BRADWELL SITE

ENVIRONMENTAL RISK ASSESSMENT FOR AQUEOUS EFFLUENT

BRAD/EN/REP/108

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ENVIRONMENTAL RISK ASSESSMENT IN SUPPORT OF AQUEOUS EFFLUENT

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PURPOSE

The purpose of this document is to provide supporting information for the application for variation to add an alternative discharge route to the current Permit PR2TS/E10760C[1].

This risk assessment supports Section 6 of application Part C2 (Varying a Bespoke Permit) and Section 10e of application Part C6 (Varying a Water Discharge Activity and Groundwater (point source) Activity).

INTRODUCTION

An environmental permit variation is required for the discharge of aqueous effluent which comprises effluent accumulation in voids, surface water, treated sewage effluent and treated radioactive effluent.

The variation is to include an alternative route of discharge to the estuary via new 180mm diameter pipelines which have been installed in the east outlet discharge tunnel. The proposed alternative route for discharge is to pump aqueous effluent directly into the estuary via the newly installed pipes.

In this report, the environmental impact of the discharge to the Blackwater Estuary has been assessed using the Environment Agency's (EA's) H1 Annex D1 Assessment of hazardous pollutants within surface water discharges[2]. The results demonstrated that all metals in the discharge screen out in the Phase 1 stage of the EA's H1 Annex D1 assessment. The discharge will therefore not cause any harm to the receiving water.

FED (Fuel Element Debris) effluent excluded from this risk assessment is covered by a bespoke permit.

Applicable Legislation and Designations

The Blackwater Estuary, the Dengie Flats and the Colne Estuary close to Bradwell site are all Sites of Special Scientific Interest (SSSI) and National Nature Reserves (NNRs). The boundaries of the Blackwater Estuary and Dengie Flats SSSIs meet on the shore adjacent to the reactor site, and the Colne Estuary designation lies off the north shore of the channel opposite the site. All three form the majority of the Mid Essex Ramsar site complex and lie within the Mid Essex Coast Special Protection Area (SPA) and the Essex Estuaries candidate marine Special Area of Conservation (cSAC). These designations recognise the national and international importance of the area for its estuarine habitats in general, for certain specified plant communities and habitat features, and for a wide range of species dependent upon these. The SPA and Ramsar designations relate especially to various wintering and breeding birds.

Assumptions for Risk Assessment

- The effluent will be diluted by a factor of 6.5 within the main drains pit before discharge. Approximately 130m^3 of effluent is pumped from the main drains pit of which only 20m^3 is the voids effluent. Therefore, an onsite dilution factor of 6.5 has been used to calculate the release concentration of pollutants in the effluent.
- The discharge is conservatively assumed to be continuous and does not take into account that it is for only approximately 20 minutes.
- The assessment does not take into account natural dilution of the estuary from non-tidal river flow.
- The radioactive effluent will be pumped at a rate of 40m^3/hr.

Onsite Effluent Profiles

The Bradwell site is permitted to discharge effluents to the Blackwater Estuary under various permits. Table 1 provides a summary of the regulated effluents and associated activities.

Table 1: Regulated Effluents under Permit PR2TS/E10760C

Effluent Description	Regulated Activity
Secondary treated sewage	Treatment and discharge of treated sewage
Trade effluent deriving from water treatment	Arisings of trade effluent from water treatment
Radioactive effluent treatment plant	The permit covers the non-radiological constituents of the radioactive effluent such as pH, no visible film of oil or grease. The radiological properties are regulated under permit EPR/ZP3493SQ[3]
Non-radioactive aqueous effluent	Arisings and treatment of general non-radioactive aqueous effluent (typically voids water)

The profiles of effluents discharged are described below.

Secondary treated sewage

Secondary treatment of sewage involves:

- primary settlement of solids;
- anaerobic Rotating Biological Contactors (RBC) providing the mechanism for the sewage to be in contact with the biomass in order to break down the constituents within the sewage;
- aerobic RBC providing similar treatment to the anaerobic; and
- final clarification of the effluent.

The measures to control the impact on the environment include:

- an alarm system to alert an authorised person when there are issues with the operation of the plant; and
- monitoring the effluent on a frequent basis to assess the performance of the plant on key environmental parameters. The parameters can include ammonia, turbidity, Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), pH, Total Organic Carbon (TOC) and Permanganate Value (PV).

The secondary treated sewage effluent does not contain dissolved metals and as such will not affect water quality in the estuary.

Trade effluent deriving from water treatment

The site operates reverse osmosis water treatment plants processing town mains water to supply the FED treatment plant and Aqueous Discharge Abatement Plant (ADAP) with demineralised water. The reverse osmosis process produces a salt concentrated by-product as waste effluent. This effluent does not contain any dissolved metals and therefore will not challenge water quality if discharged unabated.

Radioactive effluent treatment plant

In the context of permit PR2TS/E10760C, ADAP provides abatement of the non-radioactive properties of the radioactive effluent. The radioactive effluents come from a number of sources on site including general arisings from the radiological controlled areas and ad-hoc project related effluents. The radioactive effluent contains low levels of dissolved metals. Table 2 shows typical metal concentrations in the treated radioactive effluent. Treatment includes:

- adjustment of pH by neutralisation to ensure it meets the permitted range of 6-9;
- filtration of suspended solids; and
- metals removal co-incident with radioactivity abatement by ion exchange.

The measures to control the impact on the environment include:

- safety incorporated into the design and commissioning of the plant (e.g. the design codes used to build the radioactive effluent treatment plant, grade of stainless steel used in the construction of the plant, the level of leak testing prior and post installation);
- system controls, such as alarms and sequence controls in the software to ensure that the radioactive treatment process is aborted if not within specified boundaries or if the plant is outside the acceptable operational range;
- management controls in the supervision of operations by Suitably Qualified and Experienced People, control of the authorisation to discharge;
- administrative controls such as the environmental management system (e.g. Plant Item Operating Instructions, Quality Plans to authorise discharges); and
- the radioactive effluent will be monitored prior to discharge where appropriate and will only be authorised for discharge if it continues to:
    - pass the EA's tests in the Phase 1 screening assessment and so is deemed not liable to cause pollution; and
    - meet relevant requirements of the EPR permit.

Table 2: Metal Concentrations in the Primary Monitoring Tanks

Substance	Primary Monitoring Tank Effluent Metal Concentration, µg/l					Average Conc, µg/l	Highest Conc., µg/l
	39V2 ($4m^3$)	41V1 ($4m^3$)	41V2 ($3m^3$)	42V1 ($2m^3$)	42V2 ($1m^3$)		
B	1,501±39	669±8	2,258±36	573±10	629±24	1254.93	2,258
Cr	<21	<22	<21	<22	<26	21.79	<26.0
Fe	666±31	<443	<427	<443	<652	527.07	666
Ni	37±0.59	14±2.4	<4	28±1.2	29±1.9	22.66	37
Cu	<12	<25	29±2.4	31±18	36±0.15	26.95	36
Zn	854±65	604±23	367±16	526±21	223±4.5	618.18	854
Cd	<1.2	<1	<1.2	<1	4±0.94	1.40	4
Pb	<3	<3	<3	11±0.26	7±0.11	4.46	11
Hg	2.4±0.16	1.06±0.22	3.3±0.26	<3.1±0.37	1.2±0.03	2.12	3

Non-radioactive aqueous effluent

The non-radioactive aqueous effluent is derived from rain water, surface water run-off and sub-surface water from voids across the site. This effluent can be high in pH, suspended solids and/or contain measurable quantities of dissolved metals. Table 3 shows the metal concentrations found within 9 samples taken and the maximum release concentrations once diluted within the main drains pit. The concentrations are indicative and actual levels of metals may change slightly between various de-watering activities.

The measures to control the impact on the environment include:

- treatment of effluent through a silt buster to adjust the pH and remove suspended solids;
- monitoring prior to discharge into the surface water drainage system. A Suitably Qualified and Experienced Person advises on the scope of analysis. The specifics may vary depending on the source of the effluent and risk of contamination but may include ammonia, turbidity, suspended solids, BOD and COD, pH, TOC, PV and the presence of metals by using a copper strip indicator; and
- inspection of the main drains pit regularly for visible signs of oil or grease.

The voids' effluent is currently pumped from one of two inlet delivery docks (named East and West) which are the low points in the connected system of the cooling water pump house and turbine hall voids. The voids' effluent is treated to adjust the pH to a range of 6-9 and filter the suspended solids to below 50mg/l in the effluent before being added to the main drains pit.

Further, in cases where other non-radioactive effluents arising across the site are found to contain substances not controlled by emission limits, the Environment Agency's guidance[3] on complying with permits will be used. An H1 Annex D1 risk assessment will be carried out to ensure the discharge remains insignificant.

Table 3: Effluent Metals Pre and Post Abatement

Substance	Unit	Max in void effluent (Unabated)	Max Release Concentration (Abated)	Average in void effluent (Unabated)	Average Release Concentration (Abated)
Arsenic	µg/l	7	1.08	5	0.77
Copper		75	11.54	21	3.23
Chromium		44	6.77	22	3.38
Lead		10	1.54	3	0.46
Nickel		32	4.92	10	1.54
Zinc		34	5.23	10	1.54

Baseline Water Quality within the Blackwater Estuary

The background data was the most up to date at the time of producing this risk assessment. It was supplied by the Environment Agency in 2014. The concentrations (µg/l) are averaged between results from an upstream data point from Bradwell, South East of Tollesbury (National Grid Reference: TL98000 08200) and downstream of Bradwell, South East of West Mersea (National Grid Reference: TM04000 11000). The background data is summarised in Table 4.

Table 4: Average Background Concentrations within the Blackwater Estuary

Substance	Average Concentrations Upstream of Bradwell	Average Concentrations Downstream of Bradwell	Average Concentrations
	µg/l	µg/l	µg/l
Arsenic	No data available	No data available	No data available
Copper	1.07	1.11	1.09
Chromium	0.5	0.5	0.50
Lead	0.04	0.05	0.05
Nickel	0.97	0.92	0.95
Zinc	0.91	1.11	1.01
Mercury	0.0	0.01	0.01
Cadmium	0.04	0.04	0.04

Current and Alternative Discharge Routes

Currently, a set volume of main drains pit effluent, a 20m^3 portion of which is voids' effluent, enters the discharge tunnel with the outgoing tide and is discharged into the estuary over a couple of days predominantly on low tide. This creates a short term spike in concentrations, expected to be of less than one hour duration before the flow of water is into the discharge tunnel, preventing additional release of the freshwater effluent. The plume is dispersed and diluted within the main body of the estuary over the next 12 hours before another plug of effluent enters the estuary, assuming two low tides a day.

The proposed alternative discharge route is for the non-radioactive aqueous effluent to be collected in the main drains pit from where it will be pumped periodically dependent upon the volume collected directly into the estuary.

The main drains pit has four pumps but it is anticipated that only one pump would operate per day except in an extreme weather 1:100 years' event. A single pump operates at 1091m^3/hr. However, the maximum effluent expected to be discharged in any 24 hours is 130m^3 which averages as 5.4m^3 of effluent discharged per hour in a day. The pump starts when the level in the main drains pit reaches 1200mm and stops when the level gets to 300mm. This pumping removes 130m^3 in approximately 20 minutes. The effluent will be pumped directly via three of the new 180mm diameter polyethylene pipelines to the estuary.

The radioactive effluent is currently pumped into the east syphon recovery chamber where it is mixed with abstracted water achieving a dilution of 75:1. The mixed effluent is then discharged into the estuary via the east outlet discharge tunnel.

The proposed alternative route is for the radioactive effluent to be pumped directly into the estuary through the newly installed pipe. The pump operates at 40m^3/hr.

ENVIRONMENTAL IMPACT ASSESSMENT

H1 Annex D1 Assessment of hazardous pollutants within surface water discharges

The H1 Annex D1 Assessment of hazardous pollutants within surface water discharges has been used in this assessment to determine the impact of the effluent on the receiving water.

To determine the impact of aqueous effluent arising across site, assessments of the voids' and the radioactive effluents have been carried out. As previously stated, other non-radioactive effluents arising across site contain no dissolved metals and have insignificant environmental impact when discharged unabated. Therefore this assessment applies to all non-radioactive and radioactive aqueous liquids generated through the decommissioning of Bradwell site that contains metals.

Under this assessment guidance, there are two phases for transitional (estuaries) and coastal waters (TraC Waters). Phase 1 screening assesses whether substances present in the effluent are liable to cause pollution. Substances that are not liable to cause pollution to the receiving water are screened out and those that may cause pollution are assessed under Phase 2. Phase 2 modelling is a more detailed assessment of those substances which may be significant.

TraC Screening Phase 1 Part A Test 1

This test establishes whether the concentration of the substance in the discharged effluent is below the EQS-AA and EQS-MAC.

Non-radioactive effluent

From screening test 1, Arsenic, Copper, Lead, Nickel and Zinc no longer require consideration as the average and the maximum concentrations in the effluent are below the EQS-AA and EQS-MAC. Chromium is considered further in the report as it is not below the relevant EQS-AA and EQS-MAC. The maximum concentration in the effluent column in Table 5 gives the maximum predicted concentrations that would still screen out under the Phase 1 screening test. These concentrations would not be deemed liable to cause pollution to the receiving water body and therefore acceptable for discharge.

Concentrations will be diluted in the main drains pit before discharge at a rate of 6.5 (see assumptions).

Table 5: Effluent Concentrations and EQS-MAC and EQS-AA

Substance	Maximum concentration calculated to screen out in the Phase 1 H1 Annex D1 assessment, (µg/l)	Actual Average Concentration in the effluent (µg/l)	Actual Average Release Concentration following dilution (µg/l)	EQS-MAC (µg/l)	EQS-AA (µg/l)
As	24	5	0.77	N/A	25
Cu	4900	21	3.23	N/A	5
Cr	120	22	3.38	32	0.6
Pb	8900	3	0.46	N/A	7.2
Ni	23000	10	1.54	N/A	20
Zn	4800	10	1.54	N/A	40

Radioactive Effluent

Table 6 provides a summary of the characterisation results of the pre and post abated radioactive effluent. The results from the test show that for the radioactive effluent:

- Boron, Lead, Iron and Nickel no longer require consideration because the discharge concentration of these substances in the effluent would be less than 100% of the EQS AA.
- Cadmium, Chromium, Copper, Mercury and Zinc did exceed the EQS AA; these are taken forward for further assessment.
- Cadmium, Chromium and Mercury did not meet the EQS MAC, these are taken forward for further assessment.

Table 6: Radioactive effluent concentrations

Substance	Pre-abatement Maximum Concentration in the Effluent (µg/l)	Pre-abatement Average Concentration, (µg/l)	Post-abatement concentration, (µg/l)	EQS-MAC (µg/l)	EQS (AA) / µg/l
B	2,258	1254.93	879	n/a	7,000
Cr	26.0	21.79	23	32	0.6
Fe	666	527.07	485	n/a	1,000
Ni	37	22.66	14	n/a	20
Cu	36	26.95	30	n/a	5
Zn	854	618.18	122	n/a	40
Cd	4	1.40	2	1.5	0.2
Pb	11	4.46	5	n/a	7.2
Hg	3	2.12	2.1	0.07	0.05

TraC Screening Phase 1 Test 2

This test establishes whether the discharge is to a riverine estuary or direct to a low water channel within the estuary.

Non-Radioactive effluent and radioactive effluent

The aqueous effluent is discharged into the Blackwater Estuary approximately 460 metres offshore from the site boundary into a dynamic water body. More detailed modelling of the effluent is not required.

TraC Screening Phase 1 Test 3

This test establishes whether the discharge is to a location within restricted dilution/dispersion characteristics.

Non-Radioactive effluent and radioactive effluent

The aqueous effluent is discharged into the Blackwater Estuary approximately 460 metres offshore into a dynamic water body. On this basis, the discharge passes the test. More detailed modelling of the effluent is not required.

TraC Screening Phase 1 Test 4

This test establishes whether the discharge point is to a location less than 50 metres offshore from where the seabed is at chart datum or to an area where the sea bed is less than 1 metre below chart datum.

Non-Radioactive effluent and radioactive effluent

The discharge is through a dedicated outfall which is approximately 460 metres into the Blackwater Estuary from the boundary of the site and into a significant tidal estuary. The mean tidal range at Bradwell is between 4.8 metres on spring tides and 2.9 metres on neap tides. On this basis, the discharge passes the test. More detailed modelling of the effluent is not required.

TraC Screening Phase 1 Test 5

This test compares the Effective Volume Flux (EVF) (a measure of pollutant load) with the Allowable Effective Volume Flux (AEVF) for buoyant effluents. Providing the EVF is less than the AEVF then the discharge can be considered insignificant.

The EA's H1 Annex D1 Assessment of hazardous pollutants within surface water discharges defines the EVF as:

$EVF = (EFR \times RC) / (EQS\text{-}BC)\ m^3/s$

Non-Radioactive Effluent

EFR - Effluent discharge rate for EQS-AA and EQS-MAC in m^3/s are 0.0015 m^3/s and 0.3031m^3/s respectively)
(EFR for EQS-AA is calculated as 5.4m^3 volume pumped per hour / 3600 (seconds)
EFR for MAC 1091m^3 volume pumped per hour/3600seconds)
RC - Release concentration µg/l
EQS - EQS-AA and EQS-MAC µg/l
BC - Background concentration µg/l

Table 7: Effective Volume Flux Average Release Concentration

Substance	Avg. Effluent Flow Rate, m^3/s	Average Release Conc., µg/l	EQS-AA, µg/l	Background Conc., µg/l	EVF (EQS-AA), m^3/s
Cr	0.0015	3.38	0.6	0.5	0.0508

Table 8: Effective Volume Flux for Maximum Release Concentration

Substance	Max. Effluent Flow Rate, m^3/s	Maximum Release Conc., µg/l	EQS-MAC, µg/l	Background Conc., µg/l	EVF (EQS-MAC), m^3/s
Cr	0.3031	6.77	32	0.5	0.065

The AEVF in m^3/s is equal to the water depth in meters up to a maximum of 3.5m. After that the AEVF is fixed at $3.5m^3/s$.

The AEVF at Bradwell is between $2.9m^3/s$ and $3.5m^3/s$. At 2.9m the AEVF is greater than the EVF for copper and chromium so they can be screened out and no further modelling is required for this effluent.

Radioactive Effluent

EFR - Effluent discharge rate in m^3/s ($0.011m^3/s$)
(EFR calculated $40m^3$ volume pumped per hour / 3600 (seconds) i.e. Maximum pumping capacity)
RC - Release concentration µg/l
EQS - EQS-AA and EQS-MAC µg/l
BC - Background concentration µg/l

Table 9: Effective Volume Flux

Substance	Effluent Flow Rate, m^3/s	Release Concentration, µg/l	EQS-AA, µg/l	EQS-MAC, µg/l	Background Concentration, µg/l	EVF (EQS-AA), m^3/s	EVF (EQS-MAC), m^3/s
Cu	0.011	30	5	N/A	1.09	0.08	-
Cr	0.011	23	0.6	32	0.50	2.55	0.008
Zn	0.011	122	40	N/A	1.01	0.04	-
Cd	0.011	2	0.2	1.5	0.04	0.14	0.015
Hg	0.011	2.1	0.05	0.07	0.01	0.58	0.389

The AEVF in m^3/s is equal to the water depth in meters up to a maximum of 3.5m. After that the AEVF is fixed at $3.5m^3/s$.

The AEVF at Bradwell is between $2.9m^3/s$ and $3.5m^3/s$. At 2.9m the AEVF is greater than the EVF for all the metals so they can be screened out and no further modelling is required for this effluent.

TraC Screening Part B Significant Load Test

None of the metals identified in the non-radioactive effluent are listed in the priority hazardous substances (PHS) list and therefore no further screening is required.

However, the radioactive effluent contains cadmium and mercury which are listed as priority hazardous substances. Annual loads of 0.701kg/yr and 0.736kg/yr for cadmium and mercury respectively were calculated based on the flow rate and the mean discharge qualities of the substances. This is less than the 2kg/yr and 1kg/yr annual significant loads for cadmium and mercury provided by the Environment Agency in the H1 Annex D1 guidance. The substance therefore passes the significant load test and it is not considered to be significant.

Cumulative Impact of Discharges on Site

In addition to the voids' effluent, the Fuel Element Debris (FED) effluent from Bradwell site also contains the same metals but at significantly higher concentrations. The FED effluent is treated prior to discharge to minimise the release of metals into the estuary and the emission of these substances is permitted and controlled in permit EPR/DP3127XB[4]. The average constituents of the FED effluent have been modelled in two separate reports (BRAD/EN/REP/023[5]and BRAD/EN/REP/032[6]).

A variation to permit EPR/DP3127XB is being submitted to authorise the discharge of the FED and NOx scrubber effluents through the new pipelines.

A thorough assessment has been made of the potential impacts from discharging FED related effluent through the new line and it is supported by the environmental modelling work undertaken by HR Wallingford (specialists in this field). The scope of this work includes assessment of the load and behaviour of effluent containing heavy metals and nitrates that would be discharged from Bradwell Site.

The assessment of this discharge is dealt with in document BRAD/EN/REP/130[7] and concludes that the combined FED dissolution effluent (i.e. with the NOx scrubber liquor added to each batch) continues to meet the EA insignificant test.

It is therefore considered that the assessments demonstrate that the cumulative environmental impact of both the FED and void discharges from Bradwell site are insignificant for all metals.

CONCLUSION

TraC Phase 1 Screening

All of the metals have been screened out using the 5 tests in the Phase 1 screening assessment and so are deemed not liable to cause pollution. Although the unabated metal content of this effluent is insignificant, the abatement of pH and suspended solids is required for this and other aqueous effluents arising at Bradwell that are of a similar nature.

REFERENCES

1 Environment Agency Permit Number PR2TS/E10760C/V002

2 Environment Agency, 2014. H1Annex D1 Assessment of hazardous pollutants within surface water discharges

3 Environment Agency, June 2013. How to comply with your environmental Permit

4 Environment Agency Permit Number EPR/DP3127XB

5 BRAD/EN/REP/023/FED – Environmental Risk Assessment In Support of Fuel Element Debris Treatment

6 BRAD/EN/REP/032/FED – Fuel Element Debris Discharge Dispersion (Including HR Wallingford Report EX 6399 May 2001)

7 BRAD/EN/REP/130 – Environmental Risk Assessment to Support the EPR Permit Variation for FED Discharges Through the New Discharge Line