REPROCESSING DECISIONS AND IMPLICATIONS FOR WASTE MANAGEMENT

H Barton

UKAEA, UNITED KINGDOM

ABSTRACT

The reprocessing of irradiated fuels is an important operation within the nuclear fuel cycle and one which will conserve uranium resources and provide fissile material for future fast reactor systems. Reprocessing creates a variety of wastes containing the highest levels of radioactivity and their effective and safe management is an essential factor in demonstrating to the public the industry's responsible approach. Decisions made at the early stages of reprocessing plant design can have a significant influence in providing an acceptable system. This paper highlights and discusses some of the more important decisions considered necessary towards an efficient and cost effective strategy from the generation of wastes through to their safe disposal.

INTRODUCTION

Over the past two decades the growth in the commercial application of nuclear power has resulted in a progressive increase in the quantity of radioactive wastes produced in the fuel cycle. These wastes arise from both the operation of reactors and their fuel cycle plants. In the latter case however installed reprocessing capacity has in many instances not matched reactor programmes and a significant quantity of irradiated fuel has had to be stored. Where reprocessing plants are installed and operating waste management facilities have, in general, been designed and constructed to provide safe and relatively long term storage. This situation resulted from the time needed to develop suitable treatment plants for the immobilisation of the wastes together with the absence of any disposal routes other than for those wastes which could be discharged or disposed of directly to the environment, in particular gaseous and low level liquid and solid wastes.

Over the past decade as existing waste storage facilities have become filled potential problems with regard to their integrity, safety and replacement have required major capital investment focussing attention on the need to re-examine future waste management philosophy. This together with the public concern regarding the impact of nuclear power on the environment reinforced the view that substantial development programmes would need to be undertaken to review all aspects of waste management from their generation to disposal.

This paper reviews one such aspect of the subject relating to the design of future reprocessing plants. Special reference is made to the options and decisions which need to be considered in order to optimise as far as practicable within current experience and technology both the plant design and waste management systems to ensure the safe management of all radioactive wastes.

IRRADIATED FUEL REPROCESSING

Wastes from Reprocessing

Irradiated fuel reprocessing comprises a number of individual unit process or stage operations to separate the unwanted actinides, fission and activation products from the fissile and fertile materials. Many of the stages will result in radioactive wastes which can be segregated at source (primary) for either direct discharge to the environment after minimal treatment and monitoring or will need to be stored to await treatment followed by further interim storage prior to the availability of disposal routes. Secondary wastes, typically Ion exchange resins, floc precipitates, etc, will also be produced from the treatment or decontamination of some primary waste streams, eg medium and low active liquors.

Wastes can be broadly categorised into three distinct headings depending on their radioactive content as follows:

- i High Level
- ii Intermediate Level
- iii Low Level

High level or heat generating wastes arise from the 1st purification cycle of the Solvent Extraction process and contain at least 99.5% of the non-volatile fission products and unwanted actinides. These wastes constitute the smallest volume of primary liquors produced in reprocessing and are closely related to plant throughput.

Low level wastes on the other hand comprise by far the largest volume and are present as liquids, solids and in gaseous form. The majority, either primary or secondary wastes, are normally only mildly contaminated and may require little or no further pre-treatment, eg filtration, packaging, prior to monitoring before their immediate or early disposal to the environment, either by direct stack (gaseous) or sea, lake or river discharge or by shallow land burial. Disposal of these wastes are strictly controlled by the various regulatory bodies in the countries where these practices occur. Moreover some of these wastes, in particular solid wastes, are not directly related to plant throughput since they arise from other site operations such as analytical and experimental services and maintenance/refurbishing operations.

Between the above two categories the Intermediate level wastes represent the most varied selection of arisings and comprise solid, liquid and wet materials (primary and secondary) with specific activities varying by orders of magnitude, both alpha and non-alpha and in a wide range of chemical and physical forms. Waste Management requirements are influenced to a great extent by plant designs and the flowsheet adopted. This category therefore has a major impact in terms of complexity and variety of treatment options and the majority of these wastes will need to be stored until suitable disposal routes are identified.

Some indication of the rate of production and radioactivity of solid unconditioned wastes associated with reprocessing operations in the United Kingdom is given in Table I below. The list is by no means complete but emphasises the necessity for comprehensive treatment and storage facilities prior to their disposal.

TABLE I

Category	Arisings m^3/te fuel	Specific Activity (Ci/m^3) (Alpha)	(Beta/Gamma)	Options
1. High Level	0.2	$1x10^4$	$4x10^6$	Treatment and Storage. Disposal routes not yet available
2. Intermediate Level				
i Fuel cladding	0.6	$6x10^1$	$1x10^4$	
ii Concentrates	0.5-1.0	10^2	$5x10^3$	
iii Floc		10	0.5	
iv Ion Exchange Materials		2	$5x10^3$	
v Plutonium Contaminated Materials	1.5-2.5	10	$3.5x10^2$( )	
3. Low Level Solid Wastes	Not proportional	$5x10^{-4}$	$1x10^{-2}$	Disposal by shallow land burial as currently practised

Waste Management Strategy

In a number of countries designs are in hand for large commercial plants for oxide fuel reprocessing having throughputs of up to about 5 tonnes per day of irradiated fuels, and although capital costs can only be estimated within broad bands it is becoming apparent that a significant proportion of these costs ca 20 to 30% are attributable to waste management. This excludes the further costs associated with their disposal. Waste management in reprocessing is therefore an important component of fuel cycle costs.

In considering any waste management strategy it will be important initially to distinguish between those wastes which can be routinely discharged after monitoring and those which will require treatment and extended storage. In the former, their possible treatment options need to be evaluated against the environmental impact of those discharges. In this respect the recommendation of ICRP 26 relating to the As Low As Reasonably Achievable (ALARA) principle sets down guidelines for the necessary approach. This, together with the strict regulatory controls enforced in setting site discharge authorisations should ensure that the public are afforded ample protection.

However, for those wastes which can currently only be retained on site, a number of options will normally be available which must be identified and costed and their ultimate environmental impact assessed before a safe and cost effective solution can be found. The more important areas which will need to be taken into account are:

i Flowsheet and plant design implications

ii Waste handling requirements

iii Waste storage requirements

iv Treatment options and their timing with respect to disposal

v Transport and disposal options where identified.

The above cannot be considered in isolation, and their interactions with each other will need to be evaluated in some detail taking into account the following:

i Capital and operating costs

ii Safety

iii Availability and maintainability of plant and equipment

iv Generation of secondary wastes, and their suitability for treatment in plants already defined

v Volume of wastes produced and their characteristics

vi Development requirements

vii Radiation uptake to operators and the public.

The present lack of land disposal sites, uncertainties in their timing in relation to reprocessing plant design, together with the absence of regulatory requirements relating to the disposal of wastes could influence the selection of treatment and storage options.

Application of Waste Management Strategy

All solid wastes, particularly those in the Intermediate level category will either be $\beta\gamma$ activated and contaminated materials from fuel element breakdown operations, or simply contaminated as a result of their use as clean-up or decontamination agents, eg Ion exchange resins. Other contaminated components arise from their presence in process cells, eg redundant machinery, handling equipment or operational materials. In addition, and depending on the plant design principles adopted, they may be α contaminated to a greater or lesser extent with plutonium and other actinides. The segregation at source of these high or low $\beta\gamma$ wastes from α activity and into their different physical or chemical forms, eg compressive, combustible or non-combustible, will be a key factor in waste management strategy in providing and utilising treatment and storage capacity effectively and economically since it will:

i Minimise or reduce α wastes by avoiding cross-contamination ii Minimise the capital cost of storage which is significantly higher for α wastes

iii Avoid the later and increasingly difficult operation of recovery and segregation after storage for further decontamination or treatment.

iv Minimise the potential α decontamination requirements

v Segregate waste into categories requiring similar treatments

vi Maximise the plutonium recovery efficiency of the reprocessing plant

An example of the above strategy is that which has been developed in the United Kingdom at Dounreay. In the early 1970s it was decided that the irradiated mixed oxide fuel from the Prototype Fast Reactor (PFR) should be reprocessed on site and a waste management system was defined and installed to meet the standards of safety required to take account of the significant quantity of plutonium to be handled. Engineered retrievable storage facilities were provided for alpha contaminated wastes to allow time for the development of suitable decontamination and treatment facilities. In addition, a new dry High βγ facility was constructed to accept low α wastes from other areas on site including decontaminated solid wastes from the PFR reprocessing plant. Shallow land burial is also practised for Low αβγ solid wastes and represents the lowest level of activity within the system. The following table illustrates and emphasises the economic advantages which have resulted from the provision of that strategy in minimising the quantity of alpha contaminated solid wastes by their early segregation:

TABLE II

Category	Capacity (m^3)	Storage Capital Cost (£K/m^3)	Activity and Radiation Levels (mCi/m^3)	(R/hr)
High , High	100	30	20	0.075
High , Low	750	4	20	0.075
Low , High	1200	2	20	0.075
Low , Low		0.04	20	0.075

To support the above, a system of Non Destructive Assay Techniques (NDA), by neutron interrogation and passive neutron counting, is installed for the determination of the fissile material content of the wastes. This was an essential prerequisite of the adopted policy in order to make the most efficient use of the storage facilities and the system has operated extremely effectively. Some decontamination and volume reduction techniques are currently being carried out on a selection of wastes and a further decontamination facility is to be installed at the reprocessing plant to reduce the α activity on potential high αβγ wastes resulting from the dismantling of PFR fuel assemblies.

However, in arriving at an overall waste management strategy, some indication of disposal costs also needs to be considered. A number of preliminary design concepts for land burial sites have been examined and evaluated in the United Kingdom for High and Intermediate level wastes. The following table gives the indicative capital costs (£K/m^3) based on the volumes of conditioned wastes excluding any overpacking necessary to assist in the handling, transport or in the provision of long life protection after disposal.

TABLE III

Category of Waste	Capital Cost (£K/m^3)	Comments
1. High Level	200	Geological Disposal in granite at 1000 m deep.
2. Intermediate Level		
i High	2	Geological Disposal in argillaceous formations at 300 m deep.
ii High , Low	0.4	Engineered Surface Trench at 30 m deep.

REPROCESSING PLANT DESIGN INFLUENCE ON WASTE MANAGEMENT

The two main areas in reprocessing plants which generate significantly different types of primary wastes are those of Head End dismantling or breakdown and the Chemical Separation Process. In support of these two areas there are a number of ancillary services, eg waste transfer systems, liquor sampling and transfer and active maintenance. In addition, the waste management facilities themselves will result in secondary wastes.

The following sections deal with the more important requirement which will need to be considered at an early stage in design to ensure that an effective solution to waste management is produced.

Head End Plant

The process operations in this area consist of the breakdown or dismantling of the irradiated fuel elements to provide a suitable feedstock to fuel dissolution, feed clarification, fissile material accountancy and finally valency adjustment prior to the solvent extraction stages.

Once the plant throughput has been established the factors which will have an influence, to a greater or lesser degree, both on Head End plant design and waste management will be as follows:

a. Cooling time to reprocessing

b. Fuel element design and therefore reactor type

c. Method of fuel element breakdown/dismantling and the extent to which this is carried out at the reactor

Fuel Element Breakdown/Dismantling

The complexity of fuel element design and the quantity of associated wastes resulting from breakdown/dismantling operations are different for the various types of reactors currently operating or being considered throughout the world. Some indication of the approximate quantities of fuel, wastes and decay heat outputs of irradiated fuel elements at cooling times considered acceptable in in reprocessing operations are given in the following table:

TABLE IV

	Reactor Type (PWR)	Reactor Type (FBR)
1. Cooling time to reprocessing (years)	5	1
2. Fuel per element (kg)		
Uranium	450	85
Plutonium	4	12
3. Weight of components (kg)		
Fuel cladding	90	40
Structural materials, etc	30	120
4. Heat rating per element (Watts)	1000	2500
5. Ratio: Fuel Element Debris (kg) / Weight fuel (kg)	0.27	1.7
6. Heat Rating Watts/kg fuel	2	25

The quantity of waste, (item 3), is not significantly different for the two reactor types, and even when related to the scale of proposed future reprocessing plants, eg Thermal (5 te per day) and Fast Reactors (1 te per day) the difference is again not significant in terms of annual waste (weight) production. The greater complexity of Fast Reactor fuel assemblies and higher specific heat rating is apparent from items 5 and 6.

Head End development has in the past concentrated mainly on mechanical methods of breakdown based on proven technology involving either massive shearing of complete fuel elements or the progressive dismantling to a stage which will allow the extraction of individual or small bundles of pins. A decision on the method of breakdown will be strongly influenced by whether some limited dismantling is carried out at the reactor site. In the case of the PWR, the receipt of complete fuel elements will require the management of all wastes associated with the structural parts and fuel cladding. For the Fast Reactor, the development of two distinct fuel assembly designs, ie gridded and wire wrapped pins, allows different Head End options to be considered resulting in different implications on waste management. The latter, adopted in the French and US designs, is more amenable to complete dismantling at the reactor site and the receipt of bundles of pins by the reprocessor will lead to both reduced Head End plant complexity and the minimising of waste.

Again with respect to the Fast Reactor, complete or partial dismantling of fuel assemblies together with the removal of sodium at the reactor site, prior to shipment to the reprocessor, will also eliminate the need to provide comprehensive sodium handling and cleaning equipment with their waste management implications.

The main advantage claimed for massive shearing is its ability to support high plant throughputs. However, the adoption of this method needs to be carefully considered because of the following:

i All wastes will be potentially α contaminated on breakdown.

ii All wastes will be fed to the dissolver which could create handling problems in the feed system and later operations.

iii Unless effective ventilation is installed on the shear equipment high contamination of the cell with alpha activity will result.

iv With continuous dissolution, designs may be complicated in ensuring an even flow of material and fuel exacerbating the difficulties in predicting and meeting criticality safety requirements.

At the other extreme, complete or partial fuel element dismantling will minimise (a) the alpha contaminated wastes and (b) the quantity of extraneous materials fed to the dissolver. A further advantage if single or small bundle shearing is carried out will be the compactness of the shear equipment allowing a small alpha containment within the cell to localise the spread of contamination. The disadvantages of this method are:

i The need to provide complex and highly reliable mechanical equipment for the handling and dismantling of the fuel elements and the resulting wastes.

ii Dismantling equipment will need to be remotely located accurately onto the fuel element components.

iii Separate routes will need to be provided for handling the two (high $\beta\gamma$ and high $\alpha\beta\gamma$) waste streams.

iv Throughput may be limited by the number of fuel element dismantling operations.

Complete dismantling of fuel assemblies is currently carried out in the Prototype Fast Reactor Reprocessing plant at Dounreay where the use of laser cutting equipment has proved to be extremely successful. Experience has shown that the early concern regarding the laser beam accidently striking fuel to volatilise the plutonium has proved unfounded, and the absence of such active species as Mn54 and Co60 in the filter system has indicated that the laser "smoke" does not give rise to high metallic particulate production. There has also been no evidence of fuel pin damage which could affect the subsequent pin pulling operations. Recent development work carried out in the United Kingdom in support of the conceptual design study for the Demonstration Fast Reactor reprocessing plant is indicating that the reference route, ie complete fuel assembly dismantling and single pin shearing, is not as severely limited as originally thought. Throughputs approaching those for massive shearing are now considered to be practicable.

Alternative Head End processes are being considered for future plants including chemical embrittlement, electro-chemical dissolution etc. Before any decision is taken to adopt these more novel techniques their implications will need to be explored both down stream in the process line and on waste management.

As an illustrative example, highly enriched uranium/aluminium fuel elements from the United Kingdom Materials Testing Reactor Programme have been reprocessed at Dounreay for the past 20 years. The complete fuel elements are dissolved in nitric acid and mercury is added to assist in the dissolution of the large quantity of aluminium present. Studies on the vitrification of the resulting liquid waste from the 1st purification cycle have shown that:

i Because of the high aluminium content, the immobilisation of the fission products in glass would be extremely inefficient, being no more than 0.2% by weight.

ii A pre-treatment process would need to be developed to remove the mercury from the liquor prior to high temperature vitrification in order to protect the plant from enhanced corrosion.

Insoluble Residues

Feed clarification of dissolver liquors to remove the insoluble fission products and plutonium, is gaining in importance as higher burn-up targets are being set both in Thermal and Fast Reactor fuels together with the high plutonium enrichments in the latter. Equipment currently in use include mechanical filtration and high speed centrifugal separation whilst high gradient magnetic separation is at present in the early stages of development. All these systems create a waste containing a significant amount of radioactivity resulting from the predominance of Ru106, a nuclide with a half-life of one-year. Some decay cooling in storage may therefore be necessary before the wastes can be immobilised.

The choice between the different engineering solutions will influence the later waste management aspects of both storage and treatment. The major factors leading to the selection of a particular method will be:

i Throughput and cooling time at reprocessing.

ii Frequency of backwashing filters or centrifuge bowls to remove the insolubles.

iii Reliability and ease of replacement or maintenance of equipment.

iv Component size and cost.

v Type of waste produced, eg slurry or dry materials.

vi The engineering of the heat removal system.

Little experience has been obtained in this field to date with higher burn-up fuels and development programmes on both the filtration and high speed centrifuge processes are in hand in support of commercial Thermal and Fast Reactor reprocessing plants.

The high speed centrifuge separator has been successfully applied at Dounreay in the reprocessing of irradiated fuel from the Prototype Fast Reactor where fuels with burn-ups (percentage heavy atoms consumed) as high as 8.3% and plutonium enrichments of ca 25% have been handled. Analyses of the centrifuge bowls have indicated plutonium losses of less than 0.05% eliminating the need for recovery. Changing of the bowls is carried out remotely after each batch dissolution, and the bowls and contents are placed in stainless steel containers along with other metallic fuel assembly components and transferred to the High $\alpha\beta\gamma$ Engineered retrievable store where cooling facilities are provided. Proposals are in hand to incorporate these wastes into a cement matrix in a plant designed to handle a number of waste streams.

SOLVENT EXTRACTION

All the major reprocessing plants to date employ solvent extraction for the separation of fissile and fertile materials from the unwanted fission products and actinides and use a variant of the PUREX process. Although considerable experience has been built up throughout the world over the past 30 years there is still significant scope for flowsheet optimisation which can have a considerable influence on waste management. Such variations as early or late separation of Uranium and Plutonium, TBP (Tri-butyl phosphate) concentration, salt or salt free flowsheet, mixed (U and Pu) or separate products together with the product specification will all have some implication on the waste management of the resulting effluent streams in the various cycles of the plant.

High Level Liquid Wastes

These liquors arise from the 1st purification cycle of solvent extraction and constitute the major waste stream in terms of radioactive content, and the choice of method for their handling can have a significant effect on the complexity of waste management and its component in reprocessing costs. The main factors influencing the management of these high level wastes, once the plant throughput has been established, are:

i Cooling time at reprocessing.

ii Length of time which the liquors are held in storage prior to their immobilisation, eg vitrification.

iii The evaporability of the liquors either prior to storage or by tank-to-tank transfers after some decay cooling.

In the United Kingdom, the commercial reprocessing of oxide fuels will not be carried out before a cooling time of about five years and for the Fast Reactor cooling times of between one and two years will be admissible for at least two decades before there could be a need to recycle plutonium quickly. This, together with the present state of vitrification technology and the development of suitable glasses to take relatively high mass waste oxide loadings (ca 25%) and heat ratings (up to 20 watts/litre) suggests that there are no strong technical grounds or indeed necessity, to provide significant extended liquor storage. Thus future Thermal reprocessing plants should need to be provided with only sufficient liquor buffer storage to allow for any extended down time which might occur at the vitrification plant.

A further factor in reducing liquor hold-up volumes is that of evaporation. High evaporation factors will minimise tank storage but will result in more complex tank designs with respect to their increased heat removal requirements and the need to provide in-tank equipment to minimise or eliminate the settling out of solids in order to avoid the creation of local hot-spots leading to enhanced tank corrosion.

Consideration will need to be given to the presence of entrained solvent, and its degredation products, in the liquid wastes. Complexing with fission product zirconium produces the insoluble zirconium phosphate precipitate which can have a major effect on reducing the heat transfer coefficient of cooling surfaces. The removal of entrained solvent by steam stripping prior to storage of the liquors will allow higher evaporation factors to be achieved before the above effect occurs.

In considering the choice between low or high evaporation of liquors, the simpler tank design of the former, together with the possibility of adopting tank sizes which could be works fabricated and tested rather than constructed on site, may offer significant advantages in terms of both capital and operating costs and also in operating efficiency and safety. Indicative estimates of the simpler tank installation systems, based on designs in the United Kingdom, give costs of ca £15-20K per m^3. The more complex tank systems suitable for highly evaporated liquors are higher by a factor of up to about ten, although the cost per curie may not differ significantly.

Medium and Low Active Liquid Wastes

Medium and Low active liquors arise from the 2nd and 3rd purification cycles in the solvent extraction system. Volumes will be significantly higher than that of the high level (1st cycle) stream. There is considerable scope in this area for waste management options depending on the reprocessing plant flowsheet and other decisions. The more important considerations will be:

i Salt or salt free flowsheet.

ii Decontamination factors required to achieve the necessary product specifications for uranium and plutonium.

iii Whether the evaporation of high, medium and low active liquors are to be carried out.

iv The quantity and composition of other liquid waste streams from the plant requiring treatment, eg decontamination liquors and those from analytical laboratories, change rooms, etc.

v The discharge philosphy adopted for the low level liquid wastes.

Each of the above will have implications on waste management strategy and their impact on the choice of plant and equipment will need to be assessed thoroughly in order to provide an efficient and cost effective solution.

The choice between a salt or salt free process will need careful consideration and development requirements identified before a selection is made. Tight environmental controls approaching a near zero discharge philosophy will require the recycle of nitric acid and water with the evaporation of high, medium and low active liquors necessitating expensive evaporation equipment, especially with salt flowsheets. Salt free flowsheets whilst possibly offering some advantages in plant economies will require the addition of reagents such as hydroxalamine which introduce potential problems with respect to kinetics etc.

For the low active liquor, discharge authorisations laid down by the various national regulatory bodies will provide strict controls from which the waste management of the system can be developed. This, together with the application of the ALARA principle to provide a cost benefit analysis on the basis of the dose detriment, will allow a rational approach in examining the impact of the various options considered.

GASEOUS WASTES

As with low active liquors, gaseous wastes are presently discharged routinely from reprocessing plants after treatment to remove particulate activity by the use of high efficiency filtration. Of the major nuclides of concern in reprocessing, ie H3, C14, I129, I131 and Kr85, that of I131 is strongly dependent on cooling time and does not present any problems at the relatively long cooling times envisaged in future commercial plants.

With respect to the other nuclides, their impact on the environment have been the subject of examination for some time and considerable development work is in hand to identify processes for their efficient removal. However, the results of studies carried out to date by various international bodies have not yet made any firm recommendations regarding their removal. Nevertheless, the progress in the field of gaseous wastes is being constantly kept under review with respect to its implications on, and possible implementation in, future reprocessing plants.

OTHER IMPLICATIONS ON WASTE MANAGEMENT

In support of the main line processes, there are a number of ancillary services to be taken into account in the plant design which will have an influence in the setting up of an effective waste management system. The more important areas which will, with good design, be conducive to reducing waste arisings and at the same time affording more economical utilisation of resources are:

i Engineered Waste Posting systems

ii Sampling systems

iii The level of instrumentation installed for process control

iv The use of such techniques as fluidics for liquor movement and ventilation control.

v The use of operational materials which give greater life in service and are more amenable to their later treatment as wastes.

vi The approach made at the design stage to aid the ultimate decommissioning of the plant and its facilities. This can be achieved with minimal additional expenditure.

The recent use and expansion of engineered waste posting systems has had a significant effect in reducing the production of plastics and other wastes in those parts of the plant which involve the handling of alpha activity. Automatic liquor sample stations and sample transfer systems have minimised the need for flasking operations and their resulting decontamination together with reduced analytical requirements. Attention to adequate instrumentation and control of in-active and active plant feed inputs, and to provide early indication of out-of-specification waste liquors, could reduce the number of liquor monitoring and hold-up tanks significantly. The use of fluidics for liquor movements, eg to replace steam ejectors, will reduce dilution in liquor streams and the absence of moving parts and minimal maintenance and replacement will assist further in reducing wastes.

CONCLUSIONS

The development, design and construction of an efficient waste management system in support of future commercial reprocessing plants will be conditional on a number of decisions taken during the design stage, many of which will be interdependent and require the examination of alternative options to provide a cost effective solution.

It will be necessary at an early stage in reprocessing plant design to identify a comprehensive waste management strategy taking into account possible disposal scenarios against which the implications of decisions and options can be evaluated. The more important factors to be considered in achieving the objective of an efficient waste management approach in support of fuel reprocessing are:

i The selection of plant and equipment which will minimise waste arisings whilst taking into account reprocessing requirements.

ii The segregation of the various types of wastes at source.

iii The minimising of alpha contaminated wastes.

iv The application of accurate instrumentation to assist in the segregation and categorisation of wastes.

v The effective design and economic utilisation of retrievable engineered storage and waste treatment facilities on site.

vi The implications of disposal on any selected waste treatment process employed.

vii The minimising, as far as practicable, of the quantities of wastes in those categories for which disposal routes are not current available.

viii The use of cost benefit analysis as exemplified in the ALARA principle recommended by the ICRP.

Wastes arising from the reprocessing of irradiated fuels contribute by far the major source of radioactivity within the nuclear fuel cycle. A responsible approach to the design of reprocessing plants and supporting waste management strategy is now being undertaken by those countries involved or embarking on nuclear power. The successful combination of these two areas of technology will be an important factor in demonstrating the acceptability of nuclear power to the public.