Summary Guidance **Project UKRSR07**

Identification and assessment of alternative disposal options for radioactive oilfield wastes

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SNIFFER
SCOTLAND & NORTHERN IRELAND FORUM FOR ENVIRONMENTAL RESEARCH

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INTRODUCTION

This summary contains an overview of the issues discussed in the main project documents. The intended users are probably already well informed in at least some of the issues associated with oilfield NORM and are likely to have access to RPA services and advice on current NORM disposal practice.

The project documents, all of which are available on the SNIFFER website www.sniffer.org.uk, are:

Technical Summary Report: a synthesis of the findings of Phases 1 and 2 (below) plus a discussion of capacity issues. This is the main project reference to read beyond this guidance note.

Phase I Report: NORM origins, occurrence in oil and gas processing and quantification (from a variety of data sources).

Phase II Report: Legislation relevant to NORM disposal, NORM prevention and waste volume reduction, NORM removal techniques, NORM disposal routes and risk ranking of the disposal routes.

These reports should be referred to for further information on any of the issues mentioned in the following summary.

Introduction

Naturally Occurring Radioactive Material (NORM) occurs in small quantities in oil and gas industry wastes and discharges. Its occurrence has been known since the early 1900s in the US and in the UK since the 1970s. For a variety of reasons, there has been a consensus amongst regulatory bodies and government that a review of the available disposal options is now necessary, together with a quantification of NORM arisings from the UKCS and an examination of minimisation, treatment and removal options.

What are the issues?

Significant developments have recently occurred in waste disposal on land, such as the Landfill Directive, which have indirect impacts on radioactive waste disposal. Issues such as decommissioning wastes from nuclear power stations have brought the question of radioactive waste disposal capacity to the fore for all disposers, including so-called “small users” group which includes the oil and gas industry.

In the marine environment, there is an increasing focus on reduction of radioactive discharges to sea and at the same time increasing numbers of platforms are being put forward for decommissioning with potential low level radioactive waste arisings.

Onshore, there are very few outlets for decontamination wastes or for disposal of low-level wastes.

While the amount of NORM solids requiring disposal onshore is relatively small and presents no immediate problem, it is a strategically important issue that could have an impact on the UK oil and gas industry.

Quantification of likely waste arisings is necessary to consider whether there is adequate disposal capacity for these low level radioactive wastes along with other such wastes.

Regulators and industry have combined under the umbrella of SNIFFER to address this issue and identify appropriate and sustainable NORM handling, treatment and disposal techniques.

Terminology

In this summary the naturally occurring nuclides from the decay of ^{238}U and ^{232}Th found in radioactive oil and gas field wastes are referred to as NORM (Naturally Occurring Radioactive Material). Other terms appear in the literature, TENORM (technically enhanced naturally occurring radioactive material) and LSA scale (which refers only to hard mineral scales) being the most common.

Isotopes

Forms of an element that have the same number of protons (atomic number) but differing numbers of neutrons (mass numbers). The same element can have several radioactive and non-radioactive isotopes, which differ in the number of neutrons in the nucleus. These are distinguished by referring to the relative molecular mass or RMM, e.g. lead (Pb) with a RMM of 208 is non-radioactive but lead with a RMM of 210 is radioactive. These are normally labelled ^{208}Pb and ^{210}Pb.

Where the term 'total activity' is used in this report it refers to a calculated activity[1] for radium daughters. The total activity calculation assumes no loss of gaseous radon (radon emanation).

'Elemental activity' refers to the activity of a schedule 1 element[2] used to determine the applicability of RSA (Schedule 1 element limits) and exemption orders. In other EU countries levels are set for individual isotopes and this can lead to confusion in comparison of authorised limits or reported activities between countries.

Where solid NORM arisings are described as exempt and non-exempt in this report this refers to elemental activities of radium and polonium isotopes in relation to the 1962 Radioactive Substances Act (Phosphatic Substances Rare Earths etc.) Exemption Order (PSEO)[2]. Activities below 14.8 Bq/g are classed as exempt.

For liquid wastes there is no exemption order and the Schedule 1 element limits of the Radioactive Substances Act are applied. Radium is the most restrictive element; the limit at which it becomes regulated is 0.00037 Bq/g.

[1] SEPA approved calculation of Total Activity for disposals under RSA 93 (effectively $6x^{226}Ra + 8x^{228}Ra + 3x^{210}Pb$ Bq/g). In practice there is often no analysis available for ^{210}Pb either it is not present or it is recorded as below limit of detection and only the Ra terms are used.

[2] if either $1x\ ^{226}Ra + 2x\ ^{228}Ra$ or $2x^{226}Ra + 1.7 \times\ ^{228}Ra \geq 14.8$ Bq/g the material is not exempt from RSA.

Activity and Dose

Radioactivity can be measured in several ways. The SI unit is the becquerel (Bq), one Bq equals one atomic disintegration per second. Dividing by the mass of the substance (Bq/g) gives the specific activity. Since radioactive elements decay in a predictable way, it is common to measure key radionuclides e.g. total activity for disposals under RSA 93 (effectively $6x^{226}Ra + 8x^{228}Ra + 3x^{210}Pb$ Bq/g). In practice there is often no analysis available for ^{210}Pb either it is not present or it is recorded as below limit of detection and only the Ra terms are used.

The dose received from a radionuclide is dependent on the nature of the radiation and the circumstances of the exposure to it, e.g. whether skin contact, inhalation, etc. It is not possible to generalise on dose from an activity measurement. Dose is measured in sieverts (Sv) where a dose below 10 µSv is considered "trivial" by regulatory authorities. For context the annual average 'background' dose per person in the UK is 2.6 mSv (2,600 µSv).

A full glossary is included in the Technical Summary Report.

OILFIELD NORM AND ITS OCCURRENCE

Naturally occurring radionuclides are present throughout the earth's crust. The main contribution to the radioactivity in oil field NORM is from the decay products of two of the primordial nuclides: uranium-238 (^{238}U) and thorium-232 (^{232}Th) which with their very long half lives date from the formation of the earth. These nuclides are present both in the source rocks from which the hydrocarbons are extracted and in the reservoir rocks from which they are produced. The main nuclide contribution to oilfield NORM waste is from the reservoir formation (Hartog. *et al* 2002).

The relative contribution of radioactivity from the hydrocarbon source rock versus the reservoir rock is subject to discussion but the consensus is that the reservoir makes the major contribution. Some ^{226}Ra and ^{228}Ra will be derived from both but most is likely to be from the reservoir sediments. ^{222}Rn will be transported from the source rock with the hydrocarbons and gas however it has short half life and will decay en route to the reservoir depending on migration distance. Diffusion time through the reservoir will depend on pressure, porosity and temperature. The equilibrium between NORM nuclides in the reservoir is likely to be disturbed by removal of gaseous ^{222}Rn along with liquid hydrocarbons and gas.

Table 1. Summary of the main types of oil and gas industry NORM

Type	Nuclides	Characteristics	Occurrence
LSA scales	^{226}Ra, ^{228} Ra and decay products	Hard deposits of , barium, strontium sulphates plus much lower activity carbonates	Wet parts of oil production installations; well completions, water treatment plant
LSA sludge/sand	^{226}Ra, ^{228} Ra and decay products	Sands, heavy metals, waxes, sludges	Separators, skimmer tanks Water treatment equipment and water/product storage vessels
LSA films	^{226}Ra, ^{228} Ra ^{210} Pb and decay products	Thin films, thin scale deposits	Wet parts of gas production and processing installations; well completions
Gas deposits	^{210}Pb and decay products	Very thin films	gas treatment and processing, condensate/LNG plant and transport
Gas deposits	^{210}Pb and decay products	Black sludges containing ^{222}Rn daughters (^{210}Pb and ^{210}Po)	Storage vessels, filters, sediment traps
Natural gas	^{222}Rn	Noble gas	Throughout production and distribution network
Produced water (in solution and as fine particulates)	^{226}Ra, ^{228}Ra and /or ^{210}Pb	Differing degree of salinity, large volumes in oil production, less in gas production	Ubiquitous in production facilities. Low activity but very large volumes

Estimates of current UK NORM arisings have been prepared and are summarised in the table below. For a more detailed analysis refer to the Phase1 report.

The total activity discharged in produced water is relatively high due to the volumes produced.

The largest arising of solid NORM occurs through offshore decontamination, either through routine cleanout and descaling operations or from decommissioning. Terminal vessel sludges and pigging waxes account for the bulk of NORM solids dealt with onshore.

Onshore equipment decontamination accounts for a small fraction of the total activity and volume of solids discharged to sea.

The masses of solids from decommissioning are small in comparison to offshore decontamination. In all of the cases reviewed the actual amount of NORM solids disposed of from decommissioning has been significantly lower than original predictions.

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Table 2 - Estimated current annual arisings of NORM from the UK oil and gas industry

Description of NORM (report section reference**)**	**Total Activity GBq**	**Amount of material**	**Relative confidence in source data**
Produced water to sea	9840	282 Mm^3	Medium
Reinjection	278	7.5 Mm^3	Medium
Offshore decontamination	23	1,300 t	Medium
Workovers	4	35 t	Low
Platform decommissioning (offshore)	1.5	15 t	Low
Platform decommissioning (to onshore)	0.2	1.8 t	Low
Pipeline decommissioning (to onshore)	<14.8 Bq/g Ra >14.8 Bq/g Ra	0.2 t 3.8 t	Medium
Onshore decontamination	9.5	36 t (in suspension)	High
In water to terminals	12	220,000 m^3	Medium
Terminal decontamination	6	500 t	Low
Produced water discharged at terminal (by deduction)	6	220,000 m^3	Low
In product	No data		

*Exempt/non- exempt from the disposal requirements of the Radioactive Substances Act

LEGISLATION AND POLICY OVERVIEW

The Radioactive Substances Act 1993 (RSA)

The keeping of radioactive materials and the accumulation and disposal of radioactive waste is regulated in the UK under RSA 93 and permitted under authorisation from the Scottish Environment Protection Agency (in Scotland), the Environment Agency (in England and Wales) and the Environment and Heritage Service (in Northern Ireland) who are the competent authorities in the UK. They are responsible for the regulation of radioactivity both onshore and offshore. Where applicable, Southern North Sea facilities, Liverpool Bay and Morecambe Bay facilities are currently regulated by the EA and all other UKCS facilities are regulated by SEPA.

For naturally occurring radionuclides a substance is radioactive if it contains radionuclides with elemental activities above levels given in Schedule 1 of RSA. For oilfield NORM the Schedule 1 elements of most concern are radium, polonium or lead. There are different Schedule 1 limits for solids, liquids and gases (Table 3).

Exemptions from RSA

RSA defines whether a substance is deemed radioactive. Several exemption orders exist, which exempt some radioactive wastes, including those containing naturally occurring radionuclides, from the disposal requirements of RSA. For oilfield NORM, the most important of these is The Radioactive Substances (Phosphatic Substances, Rare Earths, etc.) Exemption Order 1962. This effectively exempts a significant amount of solid oilfield NORM with elemental activities of radium and polonium below 14.8 Bq/g. Exempt radioactive wastes do not have to be reported and do not require an authorisation under RSA, but remain classed as 'radioactive'.

Table 3. Schedule 1 elemental activity limits

Element	Activity (Bq/g)		
	Solid	Liquid	Gas
Actinium	0.37	$7.4x10^{-2}$	$2.59x10^{-6}$
Lead	0.74	$3.7x10^{-3}$	$1.11x10^{-4}$
Polonium	0.37	$2.59x10^{-2}$	$2.22x10^{-4}$
Protactinium	0.37	$3.33X10^{-2}$	$1.11x10^{-6}$
Radium	0.37	$3.7X10^{-4}$	$3.7x10^{-5}$
Radon	-	-	$3.7x10^{-2}$
Thorium	2.59	$3.7X10^{-2}$	$2.22x10^{-5}$
Uranium	11.1	0.74X10	$7.4x10^{-5}$

Oilfield NORM wastes as part of UK radioactive waste

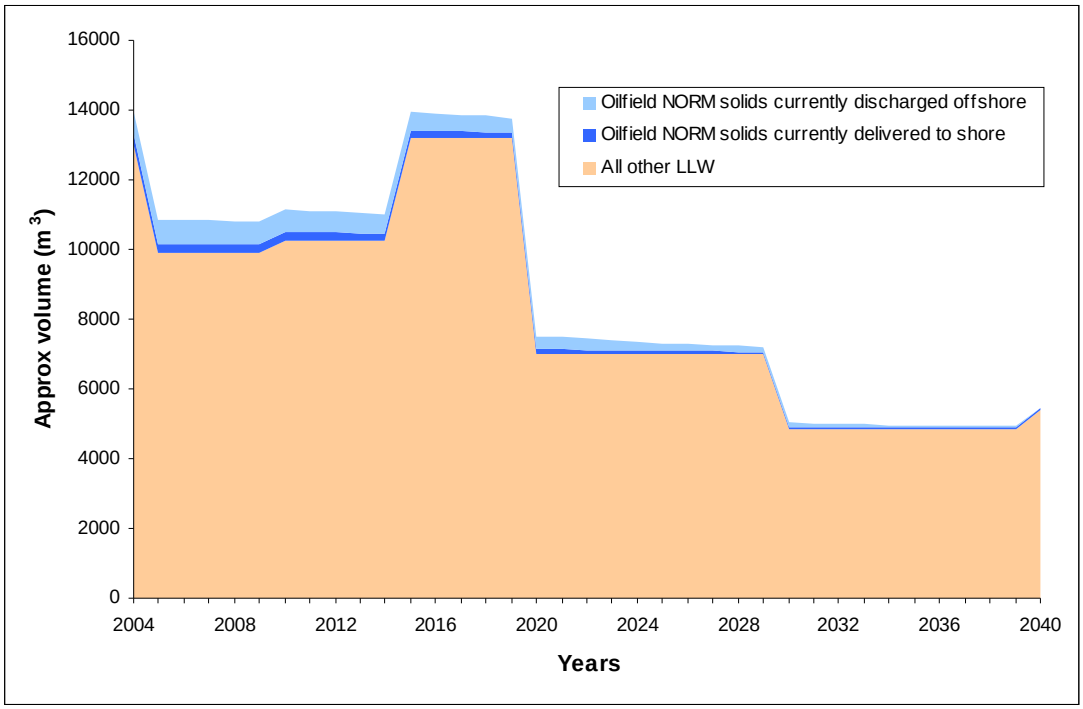
Table 4 below shows categories of radioactive waste. Oilfield NORM wastes fall into the low level waste (LLW) category and may be exempt or non-exempt dependent on specific activity.

Oilfield NORM wastes form a small fraction of the total LLW arisings for the UK (Figure 1), even when offshore discharges are included.

Table 4. Categories of radioactive waste.

Category	Definition	Application to NORM waste
"Radioactive"	Defined by the activity from Schedule 1 elements.	*e.g.* >0.37 Bq/g radium in NORM.
VLLW	"dustbin disposal" may be disposed of with ordinary refuse as long as each 0.1m^{-3} contains less than 400 kBq of beta/gamma activity in a single item containing less than 40kBq activity beta/gamma	Not normally accepted as a route for alpha emitters such as oilfield NORM
LLW	Wastes other than those suitable for disposal with ordinary refuse but not exceeding 4GBq/tonne (4,000 Bq/g) for alpha and 12GBq/tonne for beta and gamma (12,000 Bq/g)	All NORM falls into this general category but may be exempt or non exempt under RSA 93 as described above
ILW	Wastes exceeding the upper boundaries for LLW but which do not need heat to be taken into account in the design of storage facilities	Not applicable to NORM
HLW	Wastes in which the temperature may rise significantly as a result of their radioactivity.	Not applicable to NORM
Radioactive and exempt	Radioactive but with elemental activities lower than those specified in The Phosphatic Substances and Rare Earths etc. Exemption Order	e.g. 0.37Bq/g -14.8 Bq/g radium in NORM
Radioactive and non-exempt	Radioactive and with an activity concentration greater than the limit in the relevant exemption order	e.g. over 14.8 Bq/g radium in NORM

Figure 1 Relative contribution of oilfield wastes to UK LLW arisings



Source: DEFRA (2002a) and Phase 1 of this study

Waste legislation

Radioactive waste is exempt from the Waste Framework Directive and daughter Directives such as the Landfill Directive, and so 'normal' requirements relating to waste (e.g. Duty of Care) do not apply. An exception is where waste is 'hazardous' e.g. if it is oily (normally >0.1% oil), when it must be treated as if it was also a hazardous waste.

Exempt radioactive waste can be disposed of to landfill without authorisation according to its non-radioactive properties (inert, non-hazardous or hazardous).

Key guidance and policy documents

Table 5 summarises the main legislation and policy that is applicable to NORM disposal. Further sources of information are given at the end of the document.

International policy

International policy is based on the minimisation of exposure risk to the public and specific activity limits are not set. The International Atomic Energy Authority (IAEA) has published International Basic Safety Standards for Protection Against Ionising Radiation and for the Safety of Radiation Sources (IAEA, 1996). This recommends a limit of one millisievert per year (1 mSv/yr), above background for the general population, for average doses received by a critical group as a result of practices involving radioactive materials.

The International Commission on Radiological Protection (ICRP) recommends a maximum dose of 1 mSv/year over background and 100mSv over 5 years for radiation workers with a maximum of 50mSv in any one year or a basic 20 mSv per year.

The Euratom Council Directive 96/29 was adopted by the Council of the European Union in 1996. The Directive sets out the

basic safety standards and EU member states were obliged to implement the directive in their legislation by May 2000. The Euratom BSS applies to all practises involving a risk from ionising radiation such as handling and treatment of NORM.

OSPAR and EU policy

The UK is a signatory to OSPAR (www.ospar.org), which sets out agreements and targets relating to the protection of the North Sea and North East Atlantic. Under OSPAR, discharges to the sea of NORM from oil and gas platforms are permitted.

OSPAR's Radioactive Substances Strategy (2003) and Objective 6 of the EU Marine Strategy (2002) are very similar and are in accord with the UK's strategy (DEFRA, 2002b). In summary, by the year 2020 the aim is to ensure that discharges, emissions and losses of radioactive substances are reduced to levels where the additional concentrations in the marine environment above historic levels are close to zero. In practice, the UK expects to deliver this by the continuing application of Best Practicable Means to all radioactive discharges.

Exporting waste

Exporting radioactive waste is permitted providing the receiving country can manage and dispose of the waste adequately. Government policy is, however, that this is not preferred and the proximity principle must be considered. Any export option would require authorisation by the regulator as required by the Transfrontier Shipment Regulations (Table 5).

Table 5. Summary of legislation which may be relevant to NORM disposal

Legislation	Description (regulator)
Radioactive Substances Act 1993	Legislation controlling the keeping and use of radioactive materials and the accumulation and disposal of radioactive waste. (SEPA/EA)
Exemption orders under RSA 93 including: • Substances of Low activity, SI no. 1002, 1986 and amendment SI No. 647, 1992 • Phosphatic Substances Rare Earths, etc. SI 2648, 1962	Statutory instruments that exclude some materials, activities and premises from certain provisions of RSA 93. Of relevance to NORM /LSA disposals and wastes. (SEPA/EA)
Euratom Basic Safety Standards Directive 96/29 13 May 1996	Basic radiological protection criteria and definitions accepted by the UK. Most if its provisions are addressed in the Ionising Radiations Regulations 1999 (below), RSA 93 and related legislation.
The Ionising Radiations Regulations (IRR 99) SI 1999/3232	The principal safety legislation controlling work with radiation and radioactive materials. (HSE)
The Radioactive Materials (Road Transport) Regulations 2002	Includes definitions of how materials (including wastes) must be packed and labelled for transport and what paperwork must accompany consignments
TS-R 1 (ST1 revised) 2001 IAEA Safety Standard	IAEA requirements for the safe transport of radioactive materials
The Transfrontier Shipment of Radioactive Waste Regulations 1993	Implements Council Directive 92/3/Euratom on the supervision and control of shipments of radioactive waste between Member States and into and out of the Community
The Special Waste Regulations 1996 SI 972	Conditions by which a radioactive waste may also be a special waste, and conditions for handling

MINIMISING THE PRODUCTION OF NORM

In its strictest sense, NORM prevention refers to limiting the migration of radionuclides out of the reservoir. However, there is no reliable, reported means of achieving this and NORM from the reservoir will be produced along with the fluids in which it is present. NORM can be, at least partially, prevented from depositing in production and processing equipment by judicious use of chemical scale inhibitors and by removal of sulphate from seawater used for injection (refer to Phase 2 report)

NORM waste reduction may involve one or both of the following:

- Volume reduction of amount of waste at source.
- Volume reduction by treatment after production.

The first is the ideal situation but often not practicable in oil and gas installations. Although these methods reduce the volume of LLW, they still require an authorised disposal route and do not alter the activity present.

Basic waste reduction processes such as physical segregation of NORM wastes can achieve high volume reductions in primary (solid NORM) and secondary NORM wastes (contaminated equipment, PPE, containers) produced offshore and are normally incorporated in operator waste management plans.

Waste reduction of solid NORM arisings is not routinely carried out on the UKCS as most NORM is discharged to sea.

There are some chemical waste reduction methods at different stages of development but none are currently in use on UKCS. There are some novel methods at the pilot stage particularly waste reduction by chemical concentration.

In the UK supercompaction is used to reduce volumes of waste to be disposed of e.g. at Drigg (see p13). This is essentially the compaction of wastes within sealed steel drums using a large hydraulic press. This is a very effective method for items such as PPE, contaminated packaging etc. but is not suited to scrap steel or wastes that consist predominantly of minerals or that are oily. Wastes must be dry and oil-free before supercompaction.

Waste reduction techniques from other NORM industries may also be of use for oilfield NORM wastes. Most are neither expensive nor complex and are tried and tested technologies. They result in a small volume of LLW still requiring disposal with the bulk of the waste no longer radioactive as defined by RSA and therefore suitable for conventional disposal routes.

Prevention, minimisation and treatment options

Prevention and minimisation are the first steps in the waste hierarchy.

Of the NORM prevention methods, the only method widely used on the UKCS is chemical scale inhibition and to a lesser extent sulphate removal from injection water. NORM removal onshore and offshore is predominantly by mechanical means, mainly water jetting (with and without abrasives).

Based on data from operators, waste contractors, vendors and published data, the following options were identified and evaluated (refer to the Phase 2 report for more details).

Table. 6 Summary of NORM prevention, minimisation, removal and waste reduction options

	Status of techniques	Effectiveness
Prevention		
Downhole removal of NORM nuclides in the reservoir	Development	Not proven
Downhole oil water separation (DOWS)	Commercial	Not proven as NORM prevention method
Preventing and minimising NORM solids		
Scale inhibitors	Commercial	Good
Sulphate removal	Commercial	Good
Electrochemical	Development - Commercial	Selectively good
Engineering solutions	Commercial	Good/Fair
Removing NORM from produced water	Commercial	Not proven
Magnetic prevention	Trialled/commercial	Not proven
Removing NORM deposits		
In situ chemical dissolution	Commercial	Limited
In situ mechanical removal of scale	Commercial	Good
Offshore NORM removal from opened/dismantled equipment	Commercial	Good
Chemical decontamination	Commercial	Selectively good
Acoustic removal	Laboratory	Not proven
Microbial scale removal	Laboratory	Not proven
Liquid nitrogen	Laboratory	Not proven
Percussive removal	Trialled	Good
NORM waste reduction		
Chemical segregation/dissolution and separation	Development	Selectively good
Selective nuclide removal - ion exchange media	Development	Selectively good
Waste segregation/dewatering	Commercial	Good

DISPOSAL OPTIONS

Despite NORM prevention and reduction measures the majority of UKCS oil and gas production facilities have or will have NORM waste arisings.

The table below lists potential UKCS NORM disposal options. Note that not all of these are currently available for legislative and or development reasons. (refer to the following notes and to the Phase 2 Technical Report for details)

Some general points on these disposal options are included below however for detailed information on the options refer to the Phase 2 report.

None of the offshore disposal options present a significant dose risk to the public. Onshore disposal by landspreading or to sewer are unlikely to be considered suitable for NORM disposal in the UK.

Table 7 List of disposal options considered

Offshore*	Sea disposal offshore discharge
	Sea disposal nearshore discharge
	Re-injection of dissolved NORM
	Re-injection of solid NORM slurry
	In situ downhole abandonment
	Encapsulation and downhole disposal
Onshore	Onshore built disposal facility
	Onshore landfill
	Landspreading
	Smelting
	Incineration
	Disused mineworkings
	Disposal in salt caverns
	Sewer
Export	Export to any of the options above in a foreign country

- Reinjection may also occur onshore but this is of minor application in the UKCS to date

Offshore disposal

Once radioactive waste has been identified in a facility the most logical approach is to dispose of it as near to source as possible, avoiding transportation and public (involuntary) and workplace (voluntary) exposure risk.

Figure 2 illustrates the available disposal options.

Sea disposal via an offshore discharge

This is the current disposal method for solid NORM waste offshore UKCS.

With the exception of reinjection, this option has the lowest dose to the public. In spite of this, the discharge of alpha emitters from oilfields into the sea has become a reputational issue in some quarters. Sea discharge in the long term (2020) may need to be curtailed to meet UK policy aspirations, although by this time discharges will have reduced markedly as facilities are decommissioned.

Sea disposal via a nearshore discharge

This is the current route for arisings from onshore cleaning of NORM contaminated equipment. Currently there is only one onshore decontamination facility (security of supply risk) although it may be relatively straightforward to permit new discharges e.g. from terminals.

Re-injection

Re-injection offshore to the deep subsurface has distinct advantages over all the other options due to degree of isolation and minimisation of handling and transportation. Significant investment is required, however, unless cuttings re-injection equipment is already present, and the reinjection brings increased fuel use and atmospheric pollution. Centralised reinjection has attractions but the legal basis would need affirmation.

In situ downhole abandonment

This refers to leaving decommissioned equipment inside a well on abandonment, i.e. is very narrow in scope. This presents a high degree of isolation and no exposure risk. It occurs at present, being in line with the UKOOA Well Abandonment Guidelines.

Encapsulation and downhole disposal

This refers to NORM being sealed inside canisters or tubulars and placed within redundant wells. This presents a high degree of isolation but the legality of depositing containers would require confirmation. This is possibly useful for disposing of contaminated tubulars avoiding the exposures associated with decontamination.

Onshore disposal

Figure 2 illustrates the available disposal options.

Onshore built disposal facility

'Disposal facilities' specifically for radioactive waste must be licensed under RSA and are not 'landfills'. Some onshore disposal facility capacity is essential for non-exempt NORM that cannot be disposed of elsewhere (e.g. at present, some onshore arisings from decommissioning).

The only national facility for radioactive waste disposal is at Drigg, Cumbria. While this has accepted oilfield NORM in the past, there are many demands on its limited capacity for radium-containing wastes and no guarantees on what it will be able to accept in future.

Several contractors have interest or plans but are reluctant to invest without some guarantee of revenue. It is widely held

that new radioactive waste disposal facilities would have difficulty gaining public acceptance, and the volume of oilfield NORM arisings brought onshore militate against construction of an oilfield-only facility.

Onshore landfill

This splits into two issues, one for 'exempt' wastes, and one for 'non-exempt' wastes.

Exempt NORM waste may continue to go to conventional landfills according to its non-radioactive properties and this is an important route e.g. for occasional large volumes of terminal wastes.

Non-exempt wastes can be deposited in landfills under authorisation via 'special precautions burial', but this appears to be a diminishing practice. In any case, there are no sites that receive non-exempt LLW in Scotland, few in England and Wales and limited interest from waste contractors due to the controversial nature of the waste.

The proximity principle (minimal transport) and differences in regulation north and south of the border are arguments for a greater number of sites, but this is ultimately a matter for the open market.

Doses to the public from landfill disposals are uncertain although they may well be trivial subject to a proper assessment.

Smelting

Smelting is a potential outlet for used tubulars with the NORM being transferred to the slag in the process, but it is not suited to loose NORM. The doses are higher than some other options although probably still trivial.

Incineration

Practically, incineration is limited to contaminated PPE and potentially small amounts of oily wastes, and there is very little capacity in the UK.

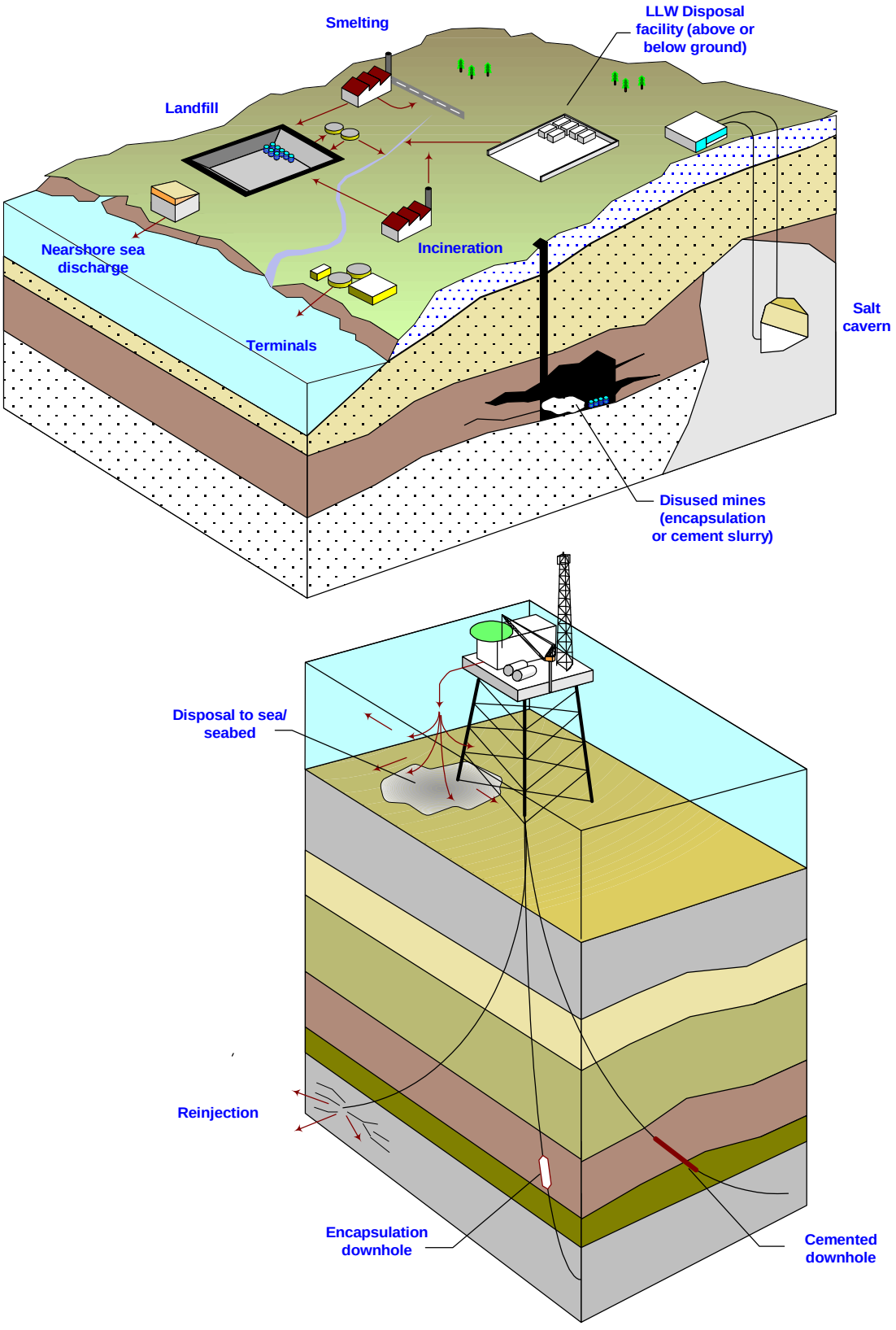
Disused mine disposal

Disposal of radioactive waste into disused mines is a method used in some other NORM industries and there is the potential to combine oilfield NORM with, for example, the disposal of pulverised fuel ash. Containment may, however, be difficult to guarantee and the route may be associated perceptually with other polluting minewater discharges. This is a possible, but unlikely, route for oilfield NORM.

Disposal in salt caverns

Salt caverns, i.e. voids within a large underground salt deposit that are effectively sealed, are used in many countries for the disposal of a variety of wastes including NORM (USA) wastes or the storage of gas. It is possible to demonstrate good containment and potential sites have been investigated in the UK. There may be technical and licensing challenges, however, so a long lead-in time could be expected for any such option.

Figure 2. Illustration of NORM disposal options



CAPACITY

A key capacity issue is the disposal of solid non-exempt LLW onshore. There are no landfills in Scotland, and very few in England and Wales, that accept non-exempt LLW. There is no guarantee as to the amount of oilfield LLW, if any, that Drigg will accept into the future, although it has been accepted in the past as a last resort. This material routinely arises onshore, from terminals and, in smaller quantities, from decommissioning.

With this qualification, there is sufficient capacity in the current disposal routes for "business as usual", but should there be a change in regulation, for example a reduction (or ban) on permitted offshore disposal, there could be a serious problem in accommodating all the solid waste currently discharged offshore to a UK onshore disposal facility. This is more of a concern as the number of oil and gas production facilities requiring decommissioning with accompanying disposal of any attached NORM wastes is set to increase in the next few years.

Capacity is dependent on disposal routes being, and continuing to be, authorised. Any disposal of non-exempt radioactive waste can only be carried out under RSA authorisation. Such disposals are therefore subject to regulatory policy for radioactive waste disposal, which continues to be under review at a UK level and a SEPA/EA level. Further, some options discussed here have never before, or never recently, been authorised and it cannot be stated whether authorisation would be forthcoming in a particular case. None of the options listed above are ruled out, however, by current radioactive waste legislation and policy. It is therefore for operators to discuss disposal options with the regulator in all cases.

The main capacity issues are:

1. Short-term capacity issues are in the disposal of NORM brought onshore. Longer-term issues are in the disposal of NORM to sea.
2. The capacity for oilfield NORM at the Drigg disposal facility is uncertain.
3. Landfill capacity for non-exempt LLW is currently zero in Scotland and very small in England and Wales.
4. Onshore decontamination has sufficient capacity under current arrangements but is effectively limited to one discharge point.
5. Incineration capacity in the UK is very small, although this is not a route much used by the oil and gas industry.
6. New facilities may be authorised to deal with NORM brought onshore although consent processes may be extensive, both in time and cost, to take public consultation into account.
7. Export options appear available under the existing legislation but would require approval on a case by case basis from the regulators. Export routes would also require justification with respect to the proximity principle.

INFORMATION SOURCES

The following are sources of information on NORM handling and disposal in the UK are a starting point for anyone with a NORM issue. It is assumed that users of this document are likely to be oil company employees, offshore cleaning and waste contractors who are likely to already have RPA services providers appointed.

Regulators

Scottish Environment Protection Agency: www.sepa.org.uk
Offshore NORM disposal: 01224 248338, advice, issuing of storage and disposal authorisations under RSA.

Environment Agencyfor general advice www.environment-agency.gov.uk
It will be necessary to contact the local EA specialist advisor for advice on individual disposals.

CoRWM Committee for Radioactive Waste Management

Radiation safety and protection.

- National Radiological Protection Board NRPB. www.nrpb.org.uk
- HSE general information www.hse.gov.uk/radiation;
  link here to HSE infoline , for policy: ionising.radiation@hse.gsi.gov.uk
- Radiation Protection Advisor services to the oil industry are commonly provided by:
  - Tracerco
  - Aberdeen Radiation Protection Services
- Society for Radiological Protection www.srp-uk.org

General

There are extensive references in the Phase I, Phase II and Technical Summary Reports.

REFERENCES

- DEFRA (2002a) The 2001 United Kingdom Radioactive Waste Inventory Main Report DEFRA Report DEFRA/RAS/02.004 Nirex Report N/042NIREX (2003)
- DEFRA (2002b) UK strategy for radioactive discharges 2001–2020
- EU (2002) COM(2002) 539 Final Communication from the Commission to the Council and the European Parliament - Towards a strategy to protect and conserve the marine environment
- IAEA (1999) Basic Safety Standards
- OSPAR (2003) Radioactive Substances Strategy
- SNIFFER (2004) UKRSR07 Identification and assessment of alternative disposal options for radioactive oilfield wastes. Phase I - NORM Origins and quantification.
- SNIFFER (2004) UKRSR07 Identification and assessment of alternative disposal options for radioactive oilfield wastes. Phase II - Minimisation and disposal options.
- SNIFFER (2005) UKRSR07 Identification and assessment of alternative disposal options for radioactive oilfield wastes. Technical Summary Report.