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TITLE

H1 WATER ASSESSMENT FOR CONNAH'S QUAY POWER STATION IN RESPONSE TO LCP BREF REGULATION 61 NOTICE

Master copy signed by J M Lines & T A Hill (01/10/2018)

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SUMMARY

Connah's Quay Power Station has received a Regulation 61 Notice to supply information to Natural Resources Wales (NRW) in relation to the LCP BRef (Large Combustion Plant Best Available Techniques Reference Document).

This Technical Information Publication forms part of the response to the Regulation 61 Notice in the form of a surface water pollution risk assessment, using the H1 screening tests to assess pollutants discharged from Connah's Quay Power Station to surface water. The guidance entitled "Surface water pollution risk assessment for your environmental permit", available on the gov.uk website, has been used for this assessment of discharges to surface water.

After H1 Test 2, all substances considered can been screened out as presenting no risk to the environment. Cadmium and mercury also meet the significant load test for priority hazardous substances. Therefore no further tests or modelling are required for discharges to surface waters from Connah's Quay.

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1 INTRODUCTION

Connah's Quay Power Station has received a Regulation 61 Notice to supply information to Natural Resources Wales in relation to the LCP BRef (Large Combustion Plant Best Available Techniques Reference Document).

The Regulation 61 Notice requires information on priority hazardous substances and any other relevant substances discharged to surface waters. Specifically the Regulation 61 Notice asks that for discharges to surface water from the site, operators must provide information for priority hazardous substances and any other relevant substances.

With reference to the risk assessment guidance in the gov.uk website entitled "Surface water pollution risk assessment for your environmental permit" (accessible via this link: https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit) [Gov.uk, 2018], the Regulation 61 Notice requires undertaking the following assessments:

- Screening tests for priority hazardous pollutants and any other relevant priority hazardous substances

- For any substance which is not screened out by the screening tests, modelling should be carried out, as described in the risk assessment guidance "Surface water pollution risk assessment for your environmental permit".

This TIP (Technical Information Publication) forms part of the response to the Regulation 61 Notice in the form of the screening tests, using the H1 tool to assess discharges to surface water.

The H1 screening tests have been set up in an excel spreadsheet. Screen shots from the excel spreadsheet are included in this document. The H1 spreadsheet will also be forwarded to NRW as part of the Regulation 61 Notice response.

2 SITE INFORMATION

Connah's Quay Power Station is a CCGT, located within the tidal reach of the River Dee in Flintshire, North Wales. The condenser is cooled by recirculating water abstracted from the Dee Estuary. The cooling water (CW) is circulated through low level hybrid cooling towers. To prevent build-up of salts in the CW system, a fraction of the CW is purged. To replace water purged and lost through evaporation from the cooling towers, make-up water is abstracted from the River Dee. Aqueous discharges from Connah's Quay, including the purged CW, are held in a purge water pond before discharge to the Dee Estuary via W1. A map of Connah's Quay showing the location of the W1 outfall (328350E, 371190N) is shown in Figure 1.

Connah's Quay Power station is permitted to discharge from the purge pond to the Dee during a three hour period on every tide (a tidal cycle is approximately 12.5 hours), from 1 hour after the predicted time of HW (high water) to 4 hours after the predicted time of HW. The discharge from the purge pond to the Dee is continuous during this period. There is mixing within the purge pond prior to discharge to the Dee.

In this assessment it is assumed that the discharge operates continuously. In reality, the discharge will not operate for more than 25% of the time, even if the power station operates

continuously. The power station will operate intermittently, further reducing the percentage of time the discharge operates. Therefore, the average impacts on the receiving water will be less than predicted here.

There are Special Areas of Conservation (SACs), Special Protection Areas (SPAs), Ramsar sites and Sites of Special Scientific Interest (SSSIs) within 10 km of Connah's Quay. These are shown in Figure 2.

3 SCREENING TESTS FOR TRANSITIONAL AND COASTAL WATERS (RIVERINE)

Connah's Quay discharges to the Dee Estuary, at a point at which the flow characteristics tend to be riverine. As can be seen in Figure 1, the discharge point is located in a channel with riverine geometry. Therefore the receiving water body is classed as TRaC riverine (TRansitional and Coastal waters). The Environmental Quality Standards (EQSs) for estuaries and coastal waters are used in the assessment, while the calculations applied relate to the H1 freshwater tests from Test 2 onwards, as the main flow direction is essentially along the riverine channel.

The guidance states that when a pollutant has both an AA (annual average) and a MAC (maximum allowable concentration) EQS (environmental quality standard), measurements should be compared with the AA, apart from Test 4 for freshwaters, where the MAC EQS should be used as well. In this assessment, the H1 spreadsheet has been set up to undertake tests for both AA and MAC for all tests, where both exist.

A screen shot of the facility reference information, objective and scope of the H1 assessment is reproduced in Figure 3.

Screen shots of the information on the water discharge locations and water release points are shown in Figure 4 and Figure 5 respectively.

Release concentrations from W1 are shown in the screen shot in Figure 6.

Screen shots of information on water temperature and pH are shown in Figure 7 and Figure 8 respectively, although these take no further part in the H1 calculations.

A screen shot of the information on local environmental quality is shown in Figure 9.

3.1 Screening Test 1

Test 1 for releases to TRaC waters checks whether the concentration of the pollutant is more than the relevant EQS for TRaC waters. A pollutant can be screened out from further tests if the discharge concentration is less than the EQS, as this indicates it is not a risk to the environment. The release concentrations, EQSs and result of Test 1 are shown in a screen shot in Figure 10. The results of the AA and MAC tests are shown separately, with the final column showing the combined result (fail is recorded if either the AA or MAC test return a fail, in addition to if they fail both the AA and MAC tests).

3.2 Screening Test 2

The first part of Test 2 is to check whether the discharge is to the low water channel ("if the water does not flow across the estuary bed at any stage of the tide") in the upper parts of an estuary where the water is mainly fresh.

As the discharge from Connah's Quay is direct to the low water channel (i.e. to TRaC waters with riverine characteristics), the H1 freshwater tests are applied from Test 2 onwards.

Test 2 introduces the dilution available in the receiving water. The process contribution, PC is defined as:

$$PC = \frac{Release\ concentration\ of\ pollutant\ in\ W1 \times W1\ flow\ rate}{W1\ flow\ rate + riverive\ flow\ rate}$$

If the PC is less than 4% of the EQS, the pollutant can be screened out as it is not a risk to the environment. The calculation of the PC along with the results of Test 2 are shown in Figure 11. Note that the PC is not calculated for pollutants that were screened out at the end of Test 1.

The riverine flow rate has been estimated as:

$$Riverine\ flow\ rate = channel\ width\ near\ discharge \times total\ water\ depth\ near\ discharge \times ebb\ current\ speed\ on\ neap\ tide$$

The ebb current speed has been used since the effluent from W1 is only allowed to discharge during the ebb tide (from HW+1 to HW+4 hours). A typical current speed on an ebb tide is 0.5 m/s, whilst the maximum maintained for several hours 1.0. m/s. These current speeds were deduced from a hydrographic survey at Connah's Quay [Odling-Smee, 1992]. The neap tide was chosen as the current speed is generally less on the neap tide than the spring tide. Lower current speeds are associated with lower flows and less water for mixing. The typical current speed on an ebb tide is therefore representative of a worst case.

At the end of Test 2, all pollutants considered have been screened out as presenting no risk to the environment. Therefore no further tests are necessary.

3.3 Priority Hazardous Substances Test

For priority hazardous substances discharged to estuaries and coastal waters, a further test must be undertaken, even if screening tests are passed. The annual discharge of priority hazardous substances must be less than the significant load. From the list of substances assessed for W1, only cadmium and mercury are priority hazardous substances. The annual load release of cadmium and mercury to surface water has been taken from the information gathered together for end of year reporting to NRW and pollutant release and transfer register (PRTP) population for 2017. The annual loads are shown in Figure 6, and comfortably meet the significant load limits for both cadmium and mercury.

4 SUBSTANCE SPECIFIC INFORMATION AND DISCUSSION OF RESULTS OF SCREENING TESTS

After Tests 1 and 2 have been completed the results are as follows:

Annual Average – all pollutants considered are screened out by Test 1, apart from ammonia, which is screened out by Test 2 as having no risk to the environment.

Maximum allowable concentration – all pollutants considered can be screened out at Test 1 as no risk to the environment.

4.1 Cadmium and Mercury

Trace elements are present as impurities in chemicals (sodium hydroxide and hydrochloric acid) required to regenerate ion exchange resin, used to produce deionised water for use in the steam raising circuit.

The long-term cadmium and mercury calculations use the annual releases for 2017 required by NRW for end of year reporting and pollutant release and transfer (PRTR) population, for both mass releases of the metals (0.00325 kg Cd, 0.00054483 kg Hg) and the volume of water discharged via W1 (6,379,529 m^3). To provide an estimate of short term concentrations, the long-term concentrations have simply been scaled up by the station load factor in 2017. Cadmium passes the short-term (annual average) Test 1 easily, while mercury passes the long-term (MAC) Test 1 easily. There is no short-term EQS for cadmium and no long-term EQS for mercury.

4.2 Ammonia

The assessment undertaken in this document for ammonia is consistent with an assessment that was undertaken using a previous version of H1 [Lines, 2014]. The relevant information is reported below.

Demineralised water used within the boilers is dosed with ammonia to inhibit corrosion. Boiler blowdown waters from both the heat recovery steam generators (HRSGs) and auxiliary boilers will contain ammonia, which is discharged into the purge pond. A worst-case approach has been taken in this H1 calculation, in which the maximum volumes of boiler blowdown waters are assumed to occur at the same time as the maximum concentration of ammonia in the blowdown waters. In reality, the concentrations of ammonia in the boiler blowdown reaching the purge pond will be many times less than used in this calculation.

To be consistent with an assessment that was undertaken using a previous version of H1 [Lines, 2014], station data from 2003 to 2013 has been used. Assuming no losses, the maximum total annual HRSG blowdown volume is 3.34×10^8 litres. In practice the HRSG boiler blowdown water volume is likely to be less than this as no losses have been accounted for. Also in future years, the volumes will be lower if the station operation is reduced.

Using information from the auxiliary boiler suppliers, the maximum auxiliary boiler blowdown from all five auxiliary boilers operating continuously for a year is 1.0×10^6 litres. Clearly all five auxiliary boilers will not operate continuously all year and the volumes of blowdown will be considerably less than assumed here.

Ammonia concentrations of 2 mg/l and 5 mg/l are assumed in the HRSG and auxiliary boiler blowdown waters respectively; theses are maximum values and are assumed to be maintained continuously throughout the entire year, with no losses.

Using the above volumes and concentrations:

- Total HRSG ammonia discharge to purge pond: 6.68×10^8 mg

- Total auxiliary boiler ammonia discharge to purge pond: 5.17×10^6 mg
- Total ammonia in to purge pond: 6.73×10^8 mg

Note that the majority of the ammonia comes from the HRSGs rather than the auxiliary boilers.

From 10 years of station data, the minimum purge water volume discharge to the Dee was 6.63×10^9 litres.

Assuming the maximum annual ammonia mass discharge coincides with the minimum annual purge volume, the maximum concentration of ammonia discharged to the Dee is 0.102 mg/l, or 83.7 µgN/l. As the annual average ammonia EQS of 21 µgN/l is measured as the mass of nitrogen in ammonia, the discharge concentration has been converted to the same basis. There is no short-term ammonia EQS for estuarine and coastal waters.

As the worst case long-term ammonia release concentration of 83.7 µgN/l is greater than the EQS of 21 µgN/l, long-term ammonia concentrations fail Test 1. Note that several worst-case assumptions have been used. It is possible that in practice, the ammonia release concentration will be less than the EQS, at least for some of the time.

In Test 2, the worst case long-term ammonia release concentration of 83.7 µgN/l is used along with the mean W1 flow rate of 1.91 m^3/s and the 240 m^3/s ebb flow. The worst case long term ammonia PC is 0.66 µgN/l [(1.91 x 83.7) / (1.91 + 240)]. As this is less than 4% of the EQS, ammonia passes Test 2.

4.3 Biocide

Mean and maximum W1 discharge concentrations of residual chlorine dioxide, residual chlorite and total residual oxidant were available directly from the power station, as displayed in **Figure 6**. There is no suitable EQS for chlorine dioxide, but it is reactive and short-lived and unlikely to persist in the receiving water. The main by-product of chlorine dioxide use as a biocide is the chlorite ion. There is no EQS for the chlorite ion. However, there is a no observable effects concentration (NOEC) for *Daphnia magna* of 15 µg/l [McCann et al, 2012], which has been used as an environmental assessment level (EAL). As the measured W1 chlorite discharge concentration is considerably below the EAL, the chlorite ion passes Test 1.

Dosing of cooling water with sodium hypochlorite results in total residual oxidant in W1. However, dosing with sodium hypochlorite is rarely used at Connah's Quay, as chlorine dioxide is the preferred biocide. The measured release concentration of total residual oxidant is considerably below the short term EQS and can be screened out at Test 1.

5 CONCLUSIONS

An H1 water assessment has been undertaken for discharges to surface waters from Connah's Quay Power Station. The guidance "Surface water pollution risk assessment for your environmental permit", available on the gov.uk website, has been followed.

After H1 Test 2, all substances considered can been screened out as presenting no risk to the environment. Cadmium and mercury also meet the significant load test for priority hazardous substances. Therefore no further tests or modelling are required for discharges to surface waters from Connah's Quay.

6 REFERENCES

Gov.uk (2018) Surface water pollution risk assessment for your environmental permit. https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit

Odling-Smee, (1992) North West Site Studies Connah's Quay Hydrographic Survey, A report by Odling-Smee, Oberman Associates, Chartered Surveyors & Hydrographic Consultants

Lines J M (2014) H1 Assessment for Ammonia discharge from Connagh's Quay to River Dee. E.ON Technologies Report ETG/14/CNS/EM/7098/R.

McCann P, Smith W, Lines J, Sadler K (2012) BAT Assessment for Chlorine Dioxide Dosing at Connah's Quay. E.ON New Build and Technology Report ENT/12/TSP/IE/90/R.

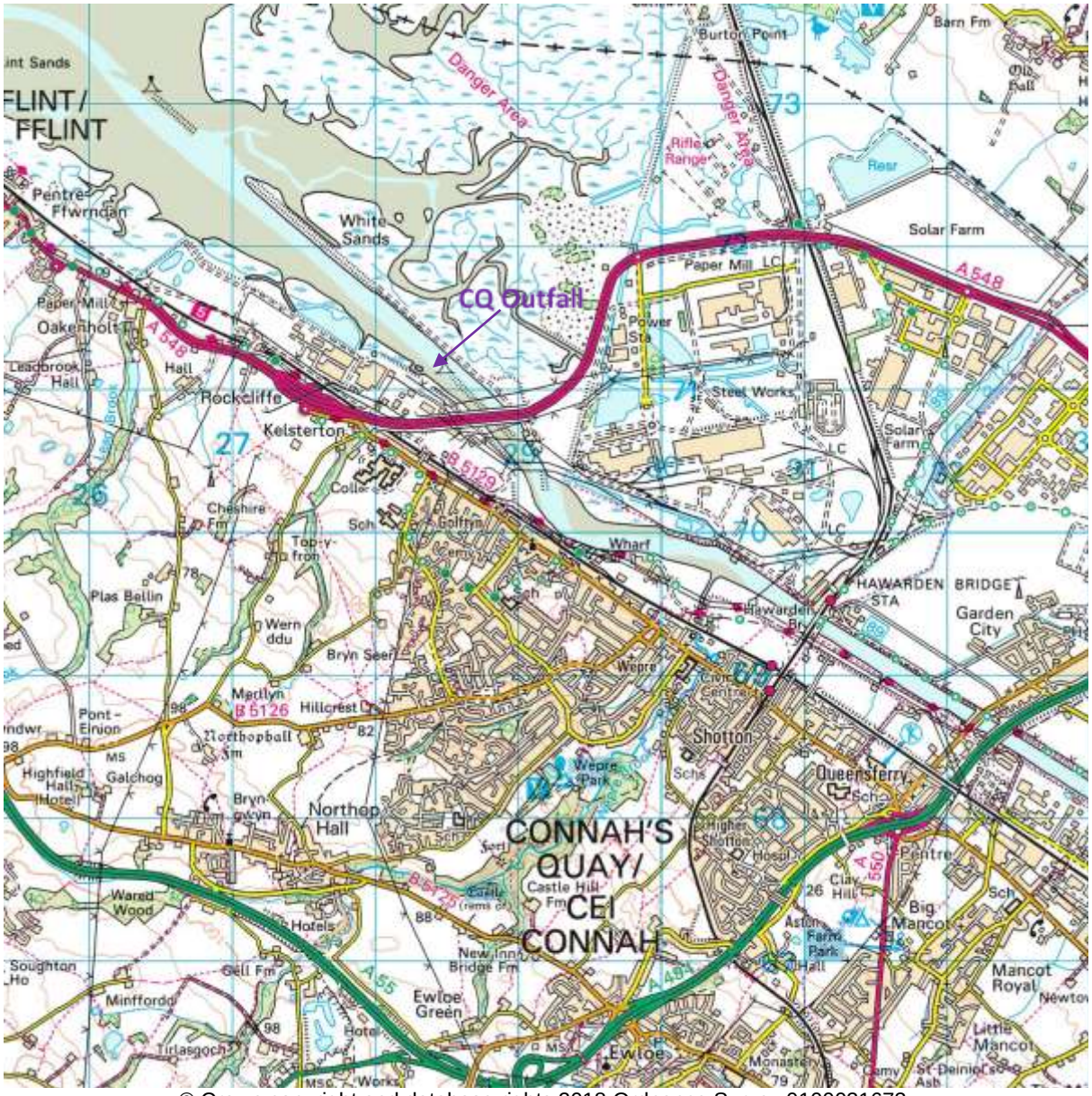

Figure 1: Map Showing Location of Connah's Quay W1 outfall

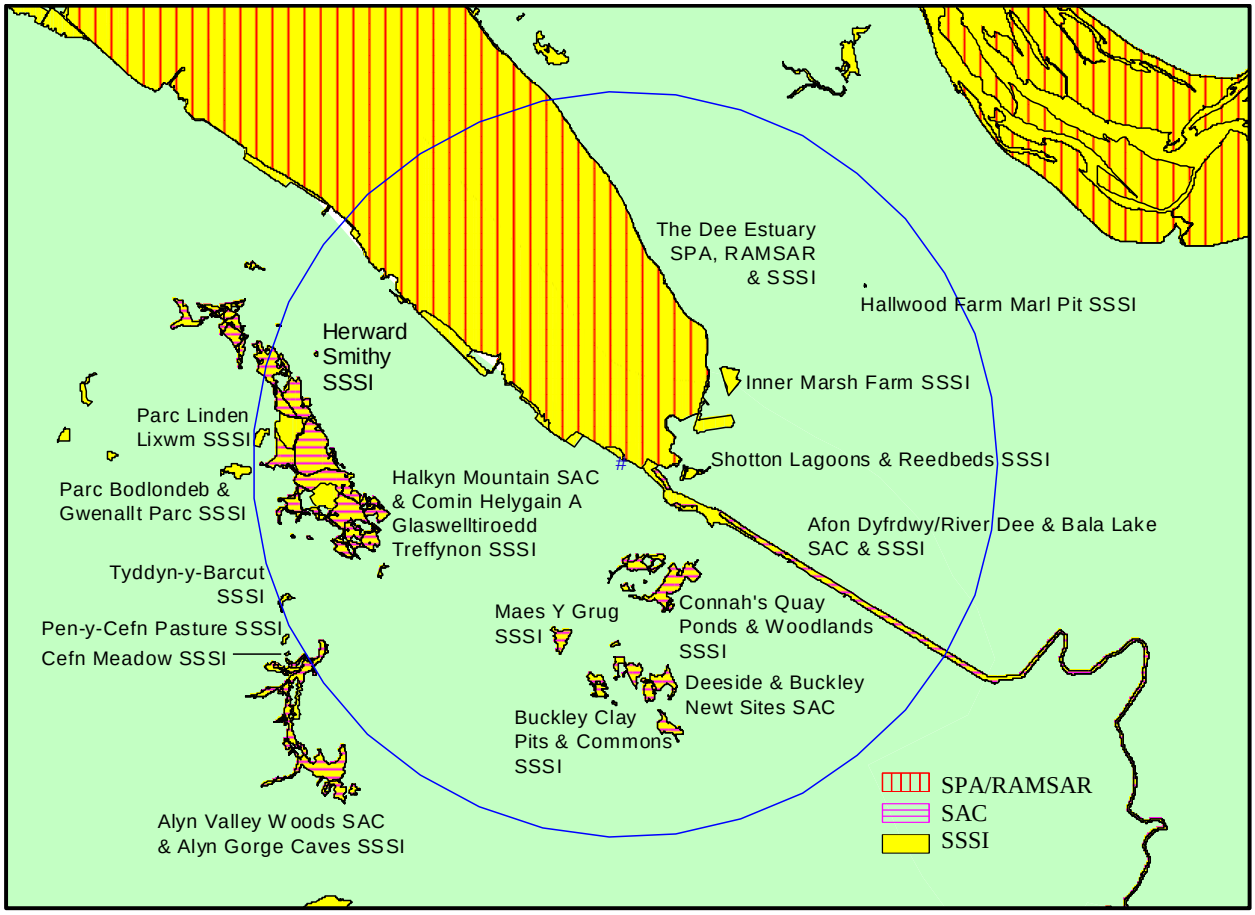

Figure 2: Map of Ecologically Sensitive Sites Lying within 10 km of Connah's Quay Power Station

Facility Reference Information	
Company Name	Uniper
Loation	Connah's Quay
Permit Number	EPR/NP3037AF

Describe the Objective	
To carry out an ENVIRONMENTAL ASSESSMENT	This is a response to the Environmental Permitting (England and Wales) Regulations 2016 Regulation 61(1) Notice Requiring Information issued by Natural Resources Wales in May 2018. Natural Resources Wales is required to review the permit, following the publication of the revised Best Available Techniques (BAT) Reference Document (BREF) for Large Combustion Plants (LCP). For discharges to surface waters, Uniper has been asked to undertake an H1 assessment to present the emissions data and to carry out screening tests.

Scope of the Environmental Assessment	
1	Connah's Quay is a combined cycle gas turbine power station
2	Connah's Quay comprises four gas turbines modules consisting of a gas turbine and a heat recovery steam generator (HRSG)
3	Natural gas is used to drive a gas turbine, generating electricity. The exhaust gases generated are used to raise steam in a boiler. This steam is used to drive a steam turbine generating electricity.
4	Typical electrical output at full load is 4 x 345 MW. Total electrical output is 1462 MW.
5	Each of the four exhaust stacks are mounted on top of the HRSGs emitted at a height opf 85 m .
6	Steam leaving the steam turbine is condensed and recycled to the HRSG.
7	The condensers are cooled by reciurculating cooling water, which in turn is cooled by hybrid cooling towers
8	Make-up water for the cooling circuit is taken from the storage pond which is filled from the River Dee.
9	Waste water is discharged to the River Dee from the Purge Storage Pond.
10	Site surface water is drained to the River Dee through a second release point protected by oil separators.
11	The boiler feed make up water is produced from towns water in a water treatment plant.
12	The boiler blowdown waters from the HRSG and auxiliary boilers is discharged to the purge pond
13	The purge pond discharges to the Dee from HW+1 hr to HW+4 hours only.

Figure 3: H1 Reference Information

Water Discharge Locations				
Are there any water Emissions	Yes			
Number	Description	Final Discharge Category		Flow rate m3/s
1	Dee Estuary	TR		240
Comments				
Flow rate is 120 x 4 x 0.5 (channel width 120 m, total water depth in vicinity of discharge 4m, ebb current speed on neap tide 0.5m/s				

Figure 4: Water Discharge Locations

Water Release Points								
Number	Description	Location or G	Activities	Final Discharge Point		Discharge via Sewer?	Mean Flow rate m3/s	Max flow rate m3/s
1	W1	SJ28357119	All effluent from site	1	Dee Estuary	No	1.91	2.5
2	W2/W3	SJ27877124	Surface water drain	1	Dee Estuary	No	Not measured	Not measured
Comments								
There is no data on flow from the surface water drains W2 and W3.								

Figure 5: Water Release Points

Release Concentrations of Substances Present in Discharges to Water

Method: Chemical Specific

Number	Substance	Measurement Method	Operating Mode (% of Year)	Average Concentration in Effluent (AA) conc µg/l	Measurement Basis	Maximum Concentration in Effluent (Max) conc µg/l	Measurement Basis	Annual Rate kg/yr	Significant Load (PHS only)	Is annual rate < significant load?
1	Cadmium and its compounds	Estimated	21%	0.000509442	Annual Avg	0.002466	Estimated	0.00325	5	Pass
2	Mercury and its compounds	Estimated	21%	8.54029E-05	Annual Avg	0.000413	Estimated	0.00054483	1	Pass
3	Ammonia (unionised)	Estimated	21%	83.7	Calculation	N/A		N/A	N/A	N/A
5	Residual chlorine dioxide	Continuous	21%	0.00198093	Annual Avg	0.002014	Instantaneous	N/A	N/A	N/A
6	Residual Chlorite ion	Continuous	21%	0.002014395	Annual Avg	0.002019	Instantaneous	N/A	N/A	N/A
7	Total residual oxidant	Continuous	21%	0.014345	Annual Avg	0.014345	Instantaneous	N/A	N/A	N/A

Comments

Annual rate is 2017 data. Releases on other years could be larger or smaller.

Trace elements are present as impurities in chemicals (sodium hydroxide and hydrochloric acid) required to regenerate ion exchange resin, used to produce deionised water in the process.
The long term concentration is estimated from the 2017 release of trace elements divided by the 2017 volume of water discharged via W1.

The maximum concentration has been estimated as the average concentration divided by the 2017 load factor (20.7%).

As a worst case ammonia is assumed to be un-ionised, for comparison with the only ammonia related EAL for estuaries and coastal waters: specific pollutants AA EQS of 21 µg/l.

Figure 6: Release Concentrations from W1

Water Temperature						
Discharge Location		Release Point		Measurement Method	High Normal Rate ˚C	High Peak Rate ˚C
1	Dee Estuary	1	W1	Continuous	22.9	25

Figure 7: Temperature Information

Water pH								
Discharge Location		Release Point		Measurement Method	High Normal Rate	High Peak Rate	Low Normal Rate	Low Peak Rate	pH of Receiving Water
1	Dee Estuary	1	W1	Continuous	8.3	9	8.3	6	8.2

Figure 8: pH Information

Local Environmental Quality	
Water Quality & Resources	
Are there any Environmental Quality Standards relating to substances released from the activities, which may be at risk due to additional contribution from the activity?	No
Are proposals to abstract water satisfactory in order toobtain an abstrction licence?	Site already has a water abstraction licence
Proximity to Sensitive Receptors	
Are there any wildlife habitats e.g. Special Areas of Conservation, or Special Protection Areas, likely to be affected by releases from the activity? (Description of requirements of Habitats Directive is provided in EPR Technical Guidance Notes)	There are SPAs, SACs, Ramsar sites and SSSIs located within 10 km, shown on Figure below

Figure 9: Information on Local Environmental Quality

Water Impatcs Test 1 - TraC Releases

		Annual Average EQS				MAC EQS			
		Test 1				Test 1			
Number	Substance	Release conc µg/l	EQS	Release conc< 100% EQS?		Release conc µg/l	EQS	Release conc< 100% EQS?	Result after Test 1
1	Cadmium and its compounds	0.000509	0.2	Pass		0.002466	No EAL	No EAL	No Risk
2	Mercury and its compounds	8.54E-05	No EAL	No EAL		0.000413	0.07	Pass	No Risk
3	Ammonia (unionised)	83.7	21	Fail		N/A	No EAL	No EAL	Fail
5	Residual chlorine dioxide	0.001981	No EAL	No EAL		0.002014	No EAL	No EAL	No Risk
6	Residual Chlorite ion	0.002014	15	Pass		0.002019	No EAL	No EAL	No Risk
7	Total residual oxidant	0.014345	No EAL	No EAL		0.014345	10	Pass	No Risk

Figure 10: H1 Test 1 – TRaC Screening

Water Impatcs Test 2 - TraC Releases

			Annual Average EQS						MAC EQS					
			Test 2						Test 2					
Number	Substance	Test 1 Result	Release conc µg/l	EQS	PC	PC/EQS %	PC< 4% EQS?		Release conc µg/l	EQS	PC	PC/EQS %	PC< 4% EQS?	Result after Test 1 and Test 2
1	Cadmium and its compounds	No Risk	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A	No Risk
2	Mercury and its compounds	No Risk	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A	No Risk
3	Ammonia (unionised)	Fail	83.7	21	0.66085	3.1%	Pass		N/A	No EAL	N/A	N/A	N/A	No Risk
5	Residual chlorine dioxide	No Risk	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A	No Risk
6	Residual Chlorite ion	No Risk	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A	No Risk
7	Total residual oxidant	No Risk	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A	No Risk

Comments

Previous H1 assesments have been carried out at Connah's Quay:
H1 Assessment for Ammonia Discharged from Connah's Quay to the River Dee. E.ON Technologires Report ETG/14/CNS/EM/709/R. June 2014
The calculation of the PC in the above Table is consistent with data and the approach used in the report
Previous modelling has been carried out at Connah's Quay for chorite and was reported in:
Assessment of Chlorite in the Cooling Water Plume from the Use of Chlorine Dioxide at Connah's Quay E.ON New Build and Technology Report ENT/12/TSP/IE/89/R January 2012
Response to 4 July 2012 Schedule 5: Further Cormix Modelling of Chlorite Discharged from Connah's Quay Power Station. E.ON New Build and Technology Report ENT/12/CNS/866/TIP July 2012
The above calculation of the PC is consistent with data used in previous modelling.

Figure 11: H1 Test 2 – TRaC (Riverine) Screening

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