste containing strong oxidising agents (including hypochlorites, chlorates, chlorites, perchlorates, bromates, iodates, periodates, persulphates, permanganates, peroxides, chromates, borates and nitrites
- Any wasteS containing solvent in such a quantities tha would cause the waste to burn unsupported at 40 ^{o}C or less
- Any waste containing unreactive styrene, acrylonitrile or isocyanates
- Any waste containing organotin compounds
- Any waste containing (or which may give rise to) free halogens including fluorine, chlorine, bromine and iodine; and
- Any waste containing solvent in such a concentrations or quantities that it may damage the landfill base liner.

Testing of the waste to ensure it meets the radioactive WAC must take place prior to disposal. For radioactive waste, this will be done by the waste consignor in accordance with their quality plan.

For non-radioactive waste, leaching tests must be carried out on the waste to assess the risks of contaminants leaching from the site. Clifton Marsh has in place its own leaching limits for non radioactive contaminants.

8.2 Proposed New Criteria for Acceptance of Radioactive Waste under the New Site Authorisation

8.2.1 Calculation of the Remaining Radiological Capacity on the Clifton Marsh Landfill Site

In order to calculate the remaining radiological capacity on the Clifton Marsh site 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 and the human intrusion and bathtubbing pathways have been extracted from the basecase model runs. This peak dose and the corresponding radionuclide inventory have then been used to calculate the maximum potential inventory for a specific 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 the waste inventory used in the modelling and the peak dose up to the screening criteria dose).

The remaining capacity of the Clifton Marsh landfill site for each radionuclide has then been calculated by subtracting the existing inventory from this maximum inventory. Since there could be significant parallel dose contributions from several radionuclides 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.

Assuming a further 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.

Given the theoretical maximum annual disposal limit for each radionuclide, as described above, the radionuclides have been grouped and assigned annual disposal limits based on the most limiting radionuclide in that 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, and the calculated annual disposal limit for each radionuclide. In general, where several radionuclides having similar properties (e.g. decay type or isotopes of the same element) or being part of the same decay chain are calculated to have maximum annual disposal limits within one or two orders of magnitude of each other they have been grouped. This grouping has also been undertaken in order to both fully optimise the site (i.e. to avoid unnecessarily restricting disposals of certain radionuclides) and to ensure the risk assessment is never compromised (i.e. to restrict the annual disposal limit of certain radionuclides where necessary). For example, 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 slightly increasing 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 10 have been derived through this iterative approach and have been used to calculate the full potential inventory to the site which has been input to the risk assessment models to ensure that the dose criteria are not exceeded.

This grouping structure is for ease of development of waste acceptance criteria and subsequent reporting and waste tracking.

It is noted that an exercise has been undertaken to consider the disposal of additional radionuclides whose impacts that have not been explicitly assessed in the radiological risk assessment. This has resulted in the assignment of surrogate radionuclides which are part of the risk assessment to these additional radionuclides and subsequent inclusion of additional radionuclides to the Clifton Marsh WAC grouping. A full description of the assignment of surrogates is given in Thorn (2010f) and summarised in Eden (2010). The additional radionuclides, their surrogate and Clifton Marsh WAC group assignment is shown in Appendix 3 along with a full list of radionuclides considered and their appropriate grouping.

The radionuclide grouping and annual disposal limits (including additional radionuclides considered in terms of a surrogate) are summarised in Table 10.

Table 10: Summary of radionuclide grouping, annual disposal limit and total remaining site capacity for each group.

Radionuclide	***Group for Waste Acceptance Criteria Annual Disposal Limit***	***Proposed Annual Limit (Bq/yr) Assuming 11 Years of Future Disposals***
U-232	Uranium (and associated surrogates)	5.00E+11
U-233		
U-234		
U-235		
U-236		
U-238		
I-129		
Th-228	Thorium (and associated surrogates)	1.00E+11
Th-229		
Th-230		
Th-232		

Radionuclide	***Group for Waste Acceptance Criteria Annual Disposal Limit***	***Proposed Annual Limit (Bq/yr) Assuming 11 Years of Future Disposals***
Th-234		
Sn-126		
Nb-94		
Ac-227	Restricted Beta	1.00E+10
C-14		
Cl-36		
Co-60		
Cs-134		
Cs-137		
Ru-106		
Sr-90		
Tc-99		
Zn-65		
Zr-95		
Nb-95		
Ru-103		
Ag-110m		
Sb-125		
Eu-155		
Ba-133		
Eu-152		
Eu-154		
Pb-210	Ra-226/Ra-228/Pb-210/Po-210	6.00E+09
Po-210		
Ra-226		
Ra-228		
Ce-144	Other Beta(and associated surrogates)	2.00E+12
Fe-55		
Ni-63		
Pu-241		
Mn-54		
Pm-147		
Am-241	Other Alpha(and associated surrogates)	5.00E+10
Np-237		
Pa-231		
Pu-238		
Pu-239		
Pu-240		
Cm-242		

Radionuclide	***Group for Waste Acceptance Criteria Annual Disposal Limit***	***Proposed Annual Limit (Bq/yr) Assuming 11 Years of Future Disposals***
Ag-108m		
Pu-242		
Am-243		
Cm-243		
Cm-244		
H-3	H3	1.00E+13

It is anticipated that where the radionuclides are grouped, the sum of the activities of the radionuclides in that group will not exceed the limit for the group.

It should be noted that since the risk assessment model calculates in-growth of radionuclides that each radionuclide specified in the inventory is therefore considered to be head of chain. The site capacity calculations described 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.

As explained above, a maximum inventory based on the full Clifton Marsh landfill site capacity has been used to input into the risk assessment models in order to confirm that the peak dose to PEGs are still within acceptable limits. This maximum inventory is the maximum allowable site capacity for each individual radionuclide in the inventory, without any grouping of radionuclides.

All of the peak doses in the post closure risk assessment using this maximum inventory comply with the EA's dose criteria for as simple assessment with the exception of the dose from Sr-90 in the human intrusion scenario which peaks at 1.84E-02 Sv yr^{-1} and Rn-222 in the human intrusion scenario which peaks at 4.05E-02 Sv yr^{-1}. As mentioned in previous sections, however, it is considered that this scenario has been conservatively modelled and the use of alternative, less conservative parameters would lead to the calculation of doses that are even closer to the dose criteria.

This peak dose exceeds the dose criterion for a simplified assessment (1.00E-3 Sv yr^{-1}) by an order of magnitude for but would fall below the dose criteria in requirement R5 and R7 of the GRA (EA, 2009).

Requirement R5 of the GRA, (2009) states 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. 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 set by the EA for a simplified assessment. Dose constraints for the human intrusion scenario are given in Requirement R7 of the GRA as between 3-20mSv/yr. If the upper bound to these limits is considered, this is over one order of magnitude greater than the dose criterion set by the EA for a simplified assessment which is 1mSv/yr.

When the operational risk assessment models are re-run with the maximum potential inventory used as a source term, several of the radionuclides exceed the dose criteria in the sewage sludge scenario (exposure to farming family) and the leachate spillage scenario. Pa-231 exceeds the dose criteria in the inhalation of aerosols from the leachate lagoon scenario. The radionuclides exceeding the dose criteria for a particular scenario are shown in Appendix 6.

As explained in previous sections, it is considered that these operational models are conservative in that they do not take account of radionuclide sorption to the waste or any barriers to infiltration or migration. The models to assess the potential maximum inventory have been re-run using indicative parameters to represent sorption to the waste mass. Using these parameters, all the dose criteria are met.

It is also emphasised that operational monitoring will take place which should mitigate the risks posed by discharges of radionuclides from the Clifton Marsh landfill site during its operational lifetime. In addition, the likelihood of actually reaching the maximum site capacity for the Clifton Marsh landfill for each radionuclide as calculated here will be monitored throughout the site's lifetime and regular risk analysis undertaken to ensure that at no point the levels of risk become unacceptable.

Since the annual disposal limit is based on 11 years of future disposals to the Clifton Marsh landfill site. An extension in the Clifton Marsh landfill site lifetime would therefore lead to a decrease in the acceptable annual disposal limit, in order to observe the calculated site capacity.

8.2.2 Specific Activity of Waste Packages

The average activity concentration of any package containing radioactive waste shall not exceed a total cumulative value within the package of 200Bq g^{-1} after summating each radionuclide within the package. This average activity concentration will be applied to each package of waste.

To meet CDG transport regulations the waste consignor will be required to ensure that each package and each consignment can be classified as "fissile exempt".

Any consignor wishing to apply for authorisation to dispose of packages with higher specific activity will require authorisation from the Environment Agency and acceptance from SITA. Such packages, if acceptable will be pre- notified as “Special Higher Activity Packages” and will only be accepted at the Clifton Marsh landfill site after prior agreement and will be immediately disposed upon receipt at Clifton Marsh.

In addition to these specific activity limits, the following criteria will also apply:

- No load or drum or special item of waste has a gamma radiation dose rate greater than 7.5 microsieverts per hour measured as near as practicable to the surface of the waste at the time of its reception at the landfill.
- No load or drum or item of waste has a gamma radiation dose greater than 2.5 microsieverts per hour measured at 1 metre from the surface of the waste at the time of its reception at the landfill.

8.2.3 Waste Form & Packaging

Radioactive wastes will only be accepted at the Clifton Marsh landfill site if they are delivered in suitably secured containers that are sufficient to retain all contents during shipment by road and to the Clifton Marsh site disposal area.

The waste consignor and/or waste carrier will, under law have to ensure that the loading, packaging and transport of all radioactive waste will meet the requirements of the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (the CDG Regulations) and the European Agreement 2007 (the ADR).

The following waste packages will be acceptable at the Clifton Marsh landfill site:

- Sealed drums;
- Sealed lift bags such as Pactec IP 2 lift bags;
- Sealed ISO containers; and
- Loose VLLW or low activity LLW contained in reusable covered skips.

A maximum of 4 drums will be loaded vertically onto a pallet for shipment and disposal. Individual pallet weight when loaded should not exceed 1200 kg. All drums and the associated pallet should be steel banded for security during shipment and offloading. All loose drums or individual drums should also be palletised and secured.

Steel ISO containers may be used if specified to Industrial Package Standards (IP1 and 2) and meeting CDG and ADR will also be accepted subject to prior notification. The gross weight of any Individual ISO Containers must not exceed 25000 kg.

For ISO Containers no single internal voids of greater than 0.250 m^3 should remain after loading and dispatch to the Site.

For sealed drums or small volume containers no single internal voids of greater than 0.05 m^3 should remain after loading, and dispatch to site.

For soft sided packages such as lift bags, normal compaction and settlement is expected to take place and these criteria will not apply.

Further detail of the acceptance criteria for waste packages is given in SITA's Waste Acceptance Criteria and Operating Procedures document (SITA, 2009).

9 SITE OPTIMISATION

Requirement R8 of the GRA requires consideration of the optimisation of the site, in particular: "*The choice of waste acceptance criteria, how the selected site is used and the design, construction, operation, closure and post-closure management of the disposal facility should ensure that radiological risks to members of the public, both during the period of authorisation and afterwards, are as low as reasonably achievable (ALARA), taking into account economic and societal factors*".

It is considered that the design, operation and future management of the Clifton Marsh site, as set out in this document meets this criterion.

The design and construction of the disposal areas of the Clifton Marsh landfill site have been discussed, in particular the following key safety aspects:

- Lining system;
- Cap;
- Slurry trench cut off wall;
- Leachate management systems;
- Gas management systems.

These components of the landfill comply with good practice for landfills and serve as barriers to migration of radionuclides from the Clifton Marsh landfill site which helps to keep the radiological risks to members of the public as low as possible.

The radiological impacts from the facility that have been calculated in the radiological risk assessment arise from historic disposals of radioactive waste to the Clifton Marsh landfill site and adjacent Grange Farm landfill and do not take into account these barriers to radionuclide migration. Despite this conservatism, the impacts are below the regulatory criteria. It is therefore considered that the engineering design outlined above is optimised for radioactive waste disposals of the specific activity limit and no further enhancement to this design is required.

However, if the impact from disposals of any waste stream were calculated to exceed the regulatory criteria, it would be considered necessary to review the specific measures in place for containment of that waste stream.

This report has also discussed the systems and procedures in place at the Clifton Marsh landfill site to ensure that radioactive waste disposals are conducted in a safe and compliant manner. These systems and procedures include the Management System, record keeping, procedures for waste disposal, enforcement of Waste Acceptance Criteria, waste and environmental monitoring and staff training. It is considered that the implementation of these procedures enable the optimisation of site operations to ensure risks to operators and the public are kept as low as reasonably achievable.

It is noted that some of the characteristics of the Clifton Marsh site may increase the risk of adverse radiological impacts in the long term future of the site and therefore optimisation of the site into the future will need to be considered. The Clifton Marsh landfill site is situated close to the banks of the River Ribble and its estuary and the area surrounding the site is prone to flooding.

A simplistic assessment of the radiological risks anticipated following erosion of the Clifton Marsh landfill site has been performed using recent research and currently available data. However, due to the large uncertainties associated with the predictions of future climate and landscape change, the results of this assessment serve only as a general indication of the sensitivity of the modelling results to large changes in the characteristics of the site.

Post closure management of the Clifton Marsh landfill site may require future expenditure. Costs may be incurred for any engineering work necessary for final site closure and site maintenance. In order to provide for this potential expenditure, SITA undertake an annual review of the Clifton Marsh landfill site capping and closure and aftercare strategy to ensure financial provisions are budgeted and incorporated to ensure sufficient future funding. SITA also has a bond with the EA covering the existing environmental permit conditions, this has an aftercare period of 30 years..

The following section briefly discussed alternative concepts for waste disposals which have been considered in this application process.

9.1 Alternative Waste Disposal Concepts

The option for segregation of radioactive and non-radioactive waste has been considered. This would involve the disposal of radioactive waste in separate cells to the non radioactive waste and would offer the following advantages:

- Clearly identified parts of the landfill where radioactive waste is disposed of, enabling future management or remediation of these specific wastes;
- Application of special engineering or management measures to these specific cells;
- Avoidance of problematic reactions between non-radioactive and radioactive wastes – e.g. generation of large quantities of carrier gas for radioactive gas and other chemical interactions.

Conversely, it is considered that mixing of radioactive and non radioactive waste during disposal offers the following advantages over segregation:

- Homogenisation of radioactive waste with non radioactive waste leading to a reduction in potential radiological impacts through intrusion into the waste;
- Minimisation of changes to operating procedures resulting in optimum site efficiency and safety.

Alternative designs for the waste disposal cells have also been considered. One option would be to build engineered vaults lined with concrete for waste disposal. It is considered, however, that the performance benefits of this type of structure would be limited and that the clay lining system is likely to provide a better barrier to radionuclide migration. This option would also be very costly and may result in reducing the cost benefits of disposing of this low activity waste to landfill.

10 SUMMARY

This document is an Environmental Safety Case (ESC) which underpins the application for authorisation under the Radioactive Substances Act (RSA) 1993 for the Clifton Marsh site to receive radioactive wastes (VLLW and lower activity LLW) containing a wider range of radionuclides onto the site.

The proposals set out in this document are in line with the 2007 Government Low Level Waste (LLW) policy (DEFRA, 2007) which outlines a flexible approach to the management of LLW and places greater emphasis on the application of the waste hierarchy prior to final disposal of LLW.

Clifton Marsh historically operated as a hazardous landfill site following the PPC permitting process and is now classified as a non-hazardous landfill site and has been operating since the early 1980s for the disposal of domestic, commercial and industrial wastes. The Clifton Marsh landfill landfill site has also accepted low level radioactive waste (LLW) disposals from the Capenhurst and Springfields sites since 1986. Disposals of VLLW and LLW are sanctioned under the RSA 93 authorisations held by the Capenhurst and Springfields sites. The site's environmental impacts have been assessed previously for the PPC permit and under a radiological risk assessment undertaken in 2002 (BNFL, 2002).

This ESC supports the application for authorisation under the RSA 93 by providing a safety assessment giving evidence of the acceptability of the disposal of radioactive waste at the Clifton Marsh site. The ESC is set out in accordance with the requirements provided by the Environment Agency (EA, 2009).

The radiological risk assessment that underpins this ESC has been undertaken according to a methodology that uses a combination of approaches including the SNIFFER model developed by Galson Sciences and the screening methodologies developed by the EA for radionuclide releases during operational procedures, along with a more complex modelling approach using the GoldSim software tool.

The risk assessment is based both on the existing radioactive waste disposal inventory as defined in BNFL (2002) which includes the historical radioactive waste disposals at the Clifton Marsh site and those to the adjacent Grange Farm landfill that took place during the period 1974 to 1986 along with an estimated potential future disposals inventory which has been based on waste arisings reported in the 2007 UK National Inventory. This future disposal inventory for the Clifton Marsh landfill site will, however, only be defined after commercial agreements between SITA and the waste consignors are concluded.

The results of this assessment have been compared to the regulatory screening criteria as set out by the EA (2009) and are considered to meet requirement R9 of the GRA which states that "*The developer/operator should carry out an assessment to investigate the radiological effects of a disposal facility on the accessible environment both during the period of authorisation and afterwards with a view to showing that all aspects of the accessible environment are adequately protected*".

The proposed Waste Acceptance Criteria for the Clifton Marsh landfill site under the new authorisation have also been discussed in this report. Annual radioactivity limits for the waste to be accepted on site have been derived from the risk assessment results and the calculated remaining site lifetime radiological capacity for the Clifton Marsh landfill site.

The management procedures in place at the Clifton Marsh site which cover waste acceptance, receipt, disposal and health and environmental monitoring have also been outlined and are considered to meet the requirement of the GRA which states that the developer/operator of a disposal facility must foster and nurture a positive environmental safety culture at all times.

In summary, the measures set out in this ESC provide assurance that the authorisation of the Clifton Marsh site to receive VLLW/low activity LLW waste for disposals from a range of consignors will be managed in a safe, compliant and effective manner and any radiological impacts will be controlled to be well within the relevant regulatory prescribed criteria.

11 REFERENCES

Atkins, 2002a, Lancashire Waste Services Ltd, Clifton Marsh Landfill Extension, Phase 4. Regulation 15 Risk Assessment, WS Atkins Report, AY2611.020/AG/sb/012.15343(2)

Atkins, 2002b, Phase 4 Groundwater Risk Assessment Document Reference AF0558.203/AJG/102.22245(01)

Beresford, N, Brown, J., Copplestone, D., Garnier, J., Howard, B., Larsson, C. M., Oughton, D., Pröhl, G., Zinger, I., 2007, D – ERICA, An integrated approach to the assessment and management of environmental risks from ionising radiation, Description of purpose, methodology and application, EC Contract FI6RCT-2004-508847

BNFL, 2002 Clifton Marsh Radiological Safety Assessment.

British Nuclear Group, Radioactive Material Transport Monitoring Certificate for Off Site Dispatch - provided by SITA UK (Nuvia Reference 89290/SC/SF/003)

Defra, DTI and the Devolved Administrations, 2007, Policy for the Long Term Management of Solid Low Level Radioactive Waste in the United Kingdom – Summary of Comments and Government Response

EA, 2002, Landfill Regulations (England and Wales) 2002 as amended

EA, 2006a, November 2006, Radioactive Substances Act 1993 Certificate of Authorisation and Introductory Note for Springfield Fuels Limited Springfields Site, Authorisation Number BX0075/BY6869, Variation Notice BX0075/CA8019

EA, 2006b, Lambers, B. and Thorne, M., Initial Radiological Assessment Methodology – Part 2 Methods and Input Data, Environment Agency Science Report SC030162/SR2, 2006.

EA, 2008a, Radioactivity in Food and the Environment, 2008, Environment Agency Report RIFE 14

EA, 2007b, September 2007, Radioactive Substances Act 1993 Certificate of Authorisation and Introductory Note for Sellafield Limited Capenhurst Site, Authorisation Number CA8191/CA8191

EA, 2009, Near-surface disposal facilities on land for solid radioactive wastes: Guidance on requirements for authorisation. Environment Agency Publication

Eden and Higgins, 2009a, Baseline Radiological Monitoring Programme for Clifton Marsh Landfill Issue 3 (Nuvia Ltd Report 89290/DE/TR/002)

Eden, 2010, Radiological Risk Assessment and Capacity Calculation for the Clifton Marsh Landfill Site, Issue 2, Nuvia Ltd Report 89290/IN/RA/002

ENPL, May 2007, Clifton Marsh Landfill Gas Collection and Utilisation Management Plan

EU, 1992, EU Habitats Directive (92/43/EEC)

GoldSim, 2008. User's Guide. http://www.goldsim.com/Content.asp?PageID=82

ICRP, 1991, 1990 recommendations of the international commission on radiological protection. ICRP Publication 60, Anals of the ICRP, 21 (1-3)

Higgins, 2009a, Clifton Marsh Hazard Identification Report, Nuvia Ltd Report, 89290/SC/HID/001 Issue 2

Higgins 2009b, Report on the Historical Radiological Monitoring undertaken for the Clifton Marsh Landfill site, Nuvia Ltd Report, 89290/DE/TR/007

NDA, June 2009, UK Strategy for the Management of Solid Low Level Radioactive Waste from the Nuclear Industry, Consultation Document

SITA, 2007a, October - December, 2007, Clifton Marsh Landfill Site, Quarterly environmental monitoring report, North West region

SITA UK, December 2007b, Layout of Phase 1 (Nuvia Reference - 89290/SC/SF/012)

SITA UK, December 2007c, Layout of Phase 2 (Nuvia Reference - 89290/SC/SF/013)

SITA UK, December 2007d, Layout of Phase 3 (Nuvia Reference - 89290/SC/SF/014)

SITA UK, December 2007e, Layout of Phase 4 (Nuvia Reference - 89290/SC/SF/015)

SITA UK, December 2008, Clifton Marsh RSA – Stakeholder Engagement Plan

SITA UK, 2009, Material Acceptance Criteria and Operational Statement

SNIFFER, 2006, Scotland and Northern Ireland Forum for Environmental Research, Development of a Framework for Assessing the Suitability of Controlled Landfills to Accept Disposals of Solid Low-Level Radioactive Waste: Technical Reference Manual, SNIFFER, Edinburgh

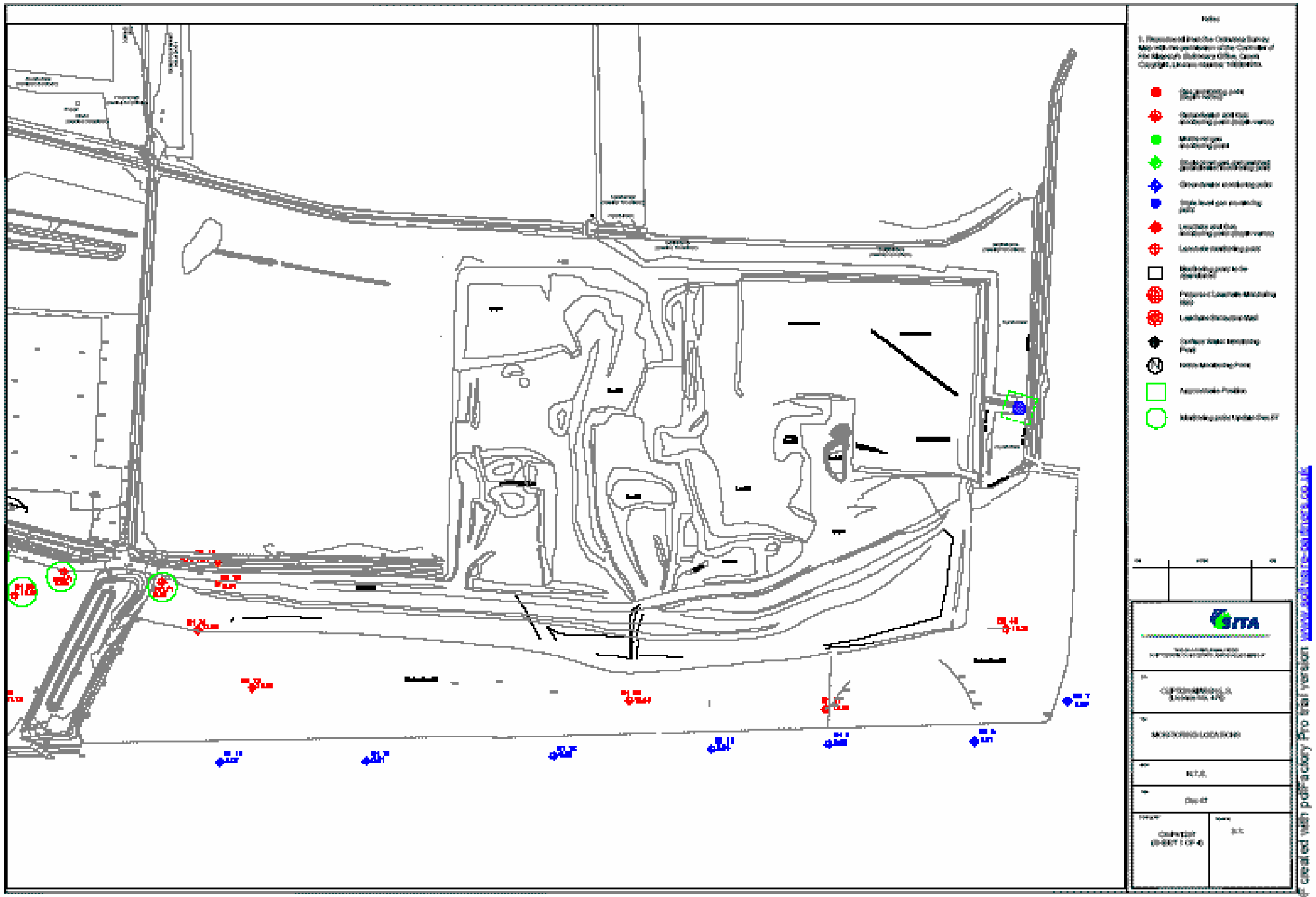
Thorne 2010a: External Memorandum – Aircraft Crashes and Explosions, Mike Thorne correspondence.

Thorne 2010c External Memorandum – Grouping of Additional Radionuclides, Mike Thorne correspondence.

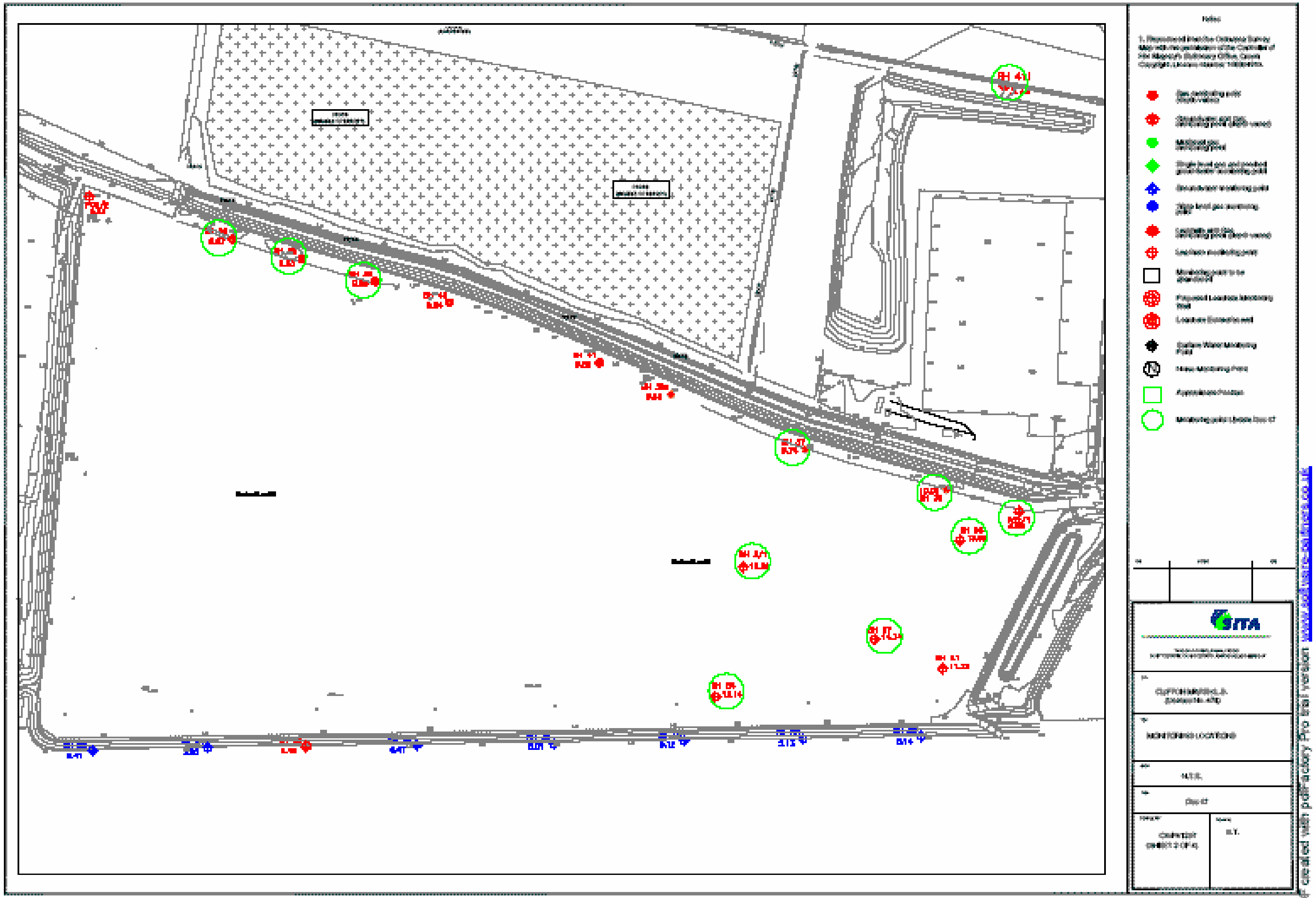
APPENDICES

Appendix 1 – Layout of the Clifton Marsh Site

Phase 1 (SITA 2007a)

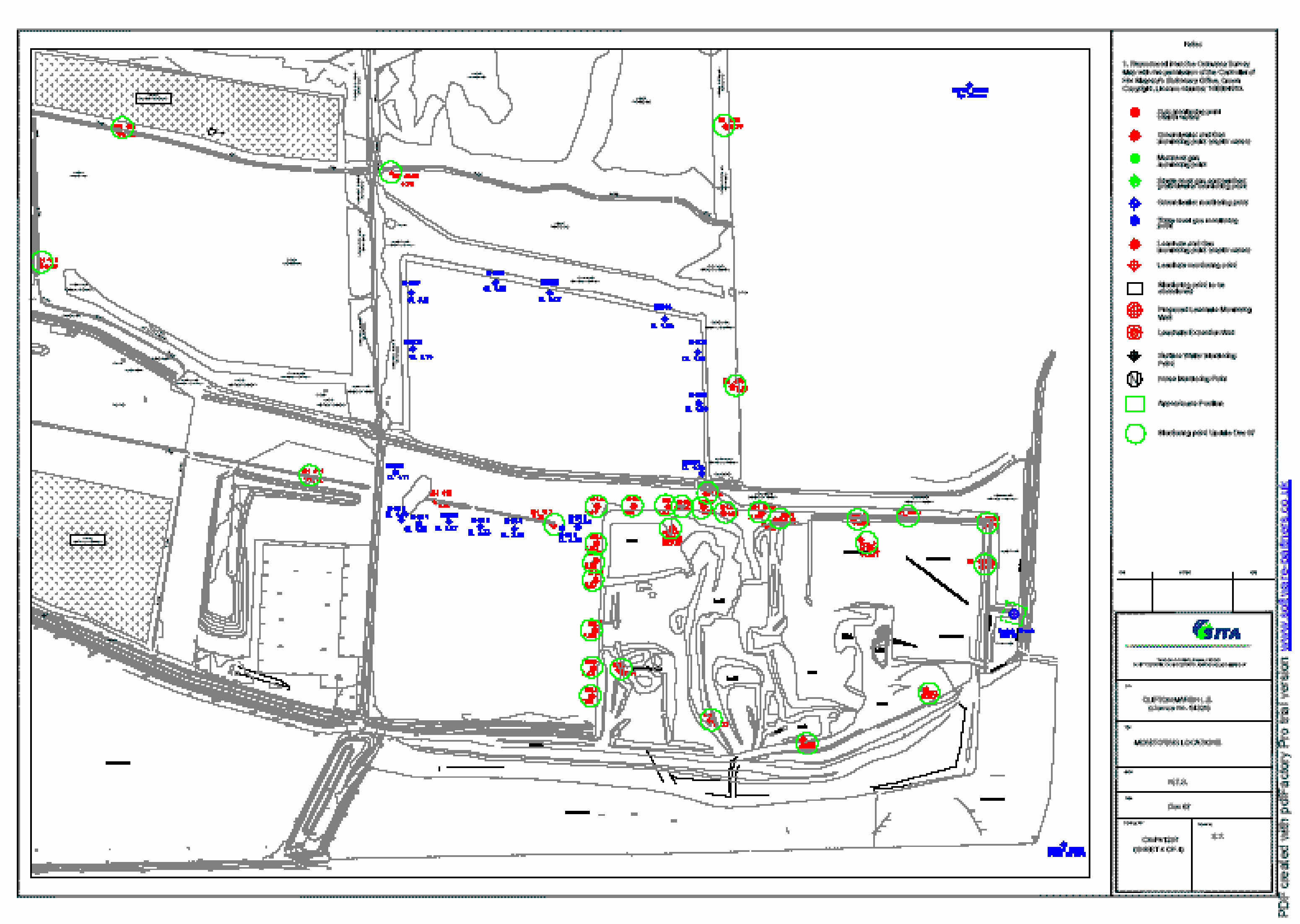


Phase 2 (SITA 2007b)

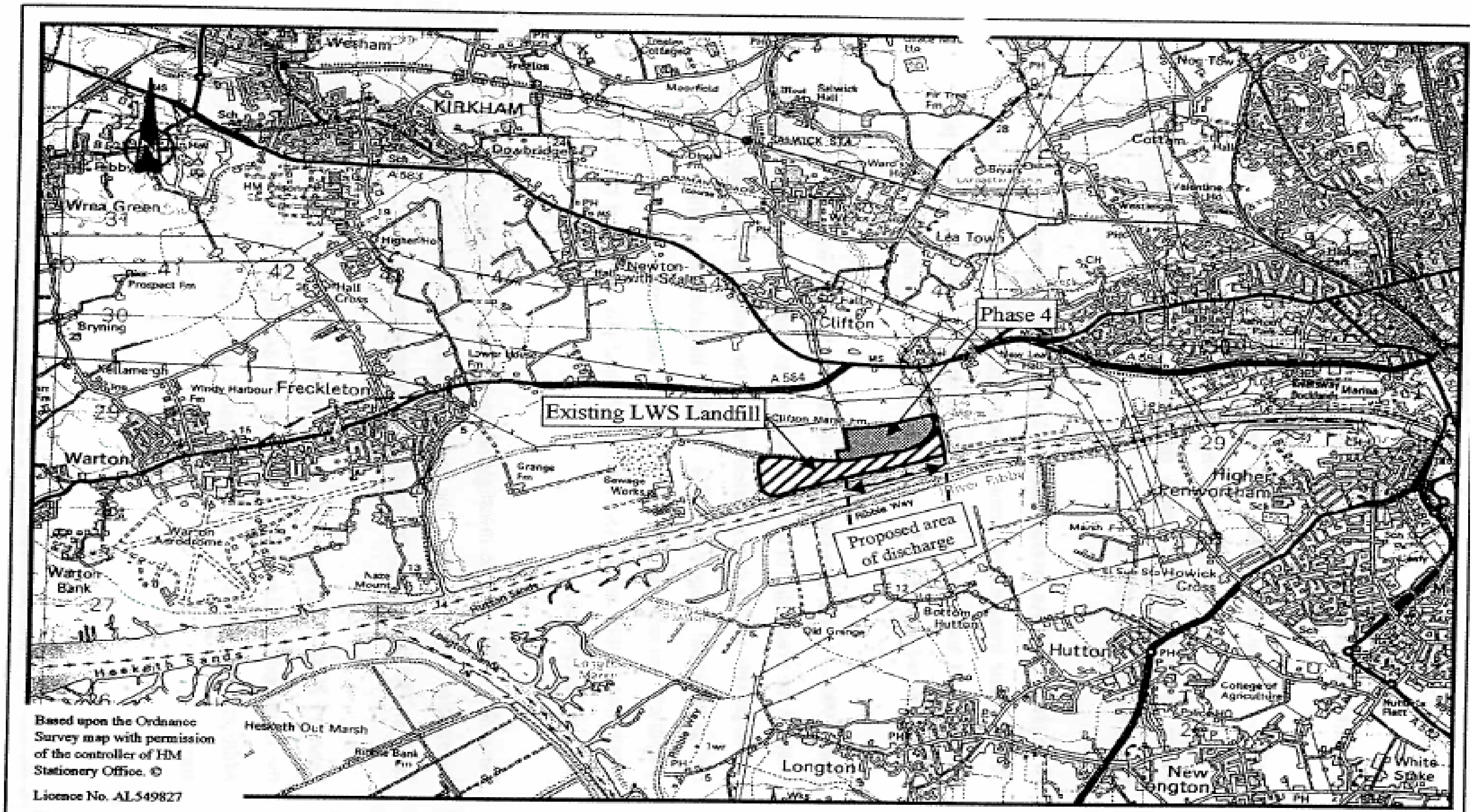


Phase 3 (SITA 2007c)

Phase 4 (SITA 2007d)

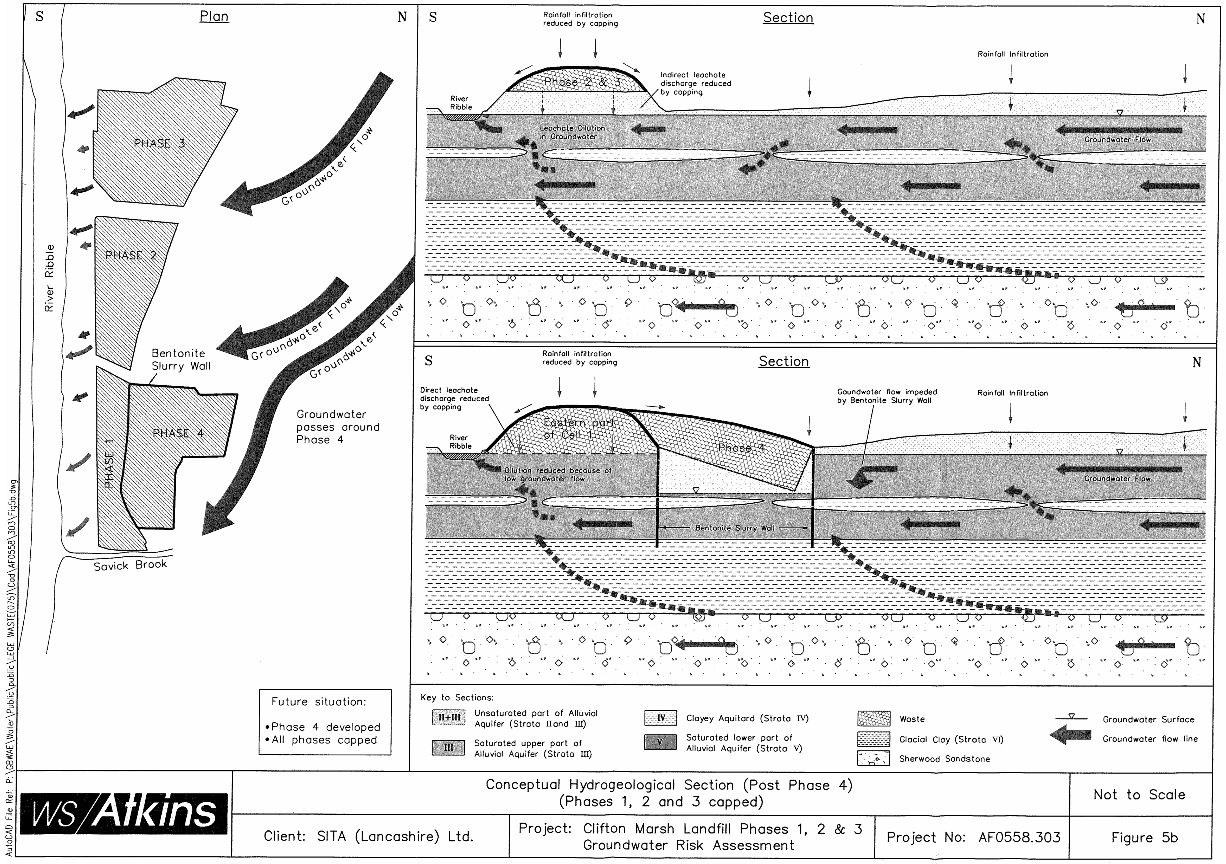


Layout of Clifton Marsh Landfill Site (Atkins 2002a)



WS Atkins	Site Location Plan			Scale 1:50,000
	Client: Lancashire Waste Services Ltd	Project: Clifton Marsh Landfill - Discharge Consent	Project No: AY 2611.020	Figure 1

Appendix 2 – Hydrogeology for the Clifton Marsh Landfill Site



APPENDIX 3 – ADDITIONAL RADIONUCLIDES AND THEIR WAC

Table 11: Additional Radionuclides not Considered in this Assessment, their Surrogates as Assigned by Thorne (2010f) and their WAC Grouping for Clifton Marsh

Additional Radionuclide	Surrogate (Thorne 2010f)	Clifton Marsh WAC Grouping
Mn-54	Fe-55	Other Beta
Zn-65	Cs-137	Restricted Beta
Zr-95	Co-60	Restricted Beta
Nb-95	Co-60	Restricted Beta
Ru-103	Ru-106	Restricted Beta
Ag-110m	Co-60	Restricted Beta
Sb-125	Cs-137	Restricted Beta
Pm-147	Ce-144	Other Beta
Eu-155	Co-60	Restricted Beta
Cm-242	Am-241	Other Alpha
Ag-108m	Am-241	Other Alpha
Sn-126	Th-232	Thorium
I-129	U-236	Uranium
Ba-133	Cs-137	Restricted Beta
Eu-152	Co-60	Restricted Beta
Eu-154	Co-60	Restricted Beta
Pu-242	Pu-239	Other Alpha
Am-243	Pu-239	Other Alpha
Cm-243	Pu-238	Other Alpha
Cm-244	Pu-238	Other Alpha
Nb-94	Th-232	Thorium

Table 12: Summary of WAC Groups and List of Radionuclides Acceptable in those Groups

Radionuclide	***Group for Waste Acceptance Criteria Annual Disposal Limit***	***Proposed Annual Limit (Bq/yr) assuming 11 years of future disposals***
U-232	Uranium (and associated surrogates)	5.00E+11
U-233		
U-234		
U-235		

Radionuclide	***Group for Waste Acceptance Criteria Annual Disposal Limit***	***Proposed Annual Limit (Bq/yr) assuming 11 years of future disposals***
U-236		
U-238		
I-129		
Th-228	Thorium (and associated surrogates)	1.00E+11
Th-229		
Th-230		
Th-232		
Th-234		
Sn-126		
Nb-94		
Ac-227	Restricted Beta	1.00E+10
C-14		
Cl-36		
Co-60		
Cs-134		
Cs-137		
Ru-106		
Sr-90		
Tc-99		
Zn-65		
Zr-95		
Nb-95		
Ru-103		
Ag-110m		
Sb-125		
Eu-155		
Ba-133		
Eu-152		
Eu-154		
Pb-210	Ra-226/Ra-228/Pb-210/Po-210	6.00E+09
Po-210		
Ra-226		
Ra-228		
Ce-144	Other Beta (and associated surrogates)	2.00E+12
Fe-55		
Ni-63		
Pu-241		
Mn-54		
Pm-147		

Radionuclide	***Group for Waste Acceptance Criteria Annual Disposal Limit***	***Proposed Annual Limit (Bq/yr) assuming 11 years of future disposals***
Am-241	Other Alpha (and associated surrogates)	5.00E+10
Np-237		
Pa-231		
Pu-238		
Pu-239		
Pu-240		
Cm-242		
Ag-108m		
Pu-242		
Am-243		
Cm-243		
Cm-244		
H-3	H3	1.00E+13