Engineering

Report

AGR Fleet

Liquid Active Effluent Discharge Credible Options Fleet Review

By: [redacted]

Date: November 2022

EDF Energy Nuclear Generation Limited

EDF ENERGY NUCLEAR GENERATION LIMITED
NUCLEAR DECOMMISSIONING ENGINEERING

SUMMARY SHEET

Power Station: AGR Fleet

Document Title: Liquid Effluent Discharge “Stage A” (Credible Options) Fleet Review

Document Reference: ND/REP/TAD/0019/GEN/22

Document Author: [redacted]

Verified by: [redacted]

Approved by: [redacted]

Date: November 2022

Summary

Following end of generation at all AGR stations the demand for Circulating Water (CW) systems will change, since the main duty of main (MCW) pumps in cooling turbine condensers will no longer be required. A secondary duty of the CW systems is to flush active effluent from the AETP from the end of dedicated active effluent pipework at Surge Chambers to the ultimate discharge point at the CW outlet.

Following defueling there will be a requirement to de-plant conventional areas including turbine halls and CW pump houses, as part of deconstructing the stations. At this point all flow of CW, Including Reactor Cooling Water (RCW), must cease. There will however continue to be active effluent generated from various decommissioning activates throughout the care and maintenance preparations phase, and potentially a requirement to manage very small volumes of effluent throughout Care and Maintenance.

This credible options paper presents strategic options for allowing Liquid Active Effluent discharges at AGR sites, when no CW systems are available. Non-Credible options are reviewed and reasons for their non-viability recorded. Note some options will be relevant to some AGR sites and not others. Where this is the case, the report identifies which sites the options are viable for and which sites they are not.

Implementation of the selected option is therefore a key enabler for the deconstruction of conventional plant and will bring about significant net zero and cost benefits, through allowing the CW systems to be taken out of service. For example, a 2MW load from keeping a typical single MCW pump in service would cost £1.6m per year, assuming a unit cost of 9p per kWh for electricity. There is significant uncertainty regarding the cost of electricity over the period that early AGR decommissioning is planned to take place, meaning this cost could in fact be much higher.

It is anticipated that there will be no ongoing requirement for CW flow around the time of FFV. Between end of generation and the cessation of CW flow there will be station specific work to optimise CW arrangements to minimise environmental and cost impact from operation of this equipment. This optimisation could involve a reduction of flow rates or operation of existing pumps, but is not expected to involve the installation of new equipment. The development of these arrangements will be led by site specific ‘Management of the Asset’ work strands and options related to this optimised CW flow phase are not presented in this paper.

Recommendations

Parties with responsibilities under the company process for BAT/BPM (BEG/SPEC/SHE/ENVI/021/02) should develop preferred strategic options from the credible options presented here through site specific strategy projects planned under the EDF Annual Liabilities Report Part 2, near term work plan. Other parts of the Nuclear Decommissioning organisation, including ND Engineering, are available to support follow on work, to progress this work in a timely manner. This will require further investigations into multi-disciplinary site-specific constraints, such as permit requirements by ESG and detailed plant configuration by Operations and Engineering.

At the time of issue of this report, there are projects to determine liquid effluent discharge strategy planned to start within the next 6 month at all Region 1 sites except HNB, where this work is already underway. Region 2 AGRs (Torness and Heysham 2) have no such work planned in the next 3 year period and therefore they have not been included in the detailed review of this document. When the equivalent work is beginning at these sites it would be prudent to review learning from the execution of associated projects across Region 1 and consider an up issue of this document, if necessary and include a detailed review by SQEP from those sites.

Verification Certificate

Document Title	Liquid Active Effluent Discharge Credible Options Fleet Review
Station	AGR Fleet
Document Reference	ND/REP/TAD/0019/GEN/22
Revision	000
Task File Number	W&D/ENG/TSK/020
QA Grade of document	3
Author	[redacted]
Author's Section	ND Engineering
Verifier(s)	[redacted]
Principal Verifier	[redacted]
Verifier's Section	Nuclear Decommissioning Engineering
Verification Statement	This document has been verified in accordance with BEG/SPEC/DAO/010. Observations from colleagues have been addressed as part of the verification process.
Approver	[redacted]
Section/Group	Nuclear Decommissioning Engineering
Technical Reviewer(s)	N/A
SQEP Status/ evidence of competence of the reviewer(s)	N/A
Commissioned by	N/A
Technical Review Commissioning Detail	N/A
Outline of, or reference to, the nuclear safety related application in which the work is to be used	N/A
Technical Review Outcome	N/A
Details of aspects of the work reviewed	N/A

DOCUMENT ISSUE/AMENDMENT CERTIFICATE

Date	Author	Revision	Amendment
July 22	[redacted]	Draft	First draft
November 22	[redacted]	Rev 0	First Issue

TERMINOLOGY

Term Used in this report	**Alternate, Broadly Similar or equivalent Terminology**
Surge Chamber	Seal Pit, Syphon Seal
AETP	AEWTP, ETP, RAETP
RCW	ECW
BAT/BPM	BAT, BPM
FDT	FMDT, DT
TWST	TWIST, TEST, TET

GLOSSARY

AAEDL	Alternative Active Effluent Discharge Line
ACW	Auxiliary Circulating Water
AETP	Active Effluent Treatment Plant
AGR	Advanced Gas-Cooled Reactor
ALARP	As Low As Reasonably Practicable
BAT	Best Available Technique
BPEO	Best Practicable Environmental Option
BPM	Best Practicable Means
C&M	Care and Maintenance
COMAH	Control of Major Accident Hazard [regulations]
CW	Circulating/Cooling Water
DNB	Dungeness B [Advanced Gas Cooled Reactor Station]
DPP	Decommissioning Programme Plan
EBFP	Emergency Boiler Feed Pumps
EDF	EDF Energy
ESG	Environmental Safety Group
FDT	Final Delay Tank
FFV	Fuel Free Verification
FORM	Fleet Operational Radwaste Management
GSW	General Service Water
HNA	Hunterston A [Magnox Station]
HNB	Hunterston B [Advanced Gas Cooled Reactor Station]
HPA	Hinkley Point A [Magnox Station]
HPB	Hinkley Point B [Advanced Gas Cooled Reactor Station]
HPC	Hinkley Point C [European Pressurised Water Reactor Station]
HRA	Hartlepool [Advanced Gas Cooled Reactor Station]
HYA	Heysham 1 [Advanced Gas Cooled Reactor Station]
MAC	Man Access Cooler
MADA	Multiple Attribute Decision Analysis
MAETP	Mobile/Modular Active Effluent Treatment Plant
NDA	Nuclear Decommissioning Authority
NDE	Nuclear Decommissioning Engineering
ONR	Office for Nuclear Regulation
POCO	Post Operational Cleanout

PWTP	Pond Water Treatment Plant
RCW	Reactor Circulating Water
SEPA	Scottish Environment Protection Agency
SQEP	Suitably Qualified and Experienced Person
TWST	Tritiated Water Storage Tank

CONTENTS

1 INTRODUCTION

Following end of generation at all AGR stations the demand for Circulating Water systems will change, since the main duty of MCW pumps in cooling turbine condensers will no longer be required. A secondary duty of the CW systems is to flush active effluent from the AETP from the end of dedicated active effluent pipework at Surge Chambers to the ultimate discharge point at the CW outlet for dilution and dispersal.

Following defueling there will be a requirement to de-plant conventional areas including turbine halls and CW pump houses, as part of deconstructing the stations. At this point all flow of CW through the Surge Chamber, Including RCW, must cease. There will however continue to be active effluent generated from various decommissioning activates throughout the care and maintenance preparations phase, and potentially beyond.

This credible options paper presents strategic options for allowing Liquid Active Effluent discharges at AGR sites, when no CW systems are available. Non-Credible options are reviewed and reasons for their non-viability recorded. Some options will be relevant to some AGR sites and not others. Where this is the case, the report identifies which sites the options are viable for and which sites they are not.

Between end of generation and the cessation of CW flow there will be station specific work to optimise CW arrangements to minimise environmental and cost impact from operation of this equipment. The development of these arrangements will be led by site specific Management of the asset work strands and options related to this optimised CW flow phase are not presented in this paper.

Note that authorised Minor discharge routes are not considered in this paper, as there is no significant strategic impact on decommissioning plans associated with these and they will continue to be available for minor discharges following FFV.

1.1 HNB Experiences

The W048 project at Hunterston B is the fleet lead and learn strategy development project for Post Operational Clean Out (POCO) and discharge management throughout the Decommissioning phase of HNB lifecycle. Work at HNB has highlighted that development of a liquid effluent strategy for each site is a significant task. Liquid Effluent “Stage A” (Credible Options) Review [13] presents the strategic decisions that need to be made regarding liquid effluents at HNB and presents credible options for each decision. The strategic decisions presented in Reference 13 are:

- Alternative Discharge arrangements/ AAEDL
- Active Effluent Processing/ MAETP
- Pond end state
- C&M effluent treatment

This paper reviews options associated the alternate discharge arrangements only, whereas Reference 13 presented options associated with all the liquid effluent decisions listed above. Installation of a direct to sea Alternative Active Effluent Discharge Line (AAEDL) is the baseline plan at all AGR sites, including HNB. This baseline position was assumed for planning and provisioning purposes and requires detailed review on a site by site basis, to ensure a robust strategy is developed and that BAT/BPM requirements are applied.

It has been further identified by the W048 project that timely decision making around the Alternative Discharge arrangements/ AAEDL in particular is important, as a key enabler for decommissioning of the CW systems. CW Systems are a significant burden on maintenance resource and site electrical load.

To allow prompt decision making for alternate discharge arrangements at follow on sites, this paper presents fleet level credible options. It will allow selection of a preferred option for each site to be undertaken as a separate exercise when the site specific follow on projects are established. Selection of the preferred option will be consistent with the requirements for the application of BAT/BPM in strategic decision making, as set out in BEG/SPEC/SHE/ENVI/021/02. At some sites this may be through production of a reasoned argument BAT/BPM paper and at others a MADA options review process may be necessary. Note that at DNB, HPB, HYA and HRA this work is to commence early in 2023.

1.2 Decommissioning Planning

Baseline decommissioning plans developed during the generating life of the AGR stations, for cost provisioning purposes, are now being reviewed and developed into deliverable Decommissioning Programme Plans (DPP). As part of this process, strategic assumptions around baseline plans now need to be reviewed and validated, or changed, as appropriate, with a further level of detail added. EA/SEPA will require waste management decisions to be appropriately underpinned at a strategic level and recognise tools such as BPEO studies as possible mechanisms for ensuring this. For example Reference 3 sets guidance from SEPA on the appropriate application of BPM at a strategic level.

2 REQUIREMENT

At present active liquid effluent from AGR stations discharge into the discharge leg of the CW outlet and flow from this system takes the effluent to sea via the outfall, see simplified diagram for a typical AGR in figure 1.

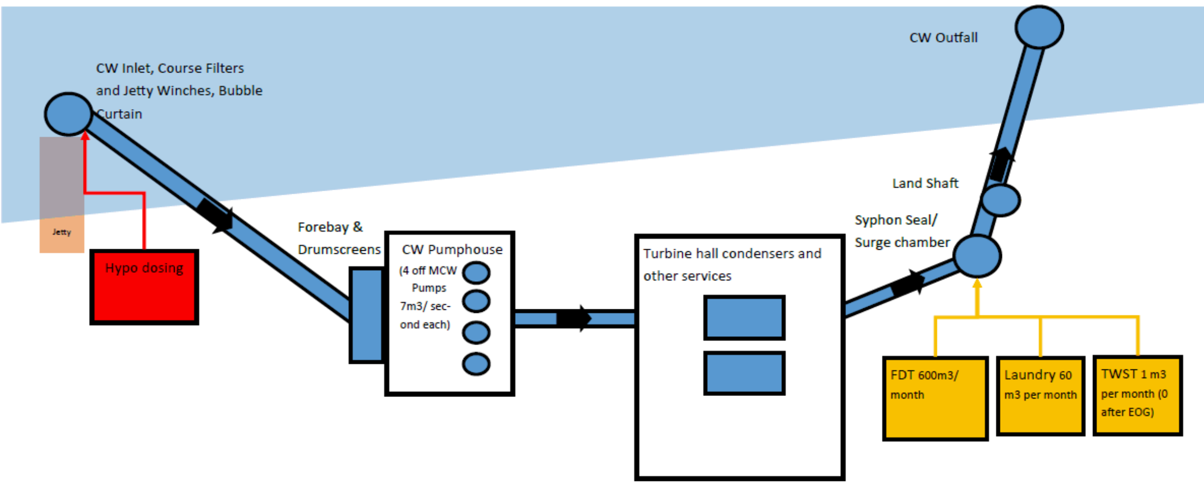

Figure 1- Simplified Typical CW And Active Effluent system diagram (Details taken from HNB).

This configuration relies on a flow of CW to flush active effluent discharges through the CW outlet to sea. Some AGR site permits specify a minimum volumetric flow rate for active effluent discharges to be conducted and at others there are no minimum limits specified.

This primary function of the MCW system, to provide cooling to the turbine condensers, will no longer be required at the end of generation. There are however several secondary functions that will still be required during defueling. For example at HNB one function is cooling the General Service Water (GSW) cooler, which in turn services the Emergency Boiler Feed Pumps (EBFPs), which will provide low pressure feed water into the main boilers in the shutdown cooling mode to be employed during defueling. Other functions of MCW are servicing the Man Access Cooler (MAC) and dump condensers, which provide defence in depth for shutdown cooling arrangements [4], at other sites generator transformers provided station wide power and are cooled via CW.

Once these secondary functions of the MCW system are no longer required, new arrangements to ensure liquid effluents are discharged to sea will be required. This will avoid disproportionate costs of running and maintaining pumps (typically 4 per site, each circa. 2 Megawatt), as well as allowing decommissioning of the Turbine Hall, CW Pump House, Drum Screens, Sodium Hypochlorite dosing plant (where applicable), Jetty course screens and associated winches. Credible options regarding these arrangements are discussed in this paper.

It is worth noting that although AGR stations are only now beginning to consider implementing such new arrangements post end of generation, there is significant experience at neighbouring Magnox sites. The only coastal Magnox site without new arrangements that allow discharges without a flow of CW is HNA, where active liquid discharges were re-routed to the HNB CW outlet, following HNA end of Generation in 1990. At all other coastal Magnox sites new discharge arrangements have been implemented with 'direct to sea' lines that do not rely on CW flow through an intermediary section of CW culvert.

2.1 Constraints and Assumptions

2.1.1 Constraints

- CW Infrastructure must be deconstructed prior to cessation of active effluent discharges to allow a timely entry into Care and Maintenance for the site and appropriate Hazard Reduction
- BAT/BPM requirements from statutory legislation implemented through BEG/SPEC/SHE/ENVI/021/02
- The ALARP principal must be adhered to.

2.1.2 Assumptions

- CW systems will facilitate active effluent discharges through CW outlets until FFV
- FFV will be achieved 3.5 years following end of generation at a typical AGR
- It is not possible to significantly decommission the CW Pump house, Turbine Hall or Circulator Halls with live MCW or RCW lines in the area
- Relevant infrastructure at neighbouring sites (AGR or Magnox) can be shared where technically possible
- A typical AGR site will take 12Y following EoG to enter C&M
- Substances listed in chemical discharge permits for AGR sites will no longer be discharged via this route following FFV and therefore requirements from chemical permits do not need to be considered for the options identified here
- The mechanism for sewage discharges is being considered under a separate project and is not considered here
- There will continue to be infrastructure for managing storm water runoff from the site and other minor discharges.

2.1.3 Risk

- It is possible that further changes to plant configuration or updates to safety cases could remove the need for CW pumps to be kept available prior to FFV. In such an eventuality new discharge arrangements may be needed sooner than assumed above.

3 OPTIONS CONSIDERED (LONG LIST)

The options considered are listed below (Long List). Each is then considered in the following sections:

- Do Nothing (Keep running MCW)
- Do Nothing (No new infrastructure after CW Flow ceases)
- Replace Pumps- Sized to match existing flow rates
- Justify reduced flow rates.
- Replace Pumps- Sized for reduced flow rates
- Install AAEDL
- Process off site
- Tie in to Direct to sea discharge line from Neighbouring Site
- Utilise CW Outlet from Neighbouring site
- Flush with townswater

3.1 Do Nothing (Keep running MCW, as per current arrangements)

In this context, do nothing would require the MCW system to be maintained as long as the site generates active liquid effluent requiring discharge.

This would require the continued use of the whole CW system solely for the purpose of transporting active effluent along the CW outlet tunnel, with significant cost in terms of energy supply and maintenance resource. Decommissioning of the turbine hall and CW pump house could not commence as there would be live CW infrastructure in these areas. A significant COMAH hazard would continue to be present on site as sodium hypochlorite dosing would need to be maintained (at sites where this is relevant). Furthermore, all the other equipment related to the system would need to be maintained such as jetty winches, course screens, drum screens, wash water, cranes, valves etc. It is clear that this approach neither allows ALARP hazard reduction, nor supports timely decommissioning of conventional plant. It is therefore not considered a credible option for further review

3.2 Do Nothing (No new infrastructure)

In this context do nothing would involve stopping running CW pumps and continuing to discharge active liquid effluent into the Surge Chamber. With no CW flow the tunnel from the Surge Chamber to the CW outfall is a 'dead leg' of pipework and active effluent would accumulate in this space without any significant mechanism for it to be discharged to sea. It would not be possible to justify such an approach as active effluent would not be discharged and would accumulate in an uncontrolled manner. It is therefore not considered credible.

3.3 Replace Pumps- Sized to meet Current Flow Rates

An option considered here is to replace the MCW pump with another pump to provide an equivalent flow to that of a MCW pump through the CW outlet to sea. This could be achieved by installing a large submersible pump in the CW forebay and running overground pipework of an appropriate diameter to the surge chamber directly.

This would make the CW pump house and turbine hall CW pipework redundant, but otherwise the same arguments made for the 'do nothing (Keep Running MCW)' option are relevant. Furthermore, this option would require a large capital investment of new infrastructure, which would itself then need to be decommissioned. This option is therefore not considered credible.

3.4 Justify reduced flow rates.

Here we could seek to modify our arrangements so that smaller discharges are conducted more frequently at a lower CW flow (RCW only). For example at HNB there are four RCW pumps located in the CW pump house that give a combined flow rate of $1.2m^3/s$, as opposed to $7.1m^3/s$ for a single MCW pump. There is precedent for this, as similar temporary arrangements have been put in place during Double Reactor Outages. A detailed review would be necessary to demonstrate that a lower volumetric flow rate through the syphon seal is adequate to disperse the liquid effluent to sea effectively and to review the possibility of any unintended consequences on related systems.

For this option all CW related infrastructure would still be required and timely hazard reduction and decommissioning of conventional plant would be prevented.

This option is clearly a non-credible solution as it does not allow the necessary decommissioning of CW related infrastructure. However, in the shorter term it is a proven method to allow active liquid discharges without MCW pumps in service and requires no physical work to implement. It is therefore a possible risk mitigation measure in the event that other options are not ready when the station is otherwise prepared to take MCW pumps permanently out of service. It is also possible that such an approach represents the 'optimised configuration' that the plant may already be in at some AGR sites prior to the requirement for new arrangements with no CW flow, as described in Section 1. At some sites, with a higher sediment loading of seawater in the local environment, this approach may not be a suitable risk mitigation measure if a reduced CW flow could result in silt blocking the CW inlet, which would in turn make RCW unavailable.

3.5 Replace Pumps- Sized for reduced flow rates

Here we could seek to modify arrangements so that smaller discharges are conducted more frequently at a lower CW flow. In this option installation of a suitably sized pump provides flow through the CW outlet tunnel and transports liquid effluent to sea. This could be by using the CW forebay as a source of water for the new pump and installing new pipework overground to the syphon seal, which would allow the CW pumphouse and turbine hall CW pipework to be taken out of service. A detailed review would be necessary to demonstrate that a lower volumetric flow rate through the syphon seal is adequate to disperse the liquid effluent to sea.

For this option most CW related infrastructure would still be required and timely hazard reduction and decommissioning of conventional plant would be prevented. Further this option requires significant physical works to implement.

This option is sub optimal compared to options that allow for decommissioning of all CW infrastructure and there would be significant physical works required for infrastructure which would itself need to be decommissioned. It is therefore not considered credible here.

3.6 Install Alternate Active Effluent Discharge Line (AAEDL)

For this option, the discharge line is extended, so that the point of discharge is moved from the Surge Chamber, directly to the sea. This eliminates the need for CW flow through the CW outlet culvert and allows decommissioning of all CW related infrastructure. It is likely the extended line would be run through the CW outlet culvert to avoid or minimise the need for new excavations. The exact point of discharge would also be subject to detailed review as part of the BAT/BPM process. It is likely at some sites the new discharge point could be at the location of the CW outfall and at others it would need to be further out to sea [14], [15]. A review of dispersal modelling conducted for several Magnox sites shows that, proving the discharge point of this line is suitably located, there would likely be no measurable increase to dose uptake from direct to sea discharge lines (compared to the baseline position of mixing with CW). Dose uptake is also likely to be below the SEPA/EA thresholds for optimisation.

Further, CW flow is important to reduce concentration of effluent at the immediate discharge point, but does not improve longer-term dispersion or cumulative effects in the local area [16]. It is therefore likely that constraints on chemical concentrations from conventional permits would be more restrictive in the reduction of CW flow than radiological substances permits, however after FFV such relevant substances would likely no longer need to be used.

Except for HNA, which is connected to the HNB CW system, this option represents the approach taken at coastal Magnox sites with equivalent decommissioning strategies to the AGR baseline and is considered credible here.

3.7 Process off site

For this option contents of the Final Delay Tanks (66m^3 to100m^3 per batch depending on station specific configuration) would likely be discharged to a road tanker to be transferred off site for disposal at another location, for example by discharge to sea at another site, or evaporation. There are clear dis-benefits to this option, such as the need for vehicle movements and stakeholders would not view it favourably at the other location. The volume of effluent generated would likely prove challenging for the existing incineration plants in the UK to manage, if that was the plant used to evaporate the waste, particularly given the uncertainty and risk around these volumes. Despite these factors, this option does appear to be technically achievable and it would allow all CW plant to be taken out of service. It is therefore considered credible here. It is considered highly unlikely that this option will represent the BAT/BPM when assessed in more detail, particularly given that Environmental Permitting Regulations 2016 require the application of BAT to consider the need to achieve “minimisation of the volume of radioactive waste disposed by transfer to other premises”. At present, no EDF Licensed sites are authorised to transfer aqueous waste off site.

3.8 Tie in to Direct to sea discharge line from Neighbouring Site

Both DNB and HPB neighbour Magnox sites which have already installed direct to sea discharge lines. This option would divert pipework-taking effluent from FDTs to an appropriate point along their neighbour’s direct to sea line rather than the CW outlet culvert. Proximity of these services and spare capacity of the existing discharge lines would need to be reviewed on a site-specific basis as part of the BAT review. The technical concept of such an approach is simple and credible. It may also be credible at HYB, if HYA were to install a direct to sea discharge line.

3.9 Utilise CW Outlet from Neighbouring site

At AGR Stations with a neighbouring operational site, effluents could be discharged into the neighbour’s CW outlet and flushed through to that outfall. This is clearly technically possible since it has been demonstrated at HNA/HNB, as discussed earlier in this report.

HYA, has a scheduled EoG date of 2024 and neighbours HYB. HYB has a scheduled EoG date of 2028 and assuming the baseline position of 12Y from EoG to C&M entry then if this option were selected it would need to be followed by another solution following the shutdown of HYB CW systems.

Conversely at HPB EoG was reached in August 2022 with defueling assumed to take 3-4Y. HPC has a target date for commissioning of 2027 and such an approach should be considered feasible for HPB, following other shorter-term arrangements from options listed here.

No other AGR sites neighbour operational stations or NNB sites with ongoing construction projects. Some sites are being considered as possible future locations for SMRs or AMRs, but no such new designs have been granted Generic Design Approval yet and on that basis it is judged they could not be operational in time to support discharges during AGR Decommissioning work, if such projects do proceed to construction.

This option is therefore credible at some sites, but must be considered in conjunction with arrangements for periods when neighbours will have not yet begun operation or have themselves reached EoG.

3.10 Dilute with towns water during discharge

This option replaces a flow of CW to flush liquid effluent through the CW outlet culvert with a flow of towns water. Assuming:

> 1, An optimised rate of approx. 1m^3 per second could be justified, consistent with the discussion in section 3.4 and that
>
> 2, provision of 1m^3 per second from the water main would not be possible without significant impact on water pressure for other customers.

Then a break tank would need to be approx.11,000 m^3 to allow such a flow rate over a typical 3h discharge window, with approximate linear dimensions of 22m for a cubic tank. Installation costs of such a system as well as resource utilisation, particularly of towns water, are considered to be clearly grossly disproportionate. For example with a unit price of £3 per m^3 for towns water each discharge would cost £33k and the foundation slab for any such tank would need to support 11,000 Tonnes, with a substantial flooding hazard introduced to site. Time to refill such a tank would also likely introduce unacceptable operational constraints on the periodicity of active liquid effluent discharges during decommissioning and this option is therefore considered not credible.

3.11 Pre- Dilute Effluents

Pre-dilution of liquid effluents within a FDT is a distinct option compared to diluting with towns water during discharge, as described in Section 3.10. It may be appropriate as a detailed sub option for consideration alongside a credible option, to meet concentrations specified in chemical permits. This approach was taken at Bradwell, where a nitric acid waste dissolution plant meant high concentrations of nitrates needed to be pre diluted prior to discharge to sea [12] and should be considered as part of the site specific BAT/BPM exercise where chemical constraints on discharge will be considered. This dilution could be provided by towns water or another suitable fluid such as seawater and would require, for example, 100m^3 of fluid to dilute a 100m3 batch of liquid effluent to 50% initial concentration. Reference 16 shows that such an approach would have no significant impact on dose accumulated from liquid effluent discharges. Pre Dilution of effluents is not a credible solution to the need to discharge effluents without CW in its own right, but it has been recorded in this section as it may be advantageous to incorporate this into the detailed design of a credible option at a later stage.

3.12 Credible Options (Short List)

From the preceding discussion, the credible strategic options are:

> 1, Install AAEDL
> 2, Process off site (Considered very unlikely to be BAT/BPM)
> 3, Tie in to Direct to sea discharge line from Neighbouring Site
> 4, Utilise CW Outlet from Neighbouring site

Should these not be ready before the station is otherwise ready to take MCW out of service there is another, short term risk mitigation option available:

5, Justify reduced CW flow (short term ‘stop gap’ option only)

Option 5 would only be suitable if the station was ready to remove the MCW pumps from service before physical work had completed on the installation of a longer term credible option. It would therefore be employed as a risk mitigation measure until a time when it is clear this risk no longer exists, or may have already been implemented as part of detailed site-specific CW optimised arrangements.

3.13 Site Specific Credible Options

The credible options identified in section 3 are presented below to summarise which sites they are credible for.

	DNB	HNB	HPB	HRA	HYA	HYB	TOR
1, Install AAEDL (Credible long term option)	Y	Y	Y	Y	Y	Y	Y
2, Process off site (Considered very unlikely to be BAT/BPM)	Y	Y	Y	Y	Y	Y	Y
3, Tie in to Direct to sea discharge line from Neighbouring Site	Y	N	Y	N	N	TBC_1	N
4, Utilise CW Outlet from Neighbouring site	N	N	Y_2	N	Y_2	N	N

Table 1 Site Specific Credible Options

Note 1 Credibility of this would depend on the strategy selected at HYA

Note 2 This would only be credible in conjunction with another option for periods where the neighbouring site is also not operational.

4 PREFERRED OPTION DEVELOPMENT

As a credible options paper this document is comparable to a Stage A submission under the NDA strategy management system (SMS). Having the credible options for Liquid Active Effluent discharges documented for all AGR sites allows site specific strategy projects to focus on selecting and justifying the site specific preferred option (NDA SMS Stage B) once these projects are established. Since selection of a preferred option for Liquid Active Effluent Discharges will determine the method of disposal of liquid Radwaste it must be supported by a BAT/BPM assessment, as required by BEG/SPEC/SHE/ENVI/021/02.

BEG/SPEC/SHE/ENVI/021/02 states that the Environmental Safety Group (ESG) Group Head is responsible for *"Identifying whether the strategic BAT / BPM assessment shall be completed as a station led or Central Support Function (CSF) led project".* BEG/SPEC/SHE/ENVI/021/02 also states the Fleet Operational Radioactive Waste Management (FORM) Group Head is responsible for *"Appointing a strategic BAT / BPM assessment Lead Engineer."*

The format of subsequent BAT/BPMs, which will support selection of a preferred option, must therefore be agreed through consultation with ESG Group Head for each site and the FORM Group Head. It is possible that some of these BAT/BPM Assessments will be valid for more than one site. Figure 2 is an extract from BEG/SPEC/SHE/ENVI/021/02 and this paper fulfils the requirement of the highlighted boxes in determining the need for a strategic BAT/BPM.

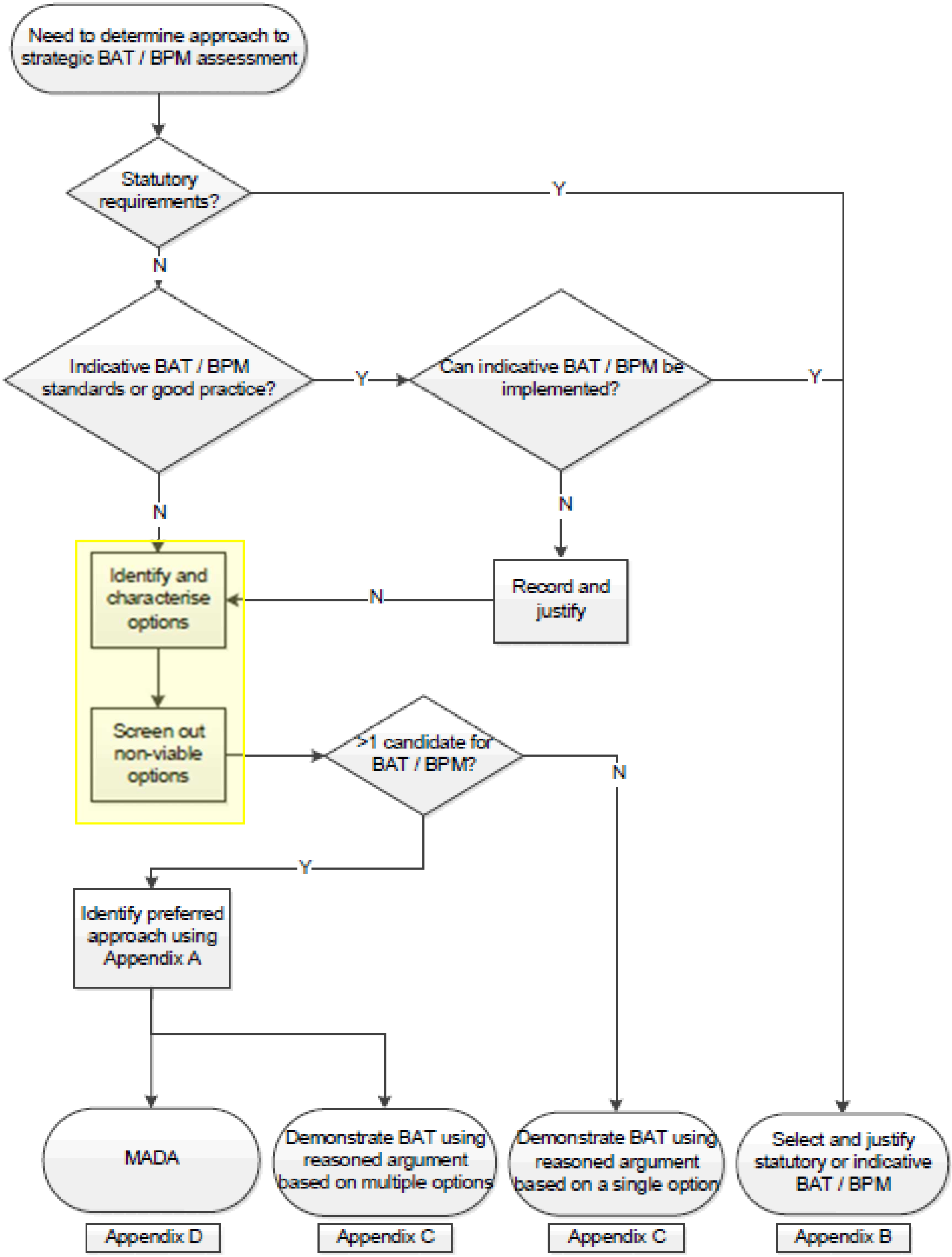

Figure 2- Extract from BEG/SPEC/SHE/ENVI/021/02

4.1 More detailed design considerations

Following the identification of a BAT/BPM strategic option an Operational BAT/BPM could consider detailed aspects of implementation of the strategy such as:

- Exact location of any new discharge point in the Sea,
- Exact route of any new pipework,
- Consideration of a diffuser at the outlet of any new discharge point,
- Method of installation any new pipework underground/overground/undersea, as necessary,
- Process engineering considerations such as pipe materials, diameters etc,
- Possible partial pre dilution of effluent in holding tanks,
- Consideration of purging lines after completion of discharges
- Consideration of a ‘Duck Bill’ type check valve at the point of discharge.

Variables that will feed into this decision making that need further investigation include:

- An understanding of dispersion characteristics in the body of water around the chosen outlet,
- An understanding of post end of generation discharges.

Modelling work to understand local dispersion will be key to underpinning the detailed BAT/BPM assessment. For example at Oldbury local conditions allowed the discharge point for an AAEDL to be at the same point as the old CW outlet [8], Whereas at Wylfa a new 320m tunnel was needed so that an AAEDL discharge point was at a suitable location further out to sea. [9].

4.2 Information supplied by W048 and Magnox

Experience gained through the W048 project at HNB has indicated that dispersion modelling will likely be needed to understand the effects from discharges conducted under proposed new configurations. This modelling will need to be contracted to a specialist supplier and could be conducted before undertaking a strategic BAT/BPM or after it providing suitable assumptions are recorded and reviewed prior to undertaking an operational BAT/BPM. Undertaking this modelling after a strategic BAT/BPM could allow the model to better support an operational BAT/BPM, alongside the detailed design of the new discharge solution.

A series of example dispersal models and BAT assessments were provided from Magnox sites under the Magnox-EDF AGR Information Sharing agreement [14][15][16][17]. A review of this information showed that, proving the discharge point of this line is suitably located, there would likely be no measurable increase in dose uptake from direct to sea discharge lines, compared to the baseline position of mixing with CW. Dose uptake is also likely to be below the SEPA/EA thresholds for optimisation.

Further, CW flow is important to reduce concentration of effluent at the immediate discharge point, but does not improve longer-term dispersion or cumulative effects in the local area. It is therefore likely that constraints on chemical concentrations from conventional permits would be more restrictive in the reduction of CW flow than radiological substances permits, however after FFV such relevant substances would likely no longer need to be used.

CW Outfalls are likely to be suitable discharge points for direct to sea discharge lines unless they are located at the shoreline

4.3 Responsibilities

The following sections outline other key stakeholders and their responsibilities relating to the strategic BAT/BPM process to be undertaken following this credible options report.

4.3.1 GEM, including FORM

GEM (Generation Environmental Management) are the Process owners for BAT/BPM (BEG/SPEC/SHE/ENVI/021/02). They provide resource to undertake Strategic BAT/BPM assessments when requested by site ESG Group heads and are the Fleet Operational Radioactive Waste Management (FORM) Group Head is responsible for *"Appointing a strategic BAT / BPM assessment Lead Engineer."*

4.3.2 ND Engineering

Nuclear Decommissioning Engineering (NDE) (formerly Post Generation Design Integrity) are the Authorised Designers for Radwaste Facilities and are responsible for maintaining the Safety Cases. NDE are responsible for Technical Oversight and Assurance of decommissioning plans and contribute to the development of Nuclear Decommissioning Plans where requested. This is an important role in ensuring appropriate use of taxpayer funds and a coherent approach across projects, which is an enabler for sanctioning of decommissioning projects.

4.3.3 Station ESG

The Environmental Safety Group are responsible for implementation of BAT/BPM at EDF Energy Generation Sites.

4.3.4 Station System Engineering

Responsible for system health and configuration control of relevant plant. Personnel with particular interest here are the Engineers responsible for liquid Radwaste and Circulating Water (CW), both main (MCW) and Auxiliary (ACW), and Reactor Circulating Water (RCW) systems.

4.3.5 Investment Delivery

Investment delivery are accountable for successful delivery of project scope and ensuring effective use of NLF funds. They provide project management services during the execution of projects.

4.3.6 Scottish Environmental Protection Agency (SEPA)

SEPA is a non-departmental public body of the Scottish Government, whose role is to make sure that the environment and human health are protected, to ensure that Scotland's natural resources and services are used as sustainably as possible and contribute to sustainable economic growth. At HNB and TOR, SEPA issue the Environmental Permit for liquid effluent discharge and are the Regulator for environmental aspects of site operations.

4.3.7 EA

EA were established in 1996 to protect and improve the environment. Within England their responsibilities include regulating major industry and waste, treatment of contaminated land and water quality and resources. At AGRs other than HNB and TOR, EA issue the Environmental Permit for liquid effluent discharge and are the Regulator for environmental aspects of site operations.

4.3.8 Office for Nuclear Regulation (ONR)

ONR are the UK's independent nuclear regulator for safety, security and safeguards. Their mission is to protect society by securing safe nuclear operations.

They deliver five statutory purposes to ensure safe nuclear operations now and in the long term. These are:

- nuclear safety;
- nuclear site health and safety;
- nuclear security;
- nuclear safeguards; and
- safety of transport of nuclear and radioactive materials

4.3.9 Magnox

It has been confirmed that Magnox will be the licenced operator of AGRs after FFV. Further there are hard interfaces with plant at neighbouring stations that rely on services and softer interfaces that may allow realisation of some opportunities to share infrastructure.

5 CONCLUSIONS AND RECOMMENDATIONS

The options strategic options considered credible are below:

1, Install AAEDL (Credible long term option)
2, Process off site (Considered very unlikely to be BAT/BPM)
3, Tie in to Direct to sea discharge line from Neighbouring Site
4, Utilise CW Outlet from Neighbouring site

	DNB	HNB	HPB	HRA	HYA	HYB	TOR
1, Install AAEDL (Credible long term option)	Y	Y	Y	Y	Y	Y	Y
2, Process off site (Considered very unlikely to be BAT/BPM)	Y	Y	Y	Y	Y	Y	Y
3, Tie in to Direct to sea discharge line from Neighbouring Site	Y	N	Y	N	N	TBC_1	N
4, Utilise CW Outlet from Neighbouring site	N	N	Y_2	N	Y_2	N	N

Table 2 Site Specific Credible Options

Note 1 Credibility of this would depend on the strategy selected at HYA

Note 2 This would only be credible in conjunction with another option for periods where the neighbouring site is also not operational.

During the verification of this paper, reviews have been conducted from representatives of different station functions at Region 1 sites to ensure completeness. However, if new options are identified at a later date this paper should be up-issued and redistributed to stakeholders across the fleet to ensure new information is considered at all sites.

It is recommended that a strategic BAT/BPM is undertaken at each site to develop site specific preferred options. These strategic BAT/BPMs should be followed by a set of detailed operational BAT/BPMs, to further develop appropriate solutions for implementing the preferred strategic options.

At the time of issue of this report, there are projects to determine liquid effluent discharge strategy planned to start within the next 6 months at all Region 1 sites except HNB, where this work is already underway. Region 2 AGRs (Torness and Heysham 2) have no such work planned in the next 3 year period and therefore they have not been included in the detailed review of this document. When the equivalent work is beginning at these sites it would be prudent to review learning from the execution of associated projects across Region 1 and consider an up issue of this document if necessary and include a detailed review by SQEP from those sites.

6 DISTRIBUTION

Hinkley Point B	[redacted] (HPB0325), [redacted] (HPB1069)
Dungeness B	[redacted] (DNB0811)
Hartlepool	[redacted] (LL01028), [redacted] (LL01020)
Heysham 1	[redacted] (HEY1342), [redacted] (HYA0140)
GEM	[redacted] (AA03174)
Infrastructure Synergy Group	[redacted] (PK00222)
FORM	[redacted] (EDAXC13)

7 REFERENCES

[1] Not Used

[2] Not Used

[3] RS-POL-001,Satisfying the optimisation requirement and the role of Best Practicable Means, May 2019, version 2.0

[4] HNB/REP/LAMP/F11/001, F11, F12 – Main and Auxiliary CW Life-Cycle Asset Management Plan, Rev 0, W Crossan, September 2020.

[5] Not Used

[6] Not Used

[7] ERO/REP/0109/GEN, Rev 0, Review of Permitted Discharge Limits and Radioactive Waste Management at EDF Energy Nuclear Generation Ltd Sites, Rev 0, Gareth David, March 2015.

[8] ERO/EAN/0049/AGR, Rev 001, Impact of the Defuelling Phase on Environmental Permits, G Gibson, March 2020

[9](https://red7marine.co.uk/projects/oldbury-nuclear-power-station/)

[10](https://www.murphygroup.com/projects/wylfa-nuclear-power-station-aedl).

[11] Not Used

[12] \\CORE.Local\BeGroupData\Projects\work delivery\HNB\W048 - G1.9 - HNB Active Gaseous Effluent BAT & Making Safe POCO\11 Minutes of Meetings\Bradwell Workshop, Minutes of meeting from "Bradwell C&M Effluent Workshop", 26/07/21.

[13] ND/REP/TAD/0004/HNB/21 HNB Liquid Effluent "Stage A" (Credible Options) Review, February 2022.

[14] ENE-092/03, Site Effluent Dispersion Model Study, OLD-PDOREP-055, December 2012, Eden Environmental

[15] ENE-120/2, WYA/REP/9702, Wylfa Active Effluent Dispersion Model, March 2013, Eden Environmental

[16] Alternative Effluent Discharge Line Best Available Technique (BAT) Assessment, OLDPDOREP-056 Issue 1, January 2013

[17] DER5230-RT001-R04-00,Hinkley Point A FED Dissolution Discharge dispersion assessment, May2014, HR Wallingford