BRADWELL SITE

An Assessment Report Demonstrating how the Proposed System for the Disposal of Radioactive Aqueous Waste and for the Discharge of Treated Sewage Effluent and Storm Water to the Blackwater Estuary Represents Best Available Techniques

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CONTENTS

1 Purpose

The purpose of this document is to demonstrate how the proposed system for the disposal of radioactive aqueous waste, treated sewage effluent and storm water to the Blackwater Estuary represents Best Available Techniques (BAT)[1]. This is in response to the Environment Agency's further information request dated 29th September 2015 to support permit variation application EPR/ZP3493SQ/v005.

2 Background and Introduction

As described in the supporting documentation associated with the permit variations, over time the inlet and outfall culverts have been silting up and present a risk of preventing future discharges to the Blackwater Estuary. The site installed four new 180mm diameter polyethylene pipes in the East Outlet Culvert to provide a discharge route to the Blackwater Estuary throughout Care & Maintenance (C&M)[2]. As a mitigation against the current discharge system silting up it is proposed that should this occur the site will implement use of the new lines earlier than planned.

The mitigation works were initiated to provide a disposal route for waste arisings now if needed and for when the site enters C&M. The existing discharge arrangement still remains the site's preferred option to discharge effluent into the estuary. It gives a slightly better dispersion than the proposed discharge arrangement and the dispersion model of the existing system that predicted no accumulation of radioactivity in the estuary has been validated by nine years of environmental survey data. As such; the site is seeking the variations to include provision for the existing permit descriptions and conditions to be maintained until discharges need to be made through the new line.

To demonstrate that the proposed discharge route remains BAT consideration has been given to:

1. The impact of de-silting upon the oyster populations in the Blackwater Estuary.
2. Compliance with the Eels Regulations.
3. The site's carbon footprint.
4. Dose assessments.
5. The proposed revisions to the Environmental Monitoring Programme.

3 BAT Justification

3.1 Turbidity

Environmental risk assessments[3][4] were undertaken to assess the potential effects of the discharges on water quality and ecology in the Blackwater Estuary to support the permit application for the new discharge line. The assessments demonstrate that the discharges will have an acceptable environmental impact on the estuary. However, if the current discharge system were to be maintained, frequent de-silting operations would need to occur to prevent the system completely silting up now and throughout C&M. During C&M provisions for aqueous discharges will still be required[5]. The re-suspension of silt particles in the water column through the de-silting operations is likely to cause localised changes in turbity. This has the potential to impact the water quality which could have detrimental effects to the organisms living in the estuary.

Research commissioned by Natural England[6] demonstrates that the oyster species in the Blackwater are particularly sensitive to changes in turbidity. The volume of material to be dredged year on year would be variable from de-silting operations on the current discharge system. The research shows that smothering by 5 cm of sediment would prevent the flow of water through the oyster that permits respiration, feeding and removal of waste. Even smaller increases of silt may have an impact, and have been found to reduce growth rates. A layer of settled material of 1-2 mm in depth was reported to prevent satisfactory settlement of oyster spat on the substrate and the native oysters permanently fixed to the substratum would not be able to burrow up through the deposited material potentially caused from frequent de-silting operations. De-silting is not only a concern for the young oysters trying to establish as suspended sediment has been shown to reduce the growth rate of adult native oysters, resulting in shell thickening. The research concludes it is likely that at normal environmental temperatures the population of oysters would be killed by smothering.

Desilting is an activity by definition which falls under the category of works 'Construction & Dredging' under Part 4 of the Marine and Coastal Access Act 2009 which requires a licence from the Marine Management Organisation (MMO) to start works. If an application is granted the licence holder is restricted by conditions prior to and during the works. In 2013 Bradwell site had a licence[7] for works to allow dredging activities in the Blackwater Estuary so that the four new pipelines could be pulled through the East culvert. The licence restricted dredging operations to November 2013 to April 2014 to ensure that juvenile oysters had sufficient time to grow and enter their winter metabolic state. Silt removal works were also restricted to a maximum of 10 hours and no more than $100m^3$ silt removed each day to minimise the level of sediment being deposited and maximise its natural dispersion through effects of the tides. The project was delayed due to health and safety as visibility for the divers at that time of year was poor due to the prevailing weather conditions which meant dive times were restricted and works were delayed. The volume of material removed was significantly smaller than would be required to reinstate the current system to its full capacity.

It would be of benefit to switch over to the proposed discharge line in preference to de-silting operations to preserve the oyster populations in the Blackwater Estuary from the potential detrimental irreversible impacts of an ongoing de-silting programme required to maintain the existing discharge system.

3.2 Eels Regulations

The Eels (England and Wales) Regulations 2009 came into force on 15 January 2010 implementing the EC Council Regulation (1100/2007) (the EC Eel Regulation). Under this EU regulation the UK must take action to halt and reverse the decline in the European eel stock, aiming to meet a target set for the number of mature adult eels leaving each river basin to return to spawn at sea[8].

The site is currently exempt from the requirement to place an eel screen on the abstraction structure because the site has been withdrawn from operational service and is progressing with decommissioning activities which is anticipated to be complete by 31st December 2018. It was deemed not cost beneficial to screen the abstraction structure to best practice to protect eels at this time, however if the current discharge system were to be used after 31st December 2018 the site would be in breach of the legislation. As detailed in the site's exemption notice[9] the exemption expires on 31st December 2018.

It would be of benefit to switch over to the proposed discharge line to preserve the current Eel population in the Blackwater Estuary from the potential detrimental impacts of continuing to abstract water from the Estuary without a screen on the abstraction structure for the next ~ 2 years.

3.3 Carbon Footprint

Currently aqueous waste is pumped from the final monitoring delay tanks (FMDTs) to the outfall in the Blackwater Estuary. The Alternative Effluent Pumping System (AEPS) provides a flow of 3,200m^3/h to ensure that the effluent is flushed through the discharge pipe and discharged during the optimum time for natural dispersion due to tidal flows. This system provides a 75:1 dilution of the effluent prior to discharge.

The current arrangements require 5 of the 6 AEPS pumps to be in service to make a discharge. The pumps are powered by electricity and using data from a test report it is possible to calculate the potential carbon footprint from discharges throughout the year:

The pumps recorded the following data during the discharge made on 27th September 2015[10]:

Table 1. AEPS pump report 27/09/2015

Pump	kW	Amps
Pump 1	15.68	27.1
Pump 2	15.27	26.4
Pump 3	16.20	27.8
Pump 4	16.56	28.3
Pump 5	15.67	27.1

The total power output for the five pumps is 79.4kW, calculated by summing the output of each pump. To calculate the energy usage for each discharge an average of 4 hours is taken as the running time. Energy usage is calculated from power (79.4kW) multiplied by time (4h).

A total of 317.6 kWh energy use is calculated per discharge.

If we were to assume that FED discharges were to increase towards desired throughput (i.e. ~ 28 discharges per month) and 2 active effluent discharges occurred per month this would approximately equate to 30 discharges per month:

30 x 317.6 kWh = 9528 kWh of electricity used for liquid discharges per month.

12 x 9528 kWh = 114336 kWh of electricity used for liquid discharges per year.

In order to convert 'energy consumed in kWh' to 'kg of carbon dioxide equivalent (CO_2e)', the energy use should be multiplied by a conversion factor[11]. CO_2e is the universal unit of measurement to indicate the global warming potential (GWP) of Greenhouse Gases (GHGs), expressed in terms of the GWP of one unit of carbon dioxide.

Using the conversion factor 0.46219 $kgCO_2e/kWh$ for scope 2 emissions[12] 'electricity generation' it was possible to calculate the CO_2e;

114336 kWh x 0.46219 $kgCO_2e/kWh$ = 52844.96 $kgCO_2e$

52844.96 $kgCO_2e$ / 1000 = 52.84 tonnes CO_2e

This is equivalent to 53 tonnes of CO_2 produced each year just to use the current discharge pumps. According to The Department for Environment, Food and Rural Affairs (DEFRA) 1 tonne of CO_2 is produced by travelling 3,001 miles in a car[13] and to offset 1 tonne of CO_2 50 trees would need to grow for one year[14]. It is widely accepted that GHGs contribute to climate change and the proposed discharge system provides an opportunity to minimise the site's carbon footprint by improving the efficiency of the discharge process. This would provide an example of meeting the site's commitment made to the Environment Agency as part of the Nuclear Sector Plan (NSP) *'Objective 1: Minimise resources consumption and carbon footprint.'*[15]

Based on the cost of electricity per KWh in 2013 (EDF energy supply the site: 16.6p)[16] it costs ~ £19,000 per year to keep the pumps running. This value does not take into account the cost of maintenance of the infrastructure to maintain the supply and therefore the true cost is likely to be much greater.

It would be of benefit to switch over to the proposed discharge system to help to reduce the site's carbon footprint as it does not require the use of the AEPS pumps for pre-dilution purposes.

3.4 Dose Assessment

Current discharge system

Based upon the current discharge system the dose to members of the public from the aqueous effluent abated in the Aqueous Discharge Abatement Plant (ADAP) discharged to the Blackwater Estuary was calculated. The radiological environmental performance criteria in the dissolved Fuel Element Debris (FED) effluent after abatement were used as a bounding case in the dose assessment[17].

Modelling was carried out utilising PC Cream, which is a proprietary modelling programme, recognised by the Environment Agency, used to model doses to the public and dispersion of radionuclides from authorised discharge routes. The programme required input of 'habits' data[18] for the local population together with details of the specific water body into which the discharge is made to account for dispersion. The output of the dose modelling is based upon the long term effect- the dose attributed per annum.

The modelled dose to members of the public was <1 μSv, however, there was a level of uncertainty within this estimate due to the variation in the proportion of the inventory modelled. Taking the uncertainty into account the potential dose to the public would still be significantly below the 10 μSv threshold of 'no significant risk'.

To put this into context 1000 μSv is the legal annual limit on dose to a member of the public. A dose of less than 10 μSv is considered to be of no regulatory concern.[19][20] The statutory guidance to the Environment Agency[21] states that where the prospective dose to the most exposed group of members of the public from discharges from a site at its current discharge limits is below 10 μSv/y the Environment Agency should not seek to reduce further the discharge limits that are in place, provided that the holder of the permit or authorisation applies and continues to apply BAT.

Proposed discharge system

The calculated annual dose from the PC-Cream remains unaffected because the inventory/loading of radioactivity from aqueous discharges to the estuary remains the same, as the site is bounded by the environmental performance criteria specified in the BAT document[22].

The Wallingford dispersion modelling reports[23][24][25] that support the permit applications indicate that there could be the potential for short durations of localised areas within the plume of discharged effluent where there will be higher concentrations of radioactivity and nitrates than for the current system. This is because the effluent will not receive the same level of initial dilution at discharge as the current discharge system. An assessment was carried out to determine the near field, short term effects at the point of discharge[17]:

External dose

The external dose predicted to be received after spending half an hour submerged in the estuary at the time of discharging FED effluent is calculated as 0.25 μSv. This is a bounding case, as it takes no account of instantaneous dilution provided by either of the discharge systems and assumes no movement of effluent within the half hour period and as such, is an over estimate of the potential dose received in the given scenario.

Internal dose

If a person drank 25ml (approx. a mouthful) of FED effluent they would receive an internal dose of 5.8 μSv. This dose and dilution factors were used to assess the impact on an individual ingesting a mouthful of estuarine water at the point of discharge. The assessment concluded that the internal dose for the current system would be 0.08 μSv and for the proposed new system the dose would be 0.4 μSv.

In summary the calculated annual dose from the proposed discharge system remains the same as the current discharge arrangements as there is no additional throughput of radioactivity per year and the site is bounded by the environmental performance criteria in the BAT document[22]. The short term impact of an individual being submerged in the estuary at the point of discharge during the discharge is 0.33 μSv for the current system and 0.65 μSv for the proposed new system. In both cases the dose is significantly below the 10 μSv dose threshold. The effluent will continue to be monitored prior to discharge and would only be discharged if it was compliant with the site's environmental performance crtieria.

3.5 Environmental Monitoring Programme (EMP)

The site is required to take samples, make measurements and assessments to ensure compliance with the permit. The EMP is part of the site arrangements and has been performed for many years and as such there is substantial information on the amount and behaviour of radionuclides in the local environment. The sampling regime is required to demonstrate BAT in that the level of survey is appropriate to the site impact[26]. It is proposed that if the new discharge system were to be put into service during C&M preparations that the site will increase the scope of the sampling programme. For a period of time it is proposed that more frequent silt samples are taken in the Blackwater Estuary to validate the modelling[3][4] and demonstrate no accumulation in the silt given the change in dispersion characteristics.

The frequency of silt sampling was increased for a period of time when the site moved from the cooling water pumphouse discharge arrangements to the current discharge system back in 2006/7. Therefore it is similarly proposed that additional silt samples are taken from the nearest location to the outfall and analysed by gamma spectrometry. The proposed extension to the EMP would be submitted to the Environment Agency in writing 28 days in advance of any changes to the environmental monitoring programme in compliance with permit condition 3.2.1 (b)[27]. Upon agreement with the Regulator the analysis would be carried out on a weekly basis for a period of 3-6 months.

4 Conclusion

The supporting documents to the permit variations include detailed risk assessments of the potential impacts to the Blackwater Estuary which concluded that the discharge of radioactive effluent, treated sewage effluent and storm water through the proposed new line would not have any adverse effect. The water quality status of the Blackwater Estuary would remain unchanged. This report further demonstrates that it would remain BAT to switch to the new discharge system if permitted.

In summary, switching over to the new discharge system has the potential to reduce carbon emissions by switching off the AEPS; there would be no additional cost or time delay associated in commissioning the proposed system as it is available and if permitted the proposed system would minimise the potential accumulation of effluents on site if the current system were to completely silt up. Utilising the proposed discharge system also has the potential to sustain the ecology of the Blackwater Estuary as a frequent de-silting programme is deemed impractical and it has the potential to cause an irreversible decline of oyster stocks. The proposed system also complies with the Eels Regulations. The dose assessments also demonstrate that there are no significant radioactive dose detriments to switching over to the proposed system now. The main benefit of using the current system, in addition to its slightly better dispersion while it remains available, is that the modelling data has been validated by nine years of environmental survey data. In the event that silting of the current system was to prevent ongoing discharges the detriment of de-silting operations would force an early change to the proposed system. If this happened the site is proposing to review the scope of the EMP to increase the frequency of silt sampling to mitigate against the loss of relevant, historical environmental survey data to validate the modelling results.

5 References:

1. BAT: defined in the 'Nuclear Code of Practice – Best Available Techniques (BAT) for the Management of the Generation and Disposal of Radioactive Wastes' means the latest stage of development of processes, facilities or methods of operation which indicate the practical suitability of a particular measure for limiting waste arisings and disposal.

2. C&M: This is a mainly quiescent phase, lasting until approximately 85-105 years after cessation of generation, during which no dismantling is carried out but the site continues to be managed, monitored and maintained to ensure that it is kept in a passively safe and in a secure state. The site will continue to be subject of a Nuclear Site Licence and Environmental Permitting Regulations during this period.

3. BRAD/EN/REP/130/FED: 'Environmental Risk Assessment to Support EPR Permit Variation for FED Discharges Through the New Discharge Line'

4. BRAD/EN/REP/146: 'Environmental Risk Assessment in Support of Active Effluent Discharges to the Blackwater Estuary.'

5. BRAD/EN/REP/070: 'Revised Estimation of Aqueous Radioactive Discharges from Bradwell Site During Care &Maintenance'

6. Natural England Blackwater, Crouch, Roach and Colne Estuaries Marine Conservation Zone (MCZ)

7. L/2013/00344/9 Marine Licence MMO

8. EA Regulatory position statement; Safe passage for Eels 2013

9. 8/37/39*T/0013 Exemption Notice dated 18th June 2015

10. Information provided from Flygt Performance Test Document 0530120.

11. CRC conversion factors as quoted in the CRC order. NSP conversion factors as quoted within the 2015 guidelines from DEFRA (DECC), http://www.ukconversionfactorscarbonsmart.co.uk/.

12. Scope 2 (Energy indirect): Emissions released into the atmosphere associated with your consumption of purchased electricity, heat, steam and cooling. These are indirect emissions that are a consequence of your organisation's energy use but which occur at sources you do not own or control.

13. http://www.rutland.gov.uk/climate_change/act_on_co2_and_your_footprint/whats_a_tonne_of_co2.aspx

14. http://climateneutralgroup.com/en/how-much-is-1-tonne-of-co2/

15. Nuclear Sector Plan Issue 3

16. http://blog.comparemysolar.co.uk/electricity-price-per-kwh-2013-comparison-of-e-on-edf-npower-british-gas-scottish-and-sse/

17. BRAD/EN/REP/139/FED: 'Revised Assessment of Doses to the Public in Support of the BPM Study for Abatement of FED Effluent Prior to Discharge to the Environment'

18. Radiological Habits Survey: Bradwell, 2007; Environment Report RL 01/08 (Cefas contract Report C2848)

19. IAEA (1988). Principles for the exemption of radiation sources and practices from regulatory control. Safety Series No 89

20. IAEA (2004). Application of the Concepts of Exclusion, Exemption and Clearance Safety Guide. IAEA Safety Standards Series No.RS-G-1.7

21. Department of Energy and Climate Change and Welsh Assembly Government (2009). Statutory Guidance to the Environment Agency concerning the regulation of radioactive discharges into the environment.

22. BRAD/BPM/010: 'Bradwell FED Dissolution: BPM for Abatement of Activity from Effluent'

23. BRAD/EN/REP/114: 'FED Discharge Arrangements: Far Field Dispersion'

24. BRAD/EN/REP/142: 'Effluent Discharge Arrangements: Initial Dilution'

25. BRAD/EN/REP/138: 'HR Wallingford Report- RT012- Annual Average Concentration – Dedicated Discharge'

26. BRAD/EN/REP/096: 'Review of Current Environmental Monitoring Programme against the Environment Agency Technical Guidance Note 2 and Draft BAT Guidance for Environmental Radiological Monitoring'

27. EPR/ZP3493SQ/V004