NFLA Radioactive Waste Policy Briefing Number 81: Radioactive Waste Disposal from HMNB Clyde

Prepared for NFLA and KIMO member authorities, February 2020

Radioactive Waste Disposal from HMNB Clyde

i. Overview of Policy Briefing

This edition of the NFLA Radioactive Waste Policy has been developed by the NFLA Secretariat and has been jointly prepared with support from our partner organisation KIMO International. The Ministry of Defence (MoD) has submitted an application to the Scottish Environment Protection Agency (SEPA) for the disposal of radioactive waste at Her Majesty's Naval Base (HMNB) Clyde, Coulport and Faslane. The application covers discharges from a new effluent treatment facility at Faslane and seeks to update existing arrangements. SEPA is now consulting on these proposals and responses can be submitted until 6th March 2020.

The consultation documents are available here:
https://consultation.sepa.org.uk/radioactive-substances-unit/hmnb-clyde-application-consultation/consult_view/

Submissions can be made in writing to: The Registry Department, Scottish Environment Protection Agency, Angus Smith Building, Parklands Avenue, Eurocentral, Holytown, North Lanarkshire, ML1 4WQ.

Or by email to: RSenquries@sepa.org.uk

1. Background

This application by the MoD covers proposed discharges from a new effluent treatment facility at Faslane and seeks to update existing arrangements. The MoD is building a Nuclear Support Hub (NSH) at Faslane which will centralise the existing radioactive waste handling facilities and radiochemistry laboratories.

The NSH is situated in a new location within the Faslane site, with a new effluent discharge point into the middle of the Gare Loch. This is one of the reasons that a new site agreement is needed. Faslane's function is to support the operation of nuclear submarines including routine maintenance and the provision of associated services. The number of nuclear submarines which operate from Faslane is scheduled to increase. This will be the main reason why, despite the application being for lower absolute limits for liquid radioactive discharges into the Gare Loch, actual discharges are expected to increase, some by very large amounts. ***NFLA strongly objects to these increased radioactive discharges which, if permitted by SEPA, would result in increased radioactive contamination of the entire Gare Loch, including its flora and fauna, and would result in increased radiation doses to people living in the vicinity of the Loch.***

The MoD is exempt from the provisions of the Environmental Authorisations (Scotland) Regulations 2018(EASR). However, MoD policy states that:

"Where Defence has exemptions, derogations or dis-applications from HS&EP legislation, we maintain Departmental arrangements that produce outcomes that are, so far as reasonably practicable, at least as good as those required by UK legislation."

In NFLA's view, there is no good reason for these exemptions, derogations and dis-applications from HS&EP legislation. These should apply to the MOD as they do to all employers. This is particularly the case for all civilian contractors.

Page 10 of document 1 says:

"It should be noted that although there are plans to increase the numbers of submarines at Faslane this does not represent any change to the nature of the radioactive waste arising although it may have an impact on the quantity of waste produced."

In other words, the amount of radioactive wastes will be substantially increased.

2. Faslane

Currently, liquid wastes generated from operations at Faslane can be conveniently split into 3 distinct groups:

1. Effluent discharged directly to Primary Effluent Tanks (PETs) for routine processing at the Radioactive Effluent Disposal Facility (REDF);
2. Liquid waste collected in carboys (a rigid container like a demijohn) from controlled contamination areas which may also include hazardous chemicals; and
3. Large volumes of conventional effluents from submarine that are not directly associated with submarine nuclear reactor plant.

Sources of liquid waste arising at Faslane include:

a. The bulk of activity discharged originates from the operation of submarine reactor circuits and associated plant.
b. Small volumes arise from maintenance work and on shore laboratories.
c. Liquid waste also arises from conventional operations within the submarine that are not associated with the reactor and are often referred to as general effluents. These effluents contain pollutants such oils, greases and sewage. Tritium has been detected at levels below 1 Bq/ml: this means 1,000 Bq per litre which is a relatively high concentration. Due to the non-radioactive contaminants these effluents are not suitable for treatment as radioactive effluents. Furthermore, the MOD application claims that there is no practical way of removing the tritium. The application seeks to increase the permitted concentration level from 1000 to 100,000 Bq/l but allegedly with no increase to the overall total activity disposed. It remains to be seen whether this will be so in practice, as higher concentrations have been found in similar effluents produced at other UK naval bases.
d. Trim and ballast water is used to adjust submarine buoyancy and manoeuvrability. This water sometimes contains allegedly "trace" amounts of tritium.
e. Chemically contaminated wastes containing low levels of radioactivity occasionally arise from submarine operations. This contains tritium but the MOD states it does not know where this tritium comes from: this does not inspire confidence in the MOD application. The chemical content means that they are unsuitable for ion exchange and are therefore unsuitable for onsite treatment. Currently there is no agreed disposal route for these wastes.

The table below outlines liquid discharges from the Faslane site.

Table 2: Liquid Discharges from Faslane

Radionuclide	Current Rolling 12 Monthly total Limit (MBq)	Previous Annual Discharges (MBq)					MoD proposed annual limits (MBq)
		2014	2015	2016	2017	2018	
Cobalt 60	500	0.12	0.63	0.33	0.68	0.49	100
Tritium	1,000,000	3810	19500	11000	330000	5816	500,000
Gross beta	500	0.25	1.47	0.66	1.36	0.99	100
Gross alpha	200	0.02	0.12	0.07	0.14	0.10	50
Carbon 14	n/a						100

3. Tritium

It is noticeable that these discharges are dominated by tritium, the radioactive isotope of hydrogen. In NFLA's view, the MOD needs to develop its awareness of the multiple hazards of tritium and its expertise in handling tritiated wastes. Contrary to the MOD's apparent view that tritium's is not very hazardous, the reality is that it is a very hazardous internal emitter indeed. (1)

In recent years liquid discharges from Faslane have been considerably lower than agreed limits. As can been seen from table 2 above MoD have proposed substantial reductions in annual limits***. In the interests of transparency, NFLA considers that an explanation for the massive increase in tritium discharge in 2017 should be explained.***

Of course, what the public will be concerned about is the actual level of discharges, rather than the proposed limit. In recent years we have seen several applications by nuclear operators where the proposed limits are being decreased, but the expected actual level of discharges is increasing.

The new proposed limits include, for the first time, a specific limit for Carbon-14. It has taken the MOD a long time to recognise that C-14 is a significant radionuclide in nuclear submarines.

4. Gaseous waste discharged at Faslane

Sources of gaseous wastes are limited to discharges from the Radiochemical Laboratory, evaporation from effluent tanks and ventilation of the solid waste handling facility; (see section 3.8 of paper 4b). MoD reviewed current practices and the arrangements for the NSH to characterise and quantify the likely gaseous wastes. This work is reported in sections and 5.8-5.10 of paper 4b and suggests the following annual numerical limits for the NSH:

Tritium - 200MBq
Carbon 14 – 1MBq
Noble Gases - 100MBq

The MOD application states "Any gaseous releases direct from the submarine are regulated by the Defence Nuclear Safety Regulator (DNSR) in accordance with the SEPA MoD agreement relating to matters involving radioactive substances."

In NFLA's view, this "sweeping under the carpet" treatment for such gaseous emissions is regrettable.

5. Solid Waste

Solid waste arises from a number of submarine support activities including routine maintenance and the decommissioning of obsolete equipment and facilities. Previously solid waste has been disposed of to Drigg or Sellafield. It is now standard practice for SEPA allow the transfer of waste to any site that is lawfully entitled to receive it without specifying the site, subject to the application of best practical means.

In summary the proposed changes to the liquid, gaseous and solid arrangements for Faslane are:

1. Continue disposal of liquid wastes to the Gare Loch but with reduced limits.
2. To increase the concentration of tritium but not the total activity in general effluents discharged.
3. Allow for the receipt, treatment and disposal of radioactive effluents associated with supporting submarines at foreign ports or Coulport.
4. To add limits for the discharge of gaseous wastes at Faslane.
5. Disposal of low-level radioactive waste (LLW) will be brought in line with SEPA standard practice for all civil sites such that it will no longer be restricted to named facilities within the UK and will not be restricted in terms of volume or additional activity constraints. Regrettably SEPA does not explain why no restrictions are to be imposed.

6. Coulport

Weapon support activities at Coulport result in the generation of small quantities of solid and gaseous waste. Gaseous waste disposal may occur during weapon container storage or when the containers are opened in the Weapon Processing Area (WPA). In addition, material used to control the environmental conditions within weapon containers may become contaminated with tritium during use and, following analysis, may require disposal as radioactive waste.

In 2011 the level at which tritium contaminated waste is considered 'out of scope' of RSA93 was raised from 0.4 Bq/g to 100 Bq/g. ***The NFLA was not consulted about this large relaxation in standards and fails to see why such a massive increase was permitted.***

This increase has meant that 95% of desiccant – used to control humidity in weapons stores and transport containers is now assessed as <100 Bq/g and disposed of as non-radioactive waste. Only a few kg of desiccant has been disposed of as radioactive waste since 2011.

Limited submarine maintenance currently takes place at the Explosive Handling Jetty (EHJ) at Coulport. Currently any radioactive waste generated (presumably not including gases?) must be stored on-board until the submarine berths at Faslane.

All solid radioactive waste generated is transferred to Faslane for storage and eventual disposal.

Gaseous releases from Coulport are solely of tritium. It is proposed to reduce the annual rolling limit from 50 GBq to 25 GBq. However, 25 GBq/a remains a very large amount.

The MoD has asked to be allowed to transfer of low-level solid wastes from Coulport to Faslane. It also wants to agree with SEPA suitable routes for liquid waste disposals from Coulport for treatment at Faslane or disposal as a general effluent.

7. Increases in liquid radioactive waste discharges

For the NFLA, the area of most concern with regard to this application is the proposed large increase in liquid radioactive discharges from the Effluent Treatment Plant when compared to discharges in 2018.

The table below, from the SEPA document outlines the discharges of liquid radioactive waste.

Radionuclide	ETP Receipt				ETP Discharge
	PETs	Active Effluent Lab	SWHP	**Total All Sources**	
H-3	1.75E+11	3.00E+06	3.58E+07	**1.75E+11**	**1.75E+11**
C-14	1.92E+08	6.00E+06	8.00E+06	**2.06E+08**	**5.15E+07**
Mn-54	1.20E+07	7.80E+04	6.30E+05	**1.27E+07**	**1.61E+06**
Fe-55	1.92E+07	2.40E+06	3.00E+06	**2.46E+07**	**6.15E+06**
Co-58	1.80E+06	7.35E+04	2.66E+05	**2.14E+06**	**3.15E+05**
Co-60	1.68E+08	9.21E+05	1.13E+07	**1.81E+08**	**2.34E+07**
Ni-63	1.31E+08	3.90E+06	5.40E+06	**1.40E+08**	**3.50E+07**
Ag-110m	9.52E+06	1.08E+05	3.10E+06	**1.27E+07**	**8.89E+05**
Sn-113	0.00E+00	0.00E+00	2.62E+05	**2.62E+05**	**4.11E+03**
Sb-124	3.52E+06	0.00E+00	4.00E+04	**3.56E+06**	**6.18E+05**
Sb-125	8.11E+06	0.00E+00	5.70E+05	**8.68E+06**	**1.54E+06**
Cs-137	2.12E+07	2.63E+05	4.18E+05	**2.19E+07**	**5.18E+06**
Ce-144	2.14E+06	3.06E+05	6.72E+05	**3.11E+06**	**4.89E+04**
Total Alpha	7.20E+05	9.00E+04	1.20E+05	**9.30E+05**	**2.33E+05**

Table 4. NSH Radionuclide Concentrations (Bq/y) - Receipt and Discharge.

Proposed increases in liquid discharges: 2018 Liquid Discharges compared to those expected from the ETP and the percentage increase.

	Liquid discharges in 2018	**Expected ETP Discharge**	**Factor Increase**
Cobalt-60	0.49 MBq	23.4 MBq	47. 76 fold
Tritium	5,816MBq	175,000 MBq	30. 09 fold

The tables above show that proposed tritium discharges could increase by 30 fold and discharges of cobalt-60 by about 50 fold.

If the MoD wishes to “produce outcomes that are, so far as reasonably practicable, at least as good as those required by UK legislation” then it is safe to assume that it would also wish to comply with international treaty obligations. At the very least SEPA should insist on such obligations being observed. ***The NFLA is concerned that this application indicates a lack of compliance with the UK’s obligations under the OSPAR Convention on the Protection of the Marine Environment of the North East Atlantic.*** Under the treaty the UK Government is committed to:

“...progressive and substantial reductions of discharges, emissions and losses of radioactive substances, with the ultimate aim of [achieving] concentrations in the environment near background values for naturally occurring radioactive substances and close to zero for artificial radioactive substances.” [by 2020].

The application of “best available techniques and best environmental practice, including, where appropriate, clean technology” is one of the Guiding Principles of the OSPAR Strategy with regard to radioactive substances.

“Clean Technology” should not, in the view of many environmental commentators, involve end-of -pipe filters to remove pollution from discharges to the environment – ***it should include techniques which produce no pollution to begin with.*** The requirement for ‘Best Available Techniques’ (and clean technology) should ***rule out the use of nuclear-powered submarines*** which produce highly dangerous wastes when alternative methods of propulsion exist which are safer, less dangerous, and do not involve hazardous radioactive wastes.

8. Application of BPM to Liquid Radioactive Waste Handling Arrangements

As a result of MoD's agreement with SEPA, the Site Operator, the Naval Base Commander (NBC), is expected to use best practicable means (BPM) for reducing both the volume and the activity of waste generated for disposal.

SEPA says "the use of BPM is of increasing importance as it is a key mechanism to achieve the Government policy aim of progressive reductions in radioactive discharges into the marine environment." (2)

BPM is defined as "…that level of management and engineering control that minimises, as far as practicable, the release of radioactivity to the environment whilst taking account of a wider range of factors, including cost-effectiveness, technological status, operational safety, and social and environmental factors".

It will be noted that this definition hinges on "practicability" and is not qualified by "reasonableness". This means that treatment technology must be closely considered. A review of treatment technology for the abatement of tritium was undertaken in 2015. The high additional cost, operator training, and maintenance of an unfamiliar system was deemed by the MOD to be "grossly disproportionate" to the "relatively low environmental benefit" of abating tritium releases.

However. NFLA begs to differ on this matter as tritium is by far the most important nuclide under consideration, and to sweep it away in such an arbitrary manner is unacceptable. At the very least, the MOD should indicate its findings from its review of the scientific literature on this matter. In addition, NFLA begs to differ from the MOD's statement that the environmental benefits would be "relatively low". Has the MOD considered the issue of organically bound tritium in the flora and fauna of the Gare Loch?

Effluent treatment in the new Effluent Treatment Plant would be a two-stage process that utilises both staged cartridge filtration and Ion Exchange (IX) resin. The process is designed to achieve optimal reduction in the radioactivity content of the treated effluent. The IX process is designed to specifically remove Co-60.

In the NFLA's view a sustainable radioactive waste management policy must be based on a clearly stated set of environmental principles, in particular:

- the polluter pays principle,
- the concentration and containment principle
- the precautionary principle and
- the proximity principle.

Management should also use the Best Practicable Environmental Option. (BPEO) which, according to the Twelfth Report of the Royal Commission on Environmental Pollution (RCEP) (1988) should be "the outcome of a systematic consultative and decision-making procedure which emphasises the protection and conservation of the environment across land, air and water."

The MOD's application signally fails to consider these principles.

In the NFLA's view, national defence should not be used as an excuse for increasing discharges into the environment when there are ways of achieving the same ends which don't require the discharge of radioactive waste into the environment. ***In other words, we should be asking ourselves whether we can achieve the defence outcome that we need without using a system which generates large amounts of radioactive wastes.***

According to Kyle Mizokami, nuclear power is not necessary for a submarine to function, and run silently if an air-independent propulsion (AIP) system is used. (3) Non-nuclear air-independent propulsion (AIP) submarines offer several important advantages over nuclear submarines, as seen in submarine development in countries such as Germany and Sweden. Conventional diesel-electric engines are a popular means of propulsion for non-nuclear boats, and there are several AIP options, but hydrogen-powered fuel cells offer more than any other option. (4) Japan's new Soryu class of submarines is one of the best non-nuclear submarines on the planet. (5) NFLA recommend the MoD pursue these alternative non-nuclear options.

9. Dose Assessments

The MoD says it has carried out comprehensive dose assessments using worst-case discharge information, and these have concluded that doses are trivial and are "well below the threshold for optimisation of 20 µSv per year". (Document 4b p5)

The predicted individual dose to the adult population (identified as the representative individual for Faslane) from all sources is 3.14 x 10-6 mSv = 0.00314µSv (document 4b page 43) (6)

The predicted collective dose to the World population over a period of 500 years from all sources is 6.15 x 10-4 manSv.

The Food Standards Agency appears to agree saying liquid waste represents the vast majority of the applied for discharge limits (approximately 99.5%) and is primarily composed of tritium (500 GBq), with much smaller contributions from Co-60, C-14, and other radionuclides. Having considered the aqueous and aerial routes for emission of radionuclide discharges to the environment under the new proposed limits, the FSA estimates an effective dose, to the representative person of 0.2 µSv/year, significantly below the exposure level that would require model refinement, of 20 µSv/year, associated with a one-in-one million risk of death. Therefore, the FSA does not believe that the applied for limits of radioactive discharges represent a significant risk to human health via the food chain.

If we assume that the computer models used by the MoD and the FSA are correct then the impact of these discharges on human health might be quite small. However, the Environment Agency (of England) points out that:

"Government policy on radioactive discharges states that unnecessarily introducing radioactivity into the environment is undesirable, even at levels where doses to humans and other species are low and, on the basis of current knowledge, are unlikely to cause harm." (7)

And it is worth noting that an important report by the UK's influential Advisory Group on Ionising Radiation (AGIR) (November 2007) (8) suggested that current dose estimates for tritiated water are too low. This is in line with similar findings by the UK Government's CERRIE report. (9)

A number of factors combine to make tritium of particular concern. Firstly, it is almost ubiquitous in the environment and biological systems, and it is very mobile due to its occurrence as water. While many radionuclides only occur as one or two common forms, tritium can become incorporated with many different organic compounds with different behaviour in the environment and human body. Tritium emits a beta particle with high energy over a short track length. Tritium is often described as a "weak" emitter, but is actually 2-3 times more hazardous than most gamma/beta emitters. (10)

Extensive studies show that different radiation types produce different biological effects per unit of absorbed dose. This is expressed as Relative Biological Effectiveness (RBE), or radiation weighting factor. Based on the available scientific evidence, AGIR strongly recommended that tritium's RBE (and radiation weighting factor) should both be doubled from 1 to 2. (The US EPA has recommended 2.5)

Dr Ian Fairlie, a former advisor to the UK Government's Committee Examining Radiation Risks of Internal Emitters (CERRIE), says current dose models for tritium are poor, as there is no recognition of tritium levels building up in tissue to high levels from chronic exposures; no consideration of the heterogeneous distribution of tritium in the body, especially Organically Bound Tritium (OBT) and OBT is badly modelled with experimental animal and human data being ignored. (11) Fairlie argues that, all factors included, we should increase tritium doses figures by a factor of at least 20.

9. Spent Submarine Reactor Fuel

The Ministry of Defence has yet to provide a credible scientific case for nuclear waste 'disposal'. A deep geological disposal facility (GDF) is not expected to be ready to receive waste until around

2040 at the earliest. It will take around 90 years for all of the UK's existing legacy waste (civil and military) to be emplaced, so spent fuel from new submarines now being constructed cannot begin to be emplaced until at least 2130. As well as being a radiation hazard, this means spent fuel containing weapons-useable highly enriched uranium will have to be safely stored and managed for over another 100 years. ***NFLA believes the MoD should not be producing more submarine reactor spent fuel when there is still no agreed long-term form of management.***

10. Conclusions

The NFLA has 5 core conclusions from the MoD's application which it wishes to bring to the attention of SEPA:

1. The MoD's application involves expected ***increases in discharges of tritium by as much as 30-fold and discharges of cobalt-60 by almost 50-fold.***
2. Whilst the individual and collective doses estimated by the MoD and FSA are relatively small, there are ***considerable uncertainties*** involved with the modelling especially with regard to tritium.
3. Doses attributed to tritium ***should be multiplied by around 20*** in order to use a precautionary approach.
4. UK Government policy is that ***unnecessarily introducing radioactivity into the environment is undesirable,*** even at levels where doses to humans and other species are purportedly low and, on the basis of current knowledge, are unlikely to cause harm.
5. The Clean Technology choice for powering submarines would not involve using a nuclear reactor. ***Non-nuclear air-independent propulsion (AIP) submarines offer particular advantages over nuclear submarines. NFLA recommend MoD pursue such an option.***

11. References

(1) See Report of Committee Examining Radiation Risks of Internal Emitters (CERRIE), 2004 https://www.researchgate.net/publication/259763240_Report_of_the_Committee_Examining_Radiation_Risks_of_Internal_Emitters_CERRIE

(2) A Review of the Application of 'Best Practicable Means' within a Regulatory Framework for Managing Radioactive Wastes, SNIFFER, March 2005 https://www.sepa.org.uk/media/101493/review_of_the-_application_of_best_practicable_means_-within_a_regulatory_framework_for_the_management_of_-radioactive_wastes.pdf

(3) National Interest 15th September 2019, https://nationalinterest.org/blog/buzz/these-are-quietest-most-stealthy-non-nuclear-subs-ever-exist-80436

(4) US Naval Institute June 2019 https://www.usni.org/magazines/proceedings/2019/june/non-nuclear-submarines-choose-fuel-cells

(5) National Interest 12th March 2019 https://nationalinterest.org/blog/buzz/run-silent-run-stealth-best-non-nuclear-submarine-planet-earth-47062

(6) To convert from collective doses to fatal cancers, the ICRP's absolute fatal cancer risk of 10% per Sv can be used.

(7) Draft decision document: Sellafield Ltd and Sellafield site Environmental permitting: radioactive substances activities October 2019 para 117 https://consult.environment-agency.gov.uk/cumbria-and-lancashire/sellafield-radioactive-substances-activities-rsa-p/supporting_documents/Sellafield%20Ltd%20RSA%20permit%20draft%20decision%20document.pdf

(8) Review of Risks from Tritium, Report of the Independent Advisory Group on Ionising Radiation, Health Protection Agency, November 2017, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/335151/RCE-4_Advice_on_tritium.pdf

(9) Report of Committee Examining Radiation Risks of Internal Emitters (CERRIE), 2004 https://www.researchgate.net/publication/259763240_Report_of_the_Committee_Examining_Radiation_Risks_of_Internal_Emitters_CERRIE

(10) See https://www.ianfairlie.org/wp-content/uploads/2011/11/Tritium-risks-not-properly-assessed-4.pdf

(11) Fairlie I (2007) RBE and wR values of Auger emitters and low-range beta emitters with particular reference to tritium. Journal of Radiological Protection. Vol 27 pp 157-168 https://iopscience.iop.org/article/10.1088/0952-4746/27/2/003/meta