Radioactive Substances Unit

Part IIA Inspection and Risk Assessment Report

Site: Alienated Land Former RAF Kinloss

February 2016

Control Sheet

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Executive Summary

This report provides the results of a series of radioactivity monitoring surveys and an assessment of the land against the Radioactive Contaminated Land (Scotland) Regulations 2007 for land previously used by the Ministry of Defence near Findhorn, Moray.

Radioactive contamination is present on the site; however when assessed against Part IIA Radioactive Contaminated Land criteria the contamination present at the site does not meet the criteria of Significant Harm or Significant Possibility of Significant Harm under its current use and therefore does not require any further action by SEPA. The Landowner and the Local Authority are aware of the condition of the land and have been advised of the required precautions with respect to development or actions that would lead to the contamination being disturbed. SEPA will maintain a watching brief, provide advice and where necessary undertake periodic site surveys. The site in its current use does not pose a risk to the public (from the radioactive contamination present).

SEPA is committed to ensure transparency and providing access to information where appropriate. This report allows the public to review SEPA's methods and overall findings, however parts of the report that allow specific locations to be identified have been placed in appendices which do not form part of the publically available documents. This includes grid reference data, detailed mapping and contextual images. Contextual images are those that may allow the identification of a general area where it is noted contamination is present.

Contents

Glossary of Terms

Artefact	a radioactive source which is different from the surrounding material and has been made by a human e.g. a dial or gauge
Confidence of detection	The assessed value for which an observed effect will be recorded e.g. a 50% confidence of detection will mean there is an equal chance or detection and non-detection
Gray	The gray (symbol: Gy) is the SI derived unit of absorbed dose, specific energy (imparted) and of kerma.
Particle	A physically small radioactive source which other than its radioactive properties is similar to that of the surrounding sediment
Sievert	The sievert (symbol: Sv) is the International System of Units (SI) derived unit of equivalent radiation dose, effective dose, and committed dose.
Source	A radioactive objective which includes both particles and artefacts
Statutory Guidance	Environmental Protection Act 1990: Part IIA Contaminated Land Statutory Guidance: Edition 2, Paper SE/2006/44 as amended by Environmental Protection Act 1990, Part IIA Contaminated Land, Radioactive Contaminated Land (Scotland) Regulations 2007 Statutory Guidance 28 May 2009 SG/2009/87.

1. Introduction

Radioactive contamination was detected on land adjacent to the current Kinloss Barracks during the investigation for a surface water facility on the then RAF Kinloss in 2005/2006. The site comprises publicly accessible open space and natural dunelands previously requisitioned by the Ministry of Defence (MoD) and part of the former RAF Kinloss, which is now owned by a number of parties including the Findhorn Trust. The area considered as part of this assessment ("the Site") is shown in Figure 1. Previous investigations commissioned by the MoD (identified a number of areas of potential contamination comprising areas where aircraft breaking and burning activities following World War II, and the tipping and landfilling of RAF Kinloss base wastes took place at the site.

Work to date has positively identified the presence of radium-226 (Ra-226) relating to past practices in aircraft maintenance and decommissioning in a number of areas within the full extent of the former RAF Kinloss site.Radium-226 together with its decay products can pose a significant hazard to human health via skin contact, ingestion, inhalation or external irradiation. Physically, it is in the form of solid radioactive sources of various shapes and physical attributes.

In 2012 and 2013, SEPA undertook a surface walkover survey of an area now outwith the site boundary of the then RAF Kinloss, (now Kinloss Barracks) where preliminary desk study research indicated the most likely location of radioactive contamination which the public could encounter. This work was built upon in late 2013 by a further walkover survey and limited intrusive investigation programme to determine the nature and extent of the contamination. SEPA returned to the site in January 2015 to monitor an adjacent section of land to that which had been monitored previously in 2014. SEPA used this visit to re-visit previous areas last monitored in 2013 to check that contamination previously detected at depth had remained undisturbed.

Monitoring work has shown that radioactive contamination has been detected and positively identified as radium-226. The extent of this area is impacted by the presence of gorse cover which is a constraint to full site monitoring coverage. The additional areas monitored in 2015 also positively identified radium-226 contamination above background concentrations.

SEPA's duties

SEPA has powers under the Radioactive Contaminated Land (Scotland) Regulations 2007 and the Environment Act 1995 to inspect land for the purpose of assessing whether land meets the definition of Radioactive Contaminated Land. Before SEPA can make the judgement if land meets the definition of Radioactively Contaminated Land SEPA must identify a Significant Pollutant Linkage. This means that each of the following has to be identified:

a) a radioactive contaminant;

b) a relevant receptor; and

c) a pathway by means of which either:

    I. that radioactive contaminant is causing Significant Harm to that receptor, or

    II. there is Significant Possibility of such harm being caused by that radioactive contaminant to that receptor.

A determination that land is Radioactive Contaminated Land is made in respect of a specific area of land. In deciding what that area is, the primary consideration is the extent of land which meets the definition of Radioactive Contaminated Land.

SEPA should determine that land is Radioactive Contaminated Land on the basis that Significant Harm is being caused where:

(a) it has carried out an appropriate scientific and technical assessment of all the relevant and available evidence; and

(b) on the basis of that assessment, it is satisfied that Significant Harm is being caused. (B.36 of the Statutory Guidance).

SEPA should determine that land is Radioactive Contaminated Land on the basis that there is a Significant Possibility of Significant Harm being caused where:

i. it has carried out an appropriate scientific and technical assessment of the risks arising from the Pollutant Linkage, according to relevant, appropriate, authoritative and scientifically based guidance on such risk assessments;

ii. on the basis of that assessment, it is satisfied that there is a Significant Possibility of Significant Harm being caused; and

iii. there are no suitable and sufficient risk management arrangements in place to prevent such harm. (B.37 of the Statutory Guidance).

This risk assessment report is an appropriate scientific and technical assessment of all the relevant and available evidence.

The objective of this risk assessment report is to:

1. Establish whether there are Significant Pollutant Linkages at the identified areas of contamination on the alienated land,
2. If there is such a Significant Pollutant Linkage, determine whether it is resulting in Significant Harm to a receptor in the Pollutant Linkage or it presents a Significant Possibility of Significant Harm being caused to that receptor.
3. If there is a Significant Possibility of Significant Harm, determine whether there are suitable and sufficient risk management arrangements in place to prevent such harm; and
4. Determine whether any land on the alienated land is Radioactive Contaminated Land.

The alienated land at Kinloss has been assessed in respect of its current use in accordance with paragraph A.27 of the Statutory Guidance, which requires SEPA only to consider receptors likely to be present given the current use of the land.

1.1. Site Description

The site is situated in a coastal location with the Moray Firth (Burghead Bay) to the north and Findhorn Bay to the west. Findhorn Bay is both a designated RAMSAR site and a Site of Special Scientific Interest. The land to the west of the site comprises a sand dune system with gorse vegetation which leads into a pine tree plantation. Beyond this residential housing including Findhorn Eco Village and a caravan park are located near the shoreline of Findhorn Bay. To the east and south of the site lies RAF Kinloss (now Kinloss Barracks).

Currently, the site is largely undeveloped open land covered in gorse with a number of wind turbines and access tracks. The area is used by visitors and for dog-walking with a number of informal paths crossing the land.

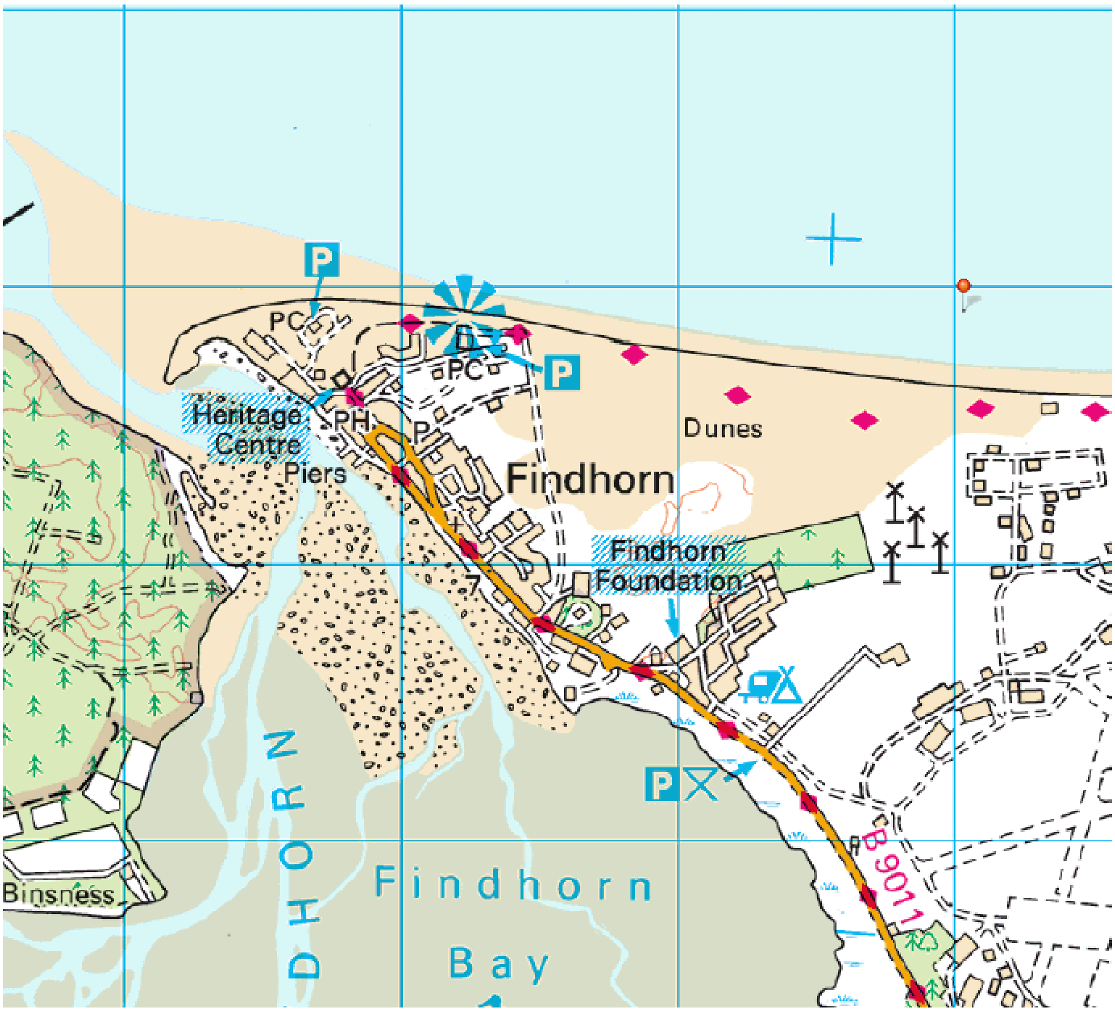

Figure 1: Site Location

1.2. Site History

RAF Kinloss previously requisitioned the site which was used for the dismantling of aircraft no longer required by the RAF following World War II. During the late 1940s the aircraft were stripped for their scrap metal, with the remains being burnt and/or buried within the area. RAF Kinloss base records also indicate that sporadic tipping of wastes from the base may have occurred on the site. It is unclear when the base ceased to utilise the site and erected fencing to the existing base boundary.

The potential for contamination, other than radioactive contaminants, on the site is outwith the scope of this report and has been investigated by Moray Council.

1.3. Monitoring

Investigations into radioactive contamination include those commissioned by Defence Estates (now Defence Infrastructure Organisation (DIO)) in 2004, monitoring work undertaken by SEPA in 2012, 2013 and also monitoring undertaken in 2015. This report details the work undertaken by SEPA in 2013 and 2015.

Walkover monitoring was undertaken using 3”x3” Sodium Iodide (NaI) detectors (instrument details in Appendix 3) and supported by RT-30 detectors with 2”x2”NaI and a compensated Geiger Muller (GM) tube, nuclide analysis was possible using the identify mode of the RT-30. Monitoring was undertaken at a detector height of 10cm, speed of ~1m/s and transect spacing of 1m or less. Monitoring results in Appendix R3 are for total gamma-ray counts which include the contribution from naturally occurring radionuclides including K-40 and radium naturally present from the decay of uranium present in rocks. A basic scale is annotated on to the images in the redacted appendix R3 to denote areas of elevated counts. It is not possible to attribute radioactivity content to the count rates as only limited intrusive work was undertaken in 2013 and different types of contamination exist across the site i.e. the precise depth of the source(s) remains largely unknown.

Previous monitoring work undertaken by the MoD and the 2013 monitoring undertaken by SEPA identified that there are a series of at least three physical forms of radium-226 contamination at the site. This includes:

a. clearly identifiable luminised artefacts e.g. a dial and an oil gauge (Appendix 1);

b. contaminated clinker (Appendix 1) ; and

c. more disperse contaminated soils. The physical extent of the area where contamination has been detected is depicted in (Appendix R3).

The work undertaken showed that the contamination identified at the site is currently buried at depth and therefore this provides low availability for migration to the surface for the land in its current use. However, actions such as thrashing of the gorse could destabilise the plant roots and allow contamination to move to the surface. Thrashing would also allow access to currently inaccessible areas allowing contact with sources which could be at surface on these current inaccessible areas of the site due to the gorse being present.

Table 1 provides a summary of the data from the monitoring undertaken in January 2015.

Table 1: Monitoring Data from January 2015

Measurement	RT30 (Counts Per Second)	Dose Rate Contact	Unit	RT30 1m (Counts Per Second)	Dose Rate 1m	Unit
1	980	426	nSv/h	417	191	nSv/h
2	118	49	nSv/h	100	49	nSv/h
3	250	95.6	nSv/h	140	64.6	nSv/h
4	930	500	nSv/h	230	95	nSv/h
5	6200	3.5	µSv/h	1350	645	nSv/h
6	1160	540	nSv/h	636	303	nSv/h
7	700	350	nSv/h	420	190	nSv/h
8	4300	2.7	µSv/h	720	355	nSv/h
9	315	145	nSv/h	-	50	nSv/h
10	1450	723	nSv/h	210	90	nSv/h
11	3654	2	µSv/h	-	437.9	nSv/h

Hotspot 1

Ra-226 identified after 600 second count on RT30 over 350 cps hotspot, which was targeted to a high of 2700 cps (under moss)

Measurement	RT30 (Counts Per Second)	Dose Rate Contact	Unit	RT30 1m (Counts Per Second)	Dose Rate 1m	Unit
Hotspot	2700	1400	nSv/h	180	79	nSv/h
1' North	189	90	nSv/h	-	-	-
1' East	132	61	nSv/h	-	-	-
1' South	150	54.5	nSv/h	-	-	-
1' West	1180	605	nSv/h	-	-	-

Hotspot 2

Hotspot	1246	532.9	nSv/h	180	70.5	nSv/h
1' North	240	99.4	nSv/h	-	-	-
1' East	183	64.9	nSv/h	-	-	-
1' South	248	102.4	nSv/h	-	-	-
1' West	235	98.7	nSv/h	-	-	-

2. Pollutant Linkage

Before SEPA can determine that any land appears to be contaminated land on the basis that significant harm is being caused or that there is a significant possibility of such harm being caused by radioactivity possessed by a substance, SEPA must identify a significant pollutant linkage. This means that each of the following has to be identified:

- A radioactive contaminant;
- A relevant receptor;
- A pathway by means of which either:
  - that radioactive contaminant is causing significant harm to that receptor, or;
  - there is a significant possibility of such harm being caused by that radioactive contaminant to that receptor.

2.1. Radioactive Contaminant

Limited intrusive investigation work undertaken by SEPA in 2013 reported individual sources with estimated activities of up to 250 kBq Ra-226. All of the sources investigated were buried at depth often within or beneath the rooting zone. The sources recovered in 2013 had sharp edges, possibly indicating that it was unlikely that they had broken up or weathered since the time of the disposal i.e. they were in the same form as when disposed. At one location the contamination appears to have been covered by jute material which made penetration extremely difficult. The site as a whole is covered by both grassland and gorse vegetation which stabilises the underlying sandy soil.

Direct measurements made from the sources recovered in trial pits in 2013 correlated to a maximum activity of 250 kBq. These sources were located approximately 10 cm below the ground surface. Dose rate measurements made in 2015 had a maximum of 3.5 microSv/hour at surface. Using a dose rate conversion for radium-226 for an assumed depth of 10 cm would suggest an activity of around 200 kBq, however the conversion is sensitive to depth measurement and a depth of 1-2 cm more would provide an activity of 250 kBq (when the effects of background and changes in depth are considered). It is noted that no sources were recovered by SEPA during 2015.

Gamma-ray dose rates can be estimated at other distances using the measurements from a known point as there is a relationship between distance and radiation intensity. This is known as the inverse square law. Table 2 provides the results of calculations of a buried source of Ra-226 of known activity at different distances.

Inverse Square Law equation

$$\frac{I_1}{I_2} = \frac{d_2^2}{d_1^2}$$

Where:

I denotes the intensity of radiation (e.g. a dose rate per unit time) at point 1 or point 2,

d denotes the distance from the radiation source that the measurement was made

Note: this equation becomes less reliable the closer to zero the measurements are made

Table 2: Modelled unshielded dose rates for a 250 kilo Becquerel radium-226 source at set distances

Activity (Bq)	Distance (cm)	Dose Rate (μSv/hr)
250,000	0.05	1.74E+05
	0.1	4.36E+04
	0.25	6974.885
	0.5	1743.71
	1	435.919
	10	4.358
	15	1.937
	20	1.089
	50	0.174
	100	0.043
	500	0.0017

2.2. Receptor

Before SEPA can establish the existence of a Significant Pollutant Linkage with respect to land, it must identify a Receptor with respect to that land. The Statutory Guidance provides that, for the purposes of the Radioactive Contaminated Land (Scotland) Regulations 2007, a Receptor is “(a) a human being which is being, or could be, harmed by a Radioactive Contaminant; or (b) a water environment which is being, or could be, polluted by a Radioactive Contaminant.”

In order to assess the people who may be receptors, as well as the pathways by which they may become exposed to radioactivity in the environment, SEPA observed the habits of people using the area and spoke to the local community.

2.2.1. Habits Observed

Walking / Dog walking
There were a small number of dog walkers (< 10) noted travelling over the affected area during the works none of these remained in the area for any significant period of time (i.e. less than 5 minutes transit time across the survey area). Additionally, a small number of walkers & runners passed through the area. Again none of these remained in the area for a prolonged duration (i.e. all had occupancies of less than 5 minutes).

Other beach activities
It has been reported horses are sometimes allowed to graze on the site. People caring for these horses will access and leave the area, however habits displayed will be consistent with a walker to the site and not involve any intrusion into the ground.

It is possible that a horse eating grass could remove some of the root material with the grass leaves however this is unlikely to include deeper roots below which the sources reside.

Further observations
In 2013 it was noted that Findhorn community wished to preserve the current ecosystem and had no plan for any change in land use or digging into the ground. However, in 2015 SEPA were informed that there were proposals for an excavation of a pond in the area which prompted a further monitoring exercise by SEPA. It is noteworthy that this would be as a permitted development and not require planning controls from the local authority.

Habit Survey Limitations
The 2013 observations of habit was limited to a time where SEPA staff were on site undertaking survey and intrusive work, however it was a period of sunny weather and it would be expected that the majority of habits would have been captured.

The repeat visit in 2015 was in January and comparable habits were observed to the August 2013 visit. The area has low occupancy and low variability in activities (i.e. walking, dog walking, horse riding). All activities would result in short transit times through the area and no stopping was observed other than to talk to SEPA staff.

2.3. Pathway

In order for radioactive material to pose any risk to the public, there is a need for a pathway to exist between the source and the public (receptor). The Statutory Guidance defines a Pathway as "one or more routes by, or through, which a Receptor is (a) being exposed to, or affected by, a radioactive contaminant or (b) could be so exposed or affected."

This risk assessment considers the following potential Pathways; ingestion, inhalation, skin contact and external gamma doses.

2.3.1. Ingestion

The hazard posed from ingestion of a radioactive source is a product of the energy deposited (irradiation) of the gut wall as the source moves through the body and the amount of the source which is retained in the body. The amount of the source which is retained is generally related to the solubility of the source in the gut thus absorbing it into the blood stream. Typical solubility values (f_1) for radium 226 and its daughters have been collated and reported in various ICRP documentation.

For an ingestion pathway to exist the source must enter the body which requires direct contact. As all of the contamination detected is currently buried at depth with no habits indication any digging, no evidence of digging on site and the owners having no plans for digging this is not considered a current valid pathway. It is notable that the highest activity found at the site was an intact instrument that would be too large to ingest accidentally. Some areas of the former RAF Kinloss site where contamination may be present and at surface have not been monitored due to access restrictions. Therefore SEPA will monitor the site periodically to determine if access to these areas changes in order to assess whether this pathway does become viable under its current use. SEPA has also advised Moray Council to advise that any change in land use will need to address the radioactive contamination present.

2.3.2. Inhalation

The inhalation pathway is the mechanism whereby particulate matter can enter the respiratory tract. This can range from fine particulates in the air to dust sized fractions which are only airborne in windy conditions or mobilised by physical actions e.g. kicking or throwing of material. The capability of radioactive contamination to cause harm via the respiratory tract is dependent upon the physical size of the source and its aerodynamic equivalent as this will dictate the position in the tract where the material is deposited. Once deposited in any given location within the respiratory tract, the activity of the source will dictate the harm occurring at that location.

In general terms the further any radioactive source can move into the respiratory tract (i.e. deeper into the lung) the more potential harm it poses, i.e. a 1kBq source poses more hazard if deposited on the deep lung than if it were in the upper trachea. Thus, any assumptions made about any relationship between physical size and radiological activity would have a significant effect on the assessment made. However, for the sources recovered from the site there is no currently established relationship between physical size and radioactive activity. It is notable that the highest activity found at the site was an intact instrument that would be too large to inhale.

For an inhalation pathway to exist the source must enter the respiratory tract which requires direct contact. As all of the contamination detected is currently buried at depth with no habits indicating any digging, nor evidence of digging on site currently this is not considered a viable pathway. However, some areas of the site where contamination may be present and at surface have not been monitored due to access restrictions, therefore, SEPA will monitor the site periodically to determine if access to these areas changes (e.g. during periods of low gorse cover) to assess whether this pathway could become viable under current use. SEPA has also written to Moray Council to advise that any change in land use will need to address the radioactive contamination present.

2.3.3. Skin contact

The effect of a radium source on the surface of the skin can either be through a long term increase in the possibility of a stochastic effect (e.g. a cancer) or a more immediate deterministic effect (e.g. a radiation burn). Charles et al (2008) discussed both the stochastic and deterministic effects of radioactive (radium-226) sources at Dalgety Bay on the skin and concluded that a source on the skin of any given activity will produce a deterministic effect of concern far more quickly than a stochastic effect of concern.

For a skin contact pathway to exist the source must have direct contact. As all of the contamination detected is currently buried at depth with no habits indicating any digging, no evidence of digging on site and the owners having no plans for digging this is not considered a current valid pathway. However, areas of the former RAF Kinloss site where contamination may be present and at surface have not been monitored due to access restrictions. Therefore SEPA will monitor the site periodically to determine if access to these areas changes and this pathway becomes viable under current use. SEPA will also write to Moray Council to advise that any change in land use will need to address the radioactive contamination present.

2.3.4. External gamma dose rates

People using the area of the site shown in Figure 1 could potentially receive a dose from sources present on or in the ground by being in close proximity to the source rather than having any direct contact with it. However, the further a person is away from the source the lower the dose rate becomes. This is further reduced by the effects of shielding via burial, together with exposure times. This is a credible current pathway of exposure.

The maximum surface dose rate for a the highest activity recovered on the site at 10 cm depth is calculated to be 4.4 microsieverts per hour, which would exceed the 3 millisievert RCL criteria in around 700 hours if the body was lying on the surface. Actual contact dose rates would be higher if the source came to the surface due to the removal of the shielding by the covering soil and reduction in distance. Dose rates at 1 m from an unshielded source are calculated to be 0.043 microsieverts per hour. For a person standing directly over this location continually for an entire year i.e. 8760 hours the dose is less than the 3mSv RCL criteria.

In 2015, SEPA returned to the area and some of the gorse appeared to have been cleared. In one area the surface dose rate was measured at 3.5 microsieverts per hour. This would correspond to an estimated activity of approximately 60 kBq should the source be located on the surface, however if the source was buried at 10 cm depth this would be the equivalent of approximately 200 kBq[1]. This would correspond with the 250 kBq estimated source detected in 2013 (as shown in table 2).

The maximum dose rate on the monitored area at 1m in 2015 was 645 nSv per hr. If a person were to stay in this exact location for an entire year (24 hours a day, 365 days a year) they could receive and annual dose slightly in excess of 3 mSv, however, it is not credible for such stationary occupation for an entire year. For precautionary occupancy times of a few hours per year on this location the dose rate received would be significantly less than the 3mSv criteria.

2.3.5. Preferential selection

The potential hazard that a radioactive source of a given activity poses to human health via the primary exposure pathways of ingestion, inhalation and skin contact are estimated on the assumption that all contact is inadvertent. Calculations for deliberate contact would involve the same pathways however exposure times/rates could be significantly different.

Using data reported on potential hazards together with the data on habits, assessments can be made on the potential risks that people encounter when using this area. This type of assessment typically assumes that one grain of sand/soil is no more likely to be contacted than another, which is true if those radioactive sources behave like the surrounding media and there is nothing unique about them.

However, some of the objects recovered from the site are likely to be visually attractive if exposed, such as luminised aircraft instrument parts (like oil gauges) which have been found. These items are likely to ‘stand out’ from the other items and also be attractive to members of the public, especially inquisitive children. However, all of the luminised artefacts found to date have been buried, which when combined with knowledge of the site and local habits, this pathway is not considered credible at this time. SEPA will keep the site under review to monitor any change in contamination depth (i.e. migration towards the surface).

[1] Calculated using the RadPro Calculator

3. Assessment of Significant Harm and Significant Possibility of Significant Harm

Part 3 of the Radioactive Contaminated Land (Scotland) Regulations 2007 Statutory Guidance (2009) sets out the criteria against which SEPA should regard whether significant harm or significant possibility of significant harm is being caused.

For land to be amenable to designation as Radioactive Contaminated Land (RCL) there is a need for contamination to be present, together with a receptor and a pathway to exist to allow the receptor to encounter the hazard i.e. a pollutant linkage.

3.1. Significant Harm

Significant Harm is defined as when lasting exposure gives rise to a dose in a year to an individual exceeding one or more of the following:

- An effective dose of 3mSv
- An equivalent dose to the lens of the eye of 15mSv
- An equivalent dose to the skin of 50mSv averaged over any $1cm^2$ area of skin, regardless of the area exposed.

SEPA considers that significant possibility of significant harm is not occurring at the area of the former RAF Kinloss site assessed within this report as there is no identified Significant Pollutant Linkage in line with the criteria set out in paragraph A.28 of the Statutory Guidance.

3.2. Significant Possibility of Significant Harm

Where in a year the doses are less than those stated for significant harm SEPA should not regard the possibility of significant harm as significant irrespective of the radiation dose being received.

SEPA shall regard the possibility of significant harm as significant, irrespective of the probability of radiation dose being received where:

- In a single exposure event, the potential effective dose would be greater than 100mSv; or
- Contact with the contamination would result in a potential absorbed dose to the skin greater than 10Gy/hr.

If the conditions stated above are not met, the probability of radiation dose being received needs to be taken into account. SEPA shall regard the possibility of significant harm as significant where in a year:

- The potential effective dose multiplied by the probability of exposure is greater than 3mSv; or
- The potential equivalent dose to the lens of the eye multiplied by the probability of exposure is greater than 15mSv; or
- The potential equivalent dose to the skin multiplied by the probability of exposure is greater than 50mSv averaged over any $1cm^2$ area of skin, regardless of the area exposed.

SEPA considers that significant possibility of significant harm is not occurring at the area of the former RAF Kinloss site assessed within this report as there is no identified Significant Pollutant Linkage in line with the criteria set out in paragraphs A.31 and A.32 of the Statutory Guidance.

The contamination detected at ***the area of the former RAF Kinloss site assessed within this report*** is all currently buried at depth. Current habits at the site do not intrude into the ground to any significant depth thus there is no current pathway for encounter via skin contact, ingestion and inhalation. Exposure via external gamma irradiation is possible but is significantly below the relevant thresholds in the RCL statutory guidance.

4. Conclusions

The contamination present at the alienated land adjacent to former RAF Kinloss does not meet the definition of Radioactive Contaminated Land under its current use.

Some areas of the alienated land adjacent to the former RAF Kinloss site where contamination may be present both at surface and at depth have not been monitored due to access restrictions. Therefore SEPA will periodically review the site to determine if access to these areas changes under the definition of current use as stipulated by Part IIA Statutory Guidance. SEPA has formally advised Moray Council to advise that any change in land use will need to address the radioactive contamination present. Periodic monitoring may also be undertaken to determine whether any changes in the distribution of the contamination may have occurred.

SEPA undertook additional monitoring and a partial resurvey in January 2015. No sources were recovered during 2015. Additional areas of contamination were identified at comparable levels to that found in 2013 (in terms of isolated areas of elevated dose rate). This additional information does not change the conclusions of this report. Moray Council and the land owner will be made aware of the new information.

5. References

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RAF Kinloss Surface Water Treatment Project – Southern Study Area, Outfall 1 to Borehole 106. Desk Study Review and Phase 2 Land Quality Assessment, Entec, 2005

Appendices

- Appendix 1	2013 Photographs
- Appendix 2	2015 Photographs
- Appendix 3	Details of Monitoring Instruments Used in 2013 & 2015
- Appendix 4	Schematic showing break down of contaminated objects

The following appendices contain data that is likely to result in identification of a contaminated area and is to be removed from the public record.

- Appendix R1	2013 Photographs
- Appendix R2	2015 Photographs
- Appendix R3	GIS Plot of 2013 & 2015 data
- Appendix R4	Location Map & GPS data

Appendix 1: 2013 Photographs

The following images are taken from SEPA's August 2013 monitoring exercise at the former RAF Kinloss. Images are selected to depict the general surroundings of the elevated areas where excavations took place. Several areas were dug by hand to ascertain the physical nature of the contamination. Prior to digging dose rate measurements were taken in around the dig location at 1 metre height (approximately hip height) in 4 compass locations, alongside a surface count rate and dose rate over the highest point. If materials were identified, these were photographed and returned to the pit. Once the pits were backfilled and the ground 'made good', the dose rate and count rate measurements were retaken. In all excavated pits the dose rate and count rate measurements were lower than pre-dig conditions, indicating that material was buried with a greater degree of shielding than existed in the pre-dig condition.

The images show the types of contamination that have identified as (1) artefacts (dials etc.), (2) clinker and (3) diffuse contamination (e.g. contamination amongst soil). Not all artefacts recovered were contaminated, but are shown to demonstrate the general wastes under the soil layers.

Figure A1-6: Red Flag indicating elevated count rate area on grassed area.

Figure A1-7: Excavation of area showing contamination at approx. 10 cm depth

Figure A1-8: Radium luminised dial with needle recovered from excavated area

Figure A1-9: Buried dial in excavation pit. Also note blue residue from suspected corroded battery residue (copper sulphate).

Figure A1-10: Spoil with elevated count rate and no point source

Figure A1-11: Close up of elevated spoil

Figure A1-12: Elevated spoil in context with surroundings

Figure A1-13: Radium 226 identified in spoil by RT-30 2x2 sodium iodide detector

Figure A1-14: Spoil returned to excavated hole

Figure A1-15: Excavated pit


Figure A1-16: Radium contaminated items within excavated core

Figure A1-17: Item recovered from excavated pit

Figure A1-18: Contaminated and other items within spoil from excavated pit

Figure A1-19: Item recovered from excavated pit

Figure A1-20: Item recovered from excavated pit


Figure A1-21: Item recovered from excavated pit

Figure A1-22: Contaminated item recovered from excavated pit (side 1)

Figure A1-23: Contaminated item recovered from excavated pit (side 2) with RT-30 elevated count


Figure A1-24: Contaminated item in excavated pit in situ


Figure A1-25: Contaminated item from excavated pit (side 3)

Figure A1-26: Contaminated item from excavated pit (side 4)

Figure A1-26: Multiple items from excavated pit

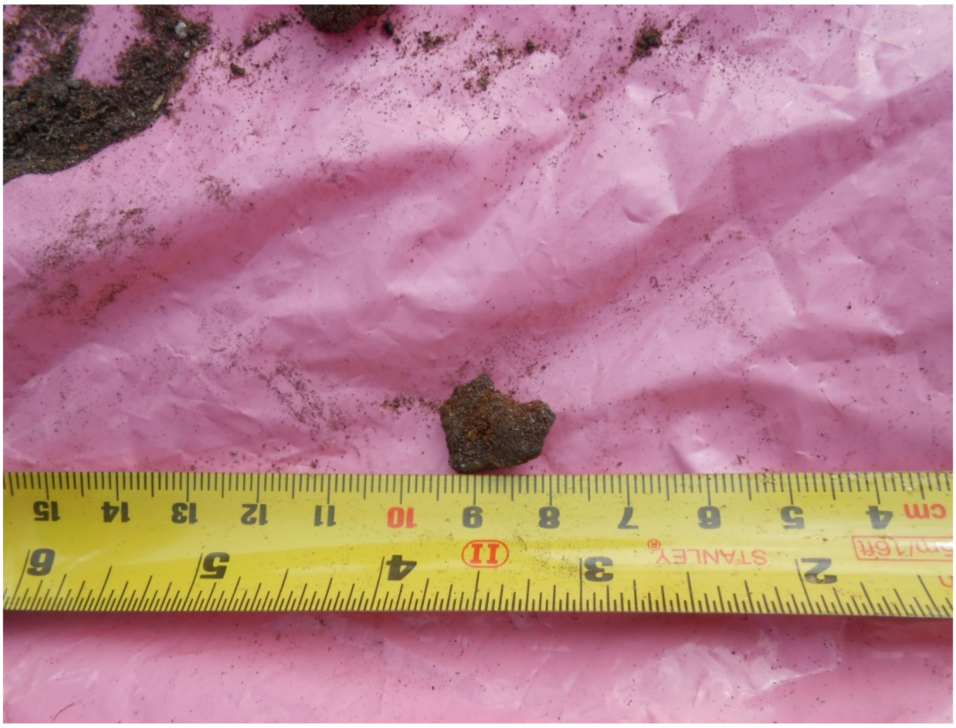

Figure A1-27: Contaminated clinker piece from excavated pit

Figure A1-28: Side profile of excavated pit (approx. 28 cm to base)

Appendix 2: 2015 Monitoring

No photographs are available from the 2015 monitoring as all photographs show images that would allow identification of the site. No pits were dug and no items were detected on the surface, therefore no photographs were obtained.

Appendix 3: Monitoring Instruments

<u>RT – 30</u>

A Sodium-Iodide (NaI) monitoring system with a compensated Geiger-Muller (GM) tube, which allows the identification of specific radionuclides in the field through an 'analysis' tool. No direct GPS output. Enclosed GM tube allows dose rate assessment.

Detector system

- NaI/(Tl), 51 x 51 mm (2" x 2") crystal, 104 cm^3 (6.3 in^3),
- Energy compensated GM tube
- Spectrometer
- 1024 channel MCA, bipolar pulse shaping – allows identification of radionuclides and an indication of natural or industrial origin
- Energy range 20keV – 3.0 MeV
- Stabilises on 3 natural radionuclides (removing the need for calibration source on site)
- Calibrated against a source of known activity annually
- Can link with other devices (GPS, PC, etc.) via bluetooth

Gamma ray sensitivity at 1m

- 160 cps/1MBq for Cs-137
- 75 cps/1MBq for Am-241
- 270 cps/1MBq for Co-60

Dose meter

- Energy corrected dose rate for NaI detector
- Compensated GM tube 10 mSv/h (1R/hr)

Display

- Counts per integration period
- Instantaneous dose rate per second
- Collective dose rate over entire monitoring period

Monitoring methodology

RT-30 Equipment Settings:

- Normal field settings
- 1 second integration time
- 1 second counting time periods
- Walk speed 1 m/s
- Transect distance 1m
- Height above ground: 10cm with locally closer when elevated count rate detected

Identify mode: Variable time period
Radionuclides identified after extended periods e.g. 1800 seconds may well be natural or very low level at point of measurement.

“SMOGSS”: SEPA Mobile Gamma Spectrometry System

A sodium-iodide (NaI) field monitoring system capable of identifying the presence of significant gamma-ray emitting radionuclides in the environment to a limited depth (dependent on instrument settings). Data stored on laptop allows direct GIS display and post monitoring examination of data.

Detector system

- 76mm x 76 mm NaI(Tl) detector (3” x 3”) by Saint-Gobain, connected to the Digibase.
- 64 bit operating system (laptop) with SMoGSS software, with three USB inputs.
- ORTEC’s Digibase© digital spectrometry electronics with “Maestro” software. Includes USB cable to the laptop.
- The GPS SX Blue II GPS system provides a nominal positional accuracy of 0.6 m, with external aerial (and hat), built by Geneq, with SC Blue software.
- Energy range 20keV – 3.0 MeV
- Full energy spectrum captured during each sampling frequency allows specific radionuclides to be examined post monitoring.
- Seven energy windows which can be preset for specific radionuclides of interest, full or part of total gamma counts.

Display
Lap top displays detectors in use and current and previous 30 seconds of spectra displayed as a rainbow. Seven windows of current and historic count rate can be observed via mouse movement on these screens. Pre-set alarms can be set either at threshold or as factor of previous data.

Monitoring Settings:

- Normal field settings
- 1 second integration time
- 1 second counting time periods
- Walk speed 1 m/s
- Transect distance 1m
- Above ground height: 10cm

Nominal LoD using these settings 95% Confidence Interval 20kBq Ra-226 source at 10cm depth

Appendix 4: Schematics showing how source breakdown could occur

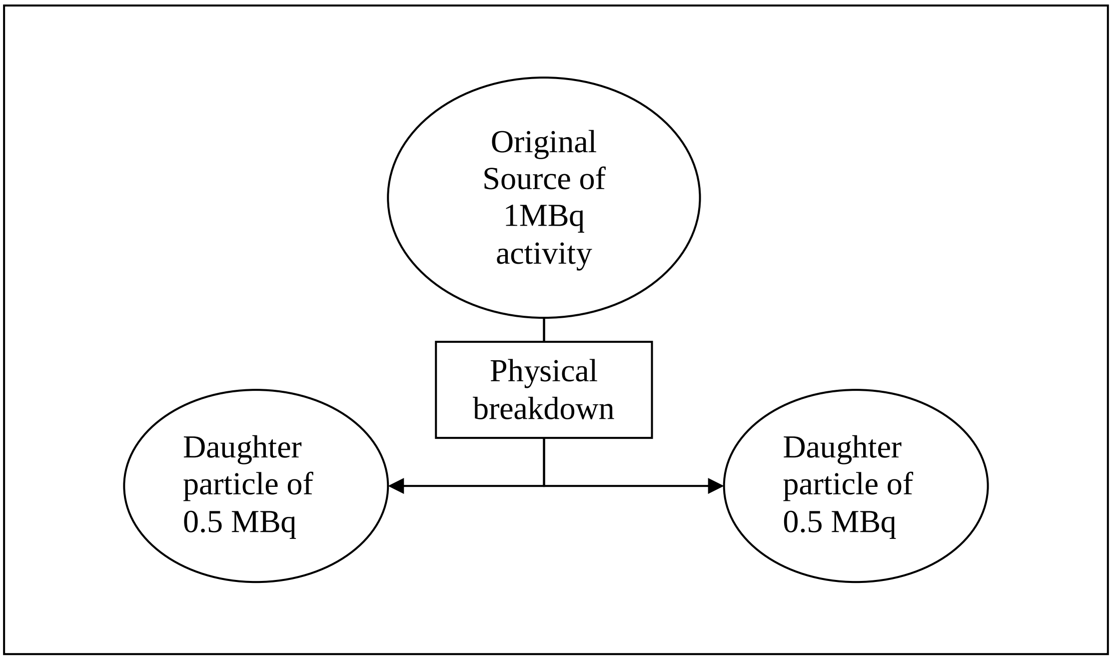

Figure A4-1: A source physically breaks into 2 equal sized particles both of which contain equal amounts of radioactivity. The hazard from skin contact is reduced, although as particles become physically smaller the possibility of ingestion and inhalation increases. As the number of sources has increased the possibility of contact has also increased

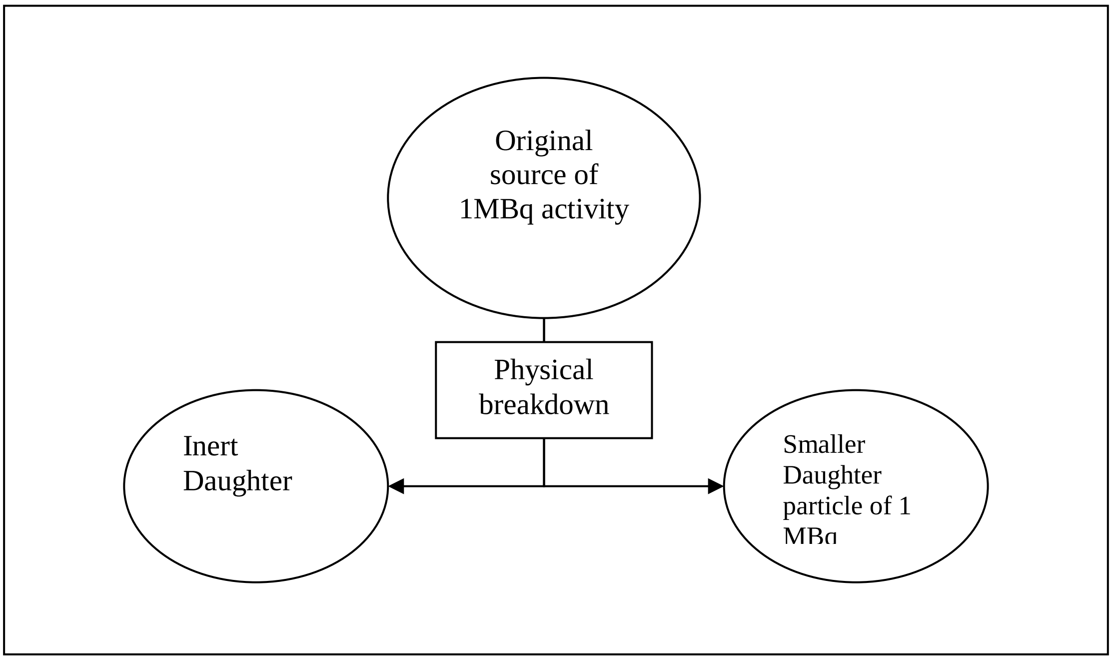

Figure A4-2: A source physically breaks into 2 equal sized particles one of which contains all the radioactivity. The hazard from skin contact remains the same, as the particle has become physically smaller the possibility of ingestion and inhalation increases. The possibility of contact remains the same**.**

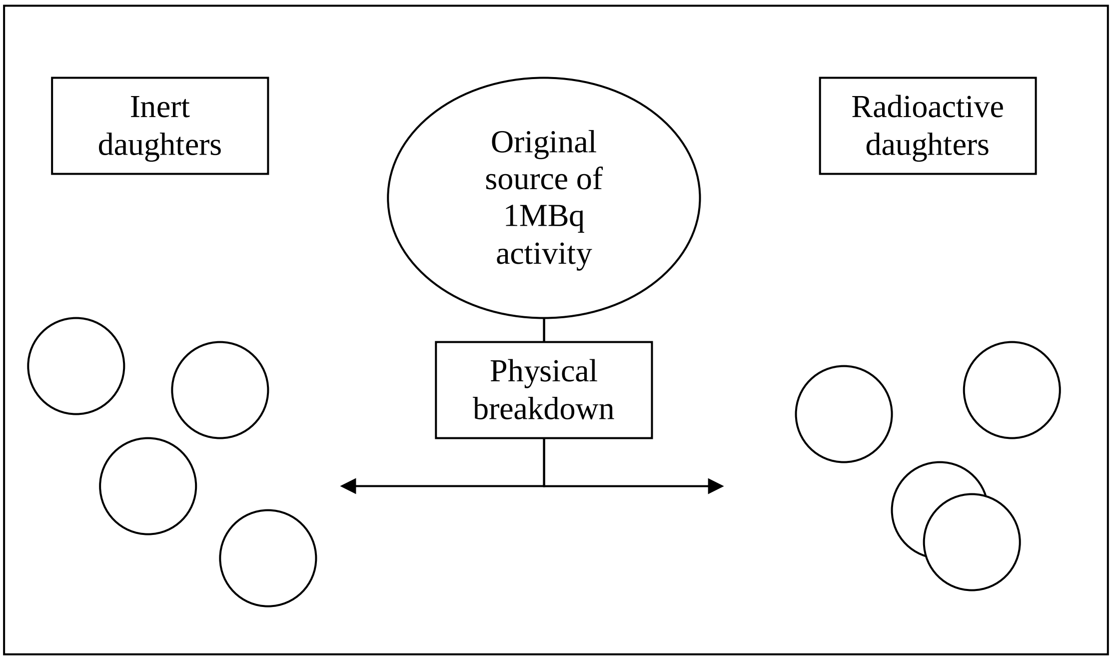

Figure A4-3: A source physically breaks into many smaller particles some of which contain radioactivity. The hazard from skin contact is reduced, although as particles become physically smaller the possibility of ingestion and inhalation increases. As the number of sources has increased the possibility of contact has also increased**.**