DISPOSAL OF RAINWATER WITH TRACE LEVELS OF RADIOLOGICAL CONTAMINATION FROM HMNB (Devonport)

Tidal X Berth Effluent System

BEST AVAILABLE TECHNIQUES ASSESSMENT

BAT/EPR/LB3730DK/2021-01

Issue 01: 22 Mar 2021

PURPOSE	This report addresses Forward Action Plan item FAP/100/068 which was identified during the 2019 annual Best Available Techniques (BAT) review of Naval Base radioactive waste disposal methods.
SCOPE	The scope of this assessment is limited to a review of the disposal method for rainwater which ingresses into the TXB Effluent system bunds and which becomes contaminated with trace quantities of radioactive material.
CATEGORY	N/A

Production and Approval of Issue 01			
	Name	**Signature**	**Date**
Author	HP(P)	Signed on original	
Checked	Asst-Hd RPA	Signed on original	
Approval for issue	NSA Dep-Hd	Signed on original	

1. Abbreviations

ALARP	As Low As Reasonably Practicable
BAT	Best Available Techniques
CHSTW	Camel's Head Sewage Treatment Works
DRDL	Devonport Royal Dockyard Limited
EA	Environment Agency
EMIT	Examination, Maintenance, Inspection and Testing
EPR	Environmental Permitting Regulations (England and Wales) 2016 (As Amended)
ET	Effluent Tank
ETP	Effluent Treatment Plant
HMNB(D)	Her Majesty's Naval Base (Devonport)
HPG(W)	Health Physics Group (Waterfront)
HTO	Hydrogen, tritium, oxygen – nomenclature for aqueously bound tritium
IXC	Ion Exchange Column
IRAT	Initial Radiological Assessment Tool
MDA	Minimum Detectable Activity
MOD	Ministry of Defence
NBC(D)	Naval Base Commander (Devonport)
NBRPA	Naval Base Radiation Protection Adviser
NBRSD	Naval Base Radiation Safety Department
NSSM	Nuclear Services Support Manager
NUB	Nuclear Utilities Building
RCA	Radiologically Controlled Areas
RCL	Radiochemistry Laboratory
RSR	Radioactive Substances Regulation
TXB	Tidal X Berth

2. Introduction

This assessment has been produced to address an outstanding issue[1] which requires a Best Available Techniques (BAT) review of the disposal of rainwater which ingresses into the Tidal X Berth (TXB) effluent receipt system pit bunds and which may become contaminated with radioactive material.

3. Scope

This assessment only applies to rainwater contaminated with low levels of tritium (<10 Bq cm^{-3}), trace gross beta (<0.1 Bq cm^{-3}) and trace cobalt-60 (<0.1 Bq cm^{-3}) which gathers in the system bunds and which meets the following criteria:

a. the effluent system tanks are confirmed not to be leaking into the bund,
b. there is no reason to suspect the rainwater has been contaminated due to any other leak or spill of radioactive effluent,

Effluent with radionuclide concentrations above these threshold values, or radionuclides other than those detailed above are outside the scope of this assessment. Advice must be sought from the Naval Base Radiation Safety Department (NBRSD).

Prior to implementing the recommendation of this assessment, the TXB effluent pits will be cleaned and resealed.

4. Background

The TXB effluent receipt system is located adjacent to 8 Wharf on the HMNB Devonport TXB Facility and includes 3 pairs of tanks located at 8W(S), 8W Central and 8W(N) which sit in separate bunded subterranean pits within buildings N256, N255 & N254 respectively - see Figure 2 below. These tanks are subject to regular Examination, Maintenance, Inspection and Testing (EMIT) to confirm they are operating as per design intent.

The system’s tanks receive radioactive liquid effluent from nuclear submarines prior to bulking, assessment and transfer to the DRDL Effluent Treatment Plant (ETP). The effluent is then treated at the ETP via filtration and passing through an Ion Exchange Column (IXC) ahead of disposal to the River Tamar / Hamoaze.

Rainwater ingress into the subterranean pits around the tanks has presented an ongoing issue for many years. It potentially limits access to the pits to operate the effluent system and if contaminated currently requires management as a radioactive waste via pumping into the effluent tanks - which limits operational capacity within the system.

Rainwater ingress is mainly from permeation of rainwater through the dockside and drainage systems, however some migration through the surrounding ground is possible.

[1] *FAP/100/068 - HMNB Devonport Management of Radioactive Wastes Improvement Report (BAT/EPR/LB3730DK/2019)*

The mode in which the tritium contamination migrates to the effluent pit sumps is not fully understood. Historically it was assumed that the rainwater became occasionally contaminated with low levels of aqueously bound tritium[2] (HTO) which passed through the effluent tank HEPA filters and vent pipe as tritiated water vapour during normal operations and enters the pit atmosphere where it mixed with the rainwater. As a result, the tank ventilation was altered to vent to atmosphere above ground approximately 10-15 years ago. Additional ventilation was fitted to vent the effluent pits to atmosphere above ground via a separate discharge route to the tank ventilation. This has not prevented tritium contamination of the rainwater ingress.

Due to the mobility of tritium, migration of tritium atoms through the tank materials and connection points may provide a contribution to the low levels detected in the rainwater, however this would be very difficult to detect and quantify.

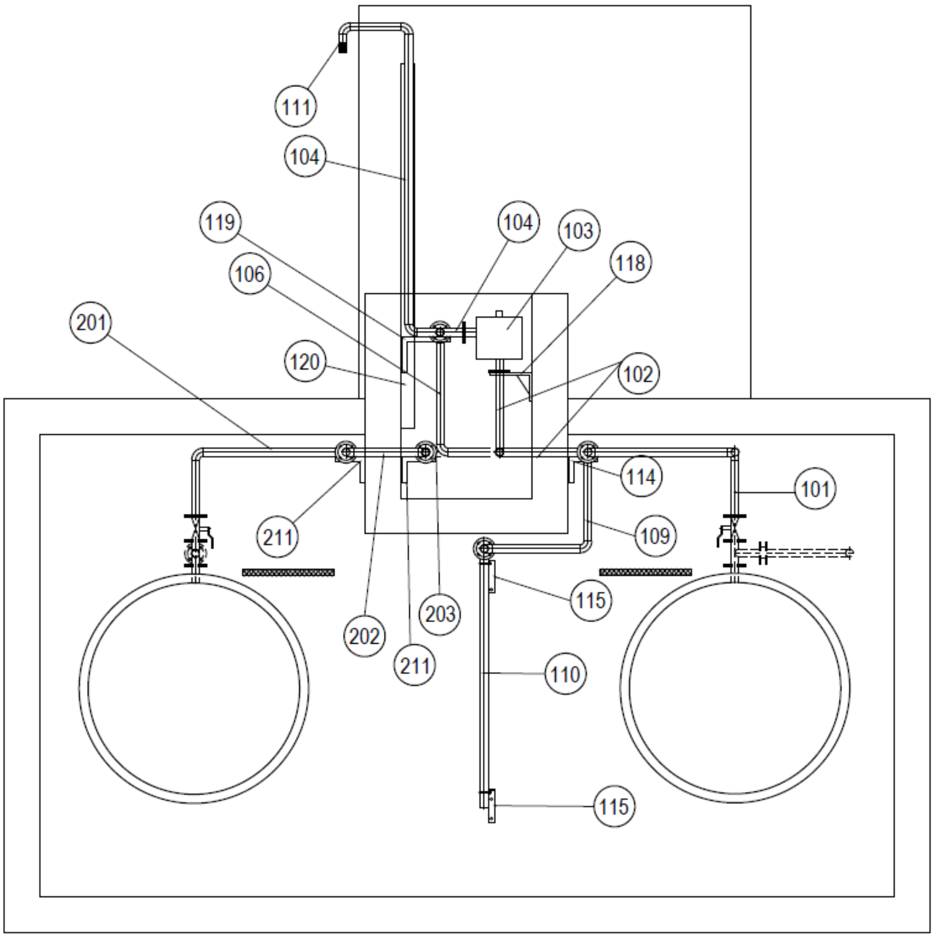

Figure 1: Diagram of effluent tanks in the pit, showing tank ventilation and discharge route through the ground level enclosure to atmosphere.

The Minimum Detectable Activity (MDA) for ^{3}H in rainwater ingress is typically 8.5×10^{-3} Bq cm^{-3}, for ^{60}Co is typically 1.3×10^{-3} Bq cm^{-3} and for gross beta is 1×10^{-1} Bq cm^{-3}. These values are consistent with other aqueous effluent analysis for the Devonport site.

2 Tritium (an isotope of hydrogen) is a highly mobile, low toxicity radioactive substance and which traditional radioactive effluent treatment systems (filtration / IXC) can't remove.

Attempts to avoid or minimise the production of this secondary waste arising have included the installation of mechanical ventilation systems in each of the pits and more recently the resealing of the adjacent road and land surfaces above the pits. Although these measures have been partially successful, they have not eliminated the issue.

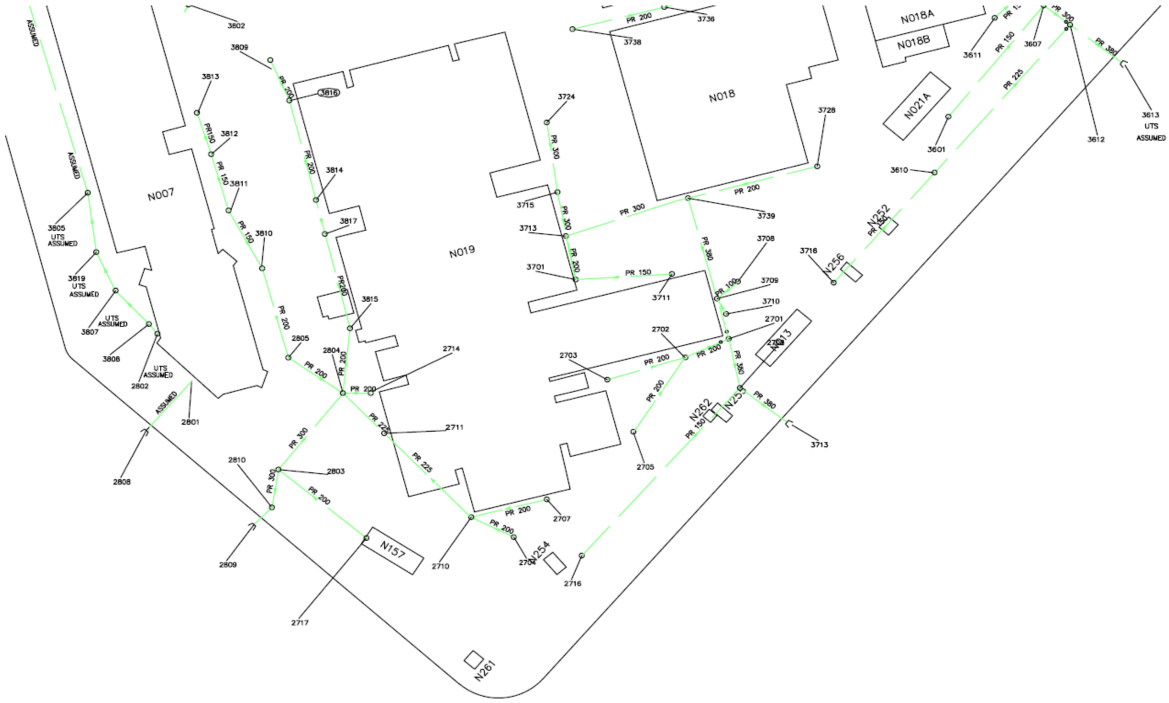

Figure 2 Locations of TXB Tanks (N254, N255 and N256), Surface Water & Storm Drains

Figure 3 Locations of TXB Tanks (N254, N255 and N256) and adjacent sewer systems

The tank levels are checked and recorded on a daily basis, this combined with the regular EMIT provides assurance there is no loss of tank contents due to leakage.

Routine analysis of the water ingress transferred to the effluent tanks includes a visual assessment of colour, suspended solids and oils, and measurement of pH and salinity. This has routinely indicated no cause for concern regarding non-radioactive pollutants. All proposals considered will ensure no increased risk of rainwater ingress becoming contaminated with non-radioactive contaminates.

5. Issue

The Naval Base is required to manage its radioactive waste processes and disposals in accordance with the requirements of an approval[3] issued by the Environment Agency (EA).

The approval requires periodic review of the techniques employed to dispose of any radioactive waste to ensure the application of BAT. The most recent review[4] in 2019 identified that the disposal methods for rainwater ingress to TXB effluent system warranted further assessment because;

- the method offered no environmental benefit (same tritium content being discharged to Hamoaze after passing through the ETP),
- processing costs - resources and time were high - potentially disproportionate,
- the process was limiting effluent system operational capacity as the tank capacity is taken up with rainwater affecting its ability to accept primary circuit discharges - with the potential to impact submarine maintenance programmes,
- due to the non-selective ion exchange process, processing rainwater through the ETP accelerates IXC exhaustion rate with non-radioactive ions and thus increases volume of radioactive waste generation

The existing arrangements limit the ability to routinely drain the effluent pit sumps due to reliability and availability of the existing effluent treatment and discharge system. This produces a conventional safety risk to operatives required to enter the effluent pits, and increased risk of accelerated corrosion of the assets in the effluent pits.

5.1 Review of existing disposal method

In 2019 the TXB effluent pits suffered approximately 70 m^3 of rainwater ingress which was subsequently transferred to DRDL as radioactive waste due to the potential that it may contain trace quantities of radioactive material. This volume represented approximately 90% of all radioactive liquid effluent transferred to DRDL from the Naval Base in 2019 and ultimately accounted for approximately 20% (by volume) of liquid waste discharged in year by DRDL via the ETP to the Hamoaze[5].

The handling of the rainwater in the manner described above meets the requirement to process and account for the effluent as radioactive waste. However, processing via the DRDL ETP IXC has no effect in abating the tritium content - which due to its

[3] *EPR/LB3730DK 08 July 2020*
[4] *BAT/EPR/LB3730DK/2019 - HMNB Devonport Management of Radioactive Wastes Improvement Report for 2019*
[5] *DNESQ-NAG-QU40(405-009/20) - DRDL Summary of Radioactive Waste Disposals During 2019*

chemical properties does not undergo ionic exchange within the ETP and is ultimately discharged to the Hamoaze.

The financial and resource costs associated with the existing arrangements are significant and need to be assessed for their socio-economic impact. The additional transfer of this secondary waste stream requires plant operators to perform a number of Radioactive Waste Operating Procedures (RWOPs) and radio chemistry sampling evolutions and in turn the subsequent processing and disposal via the ETP requires operation of further ETP plant procedures and radio chemistry sampling evolutions estimated to cost in the region of £50,000 per year.

In addition, it is reasonable to consider that the abatement performance (i.e. decontamination factor) of the DRDL ETP (for other radioactive contaminants) is being negatively influenced by the processing of such significant quantities of contaminated rainwater with relatively high levels of non-radioactive ionic contaminates.

For the reasons outlined above it is doubtful that the existing process and techniques can continue to be regarded as representing BAT and as such alternative disposal options require consideration in a proportionate and qualitative[6] manner commensurate with disposals of low environmental impact.

5.2 Radiation Dose Consequence Assessment

Two forms of radiation dose consequence assessment have been undertaken in support of this assessment. The first has involved a scaling of the consequence from tritium and cobalt-60 discharges to the river calculated within DRDL's application for its existing environmental RSR permit. The second assessment has used the Environment Agency endorsed Initial Radiological Assessment Tools (IRAT2) and guidance[7] for the assessment from tritium, cobalt-60 and gross beta discharges for both the public and wildlife across all disposal options.

5.2.1 Assessment 1 – DRDL assessment scaling

DRDL's application for its existing environmental RSR permit assessed the radiological dose impact of tritium discharges to the Hamoaze on members of the local public and specifically the representative person.

The assessment calculates that the additional annual radiation dose to the representative person is $8x10^{-4}$ µSv for discharges made at the full permit limit of 700 GBq of tritium per year. i.e. less than 1 nSv and as such is insignificant in comparison to the annual average radiation dose to a member of the public in the U.K. of approximately 2,700 µSv.

DRDL uses Marine Discharges Release Ratios to assess radiation dose to the most exposed individual based on modelling assessment of radionuclide distribution in the marine environment[8]. Marine Discharges Release Ratios are effectively a site specific dose per unit discharge factor.

[6] EA RSR : Principles of optimisation in the management and disposal of radioactive waste : April 2010
[7] LIT 15790 RSR Permitting – Prospective Radiological Impact Assessments for People and Wildlife
[8] Radiological Consequence Assessment Guidance on Methodology and Calculations – DRDL

This provides the following dose coefficients for tritium and cobalt-60 discharged to the marine environment from the Devonport site:

Tritium : 3.07×10^{-10} Sv TBq^{-1} y^{-1}

Cobalt-60 : 4.81×10^{-4} Sv TBq^{-1} y^{-1}

Assuming rainwater discharges up to an annual limit of 100 MBq (1E-4 TBq) for tritium and 1MBq (1E-6 TBq) for cobalt-60 the radiation dose to members of the public for untreated rainwater discharges from the effluent tank pits can be calculated for the two radionuclides.

^{3}H: 1×10^{-4} TBq x 3.07×10^{-10} Sv TBq^{-1} y^{-1} = 3.07×10^{-14} Sv y^{-1} = 3.07×10^{-8} µSv

^{60}Co:1×10^{-6} TBq x 4.81×10^{-4} Sv TBq^{-1} y^{-1} = 4.81×10^{-10} Sv y^{-1} = 4.81×10^{-4} µSv

The above assessment demonstrates the radiological impact to the public due to the disposal of the rainwater ingress for the effluent tank pits is insignificant, and the socioeconomic impact of the waste management process should reflect this.

5.2.2 Assessment 2 - IRAT 2

IRAT2 was used to assess radiation doses for each of the options in this assessment at annual discharge limits of 100 MBq tritium, 1 MBq cobalt-60 and 10 MBq gross beta. In all cases the maximum annual dose to a member of the public (including workers at sewage treatment works) is calculated to be less than 1 µSv, and the maximum dose rate to wildlife less than 1 µGy h^{-1}. As a result and in accordance with the IRAT2 user guidance, no further radiological assessment is deemed necessary[9].

Table 1: IRAT2 Dose Calculations for discharge options considered

Discharge Route	Dose to Public (most exposed)	Dose to Wildlife (most exposed)
Direct to Hamoaze	1.4×10^{-2} µSv y^{-1}	4.2×10^{-5} µGy h^{-1}
Sewer	2.4×10^{-2} µSv y^{-1}	1.2×10^{-5} µGy h^{-1}

5.3 Historical Information

A review of the historical radiochemical analysis results of the rainwater ingress was undertaken to inform this assessment.

Tritium above MDA has occasionally been detected in samples for many years. A focussed sampling campaign was undertaken in 2016 to assess the effectiveness of attempts to mitigate the tritium contamination following modification to the ventilation arrangements in the pit. This involved 18 samples being taken over a six-month period spanning June to November, 6 samples returned positive detection of tritium, ranging from 0.06 Bq cm^{-3} to 0.7 Bq cm^{-3}.

[9] *BAT/EPR/LB3730DK/2021-02 – Disposal of Rainwater with Trace Levels of Radiological Contamination from HMNB (Devonport) Tidal X Berth Effluent System – Radiological Impact Assessment*

In September 2020 samples of the sediment (predominantly made up of paint flakes and dirt) which had accumulated over time into the pit sumps were assessed for cobalt-60 contamination. These returned results at or just above an MDA of 20 Bq g^{-1} with the highest value recorded in the 8 Wharf North pit (27 Bq g^{-}1). A repeat sample for 8WN sediment (predominantly liquid) detected cobalt-60 at $2.1x10^{-3}$ Bq cm^{-3}.

There is no evidence of any leak or recorded spills within the pit sumps which are designated controlled areas under the Ionising Radiations Regulations 2017. Therefore, it is assumed that the presence of trace quantities of cobalt-60 in the pit sump sediment is most likely due to contamination from previous intrusive maintenance or tank modification operations. Although there is ongoing action to remove the sediment and reseal the sump surface - ongoing maintenance requirements mean that it is not possible to rule out the presence of cobalt-60 contamination in future rainwater ingress.

6. Description of Disposal Options

This section describes potential alternative disposal options, in comparison to the existing option, against a set of simple criteria - allowing a qualitative assessment of disposal options to be presented in Section 7.0.

Due to gross disproportionality the option of consignment off-site for potential treatment and disposal has not been considered further in this assessment. Based on historical consignment of effluent from the Devonport site, off-site consignment and disposal via incineration of 100 m^3 of contaminated aqueous waste is conservatively calculated to be approximately £250,000 per annum.

Ideally prevention of rainwater ingress and thus avoidance of waste generation is desirable. However, there have been several projects undertaken to address this issue with varying degrees of success, but none have prevented ingress completely. Therefore, this BAT assessment is to be used in conjunction with ongoing proportionate efforts to minimise the ingress of rainwater to the effluent tank pits.

The following disposal options are considered:

- Option 1: No Change
- Option 2: Disposal to Hamoaze via TXB storm drain
- Option 3: Disposal via Naval Base sewer

Against the following criteria[10]:

- Environmental Impact - radiation dose to representative person
- Technical feasibility
- Operational Risk (to submarine programme)
- Radiation Dose to workers
- Cost - resources and materials
- Regulatory Requirements

[10] *Criteria informed by BAT Industry Good Practice Guide : EARWG 2010*

6.1 Option 1 - No Change option

a. Description

As described in Section 5.1

b. Environmental Impact

As described in Section 5.2 - dose to representative person is extremely low.

c. Technical Feasibility

Method already in use.

d. Operational Risk

Under normal operations the risk to submarine programme is assessed qualitatively as medium noting that TXB effluent system has more frequently been used to hold relatively large volumes of effluent whilst other liquid waste streams across the site are prioritised for processing via the ETP.

DRDL's ETP is vulnerable (age / condition) to short notice unavailability which then requires very close management of TXB system inventory to maintain sufficient capacity to support the submarine programme. During such times the risk to submarine programme support is higher.

This option provides no change in radiological impact under fault conditions as all effluent is treated prior to discharge.

e. Radiation Dose to Workers

Radiation dose to workers undertaking the existing process on the TXB is low - with individual operatives receiving less than 10 µSv per year. Processing additional effluent via the ETP results in operator dose accrual in the NUB. Based on discharge information the processing and discharge of TXB rainwater accounts for up to 20% of operator doses for ETP operations in the NUB.

In recent years the annual operator doses for ETP operations have averaged approximately 150 man µSv. It is therefore estimated operator doses for processing, treatment and disposal of the rainwater is approximately 30 man µSv per year.

f. Cost

The processing of 70 m^3 of secondary liquid effluent requires approximately 9 additional tank transfers to the DRDL ETP each year. Each transfer requires the following steps prior to ultimate disposal

- Pump rainwater into ET system via RWOP
- Sample full ET prior to DRDL transfer
- Conduct Radiochemistry Lab (RCL) analysis of effluent
- Raise disposal and transfer record according to RCL results
- Transfer TXB effluent to DRDL ETP receipt tank via RWOP

- TXB effluent is bulked with other cross site arisings in ETP receipt tank
- Effluent is processed via filter and IXC - RCL samples are taken pre and post IXC to confirm acceptable decontamination factor
- Effluent is bulked in ETP discharge sentencing tanks
- Effluent is sampled again prior to discharge to Hamoaze
- Effluent is discharged to Hamoaze

Hundreds of operators' hours are estimated to be required to achieve the above process therefore resource costs alone are estimated to run into the region of approximately £50,000 per annum.

g. Regulatory Requirements

The existing process is compliant with the requirements of the EA approval for the discharge of radioactive effluents to the marine environment. The current process also prevents the potential for accidental discharges to the environment outside the scope of the current Approval, therefore risk of regulatory non-compliance due to accidental discharges is low.

The accelerated exhaustion of the ETP IXC leads to an increase in the volume of radioactive waste generated with no net reduction to total radioactivity discharged to the environment. As a result, this option could be regarded as not utilising BAT.

6.2 Option Two - Disposal to Hamoaze via TXB Storm Drains

a. Description

limited quantities of pit sump rainwater that is confirmed as contaminated below the trigger levels (<10 Bq cm^{-3} H^3, <0.1 Bq cm^{-3} ^{60}Co and <0.1 Bq cm^{-3} gross beta)[11] would be pumped into the adjacent TXB storm drain (via pump and flexible hoses) to allow discharge and disposal to river.

b. Environmental Impact

Negligible increase radiological impact to the environment compared to Option 1 - because filtration and ion exchange processes do not remove tritium and other contaminants are present in limited quantity and concentration.

Potentially ETP IXC performance would be improved due to not processing significant quantities of relatively high conductivity rainwater and thereby this option has potential to offer better abatement (column retains a higher decontamination factor for longer) of other radionuclides processed via ETP and reduced IXC waste volumes through life and hence better environmental outcome.

[11] *Contamination levels above this value would be potentially indicative of a problem / fault with the effluent system and which would require further investigation*

c. Technical Feasibility

Figure 2 shows that the TXB storm drains run close to the subterranean effluent pits and subject to confirmation from MOD Nuclear Services Support Manager (NSSM) team that:

- discharge point of storm drain adjacent to N256 pit runs to river

it is considered that this disposal method is relatively straightforward to achieve and technically feasible.

d. Operational Risk

This disposal method would significantly reduce the operational demand for effluent transfers in year and as such improve operational capacity of the system to support submarine operations.

Given the vulnerability of DRDL ETP system this method (along with pre-sentencing of the rainwater) should reduce operational demand on the ETP system by approximately 20% when assessed against 2019 transfer volumes.

With respect to the risk of creating a decommissioning legacy issue in the TXB storm drains - it is considered that this risk is low. By limiting the disposal route to effluent containing very low specific activity concentrations and with the subsequent constant flushing of the storm drains by normal rainfall it is not considered reasonably foreseeable that significant contamination will concentrate in the fabric of the drains to a level that would require eventual disposal as radioactive material[12].

Due to their location and the nature of operations on site the TXB storm drains will be subject to radiological survey for site decommissioning regardless of whether this option is implemented, therefore there will be no significant impact on the final site decommissioning strategy.

Under fault conditions, particularly regarding a tank leak, there is an increase in risk of discharging effluent with activity levels above the limits prescribed directly to the Hamoaze. This is mitigated against by daily tank level checks and planned EMIT, resulting in a low risk of non-compliance under fault conditions.

e. Radiation Dose to Workers

Requiring fewer effluent transfers (estimated to be just 1 transfer every 6 months due to submarine discharges) and fewer RWOP operations / samples to be taken and assessed in radiologically controlled areas, effluent treatment and discharge at NUB - this option is qualitatively assessed to offer a dose saving to workers when compared against the existing method of approximately 30 man µSv per year.

[12] *EPR 'Out of Scope' value of 100 Bq/g (tritium) solid material applies*

f. Cost

One off costs to purchase suitable pumps and hoses and to fund the Regulatory costs of progressing a small variation to the Environment Agency approval (to add new disposal to water option) - in total estimated to be less than (£ 20k).

It is estimated that this disposal costs for this option will be significantly less per year than the existing method which requires multiple effluent transfers and processing via the DRDL ETP. It is conservatively estimated this option will be cost neutral compared to Option 1 after one calendar year.

g. Regulatory Requirements

The Naval Base approval does not currently allow a disposal option of disposal to water (Hamoaze). As such a variation to the Approval would be required to be sought from the Environment Agency and would be subject to a limited statutory consultation requirement[13].

This option would introduce additional compliance requirements to demonstrate discharges to the Hamoaze remain within the limits and conditions of the Approval variation. These arrangements are considered not likely to introduce any significant cost, effort or risk.

6.3 Option Three - Disposal Direct to Naval Base Sewer

a. Description

limited quantities of pit sump rainwater that is confirmed as contaminated below the trigger levels (<10 Bq cm^{-3} H^3, <0.1 Bq cm^{-3} ^{60}Co and <0.1 Bq cm^{-3} gross beta) would be pumped into the nearest Naval Base sewer (via pump and flexible hoses) to allow discharge to sewer and disposal via the off-site South West Water operated Camels Head Sewage Treatment Works (CHSTW).

Due to the limitation on sewage system connection points a permanent connection is not feasible as this would restrict vehicle movements on the operational wharfs.

b. Environmental Impact

Better than Option 1 due to reduced use to the ion exchange columns. Worse than Option 2 due to the sewage cake from the local sewage treatment works being utilised for agricultural applications, marginally increasing terrestrial environmental impact

c. Technical Feasibility

Subject to confirmation from NSSM team it is assessed that this disposal option is technically significantly more challenging than Option 2 due to the absence of suitable sewer infrastructure in the vicinity of 8W Central and 8W South. The nearest likely suitable sewers would be located nearby to N019 (Defiance building) facility . It is understood that this option would require new connection

[13] Awaiting confirmation from Environment Agency - Nuclear Regulation Group

points to these sewers to be made and significant lengths of temporary hose would be required to cross the TXB access road to make the connections. While introducing limited additional complexity, effluent transfer operations on the Devonport Site are common practice and this option is technically feasible.

d. Operational Risk

Similar as Option 2 - with additional restrictions required on traffic flow in vicinity of TXB when pumping effluent to sewer. This could potentially impact on operational support to berthed submarines and surface vessels on or adjacent to the TWB.

Under fault conditions, particularly regarding a tank leak, there is an increase in risk of discharging effluent with activity levels above the limits prescribed directly to the Hamoaze. This is mitigated against by daily tank level checks and planned EMIT, resulting in a low risk of non-compliance under fault conditions.

e. Radiation Dose to Workers

Same as Option 2.

f. Cost

Similar costs to Option 2, however due to the need to make new connections to sewer infrastructure near the TXB it is conservatively assessed this option would be cost neutral to Option 2 after two calendar years.

g. Regulatory Requirements

The Naval Base approval does currently allow disposal to sewer (from N019 Defiance Change room facility) however there is no allowance from tritium and as such it is envisaged a variation to the EA approval would also be required together with direct stakeholder engagement with South West Water as operator of the CHSTW.

This option would introduce additional compliance requirements to demonstrate discharges to sewer remain within the limits and conditions of the Approval variation. It is assumed that compliance assessment would be undertaken via calculation methodology as per existing sewage discharges, therefore these arrangements are considered not likely to introduce any significant cost, effort or risk.

7. Qualitative Assessment of Disposal Options

The table below summarises the consideration of whether the proposed disposal option is considered better or worse against the assessment criteria and the no change (current) disposal method. Options have been qualitatively assessed against each other and assigned a numerical value, with 1 being the best option and 3 being the least favourable. Where there is no significant difference, options are assigned the same value.

Table 1: Qualitative relative scoring of the three options being considered

Criteria	Option 1	Option 2	Option 3
Environmental Impact	3	1	2
Technical Feasibility	1	2	3
Operational Risk	3	1	2
Radiation Dose to Workers	3	1	1
Cost	3	1	2
Regulatory Compliance	3	2	1
Total	16	8	11

It can be seen that the lowest score, and therefore best option is Option 2. The scores also indicate that there is a significant margin between the options and therefore further quantitative analysis would not be proportionate to this assessment.

8. Recommendations

8.1 Option to be Taken Forward

Based on the above assessment it can be concluded that Option 2 represents the BAT for management of the rainwater ingress. This is predicated on continuous application of proportionate maintenance activities to prevent waste generation by ingress of rainwater to the effluent tank pits.

8.2 Requirements for Implementation

Implementation of Option 2 requires assurance the radionuclide concentration in the effluent remains below the following threshold values:

^{3}H: <10 Bq cm^{-3} with annual limit of 100 MBq

^{60}Co: <0.1 Bq cm^{-3} with annual limit of 1 MBq

Gross beta <0.1 Bq cm^{-3} with annual limit of 10 MBq

All other nuclides: <MDA

As a result, control measures are required for routine assessment of radionuclide concentrations within the effluent. The use of specific activity limits ensure no primary effluent will be discharged to the Hamoaze via the new discharge route. The annual limits ensure adequate monitoring and control of the total radiological impact of discharges direct to the Hamoaze.

A detailed design optioneering study is required to optimise the implementation of this Option for disposal via the TXB storm drains. The ability to pump the pits into the tanks should be retained for managing fault conditions, such as leaks and spills.

8.3 Justification of Limits

The selection of the limits identified in Section 8.2 above was chosen with careful consideration of the ability to implement the BAT option identified in this assessment. The majority of sampling undertaken to date has been when the sumps are full, therefore there is the potential for a dilution effect, the implementation of Option 2 will result in more frequent management of smaller volumes of effluent, therefore the impact of the dilution effect of full sumps must be taken into account.

The levels selected for tritium are higher than any recorded values, predominantly to provide the ability to manage the dilution effect caused by only transferring the sump contents once a certain level is reached. As noted in this report, the DRDL ETP provides no abatement of ^{3}H, therefore ^{3}H at the maximum limits proposed would pose no net additional radiological impact to the environment compared to ETP processing prior to disposal.

The detection of cobalt-60 in sump sediment means that there is potential for the rainwater to become contaminated with low levels of cobalt-60 and other gross beta contaminants therefore activity and specific activity limits for these contaminants are required.

Discharges of known or suspected releases of primary effluent from the tanks or effluent system will be prevented, however the potential of resuspension of trace levels of contamination around detection limits remains. Therefore, to avoid technical non-compliance, low limits have been set to ensure compliance while requiring concentrations to be monitored and managed in a safe and responsible manner.

8.4 Mitigation of Fault Conditions

Control measures are required to prevent the disposal of effluent where there is reason to suspect it has become contaminated via a means other than tritium migration from the effluent tanks. These control measures will include radiochemical analysis and assessment of disposal options using BAT.

The effluent tanks are fitted with electrical control and instrumentation for the measuring and recording of tank levels. Recording of tank levels are subject to daily checks by DRDL Control Engineers (Nuclear) staff. Any unexpected drop in tank level will be reported and investigated via established reporting mechanisms. This system, or a similar one providing the same purpose will remain an operational capability of the effluent transfer system.

8.5 EA Approval

The implementation of this Option requires variation to the extant Approval for HMNB Devonport to authorise the discharge via the storm drains. Based on the conservative assessment undertaken in this report it is recommended the following specific activity limits and annual limits are required:

^{3}H	10 Bq cm^{-3} with 100 MBq annual limit
^{60}Co	0.1 Bq cm^{-3} with 1 MBq annual limit
Other beta/gamma	0.1 Bq cm^{-3} with 10 MBq annual limit

The method of assessing and reporting tritium, cobalt-60 and other beta/gamma discharges will be captured in the HMNB(D) techniques document[14].

Effluent with concentrations of radionuclides above these values will be transferred to the TXB effluent tanks for transfer to the ETP for treatment in accordance with established discharge routes, therefore no change to the EA Approval is required for these.

9. Conclusion

This qualitative BAT assessment has reviewed options for the disposal of contaminated rainwater from the TXB effluent system pit sumps. It is assumed that proportionate efforts to avoid waste generation by preventing rainwater ingress are continued in accordance with the waste management hierarchy.

It is considered that Option 2 (disposal to Hamoaze via TXB storm drain) offers the candidate BAT option because environmental impact is negligible, potentially improves overall ETP performance, it is cheaper to operate than the existing option and significantly reduce operational risk by reducing demand and dependency on the vulnerable DRDL Effluent Treatment Plant.

Implementation of Option 2 will result in increased frequency of draining and discharging the effluent pits, offset by a reduction of the bulk volume accumulated and disposed of at any given point in time.

Based on the conservatism within this assessment rainwater effluent with radionuclide concentrations above the trigger values is not anticipated. This assessment demonstrates the continued application of BAT to waste arisings.

10. Further Action Plan

The following recommendations are made:

1. A detailed optioneering study is required to develop and implement an optimised application of this discharge route - which will include the removal of sediment from pit sumps and the resealing of sump surfaces.

[14] *Assessment Techniques Employed by HMNB(D) to Determine Activity of Radioactive Waste Disposals Related to Disposal Approval EPR/LB3730DK/V002*