# APPLICATION TO SEPA FOR AN APPROVAL TO DISPOSE OF RADIOACTIVE WASTE FROM HMNB CLYDE

Issue 1.1
Feb 2019

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**Document Revision Status**

| Issue | Date | Changes |
|---|---|---|
| 1.0 | Oct 2018 | Final Draft |
| 1.1 | Feb 2019 | Amended to address SEPA comments |
| | | |

## Contents

## Executive Summary

Activities carried out at HMNB Clyde generate small quantities of solid, liquid and gaseous radioactive wastes. To ensure the continued safe management of these wastes, HMNB Clyde intends to build and operate a new waste treatment and disposal facility at the north end of the Faslane site.

A comprehensive optioneering study has been conducted to ensure the new facility is designed to reflect modern standards and adopts best practice in the treatment and management of radioactive waste. The new facility, the Nuclear Support Hub, will discharge treated effluent to the Gare Loch at a new outfall. To comply with the requirements of the MoD/SEPA Agreement on Matters Relating to Radioactive Substances, the MoD requires the approval of SEPA to dispose of radioactive wastes from the new facility.

This document makes an application on behalf of the MoD for a Letter of Approval to replace the 4 existing Letters of Agreement that cover radioactive waste disposals at the Faslane and Coulport Sites. Operational experience from across the nuclear propulsion programme, particularly at HMNB Devonport and the Naval Test Reactor Establishment at Vulcan, has resulted in the identification of additional waste streams that are not currently covered by Clyde's existing waste disposal agreements. Other factors that have influenced this application include changes in UK radioactive waste management policy and the potential for radioactive waste generation when submarines are berthed in the Explosive Handling Jetty at Coulport.

This application demonstrates that the best practicable means have been applied in a logical and proportionate manner to each of the waste streams that may arise as a result of routine and non-routine support activities. Gaseous waste discharges at Faslane have also been quantified and suitable numerical limits identified to cover these disposals. HMNB Clyde has taken the opportunity, where practical, to reduce liquid discharge limits and intends to adopt the latest SEPA guidance for the reporting of discharges.

Comprehensive dose assessments have been carried out using worst case discharge information. These assessments conclude that doses are trivial and are well below the threshold for optimisation of 20 µSv per year. The application also includes a description of the proposed environmental monitoring arrangements. The results of this monitoring programme together with the information provided in the latest Habits survey will be used to demonstrate that there is no radiological hazard to any member of the public from radioactive waste disposals from HMNB Clyde.

## 1. Introduction

1.1 Submarine and Weapon support activities carried out at HMNB Clyde generate small quantities of solid, liquid and gaseous radioactive wastes. In Scotland, the disposal of radioactive waste is controlled by the Environmental Authorisations (Scotland) Regulations 2018 (EASR18) with the Scottish Environment Protection Agency (SEPA) as the enforcing authority. The Ministry of Defence (MoD) is exempt from many of the provisions of EASR18, including the provision to have an authorisation to dispose of radioactive waste. However, MoD Policy is to apply administrative arrangements such that equivalent standards of EASR18 are applied appropriately. This is enshrined in the framework for these arrangements; the SEPA/MoD Agreement on Matters Relating to Radioactive Substances[1]. The Agreement commits MoD to seeking approval for the disposal of radioactive waste.

1.2 HMNB Clyde currently has 4 Letters of Agreement (LoAg) for the disposal of radioactive waste (see Appendix A). Two of the LoAg relate to the disposal of radioactive waste from the Faslane site and the other two LoAg cover disposals from the Coulport site. The LoAgs now require review and a new approval is sought for the following reasons:

a. The current solid and liquid radioactive waste facilities at Faslane are to be replaced by a new combined treatment and disposal facility, the Nuclear Support Hub (NSH). The NSH will be located at the north end of the Faslane Site and will discharge treated effluent to the Gare Loch via a new outfall. This new outfall is approximately 1 km due north of the current discharge point.

b. To cover the transfer of submarine related radioactive wastes from the Explosive Handling Jetty (EHJ) at Coulport to the new facilities at Faslane.

c. To ensure appropriate regulation, and the effective and timely disposal of all solid, liquid and gaseous radioactive wastes generated as a result of routine and non-routine support activities.

d. To reflect changes and improvements in UK radioactive waste management policy since the issue of the current LoAgs.

1.3 This document makes an application to SEPA on behalf of the MoD for a Letter of Approval (LoAp) for the disposal of radioactive wastes from HMNB Clyde.

1.4 The responsible person for ensuring the safe and compliant disposal of radioactive waste from HMNB Clyde is:

Naval Base Commander (Clyde)
HMNB Clyde, Faslane
Helensburgh
G84 8HL

1.5 The person who may be contacted about this application is Mr Stephen Kelly, Base Radiation Protection and Radioactive Waste Adviser.

[1] MoD/SEPA Agreement on Matters Relating to Radioactive Substances 2017.

## 2. Background

### 2.1 General Description of HMNB Clyde

2.1.1 HMNB Clyde is comprised of 2 main areas at Faslane and the Royal Naval Armaments Depot (RNAD) at Coulport.

2.1.2 Faslane is the Royal Navy's principal submarine base. It is located some 35 miles North West of Glasgow and some 7 miles North of Helensburgh on the eastern shore of the Gare Loch in Faslane Bay. HMNB Clyde is the home port of the UK's nuclear deterrent and also provides berthing facilities for conventional surface vessels. Undertakings at HMNB Clyde can be summarised as the operation and maintenance of nuclear submarines and associated services.

2.1.3 The Gare Loch is a deep-water estuary with few natural hazards. The shallowest point is at the entrance through Rhu Narrows, where the minimum depth is 13.4 m below Chart Datum. Depths elsewhere in the loch are in excess of 20 m. The Gare Loch is approached from the Firth of Clyde via Ardmore Channel which passes through an area of navigable water approximately 360 m wide.

2.1.4 RNAD Coulport is located 2 miles due West of Faslane and is responsible for the storage and handling of weapons in support of the submarine programme. It is situated on the eastern shore of Loch Long.

2.1.5 Loch Long is a deep-water loch with no natural hazards. The minimum depth of Loch Long is 13.7 m below Chart Datum at the mouth of Loch Goil.

2.1.6 Figure 1 shows an aerial photograph of the Faslane and Coulport Sites, including the various berths and weapon processing area.


**Figure 1.** Berthing Facilities and Weapon Processing Area at Faslane and Coulport.

## 2.2 Overview of Waste Generation at HMNB Clyde, Faslane

2.2.1 Regular submarine maintenance is necessary for optimising performance and ensuring safety of the Nuclear Steam Raising Plant (NSRP). Routine maintenance also ensures that radiation exposure of crews and maintenance staff is minimised.

2.2.2 As a consequence of submarine maintenance and repair operations, small quantities of radioactive waste are produced. In accordance with the MoD/SEPA agreement, SEPA has issued 2 LoAg to cover radioactive waste disposals. One letter specifies the numerical limits and conditions associated with the disposal of solid radioactive waste and the other describes the limits and requirements relating to the disposal of liquid and gaseous radioactive waste. The overriding philosophy in both LoAgs is that the Site Operator, the Naval Base Commander (NBC), should use best practicable means (BPM) for reducing both the volume and the activity of waste generated for disposal.

2.2.3 Figure 2 provides an aerial view of Faslane Naval Base. The location of the various submarine berths, existing waste processing & disposal facilities, and the supporting infrastructure such as the radiochemistry laboratories and nuclear repair workshops are identified. The existing waste facilities and supporting utilities are located at the opposite end of the Naval Base from where submarines are berthed.

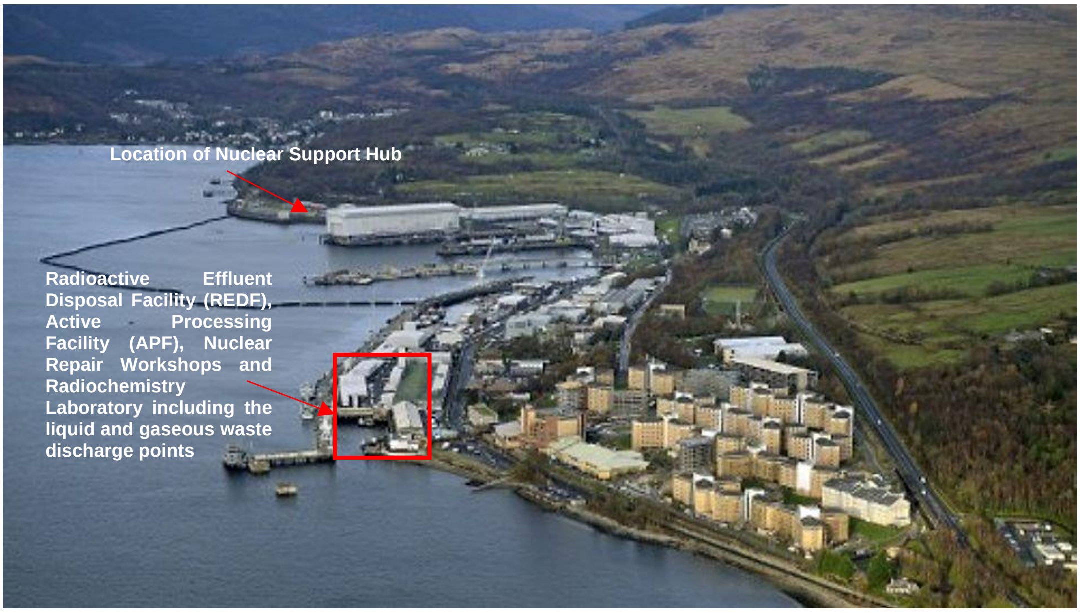


**Figure 2.** Submarine Berths and Supporting Facilities at Faslane.

## Overview of Waste Generation at HMNB Clyde, Coulport

2.2.4 The RNAD at Coulport is responsible for the storage, processing, maintenance and issue of key elements of the UK's Trident Deterrent Missile System and the ammunitioning of all submarine embarked weapons. Weapon support activities 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. SEPA has issued 2 LoAgs for Coulport; one letter covers the disposal of solid waste contaminated with tritium and the other covers the disposal of gaseous waste from the WPA. All solid radioactive waste generated at Coulport is transferred to Faslane for safe storage and final disposal.

2.2.5 In addition to the weapon processing facilities, Coulport also includes the covered EHJ where weapon loading/offloading activities are conducted. Very limited submarine maintenance is undertaken when submarines are berthed in the EHJ and any radioactive waste generated as a result of routine or non-routine activities must be stored on-board until the submarine berths at Faslane and can transfer the waste to the APF or REDF. Transfer of submarine related waste to the facilities at Coulport and then subsequent disposal to Faslane has not been agreed by SEPA.

2.2.6 Figure 3 shows an aerial photograph of the EHJ and the WPA at RNAD Coulport. For security reasons the locations of the various processing buildings have been omitted.

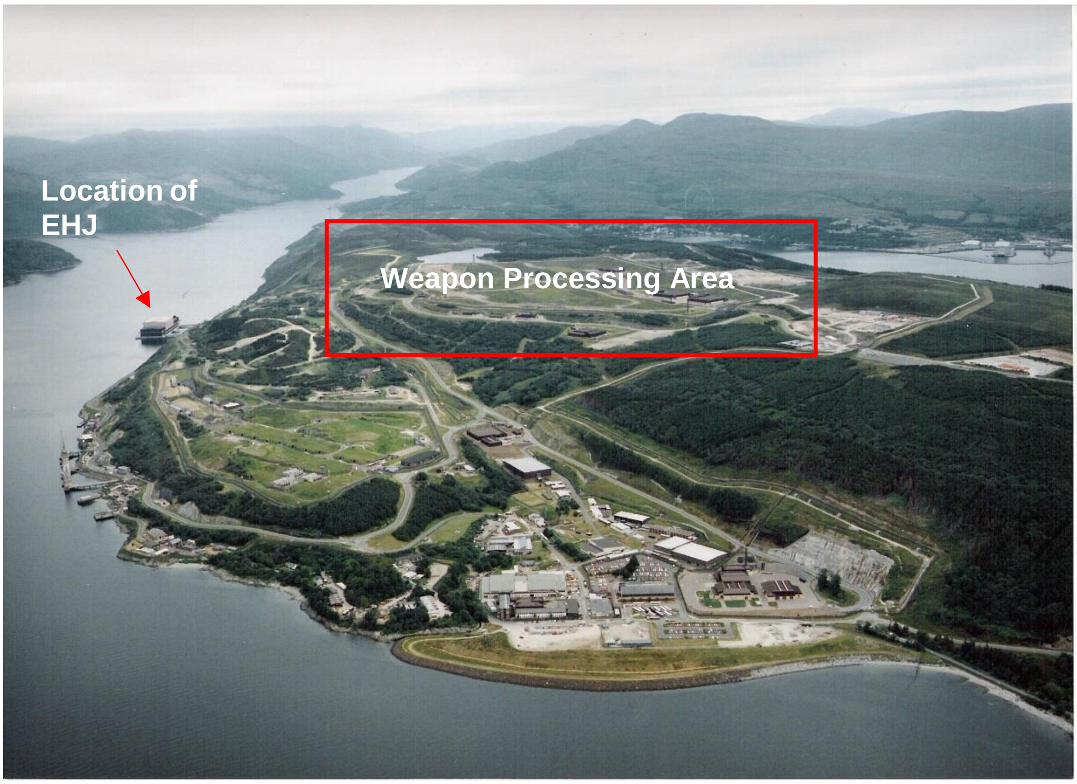


**Figure 3.** Submarine Berth and WPA at Coulport, Faslane is visible in the background.

## 2.3 Regulation of Radioactive Waste and Nuclear Safety at HMNB Clyde

2.3.1 The Faslane and Coulport sites are owned and operated for the purposes of defence and as such are exempt from the requirements of EASR18 (formerly RSA 93) and the Nuclear Installations Act 1965. Notwithstanding such exemptions, it is the policy of the MOD, where practicable, to fully satisfy the standards required by relevant legislation. The Secretary of State's policy statement[2] for health, safety and environmental protection (HS&EP) requires 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

[2] Policy Statement by the Secretary of State for Defence – Health, Safety and Environmental Protection in Defence.

required by UK legislation'. To assist in the delivery of this policy the MOD has appointed the Defence Nuclear Safety Regulator (DNSR). The DNSR's primary function is the regulation of nuclear safety across the Defence Nuclear Enterprise (DNE) holding individuals to account and providing independent assurance of compliance. To achieve this, DNSR aligns regulation as closely as possible to that of the Office of Nuclear Regulation (ONR), deviating only where necessary. DNSR provides non-prescriptive goal setting regulation, utilising Authorisation Conditions (ACs) akin to the civil sector's Licence Conditions, augmented by Further Authorisation Conditions (FAC). HMNB Clyde is an 'Authorised Site' and the Naval Base Commander, as Authorisee, is responsible for ensuring compliance with all ACs. A number of ACs relate specifically to the management of radioactive waste.

2.3.2 AC 32 refers to the accumulation of radioactive waste and requires the production and accumulation of radioactive waste to be minimised and that adequate records are maintained to enable DNSR to monitor the management of radioactive waste. AC 33 refers to the disposal of radioactive waste and gives DNSR the power to direct the Authorisee to dispose of radioactive waste. DNSR only give such direction where the disposal is to be carried out in accordance with a LoAg or equivalent issued by the appropriate Agency (i.e. SEPA in Scotland). AC 34 places a duty on the Authorisee to ensure that radioactive material and radioactive waste is adequately controlled or contained to prevent leaks and escape, and that in the event of any fault or accident, the waste or material can be detected, recorded and DNSR informed.

2.3.3 FAC 3, Radioactive Discharges, results from the need for environmental controls equivalent to those in legislation to apply to all parts of the Defence Nuclear Programme. The purpose of this condition is to ensure that discharges of radioactive waste are minimised and controlled subject to regulatory consent. Radioactive discharges from HMNB Clyde, as an Authorised site, are subject to regulation by SEPA; however, SEPA regulation specifically does not cover discharges directly to the environment from submarines. By nature of reactor and weapon design, gaseous radioactive discharges arise from both the weapon and propulsion programmes. DNSR will only issue consents under FAC3 in relation to the following activities:

a. Low level gaseous radioactive discharges from submarines directly to the environment;
b. The discharges of low level liquid waste directly to the environment where it is not practical for this to be transferred ashore for processing and disposal under a SEPA/EA agreement; for practical purposes, it is anticipated this will be restricted to discharges from submarines at sea.

2.3.4 DNSR and SEPA conduct independent and joint inspections of Clyde's radioactive waste management arrangements on a periodic basis to monitor compliance with ACs and LoAg conditions, and to ensure the application of BPM to waste production and disposal. HMNB Clyde's Assurance Department also conducts routine inspections of Clyde's radioactive waste management arrangements.

### 2.4 Safety Management Arrangements at HMNB Clyde

2.4.1 All activities that could lead to the production and disposal of radioactive waste are subject to approval and authorisation. For activities on-board submarines procedures are written and then reviewed by the Procedural Authorisation Group (PAG) prior to approval. Clyde's policy stipulates 'the PAG shall undertake to minimise and, where possible, avoid the production of radioactive waste when reviewing nuclear documentation and associated Nuclear Reactor Plant maintenance and repair activities'. Key members of the PAG include a professional Health Physicist who must ensure radiation exposures are optimised and the effective application of the BPM principle to all radioactive waste generating activities. In a similar fashion, all activities that could result in the production of radioactive waste in shore-based facilities (e.g. APF & REDF) are subject to approval by the Nuclear Services Authorisation Group.

2.4.2 In addition to approved operating procedures, the policy and strategy for radioactive waste management are captured in HMNB Clyde's Radioactive Waste Standing Orders. These Orders are periodically reviewed to reflect changes in operating practices and to address any changes to statutory requirements or guidance on the application of BPM.

### 2.5 Safety Management Organisation and Responsibilities

2.5.1 The Naval Base Commander, as Authorisee and Site Operator, is responsible for gaining approval from SEPA and consent from DNSR to dispose of radioactive waste.

2.5.2 The Base Radiation Protection Adviser (BRPA) is responsible for preparing and reviewing the applications for waste disposal approvals/consents to both SEPA and DNSR. As NBC's appointed Radioactive Waste Adviser, BRPA is the focal point for all discussions with SEPA and DNSR on waste related issues and is responsible for submitting waste disposal records to SEPA to meet the requirements of the extant LoAg. The BRPA attends the MoD Radioactive Waste Information Group (RAWIG) to ensure lessons learned from the wider defence community are promulgated locally and implemented if practical. It was through this forum that a number of the issues and challenges (e.g. tritium in general effluents) facing the wider Naval Nuclear Propulsion Programme (NNPP) community were highlighted.

2.5.3 The Base Radiation Safety Officer (BRSO) is responsible for ensuring adequate arrangements are in place for the management of radioactive waste to meet the requirements of relevant legislation, the conditions specified in the SEPA and DNSR agreements/consents and Authorisation Condition requirements. BRSO also chairs HMNB Clyde's BPM Working Group. This group was established 5 years ago and provides a forum to discuss the application of BPM to all radioactive waste related support activities.

2.5.4 Babcock Marine staff are responsible for operating the solid and liquid radioactive waste processing and disposal facilities at Faslane. The Radioactive Operations Manager (ROM) is the Facility Manager for the REDF and APF and has overall responsibility for the effective management of solid and liquid waste at HMNB Clyde, Faslane. Babcock Marine and the Oil Pipeline Agency are responsible for effective management and disposal of submarine general effluents that may contain trace levels of tritium.

2.5.5 AWE, as part of the ABL consortium, are responsible for the effective management of solid and gaseous waste at Coulport. The Trident Special Area (TSA) Facility Operator is responsible for the gaseous and solid radioactive waste that is generated in support of weapon operations at Coulport. The Health Physics section at Coulport is responsible for collating waste disposal information and forwarding to the BRPA section. Transfer and disposal of submarine general effluents arising from activities in the Explosive Handling Jetty are the responsibility of Babcock Marine.

### 2.6 Background to LoAp Application

2.6.1 Proposals to replace the REDF have previously been developed initially in 2003 and then in 2007. A decision was taken not to proceed with these projects and the current waste facilities were subject to significant refurbishment in 2009/10. The continued use of the existing REDF was justified up until the end of 2018 however it was recognised that additional recertification work could be carried out to allow the facilities to safely operate up until 2025: this safety justification work has now been completed. A detailed optioneering study for waste management at Faslane was initiated in 2010. The option study was undertaken to identify the optimum solution for waste receipt and processing and to inform the design of replacement facilities. The aim of the study was to identify the preferred solutions for the following activities:

- Effluent receipt and transfer;
- Effluent treatment and disposal; and
- Solid waste handling.

2.6.2 In advance of making any decision about the siting of the new waste facilities SEPA requested that HMNB Clyde conduct a full review of the existing LoAgs. SEPA identified that the letters were older than 10 years and that a number of changes, most notably within the nuclear waste management industry and legislative changes to RSA93, had occurred since the letters had been issued. The review was completed in 2012 and considered the impact of the following:

- The introduction of an ‘out of scope’ limit for Co-60 of 0.1 Bq/g for solid waste.
- The increase in the number of submarines to be ‘home-ported’ at HMNB Clyde.
- The intention to undertake submarine repair and maintenance activities at Coulport.

2.6.3 HMNB Clyde wrote to SEPA in 2012 and requested that the numerical limits for liquid waste disposal at Faslane and gaseous waste disposal at Coulport be reduced. HMNB Clyde also requested agreement from SEPA to allow for the disposal of solid and liquid submarine related waste from Coulport to Faslane.

2.6.4 Prior to completion of SEPA’s determination process a decision was taken in 2014 to build and operate a new combined radioactive waste facility, the NSH, at the north end of the Faslane Naval Base. HMNB Clyde wrote to SEPA in March 2016 requesting that the LoAg review process be superseded by an application for a new approval to cover operations at the NSH. Operational experience gained from Devonport Naval Base, the Naval Test Reactor Establishment (NTRE) at Vulcan and a better understanding of waste generation across the Defence Nuclear Enterprise identified the possibility of additional radioactive waste streams that had not been captured in the original 2012 LoAg review process. In addition, Clyde was keen to explore the benefits of combining the 4 LoAg for Coulport and Faslane into one approval covering the entirety of HMNB Clyde’s operations. In response to this request SEPA acknowledged that receiving additional information to inform the original 2012 review process and a separate application for the NSH could result in two separate consultations at very similar times. SEPA agreed this might cause confusion for consultees as well as adding an additional review burden. SEPA wrote to HMNB Clyde in July 2016 confirming that they had stopped processing the update to the existing 4 LoAgs pending receipt of an application for the new NSH.

2.6.5 The NSH project has now matured to the point of design freeze and the Pre-Construction Safety & Environmental Report (PCSER) for the new facility has been subject to HMNB Clyde's full safety review process. In addition, a presentation has been delivered to Clyde's SEPA inspector to explain how the design and operation of the NSH will address the requirements of BPM. A comprehensive BPM assessment report has been produced and subject to approval by Clyde's BPM Working Group. This report has been shared with SEPA and the resultant comments have been used to improve and optimise the design of the facility (e.g. introduction of a bubbler system to measure C-14 activity levels in gaseous waste discharges).

2.6.6 Lessons learned and operational experience gained from submarine and weapons activities across the DNE have been used to ensure this application fully scopes all potential radioactive waste streams arising from both routine and non-routine activities. This application therefore seeks approval for the disposal of the following waste streams:

a. Solid radioactive waste generated as a result of planned submarine maintenance, repair and support activities at Faslane.
b. Solid radioactive waste arisings from the maintenance of submarines operating with a non-routine NSRP configuration.
c. Transfer of submarine and weapon related solid and liquid wastes from Coulport to the NSH.
d. Primary coolant discharges from submarines operating with both routine and non-routine NSRP configurations. These effluents will be treated through the NSH effluent treatment plant and discharged via the new outfall. These discharges will also include small quantities of liquids from radiochemistry analysis and could include effluents generated at other UK and foreign operational berths.
e. General submarine effluents, not related to the operation of the nuclear reactor plant, that may contain trace levels of tritium. Due to their conventional hazardous properties, these effluents will require treatment by a specialist waste contractor prior to disposal.
f. Small quantities of chemically contaminated liquid waste generated as a result of both routine and non-routine support activities. This material will be unsuitable for treatment via the NSH Effluent Treatment Plant (ETP). A suitable waste contractor authorised to accept radioactive waste will be used for disposal.
g. Gaseous radioactive waste arising from routine operations of both the ETP and the Solid Waste Handling Plant (SWHP).
h. Small quantities of gaseous waste generated from radiochemistry analysis processes including that associated with the investigation of non-routine submarine configurations.
i. Disposal of gaseous waste from operations within the WPA at Coulport.

2.6.7 HMNB Clyde is also seeking approval to continue to operate the REDF and discharge from the existing discharge point for a period of 6 months after active commission/first nuclear use of the NSH. Whilst it is not anticipated this capability will be required it will ensure a degree of redundancy during the initial operating period of the NSH ETP.

During this initial operating period the combined radioactive discharges from both discharge points, if used, will be limited to the new reduced numerical limits for the NSH. After this period the existing Faslane LoAg covering liquid radioactive waste disposal will be revoked.

## 3. Existing Radioactive Waste Management Arrangements, Faslane

### 3.1 Solid Radioactive Waste – Routine

3.1.1 Small quantities of solid contaminated material are generated as a result of submarine maintenance and repair activities. This waste consists mainly of small stainless steel components such as pipework and valves, softs items such as rags and clothes used in submarine controlled contamination areas, polythene sheets that have been used to package contaminated materials and protective clothing/tenting hat has been used during repair activities. On occasion, larger items also have to be removed, such as contaminated pumps and activated steel components. As mentioned in Section 2, all submarine support activities are carefully considered to ensure the application of BPM to the generation of radioactive waste.

3.1.2 On removal from the controlled contamination areas (mainly submarine reactor compartments), the items are carefully packaged to prevent the spread of contamination, monitored for both contamination levels and dose rates and given a unique identification number for transfer to the APF. Items will be identified as waste (suitable for disposal) or for decontamination and return. Items are then logged off the submarine and transferred using a dedicated transport container equipped with suitable bunded holding areas. The items are formally receipted at handover, transferred to the APF and logged into the APF at the receipt bay. Items are held in a suitable bunded area within the receipt bay prior to activity assessment and processing. Suitable packaging and bunding are used at each stage of the transfer to ensure any residual liquids in valves, pumps or rigs are contained and escape is prevented.

3.1.3 All waste and components receipted into the APF are subject to activity assessment using Active Waste Monitors (AWM). These monitors are equipped with large area scintillation detectors and can detect gamma emitting radionuclides down to very low levels. The AWM are equipped with scales and are set up to provide a read out of both total and specific activity. Solid waste fingerprints have been established for submarine metallic and non-metallic waste and these fingerprints are used to ensure the contributions from other non-gamma emitting radionuclides (e.g. H-3 & C-14) are accurately assessed and included in the overall activity declaration. This approach is common practice in the nuclear industry and is considered to represent best practice.

3.1.4 AWMs are also programmed to visually display the location of the radioactivity in the waste bags subject to assessment. This information is used to assist APF staff when segregating non-radioactive and active items.

3.1.5 Subsequent to assessment waste bags are either designated as ‘out of scope’ (i.e. not considered as radioactive waste) or above the out of scope level. Items considered as radioactive waste are then moved to the segregation cell and subject to further assessment and segregation. On completion of this process contaminated items are subject to final AWM assessment, suitably labelled and transferred to the radioactive waste storage areas to await disposal. Disposal of all wastes assessed as ‘out of scope’ is via the Base’s conventional waste disposal route. Prior to disposal of this waste any radioactive labelling or trefoil signs are removed. All materials and components are accurately recorded into and out of the APF.

3.1.6 The solid waste characterisation process was subject to review in 2015 and results shared and agreed with SEPA. Arrangements are now in place to ensure that the solid waste characterisation is repeated approximately every seven years or when there is a significant change to operating procedures. A copy of the current waste characterisation fingerprints for metallic and non-metallic waste streams is at Appendix B. It shows that the main activity contribution arises from C-14 and tritium. As would be expected, there is very good correlation between the solid waste fingerprints and the analysis results of submarine liquid waste treated at the REDF.

3.1.7 Small quantities of solid waste may also be generated by activities in the REDF, radiochemistry lab and nuclear repair workshops. These items are transferred and processed as described above.

3.1.8 Further to activity assessment solid radioactive waste is accumulated in the APF waste store until it is economically viable to transfer. The disposal of the waste is generally managed via waste enquiry submission to Low Level Waste Repository. LLWR ensure that that most effective disposal option is identified (e.g. incineration) and records of all radioactive waste disposals are maintained and reported to SEPA periodically to satisfy the requirement of the LoAg.

3.1.9 Information on waste disposal volumes and total activity are provided in Table 1.

<table>
<tr><td></td><td></td><td colspan="6">Annual Disposal</td></tr>
<tr><td>Radionuclide</td><td>Numerical Limits (MBq)</td><td>2013</td><td>2014</td><td>2015</td><td>2016</td><td>2017</td><td>2018</td></tr>
<tr><td>Co-60</td><td>4000</td><td>2.16</td><td rowspan="5">No Disposal</td><td rowspan="5">No Disposal</td><td>5.76</td><td rowspan="5">No Disposal</td><td rowspan="5">No Disposal</td></tr>
<tr><td>Tritium</td><td>10000</td><td>0.20</td><td>0.51</td></tr>
<tr><td>Gross Alpha</td><td>30</td><td>0.0</td><td>0</td></tr>
<tr><td>Gross Beta</td><td>4000</td><td>6.17</td><td>24.44</td></tr>
<tr><td>Volume ($m^3$)</td><td>40</td><td>12</td><td>9.4</td></tr>
</table>

**Table 1.** Annual Solid Waste Disposal Volume and Activity 2013-2018.

## 3.2 Solid Radioactive Waste – Non-Routine

3.2.1 Ion Exchange Resin is used in the REDF to remove activity from submarine effluent prior to disposal to the Gare Loch. On occasion this resin needs to be replaced to ensure the continued operational effectiveness of the REDF. Samples of the spent resin are subject to radiochemical analysis to ensure the resin is appropriately characterised. Operational experience indicates resin changes are required every 10-12 years. Disposal of resins in the past has required solidification prior to transfer however future disposal will be determined on a case by case basis. The NSH will be operated to ensure that resins can be disposed of as low level radioactive waste.

3.2.2 Detailed decommissioning and disposal assessments have been carried out to identify and quantify the radioactive waste that will be produced when the current facilities are taken out of service. Additional characterisation work may be required but the assessments have confirmed that a disposal route exists for all low level wastes that will be generated. HMNB Clyde intend to initiate 'de-authorisation' and decommissioning work on successful commission and operation of the NSH.

## 3.3 Solid Waste Disposal Routes

3.3.1 The existing LoAg for the disposal of radioactive waste from Faslane, see Appendix A, specifies volume and numerical limits for the disposal of various isotope groups. The LoAg also states that waste must be disposed of by removing to the Low Level Waste Repository (LLWR) near Drigg in Cumbria. The introduction of SEPA's policy on the Regulation of Radioactive Low Level Waste from Nuclear Sites[3] provided the opportunity for nuclear sites to dispose of solid LLW to any person lawfully entitled to accept, treat and dispose of waste providing the selected disposal option represents the 'best practicable means' for disposing of that waste. The policy also states that prior notification to SEPA should be made before new transfer routes are utilised.

3.3.2 A full BPM Review of Radioactive Waste Management Arrangements within HMNB Clyde[4] was conducted in 2014 and covered all aspects of solid waste handling from the point of generation through to the final disposal. The recommendations in this report have all been fully implemented and included:

- Improvements in waste/component transfer bags.
- Improvements in waste segregation.
- Improvement in LoAg awareness training to those directly and indirectly involved with radioactive waste.

3.3.3 The report concluded that the management of solid radioactive waste was demonstrably BPM given the limited remaining operational life of the existing radioactive waste processing facilities.

## 3.4 Liquid Radioactive Waste

3.4.1 Liquid wastes generated from operations at Faslane can be conveniently split into 3 distinct groups: effluent discharged directly to Primary Effluent Tanks (PETs) for routine processing at the REDF; liquid waste collected in carboys from controlled contamination areas which may also include hazardous chemicals; and large volumes of submarine conventional effluents that are not directly associated with submarine nuclear reactor plant.

## 3.5 PET Discharges

3.5.1 A number of radioactive effluent discharge operations are carried out from submarines when berthed alongside at Faslane. Frequent discharges include:

- Discharges due to primary plant warm up operations.
- Discharges from the RC Active Drain Tanks and RC bilges.

3.5.2 Infrequent discharge operations include:

[3] SEPA Regulation of Disposal of Radioactive Low Level Waste from Nuclear Sites, RS-POL-002 Issue 1, dated May 2012.

[4] DSJ 9482 – BPM Review of Radioactive Waste Management Arrangements within HMNB Clyde- July 2014.

- Single primary loop drain.
- Double primary loop drain.

3.5.3 These discharges are made directly to Mk IV Primary Effluent Tanks (PET) and account for the majority of liquid radioactive waste. PETs are stainless steel cylindrical tanks horizontally mounted within a rigid steel frame. The maximum capacity of the Mk IV PET, including quench volume and flush, is limited to 2.7 $m^3$. The tanks are either located on the jetty or the casing of the submarine during discharge operations. Single skinned braided stainless steel discharge hoses are used to connect the PET to the submarine discharge point. On completion of the discharge the PET is transferred, on a dedicated flatbed lorry, to the REDF compound in the south end of the Base and discharged, using pressurised nitrogen gas, to the receipt tank inside the REDF. When sufficient volume has been accumulated the effluent is pumped through a series of filters to remove any fine particulate materials and then through two Ion Exchange Columns (IXCs) to remove radioactivity. The resultant treated effluent is transferred to one of two large final hold tanks. Samples of effluent receipt tank and final hold tank contents are taken and analysed by radiochemists. The results of the final hold tank are assessed by a professional Health Physicist and authorised for discharge to the Gare Loch. Procedures are in place that allows the contents of the hold tank to be recirculated via the IXC if required. During the disposal process a sample is taken from the discharge pipeline using the installed proportional flow sampler. This sample is analysed and it is these results that are used to calculate the radioactivity discharged to the Gare Loch. Results are sent to SEPA to meet the LoAg reporting requirements.

3.5.4 Table 2 details the current numerical limits and the activity and volume of effluents discharged to the Gare Loch from 2013-2018. The information in Table 2 demonstrates that the actual radioactive discharges to the environment are significantly below the current limits.

| | | Annual Discharge (MBq) | | | | | |
|---|---|---|---|---|---|---|---|
| Radionuclide | Limit (MBq) | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Cobalt 60 | 500 | 0.42 | 0.12 | 0.63 | 0.33 | 0.68 | 0.49 |
| Tritium | 1,000,000 | 8520 | 3810 | 19500 | 11000 | 33000 | 5816 |
| Gross Beta | 500 | 0.85 | 0.25 | 1.47 | 0.66 | 1.36 | 0.99 |
| Gross Alpha | 200 | 0.08 | 0.02 | 0.12 | 0.07 | 0.14 | 0.10 |
| Volume ($m^3$) | N/A | 42.2 | 12.5 | 53.2 | 33.0 | 68.0 | 49.4 |

**Table 2.** Annual Liquid Discharges to the Gare Loch 2013-2018.

3.5.5 A comprehensive BPM review of all PET waste handling arrangements was carried out in 2014[5]. The arrangements for primary effluent discharges were considered in detail and, in addition to supporting an earlier decision to procure 2 Primary Effluent Transfer Barges (PETB), a recommendation was made to install instantaneous self-sealing coupling units for PET to REDF discharges. These recommendations have been implemented in full and the new PETBs have now been built and subject to inactive commission.

### 3.6 Liquid Wastes Discharged to Carboys

3.6.1 These secondary liquid wastes could include the following:

[5] DSJ 9481 - BPM Review of Current Arrangements for Radioactive Effluent Receipt & Transfer – July 2014.

- Liquids generated in the testing & decontamination of contaminated components
- Liquid wastes from radiochemical analysis
- Small quantities of submarine wastes that are radioactive but not chemically contaminated
- Chemically contaminated waste from planned and unplanned activities on submarines

3.6.2 A brief description of the volume and current disposal routes for each of these effluent sources is provided below:

a. Components (e.g. test rigs and pumps) and tools used in contaminated areas may become contaminated during use. These items are safely transferred to the nuclear repair workshops or APF where they are tested/decontaminated with small quantities of water and decontamination solvents. The waste waters generated are drained to specially designed carboys and transferred to the REDF for testing and appropriate treatment. Carboys with acceptable chemical properties (i.e. no detectable oils) are pumped to the REDF receipt tank and treated through the effluent treatment plant. Generally there are no detectable levels of Co-60 or C-14 in this waste and up to a few tens of Bq/ml of tritium.

b. Small quantities of contaminated liquids are generated during the analysis of primary coolant samples and the cleaning of contaminated glass wear. This liquid is captured in carboys, tested and then treated via the REDF. Generally there are no detectable levels of Co-60 or C-14 in this waste and up to a few tens of Bq/ml of tritium.

c. On occasion, activities on-board submarines can result in the generation of chemically contaminated wastes. Liquids contaminated with potassium chromate, oils, hydraulic fluids or other hydrocarbons can collect in reactor compartment bilges and need to be pumped to carboys. These liquids are generally unsuitable for treatment via the REDF or discharge to the Gare Loch. These liquids may contain very low levels of Co-60 and a few hundred Bq/ml of tritium. Very low levels of C-14 is occasionally detected. Due to their combined radioactive and chemical properties they must be safely stored at the APF awaiting disposal. Faslane’s current LoAg does not specifically allow for the disposal of these liquid wastes. Carboy waste represents a small fraction of the overall liquid discharges from the REDF.

3.6.3 A comprehensive BPM review of all carboy liquid waste handling arrangements was carried out in 2014[6]. This review concluded that the handling and disposal arrangements of the small quantities of liquid waste associated with decontamination and radiochemistry arrangements were demonstrably BPM given the limited remaining operation life of the existing supporting facilities.

[6] DSJ 9482 – BPM Review of Radioactive Waste Management Arrangements – July 2014.

### 3.7 Submarine Conventional Discharges

3.7.1 The operation of submarines results in the generation of significant quantities of conventional liquid waste. This waste may contain oils, greases detergents and small quantities of biological matter and is not suitable for treatment by the REDF or direct discharge to the environment. This waste is transferred directly, or via the Oil Fuel Depot (OFD) in Garelochhead, to a commercial waste treatment plant operator. These conventional liquid wastes are subject to appropriate treatment and then discharged to the environment. Recent analysis of this conventional liquid waste has identified that it may contain very low, but detectable, levels of tritium. The specific mechanism to explain the source of this activity has not been fully established and analysis results have failed to identify any consistent detection pattern over the three classes of UK submarines. The disposal of this liquid waste is not covered by the current Faslane LoAg and Clyde has recently submitted an application to seek SEPA's approval to dispose of this low concentration aqueous waste. HMNB Clyde has requested approval to dispose of radioactivity levels up to the limit detailed in relevant exemption orders (i.e. 10 GBq for tritium). HMNB Clyde expects SEPA to approve this Addendum request within the next few months. The annual volumes of conventional liquids is approximately 5000 $m^3$ and analysis confirms that tritium levels have never exceeded 1 Bq/ml.

3.7.2 In addition to the conventional discharges described above, to manage buoyancy and manoeuvrability, submarines are designed with compensating and trim tanks. These tanks, which are isolated from the submarine reactor plant, are filled and pumped using sea water. Analysis of samples from these tanks has detected very low levels of tritium. The highest activity level detected in samples from these tanks is less than 0.1 Bq/ml.

3.7.3 The arrangements associated with handling conventional discharges have been subject to BPM assessment and it was concluded that changing the current handling or disposal arrangements would be grossly disproportionate.

### 3.8 Gaseous Radioactive Waste

3.8.1 Gaseous radioactive waste may be generated as a result of the following activities at Faslane:

a. Solid waste handling activities in the APF. All of the processing cells in the APF are ventilated via HEPA filtration. A continuous air monitoring system is operated within the APF and this system has been set to detect and alarm at very low levels of airborne activity. Gaseous waste generating activities such as cutting and grinding operations are very rarely undertaken within the APF and work of this nature would always be conducted within additional purpose-built containment arrangements. There have been no positive indications of airborne activity during the APF's 20-year operating history and activity assessment of used HEPA filters has never exceeded the 'out of scope' classification limits. These results provide confidence that any gaseous discharges due to solid waste handling are trivial.

b. Liquid Waste Processing in the REDF – receipt and final hold tanks within the REDF have been designed to ensure that air from the ullage space which may potentially contain entrained activity is discharged via HEPA extract ventilation via a single stack on the roof of the REDF. This air flow is monitored by an inline tritium bubbler system. Tritium activity levels above the limit of detection have never been detected. In addition, a number of continuous air monitoring detectors are strategically located within the facility and particulate activity has never been detected. These monitoring results provide high confidence that gaseous waste discharges from the operation of the REDF are trivial.

c. Assessment of samples in the Radiochemistry Laboratory – assessment of samples requires ‘boil down’ operations within the chemistry lab fume cupboards. These activities may result in the release of small quantities of airborne activity which is extracted via HEPA filtration and discharged via a single stack (see Figure 2). Theoretical calculations assuming worst case sample activity concentrations confirm gaseous disposals would be trivial.

3.8.2 Notwithstanding the trivial nature of these discharges the approach to the regulation of gaseous waste disposal has changed since the issue of the current LoAg and SEPA has indicated that any future gaseous waste disposals may be the subject of numerical limits.

3.8.3 As mentioned, gaseous discharges directly from the submarine to the environment are regulated by DNSR. DNSR has issued a consent to HMNB Clyde to allow the disposal of gaseous waste and has imposed numerical limits on the disposal of H-3, Co-60, C-14 & Ar-41. The most significant component of gaseous disposal occurs when radioactive effluent is transferred from a pressurised to an unpressurised state and released via the PET vessel vent directly to atmosphere. Other less significant disposal pathways include the release of tritium from weapon components on-board Vanguard class submarines. DNSR has assessed that discharges carried out at the annual authorised limit would result in a dose of around 0.08 µSv/y which is well below the 20 µSv/y threshold below which no further regulatory effort is warranted, provided the operator is using BPM to limit discharges.

# 4. Existing Radioactive Waste Management Arrangements, Coulport

## 4.1 Solid Radioactive Waste

4.1.1 Bags of desiccant are used within weapon storage and transport containers to maintain the required humidity levels. At times these containers may hold components that contain tritium and due to tritium’s high mobility characteristics, it is possible that small quantities of tritium leach out of these components and into the atmosphere within the container. As a result, it is possible that the tritium will be absorbed into the desiccant and therefore, prior to disposal, it is necessary to consider whether the bags of desiccant must be treated as radioactive waste due to their tritium content.

4.1.2 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 introduction of this new higher limit was used as a catalyst to carry out a BPM review of tritiated desiccant arrangements at Coulport. This review was completed in 2012 and concluded that ‘the current sampling and analysis regime is considered disproportionate to the benefits derived from, or likely to be derived from, employing such a regime’. The BPM review considered the following aspects:

- Justification for the use of the desiccant and the quantities used;
- The possibility of reusing or recycling desiccant; and
- Sampling and analysis arrangements.

4.1.3 The Design Authority for weapon storage and movement confirmed that desiccant represented the most effective and practical approach to removing water vapour and that the quantity of desiccant used had been theoretically calculated to optimise environmental conditions. The possibility of reusing/recycling desiccant was also discounted due to the potential uncertainties over the efficacy of recycled desiccant to maintain the required conditions. A number of options for the sampling and analysis were considered and it was concluded that mixing the desiccant bags and taking one sample from the homogenised mass followed by pyrolysis and liquid scintillation analysis represented the BPM approach. These revised arrangements were agreed with SEPA in 2015 and have been operating for the last 3 years.

4.1.4 The current waste handling arrangements at Coulport include desiccant removal, storage, sampling & analysis and then, subsequent to receipt of analysis results, segregation awaiting disposal.

4.1.5 The quantities of radioactive waste generated since the introduction the 2011 has resulted in the disposal of a few kg of desiccant as radioactive waste. In accordance with the current LoAg this waste is transferred to the APF at Faslane prior to final disposal.

4.1.6 Over 95% of desiccant has been assessed as <100 Bq/g and disposed of as hazardous waste to a suitable waste disposal contractor.

4.1.7 The current arrangements have recently been subject to an end to end review and this has resulted in the introduction of a number of improvements including: enhanced labelling and segregation; simpler handling arrangements; and improvements in verification of the final disposal route.

4.1.8 HMNB Clyde has concluded that the revised desiccant handling and disposal arrangements are now demonstrably BPM.

### 4.2 Gaseous Radioactive Waste

4.2.1 Tritium exists at Coulport in several different types of items. The vast majority is present within sealed pressure vessels designed for the purpose of storing tritium. These vessels arrive at Coulport in pressure-sealed transport containers. The containers are opened in a fume cupboard and a proportion of the tritium which has by its mobile nature, leached into the main container, is discharged to the environment via the process building's ventilation system. In addition, once the vessel is removed from the storage container, tritium will continue to slowly escape and discharge from the storage building directly to the atmosphere.

4.2.2 The manner in which gaseous discharges are calculated has recently been subject to review and amendment. The conclusions of the review have been endorsed by Clyde's BPM WG and agreed with Clyde's SEPA inspector. Additional improvements to the documentation controlling gaseous waste discharges have been implemented during 2018, and Clyde's gaseous waste assessment and reporting arrangements are demonstrably BPM.

4.2.3 Table 3 provides information on the existing gaseous limit and an indication of the discharge figures from 2013-2018. Annual discharge levels are directly related to the weapon processing programme.

| Radionuclide | Annual Limit (GBq) | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|
| Tritium | 50 | 2.18 | 6.69 | 4.23 | 2.94 | 1.78 | 1.77 |

**Table 3.** Annual Gaseous Discharge Limit and Disposal Figures for Coulport.

## 5. Proposed Changes to Waste Management Arrangements at Faslane

### 5.1 General Design of the Nuclear Support Hub

5.1.1 A number of developments have occurred since the issue of the existing LoAg. Changes include: an increase in number of submarines that will be berthed and operate out of Faslane; a better understanding of the full scope of routine and non-routine activities that Clyde may need to support to ensure Continuous at Sea Deterrence; a better understanding of the types, characterisation and potential activities of wastes associated with the full scope of operations; changes to berthing arrangements and the transfer of all submarine support activities to the north end of the Base; learning from experience gained from other NNPP operators; a recognition that the current radioactive waste processing/disposal facilities and the supporting utilities are approaching the end of their operational life and will prove more difficult to safety justify and economically maintain and operate over the next 5/10 years; and changes to the legislative framework that regulates the management and disposal of radioactive wastes.

5.1.2 All of these developments have resulted in HMNB Clyde concluding that a new combined solid and liquid waste disposal facility, the NSH, should be built and operated at the north end of the Base. In addition to including waste handling, processing and disposal capabilities, the NSH will also house related supporting services including: radiochemistry laboratories; nuclear repair workshops; and offices for Health Physics personnel and dosimetry management.

5.1.3 The NSH is to be located to the North of the existing Shiplift at the northern end of the Faslane Site. The location and an impression of how the facility will look are provided at Figure 4 & Figure 5.

**Figure 4.** Nuclear Support Hub Location.

**Figure 5.** Nuclear Support Hub including the 2 Floating Barge Berths.

5.1.4 The NSH will provide separate operational plant areas for waste treatment processes. The Solid Waste Handling Plant (SWHP) will decontaminate radioactive contaminated components and process solid radioactive waste effectively replicating the facilities provided by the existing APF. The Effluent Treatment Plant (ETP) will process liquid radioactive waste and replace the existing treatment plant located in the REDF.

5.1.5 As part of the design approach to the NSH, the outcomes from the detailed optioneering studies for waste management at Faslane conducted in 2010 have been reviewed against recent developments in radioactive waste management best practice. The review concluded that the 2010 studies remain valid and should be used to underpin the design of the NSH.

5.1.6 The NSH has been designed to incorporate current safety and environmental requirements and the facility design has been subject to a developed Safety Case encompassing current best practice for the identification, assessment, prevention and mitigation of faults. The design includes robust protective features to prevent discharge of untreated liquid or gaseous waste or the incorrect sentencing of solid radioactive waste. The design of the ETP and SWHP were further refined through consideration of operational experience with the existing plants, good engineering design and application of BPM. All plant has been specified for a 50-year general life span, with consideration given to appropriate levels of intrinsic shielding for dose reduction and all consumables have been located, where practical, to simplify maintenance.

## 5.2 Application of BPM to Solid Radioactive Waste Handling Arrangements

5.2.1 The purpose of the SWHP will be to provide a solid radioactive waste processing and decontamination service to submarines and shore facilities. It will also provide a temporary storage area and a safe keeping service for contractors' radioactive items. The simplicity of solid waste production activities at Faslane mean that there are very limited opportunities to significantly improve or enhance the current arrangements. The engineering design and equipment layout of the SWHP have been reviewed against best practice guidance provided in 'Guidance on the Segregation and

Management of Low Level Waste from the Nuclear and Associated Industries'[7]. The design has also been influenced by the optioneering study completed in 2010 and the solid waste BPM study in 2014. Improvements and the application of BPM have been applied in the following areas:

a. The NSH is located much nearer submarine berths, the main source of solid radioactive waste, and will significantly reduce the transfer distance of radioactive waste and components.

b. Increased space envelope around the receipt bay will ensure the transfer of solid waste items can be carried out more effectively.

c. The receipt area will allow all waste transfers to occur under cover and hence avoid exposure to the frequent poor weather conditions at Faslane.

d. The design of the SWHP has been based on the re-use and relocation of existing equipment currently in use at the APF. The re-use of existing equipment provides benefits in reducing the quantity of material for disposal once the APF is taken out of service and is considered the BPM option in accordance with the UK Government's waste management hierarchy. A review has been undertaken to confirm that existing equipment is fit for purpose for the processing of solid radioactive waste and that its continued use aligns with the principles of the waste hierarchy. Use of existing equipment also ensures a degree of operator familiarity and will reduce the initial training burden for NSH staff.

e. Improved lifting arrangements will mean the more effective transfer of solid radioactive materials within the facility.

f. The internal SWHP space envelope is much bigger than the current APF and this will assist in more effective segregation, processing, storage and disposal arrangements.

g. The collocation of the radiochemistry and nuclear repair workshops will simplify the transfer arrangements of secondary solid waste, reduce the potential for spillage and leaks and could reduce the amount of packaging material required.

h. The waste storage area has the capacity and suitable plant for handling Half Height ISO containers (HHISO) which has been identified as the bounding case for the packaging of wastes, including drummed non-compactable waste for offsite disposal.

i. All surfaces within the SWHP with the potential to become contaminated have been specified as having washable surfaces with the capability to transfer any liquid arising directly into separate active drainage system sumps.

### 5.3 Solid Waste Characterisation and Assessment

5.3.1 Solid wastes will continue to be activity assessed in the SWHP using the Active Waste Monitors currently located in the APF. The waste will be fully characterised by applying the agreed fingerprint for either non-metallic waste or metallic waste streams. The measurement of Co-60 as the dominant radionuclide and the application of a suitable

[7] Management of Solid Low Level Radioactive Waste from the Nuclear Industry – Guidance for the Segregation and Management of Low Level Waste from the Nuclear and Associated Industries – Oct 2011.

waste stream 'fingerprint' to calculate the contribution from β activity from radionuclides such as Tritium, Ni-63 and C-14 is common practice in the nuclear industry. Clyde's fingerprints for metallic and non-metallic waste streams have been compared with those used for similar waste groups at Devonport and were found to be broadly comparable. As mentioned in Section 3, the formal review of solid fingerprints has now been captured in Clyde's Radioactive Waste Standing Orders and will be re-validated on a 7-year basis.

5.3.2 The existing LoAg includes a numerical limit for the disposal of alpha emitting radionuclides. Fuel integrity in submarine reactor systems is very high but occasionally alpha emitting radionuclides are detected in submarine coolant using onboard analysis techniques and may therefore be present on solid radioactive waste removed from submarines. This alpha arises from natural Uranium present on the fuel cladding. The results of recent fingerprint analysis work for metallic and non-metallic wastes confirmed that waste from routine operations does not contain alpha-emitting radionuclides.

5.3.3 Operational experience from across the NNPP has identified that in the very unlikely event that a submarine reactor is operated in a non-routine configuration, very small quantities of alpha emitting radionuclides may plate out on the internal surfaces of the primary circuit plant or be removed by the on-board ion exchange column. Daily analysis of primary coolant samples would provide an immediate indication that the reactor plant was operating in a non-routine configuration. Whilst maintenance activities on any submarine operating in this non-routine configuration will be minimised there is a possibility that waste contaminated with measurable levels of alpha activity could be generated in the future. Such waste would be subject to comprehensive alpha spectrometry to accurately determine the magnitude of the alpha contamination. Disposal of alpha contaminated waste would be to an appropriately permitted operator.

### 5.4 Proposed Changes to Existing Solid Waste Disposal Approval for Faslane

5.4.1 HMNB Clyde is seeking the approval of SEPA to dispose of solid low level waste to any person that is lawfully entitled to accept and treat and or dispose of that waste. HMNB Clyde understands that the selected disposal option must represent the 'best practicable means' for disposing of that waste.

### 5.5 Application of BPM to Liquid Radioactive Waste Handling Arrangements

5.5.1 A review and appraisal of appropriate techniques for the treatment of liquid effluent at Faslane was conducted by SQEP site stakeholders as part of the 2010 optioneering study. The methods identified as potentially suitable to replace the existing REDF included:

Option 1 Centrifugation

Option 2 Solvent extraction

Option 3 Filtration and Ion Exchange

Option 4 Evaporation and Reverse Osmosis

Option 5 Gravity Solvent Extraction

5.5.2 The review concluded that filtration and ion exchange provided the optimum solution to take forward to support Clyde's future liquid waste management capability. Current practice in liquid effluent treatment in the UK nuclear industry was reviewed again in 2015 and confirmed that the use of simple filtration and ion exchange is by far the most commonly applied technique for abatement of radionuclides prior to disposal of level liquid wastes; these techniques are implemented at nearly all sites in the UK.

5.5.3 A review of treatment technology for the abatement of tritium was also undertaken in 2015. This review identified a Modular Detritiation System (MDS) process in which tritiated water is cracked into gaseous oxygen and hydrogen. The gas is then fed through a column containing a catalyst which results in concentrated tritiated water. The process is designed such that the tritium concentrations are below 10 Bq/ml at the outlet and the concentrated tritiated water can undergo stabilization for disposal as solid waste. The process could potentially abate tritium in liquid effluent discharge however the MDS process results in potentially explosive gaseous waste requiring appropriate management control. The high additional cost, operator training, and maintenance of an unfamiliar system was deemed grossly disproportionate to the relatively low environmental benefit of abating tritium releases.

5.5.4 A decision was therefore taken in 2015 to utilise filtration followed by ion exchange as the preferred option for liquid waste treatment at HMNB Clyde Faslane. The possibility of re-using existing REDF equipment was also considered but discounted for the following reasons:

- Generation of radioactive wastes during dismantling and reassembly.
- The NSH design contractor would not warrant equipment reuse as part of the design solution.
- Any reuse of the REDF equipment would leave the REDF in a degraded state and would not meet current availability requirements.
- Would not meet 50-year design life specification.

5.5.5 The ETP has been designed to receive and process up to a maximum 155 $m^3$ of liquid effluent per year: consisting of an anticipated 120 $m^3$ from submarine maintenance, 20 $m^3$ from decontamination operations at the SWHP and 15 $m^3$ radiochemistry lab. A block diagram of effluent management is provided at Figure 6. The key features and improvements associated with the new effluent treatment arrangements are described in the remainder of this section.

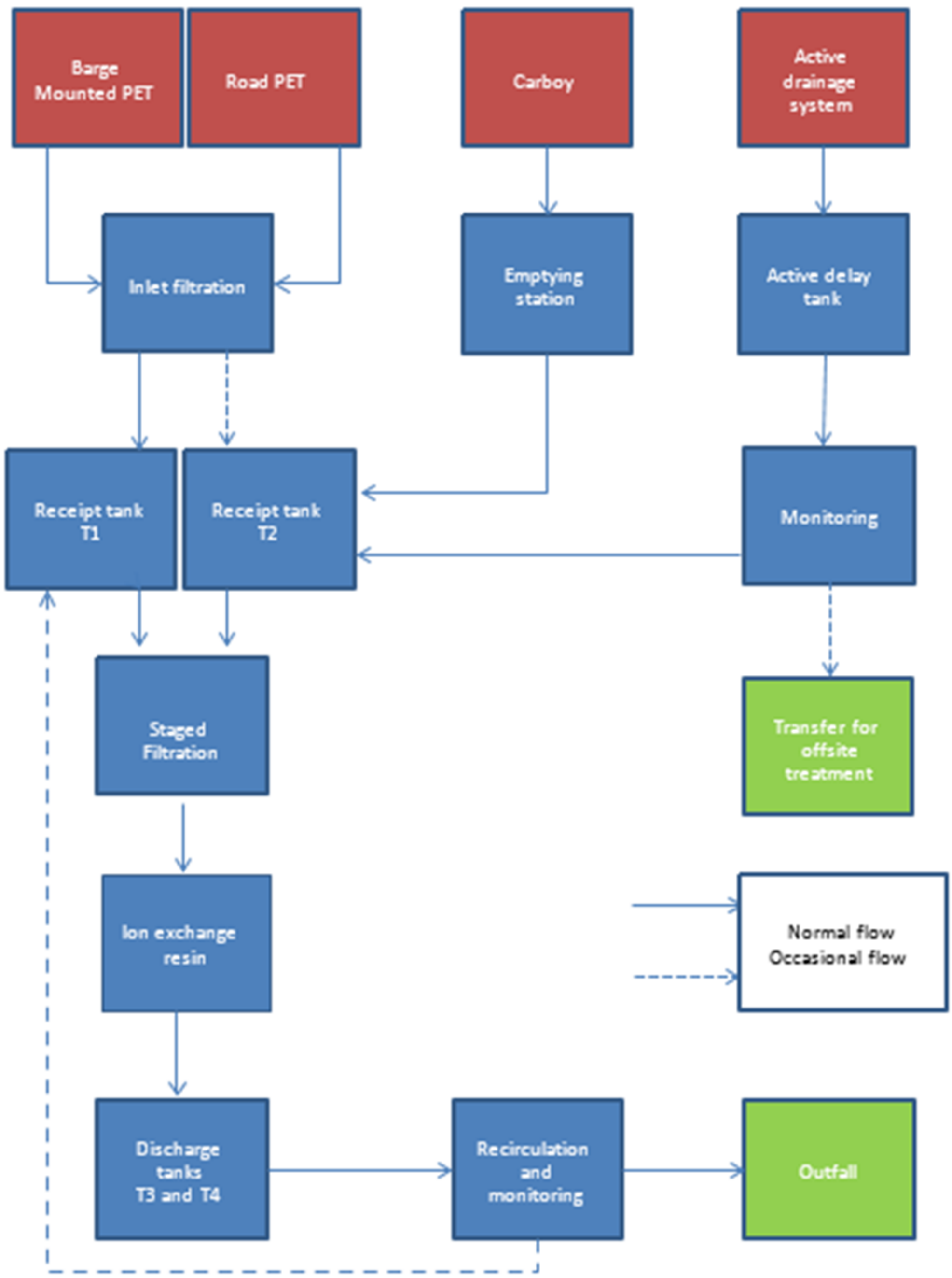


**Figure 6.** Block Diagram of the ETP Liquid Waste Processing Arrangements.

**Effluent Receipt at the ETP**

5.5.6 As mentioned in Section 3, primary effluent discharge into the ETP will be mainly via 2 new PET Barges that have been built and await active commission. The PET tanks on these barges have a much greater capacity (10 $m^3$ compared to 2.7 $m^3$ capacities of existing PET tanks) and will reduce the number of PET changes during submarine discharge operations. This will significantly reduce the number of PET connection and disconnection operations and reduce the possibility of spills and leaks. Use of the PET Barge will also negate the requirement to lift full PETs onto transport vehicles when the PET is located on the submarine casing. Once full the PET Barge will be moved to the NSH pontoon which will provide berths for two barges. Barge PETs will be connected to the offloading pipework utilising hoses and 'dry-break' couplings. The NSH pontoon will be bridged via an articulated offloading arm equipped with secondary containment and leak detection on the effluent line. A double braided stainless steel hose connected with dry-break couplings is specified between the barge and offloading arm. A double skinned hose has not been selected due to the manual handling issues of more rigid less flexible hoses which can create additional stress on connections and increase the risk of leakage. An impression of how this system will look is provided at Figure 7.

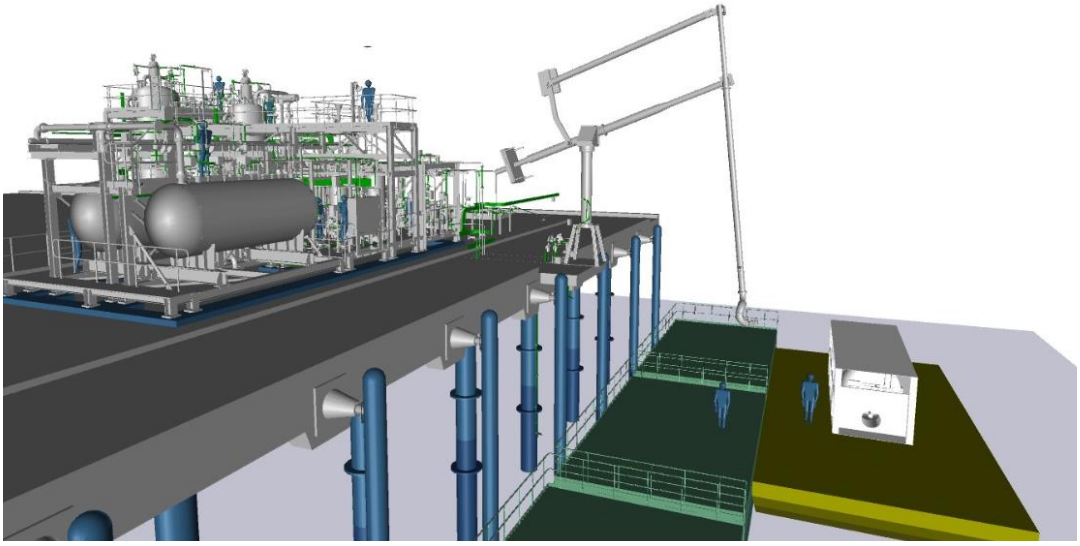

**Figure 7.** PET Barge and Proposed Discharge Arrangements.

5.5.7 In the event that the PET Barge is not available (e.g. weather and sea state prevent use, undergoing maintenance, etc.) the use of the existing Mk IV PETs will remain a suitable discharge option. The NSH has been designed such that all discharges from PETs will be under cover in a canopied area. The fixed pipework, temporary hoses & PET vehicle will all be located under the canopy and over a bunded area during effluent discharge into the ETP. The bund free drains into a low point sump which is provided with fixed pipework and can be emptied via portable sump pump into the ETP receipt tanks. The sump is provided with level monitoring indication to monitor for the presence of liquid and warn operators of potential containment loss. This represents a significant improvement from the current PET to REDF discharge arrangements. Low pressure nitrogen will be used as the motive force to transfer effluent from PETs into the ETP receipt tank. This approach removes the requirement to have additional mechanical equipment (e.g. pumps) which could potentially become a route for containment loss or create additional liquid/solid waste during subsequent maintenance.

## Effluent Receipt Tanks

5.5.8 Transfer lines into the ETP are equipped with appropriate particulate filters. Primary effluent is then normally transferred to receipt tank T1 (see Fig 7), however in the event of a lack of capacity in T1, receipt vessel T2 is used. Two receipt tanks have been chosen to ensure the design availability requirement of the ETP is met and represents a significant improvement on the current arrangements. T1 has a working capacity of 14 $m^3$ to accommodate the volume of a filled PET from a barge (10 $m^3$) and additional Mk IV discharges. Receipt tanks are provided with 75 µm filters as a BPM measure to prevent the ingress of large particulates. A duplicate inlet filter is provided on T1 to provide continued operational availability during filter clean or replacement.

5.5.9 All effluent vessels within the ETP are provided with level instrumentation which prevents further inflow in the event of a high-level tank. Each vessel is provided with an overflow line, containing a liquid seal to prevent migration of active vapour, routed to the secondary containment bund and sump. Releases from this source are transferred into the active drainage system. T1 & T2 are equipped with agitators designed to re-suspend solids prior to treatment. Agitation of the tanks is considered BPM since it will reduce dose from the ETP and minimise cleaning requirements through scale prevention which may influence the system flow and pressure. Removal of insoluble particles will reduce decommissioning requirement at the end of vessel life and minimise worker exposure during all phases of the ETP lifespan. However, agitation will lead to increased particulate entraining of ventilation gas which will require treatment in the active ventilation system. Agitation will also give rise to tritium and C-14 gaseous emissions through evaporation. The agitators will only be operated immediately prior to treatment to minimise the increase in gaseous emissions. The receipt tanks are provided with a permanent connection to the active ventilation system header which maintains a continuous draft on the vessels when they are in use. Extraction ventilation is only operational during transfer operations as a BPM measure to minimise the generation of gaseous wastes.

5.5.10 T2 has been sized for the routine active drainage system along with a Mk IV PET discharge. The vessel has a working capacity of 7.5 $m^3$. Of this, 4 $m^3$ is allocated as the volume to accommodate discharges from the SWHP and the Active Drainage Delay Tanks (ADDTs). The contents of the receipt tanks will be subject to agitation prior to pumped transfer via staged filtration onto the ion exchange resin beds.

## Effluent Treatment

5.5.11 Effluent treatment at the ETP is 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 design specification is for 10 µm, 1 µm and 0.2 µm filters that are equipped with differential pressure transmitters to allow performance monitoring and prompt cartridge replacement. Each filter is connected to process pipework via hoses and dry-break couplings to reduce the risk of containment loss during replacement. Compressed air is supplied to the filters to support drying to allow disposal as dry solid waste.

5.5.12 The IX columns will contain resin appropriate to the removal of dissolved anion and cation chemical and radionuclide species, particularly Co-60, and can be alternated to ensure optimum resin utilisation. The two beds operate in a 'lead/lag' mode with treated effluent passed to the ETP discharge tanks. The performance of the IX will be monitored by conductivity measurement and sample points provided at three points including inlet, treatment and outlet of the columns. Each column is fitted with valve drain connections and level monitoring to support removal and replenishment when required. Given the relatively low activity of the effluent, the use of the second column cannot be demonstrated to increase the achievable decontamination factor, however the second column acts as a final polishing stage and provides mitigation against the risk of blinding, depletion and chemical shock to the first column. The time taken to replace the resin in a one column solution, should this occur, could be significant resulting in prolonged storage of untreated effluent. The use of two ion exchange columns is therefore considered to represent BPM. The contents of the tanks are recirculated prior to sampling and analysis to ensure compliance with SEPA approval requirements. The ETP has been designed to allow the effluent to be recirculated back to the receipt tank to allow additional treatment. Pipe routes and valves are also provided to allow the bypass of either the filters or the IX columns.

5.5.13 An impression of how the effluent treatment plant will look is provided at Figure 8.

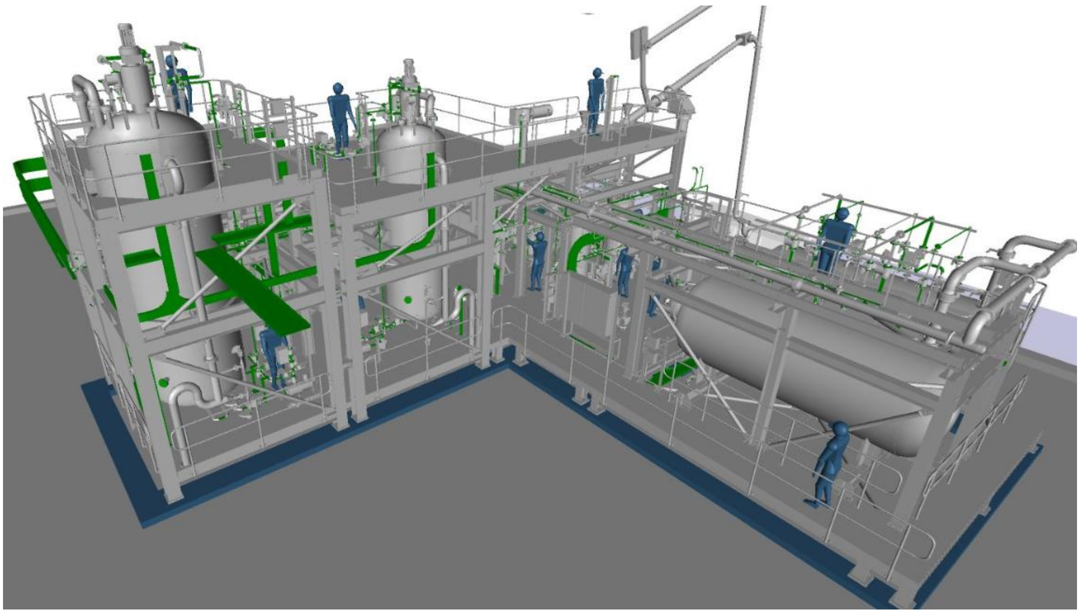

**Figure 8.** ETP Design.

**Sampling and Discharge**

5.5.14 Treated effluent is transferred into two identical 14 $m^3$ discharge tanks (T3 & T4). Prior to disposal into the Gare Loch the effluent will be recirculated to ensure a homogeneous mixture and a sample will be taken for analysis. The sample will be taken via a sample line that will feed a sample cabinet located adjacent to the ETP process. A sample cabinet will be provided in a glovebox configuration maintained under negative pressure through a fixed connection with the active ventilation system. Tie in to the ventilation system ensures the removal of activity that may be suspended in vapour in the event of a spill or splash into the drip containment. All washing and spills are collected in a sump located within the base of the cabinet. This sump is fitted with a drain line to return any accumulated liquids into the receipt tank for subsequent processing through the ETP. Taking of the samples is a semi-automated process allowing sample flow recirculation to be proven prior to sample draw off. Sample taking is to be controlled externally to the sample cabinet via a Digital Control System by the operator. Samples will be appropriately labelled, recorded and stored as part of HMNB Clyde quality arrangements. A local printer will be available to print labels for application to the sample bottles. Duplicate samples will be taken and stored in a secure location for inspection and validation by SEPA as required. Sample bottles will be bagged within the sample cabinet and transferred to the radiochemists for analysis. All sampling equipment will be appropriately maintained and calibrated in accordance with the manufacturer's recommendations at acceptable intervals by trained personnel. The sample will be analysed for each of the nuclide groups specified in Section 5.6 of this application.

5.5.15 Effluent from the discharge vessel will be pumped at a flow rate of approximately 3 $m^3$/hr and a discharge pressure of 2-2.5 barg. A flow control valve installed downstream of the pumps will ensure a constant flow during changes to tank level and tidal depth. A proportional flow sampler will be provided in the outlet line to the Gare Loch. The unit will collect samples at predetermined intervals from the effluent as it is discharged. These samples will be analysed to confirm activity levels and for subsequent reporting to SEPA. Recirculation lines will be located downstream of the sampler in order to support sampler proving and testing activities without discharging to the Gare Loch.

5.5.16 The discharge vessels will include a permanent connection to the active ventilation system header which maintains a negative pressure when they are in service. The final manual discharge valve to the Gare Loch will be maintained 'locked close' and only opened under administrative controls prior to discharge. The system within the ETP is largely automated through the use of a Programmable Logic Control (PLC) system. The PLC ensures that the correct valves are operated in the correct sequence.

**Discharge Pipeline and Outfall**

5.5.17 The discharge line comprises a pipe routed over the edge of the podium into the Gare Loch. The pipe will be bolted construction to facilitate installation, inspection and maintenance but the number of flange joints will be minimised to reduce the number of potential leak paths. Where the pipe crosses the podium, it will be within a channel that is equipped with a sump for capturing any potential leaks. The discharge pipe is supported via clamps affixed to a pile through its length into the Gare Loch. The end of the pipe is located at least 1 metre above the loch bed and below the lowest astronomical tide. This reduces the risk of silting at the end of the pipe and ensures all releases are into the main body of the loch and not tidally influenced. As a further BPM measure the discharge pipe outlet will be fitted with a Tedeflex 'duck bill' style non-return valve to prevent reverse flow and reduce the risk of line fouling when not in operation.

**NSH Active Drainage System**

5.5.18 A number of sources of potentially contaminated radioactive liquid waste exist within the NSH. In order to minimise the use of carboys or other transport containers an engineering decision was taken to design an active drainage system. Consideration of the quantities of liquid effluent produced from each of the identified areas, along with the required system availability and safety functions was used to inform the design of the active drainage system. The system uses short lines of welded steel pipe from the point of origin, such as the active sinks in the SWHP to a number of Active Drainage

Delay Tanks (ADDTs) that serve as collection points for the secondary effluents. The ADDTs can then be sampled, as required, prior to the contents being pumped to the ETP receipt tank (T2) for processing. The ADDTs minimise the risk of materials, such as oils and grease, being transferred and reducing the efficacy of the filters and IX resin. The following ADDTs have been included in the design:

**SWHP Decontamination Room**

- ADDT1 – serving the carboy emptying wand and the 2 sinks in the SWHP Decontamination Room.
- ADDT2 – serving the Decontamination Shower and Active Plantroom. This plant room include an active gulley draining the Active Air Handling Units coalescing filters and cooling coil. The active drain gulley is gravity fed into the ADDT.
- ADDT3 – serving the radiochemistry lab sinks and glass washer.

**Radiochemistry Laboratory**

- ADDT4 – serving pyrolysis air conditioning evaporator and Mass Spectrometer air conditioning unit.
- ADDT 5 – serving 4 fume cupboards.

**Active Nuclear Repair**

- ADDT6 – serving 2 fume cupboards.

Each ADDT features:

- 100% outer secondary containment
- Appropriate sizing based on expected arising
- Leak detection subsystem within the primary and secondary containments
- A sloping base to mitigate the need for mixing arrangements
- A drain test point connection with low contamination safety sampling valve. An ultrasonic fluid level sensor to indicate low level, high level and Full level at 10%, 75% and 95% of the liquid volume.
- Ventilation connection to the Active Ventilation System.
- A borosilicate glass trap on the tank inlet and a drain connection to the pump.

5.5.19 The active drain distribution pipework runs through controlled areas. The pipework uses exposed runs with all ancillaries located appropriately for ease of inspection and maintenance. The ADDT and associated pumps are controlled via a centralised active waste control panel located in the ETP control room and includes a leak detection alarm system to highlight any leaks from primary to secondary containment. Effluent contained in the ADDTs will only be pumped to the ETP receipt tank T2 if there is a free capacity signal for the receipt tank. As a BPM measure alarms will activate along the automatic isolation if the ADDTs approach full capacity and there is no available capacity in the ETP receipt tank to minimise the risk of spillage. These arrangements represent a significant improvement on the current secondary liquid waste handling arrangements.

5.5.20 Although very unlikely, if the contents of an ADDT are not suitable for treatment via the ETP, they can be transferred to a suitable container and stored onsite until a suitable treatment or disposal route is identified. ADDTs can be isolated for cleaning purposes prior to being brought back into service.

5.5.21 Carboys will only be retained for the transfer of low volume liquids from submarine (e.g. small quantities of RC bilge waste). The arrangements for handling and emptying these carboys have been significantly improved in the new facility. On receipt into the SWHP carboys will be transferred onto a bunded trolley (110% of total carboy volume), and then into a temporary waste store. This store can accommodate up to 3 full trolleys at any time. The range of carboys will be reduced with no carboy greater than 10 litres to be used. Following assessment and if suitable for processing the trolley will be docked in a dedicated docking station and emptied using a dedicated wand pump attached to an overhead lifting beam. The wand locks onto the carboy top and is equipped with a back-flow prevention isolation valve at its base to prevent escape of captured liquids. Liquids are transferred using a wand and a hydrocarbon filter into the ADDT. When not in use the wand returns to its holster which is connected to the active drainage system to capture drips or escaped liquid. Use of the wand system will significantly reduce manual handling of carboys and minimise the risk of spillages and splashes. Routine flushing of the carboys will not be carried out to minimise the production of additional secondary liquid wastes.

5.5.22 An impression of how this new system will look is provided at Figure 9.


**Figure 9.** Carboy Emptying Arrangements.

## 5.6 Liquid Waste Characterisation and Assessment

5.6.1 Activity levels in treated liquid effluent discharged to the Gare Loch have been estimated based on the maximum anticipated radionuclide levels[8] from each source received at the ETP. Table 4 provides a detailed breakdown of the various nuclides and the activity level after treatment through the ETP. These figures are worst case and include the infrequent discharge operations detailed at para 3.5.2 (i.e. single and double loop drain).

5.6.2 In previous correspondence SEPA requested that Clyde provide additional detail on radionuclide concentrations and in particular identify those radionuclides that may be present in significant quantities other than tritium and Co-60. A review of the information detailed in Table 4 together with assessment of the numerical limits in the permits at other NNPP establishments (i.e. Devonport Dockyard) indicate that other significant radionuclides, not identified by the use of high resolution γ spectrometry, include C-14, Fe-55 and Ni-63.

[8] Jacobs (2017) HMNB Clyde Faslane Nuclear Support Hub BPM Assessment.

| 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.

5.6.3 SEPA also highlighted that any new approvals would use the following definitions:

- All non-alpha emitting radionuclides taken together.
- All alpha emitting radionuclides taken together.

5.6.4 Samples of liquid waste to be discharged to the Gare Loch shall be analysed using gamma spectrometry and liquid scintillation techniques, as appropriate, to measure the activity levels of tritium, Co-60, C-14, other non-alpha emitting radionuclides, and alpha emitting radionuclides.

5.6.5 The activity of other non-alpha emitting radionuclides taken together (i.e. the total activity of all radionuclides excluding tritium, Co-60, and C-14) shall be measured by:

a. Taking a proportion of the sample and measuring the activity of all gamma emitting radionuclides, excluding Co-60, by gamma spectrometry.

b. Taking another proportion of the sample, separating out the iron constituents and measuring the activity using a liquid scintillation counter, which has been calibrated using an energy band that has been set up between 0 – 7 keV and has been calibrated for detection efficiency using an iron-55 standard.

c. Taking another proportion of the sample, separating out the nickel components and measuring the activity using a liquid scintillation counter, which has been calibrated using an energy band that has been set up between 5 – 65 keV and has been calibrated for detection efficiency using a nickel-63 standard

5.6.6 The activity of all alpha emitting radionuclides taken together shall be measured by evaporating a proportion of the sample to dryness and checking for the presence of alpha activity by measuring the activity on a gross alpha counter calibrated for detection efficiency using an americium-241 source.

5.6.7 All the radionuclides that are detected using the methods detailed above shall be summed, recorded and reported to SEPA. In accordance with regulatory guidance[9] results that are generally below the limit of detection (LoD) will be reported as 50% of the LoD. Hence, an actual discharge value will be reported (i.e. reported as X Bq and not < X Bq).

## 5.7 Proposed Changes to Liquid Waste Disposal Approval

5.7.1 Using the information in Table 4, and including some additional headroom to ensure HMNB Clyde can deal with any urgent operational requirements (e.g. significant plant discharges including loop drain operations), the MoD is seeking the approval to dispose of the following radionuclides in liquid discharges to the Gare Loch:

| Radionuclide | Proposed New Annual Limit (MBq) | Existing Limit (MBq) |
|---|---|---|
| Cobalt-60 | 100 | 500 |
| Carbon-14 | 100 | N/A |
| Tritium | 500,000 | 1,000,000 |
| All non-alpha emitting* radionuclides taken together | 100 | N/A |
| All alpha emitting** radionuclide taken together | 5** | 200 |
| * Excludes tritium, C-14 and Co-60<br><br>** Alpha activity levels in liquid waste have never exceeded the LoD. Alpha activity would generally be in particulate form and removed by filtration. | | |

**Table 5.** Proposed Rolling 12-Month Numerical Limits for Liquid Waste Discharges.

5.7.2 In addition to the approval to cover radioactive discharges from the NSH, an application will also be made to ensure compliance with the Water Environment Controlled Activities (Scotland) Regulations 2011 (CAR). The CAR registration will cover the non-radiological constituents of the discharges from the NSH.

### Submarine Conventional Liquid Waste Disposals

5.7.3 As discussed in Section 3, HMNB Clyde generates significant quantities of conventional liquid waste which may contain trace levels of tritium. To ensure this waste can continue to be disposed of in an effective manner MoD are seeking SEPA approval to dispose of up to 10 GBq per annum of tritium using the existing hazardous disposal routes for this waste. A specific activity limit of <100 Bq/ml tritium will be adequate to ensure conventional submarine effluents can continue to be disposed of in a safe and effective manner. Samples of waste will be analysed at the same periodicity as requested in the Addendum application (i.e. quarterly for OFD disposals and annually for submarine discharges to roadside tanker) and Clyde will maintain records of the volume and activity of these disposals. HMNB Clyde will continue to

[9] Radiological Monitoring Technical Guidance Note 1 Standardised Reporting of Radioactive Discharges from Nuclear Sites, May 2010, Version 1.0.

use BPM to reduce both the volume and radioactivity of these discharges.

**Chemically Contaminated Waste Disposal**

5.7.4 Liquid waste that is transferred to the APF in carboys from submarines but is not suitable for treatment via the REDF is currently stored in the APF. To ensure this material can be dealt with in a more effective manner at the NSH, MOD are seeking SEPA approval to transfer liquid wastes that cannot be processed by the NSH ETP (i.e. due to their chemical constituents) to an appropriately permitted person. These wastes will be subject to appropriate assessment prior to disposal. These arrangements are in place at other establishments and are considered good practice in the nuclear industry.

## 5.8 Application of BPM to Gaseous Waste Handling Arrangements

5.8.1 The Ventilation System serving the NSH facility is separated into two systems: Clean Ventilation System and Active Ventilation System. This is in line with good industry practice, but is also a BPM measure to minimise the volume of potentially active gaseous waste which requires treatment, reducing the volume of waste which may require decontamination during decommissioning, as well as reducing the generation of used filters. This minimises the loading on the abatement processes and reduces overall solid waste arisings.

5.8.2 The NSH ventilation systems divide into subsystems:

- Clean Ventilation:
    - Supply & Extract System;
    - Fume Cupboard Extract System from Clean Laboratory; and
    - Local exhaust ventilation serving Analytical Balance Room and COSHH Room.
- Active Ventilation System:
    - Active Supply;
    - Active extract;
    - Radiochemistry Laboratory Fume Cupboard Extract;
    - Nuclear Repair Room Fume Cupboard Extract; and
    - ETP Vessel Extract.

5.8.3 The ventilation systems work together to form a pressure cascade arranged as dictated by area classification requirements of the NSH building. Both systems require each other to function properly (to maintain designed pressure cascade) apart from the ETP vessel extract.

5.8.4 The supply rates are designed to maintain the designed pressure cascade, with a run-around coil arrangement to ensure that a proportion of energy in the form of heat is recycled from the extracted air in accordance with BPM and good engineering design. The supply ventilation is equipped with a coalescing filter to remove corrosive salt laden humidity from the air. The removal of salts and humidity is BPM as this increases the lifespan of the ventilation system and minimises the risk of water impacting on the HEPA filters. Due to the isotopes within the gaseous emissions, there is no requirement for active delay beds to be present.

5.8.5 The Active supply ventilation is designed to run continuously providing constant flow rate in two variants:

a. When the Effluent Treatment Plant is in operation (receipt and process of the effluent); and
b. When the ETP plant is not in operation.

5.8.6 The two-variant operation of the ETP ventilation feature has been specified in order to ensure that extract of air from the ullage spaces in the ETP tanks, potentially with entrained activity, only occurs as required during ETP operations. This minimises the generation of radioactive gaseous waste as far as practicable.

5.8.7 The extract ventilation system for the laboratory and the ETP ullage space are equipped with tritium bubbler systems for the monitoring of tritium emissions within the extracted air. The system continuously proportionately samples air and bubbles it through collecting bottles, arranged in two series of five collection bottles with the central three containing collection media while the outer bottles are designed to prevent collection media carryover. The second set of collection bottles is linked to the first by a furnace to oxidise gaseous tritium prior to collection. The collected tritium is then analysed using liquid scintillation counting, to monitor compliance with the numerical limits specified by SEPA.

5.8.8 The fume cupboard extract system is also equipped with a separate C-14 bubbler system for the monitoring of C-14 releases within the extracted air. The bubbler works in a similar manner to the tritium bubbler.

5.8.9 The extract system is routed to the Filter Room where it connects to a HEPA filter manifold comprising four separate filters (3 duty filters, and 1 stand-by filter). This arrangement allows for replacement & maintenance works on the filter section of the live extract system in line with good engineering practice.

5.8.10 A filter paper particulate monitoring system will be installed on the stack after the filters.

**Ventilation of ETP Effluent Tanks**

5.8.11 The ETP effluent tanks will be maintained at a slight negative pressure, in order to minimise the generation of gaseous activity, ventilation will not be continuously applied to the tanks. Evaporation of liquid effluent whilst held within the tanks will potentially saturate the tank ullage air space. Tank ullage air will be displaced into the ventilation system only during transfer operations. In order to provide a bounding estimate of potential radionuclide concentrations in the tank ullage air, conservative assumptions have been applied including assuming that radionuclide concentrations in the ullage air will be directly proportionate to activity concentrations in the liquid effluent. This represents a maximising assumption for evaluation purposes, and predominantly for suspension of particulates in air, actual concentrations would be expected to be much lower than these levels.

**SWHP Ventilation**

5.8.12 The handling and processing of solid low level waste in the SWHP has the potential to generate gaseous activity (including particulates) during the following operations:

- Segregation of waste;
- Un-bagging of waste; and
- Occasional intrusive processing

5.8.13 The SWHP waste handling operations identified above will be conducted at a waste segregation table provided with dedicated extract ventilation routed to the NSH active ventilation system. The assessment of maximum airborne activity generated during SWHP operations has been based on knowledge of waste handling operations currently conducted within the APF, typical waste fingerprint for HMNB Clyde, and assumptions on predicted quantities of LLW to be processed during operation of the SWHP.

**Radiochemistry Laboratory**

5.8.14 Assessment of ventilation to the radiochemistry laboratory has been based on information from existing procedures. Again, the assumptions used are maximum potential activities and represent a conservative estimate. These emissions have been modelled on a worst-case scenario based upon the maximum number of tritium samples which will be handled, and the maximum number of alpha/non-alpha samples which will be boiled down within the laboratory. An allowance has been included in the modelling releases for the total activity in these samples, including both tritium and C-14.

5.8.15 In addition to the routine radiochemistry analysis, additional analysis work may be required to support submarines operating with a non-routine reactor configuration. During the onboard primary coolant sample procedure, noble gases will expand out of the liquid sample and will be ventilated directly from the submarine to the environment. These discharges will be regulated by DNSR. A very small quantity of the noble gases, predominantly Xe-133 (half-life 5.2 days) and Kr-85 (half-life 10.7 years), may be retained in the liquid sample and these gases will be released during analysis conducted in Faslane's radiochemistry laboratory.

**HEPA filter abatement**

5.8.16 The individual ventilation systems as described above are routed to a common manifold on the NSH Active ventilation prior to HEPA filtration and discharge from the NSH building stack. Each line has an individual HEPA filter installed keeping all extract areas separate for filtration purposes.

5.8.17 For assessment purposes a HEPA filtration Decontamination Factor (DF) of 2,000 has been assumed. There is significant variation in quoted DFs for HEPA filtration systems, with DF's of up to 10,000 claimed for HEPA system performance. A DF of 2,000 has been assumed on a conservative basis, as the achievable DF in reality is dependent on a number of site specific and HEPA system factors and interactions. It is assumed tritium is present in the extract air as gas rather than particulate, therefore no HEPA DF has been applied. For C-14, extracts from the SWHP are assumed to be particulate in nature and therefore the standard DF has been applied to this part of the extract. However, C-14 from the ETP ventilation and radiochemist laboratory are assumed to be gaseous, and therefore no DF has been applied.

### 5.9 Gaseous Waste Characterisation & Assessment

5.9.1 The combined activities on an annual basis assumed to be present in the active ventilation system, pre- and post- HEPA filtration are presented in Table 6[10]. These figures do not include the noble gases that may be generated as a result of non-routine chemistry analysis.

| Route | ETP Effluent Tanks | SWHP ventilation | Radiochem. Lab | Total activity pre-HEPA | Total activity post-HEPA |
|---|---|---|---|---|---|
| H-3 | 1.26E+08 | - | 3.80E+07 | 1.64E+08 | 1.64E+08 |
| C-14 | 1.05E+05 | 2.07E+04 | 3.02E+04 | 2.21E+05 | 1.35E+05 |
| Mn-54 | 6.06E+03 | - | 1.04E-02 | 6.06E+03 | 3.03E+00 |
| Fe-55 | 1.26E+04 | - | 3.20E-01 | 1.53E+04 | 7.64E+00 |
| Co-58 | 1.03E+03 | - | 9.80E-03 | 1.03E+03 | 5.17E-01 |
| Co-60 | 8.65E+04 | 5.48E+00 | 1.76E+04 | 1.27E+05 | 6.33E+01 |
| Ni-63 | 7.16E+04 | 5.08E-01 | 5.20E-01 | 7.77E+04 | 3.89E+01 |
| Ag-110m | 5.86E+03 | - | 1.44E-02 | 5.86E+03 | 2.93E+00 |
| Sn-113 | 1.17E+02 | - | | 1.10E+03 | 5.52E-01 |
| Sb-124 | 1.75E+03 | - | | 1.75E+03 | 8.73E-01 |
| Sb-125 | 4.27E+03 | 8.20E-02 | | 4.27E+03 | 2.13E+00 |
| Cs-137 | 1.11E+04 | - | 3.51E-02 | 1.47E+05 | 7.37E+01 |
| Ce-144 | 1.39E+03 | - | 4.08E-02 | 1.39E+03 | 6.94E-01 |
| **Total Alpha** | **4.76E+02** | | **1.20E-02** | **4.76E+02** | **2.38E-01** |
| **Total Non-Alpha** | **1.27E+08** | | **3.85E+07** | **1.65E+08** | **1.64E+08** |

**Table 6.** Annual Gaseous Disposals from the NSH (Bq/y).

5.9.2 The assessment of these discharges will be made by analysing samples from the tritium and C-14 bubbler system fitted to the NSH active ventilation system. The assessment and declaration of the noble gases associated with a non-routine submarine configuration will be based on initial analysis, decay corrected at the time of discharge from the NSH.

### 5.10 Proposed Changes to Gaseous Waste Disposal Approval

5.10.1 HMNB Clyde's current LoAg does not include any specific numerical limits for the disposal of gaseous radioactive waste. During the initial review of the LoAgs in 2012 SEPA requested that Clyde provide information on the expected amount of gaseous waste and the derivation of these amounts. On the basis of the information in Table 6, the limits detailed in Table 7 would be adequate to cover all gaseous discharges from the NSH. The noble gas numerical limit has been based on pessimistic assumptions and operational experience within the NNPP.

[10] Jacobs (2017) HMNB Clyde Faslane Nuclear Support Hub BPM Assessment.

| Radionuclide | Activity (MBq) |
|---|---|
| Tritium | 200 |
| C-14 | 1 |
| Noble Gases | 100 |

**Table 7.** Proposed Annual Limits for Gaseous Disposals from the NSH.

## 6. Proposed Changes to Radioactive Waste Management Arrangements at Coulport

### 6.1 Changes to Solid and Liquid Waste Disposals

6.1.1 As detailed in Section 4 the solid and gaseous waste disposal agreements only permit the disposal of tritium contaminated waste and the discharge of gaseous waste from the Trident Special Area. Disposals of solid or liquid radioactive waste from maintenance of submarines in the EHJ is not included in the current LoAgs and any waste arisings on submarines must be retained on-board and transferred ashore when the submarine berths at Faslane.

6.1.2 To enhance operational flexibility the MoD are seeking SEPA approval to transfer solid and liquid waste arisings directly from the Coulport site to the Faslane NSH for processing and ultimate disposal.

6.1.3 Transfer of these wastes will utilise the existing transfer arrangements. In the event solid radioactive waste is generated, NSH staff will travel to the EHJ in the dedicated solid waste/component transfer van and will receipt and transfer the radioactive material to the SWHP of the NSH. Detailed written procedures will be prepared to cover this transfer and the EHJ Facility Safety Case will be updated to ensure these arrangements are effectively captured and safety justified.

6.1.4 Initial studies have also been carried out to determine the optimum solution for the discharge and transfer of primary coolant from submarines. Options include discharge to a PET and then subsequent transfer back to the NSH ETP by suitable road vehicle or the use of the PET transfer barge. In advance of conducting discharge operations in the EHJ a full safety justification will be developed and appropriate written procedures prepared and authorised by the PAG.

6.1.5 Since all waste will be transferred to Faslane for processing and final disposal the MoD do not believe any numerical limits need to be applied to the transfer of these wastes. HMNB Clyde will continue to apply the BPM principle to reduce both the quantity and activity that will be generated and require transfer from Coulport.

### 6.2 Changes to Gaseous Radioactive Waste Disposals

6.2.1 A review of the actual discharge figures since the introduction of LoAg combined with a detailed understanding of the weapon programme for the next 25 years indicate that that the annual numerical limit could be reduced to 25 GBq. This revised limit would ensure adequate headroom to deal with any urgent operational requirement.

6.2.2 Gaseous disposals directly from the submarine to the environment when berthed in the EHJ will continue to be regulated via the FAC3 consent issued by DNSR.

# 7. Radiological Impact Assessments

## 7.1 Methodology

7.1.1 An assessment of prospective exposure to ionising radiation to the identified critical group (representative person), collective dose, and sensitive environmental receptors resulting from planned radioactive discharges from the NSH has been conducted in order to quantify potential impacts.

7.1.2 The dose assessment from routine releases over the planned operational lifespan of the NSH has been conducted utilising the standard assessment code PC-CREAM (developed by Public Health England (PHE) for routine radiological discharge assessments), incorporating data from the most recent available Habit Surveys.

7.1.3 The International Commission on Radiological Protection (ICRP) use the term ‘representative person’ for assessing doses to members of the public. It is defined as ‘an individual receiving a dose that is representative of the more highly exposed individuals in the population’. The new term is equivalent to ‘critical group’ which has been used previously.

7.1.4 The relevant dose limits for members of the public are 1 mSv per year for whole body (more formally ‘committed effective’) dose and 50 mSv per year specifically for skin. The latter limit exists to ensure that specific effects on skin due to external exposure are prevented. It is applicable, for example, in the case of handling of fishing gear. The dose limits are for use in assessing the impact of direct radiations and controlled releases (authorised discharges) from radioactive sources. These limits are appropriate for ‘certain’ exposure situations where the encounter with radioactivity is expected to occur. In situations where this is not certain, ‘potential’ exposure routes and standards are determined.

7.1.5 The average dose received by the ’representative person’ is compared with the dose limit. They are generally people who eat large quantities of locally harvested food (high-rate consumers) or who spend long periods of time in areas where radiation sources may exist. The limits apply to all age groups. Children may receive higher doses than adults because of their physiology, anatomy and dietary habits. It follows that, if the dose to the representative person is acceptable when compared to relevant dose limits and constraints, members of the public generally will receive lower doses, and overall protection of the public is provided from the effects of radiation.

7.1.6 Collective dose represents a summation of individual doses integrated over all members of a population within a large geographic area, and over an extended timeframe much greater than an individual’s lifetime. Collective dose assessments can be used for cost benefit analysis by applying a pound sterling per man Sv conversion factor, using agreed monetary values.

7.1.7 The most recent available Radiological Habit Surveys for Faslane are for 2006 and 2011. The results from both surveys have been considered to inform the dose modelling assumptions, and where there are differences in values, the higher of the two has been used in order to provide a conservative assessment.

7.1.8 The full set of assumptions that have been used for the PC-CREAM modelling of predicted environmental concentrations and consequential dose impacts from routine discharges from the NSH are listed in Appendix C.

7.1.9 PC-CREAM is the standard software tool for calculating doses resulting from routine aerial and liquid discharges in the UK and includes Faslane as a pre-configured site within its menu system. The NSH represents a slight change to the existing discharge scenario, but PC-CREAM remains capable of incorporating the change and producing representative estimates of doses from routine operations, as discussed below.

7.1.10 Marine modelling in PC-CREAM is based on representing the sea / oceans as a series of marine compartments, typically defined by a geographic surface area and representative depth giving the compartment volume, and a series of volumetric exchange rates which defines exchanges between adjacent compartments.

7.1.11 In terms of local dispersion around the site, a local dispersion compartment is defined, which is the local mixing compartment. This compartment receives the discharge and then exchanges material with the adjacent geographic marine compartments. For Faslane, the adjacent marine compartment for mixing is the Scottish Waters West compartment.

7.1.12 The definition of the local marine compartment is driven by the need to represent local dispersion conditions on an annual basis (since this is the period over which doses are calculated). As such the compartment and model doesn't represent hour to hour and day to day dispersion resulting from tidal variation. The size of the compartment also needs to be sufficiently large that the habits of the local representative persons are adequately and conservatively covered.

7.1.13 This model output result is an annual dose requirement which is very different to a typical assessment for a "normal" chemical permitting assessment, which tends to model a maximum concentration limit in water. An assessment for chemical permitting requires assessment of peak chemical concentrations resulting from local tidal conditions and hence more complex dispersion modelling.

7.1.14 The standard local compartment for Faslane within PC-CREAM has a coast length of 30 km and a depth of 20 m giving a compartment volume of $5e^{9}$ $m^3$; and an exchange of $1e^{11}$ $m^3$/yr. This compartment is larger in extent than just the Gare Loch, but may be justified if the local tidal mixing is sufficiently uniform and covers local critical group habits. The Environment Agency have published guidance on suggested local marine compartment parameters for use in PC-CREAM. Although Scotland is not covered by the report, guidance on site-specific parameterisation is given.

7.1.15 In addition, a compartmental modelling study was undertaken for the area 'Further Estimates of Dispersion in the Gareloch, A J Elliott (University of Wales), March 2001'. The results of this study were used to derive site-specific parameters for the local PC-CREAM compartment. This compartment appears to be specific to the extent of Gare Loch and intuitively gives a more realistic representation of local dispersion and critical group habits.

7.1.16 As this modified local compartment encompasses all of Gare Loch, it is unlikely that the specific location of the pipeline at the North end of the loch, whether in its current location or the proposed new location, will have a material difference on dispersion conditions for Gare Loch as a whole either in terms of the discharge location, or in terms of local structures. This assumption is valid for assessments of dose over periods of a year or more as per regulation.

## 7.2 Doses from Routine Discharges of Liquid Effluent from the NSH

7.2.1 The ETP outlet activities listed in Table 5 have been used in PC-CREAM modelling to provide anticipated individual and collective doses. Discharges have been modelled over a 50-year period for individual doses, and over a 500-year period for collective dose to the EU12 Countries and World populations. Using the slightly higher annual discharge figures requested in Table 5 has no real impact on the trivial nature of these exposures.

### Individual Dose

7.2.2 The predicted individual dose to the adult population (identified as the representative individual for Faslane) from all sources is $3.14 \times 10^{-6}$ mSv. The individual dose is dominated by external gamma dose from beach exposure at $3.00 \times 10^{-6}$ mSv. Combined doses from all sources are dominated by Co-60 emissions at $2.92 \times 10^{-6}$ mSv.

7.2.3 The predicted individual dose to the child population (6–15 years old) from all sources is $5.18 \times 10^{-7}$ mSv. The individual dose is dominated by external gamma dose from beach exposure at $3.94 \times 10^{-7}$ mSv and consumption of molluscs at $1.00 \times 10^{-7}$ mSv. Combined doses from all sources are dominated by Co-60 emissions at $3.92 \times 10^{-7}$ mSv and C-14 emissions at $1.02 \times 10^{-7}$ mSv.

7.2.4 The predicted individual dose to the infant population (0–5 years old) from all sources is $2.56 \times 10^{-7}$ mSv. Again, individual dose is dominated by external gamma dose from beach exposure at $1.90 \times 10^{-7}$ mSv, and doses from all sources dominated by Co-60 emissions at $1.92 \times 10^{-7}$ mSv.

7.2.5 The predicted dose to the representative individual (adult population) resulting from anticipated liquid effluent discharges from the NSH of $3.14 \times 10^{-6}$ mSv based on conservative assumptions is significantly below both the regulatory constraint of 0.3 mSv/y and the threshold for optimisation of 20 µSv/y.

### Collective Dose

7.2.6 The predicted collective dose to the EU12 population over a period of 500 years from all sources is $4.04 \times 10^{-5}$ man Sv. The collective dose is dominated by global circulation at $2.09 \times 10^{-5}$ man Sv. and consumption of fish at $1.55 \times 10^{-5}$ man Sv. Combined doses from all sources are dominated by C- 14 emissions at $3.95 \times 10^{-5}$ man Sv

7.2.7 The predicted collective dose to the World population over a period of 500 years from all sources is $6.15 \times 10^{-4}$ man Sv. The collective dose is dominated by global circulation at $5.78 \times 10^{-4}$ man Sv. Combined doses from all sources are dominated by C 14 emissions at $6.08 \times 10^{-4}$ man Sv.

**Dose from the Release of Conventional Effluents**

7.2.8 Assessment of doses from the release of these conventional is based on EA guidance that uses a three-stage approach for assessing radiation exposures to the public from radioactive discharges. The dose in µSv/y is calculated by multiplying the annual discharge activity (Bq/y) by the Dose Per Unit Release (DPUR). Using a pessimistic figure of 10 GBq/y and assuming the DPUR of 8.90E-16 µSv/y per Bq/y (discharges to coastal water, fisherman family) results in an exposure of 8.90E-6 µSv/y. This is significantly below the threshold for optimisation of 20 µSv per year.

## 7.3 Doses from Gaseous Discharges from NSH

7.3.1 The annual discharge figures from Table 6 have been used to assess individual and collective exposures.

**Individual Exposures for Routine Submarine Configuration**

7.3.2 The predicted individual dose to the adult population (identified as the representative individual for Faslane) from all sources is $7.07 \times 10^{-9}$ mSv. The individual dose is dominated by plume inhalation and cow milk consumption from tritium emissions at $1.22 \times 10^{-9}$ mSv and $3.13 \times 10^{-9}$ mSv respectively.

7.3.3 The predicted individual dose to the child population (6–15 years old) from all sources is $1.12 \times 10^{-9}$ mSv. The individual dose is dominated by external gamma dose ground exposure from Co-60 emissions at $2.19 \times 10^{-10}$ mSv, and plume inhalation from tritium emissions at $8.26 \times 10^{-10}$ mSv

7.3.4 The predicted individual dose to the infant population (0–5 years old) from all sources is $9.49 \times 10^{-10}$ mSv. As with the child population, the individual dose is dominated by external gamma dose ground exposure from Co-60 emissions at $2.74 \times 10^{-10}$ mSv and plume inhalation from tritium emissions at $6.17 \times 10^{-10}$ mSv.

**Additional Exposure Associated with Non-Routine Gaseous Discharges**

7.3.5 Table 7 pessimistically assumes 100 MBq of noble gases may be discharged from the NSH to support radiochemistry analysis for non-routine reactor configurations. Assessment of doses from the release of these noble gases is based on EA guidance that uses a three-stage approach for assessing radiation exposures to the public from radioactive discharges. The first stage consists of a simple, very cautious, assessment to identify if the dose is above 20 µSv/y. The initial assessment methodology is based on a Gaussian atmospheric dispersion model. The dose in µSv/y is calculated by multiplying the annual discharge activity (Bq/y) by the Dose Per Unit Release (DPUR). Using a pessimistic figure of 100 MBq and a DPUR of 7.0E-14 µSv/y per Bq/y for Xe-133 (assuming all noble gas released is Xe-133) gives an additional exposure for non-routine discharges of 7.0E-6 µSv/y.

7.3.6 The predicted dose to the representative individual (adult population) resulting from combined routine and non-routine discharges from the NSH, based on very conservative assumptions, is significantly below the threshold for optimisation of 20 µSv per year.

**Collective Dose**

7.3.7 As there have been no historical routine emissions of gaseous radionuclides from Faslane, there is no existing population density grid for Faslane in PC-CREAM. Therefore, calculation of the collective dose from gaseous discharges at Faslane has not been possible. An indicative assessment of collective dose to the EU population has been conducted based on if the same gaseous releases were made from the Hunterston site. Given the relative proximity and scale of transfer factors used in PC-CREAM for modelling aerial dispersion throughout Europe, this is considered to provide a reasonable indication for collective dose.

7.3.8 The results indicate a collective dose to the European population (500 yrs) from gaseous discharges of $5.96 \times 10^{-7}$ man Sv. Doses are primarily from tritium and C - 14 emissions.

7.3.9 Detailed information on the dose calculations to support the individual and collective exposures detailed above are provided at Appendix D & E.

**Doses from Coulport Discharges of Tritium**

7.3.10 Using the same methodology as described at para 7.3.5, the doses associated with the discharge of the reduced annual numerical limit of 25 GBq of tritium, assuming a DPUR of 9.60E-13 µSv/y per Bq/y, is 2.40E-02 µSv/y. Doses from operations at Coulport are therefore significantly below the threshold for optimisation of 20 µSv per year.

## 7.4 Dose to Biota

7.4.1 There has been an increasing focus on the potential effects of ionising radiation on non-human species in a number of international fora. In the UK context, the environment agencies have undertaken programmes of work to fulfil their obligations, for example under the relevant conservation of natural habitats regulations, to review all existing permits/authorisations that may have an adverse effect on identified European sites.

7.4.2 Potential impacts from release of radionuclides from the Faslane NSH have been assessed by conducting an ERICA assessment of impacts to sensitive environmental receptors (e.g. Sites of Special Scientific Interest). ERICA (Environmental Risks from Ionising Radiation in the Environment: Assessment and Management) was an EU funded project, the aim of which was to develop an approach whereby the impacts of ionising radiation on the environment could be assessed. To fulfil this objective, elements related to environmental management, risk characterisation and impact assessment have been integrated into what was termed the 'ERICA Integrated Approach' supported by the ERICA software tool.

7.4.3 There are no sites designated for nature conservation interest in the immediate vicinity of HMNB Clyde. The closest Site of Special Scientific Interest (SSSI) is at Rhu Point, identified for its Quaternary geological interest (6 km to the south). To the east of the Gare Loch lie the Inner Clyde Special Protection Area (SPA), Ramsar and SSSI. This site is used by migrating birds and is of national importance for its populations of wintering wildfowl and waders and of European importance for its wintering population of redshank. In addition, Craighoyle Woodland SSSI, is located to the North West of HMNB Clyde and could potentially be impacted by gaseous emissions. The site comprises ancient native deciduous woodland and supports a number of nationally important lower plant communities, particularly bryophytes. The bryophytes flora includes a number of internationally threatened and nine nationally scare species.

7.4.4 The ERICA assessment process comprises a tiered assessment approach whereby an initial Tier 1 assessment of potential risks is conducted. Detailed Tier 2 and 3 assessments can then be conducted dependant on the level of risk identified by the Tier 1 assessment. A Tier 1 ERICA assessment is based on comparison with predicted environmental concentrations of radionuclides against Environmental Media Concentration Limits for the most sensitive species.

7.4.5 A Tier 1 ERICA Assessment has been conducted for anticipated releases from the Faslane NSH for both gaseous and liquid disposals. Outputs from the PC-CREAM modelling for routine releases have been used to provide activity concentrations in air (distance of 1 km) and in the Faslane local marine compartment (Gare Loch). Results from the Tier 1 Assessments are presented at Appendix F.

7.4.6 The predicted environmental media activity concentrations from releases from the NSH are substantially (orders of magnitude) below the ERICA Environmental Concentration Limits for the most sensitive organisms. In addition, the outputs from the ERICA assessment report estimated doses as all below the 10 µGy/h screening dose rate. Detailed assessments of the environmental impacts on biota from NSH disposals have not been conducted.

# 8. Environmental Monitoring

## 8.1 Background

8.1.1 The MoD marine environmental programme has been designed to ensure that, as a responsible operator, liquid radioactive waste discharges to the marine environment from naval establishments are not harming the environment, nor resulting in unacceptable levels of public radiation exposure in line with requirements defined under EASR18. To this end, the Defence Science and Technology Laboratory (DSTL) regularly monitors the inter-tidal and underwater zones around establishments from which small controlled discharges are routinely made.

8.1.2 Co-60 has been identified as the nuclide of main importance in discharges from nuclear powered submarines and related activities. The emphasis on the detection and measurement programme is therefore based upon this nuclide.

8.1.3 To interpret the monitoring results in terms of radiation doses to members of the public, data is required concerning the pathways of potential radiation exposure (i.e. rates of consumption of local produce, occupancy of beaches, etc.). The Habit Survey for the areas around the Gare Loch identifies external exposure from sediments and internal exposure from the consumption of fish and shellfish as the key exposure pathways. The current monitoring regime therefore concentrates on dose rate measurements on the strandline together with activity levels in biological samples such a seaweed and shellfish.

8.1.4 In addition to carrying out measurements/sample analysis at points agreed between SEPA and MoD, DSTL also conducts monitoring at various points in the vicinity of the Gare Loch.

8.1.5 The additional monitoring provides further confidence that the existing discharge arrangements are providing effective controls.

### 8.2 Future Monitoring Programme

8.2.1 Discussions with DSTL have confirmed that the current environmental monitoring strategy remains valid. DSTL and HMNB Clyde have reviewed the latest guidance on environmental radiological monitoring[11] and concluded that the current monitoring strategy fully complies with the 11 generic principles defined in this guidance. The current strategy is based not only upon the predicted dispersion of liquid radioactive waste but also upon the areas around the Gare Loch where the public and the DSTL measurement team may reasonably access. Appendix G provides detailed information on the location and the extent of the environmental monitoring programme. These areas will not change as a result of the outfall relocation.

8.2.2 Discharge information and the results of the environmental monitoring programme are published annually by the Environment Agencies in the 'Radioactivity in Food and the Environment' reports (RIFE). The MoD also produces an annual 'Marine Environmental Surveys at Nuclear Submarine Berths' report which provides detailed information on the underwater monitoring and intertidal stations around both Loch Long (Coulport) and the Gare Loch (Faslane) and the results of the monitoring programme. A review of the MoD annual reports for the last five years indicates:

- Environmental gamma and strandline dose rates at inter-tidal zone sampling locations (Appendix G) are consistent with the background levels which have been observed previously in these areas.
- No Co-60 is generally detected in the gamma spectrometry analysis results for inter-tidal sediment samples. Low levels of Cs-137 are detected in the majority of samples but are likely to be present as a result of authorised discharges from other nuclear operators and/or to atmospheric weapons testing and releases from previous nuclear accidents such as at Chernobyl.
- No Co-60 is generally detected in the gamma spectrometry analysis results of underwater sediment samples. The low levels of Cs-137 and Am-241 detected are likely to be due to authorised discharges from other nuclear operators and/or atmospheric weapons testing and releases from previous nuclear accidents such as at Chernobyl.
- Laboratory analysis results for biota samples do not generally detect Co-60 but occasionally show detectable levels of C-14.

8.2.3 Using the methodology described in the Model by Hunt[12] the total annual effective dose to the Representative Person is calculated to be well below 1 μSv and represents less than 0.1% of the UK legal limit for members of the public.

8.2.4 Both MoD and RIFE reports conclude that the existing discharge arrangements are providing effective control over environmental levels of radioactivity and there has been no radiological hazard to any member of the general public from the operation of nuclear submarines.

[11] Radiological Monitoring Technical Guidance Note 2 Environmental Radiological Monitoring 2010.
[12] Hunt, G. J. (1984) Simple Models for Prediction of External Radiation Exposure from Aquatic Pathways, Radiation Protection Dosimetry Volume 8, Number 4 p215 – 224.

## 9. Conclusions and Summary of Key Changes

This application seeks an approval to dispose of solid, liquid and gaseous radioactive waste from HMNB Clyde. If successful, this approval will replace the existing 4 LoAgs.

This application demonstrates that the principle of BPM has been applied to each of the three waste streams generated at HMNB Clyde.

Operational experience from across the NNPP, in particular Devonport Dockyard and the NRTE at Vulcan, have been used to identify and quantify all potential waste streams arising from routine and non-routine support activities.

The predicted doses to the representative person for all discharges are significantly below the threshold for optimisation of 20 µSv per year.

Environmental monitoring will be undertaken by the MoD to demonstrate that there is no radiological hazard to any member of the public from the discharges of radioactive waste from HMNB Clyde.

Key changes to the current arrangements include:

**Solid Waste**

MoD is seeking approval to dispose of solid low level waste to any person lawfully entitled to accept, treat or dispose of that waste.

MoD is seeking approval to transfer submarine and weapon related solid waste from Coulport to Faslane.

**Liquid Waste**

Liquid radioactive waste will be treated in a new facility currently under construction. This facility will discharge treated radioactive effluent at a point approximately 1 km north of the current discharge point.

The numerical limits for liquid waste disposals to the Gare Loch have, where practical, been reduced. In addition, the terminology used to describe the radionuclide groups has been updated to reflect best practice and C-14 will now be reported separately.

MoD is seeking approval to dispose of small quantities of liquid, chemically contaminated waste to any person lawfully entitled to accept, treat or dispose of that waste.

MoD is seeking approval to dispose of large quantities of conventional submarine effluents that may be contaminated with trace levels of tritium.

MoD is seeking approval to transfer submarine liquid waste from Coulport to Faslane.

**Gaseous Waste**

MoD have quantified and are seeking approval to dispose of gaseous radioactive waste from the NSH arising from routine and non-routine support activities.

The current disposal limit for gaseous disposals associated with weapon processing activities at Coulport has been reduced.

## Appendix A – Existing Letters of Agreement

Solid Faslane

CLAS Ref : RSA/N/1027543

THE SCOTTISH OFFICE

Environment Department

HM Industrial Pollution Inspectorate
27 Perth Street
Edinburgh EH3 5RB

Telephone 0131-244 3062
Out of Hours Telephone
0131-244 3060
Fax 0131-244 2903

Office of the Commodore
Clyde Submarine Base
Faslane
Helensburgh
Dunbartonshire
G84 8HL

Our ref: IPB/18/13

17 August 1995

Dear Sir

**RADIOACTIVE SUBSTANCES ACT 1993**
**DISPOSAL OF SOLID RADIOACTIVE WASTE FROM CLYDE SUBMARINE BASE, FASLANE, TO DRIGG**

I refer to the discussions between the Ministry of Defence (Navy) and Her Majesty's Industrial Pollution Inspectorate on the disposal of solid radioactive waste (hereinafter called "the waste") produced by MOD (Navy) at the Clyde Submarine Base, Faslane. This letter sets out the limitations and conditions agreed with the Chief Inspector in respect of the disposal of the waste.

1. The waste shall be disposed of by removing it or causing or permitting its removal to British Nuclear Fuels plc's facilities at either Sellafield, Cumbria, or Drigg, Cumbria, for subsequent disposal therefrom in accordance with an authorisation under Section 13 of the 1993 Act or Section 6 of the Radioactive Substances Act 1960 granted in that behalf.

2. MOD (Navy) shall use the best practicable means for reducing the activity and volume of the waste subject to disposal under the terms of this agreement having regard both to the provision and efficient maintenance of apparatus for reducing the quantities of the waste prior to disposal and also to the supervision by MOD (Navy) of the processes whereby the waste is produced. In determining whether any particular means are, or may be, required in relation to this duty MOD (Navy) shall not be required to incur expenditure, whether of money, time or trouble which is, or is likely to be, grossly disproportionate either to the benefit to be derived from, or likely to be derived from, or to the efficacy of, or the likely efficacy of, employing them, the benefits or results produced being, or likely to be, insignificant in relation to the expenditure.

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3. Without prejudice to the general requirement of the preceding paragraph, the volume of the waste, including its immediate packaging, disposed of during any period of 12 consecutive calendar months shall not exceed 40 $m^3$. In all the waste disposed from the premises during any period of 12 consecutive calendar months the activity of each of the radionuclides or groups of radionuclides listed in column 1 of the schedule shall not exceed the value specified for that radionuclide or group of radionuclides in column 2 of the schedule.

4. Notwithstanding the limitations of the previous paragraph, in any single consignment of waste the concentration of radionuclides which emit alpha particles shall not exceed 4 gigabecquerels per tonne and the concentration of all other radionuclides taken together shall not exceed 12 gigabecquerels per tonne.

5. All consignments of the waste shall be subject to quality assurance and documentation to the satisfaction of BNFL.

6. The waste shall be packed in containers appropriately labelled to show their contents and shall be made available for collection by or delivered to BNFL all in accordance with its directions.

7. The dose rate at the surface of the waste when substantially unshielded shall not exceed 2 milligrays per hour in air.

8. MOD (Navy) shall keep records in respect of each consignment of the waste showing:

a. the date of its removal from the Clyde Submarine Base;

b. the weight and volume of the waste removed;

c. the maximum surface dose rate at the surface of the waste; and

d. the activity of each of the radionuclides or groups of radionuclides listed in column 1 of the schedule.

The records maintained in pursuance of the preceding paragraph shall be kept at the Clyde Submarine Base and shall be open to examination by any person authorised for that purpose by the Secretary of State for Scotland. Any alteration of the said reports shall be so made that the original entries remain legible.

9. The records shall be preserved by MOD(N) for 30 years or for such other period as may be specified by the Chief Inspector and a copy of the records, or of any part thereof as he shall specify, shall be supplied to the Chief Inspector at such intervals as shall be agreed.

10. For the purposes of this agreement, activity expressed in becquerels or multiples thereof means the numbers of spontaneous nuclear transformations occurring in a radioactive substance in a period of one second, and any reference to activity is a reference ascertained or estimated by a method acceptable to the Chief Inspector. These conditions and limitations shall come into force on 18 August 1995.

Yours faithfully

R Thom

R THOM

Copy to: BNFL - Risley and Sellafield

CLAS Ref: RSA/N/1027837

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# THE SCOTTISH OFFICE

## Environment Department

HM Industrial Pollution Inspectorate
27 Perth Street
Edinburgh EH3 5RB

Telephone 031-244
Out of Hours Telephone 031-244 3060
Fax 031-244 2903

Office of The Naval Base Commander
Clyde Submarine Base
Faslane
HELENSBURGH
G84 8HL

NAVAL BASE COMMANDER CLYDE
21 JUN 1993
M2322/8/1
COMMODORE CLYDE

Our Ref: IPB/18/13

15 June 1993

Dear Sir

RADIOACTIVR SUBSTANCES ACT 1960 - DISPOSAL OF LIQUID AND GASEOUS RADIOACTIVE WASTES FROM THE CLYDE SUBMARINE BASE, FASLANE

1. I refer to the discussions between our respective departments on the disposal of liquid and gaseous radioactive wastes produced by MOD (Navy) at the Clyde Submarine Base, Faslane. This letter sets out the limitations and conditions agreed with the Chief Inspector of Her Majesty's Industrial Pollution Inspectorate, hereinafter called the Chief Inspector, in respect of the disposal of these wastes and shall be operative from 1 July 1993.

2. MOD (Navy) shall use the best practicable means for reducing the quantity of liquid and gaseous radioactive wastes subject to disposal having regard both to the provision and efficient maintenance of apparatus for reducing the quantities of the liquid and gaseous radioactive wastes prior to disposal and also to the supervision by MOD (Navy) of the processes whereby the wastes are produced. In determining whether any particular means are to be required in relation to this duty, MOD (Navy) shall not be required to incur expenditure, whether of money, time or trouble which is, or is likely to be, grossly disproportionate either to the benefit to be derived from, or likely to be derived from, or to the efficacy of, or likely efficacy of, employing them, the benefits or results produced being, or likely to be, insignificant in relation to the expenditure.

3. In all liquid radioactive waste discharged from the Clyde Submarine Base, Faslane during any period of 12 consecutive calendar months the activity of the radionuclides listed in Column 1 of the Schedule to this letter shall not exceed the value specified in Column 2 of the Schedule.

4. Liquid radioactive waste shall be discharged by pipeline to The Gareloch within national grid square NS 2488.

5. MOD (Navy) shall ensure that the systems by which all radioactive wastes are discharged are kept in good repair.

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6. For the purposes of determining the activity of any radionuclides contained in the radioactive wastes and of ascertaining the effects on the environment of radioactive wastes discharged, MOD (Navy) shall provide and maintain such equipment and shall take such samples, both as shall be agreed with the Chief Inspector.

7. MOD (Navy) shall examine or cause to be examined by methods that shall be agreed with the Chief Inspector any samples taken in pursuance of the preceding paragraph and shall retain for such period as the Chief Inspector may specify any such samples for examination by or on behalf of any persons authorised by the Chief Inspector in that behalf.

8. MOD (Navy) shall keep records in respect of all radioactive wastes.

These records shall comprise:-

a. a description of the outlets by which the radioactive wastes were discharged;

b. a description of the radioactive wastes discharged;

c. the date and period over which the radioactive wastes are discharged;

d. for liquid radioactive waste, the activity, expressed in becquerels or multiples thereof, of each of those radionuclides listed in the Schedule and present in the waste at the time it was discharged; and

e. such part of the information obtained by MOD (Navy) in pursuance of paragraph 7 as shall be agreed with the Chief Inspector.

9. These records shall be kept at the Clyde Submarine Base, Faslane, and shall be open to examination by any persons authorised for that purpose by the Secretary of State for Scotland. Any alteration of these records shall be so made that the original entries remain legible.

10. The records maintained in pursuance of the preceding paragraph shall be preserved by MOD (Navy) for 30 years or for such other period as may be agreed with the Chief Inspector, and a copy of the records, or any part thereof as he shall specify shall be supplied to the Chief Inspector at such intervals as shall be agreed.

11. For the purposes of this agreement, activity expressed in becquerels or multiples thereof means the number of spontaneous nuclear transformations occurring in a radioactive substance in a period of one second, and any reference to activity is a reference to activity ascertained by a method acceptable to the Chief Inspector.

Yours faithfully

R Thom

R THOM

## SCHEDULE - LIQUID WASTE

MOD (Navy)
CSB, Faslane

Operative 1 July 1993

| Column 1 | Column 2 |
|---|---|
| Cobalt 60 | 500 MBq |
| Tritium | 1 TBq |
| Gross Beta Activity | 500 MBq |
| Gross Alpha Activity | 200 MBq |

Solid Coulport

CLAS Ref. RSA/W/1027 872

SEPA
west region

Our Ref: RS/Nuc/Coulport
Your Ref:
Date: 6 December 2000

Cdre R J Lord CBE, MSc, RN
Director, Naval Base Clyde
HM Naval Base Clyde
Faslane
Helensburgh
Dunbartonshire
G84 8HL

Dear Sir

DISPOSAL OF SOLID RADIOACTIVE WASTE FROM RNAD COULPORT TO BNFL DRIGG, VIA HMNB CLYDE FASLANE.
LETTER OF AGREEMENT

I refer to the application, dated 31 July 1998 made by the Ministry of Defence for SEPA's agreement to the disposal of solid radioactive waste in the form of desiccant and associated items which have been contaminated with tritium. After consideration of your application and responses received as a consequence of a public consultation exercise SEPA agrees to the Director, Naval Base Clyde, Faslane, for the Ministry of Defence, disposing of the waste by causing or permitting its removal from the premises of RNAD Coulport to British Nuclear Fuels plc at Sellafield or Drigg, Cumbria, for final disposal at the British Nuclear Fuels plc facility at Drigg, Cumbria in accordance with an authorisation granted to the said British Nuclear Fuels plc. Any such disposal shall be made in the first instance to the Active Processing Facility, HM Naval Base Clyde, Faslane for onward shipment to British Nuclear Fuels plc as soon as is reasonably practicable after its receipt.

The agreement specified above is subject to limitations and conditions which are prescribed in the Annexe to this letter.

The agreement is also subject to the Director, Naval Base Clyde, Faslane providing appropriate facilities and reasonable access to RNAD Coulport for designated officers of SEPA in order that the necessary checking of compliance with the limitations and conditions of this agreement can be undertaken.

Yours faithfully

J M Beveridge

John M Beveridge
Director - West Region

Direct Dial : 01355 574220
enc. Annexe to Letter of Agreement for the Disposal of Solid Radioactive Waste from RNAD Coulport to BNFL Drigg, Cumbria via HMNB Clyde, Faslane.

SEPA WEST • 5 Redwood Crescent • Peel Park • EAST KILBRIDE G74 5PP
Tel: 01355 574200 • Fax: 01355 574688 • Website www.sepa.org.uk
Director John M Beveridge

SEPA

**ANNEXE TO A LETTER OF AGREEMENT FOR THE DISPOSAL OF SOLID RADIOACTIVE WASTE FROM RNAD COULPORT TO BNFL DRIGG, CUMBRIA VIA HMNB CLYDE, FASLANE.**

1. This Annexe provides the limitations and conditions to the letter of agreement reference RS/Nuc/Coulport and dated 8 December 2000 (hereinafter called "the agreement") and issued by SEPA to the Director, Naval Base Clyde, for the Ministry of Defence (hereinafter called "the Director").

LIMITATIONS AND CONDITIONS

2. The radioactive waste to which the agreement refers (hereinafter called "the waste") shall comprise waste in solid form which has arisen as a result of the operations of the Ministry of Defence (hereinafter called "the MOD") on the premises of RNAD Coulport (hereinafter called "the premises").

3. The best practicable means shall be used to minimise the activity and volume of waste subject to disposal under the terms of the agreement.

4. Without prejudice to the general requirements of the preceding condition:

 4.1 In all of the waste disposed of in any 12 consecutive calendar months the number of megabecquerels of tritium shall not exceed 20; and

 4.2 the volume of all the waste disposed of, including its immediate packaging during any such period shall not exceed 2 $m^3$.

5. In any consignment of waste removed from the premises:

 5.1 the waste shall not contain any radionuclide other than tritium, in a concentration which exceeds that which would be reasonably expected from the natural environment; and

 5.2 the average concentration of tritium shall not exceed 12 gigabecquerels per tonne.

6. The waste shall be disposed of by causing or permitting its removal from the premises to British Nuclear Fuels plc (hereinafter BNFL) at Sellafield or Drigg, Cumbria, for final disposal at the BNFL facility at Drigg (hereinafter "Drigg"), in accordance with an authorisation granted to the said British Nuclear Fuels plc for disposal at Drigg. Any such disposal shall be made in the first instance to the Active Processing Facility, HM Naval Base Clyde, Faslane for onward shipment to BNFL as soon as is reasonably practicable after its receipt.

7. PACKAGING

7.1 The waste shall be packed in such a manner to prevent as far as reasonably practicable the contamination of other articles during transport to the premises specified in condition 6.

7.1.1 Any non-fixed contamination on any container in which the waste is packed when averaged over an area of 300 square centimetres shall not exceed 4 becquerels per square centimetre for all beta and gamma emitting radionuclides taken together, and shall not exceed 0.4 becquerels per square centimetre for all alpha emitting radionuclides taken together.

7.1.2 Any packaging or containers used to contain the waste shall be appropriately labelled to show their contents.

8. SAMPLING AND ANALYSIS

8.1 The Director shall take samples of the waste and determine the activity of the radionuclides contained in the waste in accordance with a sampling and analysis plan agreed with SEPA.

8.2 When required by SEPA the Director shall obtain samples of the waste, including packaged waste, as specified by SEPA, and deliver them for examination to a laboratory specified by SEPA and after examination, and on written notification from SEPA, collect and return them to the premises, all within such time scales as may be specified in writing by SEPA.

9. RECORDS AND PROVISION OF INFORMATION

9.1 The Director shall make and shall retain on the premises, for such a period as is agreed in writing with SEPA, for inspection, by a designated officer of SEPA, a true and accurate record of all waste disposed of on or from the premises; and the said record shall comprise -

9.1.1 a description of all the waste disposed of and the source of all such waste;

9.1.2 the activity of tritium and any other radionuclide which may be present in all the waste disposed of;

9.1.3 the volume of all the waste disposed of; and

9.1.4 the means and date of disposal of all the waste disposed of.

9.2 The Director shall provide to SEPA a summary of solid waste disposed in each preceding calendar year within 30 days of the end of the calendar year. The report shall include a summary of the record kept in accordance with conditions 9.1.1, 9.1.2 and 9.1.3 of this certificate and shall be made in a format specified by SEPA.

9.3 The Director shall provide the results of any sampling and analysis carried out in accordance with condition 8 in any calendar month to SEPA within 30 days of that calendar month of the completion of the sampling or at any other time as agreed in writing by SEPA.

9.4 The Director shall provide reports in accordance with condition 9.2 and 9.3 in writing to the Director, West Region at the address specified in condition 11.~~6~~5

## 10. PROCEDURES

10.1 The Director shall prepare, record, and implement suitable procedures designed to meet the conditions of this authorisation, and :-

10.1.1. The procedures shall be subject to a documented revision and modification system;

10.1.2 The procedures shall be subject to a review by the company every twelve months, or at such other interval as may be agreed by SEPA, and details of that review shall be forwarded to SEPA within one month of the review taking place;

10.1.3 The company shall prepare and maintain an index of these procedures in such a manner as SEPA may specify;

10.1.4 The procedures shall be made available for examination by the designated officer of SEPA ; and

10.1.5 The company shall furnish copies of any of the procedures mentioned above to SEPA, at SEPA's request.

10.2 The procedures referred to in condition 10.1 shall set out amongst other things:

10.2.1 The maintenance and inspection procedures of equipment used for the handling, treatment and disposal of radioactive waste;

10.2.2 The means by which waste minimisation is achieved;

10.2.3 The arrangements for record keeping;

10.2.4 The arrangements for sampling and monitoring; and

10.2.5 The necessary training and experience of persons responsible for the disposal of waste.

10.2.6 The Director may appoint an appropriate person to have overall responsibility for ensuring compliance with the limits and conditions to which this agreement is subject and shall so advise the Director, West Region at the address specified in Condition 11.5.

## 11. INCIDENTS

11.1 In the event of any breach of any condition or limitation to which this agreement is subject the Director shall:

SEPA

11.1.1 take prompt action to prevent the continuation or recurrence of that breach and where practicable to remedy the consequences of that breach;

11.1.2 carry out an immediate investigation into the causes and circumstances of the breach;

11.1.3 make a record of the cause and action taken under condition 11.1.1.

11.2 The Director shall notify SEPA when:

11.2.1 any release of any waste is detected that has exceeded, or is likely to exceed, or has caused, or is likely to cause an exceedance of any disposal limit specified in this agreement;

11.2.2 any radioactive waste named in any relevant condition of this authorisation is detected in a disposal where the pathway of this disposal is not authorised by any condition of this agreement.

11.2.3 any disposal of any radioactive waste not agreed to be released by virtue of any condition of the agreement is detected.

11.3 The Director shall notify any incident to SEPA at the address specified under Condition 11.5 by telephone without delay and in writing by first class post on the next working day after the identification of the incident.

11.3.1 Any such notification made as a result of Condition 11.3 shall contain details relating to the following:

11.3.1.1 date, time and duration of incident;

11.3.1.2 the receiving medium or media;

11.3.1.3 an initial estimate of the quantity of waste disposed;

11.3.1.4 the nature of the waste involved;

11.3.1.5 measures taken to minimise harm; and

11.3.1.6 where possible, a preliminary assessment of the cause of the incident.

11.4 The Director shall carry out an investigation on any incident that has been notified as a consequence of Condition 11.3 and this report shall be submitted to SEPA within 14 days of the incident or such other period as agreed in writing with SEPA. Any such report shall detail, as a minimum, the circumstances of the incident and the steps taken by the Director to bring the incident to an end. It shall also set out proposals for preventing a repetition of the incident in question.

11.5 In the event of an incident occurring between 1730 hours and 0830 hours on any week day, or between 1730 hours on a Friday and 0830 hours the following Monday, or during any bank holiday, initial notification of the incident shall be by telephone to SEPA's standby telephone number 01355 574200, and should be confirmed by first class post to Director, SEPA West, 5 Redwood Crescent, Peel Park, East Kilbride, G74 5PP on the first following working day.

12 DISPLAY OF DOCUMENTS

12.1 A copy of this agreement and annexe shall be kept posted on the premises to which it relates in such a way as to be conveniently read by persons whose duties on the premises may be affected by the requirements of the agreement.

13 INTERPRETATION

In this Annexe to the Agreement -

"the Act" means the Radioactive Substances Act 1993;

"activity" expressed in becquerels means the number of spontaneous nuclear transformations occurring in a quantity of radioactive substance in a period of one second; and any reference to activity is a reference to activity ascertained or estimated by a method acceptable to the Scottish Environment Protection Agency;

"annexe" means an annexe forming part of the agreement

"authorisation" means an authorisation granted, or having effect as if granted, under section 13 of the Act;

"Authorised Person" means a person who is authorised in writing under Section 108 of the Environment Act to carry out duties on behalf of SEPA;

any reference to the contamination of a substance or article is a reference to its being affected in the manner described in section 47(5) of the Act;

"best practicable means" within a particular waste management option, means 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. In determining whether a particular aspect of a proposal represents the best practicable means SEPA will not require the Director to incur expenditure, whether in money, time or trouble, which is disproportionate to the benefits likely to be derived.

"designated officer" means the authorised person identified in writing by SEPA as the person responsible for checking Director's compliance with this agreement;

"premises", "radioactive waste" and "waste" have the same meaning as in the Act;

"radionuclide" means a species of atom characterised by its mass number and atomic number and subject to radioactive decay;

"solid radioactive waste" is radioactive waste that has been treated or packaged in such a way as to render it as far as reasonably practicable insoluble in water and not readily flammable;

J. M. Beveridge

Director - West Region

Scottish Environment Protection Agency

Date: 8th December 2000

Scottish Environment Protection Agency
5 Redwood Crescent
Peel Park
East Kilbride
G74 5PP

Telephone: 01355 574200
Fax: 01355 574688

Explanatory Notes (not forming part of the Agreement)

The attached agreement, is provided following administrative arrangements being made under Section 42 of the Act, contains the material particulars of an agreement issued by SEPA for the disposal of radioactive waste of the description specified in the agreement on or from the premises specified therein.

The agreement does not authorise the disposal of the radioactive waste in contravention of any other enactment or any order, regulation or other instrument made, granted or issued under any enactment, or in contravention of any rule of law or in breach of any agreement, particularly those pertaining to the transport of radioactive material and health and safety.

The Radioactive Substances Act 1993 consolidates earlier enactments relating to radioactive substances, including the Radioactive Substance Act 1960 (which is now repealed), and makes certain corrections and minor improvements. Any Order or Regulations made, and certificates granted, under the 1960 act continue in force as if made or granted under the 1993 Act.

The Radioactive Substances Act 1993 has been amended by both the Local Government etc. (Scotland) Act 1994 and the Environment Act 1995.

This explanatory note does not forma part of the Annexe to a letter of agreement for the disposal of solid waste from RNAD Coulport to BNFL Drigg, Cumbria via HMNB Clyde, Faslane dated: 8 December 2000

Gaseous Coulport

GASEOUS 67

CLAS ref: RSA/N/1027874

THE SCOTTISH OFFICE

Environment Department

**HM Industrial Pollution Inspectorate**
27 Perth Street
Edinburgh EH3 5RB

Telephone 0131-244
Out of Hours Telephone
0131-244 3060
Fax 0131-244 2903

The Superintendent
Royal Naval Armament Depot
Coulport
PO Box 1
HELENSBURGH
Dunbartonshire
G84 0PD

Our ref: IPB/18/6

9 June 1995

Dear Sir

**RADIOACTIVE SUBSTANCES ACT 1960**
**DISPOSAL OF GASEOUS RADIOACTIVE WASTE FROM THE ROYAL NAVAL ARMAMENT DEPOT, COULPORT**

1. I refer to the discussions between our respective departments on the disposal of gaseous radioactive waste produced by The Ministry of Defence (MOD) at the Royal Naval Armament Depot, Coulport hereinafter called the premises. This letter sets out the limitations and conditions agreed with the Chief Inspector of Her Majesty's Industrial Pollution Inspectorate, hereinafter called the Chief Inspector, in respect of the disposal of these wastes and shall be operative from 9 June 1995.

2. MOD shall use the best practicable means for reducing the quantity of gaseous radioactive wastes subject to disposal having regard both to the provision and efficient maintenance of apparatus for reducing the quantities of the gaseous radioactive wastes prior to disposal and also to the supervision by MOD of the processes whereby the wastes are produced. In determining whether any particular means are to be required in relation to this duty, MOD shall not be required to incur expenditure, whether of money, time or trouble which is, or is likely to be, grossly disproportionate either to the benefit to be derived from, or likely to be derived from, or to the efficacy of, or likely efficacy of, employing them, the benefits or results produced being, or likely to be, insignificant in relation to the expenditure.

3. In all gaseous radioactive waste discharged from the premises during any period of 12 consecutive calendar months the activity of tritium shall not exceed 50 gigabecquerels.

4. Gaseous radioactive waste shall be discharged to atmosphere from the premises.

Recycled

5. MOD shall ensure that the systems by which all radioactive wastes are discharged are kept in good repair.

6. For the purposes of determining the activity of any radionuclides contained in the radioactive wastes and of ascertaining the effects on the environment of radioactive wastes discharged, MOD shall provide and maintain such equipment and shall take samples, both as shall be agreed with the Chief Inspector.

7. MOD shall examine or cause to be examined by methods that shall be agreed with the Chief Inspector any samples taken in pursuance of the preceding paragraph and shall retain for such period as the Chief Inspector may specify any such samples for examination by or on behalf of any persons authorised by the Chief Inspector in that behalf.

8. MOD shall keep records in respect of gaseous radioactive wastes.

These records shall comprise:-

a. a description of the outlets by which the radioactive wastes were discharged;

b. a description of the radioactive wastes discharged;

c. the date and period over which the radioactive wastes are discharged;

d. the activity, expressed in becquerels or multiples thereof, of tritium present in the waste at the time it was discharged; and

e. such part of the information obtained by MOD in pursuance of paragraph 7 as shall be agreed with the Chief Inspector.

9. These records shall be kept at the premises and shall be open to examination by any persons authorised for that purpose by the Secretary of State for Scotland. Any alteration of these records shall be so made that the original entries remain legible.

10. The records maintained in pursuance of the preceding paragraph shall be preserved by MOD for 30 years or for such other period as may be agreed with the Chief Inspector, and a copy of the records, or any part thereof as he shall specify shall be supplied to the Chief Inspector at such intervals as shall be agreed.

11. For the purposes of this agreement, activity expressed in becquerels or multiples thereof means the number of spontaneous nuclear transformations occurring in a radioactive substance in a period of one second, and any reference to activity is a reference to activity ascertained by a method acceptable to the Chief Inspector.

Yours faithfully

R Thom

R THOM

VIC00035

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## Appendix B – Metallic and Non-metallic Solid Waste Fingerprints

| Nuclide | Metallic % | Nuclide | Non-Metallic % |
|---|---|---|---|
| H-3 | 0.1 | H-3 | 1.7 |
| C-14 | 29.5 | C-14 | 70.8 |
| Ru-106 | 4.1 | Ru-106 | 0 |
| Fe-55 | 40.9 | Fe-55 | 2.2 |
| Co-60 | 12.9 | Co-60 | 18.7 |
| Co-58 | 0.8 | Ni-63 | 5.1 |
| Ni-63 | 5.4 | Ag-110m | 0 |
| Ag-110m | 0.5 | Ag-108m | 0.6 |
| Sb-125 | 1.1 | Sb-125 | 0.8 |
| Mn-54 | 0.4 | Total | 100 |
| Zn-65 | 2.0 | | |
| Cs-134 | 0.4 | | |
| Cs-137 | 0.5 | | |
| Ce-144 | 1.4 | | |
| Total | 100 | | |

HMNB(C)-2-5-4 Radioactive Waste Standing Orders

## Appendix C – PC CREAM Modelling Assumptions

| Criteria | Assumption |
|---|---|
| Routine Discharges modelled for a period of 50 years | Design life basis of 50 years for the NSH |
| Routine aerial discharges effective release height – 10 m | An effective stack height for the NSH ventilation stack, considering impacts from local infrastructure etc. has not been calculated. Use of a 10 m effective stack height is considered to provide a conservative estimate. |
| **PLUME Model (Atmospheric Dispersion)** | |
| MET Sampling Scheme | PC CREAM defaults used |
| Roughness Length | 0.3 Agricultural Areas |
| Nearest Receptor | 1,000 m – conservative estimate |
| Ingestion Data | Habit Survey mean results for high rate group |
| Occupancy (h/y) | Habit Survey Data |
| Time spent indoors | Habit Survey Data |
| Cloud Gamma | PC CREAM defaults used |
| Deposited Gamma | PC CREAM defaults used |
| Cloud Beta | PC CREAM defaults used |
| Deposited Beta | PC CREAM defaults used |
| Inhalation factor | PC CREAM defaults used |
| Inhalation Rate ($m^3$/y) | PC CREAM defaults used |
| Delay Times | PC CREAM defaults used |
| MET Data | Uniform Windrose, 65% Category D and 10% Rain in C and D |
| **GRANIS Model (External Exposure)** | |
| Soil model composition | Generic Wet Soil defaults used |
| **FARMLAND Model (Food Chain)** | |
| Plant dependent model parameters | PC CREAM defaults used |
| Animal dependent model parameters | PC CREAM defaults used |
| Concentration ratios | PC CREAM defaults used |
| Animal equilibrium transfer factors | PC CREAM defaults used |
| Other element dependent parameters | PC CREAM defaults used |
| **RESUS Model (Resuspention)** | |
| Deposition Rates | PC CREAM radionuclide defaults used |
| **DORIS Model (Marine Dispersion)** | |
| Site | Faslane |
| Element Dependent Parameters | PC CREAM Defaults used |
| Local Compartment Details | Refer to Table C - 2 |
| Regional model Information | PC CREAM Defaults used |
| Volumetric exchange rates | PC CREAM Defaults used |
| Output Materials | Filtered / unfiltered seawater, Suspended Sediments, Seabed Sediments, Fish, Crustaceans, Seaweed, Molluscs |
| **DORIS Model (Marine Dispersion - Collective Dose)** | |
| Times (years) | 500 |
| Populations | World, EU 12 |

| Criteria | Assumption |
|---|---|
| Beach Occupancy near the Site | 50 man h $y^{-1}$ $m^{-1}$ |
| **DORIS Model (Marine Dispersion - Individual Dose)** | |
| Times (years) | 50 |
| Ingestion pathways | As per Habit Data |
| **PLUME (Atmospheric dispersion - Collective Dose)** | |
| Times (years) | 500 |
| Populations | World, EU 12 |
| Plume Release Height | 10m |

| Table C - 2: Gareloch parameters Criteria | Assumption |
|---|---|
| Volume of Gareloch ($m^3$) | 2.39E+08 |
| Depth (m) | 2.36E+01 |
| Coastal length (m) | 1.65E+04 |
| Volume exchange rate ($m^3$/y) | 1.45E+10 |
| Suspended sediment load (t/$m^3$) | 1E-06 |
| Sedimentation rate (t/$m^2$/y) | 1E-01 (local data for Regional Compartment) |
| Sediment density (t/$m^3$) | 2.60 |
| Bioturbation rate ($m^2$/y) | 1E-03 (local data for Regional Compartment) |
| Diffusion rate ($m^2$/y) | 1E-01 |
| Materials considered | Filtered seawater, unfiltered seawater and seabed sediments for continuous release |

## Appendix D – Detailed Dose Calculations for Liquid Discharges

Dose modelling from releases of radioactivity in treated liquid effluent from the NSH to the Gare Loch has been conducted using PC-CREAM (version 1.5.1.82). Radionuclide activity is based on the maximum annual quantities for the design basis of the ETP described in Table 5: NSH design basis liquid effluent receipt and discharge radionuclide concentrations (Bq / y). Discharges and doses have been modelled over a 50-year period using the PC-CREAM DORIS model. Assumptions used in the modelling are listed in Appendix C. Exposure pathways are based on the latest available habit surveys for Faslane (2006 and 2011).

| Radionuclide | Pathway | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | Crustaceans | Fish | Molluscs | External beta from beaches | External beta from fishing equipment | External gamma from beaches | External gamma from fishing equipment | Sea spray inhalation | |
| Ag-110m | 1.58E-07 | 1.49E-07 | 1.89E-06 | 8.30E-08 | 9.79E-10 | 5.66E-06 | 6.75E-09 | 8.62E-13 | **7.95E-06** |
| C-14 | 7.23E-06 | 6.87E-05 | 4.34E-05 | 2.81E-08 | 2.10E-08 | 0.00E+00 | 0.00E+00 | 1.25E-11 | **1.19E-04** |
| Ce-144 | 2.43E-11 | 1.14E-11 | 2.92E-10 | 7.13E-08 | 8.86E-10 | 9.33E-08 | 1.11E-10 | 5.06E-15 | **1.66E-07** |
| Co-58 | 2.06E-09 | 1.94E-09 | 6.21E-09 | 5.71E-09 | 2.00E-10 | 4.98E-06 | 5.93E-09 | 5.39E-15 | **5.00E-06** |
| Co-60 | 7.22E-07 | 6.81E-07 | 2.17E-06 | 2.26E-06 | 1.29E-07 | 2.91E-03 | 3.47E-06 | 2.56E-12 | **2.92E-03** |
| Cs-137 | 2.30E-08 | 7.28E-07 | 1.38E-07 | 5.13E-07 | 1.50E-08 | 3.08E-05 | 3.67E-08 | 2.73E-12 | **3.23E-05** |
| Fe-55 | 3.07E-08 | 2.90E-08 | 1.11E-06 | 0.00E+00 | 0.00E+00 | 4.02E-07 | 4.79E-10 | 7.47E-14 | **1.57E-06** |
| H-3 | 4.35E-08 | 4.13E-07 | 2.61E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.55E-10 | **7.18E-07** |
| Mn-54 | 5.14E-10 | 3.88E-09 | 3.09E-07 | 5.43E-10 | 0.00E+00 | 4.76E-05 | 5.68E-08 | 2.62E-14 | **4.80E-05** |
| Ni-63 | 8.96E-09 | 8.48E-08 | 1.08E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.17E-13 | **2.01E-07** |
| Sb-124 | 4.67E-10 | 7.05E-08 | 2.24E-09 | 9.19E-09 | 9.02E-11 | 1.10E-06 | 1.31E-09 | 4.81E-13 | **1.19E-06** |
| Sb-125 | 5.46E-10 | 8.26E-08 | 2.60E-09 | 1.17E-08 | 5.77E-10 | 2.17E-06 | 2.59E-09 | 9.55E-13 | **2.28E-06** |
| Te-125m (Sb-125) | 1.12E-09 | 1.18E-08 | 6.74E-09 | 4.31E-11 | 4.75E-10 | 1.35E-07 | 1.61E-10 | 4.41E-14 | **1.55E-07** |
| Sn-113 | 1.87E-09 | 1.76E-08 | 1.12E-08 | 4.11E-11 | 1.03E-12 | 1.79E-09 | 2.13E-12 | 1.39E-15 | **3.25E-08** |
| **Total** | **8.22E-06** | **7.10E-05** | **4.94E-05** | **2.98E-06** | **1.68E-07** | **3.00E-03** | **3.58E-06** | **6.76E-10** | **3.14E-03** |

**Table D-1: Predicted individual doses to the Adult Population group from releases of liquid effluent from the NSH to the Gare Loch (µSv)**

| Radionuclide | Pathway | | | | | Total |
|---|---|---|---|---|---|---|
| | Fish | Molluscs | External beta from beaches | External gamma from beaches | Sea spray inhalation | |
| Ag-110m | 6.49E-08 | 4.69E-06 | 1.09E-08 | 7.43E-07 | 1.24E-13 | **5.51E-06** |
| C-14 | 2.22E-05 | 7.98E-05 | 3.68E-09 | 0.00E+00 | 1.59E-12 | **1.02E-04** |
| Ce-144 | 5.66E-12 | 8.23E-10 | 9.36E-09 | 1.22E-08 | 7.01E-16 | **2.24E-08** |
| Co-58 | 1.05E-09 | 1.90E-08 | 7.49E-10 | 6.53E-07 | 7.33E-16 | **6.74E-07** |
| Co-60 | 5.15E-07 | 9.35E-06 | 2.96E-07 | 3.82E-04 | 3.48E-13 | **3.92E-04** |
| Cs-137 | 1.31E-07 | 1.42E-07 | 6.73E-08 | 4.04E-06 | 2.00E-13 | **4.38E-06** |
| Fe-55 | 2.26E-08 | 4.91E-06 | 0.00E+00 | 5.27E-08 | 1.10E-14 | **4.99E-06** |
| H-3 | 1.24E-07 | 4.44E-07 | 0.00E+00 | 0.00E+00 | 7.59E-11 | **5.68E-07** |
| Mn-54 | 1.66E-09 | 7.53E-07 | 7.12E-11 | 6.25E-06 | 3.80E-15 | **7.01E-06** |
| Ni-63 | 3.70E-08 | 2.68E-07 | 0.00E+00 | 0.00E+00 | 4.19E-14 | **3.05E-07** |
| Sb-124 | 3.43E-08 | 6.22E-09 | 1.21E-09 | 1.45E-07 | 6.54E-14 | **1.87E-07** |
| Sb-125 | 3.69E-08 | 6.62E-09 | 1.54E-09 | 2.85E-07 | 1.23E-13 | **3.30E-07** |
| Te-125m (Sb-125) | 6.02E-09 | 1.96E-08 | 5.65E-12 | 1.77E-08 | 5.65E-15 | **4.33E-08** |
| Sn-113 | 9.03E-09 | 3.27E-08 | 5.39E-12 | 2.35E-10 | 1.87E-16 | **4.20E-08** |
| **Total** | **2.32E-05** | **1.00E-04** | **3.91E-07** | **3.94E-04** | **7.85E-11** | **5.18E-04** |

**Table D-2: Predicted individual doses to the Child Population group from releases of liquid effluent from the NSH to the Gare Loch (µSv)**

| Radionuclide | Pathway | | | | Total |
|---|---|---|---|---|---|
| | Molluscs | External beta from beaches | External gamma from beaches | Sea spray inhalation | |
| Ag-110m | 3.95E-06 | 5.26E-09 | 3.59E-07 | 4.72E-14 | **4.31E-06** |
| C-14 | 4.98E-05 | 1.78E-09 | 0.00E+00 | 6.15E-13 | **4.99E-05** |
| Ce-144 | 9.12E-10 | 4.52E-09 | 5.91E-09 | 3.34E-16 | **1.13E-08** |
| Co-58 | 1.54E-08 | 3.62E-10 | 3.15E-07 | 3.25E-16 | **3.31E-07** |
| Co-60 | 7.17E-06 | 1.43E-07 | 1.84E-04 | 1.29E-13 | **1.92E-04** |
| Cs-137 | 5.32E-08 | 3.25E-08 | 1.95E-06 | 4.77E-14 | **2.04E-06** |
| Fe-55 | 3.35E-06 | 0.00E+00 | 2.55E-08 | 4.09E-15 | **3.38E-06** |
| H-3 | 2.90E-07 | 0.00E+00 | 0.00E+00 | 2.60E-11 | **2.90E-07** |
| Mn-54 | 5.62E-07 | 3.44E-11 | 3.02E-06 | 1.61E-15 | **3.58E-06** |
| Ni-63 | 2.51E-07 | 0.00E+00 | 0.00E+00 | 1.86E-14 | **2.51E-07** |
| Sb-124 | 5.98E-09 | 5.82E-10 | 6.99E-08 | 2.68E-14 | **7.65E-08** |
| Sb-125 | 6.01E-09 | 7.43E-10 | 1.38E-07 | 4.73E-14 | **1.45E-07** |
| Te-125m (Sb-125) | 2.03E-08 | 2.73E-12 | 8.54E-09 | 2.12E-15 | **2.89E-08** |
| Sn-113 | 3.20E-08 | 2.60E-12 | 1.13E-10 | 7.65E-17 | **3.21E-08** |
| **Total** | **6.56E-05** | **1.89E-07** | **1.90E-04** | **2.69E-11** | **2.56E-04** |

**Table D-3: Predicted individual doses to the Infant Population group from releases of liquid effluent from the NSH to the Gare Loch (μSv)**

| Radionuclide | Pathway | | | | | Total |
|---|---|---|---|---|---|---|
| | Fish | Crustaceans | Molluscs | Beach sediment gammas | Global Circulation | |
| Ag-110m | 1.01E-08 | 3.65E-08 | 3.78E-08 | 7.11E-11 | 0.00E+00 | **8.44E-08** |
| C-14 | 1.52E-05 | 2.04E-06 | 1.64E-06 | 0.00E+00 | 2.06E-05 | **3.95E-05** |
| Ce-144 | 7.79E-14 | 5.18E-12 | 4.69E-12 | 1.16E-12 | 0.00E+00 | **1.11E-11** |
| Co-58 | 2.54E-11 | 4.43E-10 | 1.01E-10 | 6.20E-11 | 0.00E+00 | **6.31E-10** |
| Co-60 | 1.68E-08 | 1.57E-07 | 3.59E-08 | 3.66E-08 | 0.00E+00 | **2.46E-07** |
| Cs-137 | 1.35E-07 | 6.24E-09 | 4.67E-09 | 4.52E-10 | 0.00E+00 | **1.46E-07** |
| Fe-55 | 1.43E-09 | 6.89E-09 | 1.97E-08 | 5.07E-12 | 0.00E+00 | **2.80E-08** |
| H-3 | 7.64E-08 | 1.19E-08 | 9.08E-09 | 0.00E+00 | 2.13E-07 | **3.10E-07** |
| Mn-54 | 7.10E-11 | 1.11E-10 | 5.05E-09 | 5.94E-10 | 0.00E+00 | **5.83E-09** |
| Ni-63 | 8.06E-09 | 2.14E-09 | 2.34E-09 | 0.00E+00 | 0.00E+00 | **1.25E-08** |
| Sb-124 | 1.65E-09 | 1.01E-10 | 3.73E-11 | 1.37E-11 | 0.00E+00 | **1.80E-09** |
| Sb-125 | 1.08E-08 | 1.38E-10 | 7.16E-11 | 2.82E-11 | 0.00E+00 | **1.10E-08** |
| Te-125m (Sb-125) | 1.90E-08 | 9.09E-10 | 1.30E-09 | 1.77E-12 | 0.00E+00 | **2.12E-08** |
| Sn-113 | 6.91E-10 | 4.14E-10 | 1.96E-10 | 2.24E-14 | 0.00E+00 | **1.30E-09** |
| **Total** | **1.55E-05** | **2.26E-06** | **1.76E-06** | **3.78E-08** | **2.09E-05** | **4.04E-05** |

**Table D-4: Predicted collective doses to the EU12 countries from releases of liquid effluent from the NSH to the Gare Loch (man Sv)**

| Radionuclide | Pathway | | | | | Total |
|---|---|---|---|---|---|---|
| | Fish | Crustaceans | Molluscs | Beach sediment gammas | Global Circulation | |
| Ag-110m | 1.68E-08 | 5.13E-08 | 3.96E-08 | 7.11E-11 | 0.00E+00 | **1.08E-07** |
| C-14 | 3.10E-05 | 2.94E-06 | 1.84E-06 | 0.00E+00 | 5.72E-04 | **6.08E-04** |
| Ce-144 | 1.20E-13 | 7.26E-12 | 4.84E-12 | 1.16E-12 | 0.00E+00 | **1.34E-11** |
| Co-58 | 3.94E-11 | 6.21E-10 | 1.04E-10 | 6.20E-11 | 0.00E+00 | **8.26E-10** |
| Co-60 | 2.64E-08 | 2.20E-07 | 3.70E-08 | 3.66E-08 | 0.00E+00 | **3.20E-07** |
| Cs-137 | 2.56E-07 | 8.94E-09 | 5.12E-09 | 4.62E-10 | 0.00E+00 | **2.71E-07** |
| Fe-55 | 2.30E-09 | 9.67E-09 | 2.04E-08 | 5.08E-12 | 0.00E+00 | **3.23E-08** |
| H-3 | 1.43E-07 | 1.70E-08 | 9.92E-09 | 0.00E+00 | 5.92E-06 | **6.09E-06** |
| Mn-54 | 1.11E-10 | 1.56E-10 | 5.21E-09 | 5.94E-10 | 0.00E+00 | **6.07E-09** |
| Ni-63 | 1.36E-08 | 3.01E-09 | 2.46E-09 | 0.00E+00 | 0.00E+00 | **1.91E-08** |
| Sb-124 | 2.61E-09 | 1.42E-10 | 3.85E-11 | 1.37E-11 | 0.00E+00 | **2.80E-09** |
| Sb-125 | 1.90E-08 | 1.96E-10 | 7.66E-11 | 2.82E-11 | 0.00E+00 | **1.93E-08** |
| Te-125m (Sb-125) | 3.41E-08 | 1.35E-09 | 1.46E-09 | 1.78E-12 | 0.00E+00 | **3.69E-08** |
| Sn-113 | 1.11E-09 | 5.81E-10 | 2.03E-10 | 2.24E-14 | 0.00E+00 | **1.90E-09** |
| **Total** | **3.15E-05** | **3.26E-06** | **1.96E-06** | **3.79E-08** | **5.78E-04** | **6.15E-04** |

**Table D-5: Predicted collective doses to the World population from releases of liquid effluent from the NSH to the Gare Loch (man Sv)**

## Appendix E – Detailed Dose Calculations for Gaseous Discharges

Dose modelling from routine releases of radioactivity in gaseous effluent from the NSH to the Gare Loch has been conducted using PC-CREAM (version 1.5.1.82). Radionuclide activity is based on the maximum annual quantities for the design basis of the NSH Active Ventilation system described in Table 7. Discharges and doses have been modelled over a 50-year period using the PC-CREAM DORIS model. Assumptions used in the modelling are listed in Appendix C. Exposure pathways are based on the latest available habit surveys for Faslane (2006 and 2011). For collective doses, a standard population grid does not exist for gaseous releases from Faslane. Collective dose has been modelled based on the same releases being made from the Hunterston site. For the purposes of assessment of doses to Europe this is considered to represent a reasonable basis for estimate.

| Nuclide | Pathway | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Inhalation of Plume | Gamma from Plume | Beta from Plume | Gamma from Ground | Beta from Ground | Resuspension | Cow meat | Cow milk | Fruit | Grain | Green vegetables | Root vegetables | Sheep meat | |
| Ag-110m | 1.67E-09 | 1.44E-11 | 1.95E-14 | 1.32E-08 | 2.02E-09 | 1.51E-12 | 2.32E-10 | 4.27E-08 | 1.11E-10 | 2.62E-10 | 4.18E-10 | 5.74E-11 | 1.78E-10 | **6.09E-08** |
| C-14 | 4.21E-08 | 0.00E+00 | 2.04E-13 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.74E-08 | 1.17E-07 | 2.75E-08 | 1.39E-07 | 2.87E-08 | 3.73E-08 | 3.32E-08 | **4.92E-07** |
| Ce-144 | 4.69E-12 | 7.07E-17 | 9.94E-18 | 1.49E-13 | 1.23E-12 | 4.35E-15 | 1.06E-14 | 8.99E-14 | 2.64E-14 | 2.04E-14 | 3.94E-13 | 3.59E-16 | 6.32E-15 | **6.61E-12** |
| Co-58 | 1.55E-13 | 2.29E-15 | 5.27E-18 | 6.29E-13 | 1.37E-14 | 1.09E-16 | 4.40E-16 | 8.71E-15 | 5.95E-15 | 1.73E-14 | 3.82E-14 | 1.39E-16 | 3.49E-16 | **8.71E-13** |
| Co-60 | 1.21E-08 | 7.00E-11 | 1.18E-13 | 3.36E-07 | 6.96E-10 | 1.77E-11 | 1.09E-10 | 6.91E-10 | 5.65E-10 | 1.74E-09 | 2.76E-09 | 1.59E-10 | 7.99E-11 | **3.55E-07** |
| Cs-137 | 4.80E-12 | 0.00E+00 | 3.04E-16 | 1.66E-10 | 3.18E-12 | 1.25E-14 | 1.13E-10 | 1.15E-10 | 2.76E-11 | 4.39E-11 | 1.19E-11 | 1.37E-11 | 1.16E-10 | **6.15E-10** |
| Fe-55 | 5.91E-10 | 5.49E-16 | 0.00E+00 | 2.95E-13 | 0.00E+00 | 7.18E-13 | 3.42E-11 | 3.62E-11 | 6.26E-11 | 2.06E-10 | 3.27E-10 | 9.39E-13 | 1.56E-11 | **1.27E-09** |
| H-3 | 1.16E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.67E-07 | 3.13E-06 | 3.28E-07 | 4.56E-08 | 3.42E-07 | 4.44E-07 | 2.30E-07 | **6.15E-06** |
| Mn-54 | 5.57E-10 | 7.47E-12 | 0.00E+00 | 8.26E-09 | 8.52E-13 | 5.27E-13 | 4.60E-11 | 1.05E-10 | 4.16E-11 | 1.09E-10 | 1.74E-10 | 1.57E-11 | 3.83E-11 | **9.35E-09** |
| Ni-63 | 1.42E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.53E-13 | 3.53E-13 | 9.31E-11 | 1.18E-11 | 2.54E-11 | 3.51E-11 | 8.39E-12 | 6.56E-14 | **3.17E-10** |
| Sb-124 | 1.05E-12 | 6.89E-15 | 1.44E-16 | 1.64E-12 | 2.77E-13 | 7.13E-16 | 6.88E-14 | 4.87E-14 | 3.20E-14 | 9.02E-14 | 2.11E-13 | 6.85E-16 | 5.96E-14 | **3.48E-12** |
| Sb-125 | 1.92E-12 | 4.18E-15 | 4.48E-17 | 1.21E-11 | 2.65E-13 | 2.35E-15 | 1.28E-13 | 6.88E-14 | 5.99E-14 | 1.83E-13 | 2.87E-13 | 9.22E-15 | 1.30E-13 | **1.51E-11** |
| **Total** | **1.22E-06** | **9.18E-11** | **3.43E-13** | **3.58E-07** | **2.73E-09** | **2.09E-11** | **5.35E-07** | **3.29E-06** | **3.56E-07** | **1.87E-07** | **3.75E-07** | **4.81E-07** | **2.63E-07** | **7.07E-06** |

**Table E-1: Predicted individual doses to the Adult Population group from releases of gaseous effluent from the NSH (μSv)**

| Nuclide | Pathway | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Inhalation of Plume | Gamma from Plume | Beta from Plume | Gamma from Ground | Beta from Ground | Resuspension | Fruit | Grain | Green vegetables | Root vegetables | |
| Ag-110m | 1.47E-09 | 1.01E-11 | 1.57E-14 | 8.59E-09 | 1.63E-09 | 1.33E-12 | 6.40E-13 | 1.35E-12 | 2.30E-12 | 1.71E-12 | **1.17E-08** |
| C-14 | 3.28E-08 | 0.00E+00 | 1.65E-13 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.18E-10 | 5.30E-10 | 1.18E-10 | 8.24E-10 | **3.44E-08** |
| Ce-144 | 3.98E-12 | 4.98E-17 | 8.00E-18 | 9.67E-14 | 9.89E-13 | 3.70E-15 | 1.73E-16 | 1.19E-16 | 2.47E-15 | 1.22E-17 | **5.08E-12** |
| Co-58 | 1.30E-13 | 1.61E-15 | 4.24E-18 | 4.09E-13 | 1.10E-14 | 9.12E-17 | 4.23E-17 | 1.10E-16 | 2.61E-16 | 5.10E-18 | **5.52E-13** |
| Co-60 | 1.01E-08 | 4.93E-11 | 9.52E-14 | 2.19E-07 | 5.60E-10 | 1.48E-11 | 5.66E-12 | 1.56E-11 | 2.65E-11 | 8.22E-12 | **2.30E-07** |
| Cs-137 | 2.15E-12 | 0.00E+00 | 2.45E-16 | 1.08E-10 | 2.56E-12 | 5.57E-15 | 6.57E-14 | 9.36E-14 | 2.71E-14 | 1.68E-13 | **1.13E-10** |
| Fe-55 | 5.36E-10 | 3.86E-16 | 0.00E+00 | 1.92E-13 | 0.00E+00 | 6.52E-13 | 6.46E-13 | 1.90E-12 | 3.23E-12 | 5.01E-14 | **5.43E-10** |
| H-3 | 8.26E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.30E-09 | 1.62E-10 | 1.30E-09 | 9.08E-09 | **8.38E-07** |
| Mn-54 | 4.96E-10 | 5.26E-12 | 0.00E+00 | 5.37E-09 | 6.86E-13 | 4.69E-13 | 2.36E-13 | 5.52E-13 | 9.48E-13 | 4.61E-13 | **5.88E-09** |
| Ni-63 | 1.15E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.68E-13 | 6.83E-14 | 1.31E-13 | 1.94E-13 | 2.51E-13 | **1.16E-10** |
| Sb-124 | 8.74E-13 | 4.85E-15 | 1.16E-16 | 1.07E-12 | 2.23E-13 | 5.95E-16 | 2.06E-16 | 5.20E-16 | 1.30E-15 | 2.28E-17 | **2.17E-12** |
| Sb-12 ( | 1.51E-12 | 2.94E-15 | 3.60E-17 | 7.85E-12 | 2.13E-13 | 1.85E-15 | 3.54E-16 | 9.69E-16 | 1.62E-15 | 2.82E-16 | **9.58E-12** |
| **Total** | **8.72E-07** | **6.47E-11** | **2.76E-13** | **2.33E-07** | **2.19E-09** | **1.76E-11** | **1.42E-09** | **7.11E-10** | **1.45E-09** | **9.92E-09** | **1.12E-06** |

**Table E-2: Predicted individual doses to the Child Population group from releases of gaseous effluent from the NSH (μSv)**

| Nuclide | Pathway | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | Inhalation of Plume | Gamma from Plume | Beta from Plume | Gamma from Ground | Beta from Ground | Resuspension | |
| Ag-110m | 1.22E-09 | 1.19E-11 | 1.66E-14 | 1.08E-08 | 1.72E-09 | 1.11E-12 | **1.37E-08** |
| C-14 | 2.76E-08 | 0.00E+00 | 1.73E-13 | 0.00E+00 | 0.00E+00 | 0.00E+00 | **2.77E-08** |
| Ce-144 | 4.14E-12 | 5.85E-17 | 8.44E-18 | 1.21E-13 | 1.04E-12 | 3.85E-15 | **5.31E-12** |
| Co-58 | 1.25E-13 | 1.89E-15 | 4.47E-18 | 5.13E-13 | 1.16E-14 | 8.83E-17 | **6.52E-13** |
| Co-60 | 8.19E-09 | 5.79E-11 | 1.00E-13 | 2.74E-07 | 5.90E-10 | 1.20E-11 | **2.83E-07** |
| Cs-137 | 1.12E-12 | 0.00E+00 | 2.58E-16 | 1.35E-10 | 2.70E-12 | 2.91E-15 | **1.39E-10** |
| Fe-55 | 4.33E-10 | 4.54E-16 | 0.00E+00 | 2.41E-13 | 0.00E+00 | 5.26E-13 | **4.34E-10** |
| H-3 | 6.17E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | **6.17E-07** |
| Mn-54 | 4.58E-10 | 6.18E-12 | 0.00E+00 | 6.74E-09 | 7.23E-13 | 4.34E-13 | **7.20E-09** |
| Ni-63 | 1.12E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.57E-13 | **1.12E-10** |
| Sb-124 | 7.82E-13 | 5.70E-15 | 1.22E-16 | 1.34E-12 | 2.35E-13 | 5.32E-16 | **2.36E-12** |
| Sb-125 | 1.27E-12 | 3.46E-15 | 3.80E-17 | 9.85E-12 | 2.25E-13 | 1.56E-15 | **1.13E-11** |

| Nuclide | Pathway | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | Inhalation of Plume | Gamma from Plume | Beta from Plume | Gamma from Ground | Beta from Ground | Resuspension | |
| **Total** | **6.55E-07** | **7.60E-11** | **2.91E-13** | **2.92E-07** | **2.31E-09** | **1.44E-11** | **9.49E-07** |

**Table E - 3: Predicted individual doses to the Infant Population group from releases of gaseous effluent from the NSH (μSv)**

## Appendix F – Tier 1 ERICA Assessment

| Radionuclide | Activity concentration in air (Bq $m^{-3}$) | Limiting Reference Organism | Terrestrial Environmental Concentration Limit (Bq $m^{-3}$) | Risk Quotient |
|---|---|---|---|---|
| Ag-110m | 5.10E-15 | Mammal – large | 5.65E+03 | 5.10E-15 |
| C-14 | 3.28E-11 | Mammal – small-burrowing | 8.40E+01 | 3.28E-11 |
| Ce-144 | 1.65E-19 | Bird | 1.04E+05 | 1.65E-19 |
| Co-58 | 6.88E-19 | Mammal – small burrowing | 1.85E+04 | 6.88E-19 |
| Co-60 | 2.18E-14 | Amphibian | 7.30E+03 | 2.18E-14 |
| Cs-137 | 6.01E-17 | Mammal – large | 2.28E+03 | 6.01E-17 |
| H-3 | 2.14E-09 | Bird | 2.64E+03 | 2.14E-09 |
| Mn-54 | 2.21E-15 | Arthropod – detritivorous | 2.21E+04 | 2.21E-15 |
| Ni-63 | 3.29E-17 | Lichen & Bryophytes | 8.77E+05 | 3.29E-17 |
| Sb-124 | 2.09E-18 | Annelid | 1.03E+04 | 2.09E-18 |
| Sb-125 | 1.19E-18 | Annelid | 4.41E+04 | 1.19E-18 |
| | | | **Sum of Risk Quotients** | **2.17 E-09** |

**Tier 1 ERICA Assessment Results for Gaseous Releases from the Faslane NSH**

| Radionuclide | Activity concentration | | Limiting Reference Organism | Environmental Concentration Limit | | Risk Quotient |
|---|---|---|---|---|---|---|
| | Water (Bq $l^{-1}$) | Sediment (Bq $kg^{-1}$) | | Water (Bq $l^{-1}$) | Sediment (Bq $kg^{-1}$) | |
| Ag-110m | 5.65 E-08 | 3.44 E-05 | Polychaete Worm | 6.37 E-02 | 4.85 E+02 | 8.87 E-07 |
| C-14 | 3.12 E-06 | 6.23 E-03 | Zooplankton | 1.16 E+01 | 3.27 E+03 | 1.91 E-06 |
| Ce-144 | 6.99 E-11 | 2.99 E-05 | Polychaete Worm | 1.66 E-03 | 4.90 E+04 | 4.22 E-08 |
| Co-58 | 1.68 E-09 | 8.60 E-05 | Polychaete Worm | 5.88 E-03 | 1.78 E+04 | 2.86 E-07 |
| Co-60 | 1.27 E-07 | 1.96 E-02 | Polychaete Worm | 2.30 E-03 | 6.99 E+03 | 5.51 E-05 |
| Cs-137 | 2.96 E-07 | 8.87 E-04 | Polychaete Worm | 7.63 E-01 | 2.48 E+04 | 3.88 E-07 |
| H-3 | 1.21 E-02 | 2.36 E-02 | Phytoplankton | 3.94 E+05 | 1.10 E+05 | 2.15 E-07 |
| Mn-54 | 8.69 E-09 | 9.60 E-04 | Polychaete Worm | 1.05 E-03 | 2.13 E+04 | 8.31 E-06 |
| Ni-63 | 3.28 E-07 | 2.97 E-02 | Sea Anemones & True Coral | 3.32 E+01 | 2.33 E+05 | 1.27 E-07 |
| Sb-124 | 3.74 E-08 | 1.03 E-05 | Mammal | 4.33 E-01 | 3.24 E+02 | 8.64 E-08 |
| Sb-125 | 9.90 E-08 | 8.52 E-05 | Reptile | 1.94 E+00 | 1.18 E+03 | 7.19 E-08 |
| | | | | | Sum of Quotients | **6.74 E-05** |

**Tier 1 ERICA Assessment Results for Liquid Releases from the Faslane NSH**

## Appendix G – Intertidal and Underwater Monitoring Stations

### Intertidal and Underwater Monitoring Stations for Gare Loch and Loch Long

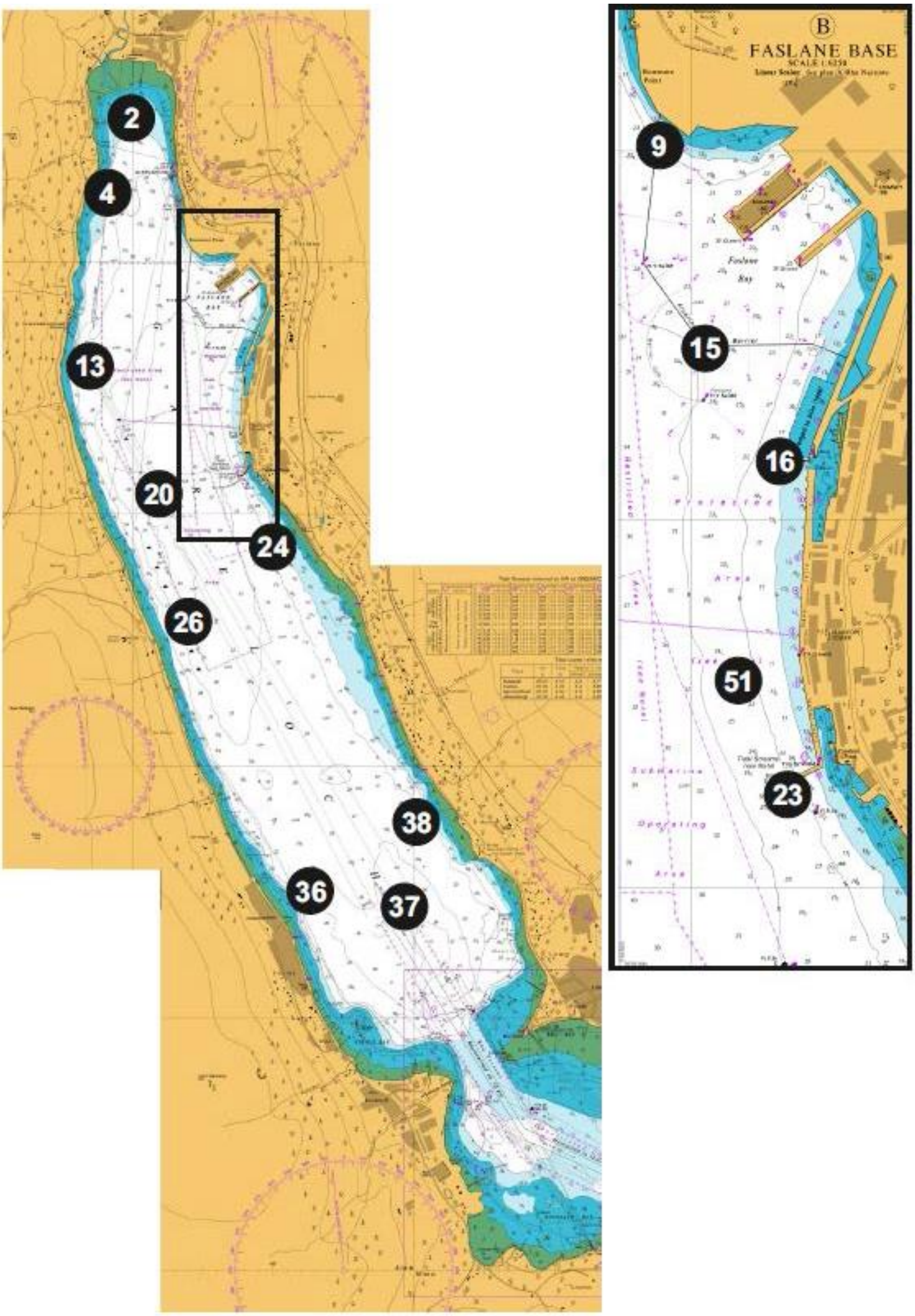


**Fig G-1 Underwater Monitoring Stations – Gare Loch**

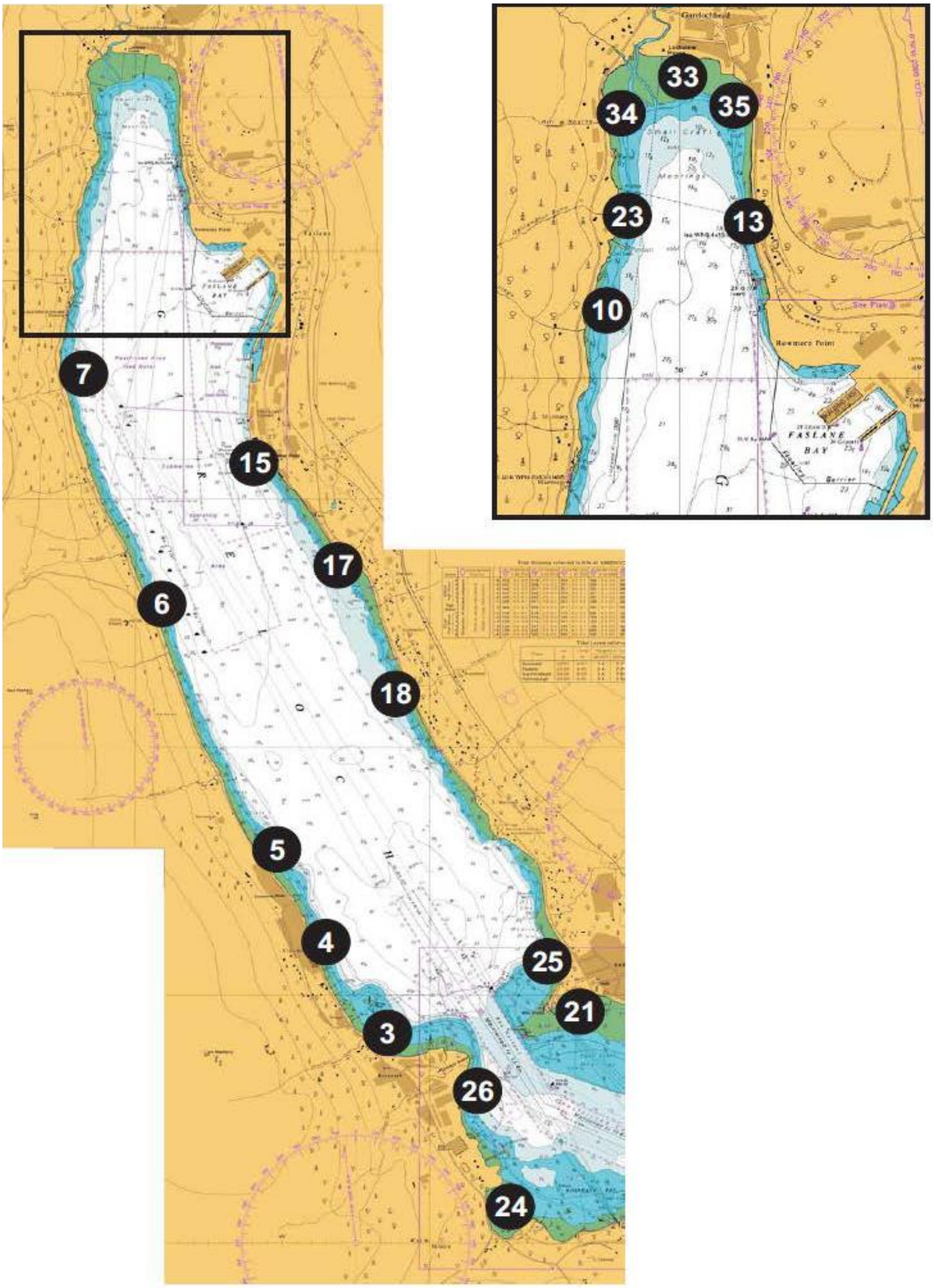


**Fig G-2 Intertidal Zone Monitoring Stations – Gare Loch**

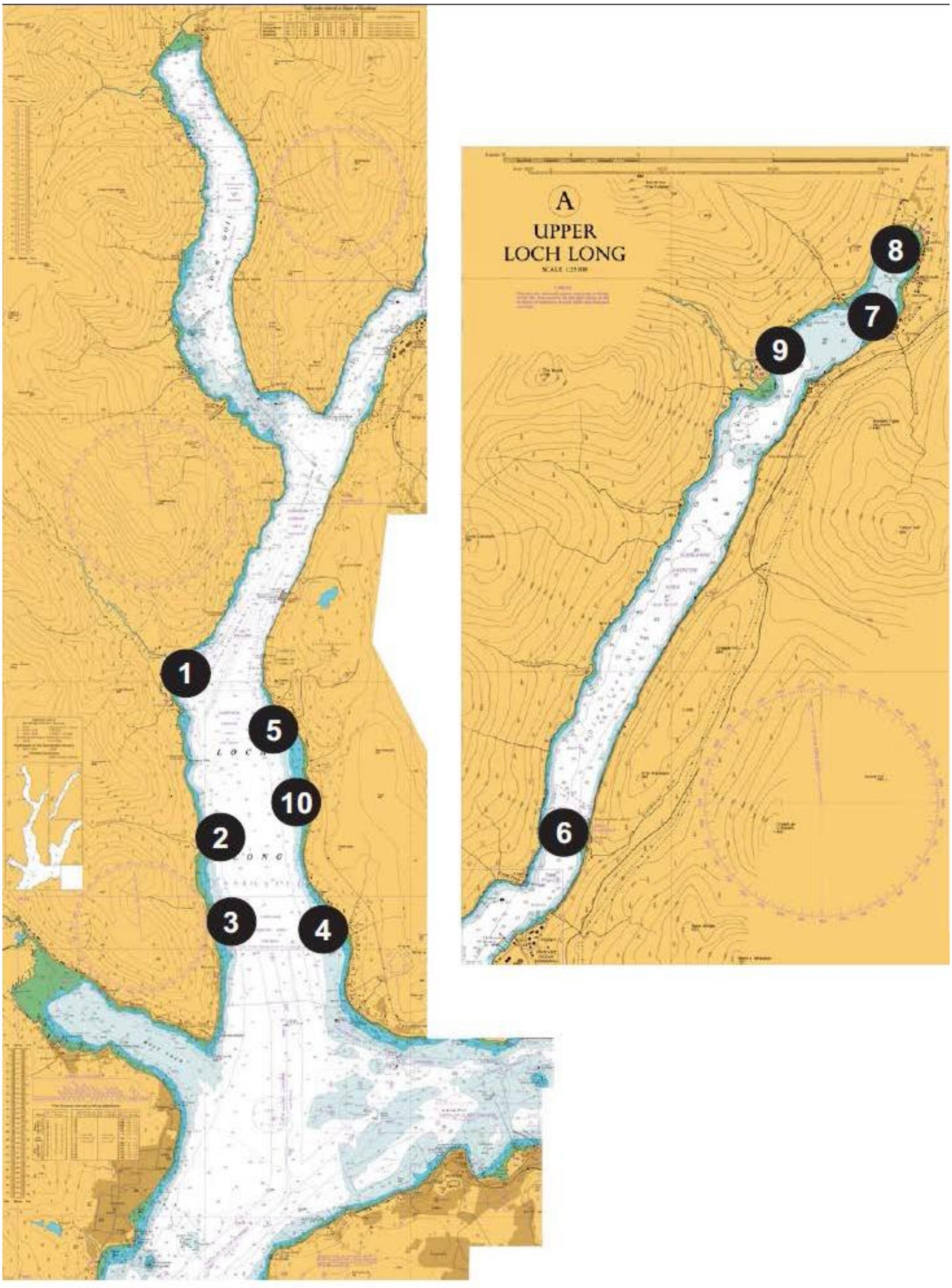


**Fig G-3 Intertidal Zone Monitoring Stations – Loch Long**

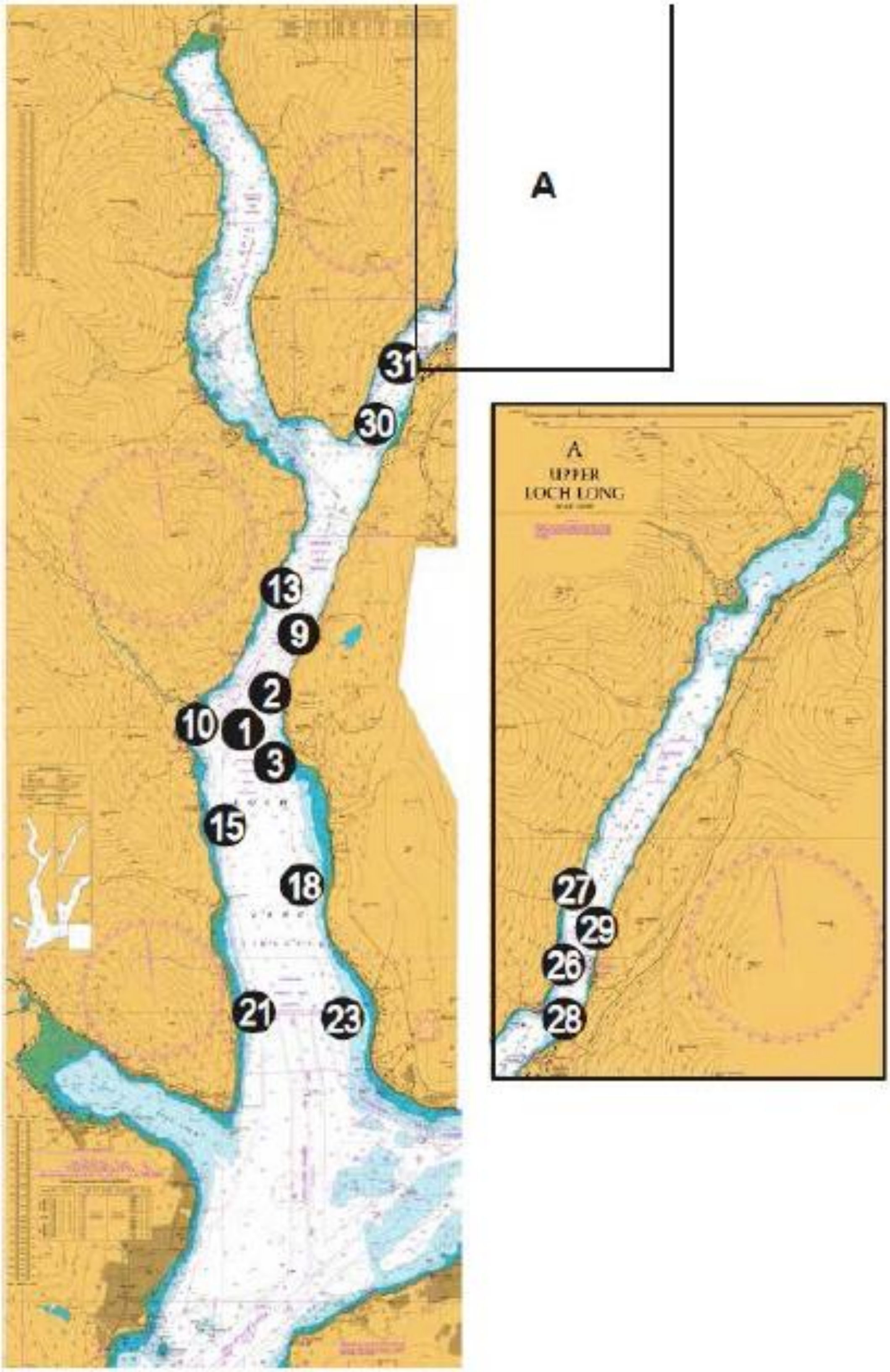


**Fig G-4** **Underwater Monitoring Stations – Loch Long**