BRADWELL SITE

FUEL ELEMENT DEBRIS (FED) TREATMENT NON-TECHNICAL SUMMARY

BRAD/EN/REP/103

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FUEL ELEMENT DEBRIS (FED) TREATMENT NON-TECHNICAL SUMMARY

1. Introduction

This application is a request from Bradwell site for a variation to the current Environmental Permit EPR/DP3127XB. The request is for the extension of the current discharge period of 12 months for a further 24 months and to allow discharge of abated aqueous FED related effluent to the Blackwater Estuary via a newly installed 180mm diameter pipe when the existing discharge route completely silts up. This report answers question 5c under Part C2 – General – varying a bespoke permit.

Recent multi-beam echo sounder surveys undertaken by Port of London Authority (on behalf of the site) indicate that the build-up of silt in the current discharge route is still happening. Consequently, the site requires a variation to the existing Environmental Permit to be able to maintain discharge to the estuary when the current line completely blocks.

The existing discharge arrangement still remains the site's preferred option to discharge effluent into the estuary as it gives a slightly better dispersion than the proposed discharge arrangement. As such, the site is seeking the variation to include provision for the existing permit descriptions and conditions to be maintained until discharges need to be made through the new line. At this point, only the descriptions, limits and conditions specified for the new line are to be effective. The site has considered the option of carrying out regular de-silting of the existing discharge line and has found it not practicable due to concerns associated with the discharge of suspended solids during the oyster spawning season. The 75:1 pre-discharge dilution will not apply when the site switches to the new discharge line. This application considers the physical and chemical properties of the FED effluent as discharges of radioactive substances are separately regulated under a Radioactive Substances Environmental Permit EPR/ZP3493SQ/V004.

Bradwell site is located at the mouth of the River Blackwater, approximately 1.5km to the north of Bradwell-on-Sea, in the district of Maldon, Essex. The site is a licensed nuclear site and is part of Magnox Limited. The nuclear power station stopped generating electricity in 2002 and it is now in the process of being decommissioned. The first phase of the decommissioning process involves dismantling most of the plants and demolition of buildings and structures. Upon completion of this first phase the site will have been put into a state where the need for human intervention to maintain acceptable conditions is minimised. One of the key activities to take place during this first phase is for all intermediate level radioactive waste to be retrieved from current storage locations, processed and then put into a new purpose-built weather proof store.

One significant proportion of the intermediate level radioactive waste is Fuel Element Debris (FED). The FED is a magnesium alloy removed from the casing of fuel elements, prior to their reprocessing at Sellafield. The FED is currently stored in designated storage vaults on site.

As part of the decommissioning programme, a Best Practical Environmental Option (BPEO) study was performed, and a number of options were investigated as to how best to deal with this FED material. The result of the study was that there were two viable options for the management of this waste.

- Encapsulation: This involves sealing the waste into concrete within containers suitable for eventual permanent disposal. The containers will be stored on site for decades until a geological disposal facility becomes available.
- Dissolution: This involves treating the FED in a diluted nitric acid solution and then treating the resulting liquid effluent so it is suitable for discharge to the estuary. As with encapsulation, the residual radioactive waste would have to be stored and disposed appropriately. However, the volume of waste requiring storage would be less than 10% of the original volume. Consequently, the study concluded that dissolution was the preferred option.

2. Process Overview

As mentioned above, FED is stored in designated storage vaults at Bradwell Site. Following retrieval and sorting, each batch of FED weighing approximately 60kg would be dissolved in a controlled concentration of nitric acid. Any solid residual waste from the dissolution process would be placed within a suitable container for long term storage in the purpose-built weather proof store. The resultant acidic effluent would be transferred into the active discharge abatement plant (ADAP) where sodium hydroxide would be used to neutralise it, precipitating heavy metals out of the solution with the aid of a flocculent. The resultant effluent would then undergo microfiltration to remove remaining suspended solids, and ion exchange for final polishing.

The batches of abated liquors will then be held in a tank for sampling and analysis prior to discharge. The effluent will only be discharged if the sampling and analysis has confirmed that it is acceptable for discharge. Each day a total of approximately 10-20m^3 of effluent will be produced. This will be discharged over a 30 minute period at one hour after High Water to two and half hours after High Water to ensure the maximum possible dispersion out into the estuary.

3. Environmental Risk Assessment

The overall environmental impact from the FED related discharges through the existing discharge route are unaffected by the request for a change in duration. Consequently, the environmental risk assessment of the current discharge route remains unchanged. Therefore, only the environmental impact of discharging through the new discharge line is considered in this report.

The Blackwater Estuary is a conservation site of international importance with multiple designations, notably for its salt marsh habitat and bird life. In addition, there is an oyster fishery within the estuary. As such it is a sensitive receiving environment for the discharge and an environmental risk assessment has been included in the application to show that the discharge will have no detrimental effect on the estuary.

To assess the likely impacts of the discharge on the estuary, the Environment Agency's guidance H1 Annex D1 assessment of hazardous pollutants within surface water discharges have been used. The assessment considers whether substances present in the discharge may be liable to cause pollution. The assessment is a two phase process – screening and modelling.

In the first Phase of the assessment, concentrations of substances in the discharge are assessed against a set of five criteria defined in the guidance. Substances that pass any of the criteria are screened out as not liable to cause pollution in the receiving environment.

Substances that are not screened out in the Phase 1 test are carried forward to the Phase 2 modelling which is a more detailed assessment.

Estuary sampling and analysis data was obtained from the Environment Agency to provide background information on the existing levels of pollutants in the estuary. The predicted discharge was modelled to determine the likely increase in the background concentrations resulting from the effluent. In addition to substances (mainly priority and priority hazardous substances) screening out in the Phase 1 and 2 assessment, the discharge should not result in an increase of the background nitrate concentration in the estuary by more than 10%.

For the first screening test of Phase 1, the concentrations of substances (mainly priority and priority hazardous substances) in the discharge were compared with the environmental quality standards (EQS). This test takes no credit for dispersion. The results showed that Boron, Iron, Lead and Zinc no longer require consideration because the concentration of these substances in the effluent would be less than 100% of the EQS annual average (AA). Cadmium, Chromium, Copper, Mercury and Nickel did exceed the EQS AA and these were taken forward for further assessment. Furthermore, Cadmium, Chromium and Mercury exceeded the EQS maximum allowable concentration (MAC) and were taken forward for further assessment. The substances taken forward passed the second, third and fourth screening test but failed the fifth test. The fifth test is only required for buoyant effluents that fail Test 4. The FED related effluent is negatively buoyant and therefore not required to be assessed under the fifth test. However, this is taken to Phase 2 for a detailed assessment.

Phase 2 modelling is a more detailed assessment of those substances that were not screened out during the Phase1 tests. HR Wallingford were commissioned to undertake modelling to define the mixing zone and an initial dilution for the discharges. The concentration of substances at the edge of the mixing zone, calculated from the dilution achieved, were less than the EQS taking into consideration the background concentrations in the estuary. This indicates that releases will not adversely impact on the estuary.

The Nitrates (as Nitrogen, N) in the discharge were considered next. In order to work out the possible effects of the short-term increase in nitrogen to the estuary, HR Wallingford modelled the movement of water in and out of the estuary and it was used to predict the future levels of nitrogen in the estuary. The modelling confirmed that 'average' nitrate levels within the estuary as a whole would not go above the existing background levels by more than 10% during the lifetime of the project. However, the model shows short duration (e.g. less than 30minutes) peak concentrations within the centre of the plume

at the time of discharge. These may go above the 10% threshold, but, mixing and spread of the effluent plume ensures the short duration peak concentrations are temporary. Further, the modelling did not take into account biological and chemical removal of nitrate from the estuary which is estimated to be about 40%. Upon cessation of the discharges the localised peak Nitrogen concentrations would immediately be eliminated and residual Nitrogen concentrations would reduce back to the background concentration. Allowing for background processes removing nitrate from the estuary, current background concentrations will be achieved in three months.

A heat transfer assessment was also undertaken to show the effect of the effluent's temperature on the Blackwater Estuary. The dissolution process is exothermic (heat releasing) and as such the final effluent will be warmer than the Blackwater Estuary water. The results of the calculation showed that changes in temperature are very small and will not affect water quality in the estuary.

4. Conclusion

This process will produce an aqueous effluent that will include components of nitrate and trace metals. An environmental risk assessment undertaken using the Environment Agency's guidance (e.g. H1 Annex D1 Assessment of hazardous pollutants within surface water discharges) indicated that listed metals in the effluent will not adversely impact on the estuary. Further, the study showed that background nitrate concentration in the estuary will not exceed 10% satisfying the 'no detriment threshold' defined by the EA.

The application seeks:

- permission to continue discharge through the existing route for a further 24 months period as the current 12 month period has expired. The site is discharging under a regulatory position statement issued by the EA - discharges are not considered to have any negative impact on the estuary;
- permission to continue to discharge treated FED effluents via the new discharge line if the existing preferred route completely silts up; and
- that the change from the limits and conditions applied to the existing discharge to the same effluent discharged through the new line takes effect when it is required. This may vary from the nominal proposed dates of the current arrangements to be effective until 31st December 2016 and the new arrangements to be effective from 1st January 2017.

BRADWELL SITE

FUEL ELEMENT DEBRIS CONSIDERATION DISCHARGE TO SEWER

BRAD/EN/REP/116

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FUEL ELEMENT DEBRIS EFFLUENT CONSIDERATION DISCHARGE TO SEWER

PURPOSE

The purpose of this document is to provide additional supporting information for the application to the Environment Agency for a variation to Environmental Permit EPR/DP3127XB in support of Fuel Element Debris (FED) Treatment. This document supports form C6, section 3b and provides an explanation of the discharge options, and the justification of not discharging to an external Waste Water Treatment Plant.

CONSIDERATIONS

The option of discharging the abated FED dissolution liquors to external sewer is not considered viable due to the following reasons:

1. The dissolution process gives rise to abated radioactive aqueous effluent. Such effluent is outside the consent of the local domestic Waste Water Treatment Facility.
2. The on-site abatement plant has been designed specifically to reduce the key constituents of FED effluent (e.g. radioactivity, pH and metals). This treatment ensures that the effluent is within the limits defined in the Site Environmental Permit, thereby minimising the impact to the environment.
3. The anticipated waste stream from the process is not biodegradable and the local biological treatment system would not offer any additional treatment benefit.
4. The existing site outfall extends into the estuary and offers a high degree of natural dispersion. In addition, the timing of the discharges has been optimised with tidal movements to offer the best possible dispersion characteristics out of the estuary.
5. Non-radioactive effluent (e.g. domestic arisings) is treated through a dedicated on-site sewage treatment plant. The on-site treatment plant ensures that the discharge will meet the requirements of the respective Site Environmental Permit.
6. The financial cost to connect into the nearest pipe from the external Waste Water Treatment Plant would be in the region of £200k. The engineering challenges would be demanding given the lie of the land. The environmental disturbance would be considerable, as some 1200m of sewage pipe would need to be laid in working arable fields. Further, the only roadway to the site and a local chicken farm would be disrupted, in addition to potential adverse impact on the local community. For a short term project this would not be seen as beneficial.

BRADWELL SITE

FUEL ELEMENT DEBRIS EFFLUENT FLOW RATE AND VOLUME DERIVATION

BRAD/EN/REP/117

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FUEL ELEMENT DEBRIS EFFLUENT FLOW RATE AND VOLUME DERIVATION

PURPOSE

The purpose of this document is to provide additional information for the application to the Environment Agency for a variation to Environmental Permit EPR/DP3127XB in support of Fuel Element Debris (FED) Treatment. Application form C6, section 4f requires the calculations used to derive the flow rate and volume of the effluent to be discharged to be shown.

FED EFFLUENT FLOW RATE AND VOLUME CALCULATIONS

Volume

The predicted volume of effluent generated per day is approximately 12 cubic metres, A worse case of 20 cubic meters has been allowed for to cover instances where higher volumes of water are required or an interruption has occurred to the previous day's discharge procedure.

Flow Rate

The maximum flow rate discharging to the Blackwater Estuary from the Final Monitoring Delay Tank is 40 cubic metres per hour.

The required flow rate in litres per second is therefore:

40 cubic metres per hour x 1000 = 40000 litres per hour

$$\equiv {}^{40000}/_{3600} = \ 11.11 \ litres \ per \ second$$

Please note that this flow rate is the treated effluent from the Final Delayed Monitoring Tank to the Blackwater Estuary.

BRADWELL SITE

FUEL ELEMENT DEBRIS EFFLUENT TREATMENT PROCESS

BRAD/EN/REP/104

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FUEL ELEMENT DEBRIS EFFLUENT TREATMENT PROCESS

PURPOSE

The purpose of this document is to provide additional information to support the variation of the Environmental Permit EPR/DP3127XB to discharge treated FED effluent into the Blackwater Estuary via a 180mm diameter pipeline. This document supports Section 6 of Part C6 and covers treatments carried out on the effluent in process order and a standard description of the operation.

Table 1: Treatments Carried Out on the FED Effluent

Order of Treatment	Code	Description
First	19	Neutralisation
Second	33	Filtration
Third	20	Activated Carbon (Adsorption)
Fourth	Other	Ion Exchange

PROCESS DESCRIPTION

The FED abatement facility comprises of a series of reactions tanks each fitted with recirculation and transfer pumps and variable speed paddle mixers to support the different process operations. The whole FED abatement facility is operated remotely using a dedicated Programmable Logic Controller (PLC)/Human Machine Interface (HMI). The PLC's function is to interface with the field equipment and instruments and provide control and instrumentation functions via the Supervisory Control and Data Acquisition (SCADA) system and the HMI in the control room. These elements constitute the Basic Plant Control System which provides all the required control and instrumentation functions, allowing the facility to be operated either automatically or under manual control. The FED abatement facility process is divided up into a set of sequences and details of each are provided below.

NEUTRALISATION AND PRECIPITATION

The effluent received from the FED dissolution plant is acidic and requires pH adjustment. The objective of the process is to enable precipitation of heavy metals and associated radionuclides as hydroxides, whilst retaining Magnesium in solution as achieved by pH control. Further, this helps the site to meet the requirements of the discharge consent.

A neutralising agent, approx. 5M Sodium Hydroxide (NaOH) is metered into the reaction tank (typically 350–550 litres) until a final pH of approximately 7.6 to 8.2 has been achieved. The pH can be re-adjusted up or down by the introduction of NaOH or Nitric Acid (HNO_3) to achieve the desired accuracy to optimise process conditions. Most of the heavy metals in the solution will react with the NaOH to form very fine colloidal particulate metal hydroxide and precipitate, whereas Magnesium remains in solution provided the pH is maintained below 8.2. Polyelectrolyte flocculent is added (typically 5-11ppm) to the suspension in the reaction tank to agglomerate the fine particulate into sufficiently large particulate (mainly metal hydroxide and associated activity) where it will settle. The resultant mixture consists of the settled metal hydroxides with a mainly Magnesium Nitrate solution supernatant. The settled sludge is transferred to the Filter Press through a positive displacement pump.

FILTRATION

The supernatant and the filtrate from the Filter Press from both of the reaction tanks are transferred to the Micro Filter Feed Tank by variable speed pumps. The combined liquor is fed at an incremental rate of approx. 70 l/min to the 1.5m^3 Micro Filtration Tank capacity. Once sufficient volume is achieved within the Micro Filtration Tank the liquor is pumped through a column consisting of a series of filters. This allows liquid to permeate through the filter array to the final polishing (Ion Exchange) stage whilst precluding all particulates in excess of 5µm that could potentially foul the ion-exchange media over an extended duration.

The Micro Filtration System is also equipped with a backwash facility to remove collected solids. Backwashing operation is initiated when the differential pressure in the backwashing equipment reaches a set limit. The Backwash Pump starts when the set differential pressure limit is reached and passes permeate back through the filter. A supply of air helps displace accumulated material on the outside of the filter and transfers this to the selected Buffer / Reaction Tank for re-processing.

ADSORPTION

A Granulated Activated Carbon (GAC) Column is used to further remove residual organics. It also provides additional security for the ion exchange resin columns.

ION EXCHANGE

Following adsorption, the filtered liquors are treated by ion selective media (Co-Treat and Cs-Treat) to target the removal of radionuclides particularly Cobalt-60 and Caesium-137, -134 activities remaining in solution. The Co-Treat media is intended to selectively remove cobalt from the FED effluent stream while Cs-Treat is intended to remove caesium from the FED effluent stream.

EFFLUENT DISCHARGE AND DISPERSAL

The abated liquors (10-20 m^3/day) will be transferred to and held within a dedicated final delay monitoring tank of 25m^3 working volume. The liquors will be subject to a monitoring programme to confirm if it is suitable for discharge. Treated effluent in the final delay tank will be pumped at a rate of 40 m^3/h through a newly installed discharge line into the estuary at an optimal time to ensure maximum dispersion. Inadvertent discharge of unsuitable effluent will be prevented through engineering controls in addition to formally documented management control procedures.

BRADWELL SITE

FUEL ELEMENT DEBRIS (FED) EFFLUENT COMPOSITION

BRAD/EN/REP/115

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FUEL ELEMENT DEBRIS (FED) EFFLUENT COMPOSITION

PURPOSE

The purpose of this document is to provide updated information on the effluent composition in support of the application to vary the FED dissolution Environmental Permit EPR/DP3127XB. It provides the information required on the final effluent quality achieved prior to discharge by the EA application form C6, section 7e.

The data presented in this document is indicative of the effluent to be discharged; there may be some differences in concentrations produced as a result of variability in feed stock from batch to batch.

Table 1 provides the pre-abatement and post-abatement effluent concentrations of metals within the combined FED effluent (i.e. FED effluent with some 50 litres of NOx scrubber liquor added to each batch as the initial acid charge).

Table 1: Concentrations of Metals in the Combined FED Effluent

Substance	Maximum Concentration of Unabated NOx Scrubber Liquor based on samples taken 24/09/14 µg/l	Maximum Concentration of the combined unabated NOx Scrubber Liquor and FED effluent in the FED Reaction Vessel µg/l	Combined Concentration of Abated FED Effluent with NOx Scrubber Liquor in the FMDT µg/l
Boron	70	101.4	86.2
Cadmium	10	30.2	1.5
Chromium	22000	2068.0	186.1
Copper	170	160.4	11.2
Iron	110000	9067.0	90.7
Lead	30	258.6	2.6
Mercury	10	5.2	5.2
Nickel	7800	840.0	226.8
Zinc	920	544.4	10.9

FED effluent contains other substances, these are summarised in Table 2.

Table 2: Other Substances in FED Effluent

Other Substances in FED Effluent	Unabated Concentration µg/l	Abated Concentration µg/l
Aluminium (Al)	187655	1876
Beryllium (Be)	3745	3745
Calcium (C)	2051	1230
Cerium (Ce)	4681	6
Cobalt (Co)	13	0
Magnesium (Mg)	23200085	23200085
Manganese (Mn)	3511	139
Neodymium (Nd)	4681	45
Silicon (Si)	2341	1170
Silver (Ag)	2468	48
Sulphur (S)	4254	2127
Titanium (Ti)	127	0
Uranium (U)+thorium	22.67	0
Zirconium (Zr)	146019	292
Nitrate	35591818	35591818
Suspended Solids	Not measured	Turbidity measured <6 NTU*

*NTU: Nephelometric Turbidity Units

Table 3 provides the pre-abatement and post-abatement effluent concentrations of metals within the NOx scrubber liquor that may potentially be discharged on an intermittent basis (anticipated to be twice a year).

Table 3: Concentrations of Metals in the NOx Scrubber Liquor

Substance	Maximum Concentration of Unabated NOx Scrubber Liquor in the FMDT based on samples taken 24/09/14 µg/l	Concentration of Abated NOx Scrubber Liquor Potentially Discharged Intermittently µg/l
Boron	70	59.5
Cadmium	10	0.5
Chromium	22000	1980
Copper	170	11.9
Iron	110000	1100
Lead	30	0.3
Mercury	10	10.0
Nickel	7800	2106
Zinc	920	18.4