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DOUNREAY

The Dounreay Nuclear Power Development Establishment, situated near Thurso, Caithness, was established in 1955 primarily to pursue the UK Government policy objective of developing fast breeder reactor technology. It was located on a remote Second World War airfield partly for safety reasons as new technology was to be used. Today the only operating reactor on the site is at the Ministry of Defence Vulcan Nuclear Reactor Training Establishment (VNRTE), which shares emergency facilities with the United Kingdom Atomic Energy Authority (UKAEA), but is separate in all other regards.

Nuclear power stations

Electricity is produced from nuclear power stations in much the same way as it is in conventional power stations. The difference is in how the steam that drives the turbines is produced. In conventional plants, fuel (e.g. gas, coal) is burnt to produce heat in order to convert water to steam. In nuclear plants the heat needed is produced from nuclear reactions within a reactor.

Fast reactor technology

The fuel most commonly used in nuclear reactors is uranium. Natural uranium consists primarily of two different isotopes: uranium-238 and uranium-235. Only uranium-235 can be used as a nuclear fuel, but in conventional thermal reactors uranium-238 can be transformed into plutonium-239, which itself can be used as nuclear fuel.

Fast breeder reactors can convert uranium-238 into plutonium-239 at a rate faster than they consume their original fuel. This means that in theory, with multiple recycling of fuel, fast reactors could extend the energy output from the world's uranium fuel reserves 25 fold.[1]

Fast breeder technology, with its associated increases in fuel efficiency, was considered a solution to the UK's future energy needs in the 1950s.

End of the fast reactor programme

Fast breeder technology at Dounreay seems to have been undermined by a number of factors. In 1988 the Government announced that funding was being withdrawn from the fast reactor programme as it was not going to live up to its economic potential. In June 1998 Donald Dewar, then Secretary of State for Scotland, and John Battle, then Energy Minister at the DTI, made a joint statement indicating that whilst the technology had been useful in the development of the nuclear industry, it was the case that:

> "there is no economic case for supporting commercial reprocessing at Dounreay over the longer term."[2]

It seems likely that the decision to halt the fast breeder programme and decommissioning was based not only on economic considerations but also on the fact that there were safety concerns over Dounreay's condition and activities, making the site politically sensitive.

The decommissioning decision is that Dounreay will accept no more commercial reprocessing contracts other than those where legally binding contracts already exist. The work involving these contracts is expected to cease in 2006.

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1 http://www.jnc.go.jp/zmonju/mjweb/fast.htm
2 www.scotland .gov.uk/news/releas98_1/pr1168.htm

THE DOUNREAY SITE

Dounreay's reactors

Three reactors were operated on the civilian site at Dounreay over a period from 1958 to 1994. These reactors are all now closed and they, together with the supporting laboratories and fuel processing areas, are in various stages of decommissioning.

Date	Event
1958	Dounreay Materials Testing Reactor (DMTR) comes online
1959	Dounreay Fast Reactor (DFR) comes online
1969	DMTR ceases operation
1974	Prototype Fast Reactor (PFR) online
1977	DFR ceases operation
1994	PFR ceases operation

The Prototype Fast Reactor (PFR) and Dounreay Fast Reactor (DFR) are undergoing stage 1 decommissioning whilst the Dounreay Materials Test Reactor (DMTR) having already undergone stage 1 decommissioning, is under a care and maintenance regime.

Essentially, the stages of decommissioning are[3]:

- Stage 1 - remove fuel, coolant and non-fixed items of plant from the site; prepare the facility for a period of care and maintenance if required;
- Stage 2 - dismantle and remove most of the remaining radioactive material; prepare the facility for a further period of care and maintenance and possible restricted use of the site;
- Stage 3 - return site to a condition where no significant radioactive hazard remains; release site for unrestricted use.

Radioactive Waste

Radioactive waste is categorised as Low Level Waste (LLW), Intermediate Level Waste (ILW) or High Level Waste (HLW). The vast majority (by volume) of radioactive waste produced at Dounreay (as at other nuclear power stations) is LLW. Although HLW is produced in small amounts, it is many thousands of times more radioactive.

Radioactive waste originates either as operational waste, that is it arises from day to day operation of a nuclear power plant, or as decommissioning waste, which tends to be bulkier items of machinery and equipment. HLW, which is essentially

[3] UKAEA Website, www.ukaea.org.uk/stages/d1.htm

waste products produced from reprocessing spent nuclear fuel, does not occur during the decommissioning phase.

The recently published Dounreay Site Restoration Plan identifies where and how future waste streams will develop[4]

- **Low level waste** pits at Dounreay are the current disposal facility for LLW but these are almost full. A possible solution is the construction of a further LLW facility - the Plan does envisage that some LLW will remain on the site, necessitating a care and maintenance regime in some areas of some 300 years.

- UKAEA's Plan assumes that a national repository **for Intermediate Level Wastes** will be available within the next 40 years. If this is the case ILW from Dounreay will be transferred there as soon as possible - until then ILW will be stored on site to current Nirex standards. The proposed new storage facilities are designed for a life of 100 years.

- Again the assumption is that a national **High Level Waste repository** will be constructed although it is acknowledged that this may not be within the timescale of the Dounreay decommissioning Plan. If this is the case, transportation of HLW to storage elsewhere will be examined to allow the site to close. According to the DTI document 'UK Civil Nuclear Policy including Plutonium', "current UK Government policy is that vitrified *(that is, made into a glassy substance)* HLW should be stored *(probably at Sellafield)* for at least 50 years to allow for cooling, followed by disposal in a deep geological repository."

Nuclear Material

Nuclear fuel, both unused and spent, is classified under current Government policy as material and not as waste. Dounreay's inventory[5] of fuels and fissile materials amounts to 109 tonnes. The majority of this is natural or depleted uranium which will be dealt with off site by other waste strategies. 92% of the fuel in the inventory is already in storage at Dounreay, but the facility is committed to take quantities of fuel (which accounts for the other 8% in the inventory) from other sites under contracts signed before the announcement that Dounreay would undertake no more reprocessing work.

Of the nuclear material at Dounreay, that which is of most concern and has the greatest technological challenges is that originating from the Prototype Fast Reactor (PFR). The difficulties involved are due to the greater quantities of plutonium contained in the fuel this reactor used. There are 24.7 tonnes of

[4] UKAEA, Dounreay Site Restoration Plan - Volume 4

[5] UKAEA - Making the Right Choice: Options for Managing the Fuel from Dounreay's Prototype Fast Reactor, Annex 1, April 2000

plutonium-bearing PFR fuel in storage, with options for its disposal/storage discussed in the consultation document 'Making the Right Choice - Options for Managing the Fuel from Dounreay's Prototype Fast Reactor'. The three options are:

1. The Dounreay Strategy - this would involve both irradiated (has been used in the reactor) and unirradiated PFR fuels being reprocessed at Dounreay. Design and installation of equipment for this would take 6 years, followed by an operating timescale of between 3 and 8 years.
2. Hybrid Strategy - irradiated PFR fuel would be reprocessed at Sellafield with unirradiated fuels being reprocessed at Dounreay.
3. Minimum Treatment Strategy - under this option all irradiated and unirradiated PFR fuel would be stored in purpose built storage facilities at Dounreay. The end point for this fuel would depend on Government policy on the management of high level radioactive substances.

RESPONSIBILITY AND REGULATION

United Kingdom Atomic Energy Authority (UKAEA)

Owned by the Government, with control from the DTI, UKAEA's main business is the safe environmental restoration of its nuclear sites. This work involves:

- Decommissioning redundant facilities;
- Managing the resulting waste in a safe and environmentally responsible way;
- Progressive de-licensing of decontaminated areas of sites; and
- Wherever possible, promoting alternative uses for the sites.[6]

Dounreay is the most complex and challenging of UKAEA's 5 sites.

Ministerial Accountabilities

An assessment of Ministerial accountabilities in the area of Nuclear Safety is available on the DTI website.[7]

Under Section D4 of the Scotland Act 1998, the Scottish Ministers have responsibility for Part I of the Environmental Protection Act 1990 (most of which has been repealed under the Pollution Prevention and Control Act 1999) and the Radioactive Substances Act 1993. These controls are exercised through SEPA.

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6 DTI website - UKAEA Quinqennial Review
7 http://www.dti.gov.uk/energy/nuclearsafety.htm

SEPA

SEPA has responsibility for radioactive waste that has an authorised route for disposal, but not for that which has no route for disposal and is in on-site storage. SEPA has no statutory powers over the storage of nuclear material at nuclear licensed sites (of which Dounreay is one).

Health and Safety Executive (HSE) / Nuclear Installations Inspectorate (NII)

The NII, a department of the HSE, (which itself operates under the remit of the DTI), has regulatory responsibility for radioactive waste which is to be stored and has no authorised route for disposal. The DTI are also responsible for co-ordinating nuclear emergency plans and for UK involvement in international nuclear work.

Memorandum of Understanding (MoU) between HSE and SEPA

This MoU, which was originally drawn up between HSE and HMIPI, is designed to give clarity of responsibility in any grey area that may arise between the remits of SEPA and NII as regards radioactive waste. Government policy is to avoid areas of dual regulation in the nuclear industry, and this MoU establishes an administrative (that is not statutory) agreement between the two organisations which allows NII to take the lead but only after consulting, and allowing input from, SEPA. This MoU is currently undergoing redrafting.

The House of Lords Select Committee on Science and Technology's report on Nuclear Waste Management in the UK indicated that this administrative arrangement, of which a similar agreement exists between NII and the Environment Agency, could be made a statutory requirement. The Government is unlikely to comment on this possibility until the forthcoming Nuclear Waste Management Consultation is complete. This is likely to be published in the near future.

National Radiological Protection Board (NRPB)

The functions of the NRPB are, amongst other things, "to provide information and advice to persons (including Government Departments) with responsibilities in the United Kingdom in relation to the protection from radiation hazards of the community"[8].

In 1998, in a joint venture with SEPA, NRPB reported on Fragments of Irradiated Nuclear Fuel in the Dounreay Local Environment.

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[8] NRPB website, www.nrpb.org.uk

RADIOLOGICAL PROTECTION

Dounreay Waste Shaft

The Shaft was originally excavated in 1956 to facilitate the removal of spoil during the construction of a liquid effluent sea discharge tunnel. The Shaft is almost 5 metres in diameter and 65m deep. At its base is a 33m long horizontal tunnel that connects to the effluent discharge tunnel - this connection tunnel is plugged 20m from the shaft by a 2.4m thick concrete plug. Because the tunnel is unlined (apart from the top few metres) it behaves like a well and is full of fresh water.

Solid ILW was disposed of in the Shaft between 1959 and 1971, after which time a purpose built Wet Silo came into operation. Items too large for the Silo continued to be disposed of in the Shaft until 1977 when an explosion occurred in the air space above the water column, damaging the cover of the Shaft. The cause of this explosion is thought to have been a reaction between sodium contaminated materials, and water.

HSE and SEPA indicate that:[9]

> *"There is some uncertainty over the contents of the Shaft but it is believed to contain contaminated equipment, chemicals, natural uranium fuel, radioactive sources, incinerator ash, filters, gloveboxes, building materials, sludges, clothing etc. These disposals took place in accordance with an authorisation made under the Atomic Energy Act 1954 (Ref 29) and subsequently the Radioactive Substances Act 1960 (Ref 25). The authorisation requires that water be pumped from the Shaft so that the water level does not rise above sea level, the intention being that groundwater flow will be towards rather than away from the Shaft. There is approximately 700m^3 of waste in the shaft and this is covered by an 8m depth of water."*

The groundwater criteria are especially important as only the top 10m of the shaft are lined.

UKAEA has investigated a few options for dealing with the Waste Shaft in the past. These included immobilising the waste in-situ, based on studies showing that coastal erosion would not affect the integrity of the Shaft for between 250-400 years, in which time coastal defences could be constructed.[10] This has been deemed as an inappropriate course of action. The Dounreay Site Restoration Plan indicates that UKAEA policy is now to remove material from the Shaft[11] following

[9] Safety Audit of Dounreay 1998, HSE & SEPA, para 507,508
[10] www.ukaea.org.uk/public/balance.htm
[11] www.ukaea.org.uk/oindex.htm

which it will be conditioned in an ILW Waste Treatment Plant and stored on site, pending the availability of a national long term radioactive waste strategy. The Shaft work (which also includes dealing with waste from the Wet Silo) has now been advertised in the Official Journal of the EU. Eighty companies have expressed an interest and their submissions are being analysed at present.[12]

Three possible routes for this complex engineering task exist:[13]

1. Freeze the rock surrounding the Shaft, together with the waste in the Shaft, and mill out the waste and some of the rock as slurry. This would be the simplest and quickest option but carries significant health and safety risks related to servicing machinery in a radioactive environment.
2. Wet retrieval - this involves keeping the water regime as it is, and retrieving waste from the shaft using robotic means. This would involve 'clear water lens technology' which uses streams of clean water to allow remote operators of robotic equipment to see what they are doing - this technique will add a lot of water to the Shaft and the potential for equipment to become entangled is high.
3. Dry retrieval - this involves reducing the water level in the shaft and remotely picking out waste as it appears. Due to the nature of the groundwater around the Shaft, this would involve problems with the water regime. This is currently the preferred strategy as the remote equipment would not be operating underwater and would be easier to control.

For options 2 and 3 above, it would be necessary to isolate the shaft from the surrounding water table. At present, $20m^3$ of water are removed daily from the Shaft to maintain the level of water below the water table. This slightly radioactive water is passed to a Liquid Effluent Treatment Plant before discharge to the sea. During retrieval operations the water would be much more radioactive - it is not possible to deal with $20m^3$ of ILW daily.

Studies examining the water flow around the Shaft are continuing, after which a decision on isolating the Shaft from the water table will be taken. Possibilities include freezing the rock around the Shaft leaving the contents unfrozen or injecting a concrete cut off wall around the Shaft.

Issues remain regarding what level of contamination could conceivably be left on the Shaft walls, and the stability of the cliff structure and Shaft to support the necessary retrieval equipment.

Dounreay Wet Silo

Constructed in 1971 as an alternative to the Dounreay Waste Shaft, the Silo is a large underground concrete vault, filled with water. Solid ILW was tipped into the

[12] Personal correspondence, UKAEA Dounreay
[13] Personal correspondence, UKAEA Dounreay

Silo via shielded openings in its roof at ground level, and it was in use until 1998. The structure of the silo is sound, however there is concern that:

> *"Records (of waste), particularly from the early years of operation, may not be complete"*[14]

It is believed that the silo contains waste consisting of fuel assembly parts (but not fuel) and other debris packed in 8 inch diameter cans.

HSE, SEPA and UKAEA are now of the opinion that the Wet Silo is "no longer an acceptable practice".[15] Under the Site Restoration Plan the policy is for the Silo to be emptied of waste, which will then be treated in the same facility as that from the Shaft. Technical issues surrounding the silo are of less concern than those relating to the Shaft. Emptying of the silo is therefore likely to be undertaken before the Shaft. This would concur with one of the 1998 Safety Audit's recommendations that:

> *"UKAEA should empty the Wet Silo as soon as is reasonably practicable and not wait for the Shaft to be emptied"*[16]

Sodium disposal

One of the complex problems on the Dounreay site relates to the disposal of sodium, the coolant from the Prototype Fast Reactor. Sodium was used to cool the reactor as water didn't have the necessary thermal capacity, that is it evaporated too quickly. Sodium in its liquid metal state has similar fluid properties to water but the problem is that liquid sodium and air react explosively, whilst sodium also reacts violently with water. 1500 tonnes of sodium are on site at PFR, with 900 tonnes of this contaminated. The 1998 Safety Audit indicated that:

> *"The removal and treatment of approximately 900 tonnes of sodium from the PFR reactor vessel is currently the largest decommissioning project being undertaken on the Dounreay site."*[17]

The turbine hall of the PFR is currently being used for the construction of a sodium coolant removal and treatment plant.

Radioactive Particles on Beaches around Dounreay

Irradiated sand sized particles of radioactive material, known as swarf, have been found intermittently on the Dounreay foreshore and beyond since 1983. These have been recovered at an average rate of one per month on the Dounreay

[14] HSE & SEPA Dounreay Safety Audit 1998, paragraph 260
[15] ibid, paragraph 261
[16] ibid, recommendation 62
[17] ibid, paragraph 242

foreshore area (which is not open to the public), whilst fourteen have been recovered on the public beach at nearby Sandside. The latest of the Sandside particles was recovered in November 2000, and although assessed by UKAEA as posing an extremely low level of danger to the public, other interest groups, including the landowner who owns the beach, and the campaigning organisation Scotland Against Nuclear Dumping (SAND), are very concerned. SAND indicate that since summer 1999, when monitoring on Sandside Beach was increased, particles have been found at a similar rate to those on the Dounreay foreshore. UKAEA indicate that they now monitor the Dounreay foreshore less than Sandside Beach[18].

The danger to the public from the particles is a topic of debate. SEPA has recently commissioned the National Radiological Protection Board (NRPB) to carry out an investigation into the health hazard from contact with, or ingestion of, contaminated particles. UKAEA indicate that:

> *"The thirteen particles so far recovered from Sandside Beach are mainly in a category of health hazard described by the NRPB SEPA as having 'no deterministic health affect"* [19]

SAND believe this sort of assessment is misleading - they are of the opinion that the particles are of a very real danger to the public and that:

> *"Members of the public cannot make an informed choice about whether to use Sandside Beach or not while Dounreay's operators play down the risk posed by the particles."*[20]

These particles have been identified as originating from cutting processes used when dealing with irradiated reactor fuel from DMTR, which was irradiated around 1965, plus or minus 2 years. The process involved cutting away aluminium cladding from nuclear fuel, sometimes cutting shards of fuel. UKAEA concede that there are 6 tonnes of particles in the Dounreay Waste Shaft, but it is not known how much of this is radioactive material.[21] It is unclear whether continuing finds indicate a continuing source.

There are a number of theories regarding how the particles have reached the environment outside the Dounreay site. The most likely option for particles appearing on beaches surrounding Dounreay is via the sea - it is acknowledged that thousands of particles are located in the sea bed off Dounreay. Work over the last three years has included diver attended radiological surveys and use of radiation detectors.

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[18] Personal correspondence, UKAEA Dounreay

[19] UKAEA, Dounreay Site Restoration Plan - Volume 7 Appendix 1

[20] BBC News, 16 August 2000

[21] UKAEA, Dounreay Site Restoration Plan - Volume 7 Appendix 1and personal correspondence UKAEA Dounreay

As far as UKAEA theories regarding the original route for the particles into the sea are concerned, possibilities include:[22]

- Particles appearing as erosion of landfilled areas on the Dounreay site occurs;
- Particles washed down through Dounreay's old low active drainage system after a spillage on site - this drainage system fed into an effluent tunnel, which flowed to an undersea 'diffusion chamber', before being carried through risers to the seabed. The pipework in the diffusion chamber is known to have leaked. This system is no longer in use and has been temporarily sealed;
- Particles finding a route from the Dounreay Waste Shaft into the surrounding rock;

UKAEA believe that:

> *"Analysis to date has produced no evidence or credible route for how these particles could continue to be released now that the old low level liquid waste discharge system is no longer used. Similarly there is no evidence of leakage from the shaft. Nevertheless, investigations and monitoring will continue."*[23]

> *"There is very strong circumstantial evidence that particles were discharged through the low level liquid effluent system and other site drains in the 1960s and perhaps into the 1970s. All practicable steps have been taken to ensure the particles are no longer leaking into the environment."*[24]

Current UKAEA thinking is that the focus of work should now be on what to do about the problem, as well as identifying pathways into the environment.[25] Monitoring of the beach environments around Dounreay will continue and options for dealing with the particles will be examined. These could include dredging the most contaminated areas of the seabed or developing a seabed crawler to identify and remove contaminated particles. UKAEA indicate that the options will be assessed through a Best Practicable Environmental Option (BPEO) study.[26]

SAND has further concerns regarding the particles problem.[27] Issues include the notions that:

- The idea that there may be a continuing on-land source of particles cannot be discounted. SAND point out that until 1990 Dounreay was not a nuclear licensed site as it was Government owned - this effectively meant it could not

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[22] Personal correspondence, UKAEA Dounreay
[23] UKAEA, Dounreay Site Restoration Plan - Volume 7 Appendix 1
[24] ibid
[25] Personal correspondence, UKAEA.
[26] ibid
[27] Personal correspondence, Scotland Against Nuclear Dumping

be prosecuted. The site is now licensed, so prosecution could be an option if particles were continuing to wash down from the Dounreay site.

- UKAEA only comprehensively monitor the strand line (that is the seaweed line deposited after tides) of Sandside Beach on a weekly basis, rather than larger areas of the whole beach, and UKAEA monitoring equipment is not of a sophisticated enough nature to measure more than ten centimetres deep. SAND believes the monitoring regime has to be substantially increased in order to identify the true danger to the public.
- Fishing limits imposed around the Dounreay site do not apply as far as Sandside Bay. Lobster cages are often set here, and can be in place for up to a week.

Further concerns have been raised following the recent find of a particle in an area within the Dounreay site previously thought to have been cleared of contamination. The find, which SEPA indicated had a higher level of radioactivity than those found around Sandside Bay, occurred on 4 December 2000 near Dounreay Castle. A press release issued on 12 December 2000 stated that:

> *"SEPA has described this as a "significant development" because it appears to rule out historical transport from the sea, believed to be the most likely explanation prior to this find."*

SEPA have asked UKAEA to urgently examine how the particle could have ended up in an area previously thought to have been clean.

SAND outlined their main areas of concern in a press release on 12 December 2000[28]. These include:

- The particle at Dounreay Castle was not present when the area was monitored six months previously;
- The particle could not have arisen through sea to land transfer as it was found above the high water mark;
- A view that the ventilation shaft of the Fuel Cycle Area *(where reprocessing takes place)* had to come under suspicion as source.

UKAEA's response to the discovery of the particle was outlined in a press release on 22 December 2000. Having conducted a 3-day investigation into the find, UKAEA are of the view that:[29]

> *"The most likely pathways are those of direct deposition from the sea, or windblown deposition from the beach following a period of submersion in the sea and deposition on the beach. All the evidence suggests that the particle has come from the sea. This is indicated by the rounded shape of the particle (particles which have never been in*

[28] SAND press release, 12 December 2000, http://www.glen.co.uk/sand/
[29] UKAEA press release, 22 December 2000, 'Particle most likely came from sea'.

the sea tend to be more angular) and by its activity which is typical of those found on the Dounreay foreshore. Documented evidence of the castle forecourt being inundated by the tide at periods of storm surge and high spring tide confirms that direct deposition would have been possible. Equally, wind speeds at Dounreay often exceed those which could have carried the particle from the beach."

This view was outlined in a letter sent to SEPA in December 2000, with a detailed report of the investigation to be submitted by the end of January 2001.

SEPA convened the Dounreay Particles Advisory Group (DPAG) in May 2000 "to provide impartial expert scientific advice on the current UKAEA research programme in respect of particles in the Dounreay local environment."[30] Members include representatives from universities, National Radiological Protection Board, Health Boards and Fisheries Science groups. The group has met 5 times since inception. Recent work has included focus on:

- Probability of ingestion and contact with fragments occurring at Sandside Bay;
- Statistical interpretation of remote offshore particle monitoring; and
- Public health implications of fragments of irradiated fuel.

In the minutes of the group's most recent meeting on 6 December 2000, it was noted that UKAEA's research programme and action plan for Dounreay particles was still awaited.

Radioactivity in household dust

A study entitled Follow Up Studies on radioactivity in household dust in Thurso, commissioned jointly by Her Majesty's Industrial Pollution Inspectorate (HMIPI, now superseded by SEPA) and UKAEA in October 1993 had its findings finally published in the summer of 2000. The report is a second draft of research that was never finalised, but contained detail of studies of household dust radioactivity levels in houses in Thurso and Banff. SEPA decided to release this information in the interests of openness to the public.

The study compared the results of a 1989 study of the levels of radioactivity in 34 Thurso households and a 1992 control study of 20 households in Banff. There are no nuclear sites within the vicinity of Banff and the levels of contamination there are those expected as background from natural and man made sources, including fallout from nuclear bomb testing from 1954 to 1980.

[30] DPAG Terms of Reference, http://www.sepa.org.uk/regs_licence/radioactivity/dpag/dpaghome.htm

Conclusions of the study include:[31]

- There are statistically significant differences between the levels of Pu-239/240 (Plutonium) and Am-241 (Americium) found in household dust of UKAEA workers and non-nuclear site households, with the former being higher. The levels in Vulcan Nuclear Reactor Training Establishment (VNRTE) workers houses cannot be distinguished from those in non-nuclear site houses for all radionuclides considered. The mean concentration of Am-241 is higher in UKAEA households than in VNRTE houses;
- Pu-238 , Pu-239/240 and Am-241 levels are higher in the household dusts of workers in the Fuel Handling area and Engineering Services Group than in other areas of UKAEA and VNRTE and non-nuclear households;
- The mechanism by which household dust becomes contaminated may be different for UKAEA workers compared with VNRTE and non-Nuclear Site workers;
- There is no proven correlation between the levels of Pu-239/240 or Am-241 and distance from the sea or with the area of Thurso where the houses are situated;
- Levels of Pu-239/240 are statistically significantly higher in Thurso than in Banff;
- The levels of Pu-239/240 found in Thurso are consistent with the hypothesis that very low level personal contamination causes contamination of household dust. Other mechanisms cannot be ruled out.

Essentially the report indicates that the levels of radioactivity in the homes of UKAEA but not VNRTE workers appear to be higher than non-nuclear worker households. UKAEA are of the view that:

> *"The radioactivity levels measured in the house dust are so low as to be virtually undetectable. Indeed, calculations in the original report estimate that the maximum radiation exposure to any person would be 500 times less than that received from natural background".*[32]

It is worth noting that the report only dealt with certain types of radioactive particles - the overall conclusion was that contamination types found at Dounreay were being transferred to the homes of workers.

However, the release of this report was greeted by some quarters with disbelief that it had not been released sooner, and concerns that nuclear installations could really be a significant threat to workers' health. Kevin Dunion, Director of Friends of the Earth Scotland said:[33]

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[31] SEPA foreword to "Follow-Up Studies on Radioactivity in Household Dust in Thurso", 2000

[32] Personal correspondence, UKAEA Dounreay

[33] Dounreay: Increased levels of radioactive dust found in workers' homes, Friends of the Earth Scotland press release, 1 October 2000

"This a very disturbing report and raises many questions about procedures designed to protect worker and public health not only at Dounreay but at every nuclear facility. As a matter of urgency we must find out if radioactive dust is still at elevated levels within homes in the area. The report not only finds evidence to support the possible transfer of radioactive materials from worker to home, but that in turn transfer of these materials to the homes of non-nuclear workers could also be occurring. Therefore, the findings of this report must be fed into those studies examining the link between nuclear plants and some leukaemias and cancers."

UKAEA have pointed out that the data for the study was gathered over 10 years ago. In recent years, UKAEA have improved procedures relating to the transfer of contamination from its facilities. These include[34]:

- Modern walk-through whole body monitors within the main changeroom of the Fuel Cycle Area (whose workers had shown highest readings in household dust radioactivity);
- Improved and extended training for personnel on changeroom procedures;
- Improvements in monitoring of personnel and equipment leaving radiological areas.

SEPA has asked UKAEA to demonstrate that these measures are effective in preventing the transfer of contamination from the Dounreay site.

Fuel Cycle Area

The Fuel Cycle Area is involved with the processing and reprocessing of nuclear fuels, both those originating from Dounreay and from outside agreements. Although Dounreay will accept no further outside contracts, those already signed will need to be fulfilled. This means the Fuel Cycle Area cannot yet be closed, and UKAEA has continued to apply for permission to carry out reprocessing work.

The Dounreay Safety Audit discussed below followed a loss of power supplies to the Fuel Cycle Area in 1998, whilst a more recent incident on 3 December 2000 led to another loss of electrical power. The more recent incident led to workers being evacuated. Reports[35] indicated that the Nuclear Installations Inspectorate were not informed until 24 hours after the incident whilst SEPA did not find out until 6 hours after that. UKAEA stated that:

"Safety related systems operated satisfactorily. The main air extract system for the fuel cycle area was not affected and remained operational at all times. Battery back-up systems installed since 1998

[34] Personal correspondence, UKAEA Dounreay
[35] The Herald, 7 December 2000, "Nuclear report on power cut delayed"

ensured that stack monitoring equipment continued to function for all facilities except one minor lab, which was closed."

The incident had been treated as a routine safety matter, hence the delay in informing the NII and SEPA.[36]

DOUNREAY SAFETY AUDIT 1998

This audit, carried out by SEPA and HSE followed an incident on 7 May 1998 which cut power supplies to the Fuel Cycle Area of Dounreay for 16 hours.[37]

The audit team ultimately made 143 recommendations for improved safety and operations on the site. An outline of the main findings is as follows:

- Organisational changes made within UKAEA over the 4 years to 1998 have so weakened the management and technical base at Dounreay that it is not in a good position to tackle its principal mission, which is the decommissioning of the site;
- UKAEA is over-dependent on contractors for the delivery of many of the key functions which should be under UKAEA's clear control as licensee for the site;
- UKAEA has not yet developed a comprehensive strategy for dealing with the various forms of radioactive waste already at Dounreay, or those which will arise in future;
- A lack of progress has been made over decommissioning;
- Decommissioning and radioactive waste strategies should be integrated together for the entire site;
- Early action is necessary to develop waste treatment plants;
- Fuel Cycle Area conditions range from the good to the very bad. There is a suspicion that UKAEA has been operating plants without clear knowledge of some of the risks;
- UKAEA should broaden the scope of its rapid reporting of incidents to regulators;
- It is evident that UKAEA needs to invest considerable effort, time and resource into bringing itself up to the standards expected of a modern nuclear licensee.

Specific recommendations of the audit ranged from organisational set up to staff training and radioactive waste management.

Progress since the 1998 safety audit

On 30 November 1998 UKAEA published the document 'Dounreay - the way ahead'[38]. This direct response to the HSE/SEPA audit outlined that the previous 5-

[36] The Herald, 7 December 2000, "Nuclear report on power cut delayed"

[37] HSE & SEPA 1998 Dounreay Safety Audit foreword

[38] Dounreay - the Way Ahead: UKAEA response to the 1998 HSE/SEPA Audit of Dounreay

year safety and environmental record had shown improvement, as well as setting out an action plan for implementing the audit's recommendations. Six teams dealing with different aspects of the operation were established to broadly mirror the themes of the audit's recommendations.

HSE and SEPA reported back[39] on UKAEA's progress in September 1999 and again on 11 October 2000. The second report[40] indicated that in general HSE/SEPA thought UKAEA's progress on the 143 recommendations the safety audit had made to be satisfactory, but significant resources were necessary to address other recommendations. By the end of August 2000, 9 of the safety audit's recommendations had been implemented with another 10 close to completion, a further 10 in a six month review phase and responses to another 51 had been submitted to HSE/SEPA to consider.

HSE/SEPA recognise that due to the complex inter-relationships between some recommendations, they may not be complete although work has been done on them, whilst some recommendations, such as the emptying of the waste shaft are very long-term projects.

The HSE/SEPA update verifies those recommendations that have been officially signed off. UKAEA were of the view, as of the end of October 2000[41], that 98 of the original 143 recommendations had been completed. Of those 98:

- 13 recommendations have been formally closed out by the regulators;
- 23 are in the review phase by agreement with the regulators;
- 45 further recommendations have been submitted to the regulators for close-out or review;
- 18 are under internal UKAEA review, prior to submission to the regulators.

THE DOUNREAY SITE RESTORATION PLAN

The Dounreay Site Restoration Plan announced in October 2000, outlines UKAEA's response to some of the longer-term recommendations of the safety audit. This is the first example in the UK of a detailed blueprint for the restoration of a major nuclear site. It is important to note that there will be an increasing demand for this type of work to be carried out in the future - this is not lost on the organisations involved with the clean-up operation at Dounreay.

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[39] Progress on UKAEA's response to the 1998 HSE/SEPA Audit of Dounreay, HSE/SEPA, September 1999

[40] Progress on UKAEA's response to the 1998 HSE/SEPA Audit of Dounreay, HSE/SEPA, September 2000, released with press release on 11 October 2000.

[41] @U - UKAEA Progress Report on Dounreay, October 2000

The Plan has been broadly welcomed by campaigning groups, who have begun to turn their focus from highlighting Dounreay's problems, to moving forward to ensure sustainable and safe solutions.

The plan sets out the desire for UKAEA to deal with the major hazards at Dounreay first, with all radiological hazards being dealt with inside 25 years. Estimates for the decommissioning programme as a whole are 50-60 years, although a period of care and maintenance will be required after this.

There are significant changes in these timescales from estimates given **two years ago** (shown below).

1998 Decommissioning targets			
Facility	**Stage 1**	**Stage 2**	**Stage 3**
PFR	ends 2007	2070 - 2075	2076 - 2095
DFR	ends 2010	2020 - 2029	2065 - 2079
MTR	complete	2016 - 2020	2021 - 2025
PFR reprocessing plant	2007 - 2008	2009 - 2013	2030 - 2031
MTR reprocessing plant	2005 - 2007	2027 - 2029	2030 - 2032
Development Laboratory	ends 2007	2024 - 2028	2030 - 2033

Source: Table 3.5, **THE 1998 United Kingdom Radioactive** Waste Inventory Main Report

The **new** Site Restoration Plan sets out a strategy that will include the following:

Period	
1	**Construction of new plants** including HLW vitrification plant, ILW treatment plant, ILW store, LLW facilities, enabling works for shaft and silo, active incinerator **Continued decommissioning** of PFR, DFR, DMTR fuel reprocessing plant, criticality facility, contaminated land **Upgrade** of ILW treatment facility, ILW stores, Highly Active Liquor Storage facility, Uranium recovery plant
2 (beginning 2025-2030)	**Retrieval of waste** from shaft and silo **Decommissioning** of ILW store, Uranium recovery plant, LLW facilities, nuclear fuel characterisation plant, carbon oxidation plant **Major radiological hazards** eliminated by this time
3	**Decommissioning** of Highly Active Liquor Storage facility, shaft & silo retrieval headworks, vitrification plant **Construction** of vitrification product store, ILW treatment plant and store

4	**Reactor decommissioning** complete **Ongoing decommissioning** of other redundant facilities
5 (beginning 2050-2060)	**Decommissioning** programme complete **Remediation** of contaminated land complete **Continued control** needed for some site areas. Major areas of site suitable for delicensing

The cost of decommissioning and restoring the Dounreay site is estimated to be in the region of £4 billion over a 50-60 year timescale. These costs will be met by the public purse.