CONTENTS

ACRONYMS

BDP	Babcock Dounreay Partnership
BPEO	Best Practicable Environmental Option
BPM	Best Practicable Means
DEC	Dounreay Environment Committee
DSG	Dounreay Stakeholder Group
EA	Environment Agency
EARWG	Environment Agencies Requirements Working Group
GDF	Geological Disposal Facility
HAW	Higher Activity Waste
HEPA	High Efficiency Particulate Air
HSE	Health and Safety Executive
HVLA	High Volume Low Activity
IAEA	International Atomic Energy Agency
IERC	Independent Environmental Review Committee
IES	Interim End State
ILW	Intermediate Level Waste
LLW	Low Level Waste
LSA	Low Specific Activity
NDA	Nuclear Decommissioning Authority
PBO	Parent Body Organisation
RSA	Radioactive Substances Act
RWMD	Radioactive Waste Management Directorate
SEPA	Scottish Environment Protection Agency
SNM	Special Nuclear Materials
TBuRD	Technical Baseline and Underpinning Research and Development
US-DOE	United States Department of Energy

1 INTRODUCTION

1.1 Purpose

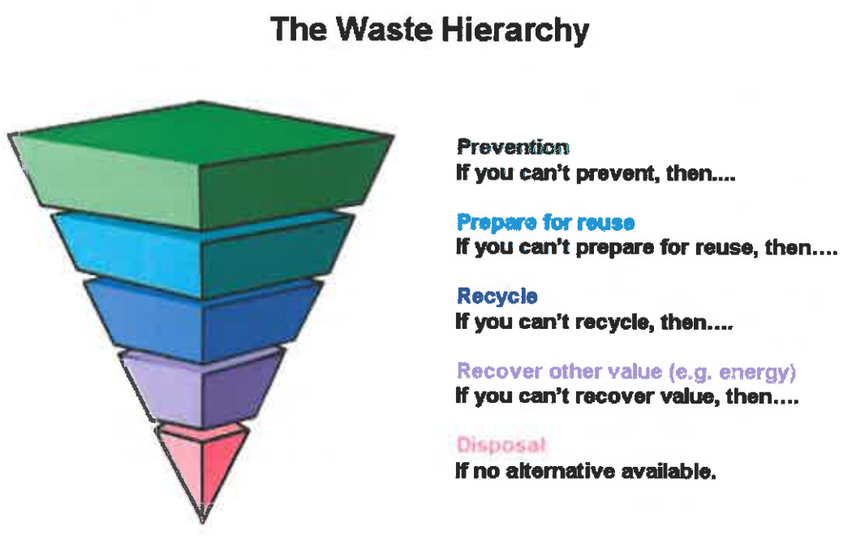
The purpose of this report is to identify the latest techniques in national and international best practice for minimising waste disposals (Schedule 11 - Item 2) and to compare this with current and planned strategies at Dounreay to determine whether the waste management practices at Dounreay continue to represent BPEO (Schedule 11 - Item 1).

1.2 Waste Minimisation

To provide a clear basis for the study it is important to clarify what is encompassed by waste minimisation. In its simplest form, this requires avoidance of waste in the first instance and reducing as far as possible the volume requiring disposal once the waste has been produced.

The Waste Management Licensing (Scotland) Regulations 2011 [1] set out in paragraph 6(2) of Schedule 4, the requirement to apply the waste hierarchy as a relevant objective. It states that the waste hierarchy is to be applied in such a manner as to deliver the best overall environmental outcome. Thus, the following figure represents the waste hierarchy and is adopted at Dounreay; it is preferred to manage wastes in order from the top to the bottom with the option at the bottom being the least favoured. It should be noted that paragraph 6(3) of Schedule 4 also allows for departure from the waste hierarchy for particular wastes types where it can be justified, in order to deliver the best overall environmental outcome

Fig 1



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1.3 Approach

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It is recogr
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skill sets and experience from other nuclear and commercial organisations. Thus, the BDP Dounreay PBO Competition document [12] has been reviewed to identify proposed technical changes to waste management and the output has also been included within this document.

2 ASSUMPTIONS AND CONSTRAINTS

The following assumptions and constraints have been made in relation to the BPEO:

- **Options must be consistent with UK Government policy on waste management**

  Although the SEPA/EA guidance states that there is no requirement to include consistency with Government policy explicitly in a BPEO study, it is important in determining how the UK meets international commitments and sets regulation on radioactive waste management. Further, the Management of Radioactive Waste is devolved to the Scottish Government. It is therefore considered that to progress the DSRL Life Time Plan, waste management options must be consistent with Scottish Government policy. Any deviation from this would require discussion with Scottish Government and would require their agreement prior to implementation.

- **Options must be consistent with regulatory requirements**

  Options must be capable of being legally implemented and therefore must not include any practices that are prohibited or do not meet legal requirements.

- **Options must comply with international conventions**

  The option must not cause a breach of duty of care to the environment outside national boundaries, breach international agreements / treaties or breach non-UK law.

- **Options must be technically feasible using existing or reasonably foreseen methods and processes and enable the achievement of the DSRL site interim end state**

  Waste management options need to exist and be able to be implemented over a reasonable timescale in line with the site programme and scheduled interim end state.

3 REVIEW OF BEST PRACTICE TECHNIQUES

Best practice techniques in waste minimisation that are either new or have been revised since 2009 are listed in Table 1 below; the full list of available techniques is presented in Appendix 1. This information was obtained from:

- The Environment Agencies Requirements Working Group (EARWG) waste minimisation best practice database. This is a live database that contains information on abatement technologies, which is the result of an ongoing review of national and international best practice and emerging technologies. The EARWG is comprised of a number of nuclear industry representatives[1]. The EARWG was formed to provide an industry approach to addressing the generic Additional Information and Improvement Requirements (AIIRs)

[1] AWE plc, Babcock International Group plc (Marine Division), BAe Systems Marine, British Energy, GE Healthcare, LLW Repository Ltd, Magnox North Ltd, Magnox South Ltd, Ministry of Defence, Rolls-Royce Marine Power Operations Ltd, Research Sites Restoration Ltd, Sellafield Ltd, Springfields Fuel Ltd, Studsvik UK Ltd and URENCO UK Ltd.

contained in the Permits and Authorisations granted to individual members by the EA and SEPA respectively.

- IAEA Waste Management literature and databases
- US-DOE Waste Management literature and databases.
- UK nuclear site Integrated Waste Strategy (including TBuRD) and Lifetime Plan documents.
- NDA RWMD website and literature
- The BDP Dounreay PBO Competition Document

Table 1 - New or Revised Techniques

Method	Technique	Date *	Utilised	Justification
Dismantling	Abrasive Water Jet Cutting	22/04/2012	No	DSRL processes are well established, utilising dry techniques (e.g. mechanical cutting and Diamond Wire Cutting) to minimise the potential for gaseous and /or liquid radioactive releases. Abrasive Water Jet Cutting produces significant radioactive aerosols and radioactive liquids which require significant treatment prior to discharge.
Encapsulation	Geomelt Vitrification	22/04/2012	No	DSRL processes are well established, utilising low complexity cementation. This process has a low potential for gaseous or liquid radioactive releases. Whereas, geomelt vitrification has a high energy consumption and the need for additional mobile (complex) abatement (particulate filtration, quenching, wet scrubbing, two stage HEPA filtration and carbon adsorption or thermal oxidation. Significant secondary waste production. Very slow process as melt is a few centimetres per hour. Requires glass forming constituents.
	Plasma Vitrification	22/04/2012	No	DSRL processes are well established, utilising low complexity cementation. This process has a low potential for gaseous or liquid radioactive releases and low energy needs. Plasma Vitrification is a very high temperature (10,000 Kelvin) process with very high energy consumption and rigorous process control.
Storage	NDA Container	11/05/2011	Yes	NDA RWMD approved range of radioactive waste containers and those currently going through approval.
	Sludge Stabilisation	22/04/2012	Yes	DSRL will have a number of localised LLW sludges being generated at a number of locations across the site at differing times into the future. The volume generated at each location with the exception of the Shaft and Silo is small. Thus, DSRL currently operate smaller scale non complex and low cost cementation plant at each location. There maybe opportunities to re-use these plant at a number of locations where the programme and scheduling are compatible. A bulk plant is currently proposed to manage wastes from the shaft and silo, as the current small scale cementation processes would not be able to support the production requirements for the Shaft and Silo.
Direct Disposal	Direct Disposal to LLW Repository near Drigg	11/05/2011	No	DSRL are not Authorised to dispose of LLW at LLWR. Thus, DSRL are currently building a LLW Repository adjacent to Dounreay for Authorised disposal of LLW.

Method	Technique	Date *	Utilised	Justification
Chemical Separation	Ion Exchange	11/05/2011	Yes	Ion Exchange is employed at DFR, PFR, D1204 and D1251
	Inorganic Media (Ion Exchange)	11/05/2011	Yes	Inorganic media is utilised to clean up the liquid discharge from the sodium/ potassium (NaK) primary coolant destruction plant and Ion Sieve 911 is utilised for pond water treatment at DFR
	Zeotypes (Ion Exchange)	11/05/2011	Yes	DSRL have installed this technique to support effluent treatment (if required) at D1224 (the shaft)
	Hexacyanoferrate (Ion Exchange)	11/05/2011	Yes	DSRL employ this technique at the Ultra Filtration Plant (UPP) for effluent treatment for the Silo.
	Other Materials (Ion Exchange)	11/05/2011	No	Not mature – still under development
	Organic Media (Ion Exchange)	05/11/2011	No	Low radiation stability for long term storage/ disposal
Treatment of Non Aqueous Liquids	Mercury Decontamination	22/04/2012	No	DSRL are going to the market place to determine what options are commercially available for mercury treatment.

* The date represents a new or modified record within the EARWG database, but does not necessarily represent a major change to the technique.

There have been relatively few updates in the past four years, although DSRL currently utilise a few of the techniques mentioned in Table 1. A number of the updated techniques listed above would not be BPM with the DSRL Plan and therefore are not employed.

It should be noted that whilst DSRL does not employ some of the techniques in Table 1, it does apply appropriate alternatives that are already in use on the site and are best practice techniques, elsewhere within the EARWG database.

4 APPLICATION OF NATIONAL AND INTERNATIONAL BEST PRACTICE TECHNIQUES

Each UK nuclear site is required to establish (through their RSA Certificates of Authorisation) how it performs against best practice for the application of the waste minimisation technique. This information, sourced from individual site Integrated Waste Strategy documents and individual sites Technical Baseline and Underpinning Research and Development documents, is summarised in Appendix 2 along with those techniques employed or proposed for use at Dounreay.

The techniques used across the UK nuclear industry are broadly similar (as is the outcome achieved) for comparable waste streams. The current DSRL approach of using a number of different containers, some self-shielded and some not, combined with grouting now or in the future will achieve the same outcome as the other UK nuclear sites in that HAW can be stored for long periods in a manner that does not preclude future disposition to a Geological Disposal Facility (GDF) should the Scottish Government Higher Activity Waste (HAW) Policy [13] change. Whilst paragraph 2.04.30 of the HAW Policy states that disposal as near to surface as practicable is one of a number of options, paragraph 2.04.03 of the same Policy gives a clear indication of Scottish Government's preference for this option. As a result HAW storage is the

Scottish Governments preferred option. The D
with the Scottish Policy and it is recognised
compliance with changes to the HAW policy.

The best practice techniques for waste minim
countries) depend upon the nature of the waste
location (country and site). No additional wa
international sites which have not already beer
national best practice.

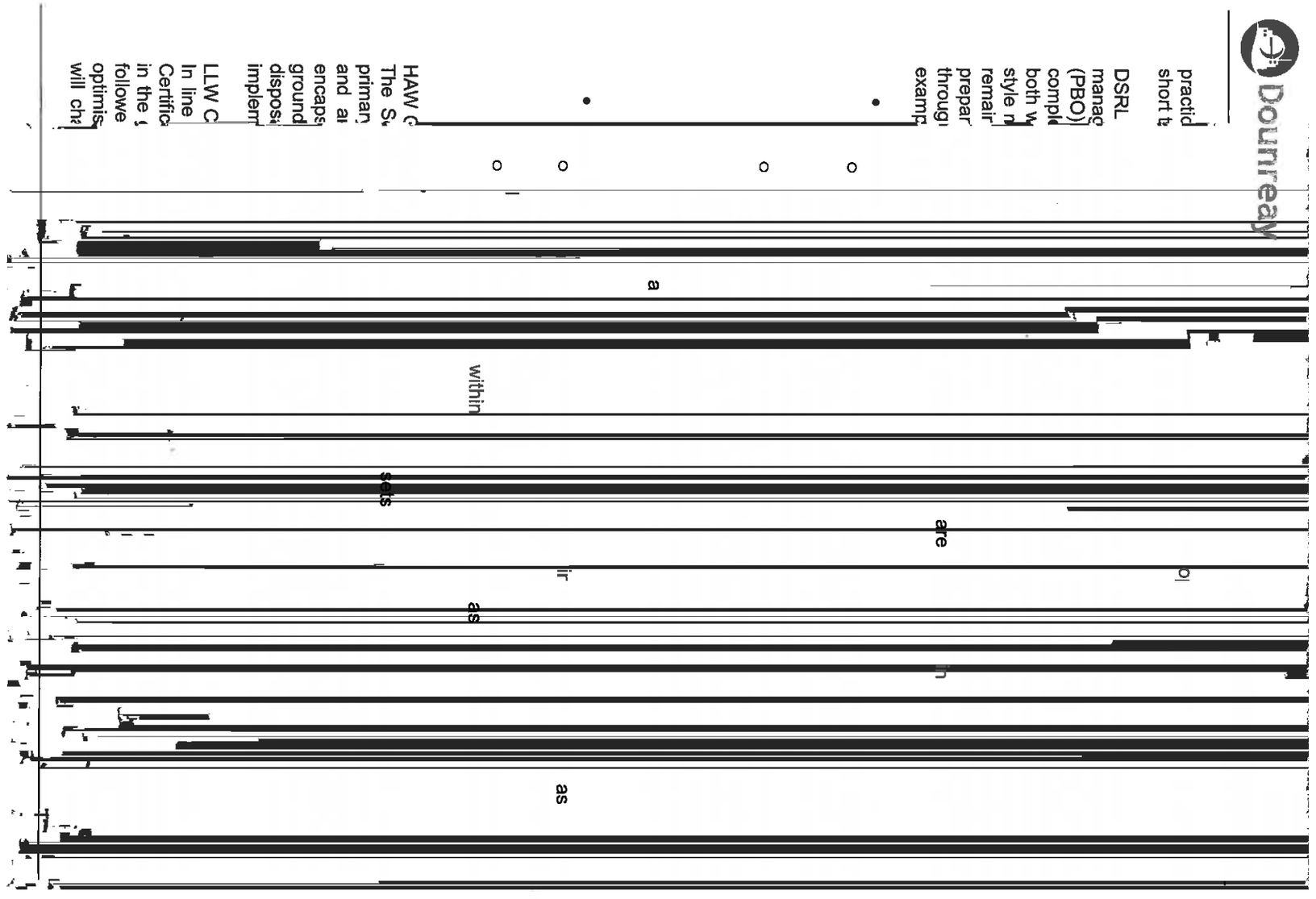
Having undertaken this review, DSRL consi it waste minimisati
continue to represent best practice in waste mini

5 BEST PRACTICABLE ENVIRONMENTAL

A comparison of the waste management str
(including the 2003 and 2009 BPEO reviews)
management strategy, to determine if the assum
determine proposed changes in waste man
assumptions remain valid. The changes to wast
introduction of the Scottish Governments HAW P

Whilst the assumptions remain valid there are a
the way wastes are managed. Where changes
BPM level and do not impact on the BPEO. For
from grout to a polymer, or a waste container b
Other changes reflect improvements in waste s
clear forward strategy for waste management,
number of management options which included t
graphite after full characterisation will be segre
considered as being ILW. Such changes are
passively safe solid waste (e.g. a liquid waste
storage and disposal whether it is ILW or LLW, r
be realised whilst minimising secondary waste
waste hierarchy and BPM. Similarly, detailed de
ILW packages will be subject to BPM review.

Since the last NIBP Review in 2009 [7], DSRL BPM
more rigorously than previously, through a 'claim This
process mirrors the BPM requirements of th
identified, actions are raised either at site or f
evidence to robustly support a claim. This rep
with the RSA Authorisations and the demonstra
noted that BPM is defined in the RSA Authoris
engineering control that minimises, as far as rea
to the environment whilst taking account o
effectiveness, technological status, operational
BPM optimises the BPEO to ensure that radioa
and the generation of secondary radioactive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disposal facility currently under construction adjacent to the Dounreay Site. Therefore, the strategy for the management of low level radioactive wastes at Dounreay represents the BPEO.

6 STAKEHOLDER COMMUNICATION

The Dounreay Stakeholder Group (DSG) was made aware on the 7 November 2012 of the RSA requirement for this review and on the approach identified above. The finalised document shall be copied to the DSG at the same time as it is submitted to SEPA, as part of DSRL's continued stakeholder engagement process.

7 REFERENCES

1. Waste Management Licensing (Scotland) Regulations 2011
2. Radioactive Substances Act 1993 (as amended)
3. Nuclear Installations Act 1962 (as amended)
4. Radioactive Substances Act Certificates of Authorisation RSA/N/50010/99 (as a varied), RSA/N/50011/99 (as varied) and RSA/N/50012/99 (as varied)
5. Nuclear Site Licence Ref. No. Sc17
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7. A Review of National and International Best Practice on Waste Minimisation, Ref No DEC(09)P175, March 2009
8. The 2008 DSRL Site Waste BPEO, Ref No DEC(09)P196, June 2009
9. Best Practicable Environmental Option Study for Management of Radioactive Waste Arisings from the Dounreay Site Restoration Plan, Issue 1 June 2003
10. Royal Commission on Environmental Pollution (RCEP) Twelfth Report 1988
11. Proposed Process for the Four Year review of Site's Waste BPEO and supporting NIBP, Ref No DEC(12)P399, September 2012
12. Babcock Dounreay Partnership - Dounreay PBO Competition - 30 Aug 2011
13. Scotland's Higher Activity Radioactive Waste Policy 2011

Dounreay

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- Authorisation of Di[illegible] assessment of Prc[illegible]
- Guidance for the E[illegible] at Nuclear License[illegible] Environmental Optic[illegible]
- The Management [illegible] the Regulatory Prc[illegible] 1
- Integrated Waste S[illegible]
- Integrated Waste S[illegible] 11
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- Integrated Waste S[illegible]

- Integrated Waste Strategy – Hunterston A Site Oct 2011
- Integrated Waste Strategy – Sizewell A Site Oct 2011
- Integrated Waste Strategy - Wylfa Site Oct 2011
- Sellafield Integrated Waste Strategy – Baseline (Version 1) May 2007
- Sellafield Integrated Waste Strategy – Version 2 Report and Recommendations, July 2007
- Sellafield Integrated Waste Strategy – Update to Version 2 June 2008
- Sellafield Integrated Waste Strategy – Sellafield Stakeholder Engagement (Version 1) May 2007
- RSRL Integrated Waste Strategy – Issue 4 March 2012
- Dounreay 'Interim' Integrated Waste Strategy – Issue 7 March 2011
- Dounreay Integrated Waste Strategy – Issue 8 (Draft) Issue March 2013
- Waste Management Strategy Report - Review of National and International Developments on Best Practice for Minimising all Radioactive Waste Disposals Devonport Royal Dockyard Ltd, Issue 1.4 July 2011
- NDA RWMD – Magnox Care and Maintenance Preparation Wastes in Ductile Cast Iron Containers (Conceptual Stage) Summary Assessment Report 19 May 2010
- Environment Agencies Requirements Working Group (EARWG) – Waste Minimisation Database - http://www.rwbestpractice.co.uk/Main.aspx
- U.S. Department of Energy web site - Energy.Gov Waste Management - http://energy.gov/em/services/waste-management
- International Atomic Energy Authority web site – Nuclear Fuel Cycle and Waste Technology - http://www.iaea.org/OurWork/ST/NE/NEFW/home.html
- NDA RWMD Document Library web site - http://www.nda.gov.uk/documents/
- IAEA Nuclear Energy Series, Policies and Strategies for Radioactive Waste Management ref No NW-G-1.1, 2009
- NDA's DRP Research and Development Reports 201011 and 2011/12

Appendix 1

National and International Best Practice Techniques in Waste Minimisation

Waste Minimisation Tech
Revised and/ or new methods are h

Method	Date Last Updated	Utilised at DSRL
Sorting		
• Hands-on	23/05/2007	Yes
• Automated	20/09/2005	No
• Magnetic Sorting	08/05/2006	No
Physical decontamination		
• Water Flushing	04/04/2005	Yes
• Washing of soil / rock /	20/12/2004	No
• Use of strippable coatin	17/12/2008	Yes
• Steam Cleaning	16/02/2007	Yes
• Low Pressure Water Je	03/11/2006	No
• Grinding / Shaving	31/01/2005	No
• Metal Milling	21/05/2005	No
• Drilling and Spalling / E	23/05/2007	No
• Jackhammer	03/11/2006	Yes
• Ultrasonic cleaning	03/11/2006	No
• Melting	17/12/2004	No
• Thermal degradation	04/04/2005	No
• Use of abrasive cleanin	17/12/2008	Yes
• Ice crystal blasting	21/12/2004	No
• Dry Ice Crystal (CO_2) B	17/12/2008	No
• Wiping / scrubbing	16/11/2006	Yes
• Vacuuming / Dusting	09/07/2007	Yes
• Scabbling / scarifying / p	16/11/2006	Yes
• Lasers	23/05/2007	No
• Vacuum Desorption	08/05/2006	No
• Microwaves	08/05/2006	No
• Cryocleaning	19/09/2007	No
• Pigging	06/10/2008	Yes
Chemical Decontamination		
• Use of Strong Mineral A	03/11/2006	Yes
• Use of Bases and Alkali	03/11/2006	No
• Use of Complexing Age	21/02\2005	No
• Bleaching	29/03/2005	No
• Use of Detergents and S	22/05/2007	Yes
• Use of Organic Solvents	03/11/2006	No
• Foam Decontamination	05/11/2008	No
• Use of Chemical Gels /	23/05/2007	No
• Chemical Fog Decontam	05/11/2008	Yes
• Exothermic Metallised P	29/03/2005	No
• Low Oxidation Metal Ion (LOMI)	22/02/2005	No
• Micro organisms	08/05/2006	No
• Dissolvable clothing	05/11/2008	Yes
• Supercritical fluids	05/11/2008	No
Electrochemical Decontamina		
• Electropolishing / Electr	16/11/2006	No
• DFDX	07/06/2007	No

Pressure Water Jets

Gas

• Electrokinetics / Electromigration	07/06/2007	No
Decommissioning – Dismantling		
• Mechanical cutting – hands on and remote	16/11/2008	Yes
• Thermal Cutting	17/12/2008	Yes
• Electrical Cutting	23/05/2007	No
• Laser Cutting	03/03/2006	No
• **Abrasive Water Jet Cutting**	**22/04/2012**	**No**
Decommissioning – Demolition		
• Mechanical Demolition	07/07/2007	Yes
• Demolition Robot	16/11/2008	Yes
Volume Reduction		
• Compaction	15/11/2006	Yes
• High Force Compaction	17/12/2008	Yes
• Incineration	17/12/2008	No
• Molten Salt Oxidation	23/05/2007	No
• Chemical Wet Oxidation	17/12/2008	No
• Electrochemical Wet Oxidation	06/03/2006	No
• Hydrothermal Wet Oxidation	06/03/2006	No
• Biodegradation	09/05/2006	No
• Cracking / Pyrolysis	16/11/2008	No
• Metal Melting	16/11/2008	Yes
• Shredding	17/12/2008	Proposed
• Thermochemical conversion	07/06/2007	No
• Freezing by cryogenics and crushing	24/09/2007	No
• Vacuum packing	22/08/2008	No
Encapsulation of Waste		
• Ceramic encapsulation	20/03/2005	No
• Cementation	16/11/2006	Yes
• Synthetic Polymer encapsulation	29/03/2005	No
• Mineral Matrix (Synroc)	29/03/2005	No
• Polymer Microencapsulation	29/03/2005	No
• Vitrification (Borosilicate Glass)	23/05/2007	No
• **Geomelt Vitrification**	**22/04/2012**	**No**
• **Plasma Vitrification**	**22/04/2012**	**No**
Storage of Waste – Waste Containers		
• Stainless Steel Drums	03/11/2006	Yes
• Cast Iron Steel Drums	12/08/2005	No
• **NIREX Container (NDA Container)**	**11/05/2011**	**Yes**
• Reinforced (Concrete)	12/01/2005	Proposed
• Solid Delay Hold-Up	15/11/2006	Yes
• **Sludge Stabilisation**	**22/04/2012**	Yes
Direct Disposal		
• **Direct Disposal to LLW Repository near Drigg**	**11/05/2011**	**No**
Liquid Filtration Techniques		
• Simple Filtration	05/11/2008	Yes
• Precoat filters	02/11/2005	No
• Funda Filter	09/05/2006	No
• Cross Flow Filtration	19/10/2005	No

• Micro / Ultra Filtration	09/07/2007	Yes
• Reverse Osmosis	04/04/2005	No
Electrochemical Separation Technologies		
• Electroflotation / electroflocculation	20/10/2004	No
• Electrochemical Ion Exchange	13/01/2005	No
• Electrodialysis	23/05/2007	No
• Plasma Mass Filter	07/06/2007	No
• Electrodeposition	20/10/2004	No
Physical Separation Techniques		
• Evaporators		
o Coil / Pot Evaporators	15/12/2004	Yes
o Horizontal Natural Circulation Evaporators	29/03/2005	No
o Vertical Thermosyphon Evaporators	29/03/2005	No
o Forced Circulation Evaporators	09/07/2007	No
o Falling Film Evaporator	20/03/2005	No
o Wiped Film Evaporator	20/03/2005	No
o Vertical Natural Circulation Evaporator	20/03/2005	No
• Microwave In-Drum Drying	06/10/2008	No
• Centrifuge / Hydroclone	03/11/2006	No
• Delay / Hold up / outgassing	05/09/2005	No
• Freeze Crystallisation	09/05/2006	No
• Calcination	07/06/2007	No
• Immobilised Moss	17/09/2007	No
• Steam Reforming	07/06/2007	No
• Gravity Settling	22/08/2008	Yes
Precipitation and Flocculation Technologies		
• Precipitation	09/07/2007	Yes
• Co-precipitation	09/07/2007	No
• Co-precipitation with Barium Nitrate Addition	09/05/2006	No
• Polyelectrolyte Bases Precipitation	09/07/2007	No
Chemical Separation Techniques		
• **Ion Exchange**	**11/05/2011**	**Yes**
o **Inorganic Media**	**11/05/2011**	**Yes**
o Zeolites	09/05/2006	No
o **Zeotypes (under development)**	**11/05/2011**	**Yes**
o **Hexacyanoferrate (under development)**	**11/05/2011**	**Yes**
o **Other Materials (under development)**	**11/05/2011**	**No**
o **Organic Media**	**05/11/2011**	**No**
• Solvent Extraction	05/11/2008	No
• UV Ozonolysis	04/04/2005	No
Treatment of Non Aqueous Liquids		
• Conversion to solid by adsorption	22/08/2008	No
• Biodegradation	06/10/2008	No
• Incineration	06/10/2008	No
• Treatment of contaminated oils	22/08/2008	Proposed
• **Mercury Decontamination**	**22/04/2012**	**No**
Airborne Particulate Removal		
• Standard HEPA Filter	05/11/2008	Yes
• Circular HEPA filter	17/09/2007	Yes

• Large Area Roll Filters	01/04/2005	No
• Cyclone Separators	03/11/2006	No
• Mechanical Centrifuge Separators	03/11/2006	No
Other Gaseous (including Volatile Abatement)		
• Delay Bed	20/04/2004	No
• Decay Tank	22/02/2005	No
• Iodine Adsorbers	12/08/2005	No
o Other Metal Oxide Adsorbers	17/01/2005	No
o Silver Nitrate Impregnated	09/05/2006	No
o TEDA Impregnated Coal Based Carbon Adsorbers	30/10/2006	No
• Gaseous Tritium Abatement	12/08/2005	No
o Molecular Sieve	04/04/2005	No
o Hydrogen Getters	05/01/2005	No
• Gas Scrubbing	03/11/2006	Yes
• Charcoal Filters	20/09/2005	No
o Coconut Based Carbon filters	30/10/2006	No
o Copper Impregnated Coconut Based Carbon Filters	30/10/2006	No
• Cryogenic Separation	30/10/2006	No
• Vapour condensers	03/11/2006	No

Appendix 2

Comparison and Application of National Best Practice in Waste Minimisation

Waste Category		D…	Sellafield Ltd Sites		Magnox	Sizewell A
		Dou…	[illegible]	[illegible]	[illegible]	
RHILW	Solid	Sortin… reduct… immob… encap… for sto…	[illegible]	[illegible]	[illegible]	
	IX Columns	Immob… encap… for sto…	[illegible]	[illegible]	[illegible]	
	Raffinate	Immob… encap… for sto…	[illegible]	[illegible]	[illegible]	N/A
	SNM * (Solids/ Liquids)	Pre-tre… immob… encap… for sto…	[illegible]	[illegible]	[illegible]	N/A
	Liquids	Immob… encap… for sto… Chemi… treatm… for ma… discha…	N/A	N/A	[illegible]	
	Sludges	Encap… cemen…	[illegible]	[illegible]	…in [illegible]	
CHILW	Solids	Sort a… segreg… Decon… where… approp… Encap… cemen… storag… Soils -… boxes,… shield… contai…	[illegible]	[illegible]	…iccants.	

Waste Category		DSRL	RSRL	Sellafield Ltd Sites				Magnox									
		Dounreay	Harwell/ Winfrith	Windscale	Sellafield	Capenhurst	Springfields	Chapelcross	Hunterston A	Oldbury	Trawsfynydd	Wylfa	Berkeley	Bradwell	Dungeness	Hinkley Point A	Sizewell A
	SNM * (Solids/ Liquids)	Pre-treat, immobilisation/ encapsulation for storage	N/A	N/A	None declared as wastes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Liquid	Wet abatement, incineration, filtration for gaseous and or marine discharge and or Immobilisation/ encapsulation for storage	Solvents and oils sent for incineration	N/A	Solvents destroyed and discharged to sea	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	High temperature processing trialled.	N/A
	Sludge	Treatment, immobilisation/ encapsulation for storage	Encapsulate sludge in cement	N/A	Oils and greases are collected and incineration is being considered	N/A	N/A	N/A	N/A	N/A	Grout encapsulate oily sludge into $3m^3$ boxes. This experience shared with all sites	N/A	N/A	N/A	N/A	N/A	N/A
LLW	Solid	Segregate LLW and potentially clean waste Decontaminate to "Out of Scope" levels Superompact Disposal in HHISOs in LLW Vaults Bulk - Immobilise/encapsulate into passively safe form for disposal to LLW Vaults Place in bags for disposal in LLW Vaults	Segregate LLW and potentially clean waste Decontaminate to "Out of Scope" levels Supercompact	Segregate LLW and potentially clean waste Decontaminate to "Out of Scope" levels Supercompact	Segregate LLW and potentially clean waste Decontaminate to "Out of Scope" levels Supercompact	Segregate HVLA for direct disposal	N/A	Segregate LLW and potentially clean waste Decontaminate to "Out of Scope" levels Supercompact	Segregate LLW and potentially clean waste Decontaminate to "Out of Scope" levels Supercompact	Segregate LLW and potentially clean waste Decontaminate to "Out of Scope" levels Supercompact	Segregate LLW and potentially clean waste Decontaminate to "Out of Scope" levels Metal recycling via LLWR Supercompact	Segregate LLW and potentially clean waste Decontaminate to "Out of Scope" levels Supercompact	Decontaminate to "Out of Scope" levels Incinerate combustible wastes Supercompact	Segregate LLW and potentially clean waste Decontaminate to "Out of Scope" levels Incinerate combustible wastes Size reduction	Decontaminate to "Out of Scope" levels Incinerate combustible wastes	Decontaminate to "Out of Scope" levels Incinerate combustible wastes Segregate metal followed by melting	Decontaminate to "Out of Scope" levels Incinerate combustible wastes

Waste Category		DSRL	RSRL		
		Dounreay	Harwell/ Winfrith	Windscale	
	Liquid	Conditioning (pH adjustment and filtering) for marine discharge Solvents/Oils - Wet abatement, incineration, filtration for gaseous and or marine discharge and or Immobilisation/ encapsulation for storage and final LLW disposal	Flocculate and settle liquid prior to discharge Sampling and analysis of liquids prior to discharge	N/A	F s p d F lo o S a liq d
	Sludge	Immobilisation/ encapsulation for disposal as solid LLW LSA Scale - Store, assay, treat and disposal as LLW solids Putrescible - Dry, assay, store treatment and immobilisation/ encapsulation for disposal as solid LLW	Encapsulate in cement	N/A	E c
HVLA waste	Solid	Place in bags in Demolition LLW Vaults	On site HVLA disposal facility	N/A	N
OoSOR and Clean Non Hazardous Waste	Solid	Segregate from inert wastes. Segregate by material type to enable maximum reuse/recycling	Segregate from inert wastes. Segregate by material type to enable maximum reuse/recycling	Segregate from inert wastes. Segregate by material type to enable maximum reuse/recycling	S fr w S m to m re g

Waste Category		DSRL	RSRL	Sellafield Ltd Sites				Magnox									
		Dounreay	Harwell/ Winfrith	Windscale	Sellafield	Capenhurst	Springfields	Chapelcross	Hunterston A	Oldbury	Trawsfynydd	Wylfa	Berkeley	Bradwell	Dungeness	Hinkley Point A	Sizewell A
OoSOR and Clean Inert Waste	Solid	Retain for recycling as backfill of voids generated during site decommissioning	Retain for recycling as backfill of voids generated during site decommissioning	Retain for recycling as backfill of voids generated during site decommissioning	Retain for recycling as backfill of voids generated during site decommissioning	N/A	N/A	Retain for recycling as backfill of voids generated during site decommissioning	Retain for recycling as backfill of voids generated during site decommissioning	Retain for recycling as backfill of voids generated during site decommissioning	Retain for recycling as backfill of voids generated during site decommissioning	Retain for recycling as backfill of voids generated during site decommissioning	Retain for recycling as backfill of voids generated during site decommissioning	Retain for recycling as backfill of voids generated during site decommissioning	Retain for recycling as backfill of voids generated during site decommissioning	Retain for recycling as backfill of voids generated during site decommissioning	Retain for recycling as backfill of voids generated during site decommissioning
OoSOR and Clean Hazardous Waste	Solid	Segregate non-hazardous wastes Segregate material type to enable maximum reuse/recycling Clearance of asbestos and non-recyclable by specialist contractor	Segregate non-hazardous wastes Segregate material type to enable maximum reuse/recycling Incinerate combustible non-recyclable wastes Clearance of asbestos by specialist contractor	Segregate non-hazardous wastes Segregate material type to enable maximum reuse/recycling Incinerate combustible non-recyclable wastes Clearance of asbestos by specialist contractor	Segregate non-hazardous wastes Segregate material type to enable maximum reuse/recycling Incinerate combustible non-recyclable wastes Clearance of asbestos by specialist contractor	Clearance of asbestos by specialist contractor	Clearance of asbestos by specialist contractor	Segregate non-hazardous wastes Segregate material type to enable maximum reuse/recycling Incinerate combustible non-recyclable wastes Clearance of asbestos by specialist contractor	Segregate non-hazardous wastes Segregate material type to enable maximum reuse/recycling Incinerate combustible non-recyclable wastes Clearance of asbestos by specialist contractor	Segregate non-hazardous wastes Segregate material type to enable maximum reuse/recycling Incinerate combustible non-recyclable wastes Clearance of asbestos by specialist contractor	Segregate non-hazardous wastes Segregate material type to enable maximum reuse/recycling Incinerate combustible non-recyclable wastes Clearance of asbestos by specialist contractor	Segregate non-hazardous wastes Segregate material type to enable maximum reuse/recycling Incinerate combustible non-recyclable wastes Clearance of asbestos by specialist contractor	Segregate non-hazardous wastes Segregate material type to enable maximum reuse/recycling Incinerate combustible non-recyclable wastes Clearance of asbestos by specialist contractor	Segregate non-hazardous wastes Segregate material type to enable maximum reuse/recycling Incinerate combustible non-recyclable wastes Clearance of asbestos by specialist contractor	Segregate non-hazardous wastes Segregate material type to enable maximum reuse/recycling Incinerate combustible non-recyclable wastes Clearance of asbestos by specialist contractor	Segregate non-hazardous wastes Segregate material type to enable maximum reuse/recycling Incinerate combustible non-recyclable wastes Clearance of asbestos by specialist contractor	Segregate non-hazardous wastes Segregate material type to enable maximum reuse/recycling Incinerate combustible non-recyclable wastes Clearance of asbestos by specialist contractor
Radio - active Discharges	Liquid	Conditioning (pH adjustment and filtering) for marine discharge	Treat prior to minimise activity discharged and exclude all entrained solids e.g. separation, flocculation, filtration Sampling and analysis of liquids prior to discharge	N/A	Treat prior to minimise activity discharged and exclude all entrained solids e.g. separation, flocculation, filtration Sampling and analysis of liquids prior to discharge	N/A	N/A	Treat prior to minimise activity discharged and exclude all entrained solids e.g. separation, flocculation, filtration Sampling and analysis of liquids prior to discharge	Treat prior to minimise activity discharged and exclude all entrained solids e.g. separation, filtration Sampling and analysis of liquids prior to discharge	Treat prior to minimise activity discharged and exclude all entrained solids e.g. separation, filtration Sampling and analysis of liquids prior to discharge	Treat prior to minimise activity discharged and exclude all entrained solids e.g. separation, filtration Sampling and analysis of liquids prior to discharge	Treat prior to minimise activity discharged and exclude all entrained solids e.g. separation, filtration Sampling and analysis of liquids prior to discharge	Treat prior to minimise activity discharged and exclude all entrained solids e.g. separation, filtration Sampling and analysis of liquids prior to discharge	Treat prior to minimise activity discharged and exclude all entrained solids e.g. separation, filtration Sampling and analysis of liquids prior to discharge	Treat prior to minimise activity discharged and exclude all entrained solids e.g. separation, filtration Sampling and analysis of liquids prior to discharge	Treat prior to minimise activity discharged and exclude all entrained solids e.g. separation, filtration Sampling and analysis of liquids prior to discharge	Treat prior to minimise activity discharged and exclude all entrained solids e.g. separation, filtration Sampling and analysis of liquids prior to discharge

Waste Category		DSRL	RSRL	Sellafield Ltd Sites				Magnox									
		Dounreay	Harwell/ Winfrith	Windscale	Sellafield	Capenhurst	Springfields	Chapelcross	Hunterston A	Oldbury	Trawsfynydd	Wylfa	Berkeley	Bradwell	Dungeness	Hinkley Point A	Sizewell A
	Gaseous	Treat by filtration prior to discharge e.g. High Efficiency Particulate in Air (HEPA) filter to remove solids	Treat by filtration prior to discharge e.g. High Efficiency Particulate in Air (HEPA) filter to remove solids	Treat by filtration prior to discharge e.g. High Efficiency Particulate in Air (HEPA) filter to remove solids	Treat by filtration prior to discharge e.g. High Efficiency Particulate in Air (HEPA) filter to remove solids Treat by wet scrubbers to remove volatile activity, electrostatic precipitators, packed beds, condensers and pre-heaters (to prevent condensation in the filters).	Treat by filtration prior to discharge e.g. High Efficiency Particulate in Air (HEPA) filter to remove solids	Treat by filtration prior to discharge e.g. High Efficiency Particulate in Air (HEPA) filter to remove solids	Treat by filtration prior to discharge e.g. High Efficiency Particulate in Air (HEPA) filter to remove solids	Treat by filtration prior to discharge e.g. High Efficiency Particulate in Air (HEPA) filter to remove solids	Treat by filtration prior to discharge e.g. High Efficiency Particulate in Air (HEPA) filter to remove solids	Treat by filtration prior to discharge e.g. High Efficiency Particulate in Air (HEPA) filter to remove solids	Treat by filtration prior to discharge e.g. High Efficiency Particulate in Air (HEPA) filter to remove solids	Treat by filtration prior to discharge e.g. High Efficiency Particulate in Air (HEPA) filter to remove solids	Treat by filtration prior to discharge e.g. High Efficiency Particulate in Air (HEPA) filter to remove solids	Treat by filtration prior to discharge e.g. High Efficiency Particulate in Air (HEPA) filter to remove solids	Treat by filtration prior to discharge e.g. High Efficiency Particulate in Air (HEPA) filter to remove solids	Treat by filtration prior to discharge e.g. High Efficiency Particulate in Air (HEPA) filter to remove solids

* Special Nuclear Material (SNM) where it is declared to be waste

Appendix 3

Comparison of the Previous BPEOs (pre PBO) to the Current DSRL Waste Management Strategy

Waste Category		Waste Stream	BPEO Treatment Proposal (Pre PBO)	Change from Post PBO	Impact of Change on BPEO	BPEO Treatment Proposal (2013)	Reason for change
RHILW	Solid	Special Nuclear Materials (SNM) *	Sorting, size reduction, immobilisation/ encapsulation for storage and final GDF	Yes	Not Significant	Sorting, size reduction, immobilisation/ encapsulation for storage	Scottish Government HAW Policy – Storage rather than GDF Proposed minor change to use TruShield drums (BPM level change)
		Other Ops and decommissioning wastes	Assay sorting by material, size reduction, volume reduction, immobilisation/ encapsulation for storage and final GDF	Yes	Not Significant	Assay sorting by material, size reduction, volume reduction, immobilisation/ encapsulation for storage	Scottish Government HAW Policy – Storage rather than GDF Proposed minor change to use WAGR boxes, Z6033 drums, TruShield drums, 500 litre drums and 2m boxes for ILW Storage (BPM level change)
		Ion Exchange columns	Immobilisation/ encapsulation for storage and final GDF	Yes	Not Significant	Immobilised in polymer and placed in Tru shields for ILW storage	Scottish Government HAW Policy – Storage rather than GDF Minor change as the immobilisation proposed is no longer cement, but immobilisation is still proposed. (Optimisation issue)
	Liquid	Reprocessing liquors (MTR, DFR, PFR)	Immobilisation/ encapsulation for storage and final GDF	Yes	Not Significant	Immobilisation/ encapsulation for storage	Scottish Government HAW Policy – Storage rather than GDF Previously proposed treatment in D3900 but now treat in modified D2700 (DCP) no change to final waste form.
		SNM *	Pre-treat, immobilisation/ encapsulation for storage and final GDF	Yes	Not Significant	Pre-treat, immobilisation/ encapsulation for storage	Scottish Government HAW Policy – Storage rather than GDF Previously proposed treatment in D3900 but now treat in modified D2700 (DCP) no change to final waste form. Minor change as solvents are washed with both potassium permangante and sodium carbonate, with the solvent being absorbed on to Nochar for LLW disposal.
		Small Volume liquors (TSV)	Immobilisation/ encapsulation for storage and final GDF or Chemical treatment/ IX for marine discharge	No	N/A	Immobilisation/ encapsulation for storage or Chemical treatment/ IX for marine discharge	No Change
		Liquid Metals Na and NaK coolants	Chemical treatment/ IX for marine discharge	No	N/A	Chemical treatment/ IX for marine discharge	No change
	Sludge	ADU Floc	Treatment, immobilisation/ encapsulation for storage and final GDF	Yes	Not Significant	Treatment, immobilisation/ encapsulation for storage	Scottish Government HAW Policy – Storage rather than GDF Previously proposed treatment in D3900 but now treat in modified D2700 (DCP) no change to final waste form.
		Shaft and Silo Sludges	Treatment, immobilisation/ encapsulation for storage and final GDF	Yes	Not Significant	Treatment, immobilisation/ encapsulation for storage	Scottish Government HAW Policy – Storage rather than GDF New plant to replace previously proposed D3200 but no change to final waste form.
CHILW	Solid	SNM *	Sorting, size reduction, immobilisation/ encapsulation for storage and final GDF	Yes	Not Significant	Sorting, size reduction, immobilisation/ encapsulation for storage	Scottish Government HAW Policy – Storage rather than GDF
		PCM	Assay sorting, volume reduction, immobilisation/ encapsulation for storage and final GDF	Yes	Not Significant	Assay sorting, volume reduction, immobilisation/ encapsulation for storage	Scottish Government HAW Policy – Storage rather than GDF
		UCM	Assay sorting, volume reduction, immobilisation/ encapsulation for storage and final GDF	Yes	Not Significant	Assay sorting, volume reduction, immobilisation/ encapsulation for storage	Scottish Government HAW Policy – Storage rather than GDF
		Thorium Contaminated Wastes	Assay sorting, volume reduction, immobilisation/ encapsulation for storage and final GDF	Yes	Not Significant	Assay sorting, volume reduction, immobilisation/ encapsulation for storage and final GDF	Scottish Government HAW Policy – Storage rather than GDF
		Irradiated Graphite	Store Encapsulated pending transfer to GDF	Yes	Not Significant	Store Encapsulated	Scottish Government HAW Policy – Storage rather than GDF The DMTR component is now anticipated to be LLW and fall outwith ILW stream
		Irradiated Graphite	Store Encapsulated pending transfer to GDF	Yes	Not Significant	Store Encapsulated	Scottish Government HAW Policy – Storage rather than GDF **PFR** – The Graphite forms the reactor neutron shield and is held within steel neutron shield rods. Rods in Row 1 (the outer most row) are now anticipated to be LLW and will fall outwith the ILW stream. Rods within 7-5 are the inner most rows and as a result are highly activated RHILW.

Waste Category		Waste Stream	BPEO Treatment Proposal (Pre PBO)	Change from Post PBO	Impact of Change on BPEO	BPEO Treatment Proposal (2013)	Reason for change
		Spoil from under building foot print	Not considered previously	**Yes**	N/A	WAGR boxes, self-shielded container store	Waste stream now considered and proposed to be treated in the manner according to its nature eg, Solid form LLW, ILW.
	Liquid	SNM (Thorium Nitrate) *	Cementation into 500 l drums	Yes	Not Significant	Cementation into 500 l drums	Scottish Government HAW Policy – Storage rather than GDF
		Contaminated solvents and oils from reprocessing)	Wet abatement, incineration, filtration for gaseous and or marine discharge and or Immobilisation/ encapsulation for storage and final GDF	Yes	Not Significant	Wet abatement, incineration, filtration for gaseous and or marine discharge and or Immobilisation/ encapsulation for storage	Scottish Government HAW Policy – Storage rather than GDF
Low Level Waste	**Solid**	Compactable	Compacted via WRACS and placed in HHISOs for LLW Vaults	No	N/A	Compacted via WRACS and placed in HHISOs for LLW Vaults	No change
		Bulk	Immobilise/encapsulate into passively safe for disposal to LLW Vaults	No	N/A	Immobilise/encapsulate into passively safe for disposal to LLW Vaults	No change
		Spoil	Place in 1 tonne bags in HHISO for LLW Vaults	No	N/A	Place in 1 tonne bags in HHISO for LLW Vaults	No change
	Liquid	Effluent for discharge	Conditioning (pH adjustment and filtering) for marine discharge	No	N/A	Conditioning (pH adjustment and filtering) for marine discharge	No change
		Solvents and oils	Wet abatement, incineration, filtration for gaseous and or marine discharge and or Immobilisation/ encapsulation for storage and final LLW disposal	No	N/A	Wet abatement, incineration, filtration for gaseous and or marine discharge and or Immobilisation/ encapsulation for storage and final LLW disposal	No change
	Sludge	Sludge /Granular media	Immobilisation/ encapsulation for disposal as solid LLW	No	N/A	Immobilisation/ encapsulation for disposal as solid LLW	No change
		LSA Scale	Assay, Store, treat and disposal as CHILW solids	No	N/A	Store, assay, treat and store as CHILW solids	Scottish Government HAW Policy – Storage rather than GDF
		Putrescible Waste	Dry, assay, store treatment and immobilisation/ encapsulation for disposal as solid LLW	No	Not Significant	Dry, assay, store treatment and immobilisation/ encapsulation for disposal as solid OoSoR – Controlled Waste	Characterisation has allowed this waste to fall out with RSA disposal
HVLA/ Demolition Waste	**Solid**	Construction and demolition wastes/spoil	Place in 1 tonne bags in HHISO for LLW Vaults	Yes	Not Significant	Place in bags in Demolition LLW Vaults	Size of bags will be optimised. Expected to be 1 tonnes or larger.
Controlled Non Hazardous Waste	**Solid**	Construction and demolition wastes/spoil	Re-use /recycle /disposal to landfill	No	N/A	Re-use /recycle /disposal to landfill	No change
		Soil	Re-use /recycle /disposal to landfill	No	N/A	Re-use /recycle /disposal to landfill	No change
		Recyclable materials	Re-use/ recycle	No	N/A	Re-use/ recycle	No change
		Non recyclable materials	Dispose to landfill	No	N/A	Dispose to landfill	No change
	Liquid	Recyclable	Re-use recycle	No	N/A	Re-use recycle	No change
		Non recyclable	Transfer to Specialist contractor	No	N/A	Transfer to Specialist contractor	No change
Controlled Inert Waste	**Solid**	Construction and demolition wastes/spoil	Re-use /recycle /disposal to landfill	No	N/A	Re-use /recycle /disposal to landfill	No change
		Soil	Re-use /recycle /disposal to landfill	No	N/A	Re-use /recycle /disposal to landfill	No change
		Recyclable materials	Re-use recycle	No	N/A	Re-use recycle	No change
		Non recyclable materials	Dispose to landfill	No	N/A	Dispose to landfill	No change
Inert Waste	**Liquid**	Recyclable	Re-use recycle	No	N/A	Re-use recycle	No change

Waste Category		Waste Stream	BPEO Treatment Proposal (Pre PBO)	Change from Post PBO	Impact of Change on BPEO	BPEO Treatment Proposal (2013)	Reason for change
		Non recyclable	Transfer to Specialist contractor	No	N/A	Transfer to Specialist contractor	No change
Controlled Hazardous Waste	Solid	Construction and demolition wastes/spoil	Treatment of chemically contaminated materials/ specialist contractor for reuse recycle or disposal	No	N/A	Treatment of chemically contaminated materials/ specialist contractor for reuse recycle or disposal	No change
		Soil	Treatment of chemically contaminated materials/ specialist contractor for reuse recycle or disposal	No	N/A	Treatment of chemically contaminated materials/ specialist contractor for reuse recycle or disposal	No change
		Recyclable materials	Specialist contractor for reuse recycle	No	N/A	Specialist contractor for reuse recycle	No change
		Non recyclable materials	Specialist contractor for disposal to landfill	No	N/A	Specialist contractor for disposal to landfill	No change
	Liquid	Recyclable	Re-use recycle or specialist contractor	No	N/A	Re-use recycle or specialist contractor	No change
		Non recyclable	Specialist contractor for disposal	No	N/A	Specialist contractor for disposal	No change
	Sludge	Milliscreen Putrescible Waste	Treatment if required and off site disposal	No	N/A	Treatment if required and off site disposal	No change
		Package Sewage Treatment Plant Sludge	New waste stream due to improved sewage treatment	No	N/A	Treatment if required and off site disposal	Waste stream now considered and proposed to be treated in the manner according to its nature eg, Controlled Waste
Gaseous	Gas	Routine Gaseous Discharges	Filtration and discharge to atmosphere	No	N/A	Filtration and discharge to atmosphere	No change

* Special Nuclear Material (SNM) where it is declared to be waste