Technical Report

Strategic BPEO For Metal Waste Management – Options Identification and Screening

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Prepared By:	……………………………………………… **DAVID ROSSITER**	**Date: 11/04/06**
Checked By:	……………………………………………… **JOE ROBINSON**	**Date: 11/04/06**
Approved By:	……………………………………………… **MARK LYONS**	**Date: 11/04/06**

Studsvik UK Limited
Unit 14, Princes Park
Fourth Avenue
Team Valley Trading Estate
Gateshead
Tyne and Wear
NE11 0NF

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Glossary

BNFL	British Nuclear Fuels Limited
BNG	British Nuclear Group
BPEO	Best Practicable Environmental Option
CO_2	Carbon Dioxide
EA	Environment Agency
EIA	Environmental Impact Assessment
EU	European Union
ISO	International Organisation of Standardisation
LCBL	Life-Cycle Base Line
LLW	Low Level Waste
LT	Long-term
NDA	Nuclear Decommissioning Authority
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention)
PCSC	Post Closure Safety Case
R&D	Research and Development
SEA	Strategic Environmental Assessment
ST	Short-term
UHP	Ultra High Pressure
UK	United Kingdom
WACM	Winfrith Abrasive Cleaning Machine

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1. Introduction

1.1. Objective

This report has been prepared on behalf of the NDA by Studsvik UK Limited (Studsvik). The NDA has the aim to ensure that the UK's 20 civil public sector nuclear sites are decommissioned and cleaned up safely and effectively. In terms of Low Level Waste, the NDA is currently considering options for the management of LLW in order to assess whether there are more cost effective and environmentally better options for the disposal of LLW than at the Drigg facility in Cumbria.

Studsvik is a specialist nuclear and waste management company with significant knowledge and experience of LLW management and in particular for metallic LLW. To this end, Studsvik has been engaged by the NDA to develop a strategic BPEO study into metal waste management. The agreed objective of this study is as follows:

To provide NDA with a full understanding of the technical and commercial arguments, justifications and issues relevant to the implementation of various management techniques on low level radioactive metals wastes in the UK. This will be achieved through the application of a BPEO assessment methodology to determine metal management options for significant aggregated waste streams in the UK.

The key outcome will be an objective understanding of the strength of case for a centralised UK metals / recycling facility. It was agreed that it is a priority to establish the key metallic wastes in the UK (i.e. the 'big hitters') and where they are located.

This report sets outs the background and findings from the initial Options Identification and Screening phase of the BPEO which included an options identification workshop on 30th September 2005. It also presents screening and development work that has been undertaken by Studsvik following the initial workshop.

The Options Evaluation stage and the conclusions of the study will be the subject of a separate report.

1.2. Strategic BPEO Approach

A BPEO assessment is a systematic approach to decision analysis that typically includes a number of environmental, economic, safety and technical attributes.

The Environment Agency has produced best practice guidance on the BPEO methodology[1] which addresses their expectations with respect to the nature and balance of attributes that might be used. In addition, the strategic nature of this particular study makes it appropriate to also consider the requirements of the Strategic Environmental Assessment (SEA) Directive[2].

Individual nuclear licensed sites often undertake BPEO studies for their specific waste streams to satisfy the requirements of their Radioactive Substances Act 1993 authorisation. However, the best options identified through these localised BPEO studies may not represent BPEO when the issue of solid metallic waste is assessed from a nationwide viewpoint. That is to say, individual sites may not consider new technologies to be practicable if substantial investment, planning and construction work is required. Whereas a UK-wide strategic BPEO study could show that such fiscal and time investment is warranted if it provides a suitable solution for all such waste produced in the UK.

This Strategic Metal Waste Management BPEO study therefore incorporates aspects of both the Environment Agency guidance note and the SEA Guidance and looks at metallic LLW from a national perspective.

The EA guidance on BPEO studies includes provisions for stakeholder consultation at various points in the BPEO assessment process. At the request of the NDA, stakeholder consultation at this stage of the BPEO study has not been undertaken, although this may be undertaken by the NDA following assessment of the technical arguments arising from this study. The intention of this BPEO is to provide the NDA with internal advice on the issues surrounding management of LLW in the UK and to recommend areas of further work that would include stakeholder engagement as a fundamental part of the process.

This strategic BPEO study also recognises the limitations of the Drigg LLW Repository capacity and the predicted LLW waste arisings under the decommissioning programme proposed in the NDA Approved Strategy[3]. This strategic BPEO assessment also attempts to capture the true cost of disposal of Drigg and explore the costs and benefits of other alternative management options and disposal routes.

It should be noted that due to the strategic and wide-ranging nature of this study, all aspects of a typical BPEO methodology cannot be rigorously applied. Instead, parts of the BPEO approach have been adapted as a framework to assess strategic options incorporating strategic environmental criteria.

2. Options Identification Workshop

2.1. Workshop Information

The options identification workshop was undertaken on 30th September 2005 and facilitated by Lise Stoyell of Studsvik UK Ltd. The attendees and their specific areas of expertise are listed in Appendix A.

The objective of the initial workshop was to undertake a brainstorming exercise to identify all possible options for management of aggregated low level radioactive metal waste streams in the UK.

2.2. Waste Information

In order to provide a framework for the Options Identification exercise, information on metallic LLW arisings was compiled and presented at the workshop and is included as Appendix B. This presentation sets out summary information on estimated UK metallic waste quantities based on data for bulk metal wastes being transferred between sites, readily available published information and Studsvik's own knowledge of UK nuclear facilities. The data used included the 2001 NIREX Waste Inventory[4] for the UK which it was recognised had some limitations for this purpose. At the time of the workshop the 2004 NIREX Waste Inventory[5] had not been published. It is subsequently noted that although there is a significant increase in the total unpackaged volume of all LLW (+460,000m^3) in the 2004 inventory compared to 2001, the inventory of metallic LLW has not significantly increased.

A discussion was undertaken to ensure that the current metal waste strategy utilised within the UK was understood by all workshop members and the challenges posed by the site-centric model of decision making. This formed a basis for understanding the relevant merits and disadvantages of proposed options during the subsequent option ID exercise.

In summary, the information collected shows that the UK's anticipated bulk metallic LLW arisings will be 450,000 tonnes[4,5], of which over 90% will be ferrous metal. The future capacity of the Drigg site was estimated in the 2004 Life-Cycle Base Line (LCBL)[6] to be around 800,000m^3, compared with future total estimated packaged LLW arisings of around 1,850,000m^3 in the 2001 waste inventory[4] and 2,520,000m^3 in the 2004 waste inventory[5]. (Note that this excludes some contaminated soils at Sellafield which could amount to over 20million m^3). Therefore as approximately half of notional Drigg capacity has already been filled[6], it emphasises the necessity to urgently consider other effective waste management options. A number of further factors were highlighted regarding the Drigg disposal route, as follows:

- There are various ongoing regulatory issues (planning permission, post closure safety case and EA authorisation) that may mean that the current capacity at Drigg will be reached during 2007/8. In addition the long term future of the facility is under consideration.

- The true cost of disposal of a half height ISO container to Drigg is not fully understood.

It is recognised that Drigg capacity should be prioritised wherever possible for wastes that could not be treated or disposed of via other routes, allowing for more 'fit for purpose' waste management solutions to be utilised including minimisation, re-use and recycling.

In the discussions on the national waste inventory it was recognised that these are largely based on estimates and there may be some inherent uncertainties in the inventory data. It was also noted that the NIREX waste inventory[4,5] data may also be out of date and that it was likely that site operators hold more accurate and up-to-date data sets for metallic waste streams. For example minor discrepancies were identified regarding the weights presented for the Trawsfynydd boilers however it was agreed that in comparison with the uncertainties associated with the metallic waste estimates on a national scale, the impact would be minor.

It is noted that waste information in the current site LCBLs are based on the long timescale for decommissioning. It is thought that some sites may not have included certain decommissioning materials in their current LLW waste estimates as the intention is to subject these materials to decay storage on-site to allow the short-lived radionuclides to decay below the LLW thresholds. This decay storage option may not however be possible under the NDA's proposed accelerated decommissioning timetable, resulting in a potential increase in waste volumes classified as LLW.

The presentation and subsequent technical panel discussion concluded that although the NIREX waste inventory may contain some inaccuracies and may be out of date, suitable assumptions about the future UK waste arisings could be drawn for the purposes of this strategic BPEO study. It was felt that the detailed arisings at any particular site would not unduly influence the selection of the BPEO. It was concluded that the largest opportunity was the quantity of ferrous metals that would arise through the NDA's decommissioning strategy which could represent over 90% of all metallic LLW waste.

2.3. Option Identification

One of the most important aspects of a BPEO study is the identification of a broad list of strategic options that are potentially capable of addressing the defined study objectives.

A systematic options identification exercise was undertaken to consider all conceivable options for the management of metallic LLW. This was undertaken by means of a facilitated brainstorming exercise and included a review of familiar, tried and tested methods from the UK and overseas in addition to more novel approaches. All options that were identified in the workshop were documented, along with the possible advantages and disadvantages of each option.

The options identification workshop resulted in over 66 candidate techniques and technologies for management of metallic LLW. These are presented in Appendix C.

It was considered at the workshop that the 66 options could be categorised into broad functional groups. The following key headings for the different techniques and technologies were agreed:

- Storage
- Disposal
- "Transfer elsewhere"
- Regulatory change
- Assay
- Re-use
- Recycling in nuclear industry
- Recycling in non-nuclear industry
- Treatment – decontamination
- Treatment – size reduction
- Treatment – process
- Waste minimisation
- Mixing (active materials with other materials)

To assist the screening process, the workshop members recorded the high-level advantages and disadvantages of each option. The options identified in the workshop are listed in Table C1 in Appendix C of this report.

2.4. Screening Criteria

To enable a more manageable number of options to be taken forward for detailed consideration, coarse screening criteria can be applied to the initial list of candidate options identified in the brainstorming session. Coarse screening criteria represent basic expectations in relation to the practicability of proposed options.

The course screening criteria were discussed and agreed at the workshop. It was considered that the possibility to implement alternative options for metallic LLW could differ in the short and long term. For this reason, screening criteria were agreed for both short and long term scenarios.

The appropriate coarse screening criteria were 'brainstormed' at the option identification workshop and the output reflects factors such as the NDA strategy for LLW management, the status of the technology and the constraints of the UK and International regulatory environment.

The agreed short-term and long-term screening criteria are described below.

It was also agreed that due to time constraints Studsvik UK would undertake the screening exercise outside of the meeting and that the output would be agreed at the subsequent Options Evaluation stage. Where relevant, the interpretation of the screening criteria is also discussed below.

2.4.1. Short-term Coarse Screening Criteria

ST1 – Option must be Operational by 2008

To be considered as a viable short-term option for management for metallic LLW, the option must be capable of being operational on a significant scale within the next 2-3 years (i.e. by 2008).

In applying this criterion we have allowed durations for design, planning, installation and commissioning that would be consistent with an "accelerated" approach, and that all regulatory approvals are made in a timely manner.

ST2 – Technology must be available now

For an option to be viable in the short-term, the technology or technique should be sufficiently developed to be considered 'available' now. This immediate availability is required to allow sufficient time for deployment (planning and regulatory approvals, construction, etc,) of the option within the 2008 timescale.

For the purposes of screening, those technologies that would require any further research and development are not considered to be 'available' within the 2008 timescale.

ST3 – Technology must be proven

For an option to be viable in the short-term it should be a tried, tested and be proven technology as a management option for metallic LLW. A technology should also be proven on a scale large enough to enable it to make a reasonable contribution to UK LLW waste volumes if implemented without significant further scale-up R&D.

In applying this criterion, it has been considered that a technology is valid if it is capable of dealing with any type of metallic LLW.

ST 4 – Option must relieve short-term pressure on current Drigg capacity

Current practice is for most UK LLW to be disposed of at the LLW repository at Drigg in Cumbria. In the next few years (i.e. the short-term), capacity at Drigg may be extremely limited due to operational constraints.

In addition, the Environment Agency is currently considering the existing facility's authorisation, and the Post Closure Safety Case (PCSC) which may affect the quantity and types of waste that can be disposed of in future.

Current estimates of LLW volumes, as a result of decommissioning activities, exceed the expected capacity of Drigg, even if the facility is extended as currently proposed in the baseline plans.

A fundamental part of the NDA's Strategy is to encourage the Government in its review of Low Level Waste (LLW) policy to adopt a more flexible approach towards LLW management arrangements. The NDA will also consider whether there are better and more cost effective options for the disposal of LLW than at the national low level waste repository facility at Drigg in Cumbria.

Therefore for the purposes of this screening exercise, for an option to be viable it should relieve the short-term pressure on the Drigg facility capacity.

ST5 – Option must be acceptable to the Regulator within current legal framework or foreseeable changes in UK policy

For an option to be viable in the short-term it must be acceptable within the current regulatory framework or foreseeable change in the UK regulatory regime.

The Government, supported by the NDA, are undertaking a review of LLW policy with the aim of producing a more flexible framework for dealing with LLW disposal. The review is expected to conclude by Summer 2006.

2.4.2. Long-term Coarse Screening Criteria

LT1 – Option must be available by 2020 with a 10 year development timetable

For a measure to be a viable long-term option it must be capable of being operational by 2020 at the latest to meet the NDA's current 'accelerated decommissioning' objectives.

To enable newer technologies to be operating at full scale by 2020, it is considered that a new LLW management technology would have to be considered 'available' around 10 years prior to full operation to allow for activities such as pilot studies, scale-up, design, construction, commissioning, planning and regulatory approval.

LT2 – Technology must be available in 5 years

For an option to be viable in the long-term, it should be sufficiently mature that the majority of the research and development required before the technology or technique is considered to be 'available' can be completed within the next 5 years. This is to allow sufficient time for testing, pilot studies, demonstrations, and operational deployment of new technologies within the 2020 timescale.

LT3 – Option must reduce LLW Liabilities

A key objective is to develop an appropriately balanced UK LLW strategy to deal with the wastes generated from decommissioning and clean-up of NDA licensed sites. This overall focus is aimed at reducing the overall liability passed on to future generations by use of effective waste management techniques and maximising value for money for the taxpayer.

Therefore, in this screening exercise, for an option to be viable in the long-term it should reduce the overall liability of metallic LLW management. For the purposes of this strategic BPEO assessment the 'liability' of metallic LLW can be defined in the following terms:

- Amount/volume of waste that requires final disposal,
- UK financial and legal responsibility for managing the waste
- Requirement for ongoing management, monitoring and maintenance over an extended period of time (i.e. intergenerational responsibility) with a preference for early waste management solutions
- Finality of the disposal solution

For an option to be considered viable it should reduce one or more of the aspects of LLW liability listed above.

Options that temporarily hold or store the metallic waste, but do not reduce the eventual disposal volume or future management burden would therefore not be considered to reduce the overall liability of the waste in the long-term.

LT4 – Option must align with international conventions

The management of the waste inventory of the UK's nuclear decommissioning programme should be in line with national and international regulatory requirements. Whilst there may be some change in national policy and regulation, for longer term options to be viable they should be compatible with all current international regulations, conventions and treaties.

Examples of relevant international regulations, conventions and treaties that have been considered in this screening exercise include relevant EU Directives, the OSPAR convention, Arctic and Antarctic treaties and conventions.

2.4.3. Results of Coarse Screening Exercise

The results of the screening process for short-term options is shown in Table D1 of Appendix D. Table 2.1 below lists those short-term options that are considered to meet all of the coarse screening criteria.

TABLE 2.1 – OPTIONS MEETING SHORT-TERM COARSE SCREENING CRITERIA

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION
1. STORAGE	1.1	DECAY STORAGE FACILITY
	1.5	LONG-TERM ABOVE GROUND STORAGE
2. DISPOSAL	2.2	EUROPEAN TYPE DISPOSAL
	2.4	LONG-TERM ABOVE GROUND DISPOSAL
	2.13	LANDFILL (Existing domestic landfills for lower activity LLW)
4. REGULATORY CHANGE	4.2	CHANGE AUTHORISATION LIMITS FOR RE-USE AND RECYCLING / RE-USE
	4.3	MOVE TO RISK BASED CATEGORISATION
5. ASSAY	5.1	IMPROVED ASSAY AND WASTE ACTIVITY ESTIMATES
6. RE-USE	6.1	RE-USE OF LLW ITEMS (e.g. SMALL ITEMS - TOOLS AND BROKKS; LARGE ITEMS - VESSELS)
7. RECYCLE IN NUCLEAR INDUSTRY	7.1	BIOSHIELDS \ SHIELDING BLOCKS (Storage in bioshields)
	7.3	REFORMATION OF COMPONENTS IN NEW NUCLEAR FACILITY
8. RECYCLE - NON-NUCLEAR SECTOR	8.3	RECYCLING TO WEAPONS PROGRAMME
9. TREATMENT - DECONTAMINATION	9.1	LOCAL DECONTAMINATION
	9.3	MOBILE / MODULAR FACILITIES
	9.4	CHEMICAL SURFACE DISSOLUTION
	9.5	SOLVENTS
	9.6	ABRASIVE GRIT BLASTING (inc WACM)
	9.7	ABRASIVE CO_2
	9.8	UHP WATER JETTING
	9.9	MECHANICAL PLANING
	9.10	MILLING
	9.11	SCABBLING AND GRINDING (needle gunning)
	9.12	WHEELABRATOR
	9.13	CLEANING SIMPLE TECHNIQUES
	9.14	ULTRASONIC
	9.15	HEAT TREATMENT (including steam)
10. TREATMENT - SIZE REDUCTION	10.1	SIZE REDUCTION
	10.2	COMPACTION (balers/in-drum)
	10.3	SUPER COMPACTION (high force)
	10.4	SEGREGATION
	10.5	SHREDDING
11. TREATMENT - PROCESS	11.1	MELTING IN UK FACILITY
	11.2	MELTING IN FACILITY OVERSEAS
12. MINIMISATION	12.1	REBANDING OF EXISTING MATERIALS

The results of the screening process for long-term options are shown in Table D2 of Appendix D. Table 2.2 below lists those long-term options that are considered to meet all of the screening criteria.

TABLE 2.2 – OPTIONS MEETING LONG-TERM COARSE SCREENING CRITERIA

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION
1. STORAGE	1.1	DECAY STORAGE FACILITY
2. DISPOSAL	2.13	LANDFILL (Existing domestic landfills for lower activity LLW)
4. REGULATORY CHANGE	4.1	CHANGE AUTHORISATION LIMITS FOR DISPOSAL
	4.2	CHANGE AUTHORISATION LIMITS FOR RE-USE AND RECYCLING / RE-USE
	4.3	MOVE TO RISK BASED CATEGORISATION
	4.4	REGULATION FOR TRACKING RECYCLED METAL WASTE AND RESTRICTION ON USE
	4.5	CHANGE LAW ON DUST-BIN DISPOSAL TO INCLUDE LARGE VOLUMES
5. ASSAY	5.1	IMPROVED ASSAY AND WASTE ACTIVITY ESTIMATES
8. RECYCLE IN NON-NUCLEAR INDUSTRIES	8.3	RECYCLING TO WEAPONS PROGRAMME
9. TREATMENT - DECONTAMINATION	9.1	LOCAL DECONTAMINATION
	9.2	CENTRAL UK DECONTAMINATION FACILITY
	9.3	MOBILE / MODULAR FACILITIES
	9.4	CHEMICAL SURFACE DISSOLUTION
	9.5	SOLVENTS
	9.6	ABRASIVE GRIT BLASTING (inc WACM)
	9.7	ABRASIVE CO_2
	9.8	UHP WATER JETTING
	9.9	MECHANICAL PLANING
	9.10	MILLING
	9.11	SCABBLING AND GRINDING (needle gunning)
	9.12	WHEELABRATOR
	9.13	CLEANING SIMPLE TECHNIQUES
	9.14	ULTRASONIC
	9.15	HEAT TREATMENT (including steam)
10. TREATMENT - SIZE REDUCTION	10.1	SIZE REDUCTION
	10.2	COMPACTION (balers/in-drum)
	10.3	SUPER COMPACTION (high force)
	10.4	SEGREGATION
	10.5	SHREDDING
11. TREATMENT PROCESS	11.1	MELTING IN UK FACILITY
	11.2	MELTING IN FACILITY OVERSEAS
	11.3	COMPLETE DISSOLUTION
	11.4	CHEMICAL SEPARATION
12. MINIMISATION	12.1	REBANDING OF EXISTING MATERIALS
	12.2	REDUCE USE OF METAL IN NEW APPLICATIONS

By applying the short and long-term coarse screening criteria to the identified options, the number of potential options is reduced to 34 short-term and 35 long-term viable possibilities.

The applicability of some of the options listed above to an individual waste stream from a particular site will depend on a number of factors such as type of metal, volume, geometry, and the level and type of contamination associated with the waste stream. This is particularly important when applying a specific decontamination technique where the best approach may well be different on a site by site basis.

It should also be noted that many of these options (e.g. regulatory change, assay, etc) are not stand-alone solutions to the management of metallic LLW and would be deployed in conjunction with other options. These factors are considered further in the following section.

3. Route Map Development

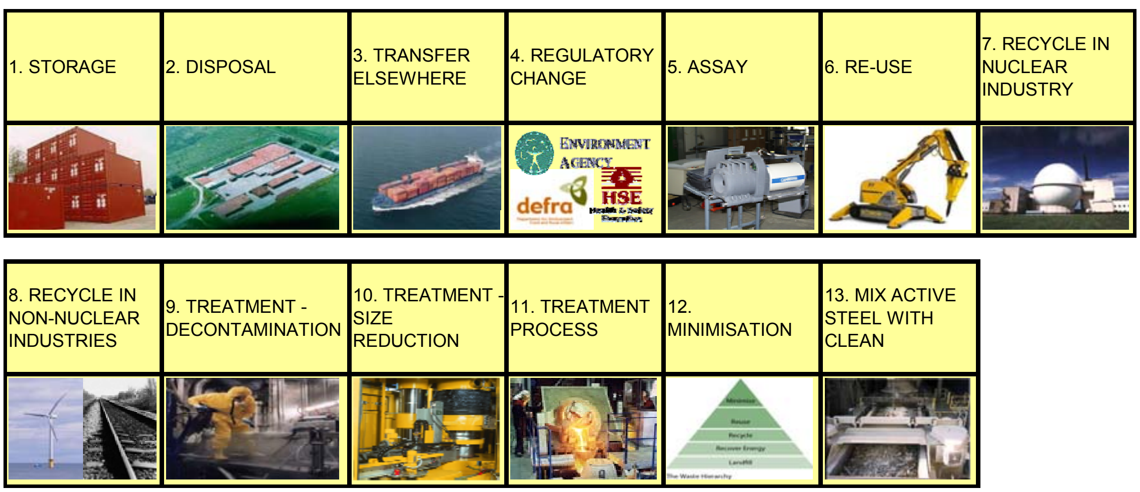
3.1. Route Maps

As many of the candidate options identified are not stand-alone solutions for metallic LLW, the development and assessment of "route maps" was discussed and agreed at the Options Identification workshop as a means to group options together. Such route maps would have the objective of identifying the generic functional blocks for short listed options as a means to aid the subsequent option evaluation exercise. The work undertaken by Studsvik outside of the meeting to formulate these route maps is described below.

The route maps have been assembled using combinations of "parent option" categories. These combinations are based on Studsvik's knowledge of UK and international decommissioning and waste treatment practices.

Figure 3.1 shows the parent options that have been used in the route-mapping process.

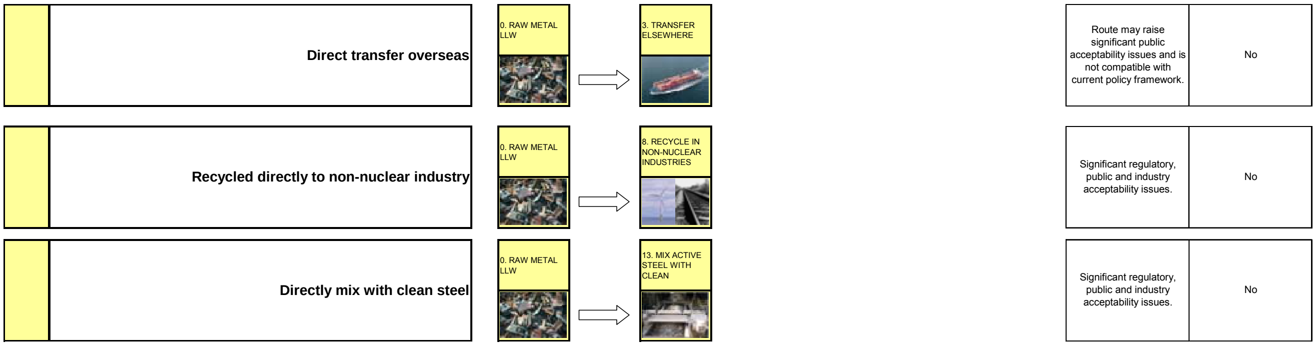
FIGURE 3.1 – PARENT OPTIONS



3.1.1. Route Maps Ruled Out

When preparing the route-maps it became clear that a number of options are clearly not compatible with the current (or reasonably foreseeable) national and international regulatory regimes can therefore be eliminated as viable waste management routes at an early stage. These are shown in Figure 3.2 below.

FIGURE 3.2 – ELIMINATED ROUTES

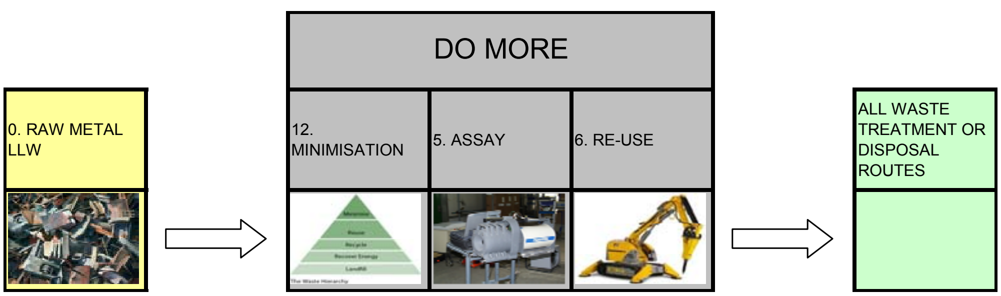


3.1.2. "Do More" Options

Government policy requires all waste producers to apply the waste hierarchy so as to minimise waste production and to adopt reuse and recycling methods in preference to disposal, where possible.

Options such as waste minimisation, improved assay and increased re-use are compatible precursors to almost all other management options. The increased use of these techniques should therefore be encouraged as part of any LLW solution as shown in Figure 3.3 below.

FIGURE 3.3 – "DO MORE" OPTIONS



Similarly, changes to the regulatory regime have the potential to influence all management solutions and maximise the benefits that can be gained from assay, re-use and recycling. These options have therefore been treated separately in the route-mapping process as they should be regarded as common factors that form part of any optimised waste management solution.

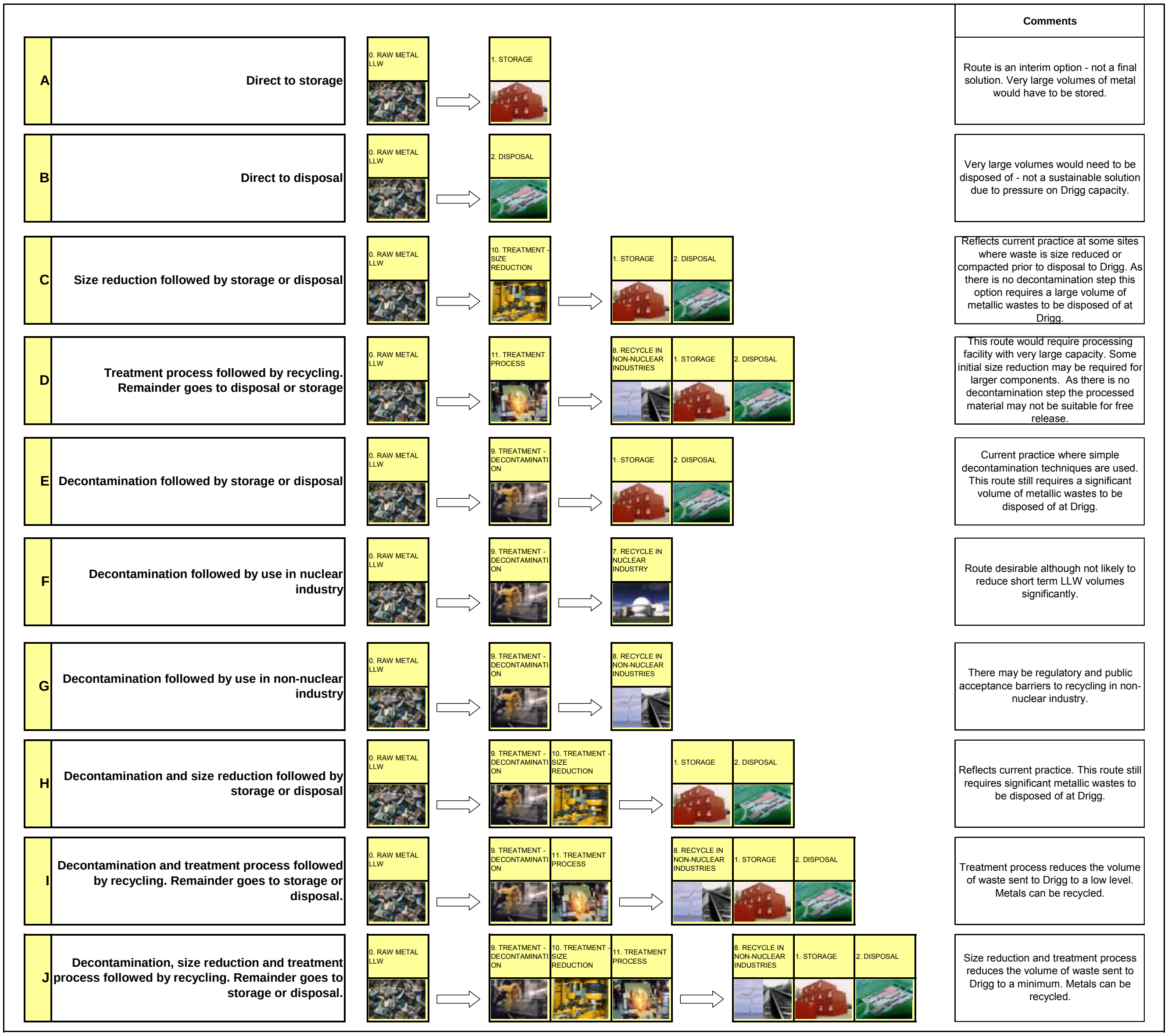
3.1.3. Structure of Route Maps

The sequence of the process functions within the route-maps have been specified in accordance with the waste hierarchy (Figure 3.4) and aim to maximise the amount of material that can be free-released or re-used in preference to treatment and disposal.

FIGURE 3.4 – WASTE HIERARCHY

In many cases, decontamination is a required or desirable precursor to other treatment or disposal solutions as it can significantly reduce the amount of primary metal waste that passes onto subsequent waste management options. For example, decontamination may *enable* the use of routes such as recycling in the non-nuclear and mixing with clean steel in certain circumstances, whereas direct use of these routes would present significant difficulties from a regulatory or operational stand point. The route maps are shown in Figure 3.5 below:

FIGURE 3.5 – ROUTE MAPS



These route maps outline how a series of potential options fit together into a complete metallic LLW management solution. Comments have been added to each route to indicate any potential problems with a particular route or the volume of waste that may require ultimate disposal. It should also be recognised that some routes may not be capable of accommodating the required amounts of LLW in the short or long term.

It is recognised that although most solutions result in some LLW (either primary or secondary) that ultimately requires disposal at Drigg or a similar LLW facility, the differences in weight, volume and form of waste requiring disposal from different solutions are highly significant.

3.2. Outcome of Route Mapping Exercise

The route mapping was utilised to further assess combinations of techniques for LLW management. This enabled elimination of some routes as unfeasible and the classification of some options as desirable components of any solution.

Nevertheless, a large number of potentially viable route maps remain that could be taken forward for further assessment. In order to reach a realistic number of options to be assessed, it was agreed with the NDA that the route mapping should be used to inform the selection of a short list of candidate solutions that could be 'fleshed-out' and presented at the options evaluation workshop for agreement. This short listing process is described below in Section 4 of this report.

4. Proposed options for BPEO Evaluation

4.1. Short listed Options

Following the screening exercise and the route-mapping process several feasible options have been shortlisted for further evaluation:

- Option 2.4 – National LLW Facility (Drigg or Drigg II)
- Option 2.15 – Engineered Onsite LLW Facility
- Option 11.2 – Overseas Waste Treatment
- Option 11.1A – Regional Waste Treatment Facility
- Option 11.1B – National Waste Treatment Facility

Table E1 in Appendix E shows how the options were shortlisted for further BPEO assessment and indicates those options that will not to be formally assessed as part of this BPEO study but should form part of any optimised waste management solution.

4.2. Justification of selected short listed options

Continuing to solely utilise a national LLW disposal facility such as Drigg represents a continuation of existing practice. This option would require little or no change to the existing LLW disposal regime and culture. Although this option has been screened out as a viable short-term and long-term solution, as it does not reduce the liability of the LLW, it is to be subjected to the more detailed assessment to provide a baseline comparison to other options. As described in Figure 3.5, several route configurations are possible for this option including:

- Route B – Direct disposal
- Route C – Size reduction followed by disposal
- Route E – Decontamination followed by disposal
- Route H – Decontamination and size reduction followed by disposal

In addition to the national LLW facility option it is proposed to evaluate engineered onsite LLW facilities. Although this option was originally screened out as it does not reduce the liability of LLW, it is proposed to subject this option to more detailed evaluation as this option has the potential to relieve much of the pressure on Drigg and also has advantages in terms of compliance with the proximity principle and minimisation of transportation of radioactive waste. The potential route configurations for this option are broadly similar to the national LLW route activities.

The screening exercise and the route-map process highlights that waste treatment is a viable option for both short-term and long-term waste management as these options satisfy the NDA's key screening criteria for reducing the short-term pressure on Drigg and the long-term liability of the waste. Facilities for waste treatment currently exist overseas which have the potential to make a significant contribution to management of UK metallic LLW therefore this option has been short listed for further evaluation. The potential route configurations for this option include:

- Route D – Waste treatment process followed by recycling
- Route I – Decontamination and waste treatment process followed by recycling
- Route J – Decontamination, size reduction and waste treatment process, followed by recycling

It is proposed to evaluate the UK waste treatment option as this also aligns with the NDA's key screening criteria. The option will be evaluated for the case of regional facilities and for a national waste treatment facility. The possible route configurations for waste treatment in the UK are similar to the waste treatment overseas option outlined above except that transport routes would be shorter.

4.3. Context for consideration of short listed options

The route-mapping process highlights the need to consider each short listed option in the context of an overall management solution from waste generation through to final disposal. The route-maps highlight that certain activities should be considered as desirable 'common' factors that should be applied to all waste management options.

The common factors are identified in Table E1 of Appendix E and have been selected with the aim of minimising the amount of waste requiring treatment and ultimately the volume requiring final disposal in accordance with the waste hierarchy and the NDA's objectives of preserving the capacity at Drigg as a finite resource.

In this study it is assumed that waste minimisation techniques, improved assay and increased re-use are precursors to each management option to minimise the amount of waste that requires processing or disposal in accordance with the waste hierarchy.

It is also assumed that in almost all cases decontamination techniques will be used as part of each management option to allow the maximum amount of material to be free released, re-used and recycled at an early stage and reduce the volume of primary waste requiring processing or disposal. The choice of a particular decontamination technique will depend on the specific properties of the metallic waste stream and will be affected by factors such as the type of metal, geometry, level of contamination, etc. The decontamination technique and the extent to which it is applied will also have an impact on the quantity of secondary wastes generated that require disposal. It is noted that the NDA are encouraging waste producers to use techniques such as Wheelabrators as best practice for sorting for recycling of as much material as possible. Specific decontamination techniques identified in the workshop are not analysed in detail in this BPEO study as it is expected that these studies would be undertaken at a more localised level for a particular waste stream.

The screening exercise indicated that several options for size reduction of metallic LLW waste meet the NDA's key strategic criteria of reducing the volume of waste sentenced for disposal thereby relieving pressure on the Drigg facility, however size reduction does not, on its own, facilitate recycling of a significant quantity of metal in accordance with the waste hierarchy.

Some simple size reduction (i.e. application of simple cutting techniques) may be an essential requirement for large components as a precursor to other treatment processing and disposal solutions.

Other more advanced size reduction techniques such as compaction and supercompaction are applied immediately prior to disposal and facilities are already operated in countries such as Germany, Sweden, France, Japan, United States and at a number of sites around the UK including Sellafield, Winfrith, and Dounreay. The route-mapping process shows that size reduction is compatible with all short-listed options described above whereby the waste is size-reduced immediately prior to disposal.

Whilst the use of a size reduction process step prior to disposal would minimise the volume requiring disposal it is recognised that it may not be practicable or economic in all situations. This is especially true where the waste is already in a particularly compact form. Where, when and how much size reduction is undertaken will be a situation specific issue.

4.4. Description of short listed options

A technical description of each option proposed for detailed BPEO evaluation is included below.

4.4.1. Option 2.4 – National LLW Facility (Drigg or Drigg II)

This option represents a continuation of current practice for disposal of the majority of LLW in the UK. Waste is packed into ISO containers at site and transported by road or rail to the national LLW repository at Drigg. Waste is then compacted (where practical), grouted into half-height ISO containers or third-height ISO containers, and placed in concrete lined trenches or vaults.

The capacity of the existing Drigg site is limited in the short-term by licensing issues and long-term by both volume and radionuclide inventory.

For the purposes of this study it is therefore assumed that, a new LLW waste repository facility (i.e. Drigg II) would be required at some stage to accommodate metallic and non-metallic waste arisings from the NDA's decommissioning strategy. This may be located close to the existing Drigg facility in Cumbria or in another area of the country.

It is assumed that a new national LLW facility would be based on the existing disposal technology currently applied at Drigg (i.e. burial in engineered trenches) rather than a 'European Type' above-ground disposal facility or an intermediate or deep LLW disposal facility.

It is however possible that the new facility may be based on more conventional landfill technology (e.g. clay or membrane lined trenches) and be designed for disposal of lower activity wastes whilst higher activity wastes are disposed of at Drigg.

4.4.2. Option 2.15 – Engineered Onsite LLW Facility

Waste would be appropriately packaged and placed in an engineered onsite LLW facility which would eventually be closed off by engineered caps and landscaped. This option requires significantly less transportation of LLW offsite.

An engineered onsite facility could be based on the approach used at Drigg (i.e. near surface disposal in concrete lined vaults or trenches) or on above ground, intermediate or deep LLW disposal solutions. An engineered near surface onsite disposal facility is likely to be utilised at Dounreay to accommodate LLW waste arisings from that site.

It is however possible that an onsite LLW facility could utilise more conventional landfill design techniques (e.g. clay or membrane lined trenches) for less active wastes (e.g. Low Activity-High Volume (LAHV) decommissioning wastes and soil) or utilise existing site structures such as turbine hall basements in conjunction with an impermeable membrane and/or clay liner. In addition to the engineered LLW waste facility at Dounreay it is proposed to construct a more simply engineered disposal facility (based on lined trench technology) to accommodate LAHV wastes from decommissioning activities.

It is unknown if the onsite disposal option is technically feasible at all UK nuclear licensed sites due to localised geological factors and risk of coastal erosion. There is currently some uncertainty over the number of onsite facilities that would be required and the feasibility of shared facilities between neighbouring sites needs to be determined. These issues are beyond the scope of this BPEO study.

Long-term management and monitoring of site discharges is likely to be necessary for onsite LLW facilities. The presence of a LLW facility would also impact on the permitted future site land usage and the ability to de-licence and release some sites for unrestricted use (i.e. the site end-state).

4.4.3. Option 11.2 – Overseas Waste Treatment using Existing Routes

The aim of treating metallic waste is to reduce the volume and weight of the waste that has to be disposed of and recycle as much material as possible.

Several candidate LLW treatment processes were documented in the options identification workshop including melting, complete dissolution, chemical separation and corrosion. It is important to note that in the context of this study ‘waste treatment’ refers to processes that change the chemical state of the waste material. This is distinct from ‘decontamination’ which typically only alters the surface of the material. As shown in the route-mapping exercise, decontamination is considered a desirable precursor to both ‘waste treatment’ and ‘disposal’ options.

It is thought that complete dissolution, chemical separation and corrosion facilities do not currently exist on a significant scale whereas overseas melting LLW treatment facilities exist in countries such as Sweden, Germany and the United States.

In this option metallic waste would be packaged onsite into ISO containers and transported by road or rail to a UK port. Containerised LLW can then be transported by sea to the overseas treatment facility. Alternatively large components could be shipped 'whole'.

Metal is received, characterised, size reduced and decontaminated prior to melting in an induction or electric-arc furnace. Once melted, the radioisotopes concentrate into the floating slag layer which can be collected and subjected to further size reduction via compaction or simply packaged for final disposal or storage. This radioactive waste is then usually returned to the customer for disposal as LLW. Where melting is undertaken in the US it may be possible for waste to be permanently disposed of in the US rather than being returned to the country of origin. The homogenised metal is then cast into an ingot which can be more easily assayed, handled, stored and recycled or cast into components for the nuclear industry such as shielding blocks. Sampling and analysis of the bulk metallic mass is undertaken in the melted state which allows representative sampling to occur (i.e. a small sample represents the characteristics of the homogenised bulk).

Even if the original radioactive contamination is too high to provide a recyclable ingot the reduced volume and stable form of the ingot facilitates easy storage of the scrap metal. In many cases a reasonable decay time may render ingots suitable for recycling. After melting the metal ingots are released for recycling subject to the Exemption Criteria prevailing in the country of treatment (it is noted that a standardised approach to this exemption exists across most of Europe).

Treatment processes such as melting can allow up to 95% of the original metal to be free-released into the steel industry for recycling. Radioactive residues and secondary wastes (estimated at around 5% of the original waste material) are returned to the UK for disposal.

As this is route uses existing facilities and proven technology there is the potential to relieve the pressure on Drigg immediately.

4.4.4. Option 11.1A – Regional Waste Treatment Facility

The aim of treating metallic waste is to reduce the volume and weight of the waste that has to be disposed of and recycle as much material as possible. Several candidate LLW treatment processes were documented in the options identification workshop including melting, complete dissolution, chemical separation and corrosion.

Metallic waste would be packaged onsite into ISO containers and transported by road or rail to the regional facility or large components could be transported 'whole'. It is assumed that a treatment facility would be constructed in each NDA region (i.e. North, South, Central and Scotland) to service the sites within that area. It is assumed that appropriate sites for the treatment facilities can be found in each region and successfully licensed/authorised.

4.4.5. Option 11.1B – National Waste Treatment Facility

The aim of treating metallic waste is to reduce the volume and weight of the waste that has to be disposed of and recycle as much material as possible. Several candidate LLW treatment processes were documented in the options identification workshop including melting, complete dissolution, chemical separation and corrosion.

Metallic waste would be packaged onsite into ISO containers and transported by road, rail or sea to a national treatment facility. Large components could be transported 'whole'. The national treatment facility would be capable of dealing with large volumes of metallic waste and benefit from economies of scale when compared to smaller regional facilities.

5. Conclusions

This report sets outs the background and findings from the initial Options Identification and Screening phase of the strategic BPEO study. A BPEO assessment is a systematic approach to decision analysis that typically includes a number of environmental, economic, safety and technical attributes.

The objective of the strategic BPEO study is to provide the NDA with a full understanding of the technical and commercial arguments, justifications and issues relevant to the implementation of various management techniques on low level radioactive metals wastes in the UK

The options identification workshop consisted of a discussion of the likely quantity of metallic LLW waste and a brainstorming exercise to identify all possible options for management of aggregated low level radioactive metal waste streams in the UK.

The options identification workshop resulted in over 66 candidate techniques and technologies for management of metallic LLW being identified. These options were subjected to a coarse screening process using short-term and long-term screening criteria to enable a more manageable number of options to be taken forward for detailed consideration.

As many of the candidate options identified are not stand-alone solutions for metallic LLW, the development and assessment of “route maps” was undertaken to group options together. This enabled elimination of some routes as unfeasible and the classification of some options as desirable components of any solution.

Following the screening exercise and the route-mapping process several feasible options have been shortlisted for further evaluation:

- Option 2.4 – National LLW Facility (Drigg or Drigg II)
- Option 2.15 – Engineered Onsite LLW Facility
- Option 11.2 – Overseas Waste Treatment
- Option 11.1A – Regional Waste Treatment Facility
- Option 11.1B – National Waste Treatment Facility

These shortlisted options have been described and discussed in the context of an overall waste management solution.

A separate report will document the Options Evaluation stage of the BPEO including how the shortlisted options were subjected to a detailed multi-attribute scoring exercise.

6. References

1. Guidance for the Environment Agencies' Assessment of Best Practicable Environmental Option Studies (BPEO) at Nuclear Sites; Environment Agency; February, 2004.
2. A Draft Practical Guide to the Strategic Environmental Assessment Directive; Office of Deputy Prime Minister; 2004. http://www.odpm.gov.uk/stellent/groups/odpm_planning/documents/page/odpm_plan_029817.pdf
3. NDA Strategy; Nuclear Decommissioning Authority; April 2006.
4. The 2001 United Kingdom Radioactive Waste Inventory - Main Report; DEFRA/RAS/02.004; NIREX Report N/042; 2002.
5. The 2004 United Kingdom Radioactive Waste Inventory - Main Report; DEFRA/RAS/05.002; NIREX Report N/090; October 2005.
6. Lifecycle Baseline 2004 - Low Level Waste Repository at Drigg - Executive Summary; British Nuclear Group; 2004.

Appendix A – List of Attendees at Options Identification Workshop

Joanne Fisher	NDA (LLW Strategy)
Martin Robb	NDA (Regional Engineer)
Dr Les Smith	NDA (Civil / Structural Engineering)
Lise Stoyell	Studsvik UK (BPEO specialist, Workshop Facilitator)
Mark Lyons	Studsvik UK (Radwaste Specialist)
Bo Wirendal	Studsvik Nuclear AB (Metals Melting Technical Manager)
Joe Robinson	Studsvik UK (Project Manager, Environmental)
Peter Holmes	Studsvik UK/EMS (Nuclear Safety/Metallurgy)
Madog Jones	BNG Trawsfynydd (Decommissioning)

Appendix B – Metallic LLW Presentation

Studsvik® NDA

Strategic BPEO for Metals Waste Management

Waste Arisings Briefing Note

September 2005



Studsvik® P0090/BN03/Rev A

Objectives

- This presentation forms part of the NDA's Strategic BPEO for Metal Waste Management
- It has been prepared by Studsvik UK Ltd as a "backgrounder" to a BPEO Options Identification Workshop to be held on 30th September 2005
- The presentation sets out available information on metallic low level waste arisings in the UK
- The information is intended to assist the process of identifying suitable management options for these aggregated waste streams from a national perspective

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Information Sources

1. NIREX 2001 UK Radioactive Waste Inventory
2. BNFL Gate B Paper P15, Sellafield Site Bulk Metal Inventory, March 2005
3. NDA Waste Material Residue Transfer between Sites Draft 270505
4. Studsvik UK Market Intelligence

Low Level Waste

- NIREX 2001 UK Radioactive Waste Inventory sets out inventory information for LLW* and covers sources from NDA and all other sites:

- Stocks & arisings (as stored**) **1,580,000 m^3**
- Total mass **2,030,000 tonnes**
- This gives rise to a total packaged waste volume of **1,850,000 m^3**
- These wastes are almost entirely *already committed*

* LLW >0.4Bg/q and <4,000Bq/g α or <12,000Bq/g β/γ
** "As stored" means storage in tanks, vaults, drums and already includes for supercompaction if relevant

Source: NIREX 2001 Inventory

Drigg Disposal Route

- Drigg LLW facility has extremely limited capacity at present
- Planned future extensions would increase disposal capacity to **1,700,000 m^3**
- This compares to the anticipated packaged disposal volume from all sources of **1,850,000 m^3**

Studsvik® Source: NIREX 2001 Inventory

Mass of Metallic Arisings

- 22% of all LLW arisings are metallic (**450,000 tonnes**)
  - This can be subdivided into Operational and Decommissioning Wastes
  - 32% of Operational wastes are metallic (**66,000 tonnes**)
  - 21% of Decommissioning wastes are metallic (**384,000 tonnes**)

Studsvik® Source: NIREX 2001 Inventory

Composition of Metallic LLW

	Mass	Approx %
Ferrous Metal	**430,000 t**	**93%**
Lead	**10,000 t**	**2%**
Nickel	**7,000 t**	**1.5%**
Aluminium	**6,000 t**	**1.3%**
Copper	**6,000 t**	**1.3%**
Brass	**1,000 t**	**0.2%**
Others	**<1,000 t**	each material

Note: these figures cannot be summed = 450,000 total metallic LLW due to intrinsic double counting in the NIREX Method

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Source: NIREX 2001 Inventory

Total LLW Arisings / Site

- Sellafield **1,000,000 m^3**
- Dounreay **48,000 m^3**
- Harwell **24,000 m^3**
- Windscale **20,000 m^3**
- Winfrith **17,000 m^3**
- Culham **17,000 m^3**
- Capenhurst **6,000 m^3**
- Springfields **4,000 m^3**
- Traws' **41,000 m^3**
- HP A **32,000 m^3**
- Hunt' A **31,000 m^3**
- Dung' A **30,000 m^3**
- Bradwell **27,000 m^3**
- Berkeley **27,000 m^3**
- Sizewell A **24,000 m^3**
- Wylfa **21,000 m^3**
- Oldbury **20,000 m^3**
- Ch'cross **17,000 m^3**
- Calder Hall **15,000 m^3**

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Source: NIREX 2001 Inventory

Total LLW Arisings / Site - Others

- Amersham **26,000 m^3**
- AWE **31,000 m^3**
- Naval **3,000 m^3**
- Submarines **1,300 m^3**
- Other MoD **2,000 m^3**
- Minor users **3,000 m^3**

- Torness **13,000 m^3**
- Heysham2 **12,000 m^3**
- Dung'B **12,000 m^3**
- Hunt'B **11,000 m^3**
- Heysham1 **8,000 m^3**
- Hartlepool **7,000 m^3**
- Sizewell B **8,000 m^3**

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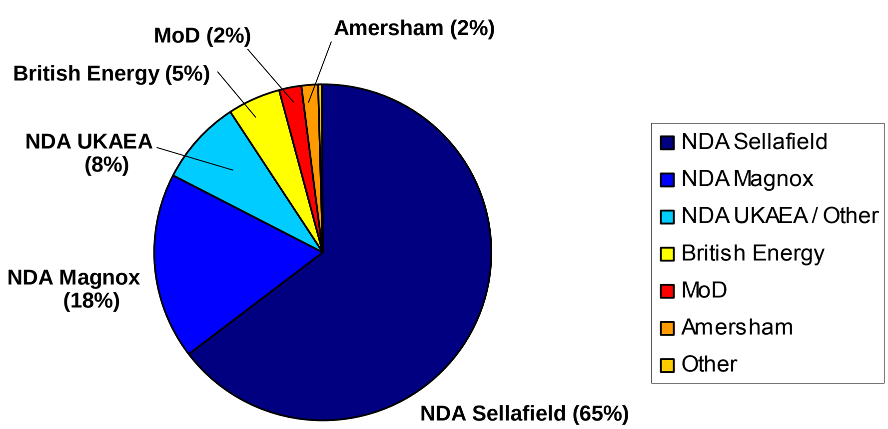
Source: NIREX 2001 Inventory

LLW arisings by producer



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Sellafield Metallic Waste

- Sellafield Site Bulk Metal Inventory*
- Total bulk LLW arisings **177,000 t**

Includes:

↗ Multi Element Bottles	15,000 t
↗ Redundant Flasks	15,000 t
↗ Pond Furniture	15,000 t
↗ Lead	10,000 t
↗ PCM	3,000 t
↗ Magnox Skips (possible)	800 t

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Source: BNFL Bulk Sellafield Bulk Metal Inventory

Magnox Metallic Waste

- Based on NIREX and gross assumptions of volumetric and materials composition, total Magnox metallic waste = **80,000 t**
- For Trawsfynydd PS this gives = **11,400 t**
- Studsvik Market information indicates this is nearer **16,000 t**

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Source: NIREX

Trawsfynydd Metallic Waste

Description	Unit Mass (t)	No.	Total	%
Boilers	1000	12	12000	75%
Hot and Cold Ducts	100	12	1200	8%
Pond Furniture/skips	1000	1	1000	6%
Gas Circulators +	20	12	240	2%
Charge Machine+	300	2	600	4%
Pile Cap Crane	40	2	80	1%
Structural Steel	500	1	500	3%
Electrical Cabinets	150	1	150	1%
Fuel Route	200	1	200	1%
			15970	

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Source: Studsvik Market intelligence

Magnox Metallic Waste

Site	Reactors	Boilers/reactor	Boilers	Mass (t)	Total Mass (t)	
Hunterston A	2	8	16	240	3840	9%
Berkeley PS	2	8	15	310	4650	11%
Bradwell	2	6	12	300	3600	8%
Chapellcross	4	4	16	200	3200	7%
Calderhall	4	4	16	200	3200	7%
Hinkley Point A	2	6	12	300	3600	8%
Dungeness A	2	4	8	300	2400	5%
Oldbury	2	4	8	300	2400	5%
Wylfa	2	4	8	300	2400	5%
Trawsfynydd	2	6	12	1000	12000	27%
Sizewell A	2	4	8	300	2400	5%
	26		**131**		**43690**	

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Source: Studsvik Market intelligence

Winfrith Metallic Waste

- Gross assumption: **4800 t**
- Example SGHWR/DRAGON
  - SGHWR Contract 1 1,600 t
  - SGHWR Contract 2 850 t
  - DRAGON Contract 1 540 t
  - DRAGON Contract 2 350 t

Studsvik® Source: NIREX / Studsvik Market intelligence

Conclusions

- Total bulk metallic LLW arisings **450,000 t** of which the majority (93%) is ferrous metals
- Sellafield is the dominant source (**177,000 t**) although Magox sites may contribute **80,000t** or more
- LCBLs are expected to contain more accurate information as will 2004 NIREX inventory

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Appendix C – Options Identification

TABLE C1 – OPTIONS IDENTIFIED AT OPTIONS IDENTIFICATION WORKSHOP

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ADVANTAGES	DISADVANTAGES
1. STORAGE	1.1	DECAY STORAGE FACILITY	No secondary/reduction in discharges Change category at end Safer decommissioning	Intergenerational equity Timescale Perception Need facilities Monitoring
	1.2	STORAGE IN HIGHER INTEGRITY CONTAINERS	Lower doses Contains for longer Storage doesn't foreclose options	Intergenerational equity + add' waste Timescale Perception Monitoring No volume reduction
	1.3	ENHANCED CORROSION FACILITY	Volume reduction	Mass increase Timescale Facility Safety case difficult Very slow
	1.4	LONG-TERM ABOVE GROUND STORAGE	Easy to build Flexibility, control	Siting Security Long design life No volume reduction
	1.5	FLOATING SEA PLATFORM	Out of sight Remote from population	Security Safety Environmental concerns Legal Perception Design life required No volume reduction

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ADVANTAGES	DISADVANTAGES
2. DISPOSAL	2.1	DEEP SEA DISPOSAL (GEOLOGICAL)	Remote from population	Technically difficult International objection Legal Over engineering Identification No volume reduction
	2.2	EUROPEAN TYPE DISPOSAL	Precedent, easy to approve Safe, scientific backing Retrievability, segregation, flexibility, local or central	Siting Local approvals Perception No volume reduction
	2.3	DRIGG EXPANSION	Precedent, existing Radiological auth in place Known technology, sufficient space	Legacy issues Local approvals Perception Coastal No volume reduction
	2.4	NEW LLW DISPOSAL FACILITY (DRIGG II)	Meets current strategy Storage doesn't foreclose options Improvement on current practice (perception)	No waste reduction Intergenerational equity Timescale Perception Time to implement No volume reduction
	2.5	LONG-TERM ABOVE GROUND DISPOSAL	Retrieval Monitoring Local or central	New idea Visual Security

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ADVANTAGES	DISADVANTAGES
	2.6	DISPOSAL IN SPACE	Effective	Risky Novel Technology issues Fuel required
	2.7	POLAR ICE-CAPS	Remote from population	International law Difficult environment Unpredictable Novel Mobility No volume reduction
	2.8	IN-SITU DISPOSAL	No transport Proximity principles	Decentralised management Uncontrolled Partial solution Coastal problems No volume reduction
	2.9	DISPOSAL IN DIS-USED MINES	Existing facilities Remote by depth	Availability of sites Licensing Cost Monitoring
	2.10	DISPOSAL IN DEEP BORE-HOLES	Existing facilities Remote by depth	Availability of sites Licensing Cost Monitoring
	2.11	DISPOSAL IN OTHER COUNTRIES	Use best technology Population density	Proximity principle Acceptability by recipient Transport

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ADVANTAGES	DISADVANTAGES
	2.12	SEA BED DISPOSAL	Dilution Remote Technically easy	Law Public acceptability Retrievability Monitoring
	2.13	LANDFILL (Existing domestic landfills for lower activity LLW)	Preserves other facilities Co-disposal dilution Technically easy	Dispersal Planning Perception
	2.14	DISCHARGE TO ENVIRONMENT (dilute & disperse)	Easy Unauthorised routes exist Quick	Change of law required Perception Lack of control
	2.15	ONSITE LLW DISPOSAL FACILITIES	Easy, existing site Proximity principle No transport, not novel	Inability to delicense Decentralised Site geology? No volume reduction
3. TRANSFER ELSEWHERE	3.1	TRANSFER TO OTHERS	Easy technically Quick Problem gone	Perception Transport Liability & ethics Loss of control
4. REGULATORY CHANGE	4.1	CHANGE AUTHORISATION LIMITS FOR DISPOSAL	Opens waste routes Reduces volumes Just legislative	Timescale Perception Regulatory resistance Public resistance
	4.2	CHANGE AUTHORISATION LIMITS FOR RE-USE AND RECYCLING / RE-USE	Opens waste routes Reduces volumes Resource utilisation	Timescale Perception Regulatory resistance Public resistance

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ADVANTAGES	DISADVANTAGES
	4.3	MOVE TO RISK BASED CATEGORISATION	Flexibility Opens alt waste routes	Timescale Case by case justification
	4.4	REGULATION FOR TRACKING RECYCLED METAL WASTE AND RESTRICTION ON USE	Opens waste routes Perception Doable for industry	Timescale Perception Complex Technology
	4.5	CHANGE LAW ON DUST-BIN DISPOSAL TO INCLUDE LARGE VOLUMES	Just legislative Opens waste routes	Monitorability Control of averaging Perception Difficult detection limits
5. ASSAY	5.1	IMPROVED ASSAY AND WASTE ACTIVITY ESTIMATES	More information to allow free release Not committing waste to Drigg Refines dataset	Culturally easier to send to Drigg Representivity Difficult to get correct inventory UK system is fingerprint dependant
6. RE-USE	6.1	RE-USE OF LLW ITEMS (e.g. SMALL ITEMS - TOOLS AND BROKKS; LARGE ITEMS - VESSELS)	Practicable to do this Minimisation technique No treatment required	Size of net effect Database required Not final solution Transportation Contaminated handling
7. RECYCLE IN NUCLEAR INDUSTRY	7.1	BIOSHIELDS \ SHIELDING BLOCKS (Storage in bioshields)	Minimises raw material use Stakeholder perception Minimises transport	Treatment required Handling contaminated materials Justify process
	7.2	NEW NUCLEAR FACILITY	Reduces volume of LLW for disposal Already on existing sites	Storage required Final solution not currently known
	7.3	REFORMATION OF COMPONENTS IN NEW NUCLEAR FACILITY	Reduces volume of LLW for disposal	

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ADVANTAGES	DISADVANTAGES
8. RECYCLE IN NON-NUCLEAR INDUSTRIES	8.1	CONVERSION LLW TO STEEL INGOTS (UK STEEL INDUSTRY)	Minimises raw material use Reduces volume of LLW for disposal Small revenue	Perception - provenance Lower limits required Loss of control Transport to facility
	8.2	CHURCH ROOF (RE-USE OF LEAD)	Revenue, & market Reduces volume of LLW for disposal	Perception
	8.3	RECYCLING TO WEAPONS PROGRAMME	Revenue, & market Reduces volume of LLW for disposal Minimises raw material use	Quality of material required Handling Assurance Perception Uncontrolled when deployed
	8.4	SCULPTURE AND ARCHITECTURE	Reduces volume of LLW for disposal Minimises raw material use	Market Perception
	8.5	RECYCLING TO REFURBISH EXISTING BUILDINGS (E.G. DOUNREAY SPHERE)	Deferment Decay	Buildings have finite life Delaying High maintenance
	8.6	OFFSHORE WAVE AND WIND PLATFORMS FOR POWER GEN	Perception Reduces volume of LLW for disposal Minimises raw material use	Perception Quality required
	8.7	RECYCLE TO RAIL INDUSTRY (USES WITH MINIMAL DIRECT HUMAN CONTACT)	Reduces volume of LLW for disposal Minimises raw material use	Perception Quality required
9. TREATMENT - DECONTAMINA TION	9.1	LOCAL DECONTAMINATION	No transport, proximity Environmentally sound Reduces volume Suitable for simple techniques	Secondary waste Discharges Authorisation No efficiency of scale Not suitable for complex techniques

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ADVANTAGES	DISADVANTAGES
	9.2	CENTRAL UK DECONTAMINATION FACILITY	Addresses complex problems; one size fits all Economies of scale, modern standards Reduces volumes to disposal Can use best practice Learning	Transport Licensing/space on licensed site Perception One size fits all Bottleneck
	9.3	MOBILE / MODULAR FACILITIES	Proximity principle, successful, within site licensing Economies of scale, modern standards Reduces volumes, skills retained with machine	Campaigns required Transport Build up, break down Storage
	9.4	CHEMICAL SURFACE DISSOLUTION	Proven Complex shapes Mobile, reduces metallic LLW	Small scale application Secondary waste Increased hazard Complex components require assay Liquids
	9.5	SOLVENTS	Proven, good application to fissile components Complex shapes Mobile, reduces metallic LLW	Small scale application Secondary waste Increased hazard Complex components require assay Liquids Secondary waste disposal route?
	9.6	ABRASIVE GRIT BLASTING (inc WACM)	Proven Complex shapes possible Complements melting Applicable to surface contamination 2ndry waste minimised, large areas, quick	Secondary waste Airborne control required Secondary waste worse when used locally
	9.7	ABRASIVE CO_2	No secondary waste Proven	Hazard of asphyxiation Gaseous discharge

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ADVANTAGES	DISADVANTAGES
			Complex shapes possible Complements melting Applicable to surface contamination	Good containment required Control required
	9.8	UHP WATER JETTING	Proven for surface contamination (as above) Complex shapes possible Complements melting	Large secondary waste volume Atomisation Airborne Control required Liquids Drying Filtration
	9.9	MECHANICAL PLANING	Effective to remove surface Good application for softer metals Thicker depth of decontamination	Airborne dust generation Restricted to large surfaces Limited application
	9.10	MILLING	As above Effective to remove surface Good application for softer metals Thicker depth of decontamination	Restricted to large surfaces Limited application
	9.11	SCABBLING AND GRINDING (needle gunning)	Flexibility for smaller components	Airborne dust generation Labour intensive Applicability to metal? Slow Not applicable to larger components
	9.12	WHEELABRATOR	Good application for flat Faster than milling, etc Mechanised	Flexibility for complex items
	9.13	CLEANING SIMPLE TECHNIQUES	Quick, cheap, proven, expected	Dose Effective only for loose contamination

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ADVANTAGES	DISADVANTAGES
				Complex items
	9.14	ULTRASONIC	Good for small components	Processing time Secondary waste Applicability
	9.15	HEAT TREATMENT (including steam)	Good for tritium Cheap Quick	Perception Containment Limited isotopes Secondary waste?
10. TREATMENT - SIZE REDUCTION	10.1	SIZE REDUCTION	Proven, decreases volume for disposal, quick Numerous techniques, linked to numerous end points	Dose Containment Does not address radioactivity
	10.2	COMPACTION (balers/in-drum)	Volume reduction Maximise disposal volume	Facility required Possible transport Less than supercompaction Does not address radionuclides
	10.3	SUPER COMPACTION (high force)	Volume reduction Maximise disposal volume	Facility required Not widespread in UK Restrictions Drums only Does not address radionuclides
	10.4	SEGREGATION	Reduces weight Pre treatment for other techniques Linked to assay	Perception it is slow
	10.5	SHREDDING	Volume reduction Maximise disposal volume	Only for lighter materials Airborne contamination

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ADVANTAGES	DISADVANTAGES
11. TREATMENT - PROCESS	11.1	MELTING IN UK FACILITY	Proven tech Complements other national initiatives Availability of route for recycled material Reduces volume & mass of LLW, Homogeneous Assay "Environmental justification" Flexible and isotopic flexibility, Linked recycling & re-use	Does not exist yet Licensing required Perception Energy usage Treatment of discharges Industry resistance Transport
	11.2	MELTING IN FACILITY OVERSEAS	As above, available, Market for recycled European release criteria	Transport Capacity Control Perception Regulatory interfaces Case by case re returned waste characteristics
	11.3	COMPLETE DISSOLUTION	Volume reduction Segregation Proven	Applicability to large items Needs size reduction Wet waste Process hazard Difficult waste stream to manage
	11.4	CHEMICAL SEPARATION	Volume reduction Segregation Proven	Applicability to large items Needs size reduction Wet waste Process hazard Difficult waste stream to manage

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ADVANTAGES	DISADVANTAGES
	11.5	CORROSION (inc. Supercorrosion)	Volume reduction of LLW	Not proven As for complete dissolution Size limited Slow
12. MINIMISATION	12.1	REBANDING OF EXISTING MATERIALS	More information to allow free release Expected (waste hierarchy) Fundamental Linked to assay-->VLLW etc re-evaluation	Time consuming Culturally easier to send to Drigg
	12.2	REDUCE USE OF METAL IN NEW APPLICATIONS	Reduces future metallic LLW	Doesn't affect pre-existing LLW Long term measure Could lead to increase in other LLW material volumes (e.g. concrete)
13. MIX ACTIVE STEEL WITH CLEAN	13.1		Simple Reduces volume No facilities	Law, and regulation Loss of control Environmental justification required Open to abuse Control of slag from smelter

Appendix D – Options Screening

TABLE D1 – SHORT-TERM COARSE SCREENING CRITERIA

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ST1 - OPTION OPERATIONAL BY 2008	ST2 - TECHNOLOGY AVAILABLE NOW	ST3 - TECHNOLOGY PROVEN	ST4 - OPTION RELIEVES PRESSURE ON CURRENT DRIGG CAPACITY	ST5 - REGULATOR ACCEPTANCE WITHIN CURRENT FRAMEWORK AND FORESEEABLE LEGAL CHANGES IN UK POLICY
1. STORAGE	1.1	DECAY STORAGE FACILITY	YES	YES	YES	YES	YES
	1.2	STORAGE IN HIGHER INTEGRITY CONTAINERS	YES	YES	YES	YES	NO
	1.3	ENHANCED CORROSION FACILITY	NO	NO	YES	YES	YES
	1.4	LONG-TERM ABOVE GROUND STORAGE	YES	YES	YES	YES	YES
	1.5	FLOATING SEA PLATFORM	NO	NO	NO	YES	NO
2. DISPOSAL	2.1	DEEP SEA DISPOSAL (GEOLOGICAL)	NO	NO	NO	YES	NO
	2.2	EUROPEAN TYPE DISPOSAL	YES	YES	YES	YES	YES
	2.3	DRIGG EXPANSION	YES	YES	YES	YES	NO

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ST1 - OPTION OPERATIONAL BY 2008	ST2 - TECHNOLOGY AVAILABLE NOW	ST3 - TECHNOLOGY PROVEN	ST4 - OPTION RELIEVES PRESSURE ON CURRENT DRIGG CAPACITY	ST5 - REGULATOR ACCEPTANCE WITHIN CURRENT FRAMEWORK AND FORESEEABLE LEGAL CHANGES IN UK POLICY
	2.4	NEW LLW DISPOSAL FACILITY (DRIGG II)	NO	YES	YES	YES	YES
	2.5	LONG-TERM ABOVE GROUND DISPOSAL	YES	YES	YES	YES	YES
	2.6	DISPOSAL IN SPACE	NO	NO	NO	YES	NO
	2.7	POLAR ICE-CAPS	NO	YES	YES	YES	NO
	2.8	IN-SITU DISPOSAL	YES	YES	YES	YES	NO
	2.9	DISPOSAL IN DIS-USED MINES	YES	YES	NO	YES	NO
	2.10	DISPOSAL IN DEEP BORE-HOLES	YES	YES	YES	YES	NO
	2.11	DISPOSAL IN OTHER COUNTRIES	YES	YES	YES	YES	NO
	2.12	SEA BED DISPOSAL	YES	YES	YES	YES	NO

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ST1 - OPTION OPERATIONAL BY 2008	ST2 - TECHNOLOGY AVAILABLE NOW	ST3 - TECHNOLOGY PROVEN	ST4 - OPTION RELIEVES PRESSURE ON CURRENT DRIGG CAPACITY	ST5 - REGULATOR ACCEPTANCE WITHIN CURRENT FRAMEWORK AND FORESEEABLE LEGAL CHANGES IN UK POLICY
	2.13	LANDFILL (Existing domestic landfills for lower activity LLW)	YES	YES	YES	YES	YES
	2.14	DISCHARGE TO ENVIRONMENT (dilute & disperse)	YES	YES	YES	YES	NO
	2.15	ONSITE LLW DISPOSAL FACILITIES	NO	YES	YES	YES	YES
3. TRANSFER ELSEWHERE	3.1	TRANSFER TO OTHERS	YES	YES	YES	YES	NO
4. REGULATORY CHANGE	4.1	CHANGE AUTHORISATION LIMITS FOR DISPOSAL	NO	YES	YES	YES	NO
	4.2	CHANGE AUTHORISATION LIMITS FOR RE-USE AND RECYCLING / RE-USE	YES	YES	YES	YES	YES
	4.3	MOVE TO RISK BASED CATEGORISATION	YES	YES	YES	YES	YES

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ST1 - OPTION OPERATIONAL BY 2008	ST2 - TECHNOLOGY AVAILABLE NOW	ST3 - TECHNOLOGY PROVEN	ST4 - OPTION RELIEVES PRESSURE ON CURRENT DRIGG CAPACITY	ST5 - REGULATOR ACCEPTANCE WITHIN CURRENT FRAMEWORK AND FORESEEABLE LEGAL CHANGES IN UK POLICY
	4.4	REGULATION FOR TRACKING RECYCLED METAL WASTE AND RESTRICTION ON USE	NO	YES	NO	YES	NO
	4.5	CHANGE LAW ON DUST-BIN DISPOSAL TO INCLUDE LARGE VOLUMES	NO	YES	YES	YES	NO
5. ASSAY	5.1	IMPROVED ASSAY AND WASTE ACTIVITY ESTIMATES	YES	YES	YES	YES	YES
6. RE-USE	6.1	RE-USE OF LLW ITEMS (e.g. SMALL ITEMS - TOOLS AND BROKKS; LARGE ITEMS - VESSELS)	YES	YES	YES	YES	YES
7. RECYCLE IN NUCLEAR INDUSTRY	7.1	BIOSHIELDS \ SHIELDING BLOCKS (Storage in bioshields)	YES	YES	YES	YES	YES
	7.2	NEW NUCLEAR FACILITY	NO	YES	YES	YES	YES

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ST1 - OPTION OPERATIONAL BY 2008	ST2 - TECHNOLOGY AVAILABLE NOW	ST3 - TECHNOLOGY PROVEN	ST4 - OPTION RELIEVES PRESSURE ON CURRENT DRIGG CAPACITY	ST5 - REGULATOR ACCEPTANCE WITHIN CURRENT FRAMEWORK AND FORESEEABLE LEGAL CHANGES IN UK POLICY
	7.3	REFORMATION OF COMPONENTS IN NEW NUCLEAR FACILITY	YES	YES	YES	YES	YES
8. RECYCLE IN NON-NUCLEAR INDUSTRIES	8.1	CONVERSION LLW TO STEEL INGOTS (UK STEEL INDUSTRY)	YES	YES	YES	YES	NO
	8.2	CHURCH ROOF (RE-USE OF LEAD)	YES	YES	YES	YES	NO
	8.3	RECYCLING TO WEAPONS PROGRAMME	YES	YES	YES	YES	YES
	8.4	SCULPTURE AND ARCHITECTURE	YES	YES	YES	YES	NO
	8.5	RECYCLING TO REFURBISH EXISTING BUILDINGS (E.G. DOUNREAY SPHERE)	YES	YES	YES	YES	NO
	8.6	OFFSHORE WAVE AND WIND PLATFORMS FOR POWER GEN	YES	NO	NO	YES	NO

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ST1 - OPTION OPERATIONAL BY 2008	ST2 - TECHNOLOGY AVAILABLE NOW	ST3 - TECHNOLOGY PROVEN	ST4 - OPTION RELIEVES PRESSURE ON CURRENT DRIGG CAPACITY	ST5 - REGULATOR ACCEPTANCE WITHIN CURRENT FRAMEWORK AND FORESEEABLE LEGAL CHANGES IN UK POLICY
	8.7	RECYCLE TO RAIL INDUSTRY (USES WITH MINIMAL DIRECT HUMAN CONTACT)	YES	YES	YES	YES	NO
9. TREATMENT - DECONTAMINATION	9.1	LOCAL DECONTAMINATION	YES	YES	YES	YES	YES
	9.2	CENTRAL UK DECONTAMINATION FACILITY	NO	YES	YES	YES	YES
	9.3	MOBILE / MODULAR FACILITIES	YES	YES	YES	YES	YES
	9.4	CHEMICAL SURFACE DISSOLUTION	YES	YES	YES	YES	YES
	9.5	SOLVENTS	YES	YES	YES	YES	YES
	9.6	ABRASIVE GRIT BLASTING (inc WACM)	YES	YES	YES	YES	YES

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ST1 - OPTION OPERATIONAL BY 2008	ST2 - TECHNOLOGY AVAILABLE NOW	ST3 - TECHNOLOGY PROVEN	ST4 - OPTION RELIEVES PRESSURE ON CURRENT DRIGG CAPACITY	ST5 - REGULATOR ACCEPTANCE WITHIN CURRENT FRAMEWORK AND FORESEEABLE LEGAL CHANGES IN UK POLICY
	9.7	ABRASIVE CO_2	YES	YES	YES	YES	YES
	9.8	UHP WATER JETTING	YES	YES	YES	YES	YES
	9.9	MECHANICAL PLANING	YES	YES	YES	YES	YES
	9.10	MILLING	YES	YES	YES	YES	YES
	9.11	SCABBLING AND GRINDING (needle gunning)	YES	YES	YES	YES	YES
	9.12	WHEELABRATOR	YES	YES	YES	YES	YES
	9.13	CLEANING SIMPLE TECHNIQUES	YES	YES	YES	YES	YES
	9.14	ULTRASONIC	YES	YES	YES	YES	YES

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ST1 - OPTION OPERATIONAL BY 2008	ST2 - TECHNOLOGY AVAILABLE NOW	ST3 - TECHNOLOGY PROVEN	ST4 - OPTION RELIEVES PRESSURE ON CURRENT DRIGG CAPACITY	ST5 - REGULATOR ACCEPTANCE WITHIN CURRENT FRAMEWORK AND FORESEEABLE LEGAL CHANGES IN UK POLICY
	9.15	HEAT TREATMENT (including steam)	YES	YES	YES	YES	YES
10. TREATMENT - SIZE REDUCTION	10.1	SIZE REDUCTION	YES	YES	YES	YES	YES
	10.2	COMPACTION (balers/in-drum)	YES	YES	YES	YES	YES
	10.3	SUPER COMPACTION (high force)	YES	YES	YES	YES	YES
	10.4	SEGREGATION	YES	YES	YES	YES	YES
	10.5	SHREDDING	YES	YES	YES	YES	YES
11. TREATMENT - PROCESS	11.1	MELTING IN UK FACILITY	YES	YES	YES	YES	YES

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	ST1 - OPTION OPERATIONAL BY 2008	ST2 - TECHNOLOGY AVAILABLE NOW	ST3 - TECHNOLOGY PROVEN	ST4 - OPTION RELIEVES PRESSURE ON CURRENT DRIGG CAPACITY	ST5 - REGULATOR ACCEPTANCE WITHIN CURRENT FRAMEWORK AND FORESEEABLE LEGAL CHANGES IN UK POLICY
	11.2	MELTING IN FACILITY OVERSEAS	YES	YES	YES	YES	YES
	11.3	COMPLETE DISSOLUTION	NO	YES	YES	YES	YES
	11.4	CHEMICAL SEPARATION	NO	YES	YES	YES	YES
	11.5	CORROSION (inc. Supercorrosion)	NO	NO	NO	YES	YES
12. MINIMISATION	12.1	REBANDING OF EXISTING MATERIALS	YES	YES	YES	YES	YES
	12.2	REDUCE USE OF METAL IN NEW APPLICATIONS	YES	YES	YES	NO	YES
13. MIX ACTIVE STEEL WITH CLEAN	13.1		YES	YES	YES	YES	NO

TABLE D2 – LONG-TERM COARSE SCREENING CRITERIA

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	LT1 - OPTION AVAILABLE BY 2020 (10 YEAR HORIZON)	LT2 - TECHNOLOGY AVAILABLE IN 5 YEARS	LT3 - OPTION REDUCES LIABILITY OF LLW	LT4 - OPTION ALIGNS WITH NATIONAL AND INTERNATIONAL CONVENTIONS
1. STORAGE	1.1	DECAY STORAGE FACILITY	YES	YES	YES	YES
	1.2	STORAGE IN HIGHER INTEGRITY CONTAINERS	YES	YES	NO	YES
	1.3	ENHANCED CORROSION FACILITY	NO	NO	YES	YES
	1.4	LONG-TERM ABOVE GROUND STORAGE	YES	YES	NO	YES
	1.5	FLOATING SEA PLATFORM	YES	YES	NO	NO
2. DISPOSAL	2.1	DEEP SEA DISPOSAL (GEOLOGICAL)	YES	YES	YES	NO
	2.2	EUROPEAN TYPE DISPOSAL	YES	YES	NO	YES
	2.3	DRIGG EXPANSION	YES	YES	NO	YES
	2.4	NEW LLW DISPOSAL FACILITY (DRIGG II)	YES	YES	NO	YES

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	LT1 - OPTION AVAILABLE BY 2020 (10 YEAR HORIZON)	LT2 - TECHNOLOGY AVAILABLE IN 5 YEARS	LT3 - OPTION REDUCES LIABILITY OF LLW	LT4 - OPTION ALIGNS WITH NATIONAL AND INTERNATIONAL CONVENTIONS
	2.5	LONG-TERM ABOVE GROUND DISPOSAL	YES	YES	NO	YES
	2.6	DISPOSAL IN SPACE	YES	NO	YES	YES
	2.7	POLAR ICE-CAPS	YES	YES	YES	NO
	2.8	IN-SITU DISPOSAL	YES	YES	NO	YES
	2.9	DISPOSAL IN DIS-USED MINES	YES	YES	NO	YES
	2.10	DISPOSAL IN DEEP BORE-HOLES	YES	YES	NO	YES
	2.11	DISPOSAL IN OTHER COUNTRIES	YES	YES	YES	NO
	2.12	SEA BED DISPOSAL	YES	YES	YES	NO
	2.13	LANDFILL (Existing domestic landfills for lower activity LLW)	YES	YES	YES	YES
	2.14	DISCHARGE TO ENVIRONMENT (dilute & disperse)	YES	YES	YES	NO

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	LT1 - OPTION AVAILABLE BY 2020 (10 YEAR HORIZON)	LT2 - TECHNOLOGY AVAILABLE IN 5 YEARS	LT3 - OPTION REDUCES LIABILITY OF LLW	LT4 - OPTION ALIGNS WITH NATIONAL AND INTERNATIONAL CONVENTIONS
	2.15	ONSITE LLW DISPOSAL FACILITIES	YES	YES	NO	YES
3. TRANSFER ELSEWHERE	3.1	TRANSFER TO OTHERS	YES	YES	YES	NO
4. REGULATORY CHANGE	4.1	CHANGE AUTHORISATION LIMITS FOR DISPOSAL	YES	YES	YES	YES
	4.2	CHANGE AUTHORISATION LIMITS FOR RE-USE AND RECYCLING / RE-USE	YES	YES	YES	YES
	4.3	MOVE TO RISK BASED CATEGORISATION	YES	YES	YES	YES
	4.4	REGULATION FOR TRACKING RECYCLED METAL WASTE AND RESTRICTION ON USE	YES	YES	YES	YES
	4.5	CHANGE LAW ON DUST-BIN DISPOSAL TO INCLUDE LARGE VOLUMES	YES	YES	YES	YES
5. ASSAY	5.1	IMPROVED ASSAY AND WASTE ACTIVITY ESTIMATES	YES	YES	YES	YES

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	LT1 - OPTION AVAILABLE BY 2020 (10 YEAR HORIZON)	LT2 - TECHNOLOGY AVAILABLE IN 5 YEARS	LT3 - OPTION REDUCES LIABILITY OF LLW	LT4 - OPTION ALIGNS WITH NATIONAL AND INTERNATIONAL CONVENTIONS
6. RE-USE	6.1	RE-USE OF LLW ITEMS (e.g. SMALL ITEMS - TOOLS AND BROKKS; LARGE ITEMS - VESSELS)	YES	YES	NO	YES
7. RECYCLE IN NUCLEAR INDUSTRY	7.1	BIOSHIELDS \ SHIELDING BLOCKS (Storage in bioshields)	YES	YES	NO	YES
	7.2	NEW NUCLEAR FACILITY	YES	YES	NO	YES
	7.3	REFORMATION OF COMPONENTS IN NEW NUCLEAR FACILITY	YES	YES	NO	YES
8. RECYCLE IN NON-NUCLEAR INDUSTRIES	8.1	CONVERSION LLW TO STEEL INGOTS (UK STEEL INDUSTRY)	YES	YES	YES	NO
	8.2	CHURCH ROOF (RE-USE OF LEAD)	YES	YES	NO	NO
	8.3	RECYCLING TO WEAPONS PROGRAMME	YES	YES	YES	YES
	8.4	SCULPTURE AND ARCHITECTURE	YES	YES	NO	NO

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	LT1 - OPTION AVAILABLE BY 2020 (10 YEAR HORIZON)	LT2 - TECHNOLOGY AVAILABLE IN 5 YEARS	LT3 - OPTION REDUCES LIABILITY OF LLW	LT4 - OPTION ALIGNS WITH NATIONAL AND INTERNATIONAL CONVENTIONS
	8.5	RECYCLING TO REFURBISH EXISTING BUILDINGS (E.G. DOUNREAY SPHERE)	YES	YES	NO	YES
	8.6	OFFSHORE WAVE AND WIND PLATFORMS FOR POWER GEN	YES	YES	NO	NO
	8.7	RECYCLE TO RAIL INDUSTRY (USES WITH MINIMAL DIRECT HUMAN CONTACT)	YES	YES	NO	YES
9. TREATMENT - DECONTAMINATION	9.1	LOCAL DECONTAMINATION	YES	YES	YES	YES
	9.2	CENTRAL UK DECONTAMINATION FACILITY	YES	YES	YES	YES
	9.3	MOBILE / MODULAR FACILITIES	YES	YES	YES	YES
	9.4	CHEMICAL SURFACE DISSOLUTION	YES	YES	YES	YES

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	LT1 - OPTION AVAILABLE BY 2020 (10 YEAR HORIZON)	LT2 - TECHNOLOGY AVAILABLE IN 5 YEARS	LT3 - OPTION REDUCES LIABILITY OF LLW	LT4 - OPTION ALIGNS WITH NATIONAL AND INTERNATIONAL CONVENTIONS
	9.5	SOLVENTS	YES	YES	YES	YES
	9.6	ABRASIVE GRIT BLASTING (inc WACM)	YES	YES	YES	YES
	9.7	ABRASIVE CO_2	YES	YES	YES	YES
	9.8	UHP WATER JETTING	YES	YES	YES	YES
	9.9	MECHANICAL PLANING	YES	YES	YES	YES
	9.10	MILLING	YES	YES	YES	YES
	9.11	SCABBLING AND GRINDING (needle gunning)	YES	YES	YES	YES
	9.12	WHEELABRATOR	YES	YES	YES	YES
	9.13	CLEANING SIMPLE TECHNIQUES	YES	YES	YES	YES

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	LT1 - OPTION AVAILABLE BY 2020 (10 YEAR HORIZON)	LT2 - TECHNOLOGY AVAILABLE IN 5 YEARS	LT3 - OPTION REDUCES LIABILITY OF LLW	LT4 - OPTION ALIGNS WITH NATIONAL AND INTERNATIONAL CONVENTIONS
	9.14	ULTRASONIC	YES	YES	YES	YES
	9.15	HEAT TREATMENT (including steam)	YES	YES	YES	YES
10. TREATMENT - SIZE REDUCTION	10.1	SIZE REDUCTION	YES	YES	YES	YES
	10.2	COMPACTION (balers/in-drum)	YES	YES	YES	YES
	10.3	SUPER COMPACTION (high force)	YES	YES	YES	YES
	10.4	SEGREGATION	YES	YES	YES	YES
	10.5	SHREDDING	YES	YES	YES	YES
11. TREATMENT - PROCESS	11.1	MELTING IN UK FACILITY	YES	YES	YES	YES

PARENT OPTIONS	OPTION NUMBER	SUB-OPTION	LT1 - OPTION AVAILABLE BY 2020 (10 YEAR HORIZON)	LT2 - TECHNOLOGY AVAILABLE IN 5 YEARS	LT3 - OPTION REDUCES LIABILITY OF LLW	LT4 - OPTION ALIGNS WITH NATIONAL AND INTERNATIONAL CONVENTIONS
	11.2	MELTING IN FACILITY OVERSEAS	YES	YES	YES	YES
	11.3	COMPLETE DISSOLUTION	YES	YES	YES	YES
	11.4	CHEMICAL SEPARATION	YES	YES	YES	YES
	11.5	CORROSION (inc. Supercorrosion)	YES	NO	YES	YES
12. MINIMISATION	12.1	REBANDING OF EXISTING MATERIALS	YES	YES	YES	YES
	12.2	REDUCE USE OF METAL IN NEW APPLICATIONS	YES	YES	YES	YES
13. MIX ACTIVE STEEL WITH CLEAN	13.1		YES	YES	NO	NO

Appendix E – Shortlisting of Options for Further Evaluation

TABLE E1 – SHORTLISTING OF SCREENED-IN OPTIONS

PARENT OPTIONS	OPTION NUMBER	SHORT/LONG TERM OPTION	SUB-OPTION	SHORTLISTED	COMMENTS
1. STORAGE	1.1	Both	DECAY STORAGE FACILITY	No	This option has not been shortlisted as it runs counter to the NDA's accelerated decommissioning strategy. Also issues with longer-term intergenerational liabilities.
	1.5	ST	LONG-TERM ABOVE GROUND STORAGE	No	This option has not been shortlisted as it runs counter to the NDA's strategy in terms of reduced liability in the longer term.
2. DISPOSAL	2.2	ST	EUROPEAN TYPE DISPOSAL	No	This option has not been shortlisted as it runs counter to the NDA's strategy in terms of reduced liability in the longer term.
	2.4	ST	LONG-TERM ABOVE GROUND DISPOSAL	No	This option has not been shortlisted as it runs counter to the NDA's strategy in terms of reduced liability in the longer term.
	2.13	Both	LANDFILL (Existing domestic landfills for lower activity LLW)	No	This option may require a regulatory change to be viable however it does have the ability to address significant quantities of very low activity waste.
4. REGULATORY CHANGE	4.1	LT	CHANGE AUTHORISATION LIMITS FOR DISPOSAL	No	These options are not stand-alone management techniques and some may require significant time to change. Changes to the regulatory regime may increase or decrease the viability of all other management solutions.
	4.2	Both	CHANGE AUTHORISATION LIMITS FOR RE-USE AND RECYCLING / RE-USE	No	
	4.3	Both	MOVE TO RISK BASED CATEGORISATION	No	
	4.4	LT	REGULATION FOR TRACKING RECYCLED METAL WASTE AND RESTRICTION ON USE	No	
	4.5	LT	CHANGE LAW ON DUST-BIN DISPOSAL TO INCLUDE LARGE VOLUMES	No	
5. ASSAY	5.1	Both	IMPROVED ASSAY AND WASTE ACTIVITY ESTIMATES	Part of all options	Should be encouraged as part of all waste management solutions.

PARENT OPTIONS	OPTION NUMBER	SHORT/LONG TERM OPTION	SUB-OPTION	SHORTLISTED	COMMENTS
6. RE-USE	6.1	ST	RE-USE OF LLW ITEMS (e.g. SMALL ITEMS - TOOLS AND BROKKS; LARGE ITEMS - VESSELS)	Part of all options	These options could help relieve pressure on Drigg in the short term and should be encouraged in accordance with the waste hierarchy. Waste would still have to be disposed in long term.
7. RECYCLE IN NUCLEAR INDUSTRY	7.1	ST	BIOSHIELDS \ SHIELDING BLOCKS (Storage in bioshields)	Part of all options	These options could help relieve pressure on Drigg in the short term and should be encouraged. Waste would still have to be disposed in long term.
	7.3	ST	REFORMATION OF COMPONENTS IN NEW NUCLEAR FACILITY	Part of all options	
8. RECYCLE - NON-NUCLEAR SECTOR	8.3	Both	RECYCLING TO WEAPONS PROGRAMME	No	Unlikely that a significant amount of LLW could be managed using this option due to quality and perception issues.
9. TREATMENT - DECONTAMINATION	9.1	Both	LOCAL DECONTAMINATION	Part of all options	Decontamination should be undertaken as part of other waste mgt routes to maximise material that can be free released. The choice of an individual decontamination technique should be based on local site factors and waste characteristics.
	9.2	LT	CENTRAL UK DECONTAMINATION FACILITY		
	9.3	Both	MOBILE / MODULAR FACILITIES		
	9.4	Both	CHEMICAL SURFACE DISSOLUTION		
	9.5	Both	SOLVENTS		
	9.6	Both	ABRASIVE GRIT BLASTING (inc WACM)		
	9.7	Both	ABRASIVE CO_2		
	9.8	Both	UHP WATER JETTING		
	9.9	Both	MECHANICAL PLANING		
	9.10	Both	MILLING		
	9.11	Both	SCABBLING AND GRINDING (needle gunning)		
	9.12	Both	WHEELABRATOR		
	9.13	Both	CLEANING SIMPLE TECHNIQUES		
	9.14	Both	ULTRASONIC		

PARENT OPTIONS	OPTION NUMBER	SHORT/LONG TERM OPTION	SUB-OPTION	SHORTLISTED	COMMENTS
	9.15	Both	HEAT TREATMENT (including steam)		
10. TREATMENT - SIZE REDUCTION	10.1	Both	SIZE REDUCTION	Part of all options	Size reduction has not been considered as a stand alone solution as it does not address the radioactive content of the waste stream or allow recycling. Size reduction should be undertaken at the appropriate stage as part of all waste mgt solutions to maximise disposal capacity. The choice of the most effective size reduction technique would be dependant on local site conditions and waste characteristics.
	10.2	Both	COMPACTION (balers/in-drum)		
	10.3	Both	SUPER COMPACTION (high force)		
	10.4	Both	SEGREGATION		
	10.5	Both	SHREDDING		
11. TREATMENT - PROCESS	11.1	Both	MELTING IN UK FACILITY	Yes	Proven technology on large scale and could take significant volumes of LLW therefore should be considered further.
	11.2	Both	MELTING IN FACILITY OVERSEAS	Yes	Facilities currently operational overseas and could take significant volumes of LLW therefore should be considered further.
	11.3	LT	COMPLETE DISSOLUTION	No	Technology not currently operated in UK or internationally on large enough scale. Hazardous process – secondary waste stream difficult to handle. May be corrosive and highly mobile. Retrieval/reforming of metal from liquid is difficult.
	11.4	LT	CHEMICAL SEPARATION	No	Technology not currently operated in UK or internationally on large enough scale. Hazardous process – secondary waste stream difficult to handle. May be corrosive and highly mobile. Retrieval/reforming of metal from liquid is difficult.

PARENT OPTIONS	OPTION NUMBER	SHORT/LONG TERM OPTION	SUB-OPTION	SHORTLISTED	COMMENTS
12. MINIMISATION	12.1	Both	REBANDING OF EXISTING MATERIALS	Part of all options	Linked to Option 5.1 ASSAY – part of overall waste mgt solution
	12.2	LT	REDUCE USE OF METAL IN NEW APPLICATIONS	Part of all options	Part of longer term overall waste mgt solution