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WYLFA NEWYDD

Wylfa Newydd Project

Construction Water Discharge Activity – Environmental Permit Application: Appendices I to K

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Construction Water Discharge Activity –
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Appendix I –
Construction H1 Assessment
(ES App D13.14)

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Appendix I – Construction H1 Assessment (ES App D13.14)

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ENERGY WORKING FOR BRITAIN

Wylfa Newydd Project

6.4.96 ES Volume D - WNDA Development App D13-14 - Marine modelling of the construction discharge

PINS Reference Number: EN010007

Application Reference Number: 6.4.96

June 2018

Revision 1.0

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Planning Act 2008
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

Contents

Executive Summary

As part Horizon Nuclear Power (Wylfa) Ltd's permit application for water discharges associated with construction works, an assessment of impacts on the receiving waters is required, following H1 Horizontal Guidance. This is required for discharges to both freshwater and to the marine environment and includes those discharges from construction phase drainage, groundwater dewatering and sewage discharges associated with the construction works.

This report compiles and presents the data sources that have been used in the H1 assessment including sampling and leaching test results which are used for determining potential concentrations for discharges from the Wylfa Newydd Development Area. The report then presents the results from the H1 assessment to determine the predicted effects so that Natural Resources Wales (NRW) can identify assessment criteria for the receiving environments.

The potential effects of substances are assessed in two phases: a screening phase and, where required, a modelling phase. In each phase, substances are assessed to determine if they are "liable to cause pollution". Those which are liable to cause pollution, in terms of potentially exceeding Environmental Quality Standards (EQSs), will need to be controlled in the permit.

The screening phase of the assessment has a number of 'tests' which increase progressively in complexity. If a substance "fails" these tests, it passes through to the next phase, the modelling assessment. If the screening tests are "passed", the substance is classed as insignificant and is screened out. The screening phase uses raw data, where available, as these represent the worst case scenario and minimise the time spent assessing substances which are not liable to cause pollution. For subsequent modelling, "cleaned up" data are used.

For freshwater discharges, the screening tests identified that orthophosphate, bioavailable copper, chromium, iron, bioavailable lead, dissolved lead, nitrate, bioavailable zinc and anionic polyelectrolyte required further modelling for one or more of the discharge points. This further modelling, undertaken using the River Quality Planning (RQP) model, identified that potentially for orthophosphate the annual average EQS (AA EQS) is exceeded in all catchments. However, in some cases the upstream orthophosphate concentration already exceeds the EQS. No other annual average EQSs are predicted to be exceeded. The RQP modelling also predicts that the downstream quality may deteriorate by more than 10% of the AA EQS for orthophosphate, bioavailable copper, iron and bioavailable lead in the Tre'r Gof SSSI drains; orthophosphate and bioavailable lead in Nant Caerdegog Isaf; and orthophosphate at the Tre'r Gof Site of Special Scientific Interest (SSSI) discharge. For exceedances of short-term EQSs, dissolved lead showed as being potentially significant for the discharge of surface water runoff to the Tre'r Gof SSSI drains.

With respect to the marine environment, the initial screening of data identified dissolved copper, lead, nickel and zinc as requiring further assessment by modelling. This further modelling was undertaken using a marine hydrodynamic model. Modelling predicted all concentrations of dissolved nickel would be below the AA EQS. For copper, zinc and lead the predicted maximum concentrations were all above the relevant AA EQSs. However, the predicted mixing zones in the marine environment are relatively small and are considered precautionary. The substances predicted to be above the AA EQS would not remain above the AA EQS in the long-term as soil stripping, earthworks, dewatering and mound creation would be carried out in different areas at different times across the Wylfa Newydd Development Area. In addition, mounds would be reseeded when left dormant for more than 60 days, or when work is complete, thereby reducing the leaching of substances from the soil.

1. Introduction

1.1 Purpose of this Report

As part of the permit application for water discharges associated with construction works, an assessment of impacts on the receiving waters is required, following H1 Horizontal Guidance (see chapter 2). Horizon Nuclear Power (Wylfa) Ltd (Horizon) has instructed Jacobs UK Limited (Jacobs) to prepare a report detailing the work undertaken to determine the effects of surface water discharges associated with construction works for development of the Wylfa Newydd Power Station on the receiving water environment.

The development of this work has been informed by a number of meetings with Natural Resources Wales (NRW) between 2015 and 2018.

1.2 Aims of this Report

The aims of the work are to:

- compile and present the data sources that are being used in the H1 surface water assessment including sampling and leaching test results which are used for determining potential concentrations for discharges from the site; and
- to undertake and present results from the H1 assessment to determine the predicted effects so that NRW can identify assessment criteria for the receiving environments.

2. Guidance Documents

2.1 Environment Agency Environmental Permit guidance

The NRW’s website [RD1] accessed 15 May 2017 shows that guidance on undertaking surface water impact assessments published by the Environment Agency on the UK Government’s website [RD2] is to be used for undertaking H1 impact assessments. The assessment described in this report primarily follows this web-based guidance, which is referred to as “the H1 guidance” (see section 3). Additional guidance provided in NRW document EPR 7.01 [RD3] has also been considered.

3. The H1 Methodology

The assessment presented in this report has been undertaken using spreadsheets based on the Environment Agency's H1 software tool and equations presented in the H1 guidance. The assessment has been made to evaluate the effect of discharges from the drainage works associated with the construction of the Power Station.

The methodology presented in the H1 guidance is used to determine how to permit discharges of hazardous pollutants to surface waters (hazardous pollutants include priority hazardous substances, priority substances, specific pollutants and substances with operational Environmental Quality Standards (EQSs)). Where an EQS is not available then other appropriate values have been applied, as described in section 4.5.

Substances are assessed in two phases: screening and modelling. In each phase, substances are assessed to determine if they are "*liable to cause pollution*". Those which are liable to cause pollution will need to be controlled on the permit.

The screening phase of the assessment has a number of 'tests' which increase progressively in complexity. If a substance fails these tests, it passes through to the modelling assessment. If the screening tests are passed, the substance is classed as insignificant and is screened out. The screening phase uses raw data, where available, as these represent a worst case scenario and minimise the time spent assessing substances which are not liable to cause pollution.

The H1 methodology is designed to assess effects following any reduction in concentrations in any treatment works, and allows for dilution of substances in the receiving water. In the screening phase of the H1 methodology a series of "tests" is undertaken whereby concentrations of substances in the discharge, allowing for dilution in the receiving water, are compared to EQSs.

For freshwater bodies these tests are as follows:

- Test 1 - Does the concentration of the substance in the discharge exceed 10% of the EQS?
- Test 2 - Does the Process Contribution (PC) exceed 4%of the EQS?
- Test 3 - Does the difference between upstream quality and the Predicted Environmental Concentration (PEC) exceed 10% of the EQS?
- Test 4 - Does the PEC exceed the EQS in the receiving water downstream of the discharge?

If the calculated concentration 'fails' the first test then the second test needs to be considered; if the substance also fails this test and either Test 3 or 4 (or both) then further assessment needs to be undertaken to clean-up the data used in the assessment and potentially, modelling of the discharge is likely to be required.

A similar approach is adopted for discharges to the marine environment (within the H1 guidance marine waters are referred to as estuaries and coastal waters). For marine discharges the tests are as follows:

- Test 1 - Does the concentration of the substance in the discharge exceed 100% of the EQS?
- Test 2 – Is the discharge to the low water channel or upper parts of an estuary where the water is mainly fresh?
- Test 3 – Is the discharge to an area with restricted dilution or dispersion?
- Test 4 – Is the discharge location less than 50m offshore from or less than 1m below chart datum?
- Test 5 – If the discharge is buoyant, does the effective volume flux exceed allowable limits?

If the calculated concentration 'fails' the first test then the second test needs to be considered; if this test is true the calculations for freshwater tests 2 to 4 are carried out; if not, if either Test 3 or 4 are true modelling of the discharge is required, or otherwise Test 5 needs to be considered. If the substance also fails this test, modelling of the discharge is required.

The assessments are undertaken to assess the effects from both long-term discharges (based on the annual average (AA) EQS) and short-term effects by comparing the peak discharge concentration to the Maximum Acceptable Concentration (MAC) or 95th percentile concentration (for ease of reporting, in this report, the short-term assessment EQSs are referred to as a 'MAC').

Within the screening methodology, there is also an independent test where for a small number of substances (those substances considered as Priority Hazardous Substances) the substance ‘load’ is calculated for each individual discharge (i.e. the mass discharged over a year). If the load exceeds the ‘significant load’ (a value determined by the Environment Agency/NRW) then the substance will need to be controlled in the permit by a numeric emission limit.

4. Data Sources

4.1 Discharges considered

The following potential construction phase discharges require consideration:

- surface water drainage system discharges dealing with rainfall runoff;
- on-land dewatering discharges from excavations;
- offshore dewatering discharges from behind coffer dams;
- concrete batching plant discharges of process water (this would be disposed of off-site and is not considered as a site discharge in this H1 assessment);
- construction site sewage discharge; and
- Site Campus sewage discharge (this would be discharged via Dŵr Cymru Welsh Water's existing Cemaes Waste Water Treatment Works and is not considered in this H1 assessment).

4.1.1 Surface water drainage

The initial stage of construction work, involves stripping of topsoil from areas of the Wylfa Newydd Development Area to a typical depth of 0.3m and stockpiling the soil in mounds at various locations around the site. Rainwater falling onto the soil mounds and the areas where vegetation and soil have been stripped has the potential to pick up polluting substances as it passes over the surface of the soil-strip areas and mounds and also where it passes through the soils. This stripped soil would eventually be used to cover the landscape mounds that would be constructed around the Wylfa Newydd Development Area. To control runoff from these mounds, which may contain elevated sediment and leached contaminant concentrations, a drainage system would be installed with the rainfall runoff being directed into settlement ponds. Water in these settlement ponds would then be discharged to local watercourses or directly to the sea, although there would be additional treatment as required such as lamella settlement, flocculant and /or coagulant dosing and pH adjustment. The location of the landscape mound areas and the discharge points are shown in Figure 4.1.

It is anticipated that surface water drainage resulting from the construction works would include that from:

- soil strip areas;
- landscape mounds;
- construction areas; and
- contractor's compounds.

As part of localised ground remediation works, some dewatering may be required in an area where trichloroethene contamination has been identified on the northern boundary of the construction area. However, it is proposed that remediation of this area would be undertaken either before construction works commence or at the start of the site clearance works and the water would be treated prior to discharge to remove trichloroethene (see appendix D7-2 (land contamination risk assessment and remediation strategy) (Application Reference Number: 6.4.25) and is therefore excluded from this assessment.

Furthermore, some areas have been identified which may contain elevated concentrations of hydrocarbons (as detailed in appendix D7-2 (Application Reference Number: 6.4.25)) in soils, and potentially in leachate from these soils. These would be subject to separate remediation and contaminated soils from these areas would be removed before any drainage reaches the surface water drainage system.

Substances running off the mounds or open construction areas may enter the drainage water either due to leaching from the soil and migrating in the dissolved phase or the substances may remain in the solid phase within suspended particles picked up by the flowing water. The latter is more likely to occur during high rainfall events when surface water flows are moving quickly. Substances in the solid phase would be removed by a treatment train including silt traps, swales, settlement ponds and associated treatment systems, including lamella clarifiers and dosing to encourage settlement of sediment, prior to discharging at the permitted outfall point.

Surface water runoff from the Site Campus would be treated separately to the rest of the Wylfa Newydd Development Area surface water drainage system. The Site Campus is expected to undergo topsoil stripping, although it is smaller than the other areas subject to topsoil removal and, as the development of this area progresses, an increasing proportion of the runoff would be from hard surfaces. Consequently, the potential to pick up polluting substances would be less than for the rest of the drainage system. Nevertheless, in the absence of a site specific assessment of the potential pollutant loading and to reflect the construction phase of the site when pollutant loading would be highest, the discharge from the Site Campus has been assessed in the same way as other discharges, assuming the same potential pollutant loading.

Where necessary, in order to aid settlement of suspended solids and to reduce concentrations at the outfalls chemicals would be added to act as a flocculent or coagulant. Following discussion with NRW, review of desk based information and laboratory tests on several chemicals an anionic or non-ionic polyelectrolyte has been determined to be the most appropriate coagulant to use.

4.1.2 On-land dewatering from excavations

Dewatering would be required to enable excavation of an area of the site to below the groundwater table during construction work. Discharge from this dewatering would be via settlement ponds (and treatment if required) and then direct to sea at a surface water (marine) drainage outfall point, but the discharge would not be processed through the surface water drainage system.

Water pumped for the initial dewatering would predominantly comprise groundwater from the higher permeability fractured zone at the top of the bedrock. Ongoing dewatering to maintain a dry working area would then consist of continued groundwater ingress plus rainfall. The ongoing discharge would be dominated by rainfall, with an estimated average direct rainfall input of $550m^3$/day compared to an estimated groundwater input of around $130m^3$/day. Maximum groundwater discharges are estimated at around $200m^3$/day with a total maximum discharge being estimated at around $5{,}700m^3$/day as detailed in appendix D8-7 (surface water and groundwater modelling results) (Application Reference Number: 6.4.32).

Although the effect of rainfall input during the ongoing dewatering phase would be to dilute any contaminants in groundwater, the H1 assessment has been based on the groundwater discharge component only in order to account for the initial groundwater dominated phase or during times when there is little or no rainfall. Discharge quality is based upon groundwater monitoring data from pumping tests undertaken within the dewatering area (as detailed in [RD4] and [RD5]). Discharge and rainfall input volumes have been obtained from the modelling detailed in appendix D8-7 (Application Reference Number: 6.4.32).

Groundwater dewatering is also expected to be required during construction of the outfall tunnel. This discharge is considered further in section 4.3.2.

4.1.3 Offshore dewatering from behind coffer dams

Offshore dewatering would take place for the cooling water intake and outfall structures from behind impounding coffer dams which would effectively create a seawater lagoon. The initial phase of dewatering of the coffer-dammed areas would be direct to sea, with the discharge transferred directly across the coffer dams after sediments have settled out in an area behind the dams. As an essentially unaltered discharge back to the same water body, the current H1 guidance [RD2] indicates that this discharge would not require permitting. Consequently, it is not included in the assessment presented in this report.

Subsequently, ongoing dewatering would be required to maintain a dry working area behind the coffer dam. This would consist of rainfall plus seawater and groundwater seepages and would be discharged via the on-land dewatering system (i.e. at a surface water drainage outfall point, but not processed through the surface water drainage system). The larger intake coffer-dam discharge would be dominated by seawater seepage and rainfall and likely volumes to be discharged have been estimated in appendix D8-7 (Application Reference Number: 6.4.32). It is estimated that a combined average input for rainwater and seawater seepage would be $194m^3$/day compared to an estimated groundwater ingress of approximately $45m^3$/day predicted by modelling (Application Reference Number: 6.4.32). Thus, the groundwater component is only up to around 20% of the total discharge. Furthermore, there would be a natural groundwater discharge into the nearshore area under present conditions. Consequently, the significance of the groundwater component would be small and it has not been considered in the assessment presented in this report

4.1.4 Concrete batching plant

All process water used in the concrete batching plant would be either recycled within the system or, where there is excess, it would be tankered off-site for disposal. There would be no on-site discharge of process water. While there would be no discharge at the site, it is acknowledged that the exported effluent would need to be managed within the permitting regime, e.g. the disposal site would need an appropriate permit, depending on the ultimate location and method of disposal.

Surface water runoff from the concrete batching plant would be discharged via the construction phase drainage system. This runoff would be from hard surfaces and would not be in contact with exposed soils. While there may be specific substances associated with this discharge the pollutant loading would be lower than that in the majority of the surface water runoff derived from the landscape mounds and construction areas due to its relatively small size. The surface water runoff from the batching plant would represent only a small percentage of the total annual surface water discharge and the discharge would be diluted within the surface water drainage system. Consequently, as the significance of this would be small, it has not been specifically considered in the assessment presented in this report.

4.1.5 Construction site sewage discharge

Construction site sewage would be treated by an on-site packaged sewage treatment system. The discharge from this would be direct to sea at the north end of the western breakwater at discharge point CSD. This discharge is considered further in section 5 of this report.

4.1.6 Site Campus sewage discharge

Sewage discharge requirements for the Site Campus would be dealt with by Dŵr Cymru Welsh Water with discharges from the existing Cemaes Waste Water Treatment Works, supplemented by package treatment plant as required, and consequently are not included in the assessment presented in this report.

4.2 Discharge assessment points

There would be eleven discharge points for water discharges associated with construction works that require consideration in this assessment, as detailed in table 4.1 and shown in Figure 4.1 (it should be noted that the grid references are approximate and may vary slightly due to actual site conditions, operation requirements etc). Seven of these discharge points (A1, A3, B1, C1, D1, D2, and E2) are initially to freshwater watercourses, including B1 which discharges to a stream that flows into the Tre'r Gof Site of Special Scientific Interest (SSSI). Discharge point A2 is located on land but is not associated with a surface watercourse. Discharges at this point would enter the sea immediately down gradient from it and, consequently, it is treated as a direct to sea discharge in this assessment. The remaining three discharge points (PA, PB, and PC) are direct to sea. Discharge points PA, PB and PC are located to the north west of the construction area and their use would vary dependent on the sequence of construction although it is likely that PA would only be used for a short time at the start of the construction works. Further details of the drainage scheme are provided in appendix D8-8 (summary of the preliminary design for construction surface water drainage) (Application Reference Number: 6.4.33).

Discharge point E1 is located on the Nant Cemlyn (figure 4.1), but during construction there would be no discharge of treated water to the Nant Cemlyn at this location and no Environmental Permit is required for this location. Instead the water would be treated and pumped to the Afon Cafnan, most likely at discharge point E2. Throughout this document, discharge E1 therefore refers to that water which is collected from the western side of Mound E and which is treated and discharged to the Afon Cafnan at point E2 on the eastern side of Mound E.

Discharge points C1, D1, E2 (including E1) and D2 are consecutive discharges to the same watercourse, the Afon Cafnan (C1 discharges to the Nant Caerdegog Isaf which is a tributary of the Afon Cafnan). Similarly, discharge points B1 and A1 are consecutive discharges to the outflow from the Tre'r Gof SSSI, with B1 entering upstream of the SSSI and A1 entering the watercourse downstream of the Tre'r Gof SSSI at the point where it discharges from the SSSI to the sea. As upstream discharges would potentially increase the upstream concentration for subsequent discharges this has been taken into account in the assessment by using the predicted environmental concentration from an upstream discharge to determine the upstream concentration for the subsequent downstream discharge.

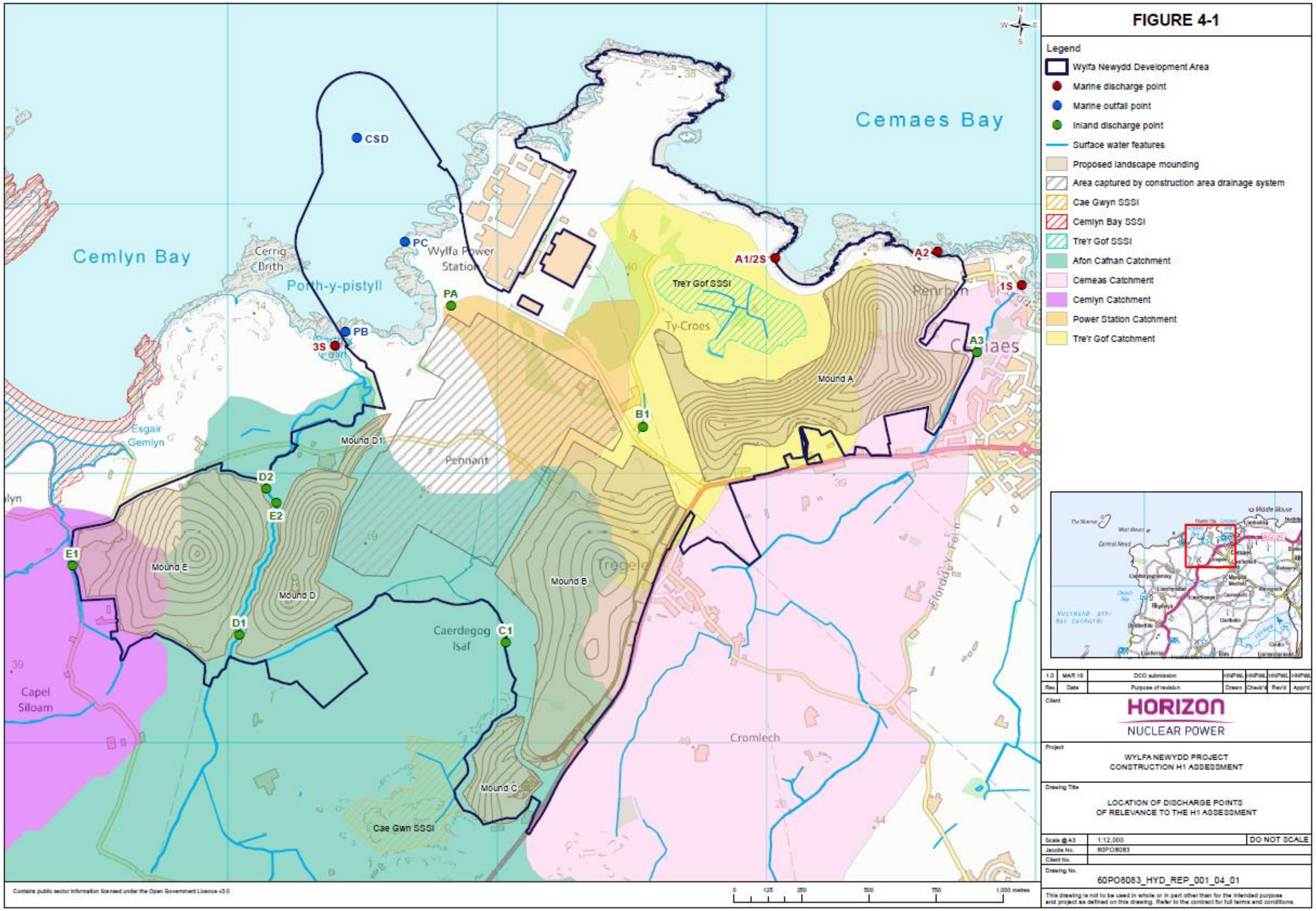
The discharge from on-land dewatering and surface water runoff from the construction platform area would be discharged at PA, PB and PC. The discharges from PB and PC have been modelled separately as the phasing is unknown at this stage. Discharges from PA have not been assessed as PA would only operate for approximately one year and discharge volumes are lower than from PB and PC. All surface water discharge points to the sea are less than 50m offshore from chart datum and the discharge areas are assumed not to have restricted dilution/dispersion characteristics.

Table 4.1 Surface water discharge points of relevance to the H1 assessment.

Runoff area	Outfall reference	Approximate Grid Reference		Receiving water
		Easting	Northing	
Mound A – West and Site Campus	A1	235983	393781	Watercourse which forms the discharge from the Tre'r Gof SSSI
Mound A – Northeast	A2	236633	393779	Cemaes Bay
Mound A - East	A3	236772	393447	Nant Cemaes
Mound B	B1	235539	393117	Small watercourse into north west of the Tre'r Gof SSSI
Mound C	C1	235027	392379	Nant Caerdegog Isaf (tributary to Afon Cafnan)
Mound D - South	D1	234042	392407	Afon Cafnan
Mound D - North	D2	234145	392938	Afon Cafnan
Mound E - West	E1: Mound runoff water captured close to point E1 but discharged at point E2 on the Afon Cafnan			Afon Cafnan
Mound E – East	E2	234174	392897	Afon Cafnan
Power Station site	PA	234825	393626	Porth-y-pistyll
	PB	234435	393528	
	PC	234653	393861	

* Grid reference is approximate pending finalisation of outfall position.

Figure 4.1 Location of discharge points of relevance to the H1 as



4.3 Sources of discharge data

For the assessment of effects, required data relate to the quantity and quality of the discharge water. As these are discharge points which are yet to be constructed, there are no existing monitoring data for the discharges. Discharge data have therefore been estimated from a number of sources as follows.

4.3.1 Discharge flow rates

Discharge flow rates for surface water drainage have been estimated using the 4Rs Model (4R) for shallow groundwater and surface water flows as detailed in appendix D8-7 (Application Reference Number: 6.4.32). The 4R model results provide an estimate of daily flows for each surface water discharge based on simulations using rainfall (and other historical meteorological) data for a 56-year period from 1960 to 2016. The modelling considered three scenarios, a Central baseline and two variants (High and Low) designed to investigate uncertainty in parameter values. The modelling work concluded that the Central baseline model provided the most credible overall results. The average daily discharge rate calculated in the Central baseline model is therefore used for assessing the effects of the long-term discharges in the H1 assessment.

For the peak discharges used to assess the short-term effects, the maximum flow rate is based on the 30-year (plus climate change) rainfall return period for which the settlement ponds and associated water treatment plant is being designed (as detailed in appendix D8-8 (Application Reference Number: 6.4.33)). The maximum discharge rate from the ponds/water treatment plant would be controlled to that which would occur under greenfield conditions. The design basis for the settlement ponds is that the ponds would be able to retain and treat the 1 in 30-year storm flows. The H1 assessment does not cover the effects of a greater than 1 in 30-year rainfall event.

For Tre’r Gof, an assessment of the SSSI has been undertaken which has included the monitoring of groundwater and surface water levels, flows and quality as shown in appendix D8-5 (Tre’r Gof hydroecological assessment) (Application Reference Number: 6.4.30). This assessment noted that based on monitoring in 2015 and 2016, direct rainfall, and not inflows from watercourses, was largely responsible for recharging the basin in which the fen is located. On this basis it was considered that the surface water inflows are not critical to recharge the fen and that direct incident rainfall is more important. As such, the surface water drainage discharges (from outfall B1) are assumed to largely remain confined to the defined drainage channel through the SSSI and discharge at the outfall from the Tre’r Gof SSSI with limited interaction with the bulk of the fen. Furthermore, the drainage system has been designed so that there would be no direct discharges to the eastern compartment of the SSSI which has been identified as the most sensitive zone of the SSSI (appendix D8-5 (Application Reference Number: 6.4.30)) (see figure 4-1 for the extent of the Tre-r Gof SSSI).

On the basis of the above, the drainage channels upstream of and within the Tre’r Gof SSSI are treated as a contiguous surface water drainage system which has limited interaction with the fen. The discharge upstream of the Tre’r Gof SSSI (B1) and the discharges at the Tre’r Gof SSSI outfall (A1) are treated as consecutive discharges to the same watercourse, with the flows provided by the 4R modelling.

The 4R modelling, which is detailed in appendix D8-7 (Application Reference Number: 6.4.32), directed the runoff from the west side of Mound A to discharge points on the south west (upstream) side of the Tre’r Gof SSSI (labelled TG3 and TG4 in the 4R modelling). This is not in accordance with the current drainage design in appendix D8-8 (Application Reference Number: 6.4.33), which routes this runoff to discharge point A1, downstream of the Tre’r Gof SSSI. To account for this difference in the drainage design, these two discharges have been applied to discharge point A1 in the H1 assessment. These two discharges have then been subtracted from the 4R outflow from the Tre’r Gof SSSI (labelled TG5 in the 4R modelling) to give an estimated outflow from the Tre’r Gof SSSI and used in the H1 assessment as the upstream surface water flow for discharge point A1. This methodology may overestimate the discharge at A1 and underestimate the outflow at TG5 from the Tre’r Gof SSSI, as in reality part of the flows at TG3 and TG4 would be natural surface water inflows to the Tre’r Gof SSSI. However, an assessment of the baseline data in the 4R model does show that for the low flow condition (the Q_{95}) the predicted flows are very low at these two points (26m^3/d and 22m^3/d for TG3 and TG4 respectively) and in the context of the H1 assessment this is a conservative approach.

The 4R modelling has not included assessment of the Site Campus area drainage flows. In order to facilitate the H1 assessment it was necessary to estimate potential drainage discharge flows from the Site Campus area. Discharge flows for this area were estimated based on comparison with the modelled flows for the landscape mound catchments as detailed in appendix D8-7 (Application Reference Number: 6.4.32), their 1:30 year runoff rates and their area (appendix D8-8 (Application Reference Number: 6.4.33)), on the assumption that runoff rates from the Site Campus would be similar during its construction. This assessment assumes that all runoff from the Site Campus area would be captured by the drainage system and conveyed to discharge point A1. It is recognised that this is likely to be an over estimate, as in practice only a proportion of the Site Campus area would be developed and this would occur in stages. However, this is a conservative assumption in the context of the H1 assessment.

The average and maximum flows per unit area across the landscape mound catchments were calculated and used to estimate the flows for the Site Campus catchment, based on the estimated catchment area (obtained from project mapping tools). Drainage from the catchment for discharge point A1 was excluded from calculation of this estimate as it includes discharge from the Tre'r Gof Catchment and is unlikely to be representative of drainage primarily from the landscape mounds. The calculations are shown in table 4.2.

The outfall discharge volumes used in the H1 assessment are shown in Table 4.3.

Groundwater discharge flow rates from the on-land dewatering of the excavation have been estimated from modelling results in appendix D8-7 (Application Reference Number: 6.4.32). An average discharge rate of $130m^3/d$ and maximum discharge rate of $192m^3/d$ have been used in the H1 assessment.

Table 4.2 Discharge calculations

Catchment	Drainage discharge point	Catchment area (ha)	Average discharge (m^3/d)	Maximum discharge* (m^3/d)	Average discharge volume (m^3/d/ha)	Maximum discharge volume* (m^3/d/ha)
Landscape mound modelled discharge point catchments						
Mound A - Northeast	A2	4.05	76	12,614	18.76	3,114
Mound A - East	A3	6.22	102	23,674	16.4	3,806
Mound B	B1	39.94	358	45,533	8.96	1,139
Mound C	C1	12.55	213	79,834	16.97	6,361
Mound D – South	D1	4.39	42	15,379	9.57	3,503
Mound D – North	D2	8.77	93	36,202	10.60	4,127
Mound E – West	E2 (water from E1)	14.58	194	83,635	13.31	5,736
Mound E - East	E2	14.68	149	66,528	10.15	4,533
Average					13.09	4,040
Estimated Site Campus catchment						
Site Campus	A1	14.22	**186**	**57,455**	Note: discharge values are indicative	

* Maximum discharge based on 1:30 year (plus climate change) figures. The maximum figures are short term maxima based on an individual storm and are unlikely to be sustained for a full day.

Table 4.3 Discharge volumes for surface water drainage used in the assessment and source of data

Drainage discharge point	Average discharge volume (m^3/s)	Maximum discharge volume (m^3/s)	Comment
A1	0.006	0.787	Includes Mound A west and Site Campus runoff. Source: 4R model output / Surface water drainage design / estimate for Site Campus.
A2	0.0009	0.146	Source: 4R model output / Surface water drainage design.
A3	0.0012	0.274	Source: 4R model output / Surface water drainage design.
B1	0.0041	0.527	Source: 4R model output / Surface water drainage design.
C1	0.0025	0.924	Source: 4R model output / Surface water drainage design.
D1	0.0005	0.178	Source: 4R model output / Surface water drainage design.
D2	0.0011	0.419	Source: 4R model output / Surface water drainage design.
E2 (water from E1)	0.0022	0.968	Source: 4R model output / Surface water drainage design.
E2	0.0017	0.770	Source: 4R model output / Surface water drainage design.
PA/PB/PC	0.005	0.064	Construction area surface water runoff. Source: 4R model output.

4.3.2 Discharge quality

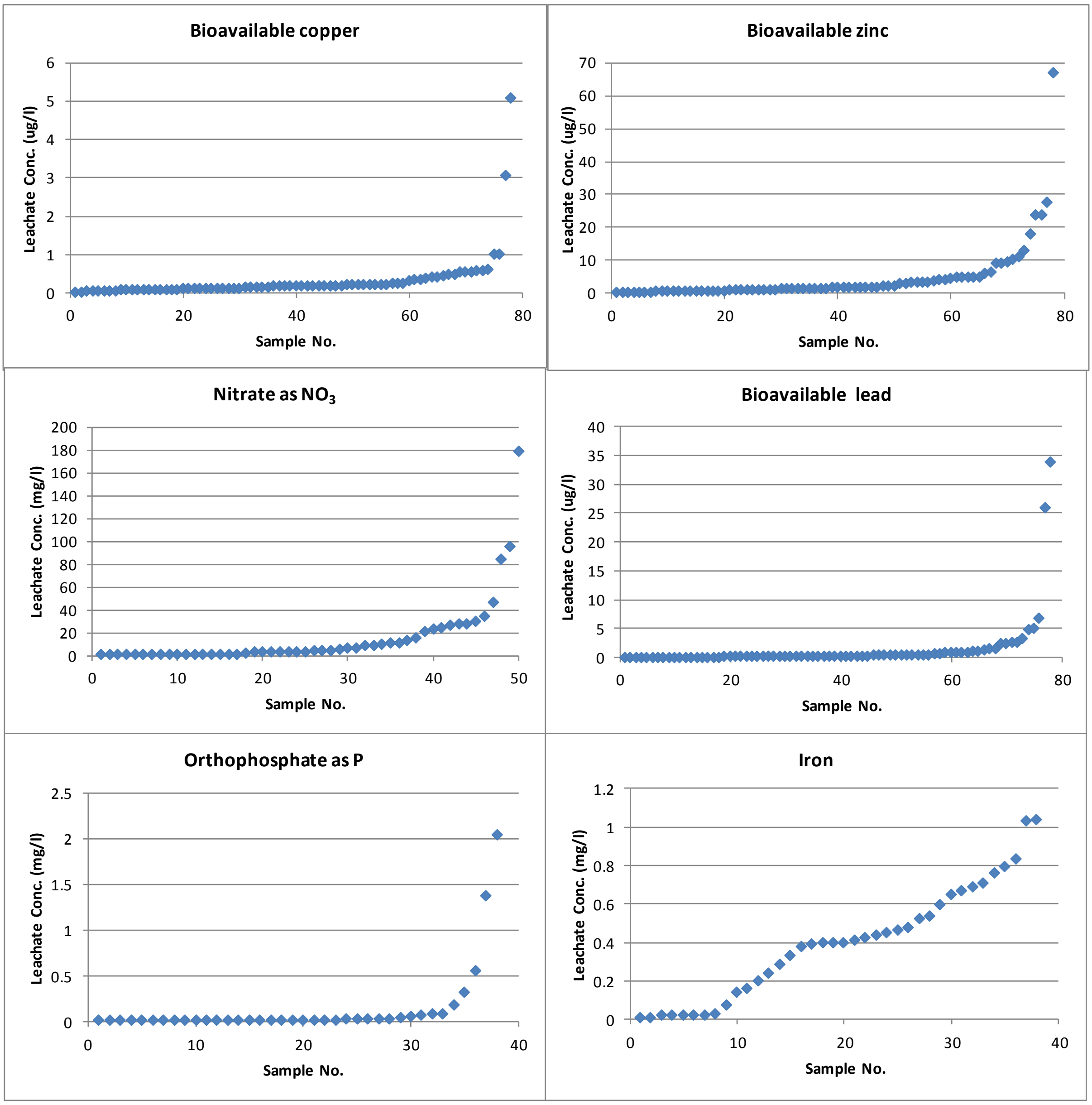
Surface water runoff discharge quality has been estimated from soil leaching tests undertaken as part of ground investigations. The construction works would involve stripping and temporary storage of near-surface soils (nominally defined as the top 0.3m although locally they may go deeper than this dependent on the soil quality) which would then be used to cover the landscape mounds and they would be vegetated. The rock forming the mounds is likely to be relatively inert in terms of leaching potential and, therefore, leaching data from soil samples taken near the surface have been used in the assessment. To ensure a sufficiently large data set and to consider the soils which would be near to the surface following the stripping of soils, data from samples taken from the top 0.5m of soils have been used. It should be noted that no attempt has been made to assign individual samples to each soil strip or landscape mound area and for the assessment it is assumed that the quality of each discharge would be the same.

Leachate testing has been undertaken in several phases of investigation at the site with the analytical schedule varying from investigation to investigation. This has resulted in different numbers of results for each substance. The testing has concentrated on the substances that are most likely to be present in soils so, for example, there are more tests for the principal toxic metals than there are for metals that are less likely to be present.

This methodology will produce a conservative assessment as the leaching tests, carried out under laboratory conditions, were only completed on topsoil, and this constitutes only a small part of the mounds, but is likely to be the most active in terms of leachability. The estimates are considered likely to overestimate the concentrations of substances that would leach from the in-situ mounds, particularly that portion resulting from contact with the more inert rock component. Additionally, it is likely that over time the concentrations of substances in the drainage water would reduce as soils become more compact and vegetation establishes itself on the bare soils such that percolation through the landscape mounds follows established flowpaths and there is less loose soil material on the surface to enter the suspended solids phase. Furthermore, as there is a finite amount of each substance in the soil within the mounds, the concentrations of substances in the dissolved phase are likely to reduce over time as the more easily leached material is removed.

Figure 4.2 shows the distribution of results for the topsoil leaching tests for selected metals and orthophosphate which have been identified later in this report as being of most concern (results are ordered in increasing concentration). It can be seen that some of these data sets have outliers. However, in line with the H1 assessment methodology the arithmetic mean value for all leachate concentrations has been used even though in some cases extreme values are creating bias in the mean (arithmetic mean values are heavily influenced by extreme values). Furthermore, and in line with the H1 methodology, where a value is detected below the limit of detection (LoD), the data used to calculate the mean uses the detection limit value in the calculation (for example, if a leachate concentration is reported as <1μg/l, then a value of 1μg/l has been used in calculating the mean). This can result in an overly conservative assessment and is considered further in the “clean-up” of data following presentation of the screening assessment.

Figure 4.2 Distribution of leachate results for selected dissolved metals, nitrate and orthophosphate



A summary of the potential discharge quality data used in the H1 assessment is provided in appendix A. The assessment has been undertaken for substances including metals (including bioavailable metals where relevant), inorganic ionic substances, and organic compounds associated with fuels (polycyclic aromatic hydrocarbons (PAHs) and total petroleum hydrocarbons (TPHs)). Only those substances where concentrations above the LoD have been detected in one or more leachate sample are considered. Figure A1 (in Appendix A) shows the location of soil sampling points which have been used to determine the discharge concentration, although it should be noted that not all samples were tested for all determinands. The sample set includes samples which have been taken from areas which have been identified as “Areas of Potential Concern” (APCs) where concentrations of certain substances may be higher (for details of the APCs see Application Main Site D7 – Soils and Geology (Application Reference Number: 6.4.7)).

For certain metals, the EQS is set as a “bioavailable” metal which cannot be directly analysed. For estimating the concentration of bioavailable metals in the discharge, the concentration has been calculated using the WFD UK Technical Advisory Group (UKTAG) m-bat spreadsheets [RD6]. Where leaching tests measured the pH, dissolved organic carbon (DOC) and calcium concentrations (which are the parameters required to calculate the bioavailable metals along with the dissolved metal concentration) these have been used to calculate the bioavailable metal in the leachate. However, not all of the leaching tests measured all of these parameters and in this case the average values recorded in surface waters has been used to calculate the bioavailable metals that may be present in the discharge.

As noted earlier, the use of a coagulant to aid the settlement of suspended solids within the drainage discharge has been considered. “Jar tests” have been undertaken to determine the likely settlement rate for solids and what the final suspended solids concentration in the discharge from each settlement pond could be. These tests have involved the use of alternative coagulants to aid settlement and assess if such treatment is required to ensure the required suspended solids concentrations are met in the discharges. The assessment of the jar tests does indicate that treatment would be required in order to achieve the suspended solids concentration specified in the project design.

An anionic or non-ionic polyelectrolyte would be used in the treatment system and the jar tests have been used to estimate the concentration of dissolved substances this may generate in the discharge, i.e. derived from the polyelectrolyte itself (referred to as “carry over”). These tests are reported in [RD7] and the results summarised in table 4.4. The results show that the carry-over of dissolved major ions associated with the use of these polyelectrolyte coagulants is relatively low and typically plus or minus a few mg/l. The polyelectrolyte dosage used in these tests ranged from 2 to 12 mg/l, considerably more than the 0.5 to 1 mg/l dosage that is proposed to be used in the drainage system (appendix D8-8) (Application Reference Number: 6.4.33). Each discharge point would have its own dosing infrastructure. The proposed polyelectrolyte dosing would also be intermittent, applied only when required. Consequently, as these are not substances of particular concern in the drainage discharges and as the potential carry over is very small, they do not affect the H1 assessment. However, the polyelectrolyte itself has been included in the H1 assessment. In the absence of a specific evaluation of potential dosage rates and durations, the maximum proposed dosage rate of 1 mg/l as a continuous discharge has been assumed.

Table 4.4 Dissolved carry over concentrations from polyelectrolyte jar tests

Substance	Potential change in discharge (mg/l)
Alkalinity (as $CaCO_3$)	0 to -10
Calcium	1 to 2
Magnesium	0.5 to 1
Sodium	2 to 5
Potassium	0 to -0.2
Chloride	0 to -2
Nitrate	2.2 to -2.4
Sulphate	3 to -4.8

To assess potential TPH levels, the analysis carried out on leachate samples involved speciation of the TPH to identify carbon chain length and split of aromatic and aliphatic compounds. TPH compounds were detected in four leachate samples and in this assessment the total aromatic and aliphatic concentration is used rather than assessing each individual class.

Whilst it is normal that for assessing short term impacts in the H1 methodology for comparison to MACs the maximum discharge concentration would be used, this really only applies where there is time series rather than spatial data. The data used for this assessment are spatially distributed so the maximum concentration for each substance derived from the leaching tests only relates to soils from that specific location and does not suggest that this value could occur at all other locations. The soils that will be placed in any particular area will be a mixture, potentially from across the Wylfa Newydd Development Area, and it is highly unlikely that soils which produced the maximum leachate concentration would be placed in isolation and so result in the maximum leachate concentration in the discharge. Furthermore, for short-term effects it is unlikely that the dissolved phase concentration would increase with a higher discharge rate (the maximum discharge rate is used for assessing short term effects). Indeed, it is more likely that at times of higher flow the concentration would decrease as there would be a higher proportion of surface runoff which has not percolated through the landscape mounds and a shorter contact time between the soil and percolating water. Therefore, in assessing the short-term effects for comparison to the MACs, the mean leachate concentration has been used which is considered to be the maximum conceivable concentration at times of high flow.

Groundwater dewatering discharge quality for the construction site excavations has been based on groundwater quality sampling carried out during on-site pumping tests as detailed in [RD4] and [RD5]. These tests were carried out in the area in which dewatering would take place and so are considered likely to reflect the water quality of the dewatering discharge. A summary of the potential dewatering discharge quality data is provided in appendix A.

Groundwater dewatering associated with construction of the outfall tunnel would take place in an area expected to reflect normal background groundwater quality. TPH contamination has been reported in this area historically, however recent groundwater sampling has not identified any significant concentrations of hydrocarbons in the area of the proposed outfall tunnel (all results from this area were below the level of detection in the August 2017 sampling round as detailed in appendix D8-3 (groundwater baseline report) (Application Reference Number: 6.4.28)). Any free-phase hydrocarbon contamination identified would be removed prior to discharge to the marine environment. Consequently, the dewatering of the tunnel would not result in any marine EQS breach

The expected discharge quality for the output from the construction site sewage plant is reported in [RD8]. This discharge is considered further in section 5.4 of this report.

4.4 Sources of data for the receiving watercourses

In relation to the watercourses which the discharges enter, required data relate to quantity and quality of the surface water in the Nant Cemaes, the Afon Cafnan and tributary and flows into and out of the Tre'r Gof SSSI. Data sources for these are outlined below.

4.4.1 Surface water flow rates

For Tests 2 to 4 of the H1 screening assessment, dilution in the receiving water is taken into account. To measure surface water flow rates, flumes have been installed on the inflows and the outflow of the Tre'r Gof SSSI and on Nant Caerdegog Isaf, the Afon Cafnan tributary. Spot gauging of flows on other watercourses has also been undertaken, although data are limited for many locations. Details are provided in appendix D8-1 (surface water baseline report) (Application Reference Number: 6.4.26) To supplement the measured surface water flows, the catchments have been modelled using the 4R model as detailed in appendix D8-7 (Application Reference Number: 6.4.32) in order to estimate flows during the construction phase. The model predicts the daily average flow at a point upstream of each discharge point based on a simulation using rainfall and associated meteorological data for the period 1960 to 2016.

In line with the H1 guidance, the dilution needs to be considered in the low flow (Q_{95}) conditions. The 4R model output, which is based on a 56 year time period, has therefore been used to provide an estimate of the Q_{95} flow at a point immediately upstream of the discharge point (where these are to a watercourse) or to assess the total flows into the Tre'r Gof SSSI. Flow rates used for the watercourse flows at each discharge point are shown in table 4.6.

Table 4.6 Receiving water flow rates (Q_{95}) used in the H1 assessment

Drainage discharge point (outfall)	Surface water flow rate upstream of discharge point (m^3/s)
A1	0.0005
A3	0.0027
B1	0.00003
C1	0.00042
D1	0.0174
D2	0.0176
E2 (from E1)	0.0180
E2	0.0177

4.4.2 Surface water quality

Surface waters have been and are continuing to be monitored for quality (although not for all determinands are used in the H1 assessment) with samples having been collected from watercourses around the Wylfa Newydd Development Area on a quarterly basis in 2013 and 2014 and more recently on a monthly basis. In addition, continuous recording of turbidity, pH, dissolved oxygen, temperature and electrical conductivity is undertaken on the Nant Caerdegog Isaf. This monitoring is reported in appendix D8-1 (Application Reference Number: 6.4.26).

Surface water quality data have been collected from spot measurements on the watercourses at or close to the various discharge points. As these are to be new discharges, results from samples collected from downstream of the proposed discharge points are also valid for establishing the existing baseline. Existing surface water quality data are shown in appendix B for the relevant discharge points.

For those metals for which the EQS is set as a bioavailable metal, the WFD UKTAG m-bat spreadsheets [RD6] have been used to estimate the concentration of the bioavailable metal. Where the dissolved organic carbon (DOC) measurement has been made, the actual recorded DOC for that sample location has been used to calculate the bioavailable concentration. If the DOC was not recorded with the sample, then the average recorded DOC concentration for all surface waters of 8.6mg/l was used. A similar approach was adopted for the other determinands required to estimate the bioavailable metal (calcium and pH) with an average value for calcium being 45 mg/l and an average pH of 7.3.

In line with the H1 guidance, where a substance has not been tested in the surface water, a value of 10% of the EQS is assumed as the upstream water quality. This assumes that as the discharges are to watercourses within a rural area, there are no other polluting discharges to the watercourse upstream of the discharge point (for those parameters which are tested, the analysis would indicate an un-contaminated stream).

4.5 Water quality standards

The water quality standards used for the assessment are primarily the EQSs provided in guidance on undertaking surface water impact assessments published by the Environment Agency on the UK Government's website [RD2]. Values applicable to freshwater and marine waters have been used where they are available.

Where an EQS is not provided in the above document, then values as shown in the Environment Agency's Chemical Standards Database [RD9] have been used. These are based on other legislative drivers, some of which are now repealed such as the Freshwater Fish Directive (which has been replaced by the requirements of the WFD). If a standard is not available from either of the above sources, then a predicted no effect concentration (PNEC) value has been used as referenced in appendix C.

Where relevant, AA and 95th percentile/MAC values have been used to assess the potential significance of long-term and short-term effects respectively. The water quality standards used for this assessment are shown in appendix C. For polyelectrolytes, the EQS provided in NRW guidance [RD3] has been used.

5. Results of Screening Assessment

5.1 Results of freshwater screening assessment

The results of the screening assessment for freshwaters where there is an EQS or PNEC are presented in appendix D. Tables 5.1 and 5.2 summarise the results (as presented in appendix D) for the four tests for the Part A assessment, for the long-term and short-term assessments respectively. These tables record failures (Y) or passes (N) of the tests summarised across all assessed discharge points. All failures are highlighted yellow.

Table 5.1 Results of surface water runoff tests for long-term freshwater assessment

Substance	Test 1	Test 2*	Test 3*	Test 4*
	Is discharge concentration > 10% of AA EQS?	Test 2 - Is PC > 4% of AA EQS?	Is difference between upstream concentration and PEC >10% of AA EQS?	Is PEC > AA EQS?
Inorganics				
Chloride	N			
Sulphate	N			
Ammoniacal nitrogen	Y	Y	N	N
Phosphate (orthophosphate as P)	Y	Y	Y	Y
Nitrate (as NO_3)	Y	Y	Y	N
Metals				
Antimony	N			
Arsenic	N			
Boron	N			
Cadmium	Y	Y	Y	Y
Cobalt	Y	Y	Y	N
Copper (bioavailable)	Y	Y	Y	N
Chromium (III)	Y	Y	Y	N
Iron	Y	Y	Y	N
Lead (bioavailable)	Y	Y	Y	Y
Manganese (bioavailable)	Y	Y	N	N
Molybdenum	N			
Nickel (bioavailable)	N			
Selenium (dissolved)	Y	Y	Y	N
Vanadium	N			
Zinc (bioavailable)	Y	Y	Y	N
Organics				
Anionic Polyelectrolyte	Y	Y	Y	N
Total petroleum hydrocarbons	N			
Anthracene	Y	Y	Y	N
Benzo(a)pyrene	Y	Y	Y	Y
Fluoranthene	Y	Y	Y	Y
Naphthalene	N			
Phenol	Y	Y	Y	N

*Tests 2, 3 and 4 apply to individual discharges. A "Y" in a yellow shaded box in the above table indicates that a test was exceeded in one or more discharge. Substances in bold show where the substance fails both Test 1 and Test 2 and either Test 3 or Test 4, indicating modelling assessment is required for that substance.

Table 5.2 Results of surface water runoff tests for short-term freshwater assessment

Substance	Test 1	Test 2*	Test 3*	Test 4^
	Is discharge concentration > 10% of MAC EQS?	Test 2 - Is PC > 4% of MAC EQS?	Is difference between u/s conc and PEC >10% of MAC EQS?	Is PEC > MAC EQS?
Metals				
Cadmium	Y	Y	Y	N
Cobalt	N			
Chromium (III)	N			
Lead (dissolved)	Y	Y	Y	N
Mercury	Y	Y	Y	Y
Nickel (dissolved)	N			
Organics				
Anthracene	Y	Y	Y	N
Benzo(a)pyrene	N			
Benzo(b)fluoranthene	Y	Y	Y	Y
Benzo(k)fluoranthene	Y	Y	Y	Y
Benzo(g,h,i)-perylene	Y	Y	Y	Y
Fluoranthene	Y	Y	Y	N
Naphthalene	N			
Phenol	N			

*Tests 2, 3 and 4 apply to individual discharges. A "Y" in a yellow shaded box in the above table indicates that a test was exceeded in one or more discharges. Substances in bold show where the substance fails both Test 1 and Test 2 and either Test 3 or Test 4, indicating modelling assessment may be required for that substance, following clean-up of data.

The results show that for the substances in bold in tables 5.1 and 5.2, the effects to the receiving waters are potentially significant and further assessment of the substances is required. This modelling assessment is provided in section 6.

5.2 Results of marine screening assessment

5.2.1 Test 1

For marine waters, Test 1 compares the discharge concentration to the marine water EQS and if the concentration of the substance in the discharge is less than the EQS then the impact of that substance can be considered as insignificant. The calculations from Test 1 for marine waters are presented in appendix D (Table 1 for surface water runoff and Table 5 for groundwater dewatering discharge) and show that the predicted discharge concentrations are in excess of the EQS for a small number of substances as summarised in table 5.3 for surface water runoff and table 5.4 for groundwater dewatering discharge.

Table 5.3 Results of surface water runoff long-term and short-term Test 1 for marine waters

Substance	Test 1 – Long-term Is discharge concentration > 100% of AA EQS?	Test 1 – Short-term Is discharge concentration > 100% of MAC EQS?
Anionic Polyelectrolyte	N	
Metals		
Antimony	N	
Arsenic	N	
Boron	N	
Cadmium	Y	
Cobalt	N	N
Copper (dissolved)	Y	
Iron	N	
Lead (dissolved)	Y	N
Mercury		Y
Molybdenum	N	
Nickel (dissolved)	N	N
Selenium (dissolved)	N	
Vanadium	N	
Zinc (dissolved)	Y	
Organics		
Total petroleum hydrocarbons	N	
Anthracene	N	N
Benzo(a)pyrene	Y	N
Benzo(b)fluoranthene		Y
Benzo(k)fluoranthene		Y
Benzo(g,h,i)-perylene		Y
Fluoranthene	Y	N
Naphthalene	N	N
Phenol	N	N

A "Y" in a yellow shaded box in the above table indicates that a test was exceeded in one or more discharges. Substances in bold show where the substance fails Test 1 indicating modelling assessment may be required for that substance, following clean-up of data

Table 5.4 Results of groundwater dewatering discharge long-term and short-term Test 1 for marine waters

Substance	Test 1 – Long-term Is discharge concentration > 100% of AA EQS?	Test 1 – Short-term Is discharge concentration > 100% of MAC EQS?
Cyanide^	Y	Y
Metals		
Arsenic	N	
Boron	N	
Cadmium	N	
Copper (dissolved)	N	
Chromium (VI)*	Y	Y
Iron	N	
Lead (dissolved)	N	N
Mercury		N
Nickel (dissolved)	Y	N
Selenium (dissolved)	N	
Vanadium	N	
Zinc (dissolved)	Y	
Organics		
Anionic Polyelectrolyte	N	
Total petroleum hydrocarbons	N	
Anthracene	Y	Y
Benzo(a)pyrene	Y	Y
Benzo(b)fluoranthene		Y
Benzo(k)fluoranthene		Y
Benzo(g,h,i)-perylene		Y
Fluoranthene	Y	Y
Naphthalene	N	N
Phenol	N	N

Substances in bold show where the substance fails Test 1 indicating modelling assessment is required for that substance.

^ For cyanide, all sample results were below the level of detection of 5µg/l or 10µg/l. The marine AA EQS for cyanide is 1µg/l and the MAC is 5µg/l. However, detection limits for cyanide lower than 5µg/l are not available at commercial laboratories. Cyanide has not been identified in ground investigations as a contaminant of concern.

* For chromium (VI), the detection limit exceeds the EQS. However, in groundwater due to the redox conditions, the chromium (III) ion predominates with little or no Chromium (VI). The groundwater analysis shows very low concentrations of dissolved chromium (a maximum of 7µg/l with 23 of the 25 samples having concentrations below the limit of detection of 1µg/l) and as such the chromium (VI) concentration is very likely to be below the marine AA EQS for chromium (VI) of 0.6µg/l and will be below the MAC of 32µg/l.

The results show that for the substances in bold in table 5.3 and table 5.4 the effects to the receiving waters are potentially significant and further assessment of the substances is required in accordance with the further tests in the H1 guidance for marine waters.

For inorganic substances that are likely to be in the groundwater discharge and for which there is no published EQS or PNEC, the concentrations of sulphate and chloride are such that the concentration will be significantly below the natural concentrations in sea water (Table 5.5). For other determinands the concentration in the groundwater is in excess of the concentration that has been typically recorded in the sea water off Wylfa Head, although as noted later in this report there will be rapid mixing of discharges in a relatively small mixing zone.

Table 5.5 Inorganic concentrations in groundwater compared to typical values for sea water (all results as mg/l)

Substance	Concentration in groundwater*	Typical sea water concentration/ values sampled off Wylfa Head	Data source
Chloride	52.44	19,400	http://www.seafriends.org.nz/oceano/seawater.htm
Sulphate	30	2,650	http://www.wcponline.com/2005/01/31/water-desalination-processes-associated-health-environmental-issues/ and from baseline data collected at Wylfa between May 2010 and November 2014
Phosphorous (total dissolved)	0.025	0.02	From baseline data collected at Wylfa between May 2010 and November 2014
Ammoniacal nitrogen (as NH_4)	0.032	0.02 or less	From baseline data collected at Wylfa between May 2010 and October 2013
Nitrate (as NO_3)	3.5	0.44	From baseline data collected at Wylfa between May 2010 and November 2014
Total nitrogen^	0.81	0.1 or less	From baseline data collected at Wylfa between May 2010 and November 2014

* Mean values with the detection limit used to calculate the mean value where required
^ For groundwater TN = sum of ammoniacal nitrogen and nitrate expressed as N. For the marine samples the analysis also included total organic nitrogen.

5.2.2 Further tests for marine discharges

For substances that fail Test 1 for marine waters, a series of further tests are specified (as described in section 3 of this report). The results of these tests are outlined below with further assessment provided in appendix E.

Test 2 – Check whether the discharge is to the low water channel in an estuary:

This does not apply to the assessed discharges.

Test 3 - Check whether the discharge is to a location with restricted dilution or dispersion

This is considered not to apply to the assessed discharges.

Test 4 - Check whether the discharge point is located less than 50m offshore from chart datum, or is located less than 1m below chart datum

This applies to all discharges and consequently all require further assessment of the identified substances by modelling.

Test 5 – Check if the effective volume flux of the discharge is within allowable limits

The further assessment of these substances by modelling is described in section 6.

5.3 Priority hazardous pollutants screening

The priority hazardous pollutants screening test calculates the annual loads discharged from each discharge point for the 13 designated priority hazardous substances shown in appendix F and compares the load to prescribed limits. Calculation of the loads for the discharges is shown in Table 1 of appendix F and shows that for substances which have been tested in leachate and groundwater samples, the substances do not exceed the prescribed limit and that the total discharge loads for the site do not exceed the prescribed limits.

For those substances where the chemical was tested in the DOnGI investigation in soils or leachate but was not detected in any sample, the load for that chemical has not been estimated as the concentrations in the discharge (if present at all) would be very low with subsequent low loads. For those determinands which have not been tested, the hazardous substances are of industrial origin and given the historical land use of the Wylfa Newydd Development Area and absence of other substances of similar origin, they are very unlikely to be present in the soils or subsequent leachate from the soils.

5.4 Construction site sewage discharge

Treated effluent from the on-site package sewage treatment plant would be discharged direct to sea from the tip of the western breakwater (CSD) in the north of Porth-y-pistyll. This discharge is distinct in character from the other surface water and dewatering discharges in that it is not driven by rainfall but by the number of workers on site and so, and in line with the H1 guidance, a separate assessment has been undertaken. The following information has been identified.

The package treatment plant maximum flow would be 990m^3/d, which includes a 10% headroom allowance. Maximum instantaneous flow would be 11.5l/s. Secondary treatment has been assumed, with a discharge quality standard of 20mg/l:30mg/l:20mg/l (BOD:Suspended Soilds:Ammoniacal Nitrogen), which reflects the effluent discharge standard at the existing Cemaes WwTW.

Only ammonia has been assessed in the sewage effluent. Unionised ammonia concentrations depend on the equilibrium between the ammonium ion (NH_4^+) and unionised ammonia (NH_3). The position of the equilibrium is affected by temperature, pH and salinity. The value for ammoniacal nitrogen would always be greater than the unionised ammonia fraction. The ammoniacal nitrogen concentrations following conventional treatment and after initial dilution would be 0.016mg/l (as N) as an Annual Average (AA) and represent a worst case. This falls below the long-term (mean) EQS for coastal waters of 0.021mg/l. Although the latter is for NH_3-N (un-ionised), as the concentration expressed as NH_4-N would be greater than when expressed as NH_3-N, the concentration after treatment would be below the EQS.

This therefore meets the required standards and would not affect water quality in coastal WFD water bodies. Assuming a worst case temperature (maximum from baseline was 16.7ºC), maximum pH (8.3) and salinity (34) the combined total ammonia concentration (baseline of <0.021mg/l plus the process contribution of 0.016mg/l as a worst case) would result in a non-ionised ammonia concentration after initial dilution of <1.57µg/l which is well inside the EQS for coastal waters (21µg/l).

Dispersion modelling to understand potential effects related to bacteria and suspended solids has been undertaken assuming a worst case flow of 18.5l/s. Details are provided in appendix D13-8 (hydrodynamic modelling) (Application Reference Number: 6.4.90).

6. Clean-up of data and modelling test results

6.1 Introduction

The H1 guidance identifies that following the screening tests, any substances which are identified in screening as being potentially significant need to be assessed (modelled) in more detail using 'cleaned-up' data. Following the modelling assessment, the results will show whether the discharges will cause pollution or not. If the modelling tests show that the discharge could cause pollution then the discharge would be controlled in the permit or, if the impact on the environment is unacceptable, a permit for a discharge of that substance may not be issued.

The methodology set out in H1 guidance has been used for the required clean-up of data. Following this methodology, the raw sample data used in the screening assessment need to be further assessed and 'cleaned up' by:

- checking whether the discharge is truly liable to contain a substance; and
- checking that the data are truly 'fit for purpose'.

6.2 Clean-up of data

6.2.1 Discharges 'liable to contain' substances

The initial stage of the clean-up of the input data checks whether the discharge is truly liable to contain a substance. A substance may have been carried through to modelling even though it was not really detected in many of the discharge samples because the 'less than' values are taken at face value in the precautionary screening stage. The H1 guidance shows the minimum number of samples that are required to exceed the LoD to determine if the discharge is liable to contain a substance (table 6.1). If the required number of samples were reported above the LoD then clean-up of the data and modelling should be undertaken.

Table 6.1 Minimum number of samples required to exceed the limit of detection

Number of samples in assessment period	Minimum number of samples which need to be equal to or above the required LOD
12 to 14	4
15 to 20	5
21 to 27	6
28 to 34	7
35 to 41	8
42 to 48	9
49 to 56	10
57 to 63	11
64 to 71	12

For those determinands shown as being carried over to modelling in tables 5.1, 5.2, and 5.3, tables 6.2 and 6.3 identify the number of samples tested for each substance and how many samples exceeded the LoD and whether the discharge is liable to contain the substance based on the H1 guidance.

The results of the assessment show that for the surface water runoff (table 6.2), the discharges are not liable to contain PAHs and no further assessment has been undertaken for these substances. The assessment also shows that for cadmium, cobalt, mercury and selenium the number of measurements greater than the limit of detection is not significant in comparison to the total number of analyses, and these metals can therefore be excluded from further assessment.

Table 6.2 Assessment of whether the surface water runoff discharges are liable to contain a substance

Substance	Number of leaching test results	Number of results equal to or above the LoD	Is the discharge liable to contain the substance and further modelling needed?	Receiving water substance applies to: F – Freshwater M– Marine water (LT) long-term (ST) short-term
		Inorganics		
Orthophosphate (as P)	38	15	Y	F (LT)
Nitrate (as NO_3)	50	42	Y	F (LT)
		Metals		
Cadmium	76	5	N	
Cobalt	46	4	N	
Copper (bioavailable)	78	77	Y	F (LT)
Copper (dissolved)	78	77	Y	M (LT)
Chromium (III)	78	47	Y	F (LT)
Iron	38	32	Y	F (LT)
Lead (bioavailable)	48	34	Y	F (LT)
Lead (dissolved)	48	34	Y	F (ST) M (LT)
Mercury	46	2	N	
Selenium	46	0	N	
Zinc (bioavailable)	78	74	Y	F (LT)
Zinc (dissolved)	78	44	Y	M (LT)
		Organics		
Anthracene	48	3	N	
Benzo(a)pyrene	48	1	N	
Benzo(b)fluoranthene	48	2	N	
Benzo(k)fluoranthene	48	1	N	
Benzo(g,h,i)perylene	48	2	N	
Fluoranthene	48	2	N	
Phenol*	10	1	N	

* For phenol, only 10 samples were analysed rather than the minimum number of 12 shown in the H1 guidance. However, given that only one sample detected phenol (and this was only marginally above the limit of detection) and phenol has not been identified as a contaminant of concern in the contaminated land assessment or elsewhere, it is considered that the discharge is not liable to contain this substance.
Data taken from table A1 of appendix A.

For the groundwater dewatering (table 6.3), the assessment shows that the discharges are not liable to contain PAHs and no further assessment has been undertaken for these substances. The assessment also shows that for cyanide and chromium VI the number of measurements greater than the limit of detection is not significant in comparison to the total number of analyses, and these substances can therefore be excluded from further assessment.

Table 6.3 Assessment of whether the groundwater dewatering discharge is liable to contain a substance

Substance	Number of sample test results	Number of results equal to or above the LoD	Is the discharge liable to contain the substance and further modelling needed?	Receiving water substance applies to^: F – Freshwater M– Marine water (LT) long-term (ST) short-term
Cyanide*	23	0	N	
Metals				
Chromium (VI)*	23	0	N	
Nickel (dissolved)	25	20	Y	M (LT)
Zinc (dissolved)	25	25	Y	M (LT)
Organics				
Anthracene	25	1	N	
Benzo(a)pyrene	25	1	N	
Benzo(b)fluoranthene	25	1	N	
Benzo(k)fluoranthene	25	1	N	
Benzo(ghi)perylene	25	1	N	
Fluoranthene	25	4	N	

* For Cyanide and Chromium (VI) the LOD is greater than the EQS. However, these substances have not been identified as contaminants of concern in the contaminated land assessment and are considered not to require further assessment.
^ Groundwater is only discharged to marine waters

6.2.2 Assessing if the data are "fit for purpose"

Before using any chemical data in the modelling, the H1 guidance states that the discharge quality data set should be checked to ensure that it is representative of the discharge. In relation to the substances which may potentially be in the discharges from the surface water drainage settlement ponds, the following checks are relevant:

- determine if there are any outliers in the data; and
- adjust "less than" values by replacing results that are reported as "less than" with 50% of the LoD value.

Table 6.4 identifies the outliers and recalculated mean values using the new leaching test data sets for surface water runoff (including results corrected to 50% of the LoD). For orthophosphate, nitrate, copper (dissolved and bioavailable) and iron no outliers are identified and the mean values do not differ significantly from the value used in the screening assessment. For the others, outliers have been identified from a visual assessment of the data presented in figure 4.2 which has resulted in mean concentrations lower than the original mean (table 6.4). For the other determinands, where the change has only been to use half of the detection limit in the calculation of the mean, the means of the original and cleaned up data show very little difference. For polyelectrolyte, the concentration in the cleaned up data has not changed from the initial concentration as this is based on a theoretical value rather than leaching test results.

Table 6.4 Clean-up of surface water runoff data to allow for outliers and correction of LoDs

Substance	Outliers identified (location, depth and concentration)	Mean value used in screening (µg/l)	Mean value of cleaned-up data (µg/l)	Standard deviation of cleaned-up data (µg/l)
Inorganics				
Orthophosphate (as P)	None	138	133	396
Nitrate (as NO_3)	None	15,036	15,006	30,556
Metals				
Copper (bioavailable)	H1S17 (0 to 0.2m) 5.08µg/l XTP068 (0.5m) 3.07µg/l	0.4	0.3	0.2
Copper (dissolved)	None	9.3	9.3	7.0
Chromium (III)	PC7TP11 (0.5m) 25.0µg/l	2.02	1.52	1.35
Iron	None	395	394	294
Lead (bioavailable)	TP700/22 (0.4m) 26.0µg/l TP800/30 (0.5m) 33.8µg/l	1.4	0.7	1.2
Lead (dissolved)	TP700/22 (0.4m) 224µg/l TP800/30 (0.5m) 291µg/l	13.0	6.5	11.0
Zinc (bioavailable)	TP800/28 (0.5m) 66.6µg/l	4.4	3.6	5.4
Zinc (dissolved)	TP800/28 (0.5m) 218µg/l	14.1	11.4	13.3
Polyelectrolyte				
Anionic polyelectrolyte	None	1000	1000	0

Table 6.5 identifies the outliers and recalculated mean values for the groundwater dewatering data set for dewatering discharge (including results corrected to 50% of the LoD). Only one outlier was identified, this being for nickel. Although the range of recorded zinc values is quite large across the two pumping tests from which the data was derived, there are no obvious outliers. As such, the mean values of the cleaned up data do not differ significantly from the values used in the screening assessment.

Table 6.5 Clean-up of groundwater dewatering data to allow for outliers and correction of LoDs

Substance	Outliers identified (location and date)	Mean value used in screening (µg/l)	Mean value of cleaned-up data (µg/l)	Standard deviation of cleaned-up data (µg/l)
Metals				
Nickel (dissolved)	PW2 (23-Oct-15)	16.5	13.8	13.1
Zinc (dissolved)	None	38	38	34

6.3 Modelling of freshwater discharges

Modelling of discharges to freshwater has been carried out using the Monte Carlo RQP (River Quality Planning) software (version 2.5) provided by the Environment Agency [RD10]. The guidance associated with the model indicates that the modelling results should be assessed by the tests outlined below.

- **Test 1 - Risk to EQS**. This test assesses whether the proposed, or permitted, load could cause failure of the receiving water EQS.
- **Test 2 - Significant deterioration of receiving water quality**. This test determines whether the discharge causes downstream deterioration with the watercourse quality deteriorating by more than 10% of the EQS.

For the Afon Cafnan and the Nant Caerdegog Isaf where there would be consecutive discharges to the same watercourse (at points C1, D1, E2 (incl. E1), and D2) and the discharge concentrations are the same, the RQP modelling assessment has been applied at the most upstream discharge point (C1) as this is the point where there would be the greatest change in concentration as further downstream the concentrations in the receiving water would be impacted by the upstream discharge(s). The predicted environmental concentrations for the substances that require modelling assessment are similar at each point and at this point the upstream flow, and consequently dilution potential, is lowest and the greatest increase over natural background concentrations is expected.

The sources of data used in this modelling are shown in table 6.6 and the results of this modelling are presented in appendix G. The model has been used in both its “forward” and “backward” modes, the former to show the predicted surface water concentration at each outfall for the expected watercourse flow rates and concentrations and the latter to determine the concentrations in the discharge which would be needed to breach the EQS in the receiving watercourse. The model has assumed a positive correlation of 0.6 for the discharge flow rate and the upstream river flow rate as it is likely that both flows would be controlled by rainfall rates. Summary of the modelling results is shown in table 6.7 for Test 1 (exceedance of the EQS) and table 6.8 for Test 2 (10% deterioration of water quality downstream of the discharge). Table 6.7 also shows what limits would be required in order to protect the immediately receiving watercourse so that the EQS is not exceeded.

Table 6.6 Data sources used in the RQP modelling

Data	Data source	Reference
Outfall discharge flow rate (mean and standard deviation)	4R model (data from 1960 to 2013) using estimated daily discharge rates. Use of these data will not include the maximum flows from the extreme storm events which would last for less than one day.	Appendix D8-7 (Application Reference Number: 6.4.32)
Outfall discharge concentration (mean and standard deviation)	Cleaned up leachate data	Provided in this report
Upstream river flow rate (mean and Q_{95})	4R model (data from 1960 to 2013)	Appendix D8-7 (Application Reference Number: 6.4.32)
Upstream river quality (mean and standard deviation)	Monitoring provided in surface water baseline report	Appendix D8-1 (Application Reference Number: 6.4.26)
River quality target downstream of discharge	EQSs	See appendix C

Table 6.7 Summary of RQP model results (see appendix G for full results) – Test 1 Predicted concentration risk to EQS

Discharge Point	Substance	AA EQS (µg/l)	Mean predicted concentration in receiving stream (µg/l)	Mean discharge concentration required to ensure AA EQS in receiving stream is not breached (µg/l)
Annual average discharges				
B1 (Tre'r Gof - upstream)	Orthophosphate (as P)	78	**125**	80
	Copper (bioavailable)	1.0	0.23	1.1
	Chromium (III)	4.7	1.56	5.15
	Iron (dissolved)	1,000	367	1,129
	Lead (bioavailable)	1.2	0.60	1.4
	Anionic Polyelectrolyte	7,500	870	8,619
C1 (Nant Caerdegog Isaf - Afon Cafnan tributary)	Orthophosphate (as P)*	78	**107**	75
	Nitrate (as NO_3)	50,000	11,241	91,850
	Copper (bioavailable)	1.0	0.16	1.9
	Chromium (III)	4.7	1.42	8.1
	Lead (bioavailable)	1.2	0.35	2.4
	Zinc (bioavailable)	13.9	2.84	11.1
	Anionic Polyelectrolyte	7,500	497	15,078
A3 (Nant Cemaes)	Orthophosphate (as P)*	78	**84**	44
	Lead (bioavailable)	1.2	0.07	17
A1 (Tre'r Gof - downstream)	Orthophosphate (as P)	78	**103**	88
	Lead (bioavailable)	1.2	0.39	2.1
Discharge Point	**Substance**	**MAC EQS (µg/l)**	**95%ile predicted concentration in receiving stream (µg/l)**	**Mean discharge concentration required to ensure MAC EQS in receiving stream is not breached (µg/l)**
Short term discharges				
B1 (Tre'r Gof - upstream)	Lead (dissolved)	14.0	**21**	4.4
C1 (Nant Caerdegog Isaf - Afon Cafnan tributary)	Lead (dissolved)	14.0	13	7.0
A3 (Nant Cemaes)	Lead (dissolved)	14.0	3.9	49

Results in bold show exceedance of the EQS
* For these discharges the mean upstream orthophosphate concentration already exceeds the EQS. The mean discharge concentration required to ensure the AA EQS is not breached is effectively showing the concentration in the discharge that would be required to dilute the upstream concentration to the EQS in the receiving watercourse.

Test 1 of the assessment shows that for the majority of discharges and substances, the concentration in the discharge does not cause the AA EQS to be exceeded. However, for orthophosphate the AA EQS is exceeded in all catchments. However, in some cases the upstream concentration already exceeds the EQS. The modelling predicts that in all cases the average discharge concentration required in order for the EQS not to be breached is exceeded by the predicted discharge concentration from the leaching tests.

Dissolved lead concentrations in the discharges from outfall B1 (Tre'r Gof) also causes the predicted 95th percentile concentrations in the watercourse to exceed the MAC EQS for short term discharges.

Table 6.8 Summary of RQP model results – Test 2 Deterioration of receiving water quality

Discharge Point	Substance	AA EQS (µg/l)	Mean upstream quality (µg/l)	Upstream concentration + 10% of EQS (µg/l)	Mean predicted concentration in receiving stream (µg/l)
Annual average discharges					
B1 (Tre'r Gof - upstream)	Orthophosphate (as P)	78	62	70	**125**
	Copper (bioavailable)	1	0.05	0.15	**0.23**
	Chromium (III)	4.7	1.53	2.0	1.6
	Iron (dissolved)	1000	110	210	**367**
	Lead (bioavailable)	1.2	0.01	0.13	**0.60**
	Anionic Polyelectrolyte	7500	0	750	**870**
C1 (Nant Caerdegog Isaf - Afon Cafnan tributary)	Orthophosphate (as P)	78	80	88	**107**
	Nitrate (as NO_3)	50,000	6980	11980	11241
	Copper (bioavailable)	1	0.06	0.16	0.16
	Chromium (III)	4.7	1.27	1.7	1.4
	Lead (bioavailable)	1.2	0.01	0.13	**0.35**
	Zinc (bioavailable)	13.9	1.99	3.4	2.8
	Anionic Polyelectrolyte	7500	0	750	497
A3 (Nant Cemaes)	Orthophosphate (as P)	78	80	88	84
	Lead (bioavailable)	1.2	0.02	0.14	0.07
A1 (Tre'r Gof - downstream)	Orthophosphate (as P)	78	62	70	**103**
	Lead (bioavailable)	1.2	0.01	0.13	0.39
Discharge Point	**Substance**	**MAC EQS (µg/l)**	**Mean upstream quality (µg/l)**	**Upstream concentration + 10% of EQS (µg/l)**	**95%ile predicted concentration in receiving stream (µg/l)**
Short term discharges					
B1 (Tre'r Gof - upstream)	Lead (dissolved)	14.0	1.39	2.8	**21**
C1 (Nant Caerdegog Isaf - Afon Cafnan tributary)	Lead (dissolved)	14.0	1.39	2.8	13
A3 (Nant Cemaes)	Lead (dissolved)	14.0	1.27	2.7	3.9

Results in bold show where the predicted mean downstream concentration leads to deterioration of more than 10% of the EQS

For Test 2, the assessment shows that certain discharges do cause a deterioration of water quality of greater than 10% of the AA EQS. These are for orthophosphate, bioavailable copper, iron, bioavailable lead and polyelectrolyte at B1 (which ultimately discharges through Tre'r Gof SSSI); orthophosphate and bioavailable lead at C1 (Nant Caerdegog Isaf); orthophosphate at A1 (Tre'r Gof downstream) and the MAC for dissolved lead at B1 (compared to the 95%ile). In the case of the B1 discharge it should also be noted that (as discussed previously) the discharges are expected to pass though drainage channels within the Tre'r Gof SSSI with minimal interaction with the fen within the SSSI.

6.4 Modelling of marine discharges

6.4.1 Results from Test 1

The results of Test 1 indicated that there are substances which would be discharged into marine waters that will require further consideration. The relevant EQSs and predicted discharge concentrations are presented in table 6.9.

Table 6.9 Predicted discharge concentrations* into marine waters

Marine discharge / outfall point and receiving water	Discharge /outfall number and pathway to discharge point	Copper (dissolved) (µg/l)	Lead (dissolved) (µg/l)	Zinc (dissolved) (µg/l)	Nickel (dissolved) (µg/l)
EQS (Annual Average)		3.76	1.3	7.9	8.6
EQS (Maximum Allowable Concentration)		n/a	14	n/a	34
Surface water discharges					
1S - Cemaes Bay	A3 via Nant Cemaes	4.31	2.85	Not exceeded	Not exceeded
A2 – Cemaes Bay	A2 direct to sea	9.3	6.5	11	Not exceeded
2S - Porth y Wylfa	A1 and B1 via Tre'r Gof channel	9.25	6.50	11.40	Not exceeded
PB and PC (surface water) - Porth-y-pistyll (direct to sea)	PB/PC direct to sea	9.3	6.5	11	Not exceeded
3S – Porth-y-pistyll	C1, D1, D2 and E1 via Afon Cafnan	8.53	5.95	10.90	Not exceeded
Groundwater discharges					
PB and PC (groundwater) - Porth-y-pistyll (direct to sea)	PB/PC direct to sea	Not exceeded	Not exceeded	38	17

*Predicted discharge concentrations to the marine environment for the streams used the PEC were calculated from the freshwater H1 assessment undertaken in 2017 for the most downstream point of any particular watercourse. Groundwater discharge concentrations are as shown in appendix A, table 2.

6.4.2 Modelling methodology

Horizon developed a marine hydrodynamic model [RD11] to aid understanding of the potential influence of the structures and discharges associated with the Power Station on the marine environment during construction and operation. The model simulated the marine environment around the Wylfa Newydd Development Area and was used to predict the effects from discharges during construction on the surrounding waters. The model was based on the Dutch Continental Shelf Model, developed by Deltares, which included the Irish Sea and has been used extensively to model marine and coastal infrastructure developments. The model utilised bathymetric (depth of the seabed) data collected during targeted surveys and from marine charts. Model runs simulated one complete spring-neap tidal cycle and the values taken a proxy annual average which could be compared with the AA EQSs for each substance. Modelling was based on a worst case scenario which assumed the following:

- All discharges from sediment settlement ponds would occur at the same time. In reality the removal of topsoil, bulk earthworks, dewatering and mound creation would be phased and works would be carried out in different areas and times during construction across the Wylfa Newydd Development Area. In addition, once completed, or dormant, mounds would be grassed to limit sediment mobilisation.

- The predicted concentration at the point furthest downstream is the same as the concentration that would enter the sea. In reality for three of the five discharges there would be further dilution in the streams prior to reaching the sea. Only A2, PB and PC discharge directly into the sea.
- The modelling scenario used 1 in 2 year storm event, with a 1 in 30 year storm event (lasting for a duration of 24 hours) randomly assigned within the modelling period. The results and corresponding averages were then compared against an AA.

6.4.3 Modelling results

The assumed flows are presented in tables 6.10 to 6.18. Due to the unknown phasing of the works, the concentrations of individual discharges are presented in tables 6.10 to 6.18 which include instantaneous maxima and highest average concentrations of individual discharges as well as the area over which the average concentration is in exceedance of the AA EQS. However, even with discharges occurring in-combination, it is expected that there would be no significant difference in the mixing zones[1] for each metal.

The modelling outputs were as follows:

- For dissolved zinc the maximum concentration occurred at marine discharge point 2S (11.39µg/l) downstream of A1 and B1 via the Tre’r Gof channel. However, the zinc AA EQS was not exceeded for any of the discharges’ average concentrations in the receiving waters.
- For dissolved lead the maximum concentration also occurred at marine discharge point 2S (6.49µg/l) downstream of A1 and B1 via the Tre’r Gof channel. The dissolved lead AA EQS was exceeded by the average discharge concentration within four areas. These areas were in the proximity of discharges 1S, 2S, 3S and PB, with 3S having the largest mixing zone. The overall area exceeding the AA EQS totalled 10.10ha; see figure 6.1 and tables 6.10 to 6.18).
- For dissolved copper the maximum concentration also occurred at marine discharge point 2S (9.24µg/l) downstream of A1 and B1 via the Tre’r Gof channel. The dissolved copper AA EQS was exceeded by the average discharge concentration within an overall area of 0.42ha (within close proximity to discharge point 3S and PB).
- For dissolved nickel the maximum concentration occurred at PB (4.54µg/l). However, the nickel AA EQS was not exceeded for any of the discharges’ average or maximum concentrations in the receiving waters.

As a worst case, the maximum concentration data for each substance was compared against the corresponding AA EQS. For dissolved zinc, the AA EQS is exceeded by the maximum concentration data within an overall area of 2.01ha in the model. For dissolved lead, the AA EQS is exceeded by the maximum concentration data within an overall area of 31.05ha in the model. For dissolved copper, the AA EQS is exceeded by the maximum concentration data within an overall area of 11.96ha in the model.

[1] Under the EQS Directive, the mixing zone is “that part of a body of surface water restricted to the proximity of the discharge within which the Competent Authority is prepared to accept EQS exceedance, provided that it does not affect the compliance of the rest of the water body with the EQS”.

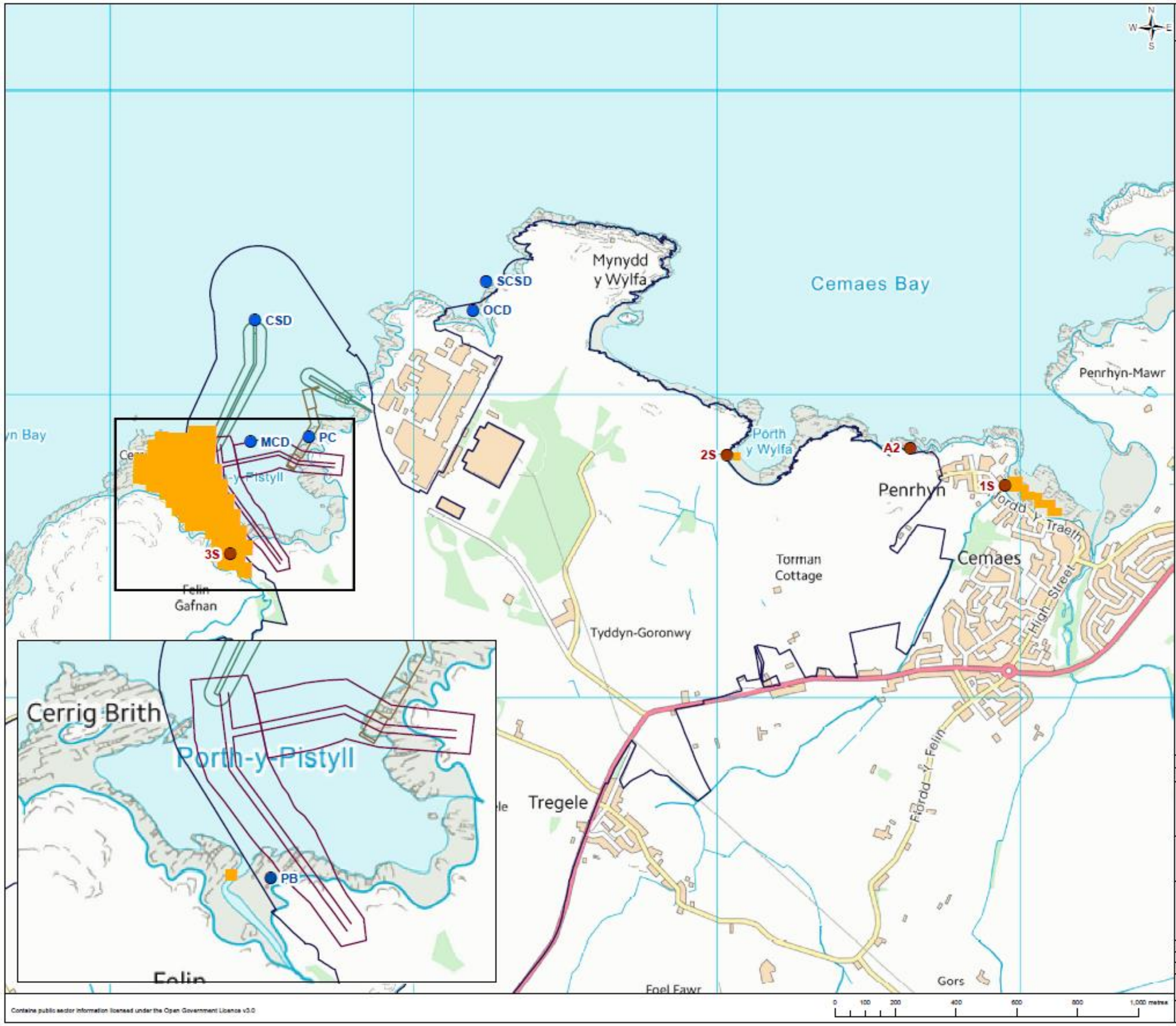


FIGURE 6-1

Legend

- Wylfa Newydd Development
- Breakwaters
- Marine off-loading facility
- Temporary cofferdam and causeway
- Marine outfall point
- Marine discharge point
- Predicted average lead concentration above EQS

Current EQS for lead is 1.3µg/l as annual average and 14µg/l as a maximum allowable concentration

Notes:
CSD: Construction sewage discharge
MCD: Main cofferdam dewatering
OCD: Outfall cofferdam dewatering
SCSD: Site campus sewage discharge (Dŵr Cymru Welsh Water)

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	FEB 18	Initial issue	VG	IL-E	MR	RB

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
CONSTRUCTION H1 ASSESSMENT

Drawing Title

PREDICTED DILUTION OF DISSOLVED LEAD
IN THE MARINE ENVIRONMENT AT SURFACE

Scale @ A3	1:12,000	DO NOT SCALE
Jacobs No.	60PO8083	
Client No.		

Drawing No.

60PO8083_HYD_REP_001_06_01

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Table 6.10 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for point 1S.*=model maximum output value at or above discharge concentration (likely to be an artefact of model processing).

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	6.99	7.9	6.99*	3.99	n/a
Lead	2.85	1.3	2.85*	1.62	0.69
Copper	4.31	3.76	4.31*	1.46	n/a
Nickel	1.35	8.6	1.35*	0.77	n/a
Assumed flow	**1.53m³/s (1:2yr flow)**				
Assumed flow	**2.85m³/s (1:30yr flow - 24hr only)**				

Table 6.11 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for point 2S.

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	11.40	7.9	11.39	2.38	n/a
Lead	6.50	1.3	6.49	1.36	0.05
Copper	9.25	3.76	9.24	1.93	n/a
Nickel	1.61	8.6	1.61	0.33	n/a
Assumed flow	**0.50m³/s (1:2yr flow)**				
Assumed flow	**0.80m³/s (1:30yr flow - 24hr only)**				

Table 6.12 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for point 3S. *=model maximum output value at or above discharge concentration (likely to be an artefact of model processing).

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	10.90	7.9	10.90*	6.1	n/a
Lead	5.95	1.3	5.95*	3.33	9.31
Copper	8.53	3.76	8.53*	4.78	0.37
Nickel	1.58	8.6	1.58*	0.88	n/a
Assumed flow	**5.62m³/s (1:2yr flow)**				

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Assumed flow	7.83m³/s (1:30yr flow - 24hr only)				

Table 6.13 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for point A2.

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	11.4	7.9	0.06	0.01	n/a
Lead	6.45	1.3	0.03	0.01	n/a
Copper	9.3	3.76	0.05	0.01	n/a
Nickel	1.61	8.6	0.01	<0.01	n/a
Assumed flow	0.0009m³/s (Average flow)				
Assumed flow	0.146m³/s (1:30yr flow - 24hr only)				

Table 6.14 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for Main cofferdam discharge (GW only).

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	37.76	7.9	0.77	0.58	n/a
Lead	1	1.3	0.02	0.02	n/a
Copper	1.32	3.76	0.03	0.02	n/a
Nickel	16.52	8.6	0.34	0.25	n/a
Assumed flow	0.0023m³/s				

Table 6.15 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for point PBGW.

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	37.76	7.9	10.38	6.84	n/a

Lead	1	1.3	0.27	0.18	n/a
Copper	1.32	3.76	0.36	0.24	n/a
Nickel	16.52	8.6	4.54	3	n/a
Assumed flow	**0.0014m^3/s**				

Table 6.16 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for point PBSW.

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	11.4	7.9	11.19	No data	No data
Lead	6.45	1.3	6.33	4.18	0.053
Copper	9.3	3.76	9.13	6.03	0.053
Nickel	1.61	8.6	1.58	7.39	n/a
Assumed flow	**0.005m^3/s (average flow)**				
Assumed flow	**1.174m^3/s (1:30yr flow - 24hr only)**				

Table 6.17 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for point PCGW.

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	37.76	7.9	0.3	0.2	n/a
Lead	1	1.3	0.01	0.01	n/a
Copper	1.32	3.76	0.01	0.01	n/a
Nickel	16.52	8.6	0.13	0.09	n/a
Assumed flow	**0.0014m^3/s**				

Table 6.18 Discharge concentrations, annual average (AA) EQS, maximum and highest average concentration values and area of AA exceedance for point PCSW.

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Zinc	11.4	7.9	0.12	0.08	n/a
Lead	6.45	1.3	0.07	0.05	n/a
Copper	9.3	3.76	0.1	0.07	n/a

Contaminant	Discharge conc. (model input conc.)	AA EQS	Model outputs		
			Maximum conc.	Highest avg. conc.	Area of AA EQS exceedance (using avg. data)
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(ha)
Nickel	1.61	8.6	0.02	0.01	n/a
Assumed flow	**0.005m^3/s (average flow)**				
Assumed flow	**1.174m^3/s (1:30yr flow - 24hr only)**				

7. Summary

This report has been produced as an assessment of the effects of surface water discharges associated with construction work for the Wylfa Newydd Project. As these are discharges yet to be established, the potential effect has utilised data from leaching tests of shallow soils from the site, results of surface water monitoring, results of pumping tests and modelling results of surface water and drainage flows. This report has presented screening and modelling of potential effects to freshwater and marine waters so that NRW can determine appropriate discharge limits for the Environmental Permit.

The H1 assessment methodology does not deal with suspended solids and therefore does not provide information with which to consider limits for this parameter.

7.1 Effects on freshwaters

For freshwaters the screening assessment indicates that the effects of certain metals, orthophosphate, polyelectrolyte and PAHs are potentially significant and need to be considered further. These determinands have therefore been carried over to the modelling stage of the assessment.

Following an assessment of whether the discharges are liable to contain a substance and clean-up of data to adjust detection limits and removal of outliers, modelling of the discharges to freshwater has been undertaken for bioavailable copper, lead and zinc and dissolved chromium (III), iron, lead, orthophosphate, nitrate and polyelectrolyte. This further modelling was undertaken using the Monte Carlo RQP model which takes into account the distribution of flows and quality in the discharge and receiving water and calculates the probability of concentrations in the receiving watercourse exceeding a particular value.

The results of the RQP modelling predict that the annual average EQS for orthophosphate is likely to be exceeded in the receiving waters downstream of the discharges in all watercourses. However, in some cases the upstream concentration already exceeds the EQS and in these cases the discharge itself would not cause the breach of the EQS. No other annual average EQS are predicted to be exceeded.

For Test 2 of the modelling assessment, the RQP modelling predicts that the downstream quality may deteriorate by more than 10% of the AA EQS for orthophosphate, bioavailable copper, iron and bioavailable lead in the Tre’r Gof SSSI drains; orthophosphate and bioavailable lead in Nant Caerdegog Isaf; and orthophosphate at the Tre’r Gof SSSI discharge.

Anionic polyelectrolyte carry-over also potentially causes the downstream quality to deteriorate by slightly more than 10% of the AA EQS in the Tre’r Gof SSSI drains. However, this is based on a conservative assumption of continuous dosage at the maximum planned rate and takes no account of polyelectrolyte that would be lost through binding to suspended solids in the discharge and streams. Therefore polyelectrolyte is not expected to cause a deterioration of the EQS by more than 10% at the planned dosage rate.

With respect to exceedances of short-term EQSs, only lead shows as being potentially significant as identified from the screening assessment and clean-up of data. The RQP model output predicts that the 95th percentile concentration resulting from discharges at outfall B1 exceeds the short term MAC EQS for dissolved lead.

7.2 Effects on marine waters

Test 1 of the Phase 1 assessment (comparing predicted discharge concentrations to the marine EQS) identifies that certain metals and PAHs could potentially be discharged at significant concentrations. Following clean-up of the input data, it was determined that effects of the discharges on marine waters from dissolved copper, lead, zinc and nickel may be significant and required further modelling.

Modelling was carried out for copper, lead, nickel and zinc using the Delft3d model developed for the project. The modelling predicted all concentrations of dissolved nickel would be below the AA EQS. For copper, zinc and lead the predicted maximum concentrations are all above the relevant AA EQSs. The highest concentrations of these metals all occur at marine discharge point 2S, downstream of Tre-r Gof. However, the only average concentrations to exceed the AA EQS were for copper (at 3S and PB) and lead (at 1S, 2S, 3S and PB) . When interpreting the mixing zones areas, it should be borne in mind that the flow data reflects peak storm flows and therefore a worst case (i.e. representing an event rather than a sustained average flow).

The predicted mixing zones are therefore considered precautionary and would not persist in the long-term as soil stripping, earthworks, dewatering and mound creation would be carried out in different areas at different times across the Wylfa Newydd Development Area; with mounds being reseeded when left dormant or when work is complete, therefore reducing the leaching of substances from the soil (see section 13.6 in chapter D13 (the marine environment) (Application Reference Number: 6.4.13)). In addition, the predicted average data are based on extreme, high flow scenarios which would again constitute a worst case owing to the relatively high volumes discharged.

8. References

ID	Reference
RD1	https://naturalresources.wales/permits-and-permissions/environmental-permits/horizontal-guidance/?lang=en [accessed May 2017]
RD2	https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit [accessed May 2017]
RD3	Natural Resources Wales. 2014. How to comply with your Environmental Permit. Additional guidance for: Water Discharge and Groundwater (from point source) Activity Permits. EPR 7.01, Version 5.0, October 2014.
RD4	Structural Soils. 2016. *Interpretative report for Task Order 001 – PW1 Pump Test*. Structural Soils Limited, Report No. 70398, April 2016.
RD5	Structural Soils. 2016. *Interpretative report for Task Order 001 - PW2 Pump Test*. Structural Soils Limited, Report No. 70398, April 2016.
RD6	United Kingdom Technical Advisory Group (UKTAG). 2014. *River & Lake Assessment Method Specific Pollutants (Metals). Metal Bioavailability Assessment Tool (M-BAT).*
RD7	Structural Soils. 2016. Task Order 7: *SP&C Jar & Liquor Testing - Factual Report* on Laboratory Testing.
RD8	Amec Foster Wheeler. 2017, Main Site Construction Foul Water Design Report. WN0902-HZCON-EPT-REP-00001. A report for Horizon Nuclear Power.
RD9	http://evidence.environment-agency.gov.uk/ChemicalStandards/home.aspx [accessed May 2017]
RD10	Environment Agency. 2014. LIT 10419, *Modelling: surface water pollution risk assessment.*
RD11	Horizon. 2012. *Wylfa Hydrodynamic and Water Quality Modelling: Phase 2 model build, Calibration and Validation* (WYL-PD-PAC-REP-00015).

Appendices

Appendix A - Discharge Quality Data

Appendix A Table 1 - Surface water discharge concentrations

Substance	No. leaching test results used to calculate mean concentration	No. of results less than the limit of detection	Mean dissolved concentration from leaching tests in top 0.5m (ug/l)
Chloride	20	1	4780
Sulphate	38	12	17620
Suspended solids	n/a	n/a	0
Ammoniacal nitrogen	50	35	175
Phosphate (orthophosphate) as P	38	23	138
Nitrate (as NO3)	50	8	15036
Sodium	8	0	9130
Calcium	8	0	13710
Potassium	38	20	2840
Metals			
Antimony	2	0	7.5
Arsenic	48	32	1.67
Boron	76	18	24.81
Cadmium	76	71	0.59
Cobalt	46	42	1
Copper (dissolved)	78	1	9.26
Copper (bioavailable)	78	1	0.35
Chromium (III)	78	31	2.02
Iron	38	14	395
Lead (dissolved)	78	14	13
Lead (bioavailabe)	78	14	1.44
Magnesium	8	1	4
Manganese (dissolved)	64	2	62.4
Manganese (bioavailable)	64	2	20
Mercury	46	44	0.09
Molybdenum	26	20	1.46
Nickel (dissolved)	78	26	1.61
Nickel (bioavailable)	78	26	0.29
Selenium	46	46	1
Vanadium	20	13	1.20
Zinc (dissolved)	78	4	14.1
Zinc (bioavailable)	78	4	4.38
Organics			
Total petroleum hydrocarbons	46	42	13.7
Trichloroethene			0
Anthracene	48	45	0.023
Benzo(a)pyrene	48	47	0.021
Benzo(b)fluoranthene	48	46	0.021
Benzo(k)fluoranthene	48	47	0.02
Benzo(g,h,i)-perylene	48	46	0.028
Fluoranthene	48	46	0.02
Naphthalene	48	44	0.082
Phenol	10	9	2.2

Appendix A Table 2 - Groundwater discharge concentrations

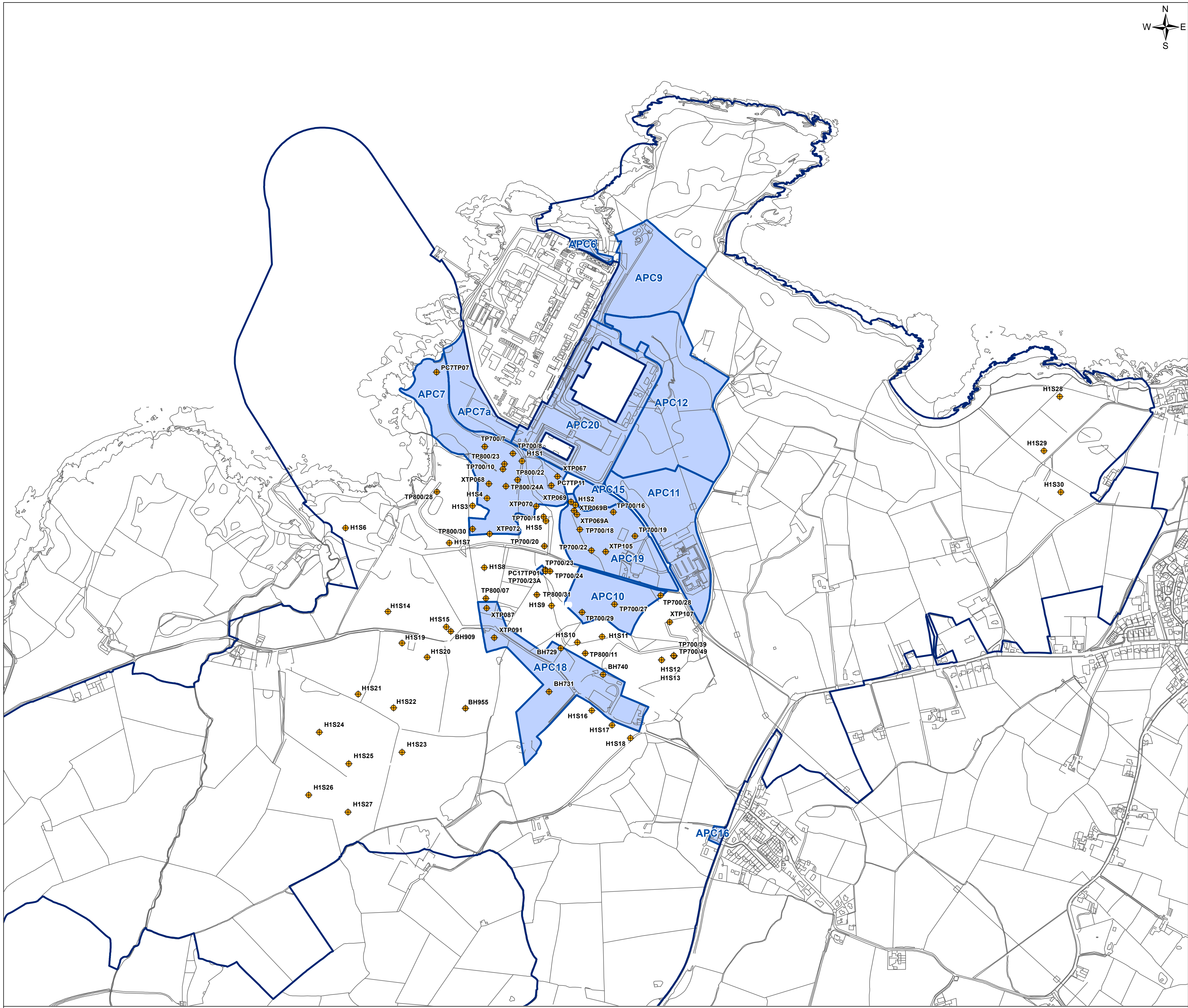
Substance	No. sample test results used to calculate mean concentration	No. of results less than the limit of detection	Mean concentration (ug/l)
Sulphate (w)	23	0	30348
Cyanide (total) (w)	23	23	6.304
Metals			
Arsenic (dissolved)	24	24	1.00
Boron (dissolved)	24	0	30.96
Cadmium dissolved 0.05ug/l)	24	24	0.05
Copper (dissolved)	25	15	1.32
Chromium (dissolved)	25	23	1.48
Chromium (VI)	23	23	52.17
Iron (dissolved)	24	12	36.13
Lead (dissolved)	25	25	1.00
Manganese (dissolved)	25	5	102
Mercury (dissolved 0.05ug/l)	25	25	0.05
Nickel (dissolved)	25	5	16.52
Selenium (dissolved)	25	25	1.00
Vanadium (dissolved)	23	22	1.00
Zinc (dissolved)	25	0	37.76
Organics			
TPH Total Dissolved >C6-C40	9	9	50.00
Anthracene (w)	25	24	0.61
Benzo(a)pyrene (w)	25	24	0.61
Benzo(b)fluoranthene (w)	25	24	0.61
Benzo(k)fluoranthene (w)	25	24	0.61
Benzo(ghi)perylene (w)	25	24	0.61
Fluoranthene (w)	25	21	0.61
Naphthalene (w)	25	13	0.64
Phenol	25	17	1.16
Hexachlorobenzene	25	25	1.00
Hexachlorobutadiene	25	25	1.00
Indeno(123-cd)pyrene (w)	25	24	0.61

PAH total		3.05

FIGURE A1

Legend

- Wylfa Newydd Development Area
- Location of leaching test result used in H1 Assessment
- Areas of Potential Concern



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
1.0	MAR 18	DCO submission	HNPWL	HNPWL	HNPWL	HNPWL

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL PERMIT

Drawing Title

CONSTRUCTION H1 ASSESSMENT
SOIL SAMPLE SITES AND AREAS OF POTENTIAL CONCERN

Scale @ A3	1:10,000	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		
Drawing No.	60PO8083_HYD_REP_001001	

Appendix B - Existing Surface Water Quality Data

Appendix B Table 1 - Background Freshwater Concentrations (all results rg/l)

Discharge point:			B1		C1, D1, E1, E2, D2		A2, WP1/2/3	A3		A1, SC1	
Freshwater monitoring point:	AA EQS (ug/l)	10% of AA EQS (ug/l)	Tre'r Gof		Afon Cafnan - Caerdegog Isaf		To sea	Nant Cemaes		Tre'r Gof	
			No. samples	Mean	No. samples	Mean		No. samples	Mean	No. samples	Mean
Inorganics											
Chloride	250000	25000	90	70720	87	48010	Discharges	27	49060	90	70720
Sulphate	400000	40000	67	30610	35	17190	direct to sea	11	35880	67	30610
Total Suspended Solids	n/a	n/a	91	523970	85	94730		27	15460	91	523970
Ammoniacal nitrogen as N	600	60	90	220	85	250		22	110	90	220
Phosphate (ortho) as P	78	7.8	61	62	70	80		21	83	61	62
Nitrate (as NO3)	50000	5000	67	13250	35	6980		11	9522	67	13250
Sodium (dissolved)			65	35360	38	26990		11	32240	65	35360
Calcium (dissolved)			77	44800	38	34360		11	67430	77	44800
Potassium (dissolved)			65	4240	38	3460		11	3560	65	4240
Metals											
Antimony	113	11.3		11.3	1	0.233		5	0.57		11.3
Arsenic (dissolved)	50	5	34	0.85	83	1.42		27	0.98	34	0.85
Boron	2000	200		200		200			200		200
Cadmium (dissolved)	0.09	0.009	34	0.10	83	0.13		27	0.10	34	0.10
Cobalt	3	0.3		0.30		0.30		5	0.16		0.30
Copper (dissolved)			34	1.59	83	2.49		27	2.16	34	1.59
Copper (bioavailable)	1	0.1	6	0.05	16	0.06		4	0.10	6	0.05
Chromium (dissolved)	4.7	0.47	22	1.53	83	1.27		27	1.21	22	1.53
Iron (dissolved)	1000	100	65	110.0	86	870		27	180.0	65	110.0
Lead (dissolved)			34	1.39	80	1.39		26	1.27	34	1.39
Lead (bioavailable)	1.2	0.12	6	0.01	16	0.010		3	0.02	6	0.01
Magnesium (dissolved)			65	10630	38	9200		11	19810	65	10630
Manganese (dissolved)			27	477.7	73	198.0		23	202.5	27	477.7
Manganese (bioavailable)	123	12.3	6	44.8	13	66.1		3	51.85	6	44.8
Mercury (dissolved)			23	0.01	83	0.01		27	0.01	23	0.01
Molybdenum	12700	1270		1270		1270			1270		1270
Nickel (dissolved)			34	1.01	80	1.33		26	1.24	34	1.01
Nickel (bioavailable)	4	0.4	6	0.25	13	0.33		3	0.37	6	0.25
Selenium (dissolved)	2	0.2	11	0.76	35	0.70		11	0.91	11	0.76
Vanadium	20	2		2		2			2		2
Zinc (dissolved)			34	6.99	82	6.78		27	5.08	34	6.99
Zinc (bioavailable)	13.9	1.39	6	4.18	16	1.99		4	1.07	6	4.18
Organics											
Total petroleum hydrocarbons	250	25		25		25			25		25
Anthracene	0.1	0.01		0.01		0.01			0.01		0.01
Benzo(a)pyrene	0.00017	0.000017		0.000017		0.000017			0.000017		0.000017
Benzo(b)fluoranthene	0.017	0.0017		0.0017		0.0017			0.0017		0.0017
Benzo(k)fluoranthene	0.017	0.0017		0.0017		0.0017			0.0017		0.0017
Benzo(g,h,i)-perylene	0.0082	0.00082		0.00082		0.00082			0.00082		0.00082
Fluoranthene	0.0063	0.00063		0.00063		0.00063			0.00063		0.00063
Naphthalene	2	0.2		0.20		0.20			0.20		0.20
Phenol (SVOC)	7.7	0.77	1	0.133	4	0.865			0.77	1	0.133

Data taken from Surface Water Baseline report (Application Reference Number: 6.4.26)

Shaded cells take 10% of EQS as no upstream data are available

Appendix C - Water Quality Standards Used in the H1 Assessment

Appendix C - EQSs used for H1 assessment

Substance	Freshwater (ug/l)		Marine (ug/l)		Source of EQS
	Long term	Short term	Long term	Short term	
Chloride	250000	NA	NA	NA	Dangerous Substances Directive
Sulphate	400000	NA	NA	NA	Dangerous Substances Directive
Ammoniacal nitrogen (as N)	600	NA	NA	NA	Water Framework Directive
Phosphorous (reactive as P)*	78	NA	NA	NA	Water Framework Directive
Nitrate (as NO_3)	50,000	NA	NA	NA	Nitrate Pollution Prevention (Wales) Regulations 2013/ Nitrates Directive. Standard for designation of nitrate pollution for fresh surface waters.
Anionic and Non-ionic Polylectrolytes	7500	NA	7500^	NA	National Resources Wales (2014) How to comply with your environmental permit. Additional guidance for: Water Discharge and Groundwater (from point source) Activity Permits. EPR 7.01, Version 5.0, October 2014.
Metals					
Antimony	113	NA	11.3	NA	Antimony PNEC from Arche, 2014. Position Paper on PBT Properties of Antimony
Arsenic	50	NA	25	NA	Water Framework Directive
Boron	2000	NA	7000	NA	Dangerous Substances Directive
Cadmium	0.09	0.6	0.2	0.6	Water Framework Directive
Cobalt	3	100	3	100	Dangerous Substances Directive
Copper (dissolved)	NA	NA	3.76	NA	Water Framework Directive
Copper (boiavailable)	1	NA	NA	NA	Water Framework Directive
Chromium	4.7	32	0.6	32	Freshwater EQS is from Water Framework Directive and for chromium (III). Marine water EQS is from Water Framework Directive and for chromium (VI)
Iron	1000	NA	1000	NA	Water Framework Directive
Lead (dissolved)	NA	14	1.3	14	Water Framework Directive
Lead (boiavailable)	1.2	NA	NA	NA	Water Framework Directive
Magnesium	NA	NA	NA	NA	No EQS or PNEC identified
Manganese (boiavailable)	123	NA	NA	NA	Water Framework Directive
Mercury	NA	0.07	NA	0.07	Water Framework Directive
Molybdenum	12,700	NA	1,920	NA	Arche, 2012. The Toxicity of Molybdate to Freshwater and Marine Organisms. II. Effects Assessment of Molybdate in the Aquatic Environment Under REACH
Nickel (dissolved)		34	8.6	34	Water Framework Directive
Nickel (boiavailable)	4	NA	NA	NA	Water Framework Directive
Selenium	2	NA	2	NA	Selenium PNEC from Sheppard et al, 2005. Ecotoxicological Probable- o- Effect Concentrations for Elements Related to Nuclear Waste (Australian Journal of Ecotoxicology, Vol 11)
Vanadium	20	NA	100	NA	Dangerous Substances Directive
Zinc (dissolved)	NA	NA	7.9	NA	Water Framework Directive
Zinc (boiavailable)	13.9	NA	NA	NA	Water Framework Directive
Organics					
Total petroleum hydrocarbons	250	NA	250	NA	Jacobs in-house assessment. The Freshwater Fish Directive refers to *"Petroleum products must not be present in the water in such quantities that they; a) form a visible film on the surface of the water of foam coatings on the beds of water courses and lakes; b) impart a detectable 'hydrocarbon' taste to fish; c) produce harmful effects on fish "*
Anthracene	0.1	0.1	0.1	0.1	Water Framework Directive
Benzo(a)pyrene	0.00017	0.27	0.00017	0.027	Water Framework Directive
Benzo(b)fluoranthene	NA	0.017	NA	0.017	Water Framework Directive for sum of benzo(b)fluoranthene and Benzo(k)fluoranthene
Benzo(k)fluoranthene	NA	0.017	NA	0.017	Water Framework Directive for sum of Benzo(b)fluoranthene and benzo(k)fluoranthene
Benzo(g,h,i)-perylene	NA	0.0082	NA	0.00082	Water Framework Directive for sum of benzo(g,h,i)-perylene and indeno(1,2,3-cd)-pyrene
Fluoranthene	0.0063	0.12	0.0063	0.12	Water Framework Directive
Naphthalene	2	130	2	130	Water Framework Directive
Phenol	7.7	46	7.7	46	Water Framework Directive

Notes for table:

NA - Non available

Dangerous Substances Directive: Council Directive on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (Dangerous Substances Directive) - List II substances (from Environment Agency Chemical Standards database)

Water Framework Directive - The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015

* Reactive phosphourous (orthophosphate) EQS is calculated from the equation given in the WFD Standards Directions using an elevation of 15mAOD and an alkalinity of 140mg/l

^ No marine EQS is available, therefore the freshwater value has been applied

Appendix D - H1 Assessment – Part A

Appendix D - Table 1 - Part A Test 1 Screening against EQSs

	Concentration used for long term assessment*	Concentration used for short term assessment*					Freshwater Test 1				Marine Test 1	
	Mean Discharge	Mean Discharge	Freshwater EQS (ug/l)**		10% of freshwater	10% of freshwater	Is discharge conc	Is discharge conc >	Marine EQS (ug/l)**		Is discharge conc >	Is discharge conc >
Substance	**Concentration (ug/l)**	**Concentration (ug/l)**	**AA EQS**	**MAC EQS**	**AA EQS (ug/l)**	**MAC EQS (ug/l)**	**> 10% of AA EQS?**	**10% of MAC EQS?**	**AA EQS**	**MAC EQS**	**100% of AA EQS?**	**100% of MAC EQS?**
Inorganics												
Chloride	4780	4780	250000		25000		N					
Sulphate	17620	17620	400000		40000		N					
Ammoniacal nitrogen	175	175	600		60		Y					
Phosphate (orthophosphate as P)	138	138	78		7.8		Y					
Nitrate (as NO3)	15036	15036	50000		5000		Y					
Metals												
Antimony	7.50	7.50	113		11.3		N		11.3		N	
Arsenic	1.67	1.67	50		5		N		25		N	
Boron	24.81	24.81	2000		200		N		7000		N	
Cadmium	0.59	0.59	0.09	0.6	0.009	0.06	Y	Y	0.2		Y	
Cobalt	1.00	1.00	3	100	0.3	10	Y	N	3	100	N	N
Copper (dissolved)	9.26	9.26							3.76		Y	
Copper (bioavailable)	0.35	0.35	1		0.1		Y					
Chromium (III)	2.02	2.02	4.7	32	0.47	3.2	Y	N				
Iron	395.0	395	1000		100		Y		1000		N	
Lead (dissolved)	13.00	13.00		14		1.4		Y	1.3	14	Y	N
Lead (bioavailable)	1.44	1.44	1.2		0.12		Y					
Manganese (dissolved)	62.40	62.40										
Manganese (bioavailable)	20.00	20.00	123		12.3		Y					
Mercury	0.09	0.09		0.07		0.007		Y		0.07		Y
Molybdenum	1.460	1.46	12,700		1270		N		1920		N	
Nickel (dissolved)	1.61	1.61		34		3.4		N	8.6	34	N	N
Nickel (bioavailable)	0.29	0.29	4		0.4		N					
Selenium (dissolved)	1.00	1.00	2		0.2		Y		2		N	
Vanadium	1.20	1.20	20		2		N		100		N	
Zinc (dissolved)	14.10	14.10							7.9		Y	
Zinc (bioavailable)	4.38	4.38	13.9		1.39		Y					
Organics												
Total petroleum hydrocarbons	13.70	13.70	250		25		N		250		N	
Anthracene	0.02	0.02	0.1	0.1	0.01	0.01	Y	Y	0.1	0.1	N	N
Benzo(a)pyrene	0.02	0.02	0.00017	0.27	0.000017	0.027	Y	N	0.00017	0.027	Y	N
Benzo(b)fluoranthene	0.02	0.02		0.017		0.0017		Y		0.017		Y
Benzo(k)fluoranthene	0.02	0.02		0.017		0.0017		Y		0.017		Y
Benzo(g,h,i)-perylene	0.03	0.03		0.0082		0.00082		Y		0.00082		Y
Fluoranthene	0.02	0.02	0.0063	0.12	0.00063	0.012	Y	Y	0.0063	0.12	Y	N
Naphthalene	0.08	0.08	2	130	0.2	13	N	N	2	130	N	N
Phenol	2.20	2.20	7.7	46	0.77	4.6	Y	N	7.7	46	N	N
Anionic Polyelectrolyte	1000	1000	7500		750		Y		7500		N	

* The concentrations are the mean dissolved concentrations from the leaching test in the top 0.5 m of soil, as presented in Appendix A
** See Appendix C for source of EQSs

Appendix D - Table 2 - Part A Test 2 Calculation of Freshwater Process Contribution

		Calculation of PC for Annual Average (ug/l)									Calculation of PC for MAC (ug/l)							
Discharge point		B1	C1	D1	E2	D2	E1	A3	A1+SC1		B1	C1	D1	E2	D2	E1	A3	A1+SC1
Discharge flow rate (m^3/s)		0.00410	0.002477	0.00049	0.00170	0.00106	0.00221	0.00116	0.00606		0.527	0.924	0.178	0.77	0.419	0.961	0.274	0.787
Receiving water Q95 flow rate (m^3/s)	Test 2 Required for AA?	0.00003	0.000417	0.01743	0.01766	0.01758	0.0180	0.00267	0.000517	Test 2 Required for MAC?	0.00003	0.000417	0.01743	0.01766	0.01758	0.01795	0.00267	0.0005
Inorganics																		
Chloride	N																	
Sulphate	N																	
Ammoniacal nitrogen	Y	173.53	149.80	4.75	15.38	9.99	19.19	52.87	161.24									
Phosphate (orthophosphate as P)	Y	136.84	118.13	3.74	12.13	7.88	15.13	41.69	127.15									
Nitrate (as NO3)	Y	14909.65	12870.82	407.95	1321.15	858.67	1648.72	4542.60	13853.84									
Metals																		
Antimony	N																	
Arsenic	N																	
Boron	N																	
Cadmium	Y	0.59	0.51	0.02	0.05	0.03	0.06	0.18	0.54	Y	0.59	0.59	0.54	0.58	0.57	0.58	0.58	0.59
Cobalt	Y	0.99	0.86	0.03	0.09	0.06	0.11	0.30	0.92	N								
Copper (dissolved)																		
Copper (bioavailable)	Y	0.35	0.30	0.01	0.03	0.02	0.04	0.11	0.32									
Chromium (III)	Y	2.00	1.73	0.05	0.18	0.12	0.22	0.61	1.86	N								
Iron	Y	391.7	338.1	10.7	34.7	22.6	43.3	119.3	363.9									
Lead (dissolved)										Y	13.00	12.99	11.84	12.71	12.48	12.76	12.87	12.99
Lead (bioavailable)	Y	1.43	1.23	0.04	0.13	0.08	0.16	0.44	1.33									
Manganese (dissolved)																		
Manganese (bioavailable)	Y	19.83	17.12	0.54	1.76	1.14	2.19	6.04	18.43									
Mercury										Y	0.09	0.09	0.08	0.09	0.09	0.09	0.09	0.09
Molybdenum	N																	
Nickel (dissolved)										N								
Nickel (bioavailable)	N																	
Selenium (dissolved)	Y	0.99	0.86	0.03	0.09	0.06	0.11	0.30	0.92									
Vanadium	N																	
Zinc (dissolved)																		
Zinc (bioavailable)	Y	4.34	3.75	0.12	0.38	0.25	0.48	1.32	4.04									
Organics																		
Total petroleum hydrocarbons	N	13.58	11.73	0.37	1.20	0.78	1.50	4.14	12.62									
Anthracene	Y	0.023	0.020	0.001	0.002	0.001	0.003	0.007	0.021	Y	0.023	0.023	0.021	0.022	0.022	0.023	0.023	0.023
Benzo(a)pyrene	Y	0.021	0.018	0.001	0.002	0.001	0.002	0.006	0.019	N								
Benzo(b)fluoranthene										Y	0.021	0.021	0.019	0.021	0.020	0.021	0.021	0.021
Benzo(k)fluoranthene										Y	0.020	0.020	0.018	0.020	0.019	0.020	0.020	0.020
Benzo(g,h,i)-perylene										Y	0.028	0.028	0.026	0.027	0.027	0.027	0.028	0.028
Fluoranthene	Y	0.020	0.017	0.001	0.002	0.001	0.002	0.006	0.018	Y	0.020	0.020	0.018	0.020	0.019	0.020	0.020	0.020
Naphthalene	N									N								
Phenol	Y	2.18	1.88	0.06	0.19	0.13	0.24	0.66	2.03	N								
Anionic Polyelectrolyte	Y	991.60	856.00	27.13	87.87	57.11	109.65	302.11	921.38									

			Test 2 - Is PC > 4% of AA EQS?								Test 2 - Is PC > 4% of MAC EQS?							
			Discharge point:								Discharge point:							
	4% of AA EQS (ug/l)	4% of MAC EQS (ug/l)	B1	C1	D1	E2	D2	E1	A3	A1+ SC1	B1	C1	D1	E2	D2	E1	A3	A1+ SC1
Inorganics																		
Chloride																		
Sulphate																		
Ammoniacal nitrogen	24		Y	Y	N	N	N	N	Y	Y								
Phosphate (orthophosphate as P)	3		Y	Y	Y	Y	Y	Y	Y	Y								
Nitrate (as NO3)	2000		Y	Y	N	N	N	N	Y	Y								
Metals																		
Antimony																		
Arsenic																		
Boron																		
Cadmium	0.004	0.024	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cobalt	0.120		Y	Y	N	N	N	N	Y	Y								
Copper (dissolved)																		
Copper (bioavailable)	0.04		Y	Y	N	N	N	N	Y	Y								
Chromium (III)	0.19		Y	Y	N	N	N	Y	Y	Y								
Iron	40.0		Y	Y	N	N	N	Y	Y	Y								
Lead (dissolved)		0.56									Y	Y	Y	Y	Y	Y	Y	Y
Lead (bioavailable)	0.05		Y	Y	N	Y	Y	Y	Y	Y								
Manganese (dissolved)																		
Manganese (bioavailable)	4.92		Y	Y	N	N	N	N	Y	Y								
Mercury		0.0028									Y	Y	Y	Y	Y	Y	Y	Y
Molybdenum																		
Nickel (dissolved)																		
Nickel (bioavailable)																		
Selenium (dissolved)	0.08		Y	Y	N	Y	N	Y	Y	Y								
Vanadium																		
Zinc (dissolved)																		
Zinc (bioavailable)	0.56		Y	Y	N	N	N	N	Y	Y								
Organics																		
Total petroleum hydrocarbons																		
Anthracene	0.004	0.004	Y	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Benzo(a)pyrene	0.00001		Y	Y	Y	Y	Y	Y	Y	Y								
Benzo(b)fluoranthene		0.0007									Y	Y	Y	Y	Y	Y	Y	Y
Benzo(k)fluoranthene		0.0007									Y	Y	Y	Y	Y	Y	Y	Y
Benzo(g,h,i)-perylene		0.0003									Y	Y	Y	Y	Y	Y	Y	Y
Fluoranthene	0.0003	0.0048	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Naphthalene																		
Phenol	0.31		Y	Y	N	N	N	N	Y	Y								
Anionic Polyelectrolyte	300.00		Y	Y	N	N	N	N	Y	Y								

Appendix D - Table 3a - Part A Test 3 Calculation of Freshwater Predicted Environmental Concentration for Annual Average

	Predicted discharge conc (ug/l)	Tre'r Gof-Upstream		Afon Cafnan		Afon Cafnan		Afon Cafnan		Afon Cafnan		Afon Cafnan-Downstream		Nant Cemaes		Tre'r Gof outflow	
		Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)
		B1		C1		D1		E2		D2		E1		A3		A1+SC1	
Inorganics																	
Chloride																	
Sulphate																	
Ammoniacal nitrogen	175	220.0	175.4	250.0	185.8	185.8	185.5	185.5	184.6	184.6	184.0	184.0	183.0	110.0	129.6	175.4	175.0
Phosphate (orthophosphate as	138	62.0	137.4	80.0	129.6	129.6	129.9	129.9	130.6	130.6	131.0	131.0	131.8	83.0	99.6	137.4	137.9
Nitrate (as NO3)	15036	13250.0	15021.0	6980.0	13875.9	13875.9	13907.4	13907.4	14006.6	14006.6	14065.4	14065.4	14171.8	9522.0	11187.9	15021.0	15034.8
Metals																	
Antimony																	
Arsenic																	
Boron																	
Cadmium	0.59	0.10	0.6	0.13	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.10	0.2	0.6	0.6
Cobalt	1.00	0.30	1.0	0.30	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.16	0.4	1.0	1.0
Copper (dissolved)																	
Copper (bioavailable)	0.35	0.05	0.35	0.06	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.32	0.10	0.2	0.3	0.3
Chromium (III)	2.02	1.53	2.0	1.27	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.21	1.5	2.0	2.0
Iron	395.0	110.0	392.6	870.0	463.4	463.4	461.5	461.5	455.7	455.7	452.2	452.2	446.0	180.0	245.0	392.6	394.8
Lead (dissolved)																	
Lead (bioavailable)	1.44	0.01	1.43	0.01	1.2	1.2	1.2	1.2	1.3	1.26	1.27	1.27	1.29	0.02	0.4	1.43	1.4
Manganese (dissolved)																	
Manganese (bioavailable)	20.00	44.8	20.2	66.14	26.6	26.6	26.5	26.5	25.9	25.90	25.56	25.6	24.9	51.85	42.2	20.2	20.0
Mercury																	
Molybdenum																	
Nickel (dissolved)																	
Nickel (bioavailable)																	
Selenium (dissolved)	1.00	0.8	1.0	0.70	1.0	1.0	1.0	1.0	1.0	0.96	0.96	1.0	1.0	0.91	0.9	1.0	1.0
Vanadium																	
Zinc (dissolved)																	
Zinc (bioavailable)	4.38	4.18	4.4	1.99	4.0	4.0	4.0	4.0	4.1	4.07	4.09	4.1	4.1	1.07	2.1	4.4	4.4
Organics																	
Total petroleum hydrocarbons																	
Anthracene	0.0230	0.010	0.023	0.010	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.010	0.014	0.023	0.023
Benzo(a)pyrene	0.0210	0.00002	0.02	0.00002	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.019	0.00002	0.006	0.021	0.021
Benzo(b)fluoranthene																	
Benzo(k)fluoranthene																	
Benzo(g,h,i)-perylene																	
Fluoranthene	0.0200	0.001	0.02	0.0006	0.017	0.017	0.017	0.017	0.018	0.018	0.018	0.018	0.02	0.0006	0.0	0.020	0.0
Naphthalene																	
Phenol	2.2	0.13	2.18	0.87	2.01	2.01	2.01	2.01	2.03	2.03	2.04	2.04	2.06	0.77	1.2	2.183	2.2
Anionic Polyelectrolyte	1000.0	0.00	991.60	0.00	856.00	856.00	859.91	859.91	872.22	872.22	879.51	879.51	892.73	0.00	302.1	991.597	999.3

	Difference of upstream quality and PEC (ug/l)								Test 3 - Is difference between u/s conc and PEC > 10% of AA EQS?							
	B1	C1	D1	E2	D2	E1	A3	A1+SC1	B1	C1	D1	E2	D2	E1	A3	A1+ SC1
Inorganics																
Chloride																
Sulphate																
Ammoniacal nitrogen	-44.6	-64.2	-0.29	-0.92	-0.55	-0.99	19.64	-0.35	N	N	N	N	N	N	N	N
Phosphate (orthophosphate as	75.36	49.65	0.23	0.71	0.42	0.77	16.62	0.588	Y	Y	N	N	N	N	Y	N
Nitrate (as NO3)	1770.99	6895.94	31.47	99.16	58.79	106.43	1665.86	13.828	N	Y	N	N	N	N	N	N
Metals																
Antimony																
Arsenic																
Boron																
Cadmium	0.49	0.39	0.002	0.006	0.003	0.006	0.15	0.0038	Y	Y	N	N	N	N	Y	N
Cobalt	0.69	0.60	0.00	0.01	0.01	0.01	0.25	0.0054	Y	Y	N	N	N	N	N	N
Copper (dissolved)																
Copper (bioavailable)	0.30	0.25	0.001	0.004	0.002	0.00	0.08	0.0023	Y	Y	N	N	N	N	N	N
Chromium (III)	0.49	0.64	0.00	0.01	0.01	0.01	0.24	0.0038	Y	Y	N	N	N	N	N	N
Iron	282.6	-406.6	-1.86	-5.85	-3.47	-6.28	64.95	2.207	Y	N	N	N	N	N	N	N
Lead (dissolved)																
Lead (bioavailable)	1.42	1.22	0.01	0.02	0.01	0.02	0.43	0.011	Y	Y	N	N	N	N	Y	N
Manganese (dissolved)																
Manganese (bioavailable)	-24.54	-39.50	-0.18	-0.57	-0.34	-0.61	-9.62	-0.192	N	N	N	N	N	N	N	N
Mercury																
Molybdenum																
Nickel (dissolved)																
Nickel (bioavailable)																
Selenium (dissolved)	0.24	0.26	0.001	0.004	0.002	0.00	0.03	0.002	Y	Y	N	N	N	N	N	N
Vanadium																
Zinc (dissolved)																
Zinc (bioavailable)	0.20	2.05	0.009	0.029	0.017	0.03	1.00	0.002	N	Y	N	N	N	N	N	N
Organics																
Total petroleum hydrocarbons																
Anthracene	0.01	0.01	0.000	0.000	0.000	0.00	0.0039	0.00010	Y	Y	N	N	N	N	N	N
Benzo(a)pyrene	0.02	0.02	0.0001	0.0003	0.0002	0.00	0.0063	0.00016	Y	Y	Y	Y	Y	Y	Y	Y
Benzo(b)fluoranthene																
Benzo(k)fluoranthene																
Benzo(g,h,i)-perylene																
Fluoranthene	0.02	0.02	0.0001	0.0002	0.0001	0.00	0.01	0.00015	Y	Y	N	N	N	N	Y	N
Naphthalene																
Phenol	2.05	1.14	0.0052	0.0164	0.0097	0.02	0.43	0.01600	Y	Y	N	N	N	N	N	N
Anionic Polyelectrolyte	991.60	856.00	3.9070	12.3094	7.2974	13.21	302.11	7.74267	Y	Y	N	N	N	N	N	N

Shaded cells take 10% of EQS as no upstream data are available

Shaded cells are consecutively downstream of each other in the same receiving watercourse

Appendix D - Table 3b - Part A Test 3 Calculation of Freshwater Predicted Environmental Concentration for MAC

		Tre'r Gof-Upstream		Afon Cafnan		Afon Cafnan		Afon Cafnan		Afon Cafnan		Afon Cafnan-Downstream		Nant Cemaes		Tre'r Gof outflow	
	Predicted discharge conc (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)	Upstream conc (ug/l)	PEC (ug/l)
		B1		C1		D1		E2		D2		E1		A3		A1+SC1	
Inorganics																	
Chloride	4780																
Sulphate	17620																
Ammoniacal nitrogen	175																
Phosphate (orthophosphate as F	138																
Nitrate (as NO3)	15036																
Metals																	
Antimony	7.5																
Arsenic	1.7																
Boron	24.8																
Cadmium	0.6	0.10	0.59	0.13	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.10	0.59	0.59	0.59
Cobalt	1.0																
Copper (dissolved)	9.3																
Copper (bioavailable)	0.4																
Chromium (III)	2.0																
Iron	395.0																
Lead (dissolved)	13.0	1.39	13.0	1.39	13.0	13.0	13.0	13.0	13.0	13.00	13.0	13.00	13.0	1.27	12.9	13.00	13.0
Lead (bioavailable)	1.4																
Manganese (dissolved)																	
Manganese (bioavailable)	20.0																
Mercury	0.1	0.010	0.09	0.01	0.09	0.09	0.09	0.09	0.09	0.09	0.1	0.09	0.1	0.01	0.09	0.09	0.09
Molybdenum	1.5																
Nickel (dissolved)	1.6																
Nickel (bioavailable)	0.3																
Selenium (dissolved)	1.0																
Vanadium	1.2																
Zinc (dissolved)	14.1																
Zinc (bioavailable)	4.4																
Organics																	
Total petroleum hydrocarbons	13.7																
Anthracene	0.023	0.01	0.023	0.01	0.02	0.023	0.02	0.023	0.02	0.023	0.023	0.02	0.023	0.010	0.023	0.02	0.023
Benzo(a)pyrene	0.021																
Benzo(b)fluoranthene	0.021	0.0017	0.021	0.0017	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.02	0.021	0.002	0.021	0.02	0.021
Benzo(k)fluoranthene	0.020	0.0017	0.020	0.0017	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.02	0.020	0.002	0.020	0.02	0.020
Benzo(g,h,i)-perylene	0.028	0.0008	0.028	0.0008	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.03	0.028	0.001	0.028	0.03	0.028
Fluoranthene	0.020	0.0006	0.020	0.0006	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.02	0.020	0.001	0.020	0.02	0.020
Naphthalene	0.082																
Phenol	2.2																
Anionic Polyelectrolyte	1000.0																

	Difference of upstream quality and PEC (ug/l)								Test 3 - Is difference between u/s conc and PEC > 10% of MAC EQS?							
	B1	C1	D1	E2	D2	E1	A3	A1+SC1	B1	C1	D1	E2	D2	E1	A3	SC1
Inorganics																
Chloride																
Sulphate																
Ammoniacal nitrogen																
Phosphate (orthophosphate as F																
Nitrate (as NO3)																
Metals																
Antimony																
Arsenic																
Boron																
Cadmium	0.49	0.46	0.00	0.00	0.00	0.00	0.49	0.0000	Y	Y	N	N	N	N	Y	N
Cobalt																
Copper (dissolved)																
Copper (bioavailable)																
Chromium (III)																
Iron																
Lead (dissolved)	11.61	11.60	0.00	0.00	0.00	0.00	11.62	0.0008	Y	Y	N	N	N	N	Y	N
Lead (bioavailable)																
Manganese (dissolved)																
Manganese (bioavailable)																
Mercury	0.08	0.08	0.00	0.00	0.00	0.00	0.08	0.0000	Y	Y	N	N	N	N	Y	N
Molybdenum																
Nickel (dissolved)																
Nickel (bioavailable)																
Selenium (dissolved)																
Vanadium																
Zinc (dissolved)																
Zinc (bioavailable)																
Organics																
Total petroleum hydrocarbons																
Anthracene	0.013	0.013	0.000	0.000	0.000	0.000	0.013	0.000	Y	Y	N	N	N	N	Y	N
Benzo(a)pyrene																
Benzo(b)fluoranthene	0.019	0.019	0.000	0.000	0.000	0.000	0.019	0.0000	Y	Y	N	N	N	N	Y	N
Benzo(k)fluoranthene	0.018	0.018	0.000	0.000	0.000	0.000	0.018	0.0000	Y	Y	N	N	N	N	Y	N
Benzo(g,h,i)-perylene	0.027	0.027	0.000	0.000	0.000	0.000	0.027	0.0000	Y	Y	N	N	N	N	Y	N
Fluoranthene	0.019	0.019	0.000	0.000	0.000	0.000	0.019	0.0000	Y	Y	N	N	N	N	Y	N
Naphthalene																
Phenol																
Anionic Polyelectrolyte																

Shaded cells take 10% of EQS as no upstream data are available

Shaded cells are consecutively downstream of each other in the same receiving watercourse

Appendix D - Table 4 - Part A Test 4 Comparison of Predicted Environmental Concentration to EQS

	Test 4 - Is PEC > AA EQS?									Test 4 - Is PEC > MAC EQS?							
	B1	C1	D1	E2	D2	E1	A3	A1+ SC1		B1	C1	D1	E2	D2	E1	A3	A1+ SC1
Inorganics																	
Chloride																	
Sulphate																	
Ammoniacal nitrogen	N	N	N	N	N	N	N	N									
Phosphate (orthophosphate as P)	Y	Y	Y	Y	Y	Y	Y	Y									
Nitrate (as NO3)	N	N	N	N	N	N	N	N									
Metals																	
Antimony																	
Arsenic																	
Boron																	
Cadmium	Y	Y	Y	Y	Y	Y	Y	Y		N	N	N	N	N	N	N	N
Cobalt	N	N	N	N	N	N	N	N									
Copper (dissolved)																	
Copper (bioavailable)	N	N	N	N	N	N	N	N									
Chromium (III)	N	N	N	N	N	N	N	N									
Iron	N	N	N	N	N	N	N	N									
Lead (dissolved)										N	N	N	N	N	N	N	N
Lead (bioavailabe)	Y	Y	Y	Y	Y	Y	N	Y									
Manganese (dissolved)																	
Manganese (bioavailable)	N	N	N	N	N	N	N	N									
Mercury										Y	Y	Y	Y	Y	Y	Y	Y
Molybdenum																	
Nickel (dissolved)																	
Nickel (bioavailable)																	
Selenium (dissolved)	N	N	N	N	N	N	N	N									
Vanadium																	
Zinc (dissolved)																	
Zinc (bioavailable)	N	N	N	N	N	N	N	N									
Organics																	
Total petroleum hydrocarbons																	
Anthracene	N	N	N	N	N	N	N	N		N	N	N	N	N	N	N	N
Benzo(a)pyrene	Y	Y	Y	Y	Y	Y	Y	Y									
Benzo(b)fluoranthene										Y	Y	Y	Y	Y	Y	Y	Y
Benzo(k)fluoranthene										Y	Y	Y	Y	Y	Y	Y	Y
Benzo(g,h,i)-perylene										Y	Y	Y	Y	Y	Y	Y	Y
Fluoranthene	Y	Y	Y	Y	Y	Y	Y	Y		N	N	N	N	N	N	N	N
Naphthalene																	
Phenol	N	N	N	N	N	N	N	N									
Anionic Polyelectrolyte	N	N	N	N	N	N	N	N									

Appendix D - Table 5 - Part A Test 1 Screening against EQSs for Groundwater Discharges to the Marine Environment

Substance	Concentration used for long term assessment Mean Discharge Concentration (ug/l)	Concentration used for short term assessment Mean Discharge Concentration (ug/l)	Marine EQS (ug/l) AA EQS	MAC EQS	Marine Test 1 Is discharge conc > 100% of AA EQS?	Is discharge conc > 100% of MAC EQS?
Inorganics						
Sulphate	30348	30348	-	-		
Cyanide (total)	6.30	6.30	1	5	Y	Y
Metals						
Arsenic	1.00	1.00	25	-	N	
Boron	30.96	31	7000	-	N	
Cadmium	0.05	0.05	0.2	-	N	
Copper (dissolved)	1.32	1.32	3.76	-	N	
Chromium (VI)	52.17	52.17	0.6	32	Y	Y
Chromium (III)	1.48	1.48	-	-		
Iron	36.13	36.13	1000	-	N	
Lead (dissolved)	1.00	1.00	1.3	14	N	N
Manganese (dissolved)	102.00	102	-	-		
Mercury	0.050	0.050	-	0.07		N
Nickel (dissolved)	16.52	16.52	8.6	34	Y	N
Selenium (dissolved)	1.00	1.00	2	-	N	
Vanadium	1.00	1.00	100	-	N	
Zinc (dissolved)	37.76	37.76	7.9	-	Y	
Organics						
Total petroleum hydrocarbons	50.00	50.00	250	-	N	
Anthracene	0.61	0.61	0.1	0.1	Y	Y
Benzo(a)pyrene	0.61	0.61	0.00017	0.027	Y	Y
Benzo(b)fluoranthene	0.61	0.61	-	0.017		Y
Benzo(k)fluoranthene	0.61	0.61	-	0.017		Y
Benzo(g,h,i)-perylene	0.61	0.61	-	0.00082		Y
Fluoranthene	0.61	0.61	0.0063	0.12	Y	Y
Naphthalene	0.64	0.64	2	130	N	N
Phenol	1.160	1.160	7.7	46	N	N
Anionic Polyelectrolyte	1000	1000	7500		N	

Shaded cells are below the limit of detection in all samples.

Appendix E - H1 Assessment – Further Tests for Marine Discharges

Appendix E – Further tests for marine discharges

Test 2 – Check whether the discharge is to the low water channel in an estuary

Test 3 - Check whether the discharge is to a location with restricted dilution or dispersion

Test 4 - Check whether the discharge point is located less than 50m offshore from chart datum, or is located less than 1m below chart datum

Test 5 – Check if the effective volume flux of the discharge is within allowable limits

Although the majority of discharges are not direct to Marine waters (only the discharge from A2 and PA/PB/PC are considered as discharges direct to coastal waters), the assessment of discharges to freshwater show that the discharge is not diluted greatly and given the relatively short distance to the coast for most of the other discharges, concentrations at the coast would not be much lower than the discharge concentration at the point of discharge following mixing. As such, assessment of secondary effects on marine waters from those substances in freshwater outflows “failing” Test 1 for marine waters is warranted.

The further tests for marine waters for those substances failing Test 1 relate to the location of the discharge and whether there is likely to be mixing and dilution of the substances in the coastal water. For the discharges considered here (A2 and PA/PB/PC), the discharge locations are both new direct to sea discharge points and so there will be no freshwater channel. Test 2 therefore does not apply.

Test 3 for marine waters relates to assessing whether the discharge is to a zone with high or low natural dispersion. In this case the discharges are not believed to be to areas with restricted dilution or dispersion and it is not considered to be of relevance. Test 4 considers the location of the discharge and states that if the discharge does contain substances at concentrations above EQS and if the discharge location is less than 50m offshore from where the sea-bed is at Chart Datum (CD) or the sea-bed at the discharge location is less than 1m below CD, then Phase 2: Modelling should be undertaken to ascertain in detail the area of impact above EQS.

Test 5 for marine waters considers the Effective Volume Flux of the discharge. This test is not required for the assessed discharges as both are indicated for modelling assessment at Test 4.

The assessment of the further tests for marine waters does indicate that further modelling of the discharges should be undertaken.

Appendix F - H1 Assessment – Calculation of Substance Loads

Appendix F Table 1 - Part B Calculation of Substance Loads

Substance	Annual Significant Load (kg/yr)	Calculation of Significant Load for each Discharge Point (kg/yr)										Groundwater	Site Total (kg/yr)	Comments
		B1	C1	D1	E2	D2	E1	A3	A1	A2	PA/PB/PC	PA/PB/PC		
Anthracene	1	0.0030	0.0018	0.0004	0.0012	0.0008	0.0016	0.0008	0.0044	0.0006	0.0037	0.0267	**0.0450**	
Brominated diphenyl ether	1													Not tested in leaching or soil tests but unlikley to be present
Cadmium	5	0.0762	0.0461	0.0090	0.0317	0.0198	0.0411	0.0215	0.1127	0.0164	0.0941	0.0022	**0.4708**	
C10-13 Chloroalkanes	1													Not tested in leaching or soil tests but unlikley to be present
Endosulphan	1													Not tested in leaching or soil tests but unlikley to be present
Hexachlorobenzene	1													Not detected in soils or leaching tests conducted during DOnGI
Hexachlorobutadiene	1													Not detected in soils or leaching tests conducted during DOnGI
Hexachloro-cyclohexane	1													Not tested in leaching or soil tests but unlikley to be present
Mercury and its compounds	1	0.0116	0.0070	0.0014	0.0048	0.0030	0.0063	0.0033	0.0172	0.0025	0.0144	0.0022	**0.0737**	
Nonylphenol (4-Nonylphenol)	1													Not tested in leaching or soil tests but unlikley to be present
Pentachlorobenzene	1													Not tested in leaching or soil tests but unlikley to be present
Polycyclic aromatic hydrocarbons (PAHs)*	5	0.014	0.009	0.002	0.006	0.004	0.008	0.0041	0.0214	0.0031	0.0179	0.1335	**0.2225**	
Tributyltin compounds	1													Not tested in leaching or soil tests but unlikley to be present

* The sum of the annual load calculated for the individual PAH Benzo(a)-pyrene and the annual loads calculated from the combined determinands Benzo(b)-fluor-anthene + Benzo(k)fluor-anthene and Benzo(g,h,i)-perylene + Indeno(1,2,3-cd)-pyrene.

Annual loads are calculated by multiplying the average discharge concentration by the average discharge flow rate

Appendix G - Freshwater Modelling Results

Appendix G – Freshwater modelling results

RQP forward model runs

UNITS

All flows: m^3/d

All concentrations: $\mu g/l$

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 13.58

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Orthophosphate (P)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	62.00
Standard deviation of quality	120.00
90-percentile	140.83

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	133.00
Standard deviation of quality	395.98
... or 95-percentile	510.04

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	124.63
Standard deviation of quality	249.47
90-percentile quality	280.06
95-percentile quality	482.79
99-percentile quality	1184.8

DISCHARGE QUALITY

Mean quality	132.60
Standard deviation of quality	276.07
95-percentile quality	526.41
99-percentile quality	1354.1
99.5-percentile quality	1749.1

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.03

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Copper (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	0.05
Standard deviation of quality	0.01
90-percentile	0.06

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	0.25
Standard deviation of quality	0.19
... or 95-percentile	0.60

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	0.23
Standard deviation of quality	0.16
90-percentile quality	0.43
95-percentile quality	0.56
99-percentile quality	0.81

DISCHARGE QUALITY

Mean quality	0.26
Standard deviation of quality	0.18
95-percentile quality	0.61
99-percentile quality	0.92
99.5-percentile quality	1.03

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.05

ENVIRONMENT AGENCY

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Iron (dissolved)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	110.00
Standard deviation of quality	280.00
90-percentile	247.66

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	394.00
Standard deviation of quality	294.00
... or 95-percentile	943.32

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	366.91
Standard deviation of quality	259.09
90-percentile quality	682.81
95-percentile quality	882.46
99-percentile quality	1289.9

DISCHARGE QUALITY

Mean quality	404.27
Standard deviation of quality	285.78
95-percentile quality	956.52
99-percentile quality	1449.2
99.5-percentile quality	1621.9

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 14.07

ENVIRONMENT AGENCY

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Lead (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	0.01
Standard deviation of quality	0.01
90-percentile	0.02

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	0.67
Standard deviation of quality	1.23
... or 95-percentile	2.36

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	0.60
Standard deviation of quality	0.93
90-percentile quality	1.40
95-percentile quality	2.25
99-percentile quality	4.50

DISCHARGE QUALITY

Mean quality	0.68
Standard deviation of quality	1.03
95-percentile quality	2.42
99-percentile quality	5.16
99.5-percentile quality	6.33

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.08

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Lead (dissolved)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	1.39
Standard deviation of quality	0.88
90-percentile	2.47

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	6.45
Standard deviation of quality	11.01
... or 95-percentile	22.27

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	5.97
Standard deviation of quality	8.47
90-percentile quality	13.42
95-percentile quality	21.23
99-percentile quality	41.35

DISCHARGE QUALITY

Mean quality	6.60
Standard deviation of quality	9.42
95-percentile quality	22.82
99-percentile quality	47.33
99.5-percentile quality	57.67

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 14.09

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Anionic Polyelectrolyte

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	0.00
Standard deviation of quality	0.00
90-percentile	

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	1000.0
Standard deviation of quality	0.00
... or 95-percentile	1000.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	870.14
Standard deviation of quality	112.45
90-percentile quality	972.76
95-percentile quality	981.15
99-percentile quality	989.32

DISCHARGE QUALITY

Mean quality	1000.0
Standard deviation of quality	0.25
95-percentile quality	1000.0
99-percentile quality	1000.0
99.5-percentile quality	1000.0

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 09/02/2018 at 14.36

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Chromium (iii)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	1.53
Standard deviation of quality	2.00
90-percentile	3.34

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	1.52
Standard deviation of quality	1.35
... or 95-percentile	3.98

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.56
Standard deviation of quality	1.19
90-percentile quality	3.00
95-percentile quality	3.89
99-percentile quality	5.99

DISCHARGE QUALITY

Mean quality	1.56
Standard deviation of quality	1.29
95-percentile quality	4.04
99-percentile quality	6.51
99.5-percentile quality	7.40

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 14.12

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Orthophosphate (P)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	80.00
Standard deviation of quality	200.00
90-percentile	180.38

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	133.00
Standard deviation of quality	395.98
... or 95-percentile	510.04

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	107.30
Standard deviation of quality	171.51
90-percentile quality	251.25
95-percentile quality	382.24
99-percentile quality	816.48

DISCHARGE QUALITY

Mean quality	132.60
Standard deviation of quality	276.07
95-percentile quality	526.41
99-percentile quality	1354.1
99.5-percentile quality	1749.1

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.15

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Copper (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	0.06
Standard deviation of quality	0.03
90-percentile	0.10

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	0.25
Standard deviation of quality	0.19
... or 95-percentile	0.60

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	0.16
Standard deviation of quality	0.10
90-percentile quality	0.28
95-percentile quality	0.36
99-percentile quality	0.53

DISCHARGE QUALITY

Mean quality	0.26
Standard deviation of quality	0.18
95-percentile quality	0.61
99-percentile quality	0.92
99.5-percentile quality	1.03

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 14.16

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Lead (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	0.01
Standard deviation of quality	0.01
90-percentile	0.02

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	0.67
Standard deviation of quality	1.23
... or 95-percentile	2.36

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	0.35
Standard deviation of quality	0.56
90-percentile quality	0.80
95-percentile quality	1.31
99-percentile quality	2.76

DISCHARGE QUALITY

Mean quality	0.68
Standard deviation of quality	1.03
95-percentile quality	2.42
99-percentile quality	5.16
99.5-percentile quality	6.33

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 14.18

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Lead (dissolved)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	1.39
Standard deviation of quality	1.32
90-percentile	2.82

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	6.45
Standard deviation of quality	11.01
... or 95-percentile	22.27

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	4.03
Standard deviation of quality	5.15
90-percentile quality	8.32
95-percentile quality	13.20
99-percentile quality	26.37

DISCHARGE QUALITY

Mean quality	6.60
Standard deviation of quality	9.42
95-percentile quality	22.82
99-percentile quality	47.33
99.5-percentile quality	57.67

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 13/02/2018 at 11.01

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Nitrate (NO3)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	6980.0
Standard deviation of quality	5330.0
90-percentile	13221.7

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	15006.0
Standard deviation of quality	30555.9
... or 95-percentile	54309.9

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	11240.8
Standard deviation of quality	13594.7
90-percentile quality	21768.5
95-percentile quality	34230.7
99-percentile quality	71566.9

DISCHARGE QUALITY

Mean quality	15264.9
Standard deviation of quality	24796.4
95-percentile quality	55781.3
99-percentile quality	124057.4
99.5-percentile quality	154058.2

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 12/12/2017 at 14.22

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Anionic Polyelectrolyte

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	0.00
Standard deviation of quality	0.00
90-percentile	

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	1000.0
Standard deviation of quality	0.00
... or 95-percentile	1000.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	497.41
Standard deviation of quality	168.69
90-percentile quality	721.54
95-percentile quality	770.43
99-percentile quality	837.99

DISCHARGE QUALITY

Mean quality	1000.0
Standard deviation of quality	0.25
95-percentile quality	1000.0
99-percentile quality	1000.0
99.5-percentile quality	1000.0

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 09/02/2018 at 14.42

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Chromium (iii)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	1.27
Standard deviation of quality	1.80
90-percentile	2.81

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	1.52
Standard deviation of quality	1.35
... or 95-percentile	3.98

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.42
Standard deviation of quality	1.10
90-percentile quality	2.70
95-percentile quality	3.54
99-percentile quality	5.56

DISCHARGE QUALITY

Mean quality	1.56
Standard deviation of quality	1.29
95-percentile quality	4.04
99-percentile quality	6.51
99.5-percentile quality	7.40

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 09/02/2018 at 17.10

ENVIRONMENT AGENCY

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Zinc (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	1.99
Standard deviation of quality	3.63
90-percentile	4.51

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	3.56
Standard deviation of quality	5.42
... or 95-percentile	11.84

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	2.84
Standard deviation of quality	3.05
90-percentile quality	5.99
95-percentile quality	8.66
99-percentile quality	15.00

DISCHARGE QUALITY

Mean quality	3.65
Standard deviation of quality	4.78
95-percentile quality	12.11
99-percentile quality	24.00
99.5-percentile quality	28.89

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.24

Name of discharge	A3
Name of river	Nant Cemaes
Name of determinand	Orthophosphate (P)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	2344.0
95% exceedence flow	231.00
Mean quality	80.00
Standard deviation of quality	40.00
90-percentile	131.07

DISCHARGE DATA

Mean flow	100.00
Standard deviation of flow	107.00
Mean quality	133.00
Standard deviation of quality	395.98
... or 95-percentile	510.04

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	84.01
Standard deviation of quality	43.55
90-percentile quality	135.11
95-percentile quality	164.41
99-percentile quality	233.45

DISCHARGE QUALITY

Mean quality	132.60
Standard deviation of quality	276.07
95-percentile quality	526.41
99-percentile quality	1354.1
99.5-percentile quality	1749.1

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 14.26

ENVIRONMENT AGENCY

Name of discharge	A3
Name of river	Nant Cemaes
Name of determinand	Lead (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	2344.0
95% exceedence flow	231.00
Mean quality	0.02
Standard deviation of quality	0.01
90-percentile	0.03

DISCHARGE DATA

Mean flow	100.00
Standard deviation of flow	107.00
Mean quality	0.67
Standard deviation of quality	1.23
... or 95-percentile	2.36

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	0.07
Standard deviation of quality	0.09
90-percentile quality	0.13
95-percentile quality	0.20
99-percentile quality	0.46

DISCHARGE QUALITY

Mean quality	0.68
Standard deviation of quality	1.03
95-percentile quality	2.42
99-percentile quality	5.16
99.5-percentile quality	6.33

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 14.27

Name of discharge	A3
Name of river	Nant Cemaes
Name of determinand	Lead (dissolved)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	2344.0
95% exceedence flow	231.00
Mean quality	1.27
Standard deviation of quality	0.95
90-percentile	2.39

DISCHARGE DATA

Mean flow	100.00
Standard deviation of flow	107.00
Mean quality	6.45
Standard deviation of quality	11.01
... or 95-percentile	22.27

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.64
Standard deviation of quality	1.20
90-percentile quality	2.98
95-percentile quality	3.86
99-percentile quality	6.08

DISCHARGE QUALITY

Mean quality	6.60
Standard deviation of quality	9.42
95-percentile quality	22.82
99-percentile quality	47.33
99.5-percentile quality	57.67

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 14.28

ENVIRONMENT AGENCY

Name of discharge	A3
Name of river	Nant Cemaes
Name of determinand	Anionic Polyelectrolyte

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	2344.0
95% exceedence flow	231.00
Mean quality	0.00
Standard deviation of quality	0.00
90-percentile	

DISCHARGE DATA

Mean flow	100.00
Standard deviation of flow	107.00
Mean quality	1000.0
Standard deviation of quality	0.00
... or 95-percentile	1000.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	66.80
Standard deviation of quality	56.20
90-percentile quality	137.87
95-percentile quality	179.84
99-percentile quality	269.26

DISCHARGE QUALITY

Mean quality	1000.0
Standard deviation of quality	0.25
95-percentile quality	1000.0
99-percentile quality	1000.0
99.5-percentile quality	1000.0

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.30

Name of discharge	A1
Name of river	Trer Gof
Name of determinand	Orthophosphate (P)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	747.00
95% exceedence flow	45.00
Mean quality	62.00
Standard deviation of quality	120.00
90-percentile	140.83

DISCHARGE DATA

Mean flow	523.00
Standard deviation of flow	321.00
Mean quality	133.00
Standard deviation of quality	395.98
... or 95-percentile	510.04

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	103.33
Standard deviation of quality	182.58
90-percentile quality	232.56
95-percentile quality	382.45
99-percentile quality	802.07

DISCHARGE QUALITY

Mean quality	132.60
Standard deviation of quality	276.07
95-percentile quality	526.41
99-percentile quality	1354.1
99.5-percentile quality	1749.1

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.34

Name of discharge	A1
Name of river	Trer Gof
Name of determinand	Anionic Polyelectrolyte

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	747.00
95% exceedence flow	45.00
Mean quality	0.00
Standard deviation of quality	0.00
90-percentile	

DISCHARGE DATA

Mean flow	523.00
Standard deviation of flow	321.00
Mean quality	1000.0
Standard deviation of quality	0.00
... or 95-percentile	1000.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	556.47
Standard deviation of quality	207.60
90-percentile quality	831.73
95-percentile quality	873.78
99-percentile quality	926.83

DISCHARGE QUALITY

Mean quality	1000.0
Standard deviation of quality	0.25
95-percentile quality	1000.0
99-percentile quality	1000.0
99.5-percentile quality	1000.0

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 09/02/2018 at 14.46

ENVIRONMENT AGENCY

Name of discharge	A1
Name of river	Trer Gof
Name of determinand	Lead (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	747.00
95% exceedence flow	45.00
Mean quality	0.01
Standard deviation of quality	0.01
90-percentile	0.02

DISCHARGE DATA

Mean flow	523.00
Standard deviation of flow	321.00
Mean quality	0.67
Standard deviation of quality	1.23
... or 95-percentile	2.36

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	0.39
Standard deviation of quality	0.66
90-percentile quality	0.92
95-percentile quality	1.48
99-percentile quality	3.07

DISCHARGE QUALITY

Mean quality	0.68
Standard deviation of quality	1.03
95-percentile quality	2.42
99-percentile quality	5.16
99.5-percentile quality	6.33

Appendix G – Freshwater modelling results

RQP backward model runs

UNITS

All flows: m^3/d

All concentrations: $\mu g/l$

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 14.53

ENVIRONMENT AGENCY

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Orthophosphate (P)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	62.00
Standard deviation of quality	120.00
90-percentile	140.83

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	133.00
Standard deviation of quality	395.98
... or 95-percentile	510.04

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	78.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	78.00
Standard deviation of quality	150.21
90-percentile quality	171.43
95-percentile quality	290.10
99-percentile quality	712.36
Quality target (Mean)	78.00

DISCHARGE QUALITY NEEDED

Mean quality	79.65
Standard deviation of quality	165.83
95-percentile quality	316.20
99-percentile quality	813.34
99.5-percentile quality	1050.6

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 15.02

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Copper (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	0.05
Standard deviation of quality	0.01
90-percentile	0.06

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	0.25
Standard deviation of quality	0.19
... or 95-percentile	0.60

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	1.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.00
Standard deviation of quality	0.73
90-percentile quality	1.91
95-percentile quality	2.47
99-percentile quality	3.56
Quality target (Mean)	1.00

DISCHARGE QUALITY NEEDED

Mean quality	1.14
Standard deviation of quality	0.81
95-percentile quality	2.70
99-percentile quality	4.09
99.5-percentile quality	4.58

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 15.04

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Iron (dissolved)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	110.00
Standard deviation of quality	280.00
90-percentile	247.66

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	394.00
Standard deviation of quality	294.00
... or 95-percentile	943.32

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	1000.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1000.0
Standard deviation of quality	722.45
90-percentile quality	1889.5
95-percentile quality	2447.8
99-percentile quality	3514.5
Quality target (Mean)	1000.0

DISCHARGE QUALITY NEEDED

Mean quality	1129.0
Standard deviation of quality	798.10
95-percentile quality	2671.3
99-percentile quality	4047.3
99.5-percentile quality	4529.6

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 15.07

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Lead (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	0.01
Standard deviation of quality	0.01
90-percentile	0.02

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	0.67
Standard deviation of quality	1.23
... or 95-percentile	2.36

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	1.20

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.20
Standard deviation of quality	1.85
90-percentile quality	2.78
95-percentile quality	4.48
99-percentile quality	8.98
Quality target (Mean)	1.20

DISCHARGE QUALITY NEEDED

Mean quality	1.37
Standard deviation of quality	2.05
95-percentile quality	4.83
99-percentile quality	10.30
99.5-percentile quality	12.64

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 15.08

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Lead (dissolved)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	1.39
Standard deviation of quality	0.88
90-percentile	2.47

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	6.45
Standard deviation of quality	11.01
... or 95-percentile	22.27

DOWNSTREAM RIVER QUALITY TARGET

Quality target	14.00
Percentile	95.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	4.00
Standard deviation of quality	5.58
90-percentile quality	8.87
95-percentile quality	14.00
99-percentile quality	27.29
Quality target (95-percentile)	14.00

DISCHARGE QUALITY NEEDED

Mean quality	4.35
Standard deviation of quality	6.21
95-percentile quality	15.04
99-percentile quality	31.19
99.5-percentile quality	38.01

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 15.12

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Anionic Polyelectrolyte

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	0.00
Standard deviation of quality	0.00
90-percentile	

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	1000.0
Standard deviation of quality	0.00
... or 95-percentile	1000.0

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	7500.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	7500.0
Standard deviation of quality	969.25
90-percentile quality	8384.5
95-percentile quality	8456.8
99-percentile quality	8527.3
Quality target (Mean)	7500.0

DISCHARGE QUALITY NEEDED

Mean quality	8619.4
Standard deviation of quality	0.00
95-percentile quality	8619.3
99-percentile quality	8619.3
99.5-percentile quality	8619.3

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 09/02/2018 at 15.00

Name of discharge	B1
Name of river	Trer Gof
Name of determinand	Chromium (iii)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	60.00
95% exceedence flow	3.00
Mean quality	1.53
Standard deviation of quality	2.00
90-percentile	3.34

DISCHARGE DATA

Mean flow	354.00
Standard deviation of flow	390.00
Mean quality	1.52
Standard deviation of quality	1.35
... or 95-percentile	3.98

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	4.70

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	4.70
Standard deviation of quality	3.84
90-percentile quality	9.17
95-percentile quality	12.62
99-percentile quality	18.97
Quality target (Mean)	4.70

DISCHARGE QUALITY NEEDED

Mean quality	5.15
Standard deviation of quality	4.26
95-percentile quality	13.33
99-percentile quality	21.45
99.5-percentile quality	24.40

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 15.18

ENVIRONMENT AGENCY

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Orthophosphate (P)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	80.00
Standard deviation of quality	200.00
90-percentile	180.38

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	133.00
Standard deviation of quality	369.02
... or 95-percentile	506.76

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	78.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	78.00
Standard deviation of quality	118.05
90-percentile quality	183.05
95-percentile quality	276.47
99-percentile quality	576.62
Quality target (Mean)	78.00

DISCHARGE QUALITY NEEDED

Mean quality	74.93
Standard deviation of quality	149.43
95-percentile quality	293.96
99-percentile quality	736.49
99.5-percentile quality	944.61

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 15.21

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Copper (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	0.06
Standard deviation of quality	0.03
90-percentile	0.10

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	0.25
Standard deviation of quality	0.19
... or 95-percentile	0.60

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	1.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.00
Standard deviation of quality	0.80
90-percentile quality	1.96
95-percentile quality	2.57
99-percentile quality	3.90
Quality target (Mean)	1.00

DISCHARGE QUALITY NEEDED

Mean quality	1.93
Standard deviation of quality	1.37
95-percentile quality	4.58
99-percentile quality	6.95
99.5-percentile quality	7.79

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 15.22

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Lead (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	0.01
Standard deviation of quality	0.01
90-percentile	0.02

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	0.67
Standard deviation of quality	1.23
... or 95-percentile	2.36

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	1.20

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.20
Standard deviation of quality	1.94
90-percentile quality	2.75
95-percentile quality	4.51
99-percentile quality	9.52
Quality target (Mean)	1.20

DISCHARGE QUALITY NEEDED

Mean quality	2.36
Standard deviation of quality	3.55
95-percentile quality	8.36
99-percentile quality	17.82
99.5-percentile quality	21.88

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 15.24

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Lead (dissolved)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	1.39
Standard deviation of quality	1.32
90-percentile	2.82

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	6.45
Standard deviation of quality	11.01
... or 95-percentile	22.27

DOWNSTREAM RIVER QUALITY TARGET

Quality target	14.00
Percentile	95.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	4.25
Standard deviation of quality	5.48
90-percentile quality	8.75
95-percentile quality	14.00
99-percentile quality	28.02
Quality target (95-percentile)	14.00

DISCHARGE QUALITY NEEDED

Mean quality	7.03
Standard deviation of quality	10.04
95-percentile quality	24.31
99-percentile quality	50.42
99.5-percentile quality	61.44

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 13/02/2018 at 10.50

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Nitrate (NO3)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	6980.0
Standard deviation of quality	5330.0
90-percentile	13221.7

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	15006.0
Standard deviation of quality	30555.9
... or 95-percentile	54309.9

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	50000.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	50000.0
Standard deviation of quality	81065.2
90-percentile quality	109717.7
95-percentile quality	186345.3
99-percentile quality	402273.1
Quality target (Mean)	50000.0

DISCHARGE QUALITY NEEDED

Mean quality	91846.3
Standard deviation of quality	149195.9
95-percentile quality	335627.7
99-percentile quality	746434.1
99.5-percentile quality	926944.5

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 15.16

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Anionic Polyelectrolyte

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	0.00
Standard deviation of quality	0.00
90-percentile	

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	1000.0
Standard deviation of quality	0.00
... or 95-percentile	1000.0

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	7500.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	7500.0
Standard deviation of quality	2543.6
90-percentile quality	10879.4
95-percentile quality	11616.7
99-percentile quality	12635.3
Quality target (Mean)	7500.0

DISCHARGE QUALITY NEEDED

Mean quality	15078.1
Standard deviation of quality	33.33
95-percentile quality	15078.2
99-percentile quality	15078.2
99.5-percentile quality	15078.2

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 09/02/2018 at 14.56

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Chromium (iii)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	1.27
Standard deviation of quality	1.80
90-percentile	2.81

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	1.52
Standard deviation of quality	1.35
... or 95-percentile	3.98

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	4.70

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	4.70
Standard deviation of quality	3.84
90-percentile quality	9.14
95-percentile quality	12.24
99-percentile quality	18.49
Quality target (Mean)	4.70

DISCHARGE QUALITY NEEDED

Mean quality	8.08
Standard deviation of quality	6.69
95-percentile quality	20.93
99-percentile quality	33.67
99.5-percentile quality	38.30

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 09/02/2018 at 17.21

Name of discharge	C1
Name of river	Nant Caerdegog Isaf (Afon Cafnan)
Name of determinand	Zinc (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	229.00
95% exceedence flow	36.00
Mean quality	1.99
Standard deviation of quality	3.63
90-percentile	4.51

DISCHARGE DATA

Mean flow	214.00
Standard deviation of flow	220.00
Mean quality	3.56
Standard deviation of quality	5.42
... or 95-percentile	11.84

DOWNSTREAM RIVER QUALITY TARGET

Quality target	13.90
Percentile	90.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	6.59
Standard deviation of quality	8.05
90-percentile quality	13.90
95-percentile quality	21.85
99-percentile quality	40.27
Quality target (90-percentile)	13.90

DISCHARGE QUALITY NEEDED

Mean quality	11.08
Standard deviation of quality	14.50
95-percentile quality	36.77
99-percentile quality	72.87
99.5-percentile quality	87.70

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 15.28

Name of discharge	A3
Name of river	Nant Cemaes
Name of determinand	Orthophosphate (P)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	2344.0
95% exceedence flow	231.00
Mean quality	80.00
Standard deviation of quality	40.00
90-percentile	131.07

DISCHARGE DATA

Mean flow	100.00
Standard deviation of flow	107.00
Mean quality	133.00
Standard deviation of quality	369.02
... or 95-percentile	506.76

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	78.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	78.00
Standard deviation of quality	38.15
90-percentile quality	124.87
95-percentile quality	150.54
99-percentile quality	209.73
Quality target (Mean)	78.00

DISCHARGE QUALITY NEEDED

Mean quality	43.63
Standard deviation of quality	87.01
95-percentile quality	171.17
99-percentile quality	428.86
99.5-percentile quality	550.05

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 15.29

ENVIRONMENT AGENCY

Name of discharge	A3
Name of river	Nant Cemaes
Name of determinand	Lead (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	2344.0
95% exceedence flow	231.00
Mean quality	0.02
Standard deviation of quality	0.01
90-percentile	0.03

DISCHARGE DATA

Mean flow	100.00
Standard deviation of flow	107.00
Mean quality	0.67
Standard deviation of quality	1.23
... or 95-percentile	2.36

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	1.20

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.20
Standard deviation of quality	2.31
90-percentile quality	2.92
95-percentile quality	4.63
99-percentile quality	11.36
Quality target (Mean)	1.20

DISCHARGE QUALITY NEEDED

Mean quality	17.46
Standard deviation of quality	26.25
95-percentile quality	61.78
99-percentile quality	131.69
99.5-percentile quality	161.66

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 15.31

ENVIRONMENT AGENCY

Name of discharge	A3
Name of river	Nant Cemaes
Name of determinand	Lead (dissolved)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	2344.0
95% exceedence flow	231.00
Mean quality	1.27
Standard deviation of quality	0.95
90-percentile	2.39

DISCHARGE DATA

Mean flow	100.00
Standard deviation of flow	107.00
Mean quality	6.45
Standard deviation of quality	11.01
... or 95-percentile	22.27

DOWNSTREAM RIVER QUALITY TARGET

Quality target	14.00
Percentile	95.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	4.54
Standard deviation of quality	6.31
90-percentile quality	9.58
95-percentile quality	14.00
99-percentile quality	31.65
Quality target (95-percentile)	14.00

DISCHARGE QUALITY NEEDED

Mean quality	49.43
Standard deviation of quality	70.60
95-percentile quality	170.96
99-percentile quality	354.56
99.5-percentile quality	432.04

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 15.33

Name of discharge	A3
Name of river	Nant Cemaes
Name of determinand	Anionic Polyelectrolyte

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	2344.0
95% exceedence flow	231.00
Mean quality	0.00
Standard deviation of quality	0.00
90-percentile	

DISCHARGE DATA

Mean flow	100.00
Standard deviation of flow	107.00
Mean quality	1000.0
Standard deviation of quality	0.00
... or 95-percentile	1000.0

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	7500.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	7500.0
Standard deviation of quality	6309.5
90-percentile quality	15478.9
95-percentile quality	20191.3
99-percentile quality	30230.9
Quality target (Mean)	7500.0

DISCHARGE QUALITY NEEDED

Mean quality	112272.1
Standard deviation of quality	85.35
95-percentile quality	112272.9
99-percentile quality	112273.0
99.5-percentile quality	112273.0

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 31/01/2018 at 14.51

Name of discharge	A1
Name of river	Trer Gof
Name of determinand	Orthophosphate (P)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	747.00
95% exceedence flow	45.00
Mean quality	62.00
Standard deviation of quality	120.00
90-percentile	140.83

DISCHARGE DATA

Mean flow	523.00
Standard deviation of flow	321.00
Mean quality	133.00
Standard deviation of quality	369.02
... or 95-percentile	506.76

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	78.00

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	78.00
Standard deviation of quality	122.59
90-percentile quality	178.23
95-percentile quality	271.33
99-percentile quality	549.95
Quality target (Mean)	78.00

DISCHARGE QUALITY NEEDED

Mean quality	88.48
Standard deviation of quality	176.43
95-percentile quality	347.09
99-percentile quality	869.60
99.5-percentile quality	1115.3

MASS BALANCE CALCULATION: MONTE CARLO METHOD

Version 2.5

Calculations done on 31/01/2018 at 14.47

Name of discharge	A1
Name of river	Trer Gof
Name of determinand	Anionic Polyelectrolyte

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	747.00
95% exceedence flow	45.00
Mean quality	0.00
Standard deviation of quality	0.00
90-percentile	

DISCHARGE DATA

Mean flow	523.00
Standard deviation of flow	321.00
Mean quality	1000.0
Standard deviation of quality	0.00
... or 95-percentile	1000.0

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	7500.0

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	7500.0
Standard deviation of quality	2798.1
90-percentile quality	11210.0
95-percentile quality	11776.8
99-percentile quality	12491.8
Quality target (Mean)	7500.0

DISCHARGE QUALITY NEEDED

Mean quality	13478.0
Standard deviation of quality	0.00
95-percentile quality	13478.0
99-percentile quality	13478.0
99.5-percentile quality	13478.0

MASS BALANCE CALCULATION: MONTE CARLO METHOD
Version 2.5
Calculations done on 12/02/2018 at 13.37

Name of discharge	A1
Name of river	Trer Gof
Name of determinand	Lead (bioavailable)

INPUT DATA

UPSTREAM RIVER DATA

Mean flow	747.00
95% exceedence flow	45.00
Mean quality	0.01
Standard deviation of quality	0.01
90-percentile	0.02

DISCHARGE DATA

Mean flow	523.00
Standard deviation of flow	321.00
Mean quality	0.67
Standard deviation of quality	1.23
... or 95-percentile	2.36

DOWNSTREAM RIVER QUALITY TARGET

Quality target (Mean standard)	1.20

RESULTS

RIVER DOWNSTREAM OF DISCHARGE

Mean quality	1.20
Standard deviation of quality	2.03
90-percentile quality	2.82
95-percentile quality	4.55
99-percentile quality	9.42
Quality target (Mean)	1.20

DISCHARGE QUALITY NEEDED

Mean quality	2.10
Standard deviation of quality	3.16
95-percentile quality	7.45
99-percentile quality	15.87
99.5-percentile quality	19.49

J

Wylfa Newydd Project

Construction Water Discharge Activity –
Environmental Permit Application: Appendices I to K

Appendix J –
Main Site Construction Phase Foul Water Design Report

PŴER NIWCLEAR HORIZON NUCLEAR POWER

WYLFA NEWYDD

Wylfa Newydd Project

Construction Water Discharge Activity – Environmental Permit Application: Appendices I to K

Appendix J – Main Site Construction Phase Foul Water Design Report

Contents

1. Introduction

1.1 Terms & Definitions

Table 1.1 Terms and definitions

Term	Definition
AA	Annual Average
ASP	Activated Sludge Process
BOD	Biochemical Oxygen Demand
CAPEX	Capital Expenditure
CFU	Colony Forming Units
COD	Chemical Oxygen Demand
DCO	Development Consent Order
DS	Dry Solids
ELV	Emission Limit Values
EPR	Environmental Permitting Regulations 2016
EQS	Environmental Quality Standards
FRA	Flood Risk Activity
FST	Final Settlement Tank
HNP	Horizon Nuclear Power
IFAS	Integrated Fixed-film Activated Sludge
MAC	Maximum Allowable Concentration
MBBR	Moving Bed Biofilm Reactor
MBR	Membrane Biofilm Reactor
MLWS	Mean Low Water Springs tides
N	Nitrogen
NRW	Natural Resources Wales
OCS	Odour Control System
OPEX	Operating Expenditure
PE	Population Equivalent
PST	Primary Settlement Tank
RAS	Return Activated Sludge
RBC	Rotating Biological Contactor

Term	Definition
SAF	Submerged Aerated Filter
SAS	Surplus Activated Sludge
SBR	Sequencing Batch Reactor
SS	Suspended Solids
SSSI	Sites of Special Scientific Interest
SAC	Special Areas of Conservation
SPA	Special Protection Area
TN	Total Nitrogen
TP	Total Phosphorous
TSS	Total Suspended Solids
WwTW	Waste Water Treatment Works
WDA	Water Discharge Activity
UV	Ultra Violet

1.2 Background/Introduction

Horizon Nuclear Power (HNP) is in the process of preparing the Development Consent Order (DCO) application for Wylfa Newydd Power Station. During the construction phase of the works a range of water/wastewater streams will be discharged to the environment, the Irish Sea – including surface water, foul water and excavation de-watering from various locations within the WDA.

Figure 1.1 Wylfa Newydd Power Station Construction Units 1 and 2 - 2023

Initial estimates are that the main construction site will host up to a maximum of 9,000 personnel peaking in 2023/24[1]. In terms of sewage treatment this is a significant flow and load comparable to a small town.

The work package considered within this proposal is limited to the Main Construction Site activities associated with wastewater collection, treatment and discharge to the environment. The management of the other discharges will be developed as separate work packages.

1.3 Objectives

The purpose of the 'Main Site Construction Phase Sewage Treatment Design' work package is to provide a basis of design and outline design of the wastewater collection, treatment and discharge systems. The design deliverables will form part of the construction phase Environmental Permit application. This Environmental Permit forms part of the wider DCO submission.

1.4 Scope

The engineering scope is limited to the Main Construction Site activities associated with wastewater collection, treatment and discharge to the environment. The assessment is based on feasibility stage assessment with associated deliverables suitable for inclusion in the Environmental Permit application. The scope includes a qualitative commentary on likely capital costs.

The deliverables are specified in the section below.

1.5 Deliverables

This report is limited to a short summary of the required information suitable for inclusion in the Environmental Permit application.

Wastewater Impact Modelling

The Main Construction Site Sewage Outfall Options Study includes the following deliverables.

1. Outfall location
   1.1. Identification of sensitive receptors
   1.2. Identification of applicable environmental quality standards (EQS)
   1.3. Description of dispersion characteristics of the local marine environment
   1.4. Qualitative/semi-quantitative comparison of dispersion characteristics from the outfall locations specified in WN0902-HZCOMN-EPT-TEC-00001
   1.5. Recommendation (with appropriate forward actions if necessary) on the preferred outfall location.
2. Final effluent quality required from the waste water treatment plant
   2.1. Identification of parameters where a more stringent, more relaxed or additional effluent limit value may be required (compared with the assumed baseline effluent standard of 20:30:20 mg/l as BOD:SS:ammonia).

Wastewater Treatment Evaluation

The wastewater treatment package includes the following deliverables;

1. Basis of design information
   1.1. Raw wastewater specification (flow and load) – including justification
   1.2. Treated final effluent specification (flow and quality) – including justification
   1.3. Treatment process design parameters – including justification
2. Preferred solution identification
   2.1. Project success criteria
   2.2. Long-list/short-list
   2.3. Preferred option selection – including justification
3. Preferred solution design package
   3.1. Process block flow (single line diagram)
   3.2. Process description & operating/control statement
   3.3. WwTW plot plan
   3.4. Power demand
   3.5. Waste (sludge) generation

Sewerage Infrastructure (Collection/Discharge)

The sewerage infrastructure package includes the following deliverables;

1. Collection system layout drawings;
2. Typical pumping station detail;
3. Typical outfall detail;
4. Rising main routing drawing.

2. Methodology

2.1 Overall Approach

The overall methodology adopted for the study was;

1. Initiation meeting with HNP
    1.1. Plan and programme project.
    1.2. Communications plan etc.
2. Determine base project information
3. Determine raw wastewater specification (flow and load)
4. Determine potential treated final effluent specification(s)
5. Determine indicative preferred outfall location and acceptability of suggested final effluent specification
6. Develop WwTW design
7. Develop sewage infrastructure
    7.1. Raw sewage collection system design
    7.2. Treated final effluent transfer/discharge design

3. Wastewater Impact Modelling

3.1 Input data for the study

Sewage arising

The sewerage and sewage treatment design is based on a flow of 100 litres/day/capita, based on the British Water Code of Practice for Flows and Loads [2] for sites with provision of good welfare and canteen facilities. It is assumed that sewage arising from fewer than 350 workers on site will be removed by tanker to an external facility. Once numbers reach 350 (anticipated in early 2019), sewage treatment will be provided by the on-site construction phase WwTW. The maximum number of workers on the main site is anticipated to be 9000, expected to be reached in 2023, declining again from 2025 onwards. Thus the maximum flow is assumed to be 900 m^3/d [1][2]. An inclusion of a 10% allowance for infiltration, based on industry practice for new development sewerage system pipework, gives a maximum daily flow of 990 m^3/d.

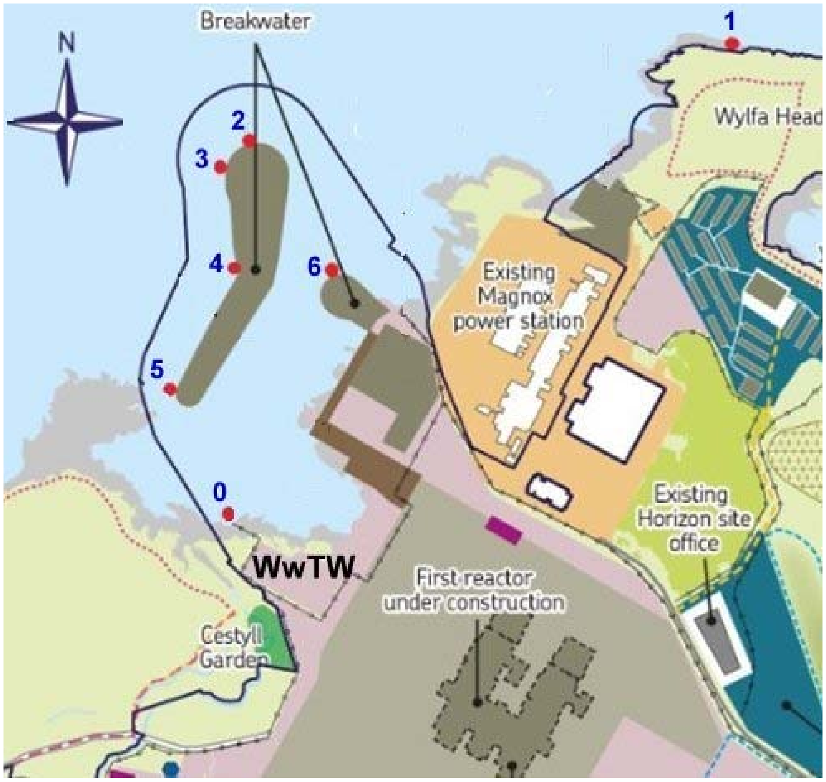
Characteristics of the raw sewage input to the WwTW were taken as in Table 3.1. Note that the inflow is generated for only 12 hours each day giving a maximum flow to the WwTW of 22.9 l/s but (for optimisation of operation of the biological treatment stage) it is assumed that the design will include balancing tanks giving an average flow over a 24-hour period of 11.5 l/s at a maximum population of 9000 workers. For the purposes of the optioneering study presented here, a maximum flow of 18.5 litres/s has been used, in accordance with the Project Note supplied by Horizon [1], to represent a worst-case scenario.

Table 3.1 Characteristics of Raw Sewage Input to WwTW [2]

Parameter	Flow Related	Concentrations mg/l	Loads kg/d
Population	9000		
Population equivalent (PE)	5700		
Daily flow (including 10% infiltration)	990 m^3/d		
Daily operating time	12 hours		
Number of days per week	7		
Maximum instantaneous flow	22.9 l/s		
Biochemical oxygen demand (atu) (BOD_5)		345 mg/l	342 kg/d
Chemical oxygen demand (COD)		760 mg/l	752 kg/d
Total suspended solids (TSS)		432 mg/l	428 kg/d
Total nitrogen (as N)		69 mg/l	68 kg/d
Total ammoniacal nitrogen (as N)		45 mg/l	45 kg/d
Total phosphorus (as P)		17 mg/l	17 kg/d
Phosphates (as P)		6 mg/l	6 kg/d

Potential outfall locations

Figure 3.1 Outfall Locations Considered



The potential outfall locations shown in Figure 3.1 (red dots, blue numbers) were taken forward for consideration [1].

This includes direct discharge from the sewage treatment plant to the coastal water immediately adjacent; this is identified as Location 0.

Environmental designations

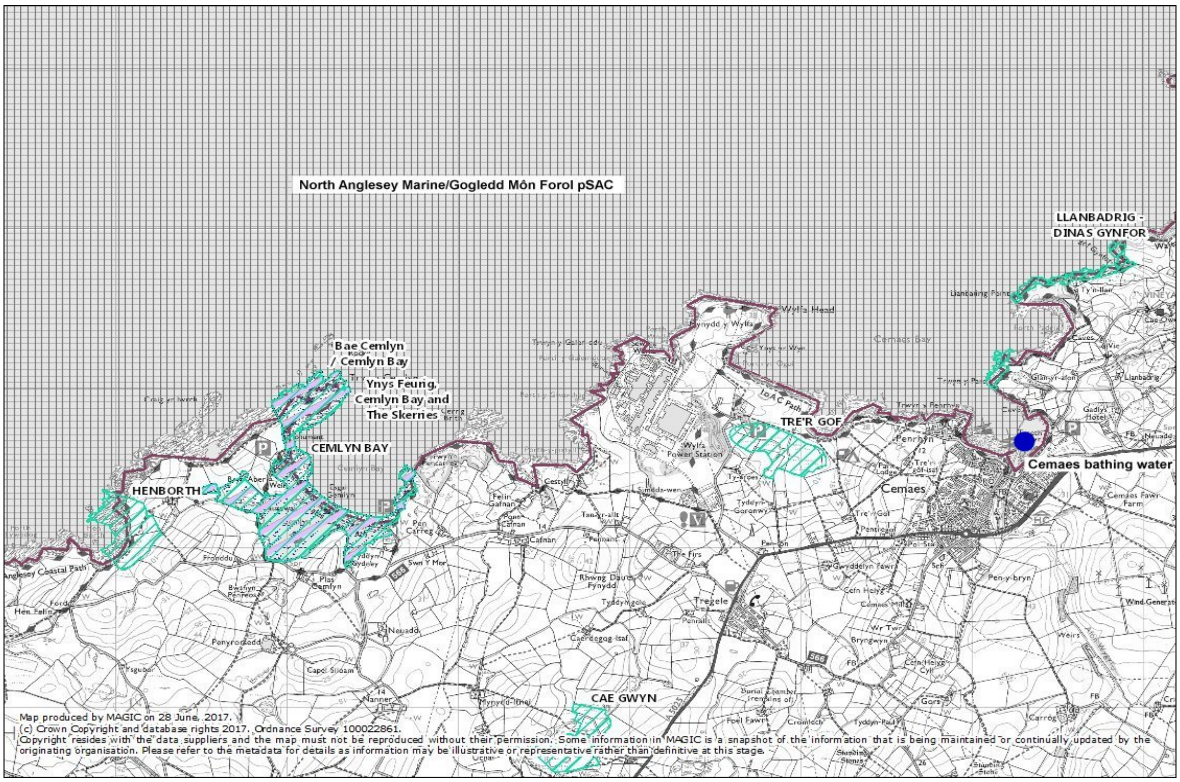
The following environmental designations were identified in the using MAGIC map (www.magic.gov.uk) as having potential to be affected by a marine WDA from main site construction phase sewage treatment at Wylfa Newydd:

- North Anglesey Marine/Gogledd Môn Forol pSAC;
  - possible special area of conservation for protection of harbour porpoise (*Phocoena phocoena*);
- Bae Cemlyn/Cemlyn Bay SSSI and SAC;
  - site of special scientific interest and special area of conservation for the coastal lagoon and shingle ridge (note water interchange between the sea and the lagoon is limited by the shingle ridge);
- Ynys Feurig, Cemlyn Bay and the Skerries SPA
  - special protection area for breeding terns (4 species) (note the key interest feature, the breeding area, is located above high water mark);

- Llanbadrig Dinas Gynfor SSSI
  - site of special scientific interest for its geological interest (unlikely to be affected by changes in marine water quality);
- Cemaes bathing water;
  - designated under the EU Bathing Waters Directive (compliance with bacteriological EQS potentially sensitive to sewage discharges).

Locations are shown in Figure 3.2.

Figure 3.2 Marine Environmental Designations



The designations listed above all represent 'protected areas' in terms of Article 6 of the Water Framework Directive (2000/60/EC).

No specific protected species constraints or shellfish water constraints were identified using MAGIC.

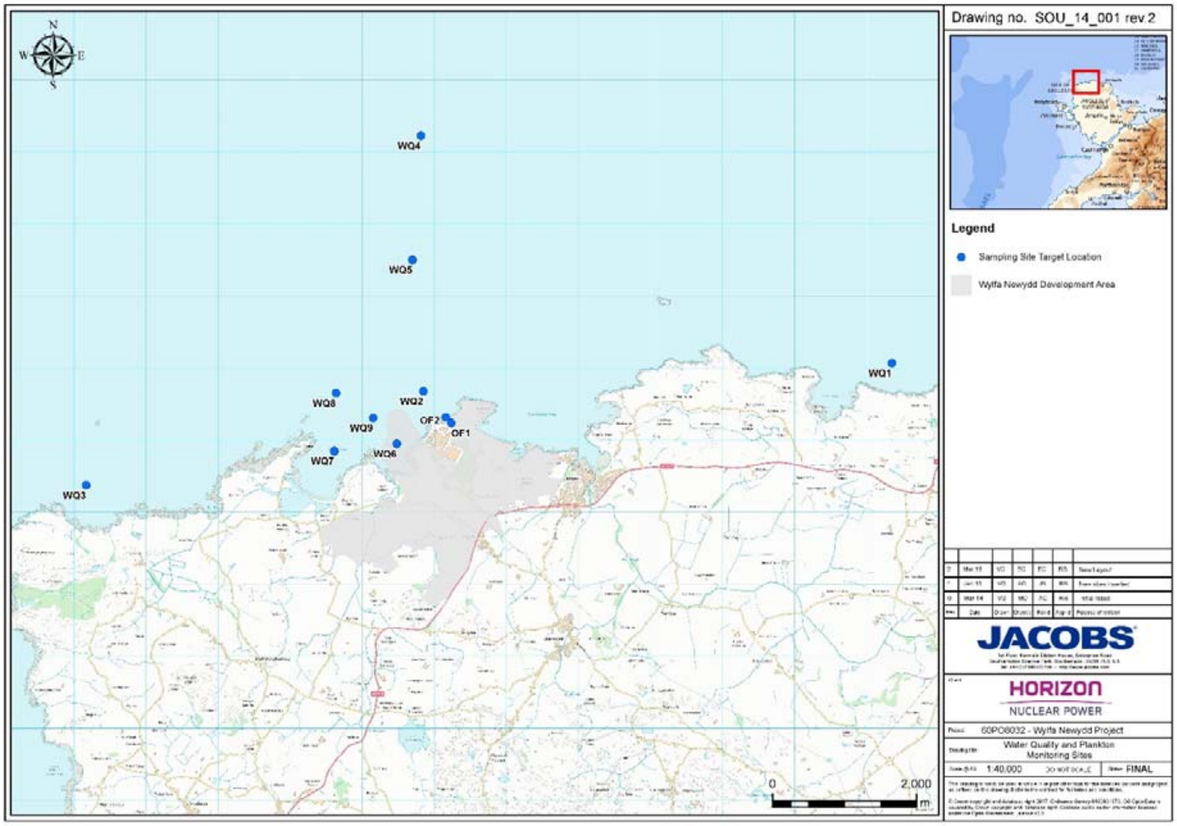
Thus the key constraints requiring consideration in the options study appeared to be:

- Cemaes bathing water;
- additional draft environmental quality standards (EQS) applicable within North Anglesey Marine pSAC.

Baseline receiving water quality

Baseline monitoring of sea water quality has been undertaken in the area around Wylfa and extending to sampling sites off Carmel Head/Trwyn y Gader to the west, Trwynbychan to the east and 4km out to sea (see Figure 3.3).

Figure 3.3 Marine water quality sampling target locations



Following the workshop (see Section 3.3), sea water quality data were supplied by Jacobs, for the period 2010 to 2016, as monthly means across all sites. Key characteristics of particular relevance to the proposed treated sewage discharge are shown in Table 3.2. Temperature and pH are included because of their relevance in calculating non-ionised ammonia concentrations.

Table 3.2 Characteristics of Receiving Sea Water

Parameter	Maximum	Mean	Minimum
Temperature	16.7 °C	11.7 °C	6.4 °C
pH	8.42	8.07	7.27
Biochemical oxygen demand (atu) (BOD_5)	<2.9 mg/l	<2.9 mg/l	<2.9 mg/l
Total suspended solids (TSS)	21.6 mg/l	8.8 mg/l	3.2 mg/l
Total ammoniacal nitrogen (as N) (filtered)	0.076 mg/l	-	<0.02 mg/l
Dissolved inorganic nitrogen (as N) (November-February only)	<0.21 mg/l		<0.12 mg/l

Bathing water data are provided in the NRW report *Bathing waters in Wales 2016* [5]. This reports that Cemaes was the only non-compliant bathing water in Wales in 2016. Cemaes failed in 2016 due to two samples with high bacterial values. The first of these was during wet weather and was predicted using a model [5]. The sample was not eligible to be discounted from the dataset due to the pollution event lasting longer than the 72-hours defined as "short-term" in the Directive [6]. The second of these did not coincide with heavy rainfall and the source is unknown. The impact of the two poor samples on the mean and standard deviation of the data was enough to bring Cemaes narrowly below the threshold for compliance on the intestinal enterococci determinand, which caused the bathing water to be classified poor overall.

Environmental quality standards (EQS)

Relevant environmental quality standards in relation to sewage discharges to sea water are those for ammoniacal nitrogen and dissolved inorganic nitrogen, as set out in Table 3.3. No EQS are established for BOD_5 or TSS or other nutrients in sea water.

Table 3.3 EQS in Sea Water

	Standard	Expressed as	Source
Non-ionised ammonia (as N) (filtered)	21 µg/l	AA	The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015[7]
Total ammoniacal nitrogen (as N) (filtered) Row heading	1 mg/l	AA	Habitats Directive Technical Advisory Group on Water Quality – Ammonia standards in estuaries WQTAG086 (2005) [8]
	8 mg/l	MAC	Habitats Directive Technical Advisory Group on Water Quality – Ammonia standards in estuaries WQTAG086 (2005) [8]
Dissolved inorganic nitrogen (as N) (November-February only)	0.252 mg/l [$$]	Winter mean	The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015[7]
Escherichia coli	500 CFU/100ml	95%ile	Bathing Waters Directive[6] – for good status
Intestinal enterococci	200 CFU/100ml	95%ile	Bathing Waters Directive[6] – for good status

AA – annual average

MAC – maximum allowable concentration

CFU – colony forming units

** - draft standard set for estuaries which are Habitats Directive sites (SAC) but applied here on a precautionary basis within embayments where dispersion may be limited

$$ - standard for 'good' status applicable in 'clear' waters (with annual mean TSS <10 mg/l)

3.2 Marine modelling

Initial dilution calculations

For locations 1, 2 and 5, results were available for initial dilution (ID) calculations (i.e. dilution occurring as the buoyant effluent rises to the sea surface) for a flow of 18.5 litres/s. For lower flows, dilutions will be greater. The calculation takes account of the water depth at each location.

For the initial dilution calculations, outfall pipe jet diameter was set at a value to give a minimum discharge velocity of 1 m/s, to achieve self-cleansing and minimise ingress of marine sediments.

The calculated initial dilutions shown in Table 3.4 were provided a workshop with HNP, Jacobs and Coastal Sciences. These are based on the Cederwall equation and equations for buoyant effluents discharged to moving water developed by WRc (see notes in Appendix B).

Table 3.4 Initial Dilution Calculations

Outfall Location	95%ile initial dilution	Mean initial dilution
1	200	1343
2	722	2764
5	8.6	39

Hydrodynamic model

A 3-D hydrodynamic model of the sea around Wylfa has been developed by Jacobs and Coastal Science using the Deltares Delft-3D modelling package.

We understand this model has been fully calibrated based on high resolution bathymetric surveys, deployment of acoustic Döppler current profilers (ADCP) and drogue releases [4]. The model has also been externally audited [3] and found to be appropriate for purpose for modelling thermal cooling water discharges from Wylfa (its principal purpose). However, with a grid mesh size of 23.3 m in the area close to the sewage outfall locations being compared in this study, it was considered that use of the particle tracking module to examine plume behaviour would provide valid data for use in the optioneering.

Initial plume modelling

For locations 1, 2 and 5, results were presented at the workshop from plume modelling using the Delft-3D hydrodynamic model and the particle tracking module. Note that these plume data are depth-averaged. Although we understand the model has been fully calibrated and externally audited, the initial plume modelling available at this stage has not been subjected to a full audit.

The modelling of discharge plumes was based on a discharge of 18.5 litres/s (the maximum assumed discharge rate specified in the Horizon Project Note [1]), so represents a worst case (highest discharge rate) situation at this stage. The locations modelled provided a wide range of dispersion conditions and facilitated inference of likely plume behaviour at intermediate positions.

Based on a discharge concentration of *Escherichia coli* in the treated sewage of 3 x 10^6 CFU/100ml [8] and T_{90} values of 10 hours for daytime and 55 hours at night, the modelling provided predictions of bacterial (*E. coli*) contributions at Cemaes bathing water. Results are shown in Table 3.5.

Table 3.5 Initial Plume Modelling for *E. coli* Bacteria reaching Cemaes Bathing Water

Outfall Location	95%ile contribution at Cemaes bathing water	Note
1	10.8 CFU/100ml	Approximately 2% of the EQS for good status
2	7.9 CFU/100ml	<2% of the EQS for good status
5	2.0 CFU/100ml	<1% of the EQS for good status

3.3 Outfall location optioneering

Options considered

At an optioneering workshop held at Horizon's offices in Gloucester on 28th June 2017, the outfall locations shown in Figure 2.1 were compared, subject to assumptions based on our understanding of the current proposals for the Wylfa Newydd development and certain caveats, as listed below. Using a scoring system based on environmental, regulatory, engineering and cost constraints, a preferred outfall location was identified.

Assumptions

The following design assumptions were agreed at the workshop as the basis on which the specified outfall location options and the level of treatment required would be considered.

- For discharge locations located on the offshore breakwater:
  - the currently proposed overall construction schedule (determining the phasing of sewage loads) and the proposed schedule for the construction of the breakwater mean that it is likely that the sewage outfall will need to be in place by the start of Q2 2019, before causeway construction and breakwater construction, both currently planned to commence in Q2 2019
  - it is assumed that, if constructed by a cut and cover method or laid on the sea bed, the sewage outfall pipe will be located under the footprint of the breakwater and the causeway, thus avoiding any additional seabed habitat loss (NB this is not intended to rule out alternative construction methods that would not disturb the seabed, for example, directional drilling).
- It has been assumed that cooling water abstraction will not take place during the period when construction site sewage discharges will occur (so the entrainment of treated sewage into the cooling water intake was not considered a relevant factor in the outfall location options study).
- For all locations examined, there will be a simple diffuser arrangement (designed to avoid visible boil, limit sediment ingress and improve initial dilution) that requires only basic maintenance and will be removed following the Wylfa Newydd Construction phase.
- In all cases it is assumed that the outfall extends at least 50 metres offshore of where the seabed is at chart datum (CD) and the seabed at the discharge point is at least 1 metre below chart datum (i.e. a minimum water cover of 1 metre is provided at the lowest tides) (this means that the discharge complies with the EA/NRW screening Test 4 for discharges to coastal waters).
- Any concerns about construction noise affecting nesting terns within the Ynys Feurig, Cemlyn Bay and The Skerries SPA can be mitigated by selection of construction techniques, noise control and/or seasonal restrictions on construction and are therefore not a differentiating factor to be taken into account in selecting the preferred outfall location, although seasonal restrictions might affect the scheduling of the works. This takes account of the fact that noise generated by outfall construction at the locations nearest to the SPA is likely to be minimal compared with noise produced by breakwater construction, so any concerns will need to be addressed anyway.

In relation to the exact position of the outfall release point, a 12 figure National Grid Reference (NGR) has been supplied by AFW, as this is required for completion of the application forms for an environmental permit for a WDA. Note that this NGR is supplied based on the following assumptions.

- Several of the potential outfall locations considered at the workshop on 28th June 2017 were related to the position of the offshore breakwater. For the purposes of deriving an NGR, the location of this breakwater has been assumed to be as shown on drawing WN0907-HZCON-LAP-DRG-0004 Rev 2. It has also been assumed that the outer outline of the breakwater shown on this drawing represents the point at which the elevation of the outer edge of the structure passes through CD. The northern extent of the breakwater shown on this drawing differs slightly from various positions provided previously, for example, in the project specification and on the tidal plots shown at Figure 4.1 in this report; however, after post-workshop review of the differences in location, AFW believes that these differences are not material to the workshop conclusions.
- Regarding water depth at the proposed NGR for the outfall release point, CD is assumed to be 3.6m below OD, as quoted on drawing CS0257/D5/V2 supplied by Horizon.

Workshop held and outcome

Objectives

The objectives of the workshop related to sewage arising's during construction from the main construction site only and were to:

- determine the optimum location for discharge of treated sewage based on comparison of 6 locations suggested in the Project Note from Horizon [1];
- assess whether the default effluent limit values suggested in the Project Note [1] (20:30:20 mg/l for [BOD]:[SS]:[ammoniacal N]) are appropriate or whether alternative more or less stringent values are appropriate;
- consider whether any other ELVs would be appropriate (for example for faecal bacteria or for nutrients).

Workshop outputs in relation to the level of treatment required are described in Section 3.4.

The outputs from the workshop provided the information to allow the WwTW evaluation to progress.

Note that the project does not include any design or assessment work for discharges from the construction site campus and this aspect was not discussed at the workshop.

Approach

Attendees at the workshop are listed in Appendix A.

Three PowerPoint presentations were given providing:

- an overview of the workshop objectives, constraints on outfall locations and consideration of ELVs;
- a presentation on phasing of engineering works for the whole site for every quarter from 2019 to 2027;
- an overview of the Delft-3D hydrodynamic marine model established for the coastal waters around Wylfa and preliminary results for plume modelling for outfall location options 1,2 and 5, with estimates of bacterial loadings at Cemaes bathing water.

Selection criteria

The potential outfall locations were then compared using a scoring matric against the criteria listed in Table 3.6, using a scoring system from 1 to 5 (1 being most negative/least acceptable and 5 the most beneficial/most acceptable), then applying the weightings indicated:

- environmental constraints – mainly based on compliance with environmental quality standards (EQS);
- permitting – based on likelihood of obtaining relevant environmental permits (for water discharge activity (WDA) and possibly flood risk activity (FRA)) and marine licences;
- engineering – considering construction, operation and maintenance and health & safety;
- schedule – covering delays to the schedule or incompatibility with the currently proposed scheduling of other construction activities – after examination of the proposed phasing and discussion at the workshop it was decided that, as the outfall was required before any incompatibilities would arise, it was not a useful differentiating factor so was not considered further;
- cost – taking account of both CAPEX and OPEX for the outfall and, for locations which would only be acceptable with additional treatment, extra costs of such additional treatment.

An iterative approach to location and level of treatment was required. Where an outfall location would require significant additional treatment, this was reflected in the costs aspect of the options scoring criteria.

Decommissioning was felt not to be a differentiating factor, as the only components likely to be decommissioned were the WwTW and the diffusers, which would involve similar costs for all locations.

Table 3.6 Proposed Optioneering Criteria for Outfall Location Options Study

Category	Criterion Detail	Notes	Sources of Information
Environmental (25% weighting)	1. Dispersive nature of receiving water	Including occurrence of slack water periods	Jacobs model calibration report and modelling reports (with breakwater in place). Qualitative assessment at workshop
	2. Effects of wind on plume direction	To help define worst case conditions	Jacobs model calibration report and modelling reports (with breakwater in place). Qualitative assessment at workshop
	3. Available water depth close to MLWS	Re availability of initial dilution as plume rises through water column	TITAN baseline bathymetric survey data Proposed pipe diameter required from Horizon
	4. Presence of protected areas within likely plume extent	E.g. nature conservation designations, shellfish areas, bathing waters	On-line sources – e.g. MAGIC map, NRW data, Cefas shellfish report
	5. Amenity use in the vicinity	Beach and waterborne activity	Beach classifications from Isle of Anglesey County Council
	6. Potential for cumulative effects with other discharges		Published data (public register and various reports)
Permits/ consents/ licences (25% weighting)	1. Likely constraints on obtaining environmental permit for water discharge activity	See environmental section above for constraints	See above
	2. Likely constraints on obtaining environmental permit for flood risk activity	E.g. presence of coastal flood defences	Aerial photos, shoreline management plan (SMP2)
	3. Likely constraints on obtaining marine licence	E.g. presence of valued habitat	NRW data
	4. Likely constraints on obtaining planning permission/powers in DCO	E.g. visual impact, disruption of amenity	Aerial photos, beach classifications, Anglesey AONB Management Plan Review

Category	Criterion Detail	Notes	Sources of Information
Engineering **(20% weighting**	**1. Constructability** 2. Health & Safety issues (construction) 3. Access and maintenance 4. Health & Safety issues (operation)	High level appraisal only	Advice from Horizon on nature of route, geology and seabed data. Supplied plans, aerial photos.
Schedule **(15% weighting)**	1. Likely availability of outfall location when required 2. Time required to construct	Potential interaction with breakwater construction	Notes in Project Note WN0902-HZCON-EPT-TEC-00001 – page 11 Update at workshop
Cost **(15% weighting)**	1. Cost of outfall construction (and removal if this will be required) (CAPEX)	Information behind these statements on cost in project specification	Information from Horizon If no data available, simply compare construction length and add factors for specific difficulties regarding route
	2. Operating costs (OPEX)	E.g. pumping costs	Information from Horizon

Options assessment

The results of the scoring are shown in Table 3.7 below. The following notes in Table 3.8 give some additional detail on how scores were allocated.

Table 3.7 Scoring of Outfall Locations Allocated at Workshop

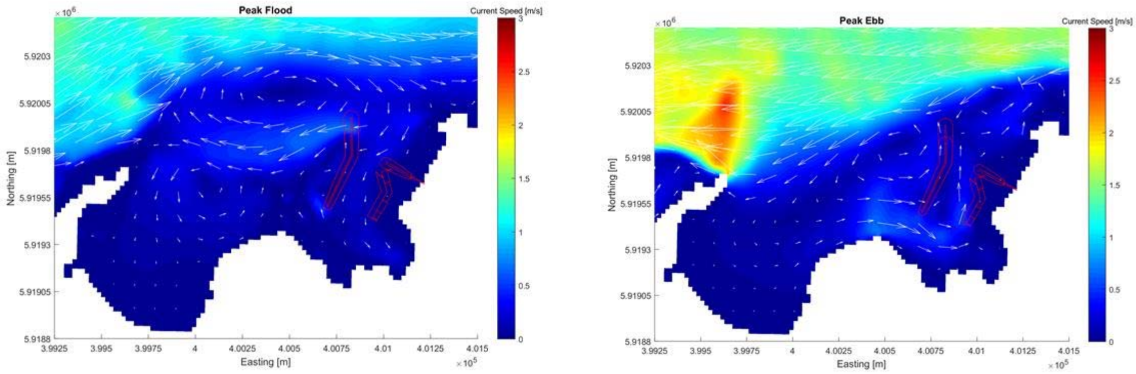
Topic	Outfall location						
	0	1	2	3	4	5	6
Environmental	1	4	5	4	2	1	2
Weighting 25%	0.25	1	1.25	1	0.5	0.25	0.5
Permits	1	4	5	4	2	2	2
Weighting 25%	0.25	1	1.25	1	0.5	0.5	0.5
Engineering							
• **Construction**	5	1	3	3	3	3	4
• **Construction H&S**	5	1	2	2	2	2	3
• **Access & maintenance**	5	1	3	3	3	3	4
• **Operation H&S**	5	2	3	3	3	3	4
Weighting (engineering total) 20%	1	0.25	0.55	0.55	0.55	0.55	0.75
Schedule	Not required as differentiator						
Weighting 15%	0	0	0	0	0	0	0
Cost							
• **CAPEX**	1	1	3	3	3	2	3
• **OPEX**	1	3	4	4	4	1	3
Weighting (cost total) 15%	0.15	0.25	0.5	0.5	0.5	0.25	0.45
OVERALL TOTAL	**1.65**	**2.5**	**3.55**	**3.05**	**2.05**	**1.55**	**2.2**
OVERALL RANK	**6**	**3**	**1**	**2**	**5**	**7**	**4**

Notes below in Table 3.8 consider each location in turn. Outfall locations considered are shown in Figure 2.1. For more discussion on calculation of pollutant concentrations, refer to **Section 5** on Effluent Limit Values.

For locations 1, 2 and 5, results were available for initial dilution (ID) calculations (i.e. dilution occurring as the buoyant effluent rises to the sea surface) both as average and 95%ile values, and from depth averaged plume modelling using the Delft-3D hydrodynamic model.

For outfall locations not specifically modelled, scoring took account of the hydrodynamic conditions indicated by the model and conveniently summarised in the mid-flood and mid-ebb vector plots in Figure 4.1 generated by the hydrodynamic model with the breakwaters in place These show clearly areas of low tidal currents and the presence of eddies (gyres) at least during some parts of the tidal cycle.

Figure 3.4 Tidal streams in the vicinity of the potential discharges



Calculations based on the background data supplied after the workshop served to confirm conclusions based on approximate calculations undertaken during the course of the workshop.

Table 3.8 Initial Plume Modelling for Bacteria reaching Cemaes Bathing Water

Outfall location	Topic	Rationale
0	Environmental Permitting Engineering Cost	Not modelled but given lowest score as within highly enclosed area and expected to behave similarly to location 5, where modelling showed very poor initial dilution and dispersion, so large mixing zone and high ammonia concentration likely to come into contact with valued biological receptors in the intertidal area with potential adverse effects on intertidal benthos. Only possible to make environmentally acceptable with additional treatment and even then difficult to avoid some adverse effects from plume impingement on a large length of shore. Unlikely to be acceptable due to minimal water depth (giving minimal ID and thus excessive mixing zone unless very stringent treatment is applied) Minimum amount of engineering and easy access so high score Poor CAPEX score as additional treatment required, poor OPEX score due to ongoing additional treatment costs.
1	Environmental Permitting Engineering Cost	High ID and good dispersion but nearest location to Cemaes bathing water, so score reduced to 4. Expected to be acceptable for permitting and marine licence (as most of outfall route on land) but concerns about Cemaes bathing water may reduce NRW enthusiasm Very difficult route and hazardous discharge location on headland, so low score Poor CAPEX due to length and difficult route, OPEX medium because of pumping costs
2	Environmental Permitting Engineering Cost	Best ID and good dispersion and more remote from Cemaes bathing water than location 1 Expected to be acceptable to regulators; limited effect on seabed in addition to breakwater. Some difficulty as more offshore work than 0 or 6. H&S concerns re construction CAPEX medium score, OPEX
3	Environmental Permitting Engineering Cost	Similar to location 2 but location more likely to catch southward circulation taking plume into low dispersion area at some tidal states, so score reduced Expected to be slightly less acceptable to NRW than location 2 due to poorer dispersion As location 2 CAPEX and OPEX as location 2
4	Environmental Permitting Engineering	Tidal plots show low dispersion at some tidal states; eddies likely to take plume southward into low dispersion area at some tidal states, may need to agree large mixing zone, so score reduced Probably difficult to persuade NRW this would be the best option As location 2 – shorter but most issues the same

Outfall location	Topic	Rationale
	Cost	CAPEX and OPEX as location 2
5	Environmental	Minimal water depth giving low ID, very poor dispersion area, so large mixing zone impinging on shore, thus high ammonia concentration more likely to come into contact with valued biological receptors in the intertidal area with potential adverse effects on intertidal benthos, unless additional treatment is applied
	Permitting	Probably difficult to convince NRW this would be the best option
	Engineering	As location 2 – shorter but most issues the same
	Cost	Shorter outfall not under breakwater, so CAPEX less than locations 2,3 and 4 but offset by extra treatment cost, poor OPEX score as additional treatment required
6	Environmental	Partially enclosed, plus similar concerns to location 4
	Permitting	Probably difficult to convince NRW this would be the best option
	Engineering	Onshore, so easier than on offshore breakwater
	Cost	CAPEX as location 2, OPEX medium because of pumping costs

Conclusions

The following conclusion on outfall location was reached by consensus at the workshop.

- Sewage treatment and sewerage design and environmental impact assessment should proceed on the basis that the outfall will be located at location 2, immediately off the north end of the offshore breakwater, with the outfall extending at least 50m beyond the level of lowest tides (Chart Datum (CD)) and in a water depth of at least 1m below CD.

AFW recommends that, in order to meet screening test criteria set by EA/NRW, the outfall should extend at least 50m beyond where the seabed is at CD and should end in water at least one metre deep when the tide level is at CD. Based on the position of the north end of the breakwater shown in the plot plan supplied by Horizon on 4th July 2017 (Drawing 5151821-ATK-ZZ-XX-DR-D-0001), subsequent to the workshop, and on the assumption that the outer margin of the breakwater marked on the plot plan may have any gradient up to vertical, the outfall discharge point should be located 50m north of this margin to ensure that, whatever the breakwater design, the outfall extends 50m beyond the point where the margin of the breakwater is at CD.

- On this basis, the proposed location of the discharge (as a 12 figure National Grid Reference) is at NGR 234475 394323.

This will give a minimum water depth at the discharge point of 20.4 m (depth below Ordnance Datum) (by interpolation using bathymetric data supplied in file CS0257_D5_V2 Bathymetry.dxf), which corresponds to a depth at lowest astronomical tide (i.e. depth below Chart Datum) of 16.8m. Note that design of the outfall structure may need to take account of navigation requirements for vessels accessing the marine offloading facility.

3.4 Treated sewage effluent standards

Treatment options considered

The level of sewage treatment necessary was also considered, taking account of effluent limit values (ELVs) likely to be required at the different outfall locations. Three levels of treatment were considered (concentrations as mg/l):

- conventional treatment (20:30 mg/l BOD:SS standard), with no specific provision to achieve nitrification;

- extended treatment providing nitrification (providing at least the 20:30:20 BOD:SS:amm-N standard suggested in the Horizon Project Note [1]; in practice nitrification would probably achieve 20:30:10 mg/l – as shown in the table below);
- treatment including nutrient (N and P) removal to Urban Waste Water Treatment Directive sensitive area standards.

In each case, the need for ultra-violet (UV) disinfection to reduce concentrations of faecal bacteria was considered as a separate issue, as disinfection can be added to any of the other forms of treatment. The alternatives considered are summarised in Table 3.9, along with associated effluent standards.

Table 3.9 Potential Standards for Treated Final Effluent WDA Permit (concentrations)

Treatment Parameter	Conventional	Conventional + disinfection	Nitrifying*	Nitrifying* + disinfection	Nutrient removal	Nutrient removal + disinfection
Biochemical oxygen demand (atu) (BOD) (mg/l)	20	20	20	20	20	20
Chemical oxygen demand (COD) (mg/l)	120	120	120	120	120	120
Total suspended solids (TSS) (mg/l)	30	30	30	30	30	30
Total nitrogen (as N) (mg/l)	N/a	N/a	N/a	N/a	15	15
Total ammoniacal nitrogen (as N) (mg/l)	N/a	N/a	20**	20**	5	5
Total phosphorus (as P) (mg/l)	N/a	N/a	N/a	N/a	2	2
***Escherichia coli* (CFU/100ml)**	3×10^6	2×10^3	3×10^6	2×10^3	3×10^6	2×10^3
***Escherichia coli* ($\log_{10}$ CFU/100ml)**	6.5	3.3	6.5	3.3	6.5	3.3

* - default standard provided in project specification [1]

** - note typical nitrifying treatment will in practice reduce ammoniacal nitrogen concentrations to 10 mg/l (as N)

It is possible that the water discharge activity (WDA) environmental permit may only place limits on BOD and TSS. However, it will still be necessary in the permit application to demonstrate that other components of the treated sewage will not compromise compliance with chemical or ecological standards set under the Water Framework Directive (WFD), including additional ammoniacal nitrogen standards applicable to protected areas such as the North Anglesey Marine/Gogledd Môn Forol pSAC (proposed designation for harbour porpoise) and bacterial standards applicable to Cemaes designated bathing water.

No other protected areas were considered close enough to be relevant to the optioneering process (see section on Environmental Designations).

Criteria considered

Key parameters affecting level of treatment required were judged to be:

- faecal bacteria – in relation to compliance with bathing water standards at Cemaes; this is relevant to whether disinfection is required;

- ammoniacal nitrogen – in relation to the EQS set for all coastal waters for non-ionised ammonia of 21 µg/l (as N) as an annual average (AA) and the proposed EQS for total ammoniacal nitrogen set by the UK's WQTAG for designated Habitats Directive sites (1 mg/l (as N) annual average (AA) and 8 mg/l (as N) maximum allowable concentration (MAC)); this is relevant to whether nitrification is required;
- nutrients – in relation to standards for dissolved inorganic nitrogen as a winter average for 'clear' waters, where the EQS is 0.25 mg/l for 'good' status; this is relevant to whether nutrient removal is required.

Assessment

Bacteria

The bathing water of concern is Cemaes which is currently classified as 'poor' due to high inputs of faecal bacteria from local rivers during rainfall events.

For the three modelled outfalls, estimates of worst-case 95%ile contributions of *Escherichia coli* to the bathing water at Cemaes, based on a discharge being made continuously at the design maximum of 18.5 litres/s and an *E.coli* bacterial concentration in the treated sewage of 3 x 10^6 CFU/100ml, are given in Table 3.6.

These results reflect the fact that location 1 (Wylfa Head) is nearer to the bathing water than location 2 (breakwater north end). Location 5 provides least bacterial input at it is more remote and also in a low dispersion area, so the effluent is held west of Wylfa Head for longer, allowing greater die off before dispersion during a longer transit to the bathing water. However, all three give very low contributions compared with the EQS for *E. coli* for 'good' classification of 500 CFU/100ml as a 95%ile, even based on a worst case flow of 18.5 l/s. For the expected flow of 11.5 l/s, values would be even lower. Nevertheless, it is still possible that the regulator may see a small increase as being of concern in terms of tipping the balance between failure and compliance at Cemaes and allowing space on the WwTW site for possible retrofitting of UV disinfection at a later date may be a wise precaution, unless agreement can be reached in advance with Natural Resources Wales (NRW) that the predicted contributions can be screened out.

Ammoniacal nitrogen

The worst-case AA process contribution of a discharge from a conventional treatment process (i.e. with no nitrification and ammoniacal nitrogen concentration in the treated discharge of 45 mg/l – as at the works inlet), at preferred location 2, after average initial dilution calculated to be 2764 times (Table 3.5), is 0.016 mg/l (as N). The average recorded in the marine baseline studies is <0.076 mg/l (as N), thus the recommended EQS (AA) for Habitats Directive sites of 1 mg/l is met by a large factor immediately after ID. Similarly, applying the 95%ile ID value of 722 gives a maximum process contribution of 0.062 mg/l (as N) immediately after ID. The maximum recorded baseline value is 0.076 mg/l, thus the MAC EQS of 8 mg/l is also met by an even larger factor. Similar conclusions are reached for outfall location 1, while for outfall location 5 the process contribution alone after ID, at 1.15 mg/l, would breach the total ammonia recommended AA standard for Habitats Directive sites at a flow rate of 18.5 l/s, potentially leading to a requirement for treatment to include nitrification or agreement on a mixing zone extending well beyond the immediate ID zone.

Non-ionised ammonia concentrations depend on the equilibrium between the ammonium ion (NH_4^+) and non-ionised ammonia (NH_3). The position of the equilibrium is affected by temperature, pH and salinity. Calculation is undertaken using a spreadsheet tool supplied by the Environment Agency, into which the values of temperature, pH, salinity and total ammoniacal nitrogen concentration are entered.

Taking the average temperature of 11.7°C, average pH of 8.07 and salinity as 34 (full sea water in the UK), for location 2, the combined average total ammonia concentration after ID (baseline plus process contribution) of <0.076+0.016 = <0.092 mg/l would result in an average non-ionised ammonia concentration of <1.79 µg/l (as N), well inside the WFD EQS of 21 µg/l as an AA. Even taking worst case baseline conditions of maximum temperature (16.7 °C) and maximum pH (8.42) for location 2, the combined average total ammonia concentration (baseline plus process contribution) of <0.092 mg/l would result in a non-ionised ammonia concentration immediately after ID of <5.67 µg/l, still well inside the WFD EQS. Thus for location 2 there would be no requirement to agree a mixing zone beyond the initial dilution phase as the effluent rises through the water column.

Similar conclusions are reached for outfall location 1, while for outfall location 5 the non-ionised ammonia concentration would be more than double the EQS after ID, potentially leading to a requirement for treatment to include nitrification or agreement on a mixing zone extending well beyond the immediate ID zone.

Overall, the conclusion is that there is no requirement for nitrification to be incorporated into the sewage treatment process for discharge of treated sewage at preferred location 2. The same conclusion would apply at location 1 but not at location 5.

Nutrients

Dissolved inorganic nitrogen is usually the limiting nutrient for algal growth in the sea and is therefore the nutrient group for which an EQS has been established. No EQS is set for phosphates in the sea.

The worst case discharge from a conventional treatment process (i.e. with no nutrient removal and discounting losses in the sludge, giving a nitrogen concentration in the discharge of potentially up to 69 mg/l – as at the inlet) gives a process contribution at preferred outfall location 2, after average ID of 2764 times (Table 3.1), of 0.025 mg/l (as N), only 10% of the EQS.

Baseline data are limited, as most are reported as ‘less than’ values, but even taking the highest of these values (<0.21 mg/l) and adding the process contribution from the discharge immediately after ID would still result in compliance with the EQS which is 0.252 mg/l as N, based on winter average concentrations. On this basis, there is no justification for nutrient stripping.

For outfall location 1, ID is slightly poorer, so results are less clear cut (due to the prevalence of ‘less than’ values) but discharge would still be likely to be acceptable without nutrient removal. For location 5, the process contribution alone would exceed the EQS by a factor of 7, potentially leading to a requirement for treatment to include nutrient removal or agreement on a mixing zone extending well beyond the immediate ID zone. Such a mixing zone would be unlikely to be acceptable so close to the shoreline, where elevated nutrient concentrations could cause adverse effects on the algal (seaweed) flora, leading to dominance by green algae and consequent adverse effects on the intertidal fauna.

Conclusions

The following conclusions were reached on level of treatment.

- The worst-case contribution of the discharge at preferred location 2 to bacterial counts at Cemaes bathing water, assuming conventional treatment only, is an increase in 7.9 CFU/100ml (as a 95%ile), which is a negligible concentration compared with the bathing water standards and does not indicate a need for disinfection of the treated Main Site Construction Phase sewage discharge. However, this will be subject to further discussions with NRW.
- With the outfall at location 2, based on initial dilution calculations for conventional treatment only (no nitrification), the EQS for total ammoniacal nitrogen within Habitats Directive sites and the WFD EQS for non-ionised ammonia would be met by a large margin immediately after initial dilution. Therefore, there is no requirement for nitrification.
- With the outfall at location 2, based on initial dilution calculations for conventional treatment only (no nutrient removal), the EQS for dissolved inorganic nitrogen would be met immediately after initial dilution. Therefore, there is no requirement for nutrient removal.

The overall conclusion is that conventional treatment will be adequate provided outfall location 2 is selected. The results of the optioneering exercise provide no justification for disinfection, nitrification or nutrient removal. However, circumstances at Cemaes bathing water may still result in a requirement from NRW to minimise bacterial loads and it may be wise to leave space for possible future retrofitting of a UV disinfection unit.

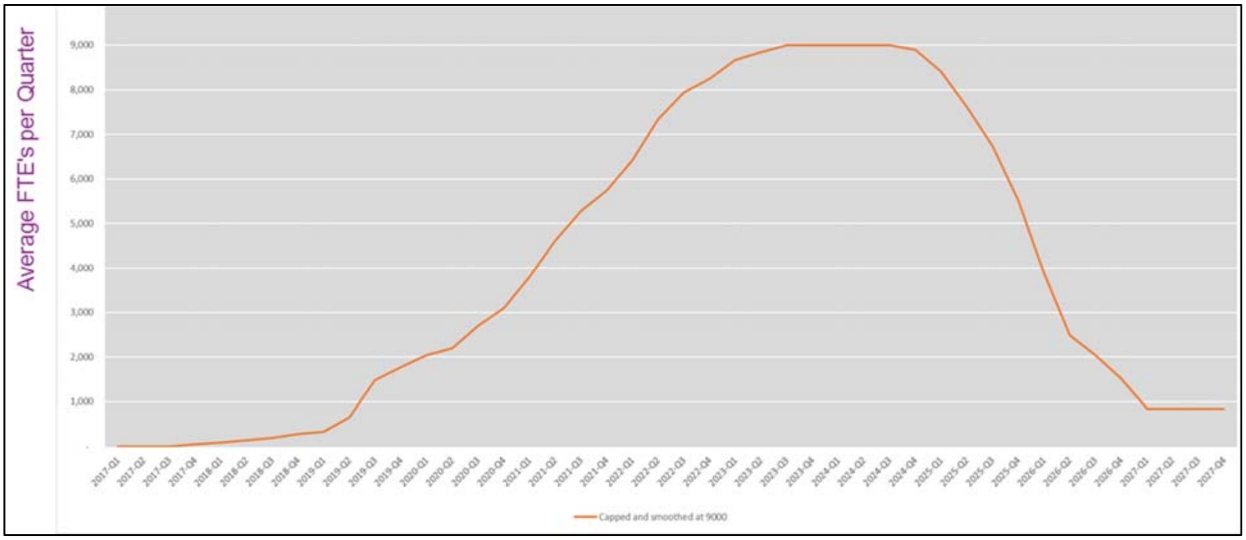
4. Wastewater Treatment Evaluation

4.1 Project Information

Raw Wastewater Point Sources

The workforce will vary over the construction period as shown in Figure 4.1. The peak occupancy of the Construction Site will likely be Q3-2023 to Q3-2024 with 9,000 personnel being accommodated [1].

Figure 4.1 Construction Site Workforce Profile [1]



With a large construction workforce, HNP has indicated that there will be canteens and good welfare facilities on-site. Whilst the construction workforce is less than 350, i.e. until Q2 2019, the sewage will be collected and tankered off site to a nearby WwTW.

HNP Particular Specifications

At this stage no particular specifications have been identified. The WwTW should be constructed to typical industry and specialist vendor standards. This will be detailed during the subsequent design phases.

Site Plot Plan/Land-Take Availability

A 100 x 100 m plot had been initially suggested by HNP to site the Construction Site WwTW, which is located to the North of the construction compound. However, HNP has stressed the value of land and its limited availability and, therefore, seeks to minimise land-take for the WwTW.

Planning / Permitting Constraints

Potential odour emissions from the sewage treatment work with regard to nearby receptors. Nearby receptors have been identified;

- National Trust rented residential property within 200 m
- Wales Coast Path within 75 -100m
- Cestyll Garden registered historic park and garden within 50-75 m

Odour emission is scrutinised as part of planning application and regulated under waste management as part of the Environmental Permit Regulations (EPR).

Utility Infrastructure

No limitations are identified. This project shall identify electrical power and other utilities required for operation.

Success Criteria

The following success were discussed and agreed with HNP as a basis for assessing treatment options.

- Landtake/footprint
- Odour minimisation
- Operability/maintainability
- Constructability/demolition
- Prefabrication/package
- Technology vendor flexibility
- Sludge production
- OPEX/CAPEX

Land-take and odour emission were identified as key criteria subject to increased weighting.

4.2 Raw / Treated Final Effluent Specifications

The raw wastewater specification was developed for the anticipated worker profile over the construction period provided by HNP [1]. This wastewater will be generated from toilet & shower blocks, offices and significantly any canteen facilities to be provided on-site. AmecFW used the British Water [2] guidance for determining population equivalent (PE) and the associated loads of the sanitary determinands: COD, BOD, TSS, total-nitrogen, ammoniacal-nitrogen, total-phosphorus and phosphate-phosphorus. Microbiological contamination levels are based on common industry practice values adopted for disinfection analysis. The temperature range is based on common industry practice of 8 – 18 °C for typical domestic sewage, increased noting that the cooling effect of infiltration and surface water is minimal in this case.

The key design data is

- Population 9,000[1]
- Population Equivalent (PE) 5,700
- Daily Operating Time 12 h/d, 7 d/week[1]
- Flow 990 m^3/d, 22.9 l/s
- Temperature 10-25 ^oC

Table 4.1 summarises the raw wastewater specification recommended for the Construction Phase WwTW.

Table 4.1 Raw wastewater specification

	Design Load (kg/d)	Design Concentration (mg/l)
Biochemical oxygen demand (atu) (BOD_5)	342	345
Chemical oxygen demand (COD)	752	760
Total suspended solids (TSS)	428	432
Total nitrogen (as N)	68	69
Total ammoniacal nitrogen (as N)	45	45
Total phosphorus (as P)	17	17
Phosphates (as P)	6	6
Faecal coliform		8 CFU/100 ml in

The load is based on 38 g/hd.d BOD and 5 g/hd.d ammoniacal-nitrogen and an associated flow of 100 L/hd.d - as recommended by British Water [2] for discharges from *'INDUSTRIAL - Office/Factory with canteen'*. Whilst this British Water classification generates a relatively high flow and load, it does include discharges associated with canteen facilities, which in this case could be serving multiple meals over the working day. However, it is unlikely that a maximum 27,000 meals (= 9,000 x 3) will be prepared as a significant diversity factor (or simultaneity factor) will apply. The total flow value incorporates 10 % infiltration to the flow determination, which is industry practice for new development sewerage system pipework. Surface water will be separated from the sewerage system and discharged through a dedicated system. Amec FW believes the derived flow and load basis is a reasonable and realistic basis of design for the proposed Construction Site WwTW. The flow and load represents about 65 % that of a typical residential population – i.e. a population equivalent of 5,700.

Amec FW suggested a range of possible consent standards which correspond with treated final effluent quality from typical treatment technology implemented for coastal applications - with advanced disinfection technology to achieve tighter bacteriological standards associated with bathing water requirements.

Three levels of treatment were considered (concentrations as mg/l):

1. Conventional treatment (20:30 BOD:SS standard), with no specific provision to achieve nitrification;
2. Extended treatment providing nitrification (providing at least the 20:30:20 BOD:SS:amm-N standard suggested in the Horizon Technical Note [1]; in practice nitrification would probably achieve 20:30:10, as shown in Table 4.2 below);
3. Treatment including nutrient (N and P) removal to Urban Waste Water Treatment Regulation for sensitive area standards.

Table 4.2 summarises the three standards each with/without disinfection.

Table 4.2 Potential Treated Final Effluent Specifications (NRW Consent ELVs)

		Conventional		Nitrifying		Nutrient Removal	
			with disinfection		with disinfection		with disinfection
Biochemical oxygen demand (atu) (BOD_5)		20	20	20	20	20	20
Chemical oxygen demand (COD)		120	120	120	120	120	120
Total suspended solids (TSS)		30	30	30	30	30	30
Total nitrogen (as N)		N/A	N/A	N/A	N/A	15	15
Total ammoniacal nitrogen (as N)		N/A	N/A	10	10	5	5
Total phosphorus (as P)		N/A	N/A	N/A	N/A	2	2
Faecal Coliform	**(CFU /100 ml)**	3.0E+06	2.0E+03	3.0E+06	2.0E+03	3.0E+06	2.0E+03
	($\log_{10}$)	6.5	3.3	6.5	3.3	6.5	3.3

Following the outfall optioneering workshop held on 28th June 2017, it was concluded that

- Conventional treatment would be sufficient to meet the required ELVs
- No ammoniacal-nitrogen removal would be required.
- No nutrient removal would be required.
- It was concluded that the treated effluent would contribute only a negligible bacteriological concentration compared with the bathing water standards and so would unlikely require disinfection. Nevertheless, space has been left for future retrofit of UV disinfection should this become a requirement.

The WwTW design was progressed on the basis of achieving the emission limit values (ELVs) presented in Table 4.3 Proposed Design Consent.

Table 4.3 Proposed Design Consent

Biochemical oxygen demand (atu) (BOD_5) (mg/l)	20
Chemical oxygen demand (COD) (mg/l)	120
Total suspended solids (TSS) (mg/l)	30

4.3 Preferred Solution Identification

High Level Concept

The high-level concept of the treatment works is as follows:

- 6mm screens
- Balance Tank
- Screened effluent pumping station
- Flow Splitter box(es)
- Primary settlement
- Biological treatment
- Secondary settlement
- Disinfection (possible)
- Sludge treatment
- Ancillaries- service water, poly, blowers,
- Building with switchgear, welfare, sludge and office/lab
- Odour treatment
- Treated wastewater pumping station

Odour Emission

The treatment of domestic type wastewater inherently generates objectionable odours. However, odour emission can be managed with odours contained and actively managed. Given the location of 'sensitive' receptors located adjacent to the WwTW the solution includes containment and active treatment to reduce odour concentration to the minimum practically possible.

Waste (Sludge) Generation

Sludge is generated in the primary and secondary treatment systems. To minimise odour emission sludge dewatering on-site was excluded from the scope of the design. However, sludge thickening is included to minimise the export of sludge from site therefore minimising the number of tanker movements (approximately 10 tankers/month).

4.4 No of treatment streams

Amec FW proceeded with a four-treatment stream concept for the following reasons

- treatment process turndown to match workforce profiling over the construction phase time period;
- maintain most equipment within the range suitable for off-site fabrication (package type);
- package plant supplier recommendations from previous reports.

There is the potential for optimisation of this arrangement in future.

Odour treatment, screens and sludge treatment will be shared across all four streams.

4.5 Biological Treatment

Based on the estimated flows & loads and proposed consent, a number of process solutions have been assessed for secondary treatment.

Long List Options

The "long list" of potential secondary treatment options is presented below.

- Activated Sludge Process (ASP)
- Oxidation Ditch
- Sequencing Batch Reactor (SBR)
- Nereda (granular activated sludge technology)
- Biological (trickling) Filter
- Submerged Aerated Filter (SAF)
- Rotating Biological Contactor (RBC)
- Integrated fixed-film activated sludge (IFAS)
- Membrane Bio Reactor (MBR)
- Moving Bed Biofilm Reactor (MBBR)

Table 4.4 compares the advantages and disadvantages of the long list of treatment options.

Table 4.4 Advantage and Disadvantages of long list biological treatments

Biological Treatment Technology	Advantages	Disadvantages
Activated Sludge Plant	Low footprint Not vendor specific	Increased operator input
Oxidation Ditch	Not vendor specific Simple operation	Larger footprint No process guarantee
Sequencing Batch Reactor	Low footprint	More complicated control
Nereda	Low footprint	More complicated control Unproven technology in UK Vendor specific
Biological Filter	Simple technology	Large footprint
Submerged Aerated Filter	Package plant Process guarantee lies with vendor	Vendor specific
Rotating Biological Contactor	Package plant Process guarantee lies with vendor	Vendor specific Large footprint
Integrated fixed-film activated sludge	More compact than conventional activated sludge	Vendor specific
Membrane Bio Reactor	Compact technology Process guarantee lies with vendor	Known to have operational issues UK water companies have removed from process selection matrices
Moving Bed Biofilm Reactor	Package plant Process guarantee lies with vendor	Vendor specific

Short List Options

From a high-level assessment of the long list, based on Amec FW experience and judgement, a short-list of solutions was selected for a more detailed assessment, as follows:

- Activated Sludge Plant
- Submerged Aerated Filter
- Rotating Biological Contactor

These three technologies represent the most common package-type treatment technologies utilised in the UK – and are available from a number of vendors.

Preferred Solution Selection

The three short listed options were assessed against the project success criteria in Section 4.1.

Table 4.5 Short List Scoring Matrix

Project Success Criteria	ASP	RBC	SAF
Landtake/footprint*	3	1	2
Odour minimisation*	2	3	1
Operability	1	3	2
Maintainability	3	2	3
Constructability/demolition	2	1	3
Prefabrication/package	3	3	3
Technology vendor flexibility	3	2	2
Sludge production	3	3	3
CAPEX	3	3	3
OPEX	2	3	1
Total	25	24	23

* Most heavily weighted criteria

Based on the scoring matrix (3 being a 'high' score), activated sludge has been selected as the preferred solution. In particular ASP technology does minimise land-take/footprint and odour emission.

Odour Emission

The treatment of domestic type wastewater inherently generates objectionable odours. However, odour emission can be managed with odours contained and actively managed. Given the location of 'sensitive' receptors located adjacent to the WwTW the solution includes containment and active treatment to reduce odour concentration to the minimum practically possible.

The Construction Wastewater Treatment Works (WwTW) concept includes minimisation of odour release from high-odour emission processes such as – preliminary treatment (screens), balance tanks, primary treatment, sludge storage and sludge treatment. This is achieved by covering tanks fitted with active extraction to maintain a slight under-pressure within the process units. In this way any air 'leakage' is induced into the process rather than an uncontrolled leakage to the environment. The air is transferred to an Odour Control System (OCS) based on biological biofilters and granular activated carbon filters, which minimises odour release to the environment. The treated air stream is released through a stack to optimise aerial dispersion minimising odour at local receptors.

Waste (Sludge) Generation

Sludge is generated through settlement in the PSTs and the FSTs with a proportion of the sludge settled in the FSTs being returned to the activated sludge tanks. Both sludges combine in an unthickened sludge holding tank with the combined sludge having an assumed thickness of 0.8% D.S. This unthickened sludge will be thickened in a set of duty/standby belt thickeners to a thickened sludge thickness of 6%.

4.6 Preferred Solution Definition

Design Information

Table 4.6 below summarises the design and sizing of the process units.

Table 4.6 Basis of Design

Process Unit	No	Volume (m3)	Width/Diameter (m)	Length/Diameter (m)	Design Parameters
Screens	2 (duty/standby)	-	2	5	Screened to < 6 mm (2-D)
Balance Tanks	4	495	6	-	To balance daily raw sewage over 24 hours
Primary Settlement Tanks	4	-	4.2	-	Hydraulic loading rates of 1.2 m/h with all in service, 2 m/h with one out of service (diameters rounded up to 4.2m so same diameter as FSTs)
Aeration Tanks	4	-	3	-	Sludge Age 5 d Temperature 10 – 25 °C Sludge Yield 1.0 kgSS/kgBOD
Final Settlement Tanks	4	-	4.2	-	Stirred Specific Volume Index 120 mL/g Hydraulic loading rates of 0.8 m/h
UV Disinfection Unit	2	-	2	5	< 2.0E+03 CFU /100 ml
Unthickened Sludge Holding Tank	1	233	6	-	Based on 4 days' storage of 0.8% unthickened sludge
Belt thickeners	2 (duty/standby)		1.5	2.5	150 kgDS/m.h
Thickened Sludge Holding Tank	1	89.4	4.3	-	Based on 10 days' storage of 6% unthickened sludge

Process Block Flow Diagram

Appendix B contains the process block flow diagram of the proposed WwTW.

WwTW Plot Plan

Appendix C contains the plot plan of the proposed WwTW. It is recommended to assume a plan area of 64 m by 45 m.

Process Description

Preliminary treatment

The crude sewage and sludge liquors will be pumped through a set of duty/standby 6mm screens into a set of 4 No. balance tanks.

There are four treatment streams downstream of the balance tanks.

Primary treatment

There are 4 No. up flow conical primary settlement tanks (PSTs).

Sludge from the PSTs (as well as scum) is automatically transferred to the unthickened sludge holding tank on a timed basis.

Secondary treatment

Primary effluent is treated in an activated sludge plant comprising 4 No aeration lanes in parallel.

Final settlement

Secondary settlement takes place in 4 No. radial flow final settlement tanks (FSTs). Settled mixed liquor from the FSTs is desludged to a pumping station where it is returned to the aeration tank as Return Activated Sludge (RAS). A fraction is removed from the process as Surplus Activated Sludge (SAS) from the discharge line of the RAS pumps (by means of an actuated valve), into the unthickened SAS holding tank.

Effluent from the FSTs discharge is pumped to a sea outfall.

Disinfection

Space has been allocated for a UV reactor should this be required.

Sludge treatment

Primary sludge and SAS sludge are produced onsite and are combined in the unthickened sludge holding tank.

The sludge system consists of an unthickened holding tank which acts as a feed tank to the 2 No. gravity belt thickeners. Thickened sludge from the belt thickener then discharges into a thickened sludge holding tank.

The filtrate from the belt thickener is returned to the inlet balance tanks. The thickened sludge is tankered away for off-site disposal.

Odour Treatment

High-odour emission processes such as – preliminary treatment (screens), balance tanks, primary treatment, sludge storage and sludge treatment are covered with active extraction to maintain a slight under-pressure within the process units. In this way any air ‘leakage’ is induced into the process rather than an uncontrolled leakage to the environment. The air is transferred to an Odour Control System (OCS) based on biological biofilters and granular activated carbon filters, which minimises odour release to the environment. The treated air stream is released through a stack to optimise aerial dispersion minimising odour at local receptors.

Operating/control statement

The WwTW will be automated to industry standard capable of full automatic control and alarm annunciation. However, the plant will require operator supervision for a minimum period, for a number of days each week to monitor process performance and equipment operation. A number of operations will require manual intervention/initiation, notably sludge thickening and sludge tanker loading – and chemical (polymer) unloading. Operator input will be approximately 4 man-days/week for the full plant and supervisor input will be 1 man-day/week. However, the manning level will depend on how the operating contract is let.

Power Demand

- Biological treatment Demand 40 kW
- Pumping Demand 10 kW
- UV Demand 2.4 kW

4.7 Wastewater Treatment Conclusions

The main conclusions for the WwTW package are;

The Wastewater Impact Modelling package determined that a 'conventional' treated final specification – 20 mg/l BOD and 30 mg/l TSS - is adequate to satisfy environmental regulation requirements. Microbiological contamination at 3.0 x 10^6 CFU/100 ml associated with conventional treatment was determined to be acceptable.

The load is based on 38 g/hd.d BOD and 5 g/hd.d ammoniacal-nitrogen and an associated flow of 100 L/hd.d - as recommended by British Water for discharges from 'INDUSTRIAL - Office/Factory with canteen'. The flow and load from a maximum site occupancy of 9,000 represents about 65 % that of a typical residential population – i.e. a population equivalent of 5,700.

The treatment plant is based on four streams to allow adequate turndown of treatment as the site population increases/decreases over the construction period. The WwTW design for the preferred solution is based on secondary treatment provided by the activated sludge process, which provides a minimum footprint and can be supplied by a wide range of process contractors. Whilst disinfection is not currently deemed to be required – retrofit of duty/standby UV units into the treatment process has been allowed.

'Sensitive' receptors, with respect to odour, have been identified adjacent to the proposed site. The solution includes containment of high-odour emission processes and active treatment to reduce odour concentration to the minimum practically possible. To minimise the odour emission sludge treatment has been limited to thickening only.

The following are key WwTW package deliverables;

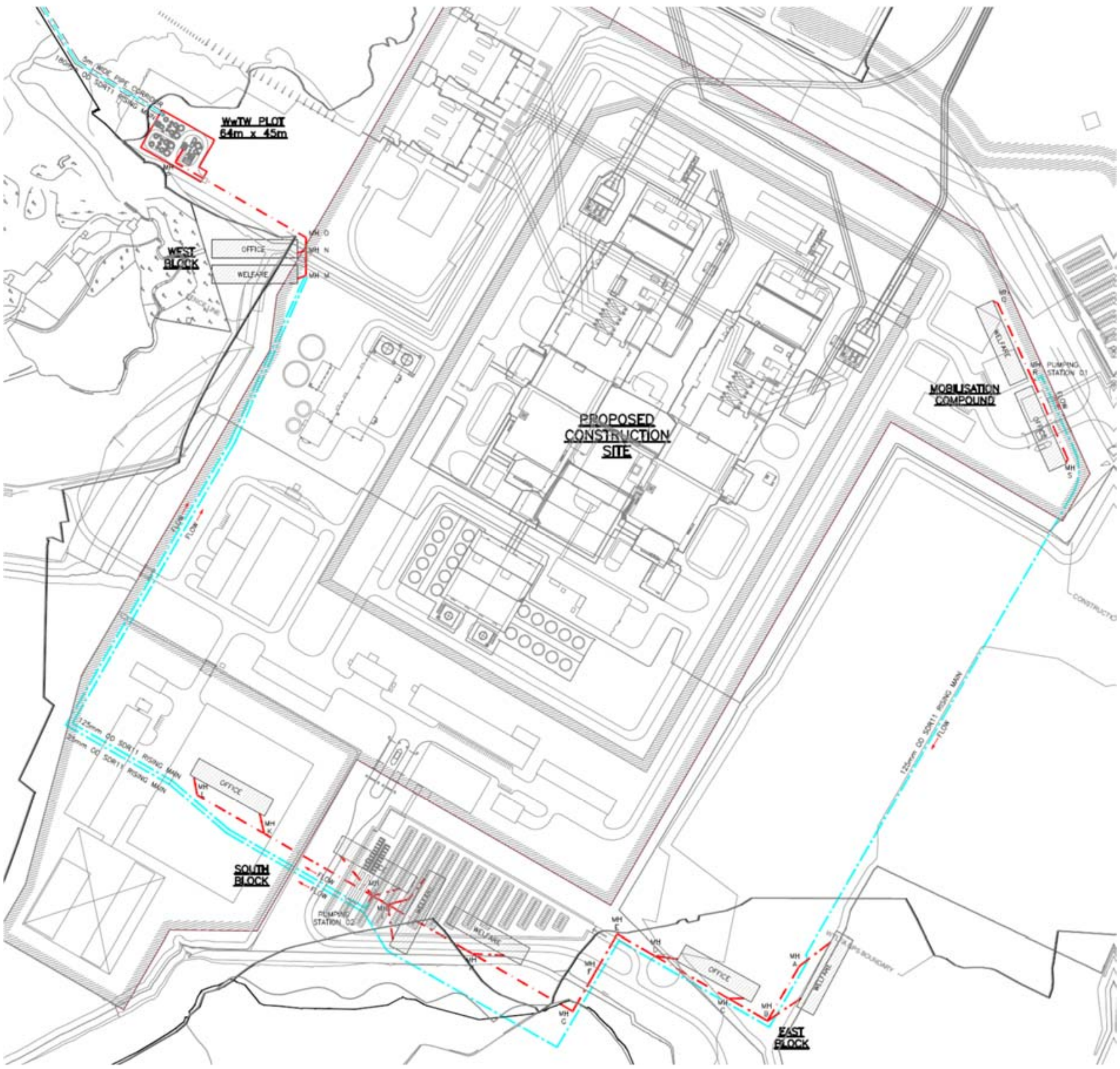
- Maximum site occupancy 9,000 (residential population equivalent 5,700)
- Maximum flow 990 m^3/d (22.9 l/s input - 11.5 l/s output)
- Treated final effluent quality - 20 mg/l BOD, 30 mg/l TSS (3.0 x 10^6 CFU/100 ml – and 8 to 22 ^{o}C)
- Minimum WwTW foot-print – 64 m x 45 m
- Thickened sludge export 470 kg/d DS, 8.9 m^3/d (approximately 10 tankers /month)
- Connected power demand – 75 kW

5. Sewerage Infrastructure (Collection/Discharge)

5.1 Construction Welfare Facilities

The construction welfare facilities on site are shown on drawing 39813/GOS/CVD/002 in Appendix E. The foul flows from these areas will be collected and conveyed, by means of gravity and pumping to an on-site Wastewater Treatment Works (WwTW) for treatment before being discharged out to sea.

Figure 5.1 Construction Welfare Facilities



The population, population equivalent and inflow used in the design of the sewers were taken as in Table 3.1. Note that the inflow is generated for only 12 hours each day giving a maximum flow to the WwTW of 22.9 l/s. For the purposes of the design the sewers have been sized to deal with a % of the maximum flow as noted in Table 5.1.

Table 5.1 Construction Welfare Facilities

Construction Welfare Facilities	Type of Facilities	Area (m^2)	%age of Total Flow
Mobilisation Compound	Office	3,375	10.9
	Welfare	3,600	
East Block (Unit 2)	Office	9,750	25.9
	Welfare	6,750	
South Block (Project Offices)	Office	15,750	39.2
	Welfare	9,300	
West Block	Office	9,000	24.0
	Welfare	6,300	

The design flow for the population equivalent of 9000 (990m^3/d) gives a minimum dry weather flow (DWF) of 11.46l/s which includes 10% infiltration.

5.2 Proposed Works

This section is to be read in conjunction with the drawings in Appendix E & F. The proposed works are summarised as follows:

- 190m of 150mm diameter vitrified clay foul sewer from the Mobilisation Compound to pumping station 01 (PStn.1);
- 2265m of 125mm OD PE100 SDR 11 rising main between PStn.1 and manhole MH M;
- 1175m of 150mm diameter vitrified clay foul sewer from East Block and South Block welfare facilities to pumping station 02 (PStn.2);
- 910m of 125mm OD PE100 SDR 11 rising main between PStn.2 and manhole MH M;
- 230m of 150mm diameter vitrified clay foul sewer from East Block and South Block welfare facilities to the WwTW inlet screens;
- 19 No. manhole chambers with internal dimensions of 1200mm diameter in accordance with Sewers for Adoption 7th Edition;
- 1 No. 1800mm diameter pumping station (PStn.1);
- 1 No. 2400mm diameter pumping station (PStn.2);
- 2 No. 1800mm x 2400mm valve chambers for each pumping station (PStn.1 and PStn.2);
- Power supply and telemetry to each pumping station;
- Access track to each pumping station;
- 985m of 180mm OD PE100 SDR 11 rising main from the WwTW to the outfall;
- 1 No. Tideflex effluent diffuser system installed at the end of the outfall pipe.

5.3 Sewer Design

Outline design of the sewers has been completed using a crushing strength of 45KN and in accordance with 'Structural design of buried pipelines under various conditions of loading' BS EN 1295-1:1997 and BS 9295:2010.

The manholes are in accordance with Sewers for Adoption 7th Edition. Early contractor involvement during detailed design may allow for an alternative method of manhole construction saving time and money. Any proposed design change would require acceptance from Horizon.

Possible future loads from the construction of the power station have not been accounted for.

No provision has been made for the potential future expansion of the construction welfare facilities. If required spare stubs and rockers could be installed within the new manholes.

Foul Sewer

To achieve self-cleansing velocity in the gravity sewer it has been designed to be laid at gradients to achieve a minimum flow velocity of 0.75m/s at one third design flow. Where this is not possible to meet this requirement, the following criteria are considered to be satisfactory;

- A 150mm nominal diameter gravity sewer laid at a gradient of not less 1:150

Pumping Stations and Rising Mains

The pumping stations would empty via duty/standby submersible sewage pumps installed in a sump in the base of the pumping station wet well.

Operation of the pumps would be controlled by an ultrasonic level detector installed within the pumping station.

The pumping stations and rising mains should meet the following criteria:

- Be a minimum 15m from a habitable building;
- Provide one hour storage at maximum flow in case of pump or power failure;
- Should be located in an accessible area (not in roads or car parks);
- Provide air release valves at high points in the system;
- Provide washout facilities at any low points.

Outfall

The outfall pipe will be constructed from polyethylene (PE100) with welded joints. The main advantages of using PE100 are as follows:

- High resistance to corrosion from sea water;
- Excellent performance against tidal actions of the sea;
- Flexibility and strength.

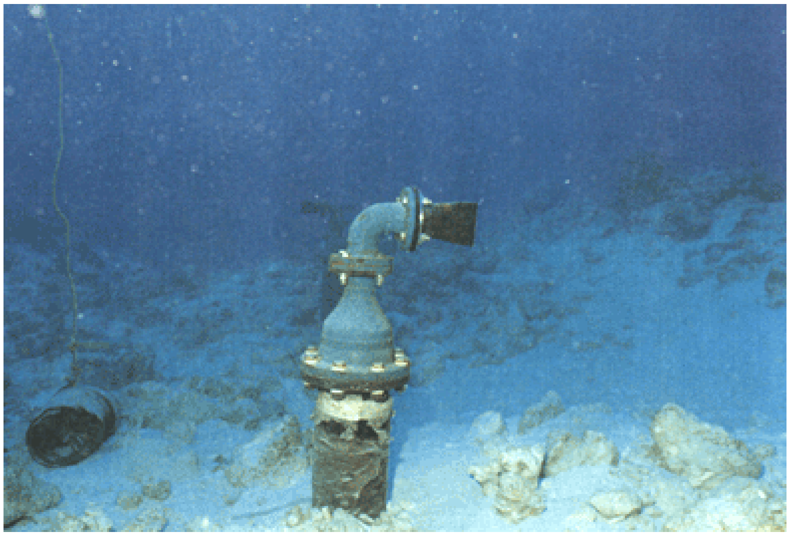
The outfall pipe would be constructed on land and floated out to sea. Once in position the pipe will be progressively flooded to allow the pipe to be positioned in a controlled sinking operation. The pipe will be fitted with concrete ballast weights to prevent the pipe from moving once on the sea bed. Figure 5.2 shows a typical outfall pipe being floated ready for installation.

Figure 5.2 Typical Outfall Pipe under Construction

The route of the outfall pipe is shown indicatively on the drawing within the centre of the breakwater. The outfall pipe will need to be constructed at the same time as the breakwater. Care should be taken when constructing the breakwater not to damage the outfall pipe.

The Tideflex diffuser provides good dilution in the receiving watercourse and prevents the intrusion of sand, mud, debris and salt water into the outfall pipe. Figure 5.3 shows a typical outfall installation including a Tideflex diffuser.

Figure 5.3 Typical Outfall Diffuser Arrangement



The exact orientation of the diffuser will need to be determined at the next design stage taking into account that it sits within the navigation channel to the harbour.

5.4 Design Criteria

The proposed solution shall be designed to provide an effective sewerage infrastructure from the proposed construction welfare facilities to the Waste Water Treatment Works (WwTW). A list of design guidelines and codes of practice used is provided below:

- Construction (Design and Management) Regulation 2015;
- Civil Engineering Specification for the Water Industry (CESWI), 7th Edition;
- Sewers for Adoption 7th Edition or subsequent edition;
- BS EN 1295-1:1997 Structural design of buried pipelines under various conditions of loading. Viewed in conjunction with BS 9295:2010.

5.5 Maintenance and Operational Issues

An access track to the pumping stations and valve chambers would be provided for maintenance issues. It is envisaged that the pumps will be inspected every twelve months with a major overhaul every three years.

Guide rails for the duty/standby pumps would be installed. This would allow for easy removal of the pumps if maintenance was required.

It is envisaged that the gravity sewer and pumping stations would need no specific inspection programme by Horizon Operations. To aid self-cleansing in the foul sewer a minimum velocity of 0.75m/s at one third design flow will be achieved where possible. During the period where site populations are low the sewers will not achieve self-cleansing velocities and there will be a risk that the sewage in the rising mains may turn septic.

5.6 Geotechnical Information

The design of the pipework has been undertaken assuming good ground conditions with no contamination.

5.7 Services

No utility service diversions are anticipated prior to the construction of the proposed works.

5.8 Buildability/Early Contractor Involvement

It is considered that early contractor involvement would be beneficial during the next design phase in order to determine the optimum locations for the proposed manholes, sewers and pumping stations and the construction of the outfall pipe. The particular constraints posed by this scheme include:

- Position of outfall i.e. within or outside of the breakwater;
- Orientation of the diffuser in the navigation channel.

5.9 Actions to be Addressed at the Next Stage

The key actions to be considered as part of the next design stage are:

- Orientation and height of the diffuser in the navigation channel;
- Power supply requirement;
- Telemetry requirement;
- Septicity assessment;
- Surge analysis on rising mains, including position of air valves and washouts;

- Site access constraints.

5.10 Construction (Design and Management) Regulations 2015 (CDM 2015)

The CDM regulations place duties on the client, the designers and principal designers (as well as contractors and principal contractors) with regards to managing health and safety on projects.

This scheme will be 'notifiable' under CDM 2015 and there will be more than one contractor on site so the client will need to appoint the following in writing:

- A designer with control over the pre-construction phase as principal designer; and
- A contractor as principal contractor.

The key client duties are to make suitable arrangements for managing a project with regards to health and safety. This includes making sure:

- Other dutyholders are appointed;
- Sufficient time and resources are allocated;
- Relevant information is prepared and provided to other dutyholders;
- The principal designer and principal contractor carry out their duties;
- Welfare facilities are provided.

Health and Safety Risks

Significant health and safety issues specific to the proposed works include:

- Confined space working;
- Working at height;
- Working above/adjacent to water;
- Working in excavations;
- Working with pressurised pipelines;
- Lifting operations;
- Hot working;
- Noise;
- Working with electricity;
- Contact with raw sewage;
- Unforeseen ground conditions.

Health and safety issues would be considered further during the next design stage.

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6. Assumptions & Risks

6.1 Assumptions

The following design assumptions were agreed at the workshop.

- For discharge locations located on the offshore breakwater:
  - the currently proposed overall construction schedule (determining the phasing of sewage loads) and the proposed schedule for the construction of the breakwater mean that it is likely that the sewage outfall will need to be in place by the start of Q2 2019, before causeway construction and breakwater construction, both currently planned to commence in Q2 2019
  - It is assumed that, if constructed by a cut and cover method, the sewage outfall pipe will be located under the footprint of the breakwater and the causeway, thus avoiding any additional seabed habitat loss (NB this is not intended to rule out alternative construction methods that would not disturb the seabed, for example, directional drilling).
- It has been assumed that cooling water abstraction will not take place during the period when construction site sewage discharges will occur (so the entrainment of treated sewage into the cooling water intake was not considered a relevant factor in the outfall location options study).
- For all locations examined, there will be a simple diffuser arrangement (designed to avoid visible boil, limit sediment ingress and improve initial dilution) that requires only basic maintenance and will be removed following the Wylfa Newydd Construction phase.
- In all cases it is assumed that the outfall extends at least 50 metres offshore of where the seabed is at chart datum (CD) and the seabed at the discharge point is at least 1 metre below chart datum (i.e. a minimum water cover of 1 metre is provided at the lowest tides) (this means that the discharge complies with the EA/NRW screening Test 4 for discharges to coastal waters).
- Any concerns about construction noise affecting nesting terns within the Ynys Feurig, Cemlyn Bay and The Skerries SPA can be mitigated by selection of construction techniques, noise control and/or seasonal restrictions on construction and are therefore not a differentiating factor to be taken into account in selecting the preferred outfall location. This takes account of the fact that noise generated by outfall construction at the locations nearest to the SPA is likely to be minimal compared with noise produced by breakwater construction, so any concerns will need to be addressed anyway.

In relation to the exact position of the outfall release point, a 12 figure National Grid Reference (NGR) has been supplied by AFW, as this is required for completion of the application forms for an environmental permit for a WDA. Note that this NGR is supplied based on the following assumptions.

- Several of the potential outfall locations considered at the workshop on 28th June 2017 were related to the position of the offshore breakwater. For the purposes of deriving an NGR, the location of this breakwater has been assumed to be as shown on drawing WN0907-HZCON-LAP-DRG-0004 Rev 2. It has also been assumed that the outer outline of the breakwater shown on this drawing represents the point at which the elevation of the outer edge of the structure passes through CD. The northern extent of the breakwater shown on this drawing differs slightly from various positions provided previously, for example, in the project specification and on the tidal plots shown at Figure 4.1 in this report; however, after post-workshop review of the differences in location, AFW believes that these differences are not material to the workshop conclusions.
- Regarding water depth at the proposed NGR for the outfall release point, CD is assumed to be 3.6m below OD, as quoted on drawing CS0257/D5/V2 supplied by Horizon.

The following assumptions have been made during the study

1. The deliverables provided comprise reference documents to support the DCO - Development Consent Order submission and the application for a Bespoke Environmental Permit for a Water Discharge Activity (WDA). The scope of the activities to be addressed in the deliverables will be limited to the release of treated sewage arising during the construction phase (excluding flows arising from the site campus), to one of the discharge points identified in the specification. On this basis, it is assumed that:
   - Horizon will subsequently produce an overarching technical report to support the application forms for the WDA Permit application. This will include interpretation of the information provided in these deliverables and, where appropriate, relevant extracts and forward actions/recommendations;
   - with the exclusion of plans and figures, the deliverables prepared by AmecFW will not comprise the responses to the specific questions specified in the B series Permit application forms.
2. The potential cumulative effects with other sewage discharges has not been included in this study.
3. It has been assumed that the cooling water abstraction will not take place at during the period when construction site sewage discharges will occur (so the entrainment of treated sewage into the cooling water intake will not be a relevant factor in the outfall location options study).
4. The design of the pipework has been undertaken assuming good ground conditions with no contamination.
5. No allowance in the sewer design for possible future loads from the construction of the power station has been accounted for.

6.2 Risks

Table 6.1 below provides a breakdown of some of the key project risks identified at this stage.

Table 6.1 Risks

Risk	Mitigation
Detailed modelling could show a slightly different environmental ranking for the outfall locations	Based on the results from workshop very confident that outfall position 2 will remain the best location.
WwTW plot size decreases	Consider niche low footprint technologies – granular activated sludge (Nereda), MBR etc.
Odour emission limit values reduced to very low concentration	Consider enhanced odour control system based on chemical scrubbing technology
Sludge disposal strategy limits quantity and/or quality exported from site	Consider on-site mini-anaerobic digestion and sludge dewatering
Improved treated final effluent required – low ammoniacal-nitrogen	Consider incorporating/retrofit of IFAS technology to secondary treatment ASP
Flow higher than design estimate	Retrofit chemically assisted primary settlement system (coagulant)
Load higher than design estimate	Retrofit IFAS technology to secondary treatment ASP
Flow/load lower than design estimate	Operate with reduced number of treatment streams
Position of outfall i.e. within or outside of the breakwater;	Early contractor involvement for outfall construction
Orientation of the diffuser in the navigation channel.	Early contractor involvement for outfall construction

7. Conclusions

7.1 Wastewater Impact Modelling

The following conclusions were reached on level of treatment.

- The worst case contribution of the discharge at preferred location 2 to bacterial counts at Cemaes bathing water, assuming conventional treatment only, is an increase in 7.9 CFU/100ml (as a 95%ile), which is a negligible concentration compared with the bathing water standards and does not indicate a need for disinfection of the treated Main Site Construction Phase sewage discharge. However, this will be subject to further discussions with NRW.
- With the outfall at location 2, based on initial dilution calculations for conventional treatment only (no nitrification), the EQS for total ammoniacal nitrogen within Habitats Directive sites and the WFD EQS for non-ionised ammonia would be met by a large margin immediately after initial dilution. Therefore there is no requirement for nitrification.
- With the outfall at location 2, based on initial dilution calculations for conventional treatment only (no nutrient removal), the EQS for dissolved inorganic nitrogen would be met immediately after initial dilution. Therefore there is no requirement for nutrient removal.

The overall conclusion is that conventional treatment will be adequate provided outfall location 2 is selected. The results of the optioneering exercise provide no justification for disinfection, nitrification or nutrient removal. However, circumstances at Cemaes bathing water may still result in a requirement from NRW to minimise bacterial loads and it may be wise to leave space for possible future retrofitting of a UV disinfection unit.

7.2 Wastewater Treatment

The Wastewater Impact Modelling package determined that a ‘conventional’ treated final specification – 20 mg/l BOD and 30 mg/l TSS - is adequate to satisfy environmental regulation requirements. Microbiological contamination at 3.0 x 10^6 CFU/100 ml associated with conventional treatment was determined to be acceptable.

The load is based on 38 g/hd.d BOD and 5 g/hd.d ammoniacal-nitrogen and an associated flow of 100 L/hd.d - as recommended by British Water [2] for discharges from ‘INDUSTRIAL - Office/Factory with canteen’. The flow and load from a maximum site occupancy of 9,000 represents about 65 % that of a typical residential population – i.e. a population equivalent of 5,700.

The treatment plant is based on four streams to allow adequate turndown of treatment as the site population increases/decreases over the construction period. The WwTW design for the preferred solution is based on secondary treatment provided by the activated sludge process, which provides a minimum footprint and can be supplied by a wide range of process contractors. Whilst disinfection is not currently deemed to be required – retrofit of duty/standby UV units into the treatment process has been allowed.

‘Sensitive’ receptors, with respect to odour, have been identified adjacent to the proposed site. The solution includes containment of high-odour emission processes and active treatment to reduce odour concentration to the minimum practically possible. To minimise the odour emission sludge treatment has been limited to thickening only.

The following are key WwTW package deliverables;

- Maximum site occupancy 9,000 (residential population equivalent 5,700)
- Maximum flow 990 m^3/d (22.9 l/s input - 11.5 l/s output)
- Treated final effluent quality - 20 mg/l BOD, 30 mg/l TSS (3.0 x 10^6 CFU/100 ml – and 8 to 22 ^oC)

- Minimum WwTW foot-print – 64 m x 45 m
- Thickened sludge export 470 kg/d DS, 8.9 m^3/d (approximately 10 tankers /month)
- Connected power demand – 75 kW

8. References

[1] Horizon (2017) *Project note for Construction Phase Foul Water Design*. DCRM Ref number WN0902-HZCON-EPT-TEC-00001. Rev. 1.0.

[2] British Water (2013) *Code of Practice. Flows and loads – 4 Sizing Criteria, Treatment Capacity for Sewage Treatment Systems*.

[3] Horizon (undated) Wylfa *Hydrodynamic & Water Quality Modelling*. *Phase 2 Model Build, Calibration & Validation.* DCRM Ref Number: WYL-PD-PAC-REP-00015. Revision: 0.1

[4] Natural Resources Wales (NRW) (2016) *Bathing waters in Wales 2016*. Official statistics published by Natural Resources Wales, Cardiff.

[5] European Commission (2006) *Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC*.

[6] Defra (2015) *The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015*.

[7] Habitats Directive Technical Advisory Group on Water Quality (WQTAG) (2005) *Ammonia standards in estuaries. Final for implementation.* WQTAG086 revised #4.

[9] Metcalf & Eddy, Inc. (2003). *Wastewater Engineering: Treatment and Reuse*. Boston :McGraw-Hill

Appendix A Attendees at Outfall Location Optioneering

The optioneering workshop on 28th June 2017 was attended by:

- John Pomfret (AmecFW) (facilitator)
- Peter Walbridge (Horizon)
- Alex Garman (Horizon)
- Matt Robson (Jacobs)
- Phil Shepperd (Coastal Science) (from 1200h)
- Nicholas Gill (Horizon)

Appendix B Initial Dilution Calculations for Buoyant Plumes

Calculation - worst case condition

The initial dilution of a buoyant jet has been most accurately predicted in still water using the Cedarwall equation (Cedarwall 1968[1]) but it is more difficult to predict dilutions in moving waters. The inability to predict this effect accurately results in under-estimation of the dilution effect. A more reliable prediction model for dilution in moving water has been produced, as described by WRc[2], which uses theoretical dimensional analysis backed up by field data collected on initial dilutions above outfalls. This is described in the next section.

For a tidal receiving water, the worst case conditions will usually be in still water at low tide. Here the Cedarwall equation is the most appropriate.

The densimetric Froude number (F) is given by:

$$F = \frac{v_j}{\left(\frac{\rho_a - \rho_o}{\rho_a} gd\right)^{1/2}}$$

From the Cedarwall equation:

$$S = 0.54F\left(\frac{0.38H}{dF} + 0.66\right)^{5/3}$$

where:

v_j = jet velocity (m/s)	g = acceleration due to gravity (m/s^2)
d = jet diameter (m)	H = water depth above outlet (m)
ρ_a = ambient water density	S = dilution ratio
ρ_o = effluent density	

Calculation for moving receiving water

The WRc analysis method suggests two regimes for buoyant discharges, the buoyancy dominated near field (BDNF) and the buoyancy dominated far field (BDFF). In the case of BDNF, the discharge is influenced primarily by the discharge buoyancy and occurs where there are weak ambient currents. BDFF occurs in conditions of strong ambient current where the initial dilution is influenced less by buoyancy and more so by ambient current. In each case, the appropriate regime was tested, allowing the most appropriate dilution calculation to be employed. The predictions require data on the density of the effluent, the density of seawater, effluent port flow, the mean current velocity of the receiving waters and the depth of the outfall port below surface water level.

[1] Cederwall, K. (1968) Hydraulics of marine waste water disposal, Hydraulic Division. In: *Report No. 42*, Chalmers Institute of Technology, Gothenburg, Sweden January 1968
[2] WRc (1990) *Design Guide for Marine Treatment Schemes.*

The initial step is to calculate B (the effluent buoyancy flux) (m^4/s^3).

$$B = \left(\frac{\rho_a - \rho_o}{\rho_a} \right) g\, q_p$$

If:

$H < \dfrac{5B}{U_a^3}$ then a BDNF condition exists and initial dilution (S) is given by:

$$S = C_1 \frac{B^{1/3} H^{5/3}}{q_p}$$

where C_1 is a constant based on experimental data.

If:

$H > \dfrac{5B}{U_a^3}$ then a BDFF condition exists and initial dilution (S) is given by:

$$S = C_3 \frac{U_a H^2}{q_p}$$

where

q_p = effluent flow rate (m^3/s)

g = acceleration due to gravity (m/s^2)

ρ_a = ambient water density

H = water depth above outlet (m)

ρ_o = effluent density

U_a = ambient current velocity (m/s)

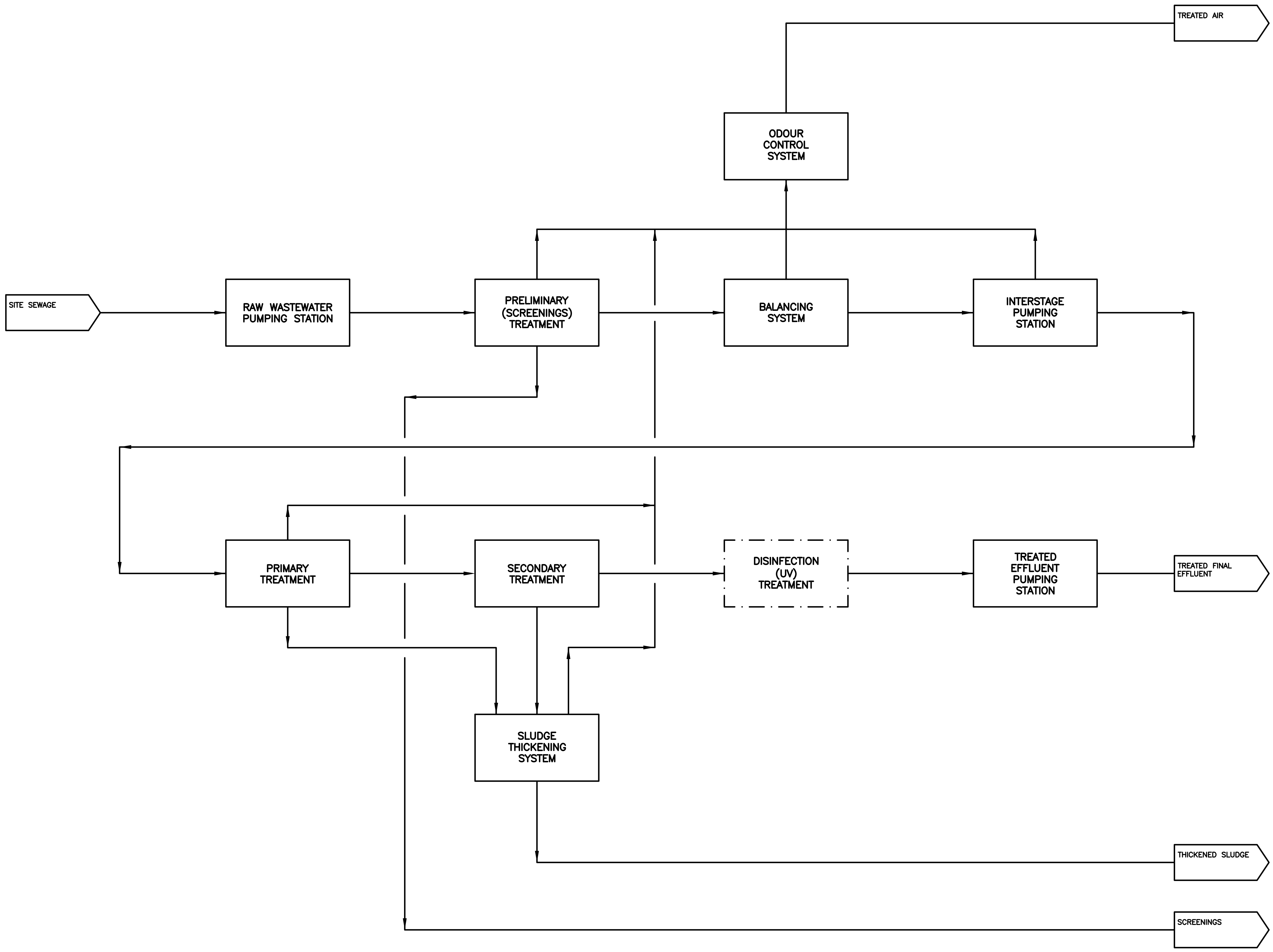
and C_3 is a constant based on experimental data.

Values for the constants are given in the table below.

Values for constants C1 and C3 in columns H and I	C_1 (for BDNF)	C_3 (for BDFF)
95%ile exceedance - i.e. to predict dilution rate likely to be exceeded 95% of the time	0.16	0.11
Median minimum dilution values - i.e. to predict dilution rate likely to be exceeded 50% of the time	0.27	0.27
Mean minimum dilution values - i.e. to predict dilution rate likely to be exceeded 38-40% of the time	0.34	0.32

Appendix C
WwTW Block Flow Diagram

NOT PROTECTIVELY MARKED



Original Drawing Size – A1 DO NOT SCALE

DESCRIPTION

REV	DATE		DWN	CHK	APP
A	20/07 2017	ISSUED FOR WDA APPLICATION	PM	AH	HT

REVISIONS

REV	DATE		DWN	CHK	APP

NOTES:

SCALES: NTS

PROJECT TITLE:
WYFLA NUCLEAR POWER PLANT
CONSTRUCTION PHASE
WWTW

DRAWING TITLE:
PROCESS BLOCK FLOW DIAGRAM

CLIENT:
HORIZON NUCLEAR POWER

REF:

amec foster wheeler

PARTNERSHIP HOUSE, REGENT FARM ROAD,
GOSFORTH, NEWCASTLE UPON TYNE NE3 3AF
TEL: (0191) 2726100 FAX: (0191) 2726515

DRAWING No. 39813/GOS/PRD/510

REV. A

Appendix D
WwTW Plot Plan

REV	DATE	DESCRIPTION	DWN	CHK	APP
A	06/07 2017	FIRST ISSUE	PR	JK	HT

REVISIONS

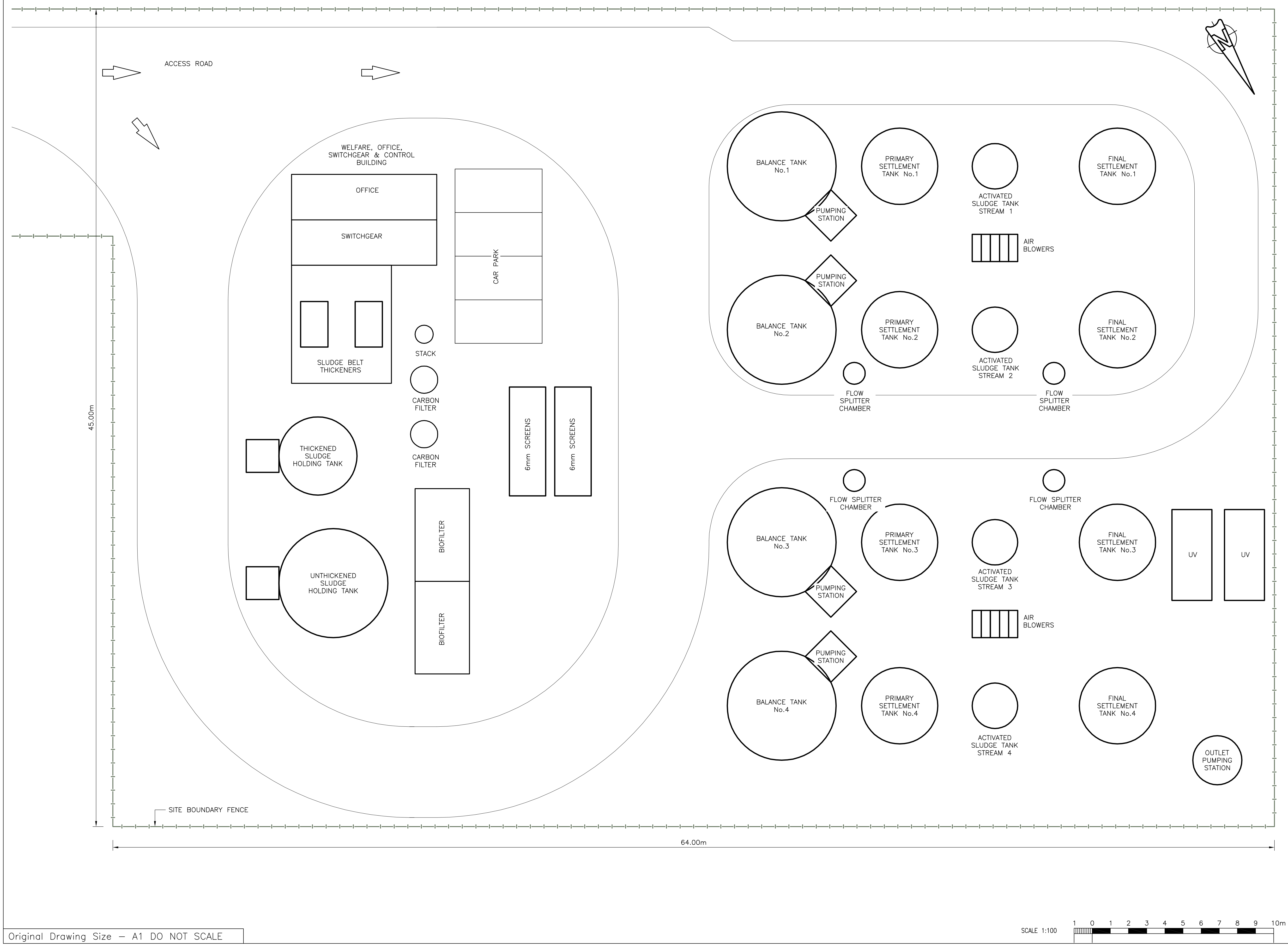
REV	DATE		DWN	CHK	APP
B	24/7 2017	ISSUED FOR WDA APPLICATION	PR	JK	HT

NOTES:

1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED. ALL LEVELS IN METRES UNLESS OTHERWISE STATED.
2. DIMENSIONS ARE NOT TO BE SCALED FROM THIS DRAWING. ANY DIMENSIONS NOT SHOWN ARE TO BE CHECKED ON SITE.
3. NO VARIATION TO THIS DRAWING SHALL BE PERMITTED UNLESS AUTHORISED IN WRITING BY THE ENGINEER.

LEGEND

PROPOSED FENCE



SCALES: 1:100

PROJECT TITLE:
WYFLA NUCLEAR POWER PLANT CONSTRUCTION PHASE WWTW

DRAWING TITLE:
PRELIMINARY PLOT PLAN

CLIENT:
HORIZON NUCLEAR POWER

REF:

amec foster wheeler

PARTNERSHIP HOUSE, REGENT FARM ROAD, GOSFORTH, NEWCASTLE UPON TYNE NE3 3AF
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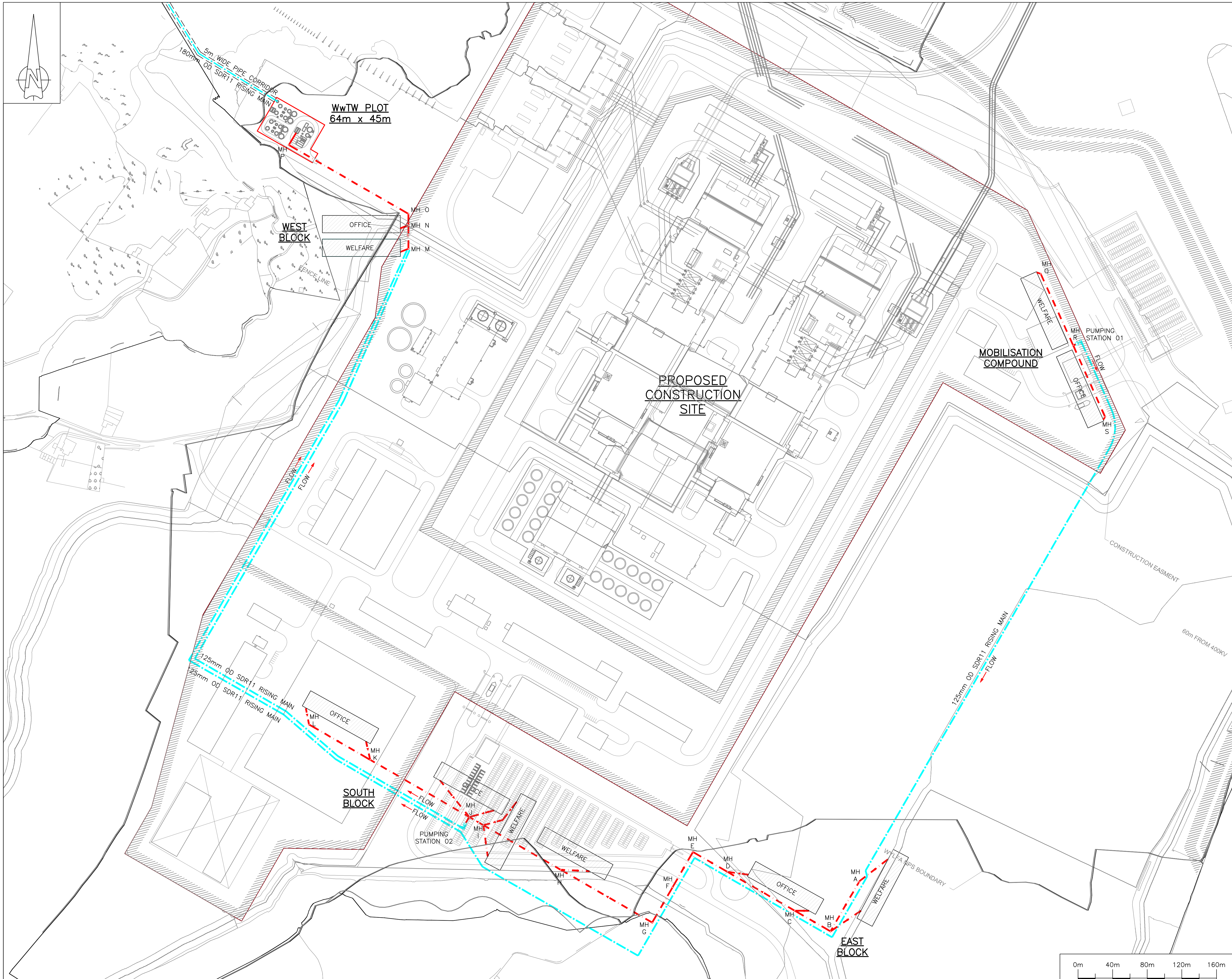
DRAWING No. 39813/GOS/PRD/511 REV. B

Original Drawing Size – A1 DO NOT SCALE

Appendix E
Site Sewage Layout



Original Drawing Size – A1 DO NOT SCALE

DESCRIPTION					
REV	DATE		DWN	CHK	APP
A	25.07 2017	FIRST ISSUE	MMc	RM	NM

REVISIONS

REV	DATE		DWN	CHK	APP

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS STATED OTHERWISE.
2. ALL LEVELS ARE IN METRES AOD UNLESS STATED OTHERWISE.
3. ALL DIMENSIONS ARE APPROXIMATE.
4. BACKGROUND INFORMATION PROVIDED BY HORIZON NUCLEAR POWER.
5. LOCATION OF PROPOSED CONSTRUCTION SITE CABINS AS INDICATED ON HORIZON DRAFT SITE SEWAGE DRAINAGE PLAN.
6. ALL GRAVITY SEWERS 150mm DIAMETER.

LEGEND:

PROPOSED SITE CABINS
PROPOSED FOUL RISING MAIN
PROPOSED FOUL GRAVITY SEWER
MH A PROPOSED FOUL MANHOLE
PROPOSED PIPE CORRIDOR

SCALES: 1:2

PROJECT TITLE:
WYLFA NUCLEAR POWER PLANT
CONSTRUCTION PHASE
WwTW

DRAWING TITLE:
PROPOSED SITE SEWAGE LAYOUT

CLIENT:
HORIZON
NUCLEAR POWER

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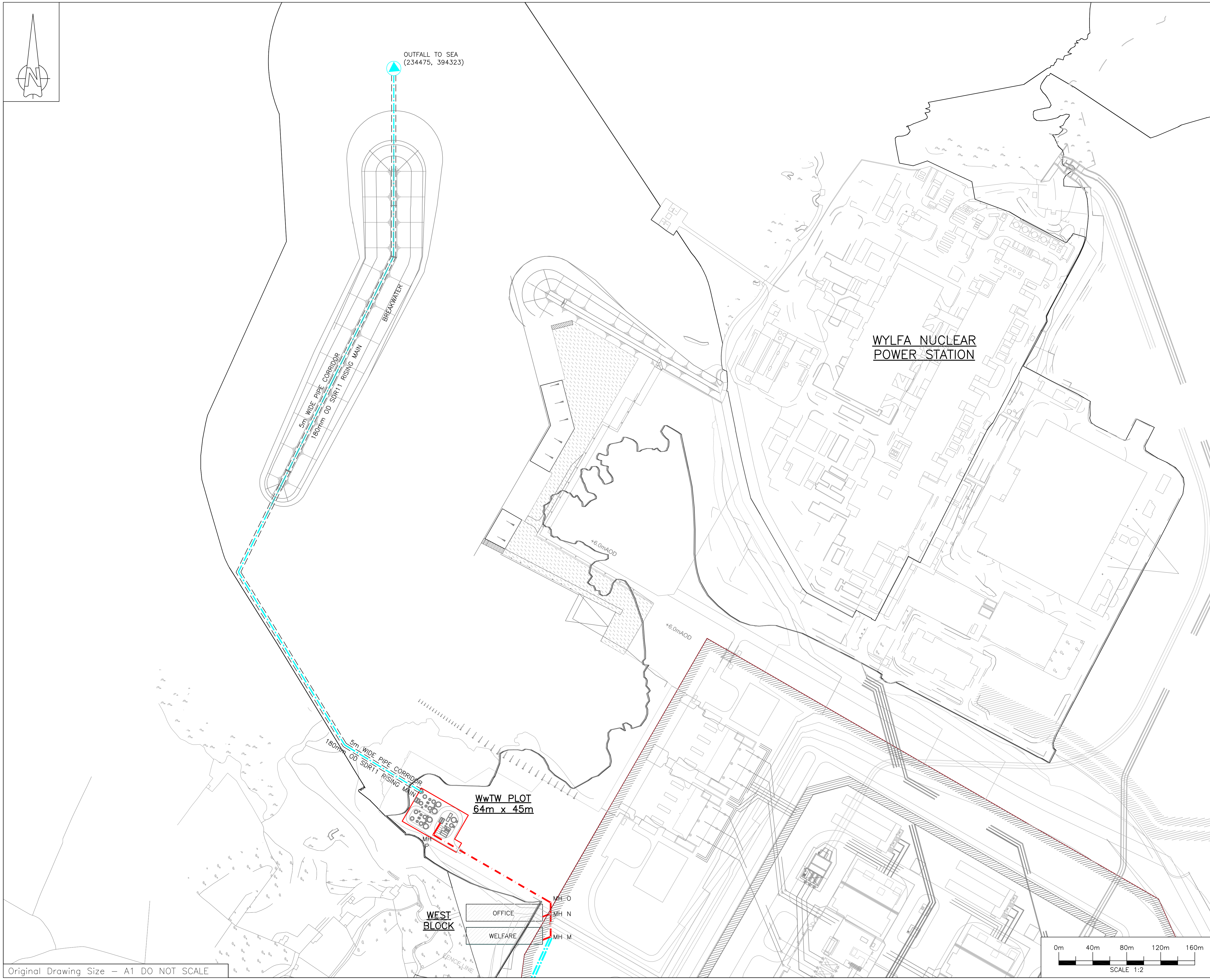
DRAWING No. 39813/GOS/CVD/001
REV. A

Appendix F
Outfall Pipe Layout



DESCRIPTION

REV	DATE		DWN	CHK	APP
A	25.07 2017	FIRST ISSUE	MMc	RM	NM

REVISIONS

REV	DATE		DWN	CHK	APP
B	10/11 2017	ROUTE OF OUTFALL PIPE AMENDED	MMc	RM	NM

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS STATED OTHERWISE.
2. ALL LEVELS ARE IN METRES AOD UNLESS STATED OTHERWISE.
3. ALL DIMENSIONS ARE APPROXIMATE.
4. BACKGROUND INFORMATION PROVIDED BY HORIZON NUCLEAR POWER.
5. LOCATION OF PROPOSED CONSTRUCTION SITE CABINS AS INDICATED ON HORIZON DRAFT SITE SEWAGE DRAINAGE PLAN.
6. ALL GRAVITY SEWERS 150mm DIAMETER.

LEGEND:

- PROPOSED SITE CABINS
- PROPOSED FOUL RISING MAIN
- PROPOSED FOUL GRAVITY SEWER
- MH A — PROPOSED FOUL MANHOLE
- PROPOSED PIPE CORRIDOR

SCALES: 1:2

PROJECT TITLE:
WYLFA NUCLEAR POWER PLANT CONSTRUCTION PHASE WwTW

DRAWING TITLE:
WwTW AND OUTFALL PIPE LAYOUT

CLIENT:
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DRAWING No. 39813/GOS/CVD/002

REV. B

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WYLFA NEWYDD

K

Wylfa Newydd Project

Construction Water Discharge Activity –
Environmental Permit Application: Appendices I to K

Appendix K –
Bulk Earthworks & Drainage:
Summary of Preliminary Design for Construction Surface Water Drainage

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WYLFA NEWYDD

Wylfa Newydd Project

Construction Water Discharge Activity –
Environmental Permit Application: Appendices I to K

Appendix K –
Bulk Earthworks & Drainage:
Summary of Preliminary Design for
Construction Surface Water Drainage

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1. Introduction

This report has been prepared as a technical summary which outlines the preliminary design for the proposed surface water drainage system and a concept drainage design for the management of surface water in the landscaped areas post construction for the Wylfa Newydd Development Area (WNDA). A description of the proposed drainage system and related mitigation measures (particularly focussed upon the Construction Phase) will be provided together with an overview of catchments on the WNDA and a summary of discharges proposed to the aquatic environment. This section of the report outlines the proposed drainage system, whilst Section 2 presents catchment analysis to refine the proposed sediment or total suspended solids (TSS)[1] limits for each catchment. Section 3 sets out recommendations for future work.

1.1. Wylfa Newydd Development Area

The WNDA is approximately 406 hectares (ha) in size and is located on the Wylfa peninsula, between the bays of Cemlyn and Cemaes on the northern coastline of the Isle of Anglesey, North Wales. The WNDA, in its current form, is predominantly greenfield agricultural land and is sited on an area of glacial till, described as comprising clays, silts, sands and gravels, with metamorphic bedrock. The most predominant land use within the catchments has been identified as pastoral farming.

There are five existing surface water catchments located within the WNDA, these are listed as follows:

- Tre’r Gof Catchment
- Afon Cafnan Catchment
- Cemlyn Catchment
- Cemaes Catchment, and,
- Power Station catchment.

Catchment areas and notable features such as Sites of Special Scientific Interest (SSSI) are provided in table 1-1.It should be noted that discharge references quoted in this report may be subject to future change or variation to suit project requirements.

[1] “Total suspended solids” is a measure of particles suspended in the water column and is used as an indicator of water quality. Changes to natural levels of TSS (i.e. large increases or large decreases) can impact the ecology of aquatic environments.

Table 1-1 Catchment Summary

Catchment	Area (km^2)	Watercourses and designated areas (within the WNDA)	Existing point of discharge
Tre'r Gof	1.0	Catchment drains into the Tre'r Gof SSSI	Irish Sea via culvert and outfall at Porth Wylfa
Afon Cafnan	9.9	Afon Cafnan Nant Caerdegog Isaf Cae Gwyn SSSI	Irish Sea at Porth-y-Felin
Cemlyn	2.3	Nant Cemlyn (Cemlyn Bay SSSI and SAC[1] and Anglesey Terns SPA[2])	Cemlyn Lagoon at Cemlyn Bay
Cemaes	3.0	Nant Cemaes Foel Fawr	Cemaes Bay via culvert
Power Station	0.3	Nant Porth-y-pistyll	Porth-y-pistyll

1 – Special Area of Conservation
2 – Special Protected Area

It should be noted that the Cemlyn Bay SSSI and Special Area of Conservation (SAC) and Anglesey Terns Special Protected Area (SPA) are not within the WNDA area. These catchments are included as E1 discharges into the Nant Cemlyn, which flows into Cemlyn Lagoon. All catchments discharge into North Anglesey Marine Candidate Special Area of Conservation (cSAC) and Anglesey Terns SPA, both of which encompass the entire coastline adjacent to the WNDA.

1.2. Proposed Drainage System

1.2.1. Drainage Principles

The existing land use within the WNDA is predominantly agricultural. During storm events, rainfall can either infiltrate the ground and fill pore spaces in the soil / rock, or run across the surface (commonly referred to as runoff). The rate at which runoff will occur is typically influenced by the slope of the landform, or catchment, and/or the type of surface over which water will flow across. For example, the runoff rate from a steeply sloped catchment or an artificial (and impermeable) paved surface will be significantly greater than that generated from a shallow slope or a vegetated (and permeable) surface. The construction of the proposed landform within the WNDA will result in earthwork mounds that are both higher and steeper than they are currently and may also be formed using soils that have less space within them to allow for a flow of water through them. As a result, higher rates of runoff from the development are anticipated and these will need to be managed alongside potential changes to the water quality in receiving watercourses and/or water bodies as a result of construction activities.

Planning Policy Wales[2] and related supplementary technical advice[3] recommends how flood risk issues should be determined and action that should be taken through development plans to mitigate flood risk. The proposed drainage system that will serve the WNDA landscaped areas has been designed in line with current planning policy so as not to increase local flood risk and will be achieved through the adoption of industry good practice that promotes a natural approach to managing drainage in and around developments. Sustainable Drainage Systems (SuDS) work by slowing and holding back the water that runs off from a site whilst allowing natural processes to break down pollutants and/or remove sediment. The proposed drainage system will be sized so that it can manage increased flows from extreme storm events to ensure that flood risks are managed to an acceptable level throughout the lifetime of the development.

High concentrations of suspended solids can lower water quality. Any organic matter in the solid material (particulate or dissolved) may reduce dissolved oxygen through reduction reactions or microbial action. Monitoring data suggests that there is an existing occurrence within the WDNA of elevated suspended solids from both natural and artificial sources that will need to be managed. During the Construction Phase of the earthwork mounds it is likely that, under rainfall onto unvegetated slopes, fine soil particles will become suspended and flushed into the drainage system. The proposed SuDS system will be designed to remove the majority of suspended sediments that are generated because of construction activities to meet permitted limits stipulated by Natural Resources Wales (NRW). The system is both flexible and adaptable to ensure that flows can be routed, managed and treated to suit construction activity whilst also replicating baseline conditions as far as practicable. To ensure that there are sufficient safeguards in place to manage risks across a range of storm events additional measures have been incorporated into the drainage system. These will include soil management techniques, the use of artificial barriers to capture/trap sediments and only where considered necessary a system of dosing, i.e. using coagulants or flocculants to reduce suspended sediment concentrations. These artificial measures would be kept in place until vegetation on the mounds matures and the risk from suspended solids decreases to an acceptable level. The following section discusses and further develops these principles.

1.2.2. Drainage Design

As stated in Section 1.1 the proposed development will alter existing drainage catchment characteristics through the construction of platforms to accommodate the new Power Station, associated infrastructure and earthwork mounds (that will be formed using material excavated during construction of the platforms). A total of five earthwork mounds will be located on the WNDA.

The surface water management proposals to be implemented aim to maintain an overall surface water balance within existing drainage catchments with key focus on minimising impacts to the SSSIs and European designated sites located within, or close to, the development area. Flows and related volumes have been derived using hydraulic modelling software used to design the drainage system. Alongside maintaining the surface water balance within the WNDA, there is also the requirement to maintain water quality with consideration being given to TSS, nitrates and phosphates.

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[2] Planning Policy Wales: Edition 9 November 2016: Welsh Assembly Government

[3] Technical Advice Note 15 (TAN15): Development & Flood Risk:2004: Welsh Assembly Government

Exposed topsoil during construction and later from the newly formed landscape mounds could potentially increase sediment levels in surface water runoff. Surface water runoff carrying sediment could also be a source of nutrients, i.e. nitrates and phosphates, and other substances that may potentially effect water quality (further discussion is provided in Sections 2.3 and 2.4).

A flexible multi-stage treatment solution has been designed using good practice soil management, SuDS and polyelectrolyte coagulant dosing. A high level summary of the proposed treatment train is presented in figure 1-1 and is discussed further in Sections 1.2.3, 1.2.4 and 3.2. Drainage drawings will include details of drainage features (ditches, swales, ponds, outfall details).

This multi-stage approach:

- Uses surface water runoff as a resource
- Manages rainwater close to where it falls
- Manages runoff on the surface
- Promotes evapotranspiration
- Slows and stores runoff to mimic natural runoff characteristics
- Reduces contamination of runoff through pollution prevention and controlling runoff at source
- Treats runoff to reduce the risk of construction contaminants causing environmental pollution
- Provides a flexible and adaptable system capable of replicating, as far as, practicable baseline conditions within the existing drainage catchments

Soil Management

Erosion and sediment loss during and after construction will be managed in accordance with the Code of Construction Practice. As part of soil management it is proposed that any slopes that will remain in-situ for more than 60 days will be grass seeded at the earliest opportunity.

Silt fences

Silt fences at the toe of unseeded earthwork mounds and/or erosion control matting on the face of the mounds. Soil management and silt fences will, at source, provide an initial defence against the migration of sediment into the drainage system. Silt fences are used at the toe of exposed ground and stockpiles to reduce silt transport; they are made from geotextiles (a permeable synthetic textile material).

Silt traps, silt curtains and lined channels

Silt traps, silt curtains and lined channels can be used at intervals along ditches and support localised silt removal principally by slowing the velocity of flow. Silt traps use sized wells, below an outlet, which collect rainwater and allows the deposition of silt and sand. Silt curtains are flexible, impermeable barriers used to trap sediment in water bodies.

Swales

Swales are shallow, broad and vegetated channels designed to store and/or convey runoff and remove pollutants.

Sedimentation Ponds

Ponds incorporating permeable berms and silt forebays have been sized to attenuate surface water flows and are sufficiently large to allow for suspended sediment to settle prior to discharge into the receiving watercourse. These permanent pools of water can be used to provide attenuation and treat runoff, where outflows are controlled and water levels can increase following rainfall.

Polyelectrolyte Coagulant Dosing

Where required, a containerised polyelectrolyte coagulant dosing system would be used to treat surface water runoff where particulates are less than 0.002mm.

Figure 1-1 Multi-stage treatment summary

As shown in figure 1-1 above, the proposed drainage system (that includes a polyelectrolyte coagulant dosing system) will be both flexible and adaptable. This has been selected for the following key reasons.

1) To robustly protect against peaky and flashy TSS concentrations in the surface flow from the mounds.
2) To adequately treat and remove finer particles in the flow, such as clays and silts.
3) To robustly ensure that TSS limits are met whilst taking consideration of existing baseline conditions and the variability of the mound environment throughout its construction.

At this stage, a “family based” approach has been taken prior to permit issue. Further details on the polyelectrolytes will be available during the determination period as part of a developed design package. Final details will be provided during the detailed design phase.

During construction, the TSS concentration that will be generated within the surface flow from the mounds is, at this stage, largely unknown. For the majority of a mound’s life TSS concentrations in surface flow are expected to be low and this consequently supports the use of a natural SuDS design as mitigation. Notwithstanding this, there will be occurrences where TSS concentrations in the surface flow could peak considerably. Several factors will affect concentrations, such as storm intensities, mound surfacing make-up (the material used within it), mound surfacing finish (whether it is grassed or bare earth) and the construction activities taking place on the mound at any given time. Data for the baseline environment indicates that drainage catchments are characterised as flashy whilst also highlighting that TSS concentrations are typically low. This aspect is discussed in later sections but does highlight the need to consider and protect against high concentrations.

During or immediately following periods of rainfall the drainage system will operate in a natural way and often without the need for coagulant dosing. A SuDS system can be used to remove sediment from flows, however the effectiveness of the treatment process is reduced when fine soil particles are mobilised and raises the prospect of these particles passing through the system largely untreated. However, where TSS concentrations increase because of construction activity, there will be occurrences that would rely on a polyectrolyte dosing system to improve the level of treatment prior to discharge into the receiving watercourse. Whilst these occurrences are expected to be infrequent in nature, and of short duration, they cannot be ignored.

Where monitoring data indicates that TSS concentrations will be raised and have the potential to exceed consented limits then the dosing system will automatically be engaged. Dosing of coagulant will be undertaken proportional to flow to achieve the consented TSS limit; once sediment concentrations (only because of construction activity) have been shown to reduce to below the consented limit the dosing system would then cease to operate. It should also be noted that in the vast majority of storms, the ‘first flush’ contains the initial surface water of the rainstorm and transports the highest concentrations of the pollutants, including TSS. Once this ‘first flush’ has passed, it is likely that the natural SuDS system will suffice.

Existing watercourses within the WNDA will be fenced off to prevent the deterioration of riverbanks by livestock which in turn will result in lower sediment levels to the watercourses and could contribute to an overall improvement in the water quality of the existing environment.

1.2.3. Sustainable Drainage System Design

SuDS work by mimicking natural drainage systems and provides a method that can decrease the peak rate of surface water runoff, and hence reduce the risk of flooding. In addition, these features can help to control surface water runoff quality and provide biodiversity benefits. Biodiversity benefits can include provision of habitats and diversifying landscapes.

The associated ponds have been sized so that the permanent pool volume contains 4 times the design treatment volume to provide sufficient settling time for sediment. As an alternative option, for future design stages, the sedimentation pond sizes could be reduced if silt curtains are introduced within the ponds. The total pond volume shall be a combination of the permanent required treatment volume **plus** the attenuation volume requirements (noting that the attenuation sizes are relatively insignificant when compared with the required treatment volumes). Attenuation volumes have been calculated based on the 100 year + 20% climate change storm with a discharge rate limited to the 100 year greenfield runoff rate.

The design will capture the majority of sediments down to a particle size of approximately 0.002mm. Excavated material from the site will however include clay; clay particles are typically less than 0.002mm in size and as such a purely SuDS based system will not effectively remove these particles. Release of these fine particles in surface water runoff would typically be expected during construction activities and whilst mounds are not vegetated. Due to the nature of these particles, further treatment may be required using a polyelectrolyte coagulant dosing system which is discussed further in Section 1.2.4. Notwithstanding this the proposed SuDS system is considered both flexible and adaptable to be responsive to construction needs whilst continuing to offer protection to the downstream aquatic environment. The system is predominantly soft-engineered and as such means that it can be amended or adapted to respond to site conditions, for example the location and length of swales can be altered (to provide additional treatment volume) or the number of silt traps can be increased.

Each of the five mounds will have an associated drainage system and outfalls will discharge into the existing aquatic environment. Surface water runoff will be collected using a system of open ditches and swales. Where swales can be used, they will be constructed with a french drain[4] below to improve silt capture efficiency and capacity. The sedimentation ponds have been designed to receive runoff generated in a 1 in 100 year storm event with an additional 20% climate change factor.

Increased levels of sediment suspended within surface water runoff will be the main source of risk to watercourses during the Construction Phase and will remain so until vegetation becomes established and matures on earthwork mounds. The proposed drainage system will be of low maintenance, although sediment loads during the Construction Phase will influence the frequency of maintenance required. Regular inspection will be required to monitor sediment build-up that could have an adverse effect on the efficiency of the system. Notwithstanding this, the frequency of maintenance, including sediment removal requirements, will reduce over time as vegetation on the mounds becomes established and matures.

1.2.4. Polyelectrolyte Coagulant Dosing System

Additional mitigation, in the form of polyelectrolyte coagulant dosing is proposed alongside the SuDS system to provide further treatment of sediment within surface water run-off should this be required (noting that discharge E1 will be removed see Section 2.2.5). At this stage, it is planned that dosing will only be used to respond to rapid increases in TSS concentrations from within the WNDA construction areas (the SuDS system will manage TSS at all other times). A containerised polyelectrolyte coagulant dosing system[5] will be established at each discharge location to treat surface water runoff particulates less than 0.002mm because of construction activity and based on the particular TSS limit imposed. Treatment by dosing can, if required, reduce TSS concentrations to 25mg/l, although it should be recognised that these lower limits are achieved through larger volumes of coagulant. A flow proportional system of dosing is proposed, i.e. dosing will be directly proportional to the incoming flow. This method of treatment is more efficient than other treatment methods that are available; an example of this is a “floc-block” system, which uses a solid block of a flocculant continually releasing small amounts into the water.

The dosing units would be installed between the SuDS sedimentation pond outfalls and the eventual discharge point. Intake to the unit would be controlled either using a weir or penstock gate and/ or by pumping. Flow enters a mixer tank where polyelectrolyte dosing takes place prior to discharge into the clarifier tank (where sediment is treated[6]).

Each dosing unit will have a limiting capacity; a typical unit has a capacity of 200m^3/hr (55l/s). Multiple units are expected to be required at each discharge point with the estimated number of units required to treat flows generated during a 1 in 2 year storm event at each discharge point being stated in Section 2.2. The 1 in 2 year storm event has been selected because the lower return period storm events have the higher probability of occurrence but also recognises the practical limitations of providing further units to treat runoff (this is a reasonable balance between the provision of treatment to limit sediments against the number of dosing units required). Notwithstanding this the proposed sedimentation ponds have been sized to provide volume for storms up to and including the 1 in 100 year plus climate change storm event; the system therefore has capacity to treat runoff associated with the higher return period events.

[4] French drains temporarily store runoff below the surface in a shallow trench filled with stone/ gravel. They provide attenuation, conveyance and treatment (via filtration).
[5] The use of coagulant within contained mixing and settlement containers.
[6] Lamella clarifiers will aid settlement of TSS to reduce sediment load in the discharge.

The following sets out the requirements for a typical single unit:

- Typical footprint for an installation with a 55l/s capacity unit is 15m x15m, to be sited on a compacted unbound surface.
- Power requirement (per unit): minimum 30kVA 415V three-phase supply
- Noise emissions:
    - Treatment unit: 70dB (excluding power generation)
    - Power generator (silenced and diesel operated): 70dB

Regular maintenance/ management of the dosing system will be required and activities would typically include checking of coagulant levels, desludging of sumps together with checks to pumps and pipelines, it is expected that this would be undertaken on a daily basis. As the dosing system is a proprietary asset the supplier will recommend their own maintenance requirements and as such the exact maintenance requirements cannot be confirmed at this stage. The frequency of maintenance will be sufficient to ensure an operable system but can only be confirmed once detailed design for it has been completed.

Polyelectrolytes are commonly used in water treatment to control and enhance the coagulation and flocculation of suspended particulate matter. Polyelectrolytes have been proposed in preference to a metal-based flocculant such as aluminium. The principal reason for this being that polyelectrolytes produce a lower quantity of waste than the metal-based flocculants.

A review of polyelectrolytes undertaken for the Environment Agency (WRc, 1996) found that the impact of polyelectrolytes on the aquatic environment is low due to the strong and irreversible sorption (or binding) to suspended and dissolved organic matter, losses due to hydrolysis and biodegradation (processes to breakdown substances) and a low potential to bioaccumulate (accumulation of substances within an organism). The study mainly focussed on impacts to a freshwater environment. The majority of proposed discharge locations within the WNDA outflow into a freshwater environment.

Impacts to brackish environments are not as widely studied as those to freshwater environments. However, in assessing the reasons given in the WRc report it is considered that any potential impact in a brackish environment would not greatly differ from those found in a freshwater body. For example, if additional binding in the brackish environment were to occur due to residue of polyelectrolytes, this would lead to some additional settlement of suspended solids in the immediate vicinity of the outfall and as such may be managed as part of the wider monitoring and mitigation of the system.

Under the proposed operational conditions with flow proportional polyelectrolyte dosing, it is very unlikely that there will be any notable concentrations of residual polyelectrolytes present in the effluents. Dosing is expected to be in the range of 0.1-1mg/l, thus any accidental releases or over-dosing of the polyelectrolyte would be in concentrations of less than 1mg/l. In addition, it is anticipated that the effects of any residual polyelectrolytes will be significantly reduced by losses due to sorption and degradation within the aquatic environment. Dilution would also reduce the concentration of any residual polyelectrolytes.

A well-maintained system will prevent unintentional discharges of polyelectrolytes to the aquatic environment. Accidental releases or over-dosing could be caused by inappropriate storage of coagulant or inadequate maintenance of the dosing units. As regular maintenance and best practice for material storage is proposed there is a low likelihood of occurrence. Furthermore, the risks on the aquatic environment, should releases occur, are expected to be minimal as the coagulant will bind with suspended solids in the receiving watercourse and become inert. It should also be noted that there are no proposals to store polyelectrolyte less than 10m from a watercourse.

Jar testing of various ionic strength polyelectrolytes has been undertaken. The results of the test indicated that there were no clear effects on the following parameters /substances (in comparison to tests where no polyelectrolyte had been added): alkalinity, biological oxygen demand, chloride, nitrate, potassium, sulphate, electrical conductivity and pH. Slight effects were observed on the following: calcium, magnesium, dissolved organic carbon and total organic carbon. The results of this test suggest a limited impact to the aquatic environment from polyelectrolyte dosing on site.

1.2.5. Post Construction Design

In terms of post-construction design, it is proposed that all completed mound slopes will be grassed / vegetated with the overall SuDS principle remaining unchanged, whereby ditches will remain connected to sedimentation ponds. Temporary measures such as silt fences, curtains etc. and dosing installations will be removed as vegetation becomes established and monitoring confirms its effectiveness.

2. Water quality

Available monitoring data had been used to inform a baseline assessment of a WNDA catchment wide TSS limit. Existing water quality data has been analysed for each catchment, which are expected to receive discharges from the drainage system and this is detailed in the Jacobs (2018) Assessment of Appropriate Suspended Sediment Concentrations for Water Discharge Location (60PO8083/HYD/REP/002 V1.2).

Long term water quality monitoring has included the following:

- Spot sampling at five sites since 2012 and expanded to 27 sites by 2014 across WNDA. This consists of monthly in-situ monitoring and quarterly laboratory analysis.

- One round of monitoring at eight locations around Tre'r Gof in February 2015, which was extended to monthly sampling between November 2015 and May 2016, and further extended to quarterly monitoring since May 2016.

- Monthly monitoring at accessible hydrological features around Cae Gwyn between November 2015 and May 2016, which was extended to quarterly monitoring since May 2016.

- Continuous water quality monitoring on Nant Cemlyn and Nant Caerdegog Isaf installed in May and July 2015 respectively.

The existing monitoring and proposed discharge locations are show in in figure 2-1 below whilst an overview of the drainage network is shown in figure 2-2 below. For more detailed drawings of the drainage network please refer to drawings 5151821-ATK-ZZ-XX-DR-D-0001 to 0012.

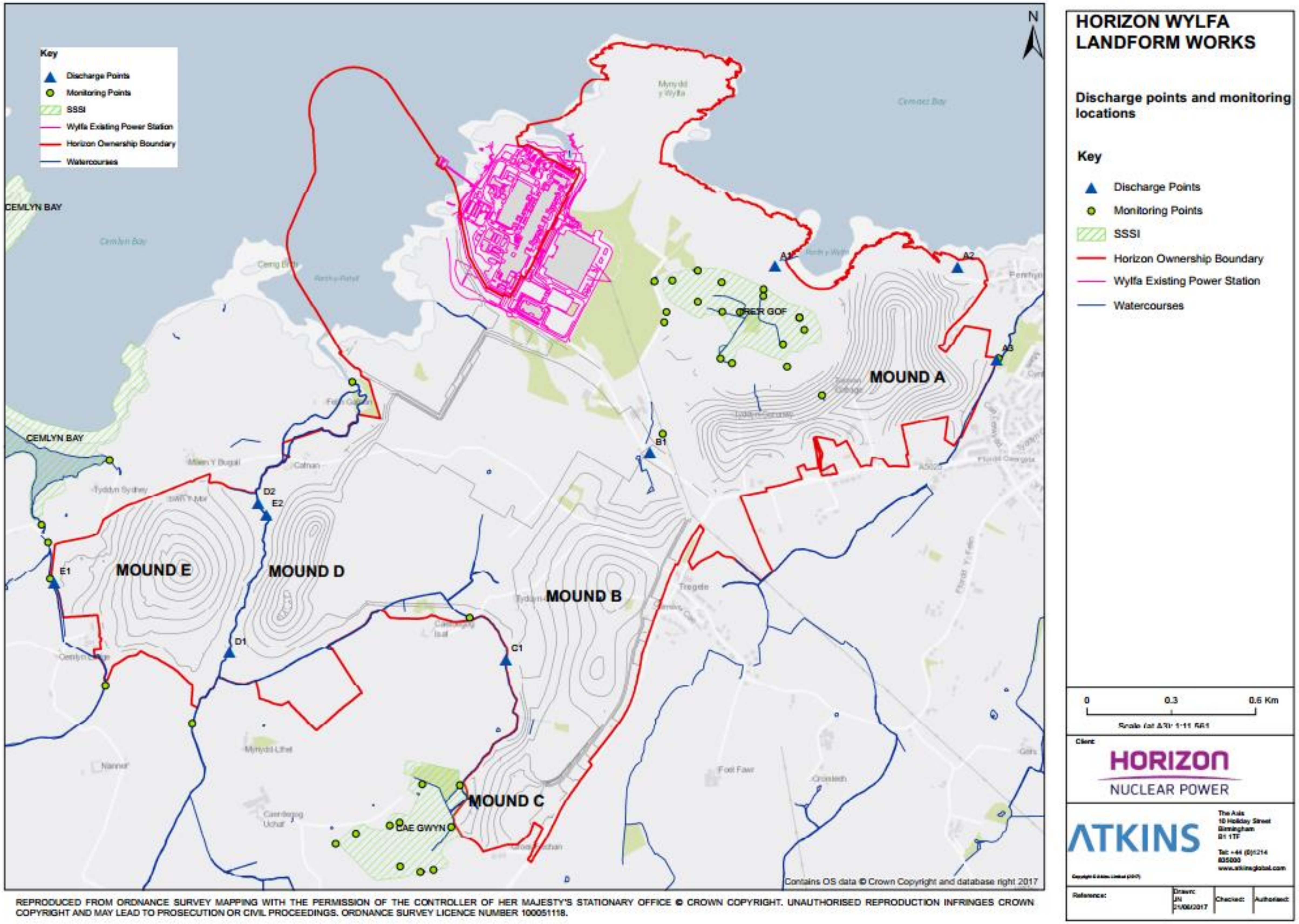

Figure 2-1 Existing monitoring and proposed discharge locations

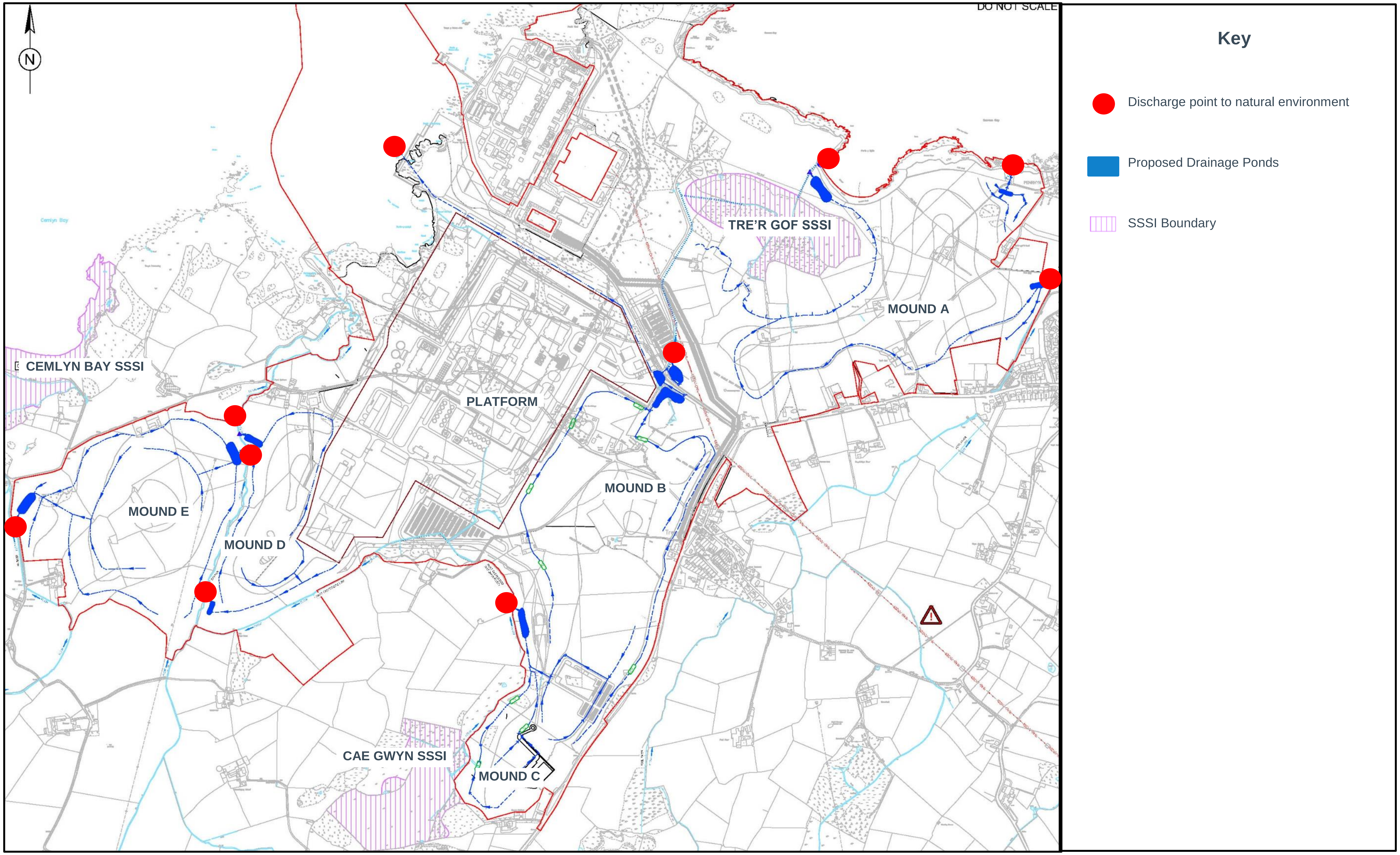

Figure 2-2 **Surface Water Drainage Overview**

In addition to water quality monitoring, flow and meteorological monitoring is also undertaken on site at regular intervals. Results from the flow data indicate flows in the surface waters are influenced by groundwater. The data also highlights the flashy nature of catchments within the WNDA, which results in natural exposure to high peaks of TSS and nutrients within watercourses. The monitoring of these parameters will continue to support detailed design and management of the drainage system during the Construction Phase. Relevant data has been used to understand catchment concentrations and loadings, in terms of TSS as part of this report only.

It should be noted that although the drainage design focusses on mitigating risks of elevated TSS in surface water runoff, there are further benefits to water quality in terms of nutrient management. As noted in Section 1.2, sediment can also be a source of nutrients and other determinands to surface waters. The treatment train can facilitate the retention of nutrients in vegetation and thus reduce the potential load discharged to receiving waters. Natural calcium and carbonate concentrations entering Tre'r Gof are also maintained through this drainage design.

The following sections provide a summary of the current proposed high-level limit for TSS and any required adjustments for individual catchments.

2.1. Total Suspended Solids Limit

When proposing a Total Suspended Solids (TSS) limit it is important to understand the varying conditions that the drainage system will experience. For example, some watercourses within the WNDA have been found to exhibit lower mean TSS concentrations whilst others exhibit higher levels, or fluctuate considerably within the TSS concentration ranges monitored.

A passive and natural SuDS system will provide a treatment reduction of TSS but cannot be relied upon to do so without supplementation by active systems. This is because the TSS input to the drainage system will vary based on the rainfall intensity, rainfall volume, the current condition of the mounds (seeded or unseeded) and/or any construction activities that may or may not be ongoing during, or before, any given storm event. The effectiveness of a natural SuDS system against finer clay and silt particles is also a consideration that needs to be made, as stated in Section 1.2.3. Notwithstanding this, once each of the mounds have been seeded, and construction activities completed, the TSS input to the drainage system will lower considerably. The TSS limits proposed herein relate to the Construction Phase of the project only and in particular the Construction Phase of each of the mounds.

An assessment of each mound and catchment, using baseline data, has been undertaken to derive and propose a catchment-based limit for each discharge location. The findings of the assessment initially proposed a single, overarching, and upper TSS limit of 70 mg/l for all discharges across the WNDA, as a first pass that that could be reached by passive treatment. An upper limit of 70mg/l is enveloped and conservative, and can be seen to be within the same bounds as the existing catchment characteristics. It should be noted that the TSS concentrations that will be discharged from the proposed drainage systems, during lower return period events, which will be the predominant rainfall, are expected to be less than the 70mg/l proposed limit but greater than or equal to 25mg/l. The actual range of discharge concentrations will be determined during the detailed design stage.

An assessment of appropriate suspended solids concentrations for water discharge locations has been undertaken, taking further consideration of catchment monitoring has been undertaken by Jacobs (2018), these are discussed in the following section. The system will be designed and managed to meet the conditions of these limits which have been set for the discharge permit application.

2.2. Catchment Based Water Quality Limits

A total of nine discharges from the five mounds are currently planned within the WNDA, the following sections provide a summary of each of the discharges. For details of catchment water quality conditions refer to Table 6 in the Jacobs (2018) Assessment of Appropriate Suspended Sediment Concentrations for Water Discharge Location (60PO8083/HYD/REP/002 V1.2).

2.2.1. Mound A

Mound A drainage will discharge at three locations as shown in figure 2-2.

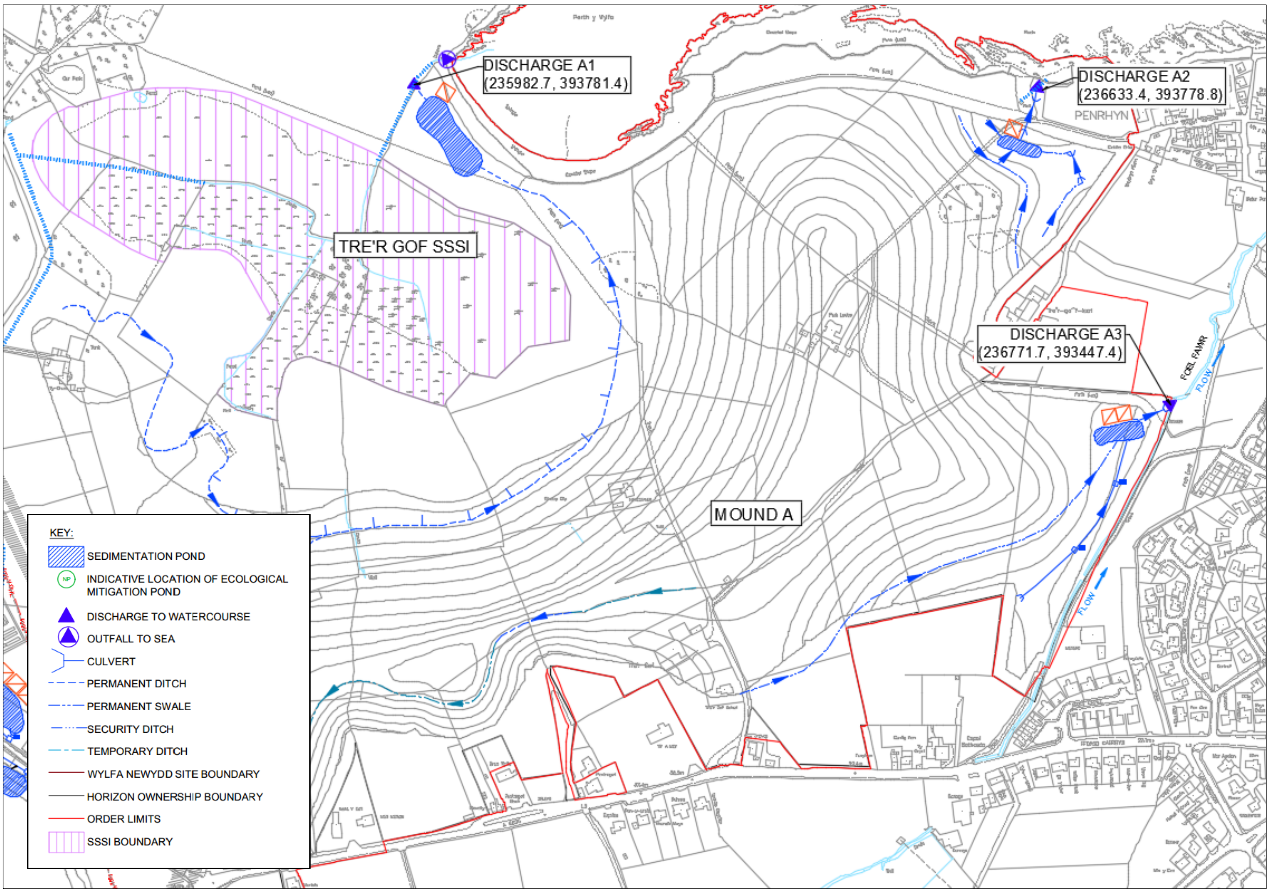

Figure 2-3 Mound A Site Location

2.2.1.1. Discharge A1

Mound A is in close vicinity to the Tre'r Gof SSSI, see figure 2-3. All associated earthworks on the northern and western side of Mound A are planned to be completed within the first earthworks season of the construction programme or full year. It is likely that would cover a period of around three months. This timescale is proposed in order to mitigate against potential impacts to the SSSI by working within the drier months and assumes favourable weather conditions. The proposals include reinstatement of topsoil and re-establishment of vegetation.

There are known existing springs and seeps that feed the Tre'r Gof SSSI; the basis of the drainage design at Mound A is to ensure that the springs and seeps continue to contribute to the existing flow regime. A new ditch is proposed at the toe of Mound A for drainage and to support the removal of sediment. It is recognised that this proposal would intercept runoff that in the existing situation would normally be directed into the SSSI. To ensure that the existing runoff regime is, as far as practicable, maintained the design of the ditch will incorporate a series of suitable connections at 50m intervals, set just above or at ditch bed level. The upstream end of each connection would be designed to incorporate stop logs to manage flows (and sediment) into the pipe; the number of stop logs could be adjusted during operation, as required, to suit site conditions and/or TSS related risks. At the downstream end of each connection, flows would be passed through a silt trap prior to dispersal across the vegetated buffer strip (existing vegetation would also support sediment removal prior to discharging into the SSSI).

A crushed rock drainage blanket would be constructed below Mound A using either imported fill or material generated from the deep excavation operations. It is expected that this drainage blanket will be the primary contributor of water into the SSSI. Material used to form the blanket would be inert and is not expected to have any impact on surface water quality. The function of the drainage blanket is to enable flows from springs and seeps to make their way into the Tre'r Gof SSSI catchment. The schematic diagram presented in figure 2-4 illustrates how, as far as practicable, the existing flow regime will be maintained.

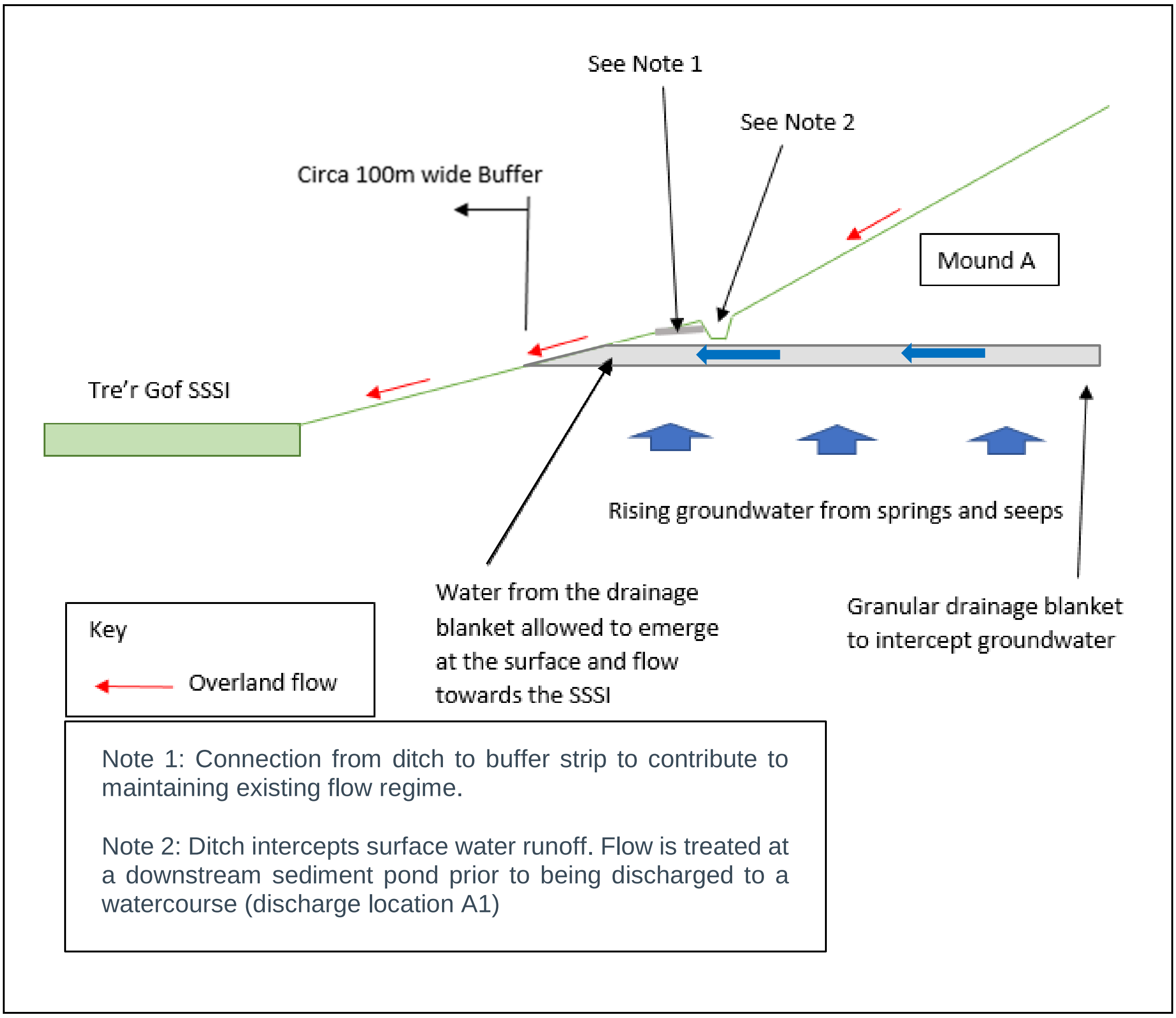

Figure 2-4 Mound A (Western Side): Drainage Schematic Diagram

Furthermore, vegetation on the western side of Mound A will be accelerated through the implementation of appropriate surface binding techniques, such as hydroseeding[7], or impregnated matting, thereby reducing the likelihood of elevated and/or uncontrolled sediment runoff from unvegetated surfaces. As discussed in Section 1.2.5, the requirement for dosing will cease when vegetation is fully established on the mound. A circa 100m buffer strip[8] will be established between the western toe of the mound and the SSSI prior to the commencement of earthworks operations and will be maintained until completion.

There is an aspiration that, post construction, the drainage systems associated with Discharge A1 will be removed and returned to its original and natural form. However, to enable this it is imperative that the existing flow regime is matched and this can only be confirmed during the detailed design stage. The drainage system proposed at Mound A is deemed to be flexible to enable alterations to be made as necessary throughout the Construction and Operational phases. The Tre'r Gof SSSI is a highly variable environment and the drainage system proposed, that interfaces closely with it, has been made flexible and low maintenance to manage the water flow into and around the SSSI as far as is reasonably practicable.

[7] Hydroseeding is a planting process that uses a slurry of seed and mulch. It is often used as an alternative to traditional sowing of dry seed because it offers a shorter and more successful germination period.
[8] Buffer strips is land that will remain vegetated and where construction work/activity will be prohibited.

A summary of discharge A1 is provided in table 2-1.

Table 2-1 Discharge A1

Catchment	Tre'r Gof
Receiving watercourse (Freshwater/ Coastal)	Existing drainage ditch (north of Tre'r Gof) that drains into Porth Wylfa **Freshwater discharge**
Grid Reference	235983, 393781
Catchment area (ha)	19.14
Combined inlet rate (30yr return period) (l/s)	126.6
Outlet rate (30yr return period) (l/s)	121.8
Cumulative volume (m^3/ day) (30yr return period)	389.2
Estimated no. of dosing units required	1

Catchment based TSS limit: A derived limit of 30mg/l from baseline data was noted to be overly stringent and therefore a limit of **40mg/l** has been proposed (Jacobs, 2018), further monitoring is required to justify this limit.

2.2.1.2. Discharge A2

A summary of discharge A2 is provided table 2-2.

Table 2-2 Discharge A2

Catchment	N/A
Receiving watercourse (Freshwater/ Coastal)	Drainage channel from an existing well installation. Existing channel ultimately discharges directly to Cemaes Bay **Freshwater Discharge**
Grid Reference	236633, 393779
Catchment area (ha)	4.05
Combined inlet rate (30yr return period) (l/s)	322.5
Outlet rate (30yr return period) (l/s)	145.6
Cumulative volume (m^3/ day) (30yr return period)	960.4
Estimated no. of dosing units required	1

Catchment based TSS limit: As the outfall will effectively be discharged to the marine environment at Cemaes Bay, a **70mg/l** limit for TSS is proposed (Jacobs, 2018).

2.2.1.3. Discharge A3

A summary of discharge A3 is provided in table 2-3.

Table 2-3 Discharge A3

Catchment	Cemaes
Receiving watercourse (Freshwater/ Coastal)	Nant Camaes **Freshwater Discharge**
Grid Reference	236772, 393447
Catchment area (ha)	6.22
Combined inlet rate (30yr return period) (l/s)	516.4
Outlet rate (30yr return period) (l/s)	273.5
Cumulative volume (m^3/ day) (30yr return period)	1475.9
Estimated no. of dosing units required	2

Catchment based TSS limit: A derived limit of 20mg/l from baseline data was noted to be overly stringent and therefore a limit of **40mg/l** has been proposed (Jacobs, 2018), further monitoring is required to justify this limit.

2.2.2. Mound B

Surface water drainage to Mound B will be provided principally by means of ditches that will drain in a northerly direction, see figure 2-5. As Mound B will be used as a laydown area the drainage ditches positioned for the Construction Phase will be temporary and will need to be repositioned prior to forming the final mound profile at the end of the Construction Phase; it should be noted that the laydown area has been omitted from figure 2-4 for clarity.

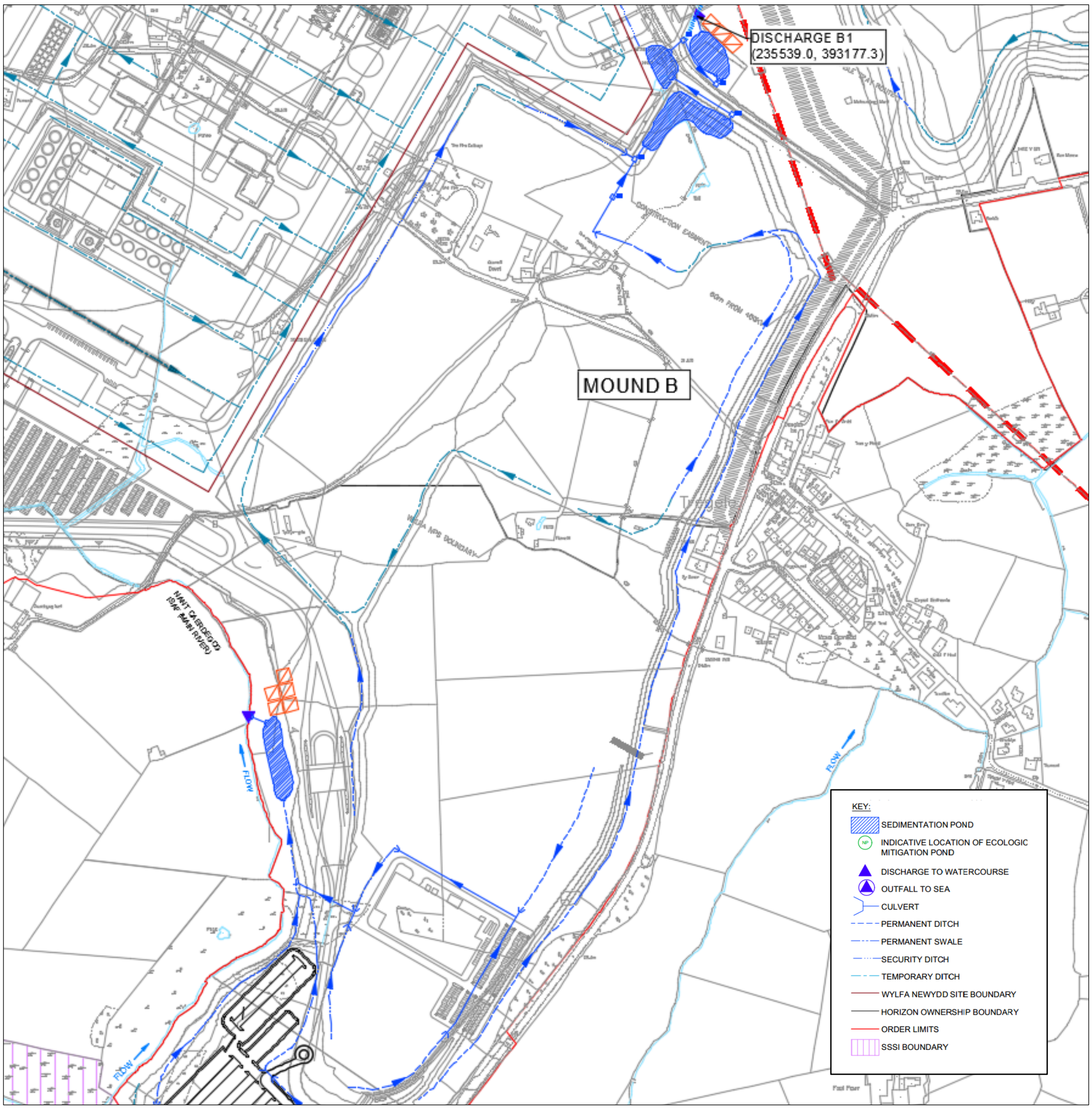

Figure 2-5 Mound B Site Location

2.2.2.1. Discharge B1

A summary of discharge B1 is provided in table 2-4.

Table 2-4 Discharge B1

Catchment	Tre'r Gof
Receiving watercourse (Freshwater/ Coastal)	Existing drainage ditch (West of Tre'r Gof) **Freshwater Discharge**
Grid Reference	235539, 393117
Catchment area (ha)	39.94
Combined inlet rate (30yr return period) (l/s)	1275.4
Outlet rate (30yr return period) (l/s)	527.3
Cumulative volume (m^3/ day) (30yr return period)	9,969.3
Estimated no. of dosing units required	3

Catchment based TSS limit: A **70mg/l** limit for TSS is proposed and will be achieved, as required, with dosing during construction activities (Jacobs, 2018).

2.2.3. Mound C

Mound C has been located to the northeast of the Cae Gwyn SSSI, see figure 2.6. Mound C will be characterised by an 1100 space temporary car park during construction that is significantly reduced to a smaller and permanent Visitor Centre car park on completion. This introduces additional impermeable surfaces into the catchment that will require mitigation to avoid impacts of higher rates of runoff. The majority of surface water runoff from the temporary car park will be drained northwards and will be discharged into the Nant Caerdegog Isaf, located to the west of the mound. The drainage system will also incorporate an overflow arrangement, or localised permeable surfacing with a dispersion ditch that will allow a controlled volume of runoff, equivalent to the existing greenfield runoff that will be removed from the Cae Gwyn catchment, to be discharged as sheet flow onto land adjacent to the car park.

The construction of a car park will introduce a risk of pollution from hydrocarbons entering the drainage system. Overall the risk of a significant polluting incident is considered low, however the design of each car park will need to incorporate appropriate mitigation to downstream pollution of the aquatic environment. This could preferentially include the use of SuDS features such as bio-retention strips, ponds incorporating reed beds or permeable paving. Oil separators would also be an acceptable form of mitigation. All related features would require ongoing maintenance to ensure that they remain effective.

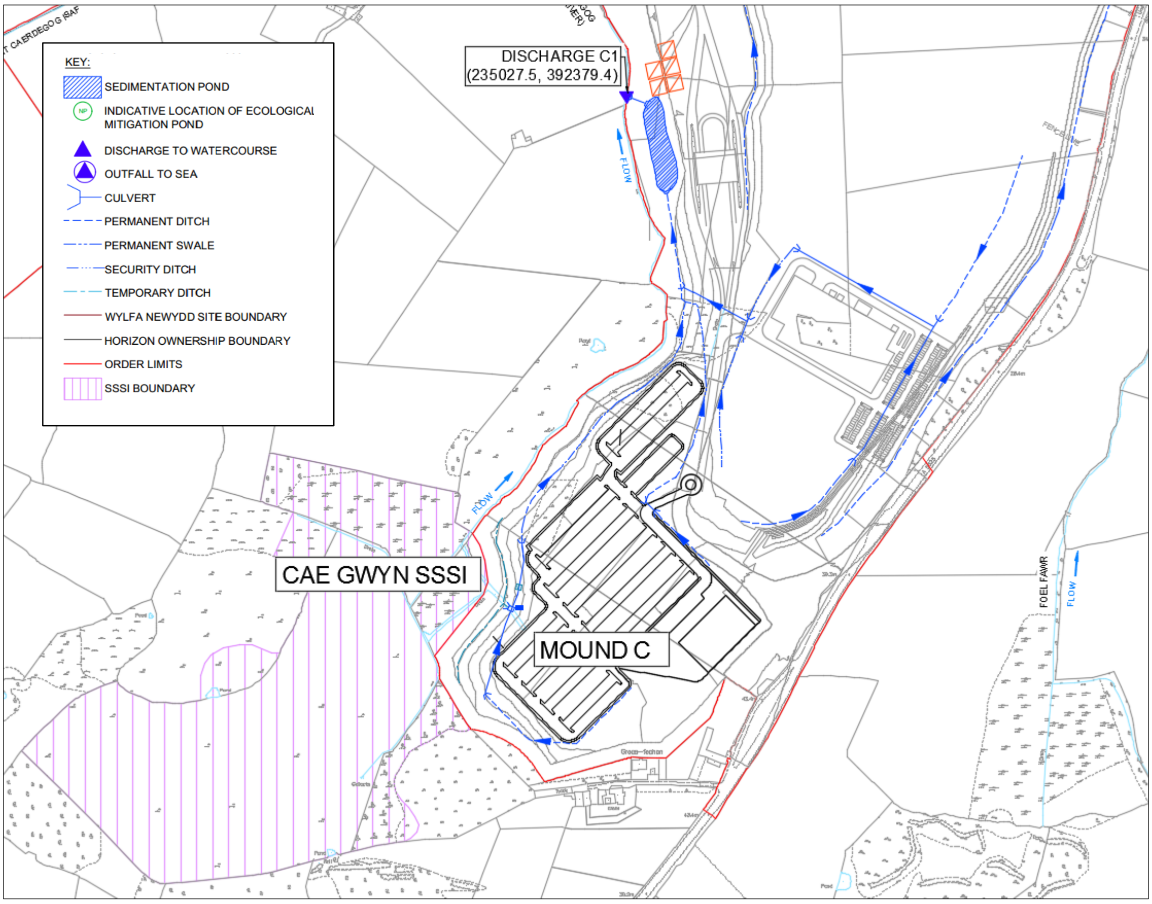

Figure 2-6 Mound C location

2.2.3.1. Discharge C1

A summary of discharge C1 is provided in table 2-5.

Table 2-5 Discharge C1

Catchment	Afon Cafnan
Receiving watercourse (Freshwater/ Coastal)	Caerdegog Isaf **Freshwater Discharge**
Grid Reference	235026, 392379
Catchment area (ha)	12.55
Combined inlet rate (30yr return period) (l/s)	1355.2
Outlet rate (30yr return period) (l/s)	924.3
Cumulative volume (m^3/ day) (30yr return period)	5,894.3
Estimated no. of dosing units required	5

Catchment based TSS limit: A **70mg/l** limit for TSS is proposed and will be achieved, as required, with dosing during construction activities (Jacobs, 2018).

2.2.4. Mound D

The Mound D area, see figure 2-7 will be used as a laydown area and most of the drainage ditches positioned for the Construction Phase will be permanent and will also provide the drainage for the final stage. However, there are areas where the drainage ditch will need to be relocated for the final Stage 5 proposal. Surface water runoff from Mound D will be discharged to the Afon Cafnan to the west. A minimum 15 metres construction buffer zone will be established and maintained immediately adjacent to the river edge to reduce the risk of uncontrolled sediment migration into the channel.

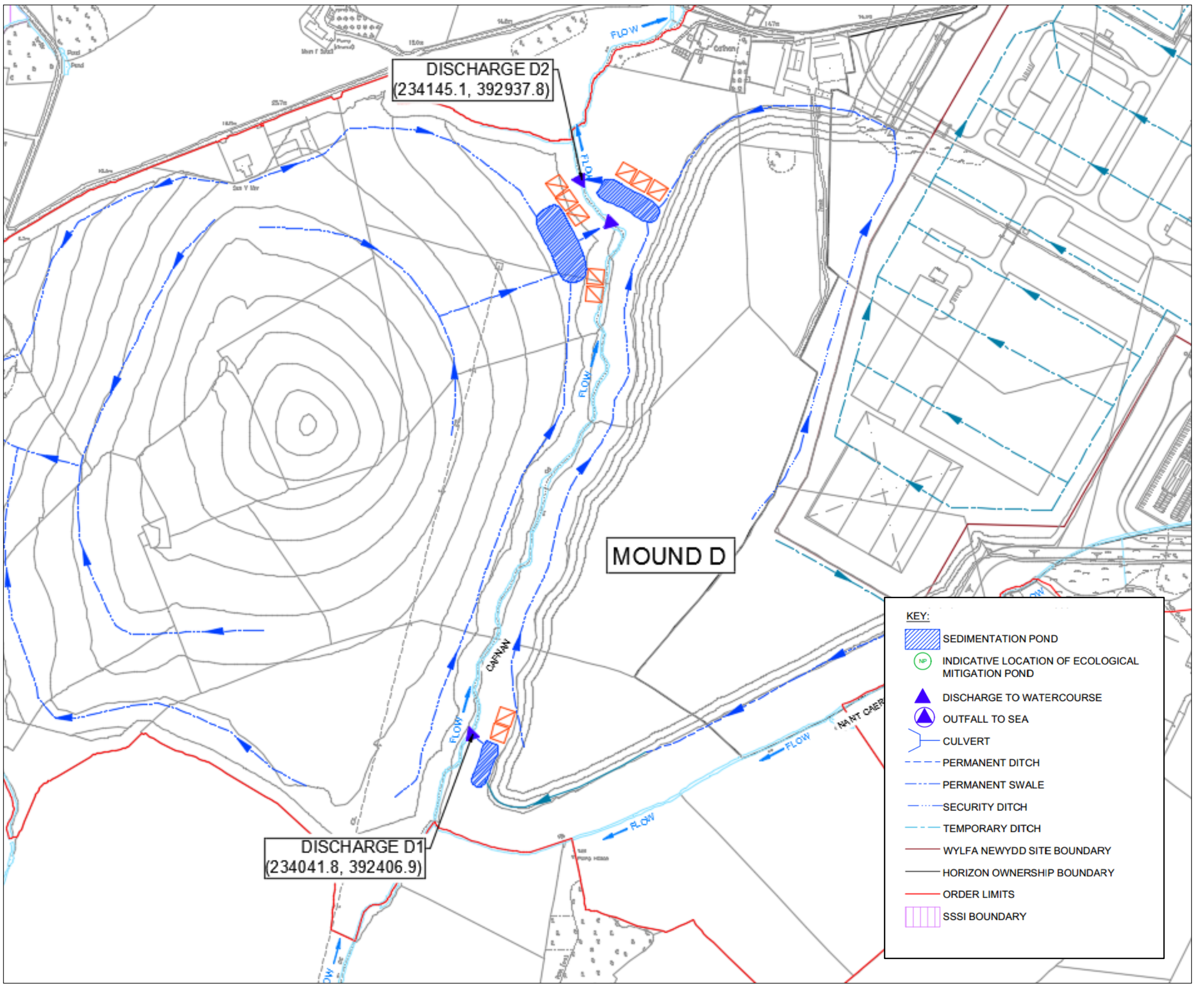

Figure 2-7 Mound D Site Location

2.2.4.1. Discharge D1

A summary of discharge D1 is provided in table 2-6.

Table 2-6 Discharge D1

Catchment	Afon Cafnan
Receiving watercourse (Freshwater/ Coastal)	Afon Cafnan **Freshwater Discharge**
Grid Reference	234042, 392407
Catchment area (ha)	4.39
Combined inlet rate (30yr return period) (l/s)	491.6
Outlet rate (30yr return period) (l/s)	178.4
Cumulative volume (m^3/ day) (30yr return period)	2361.6
Estimated no. of dosing units required	2

Catchment based TSS limit: A **40mg/l** limit for TSS is proposed and will be achieved, as required, with dosing during construction activities (Jacobs, 2018).

2.2.4.2. Discharge D2

A summary of discharge D2 is provided in table 2-7.

Table 2-7 Discharge D2

Catchment	Afon Cafnan
Receiving watercourse (Freshwater/ Coastal)	Afon Cafnan **Freshwater Discharge**
Grid Reference	234145, 392938
Catchment area (ha)	8.77
Combined inlet rate (30yr return period) (l/s)	192.7
Outlet rate (30yr return period) (l/s)	419.2
Cumulative volume (m^3/ day) (30yr return period)	1,047.8
Estimated no. of dosing units required	3

Catchment based TSS limit: A **40mg/l** limit for TSS is proposed and will be achieved, as required, with dosing during construction activities (Jacobs, 2018).

2.2.5. Mound E

Surface water runoff from Mound E, see figure 2-8, will discharge into the Nant Cemlyn and Afon Cafnan.

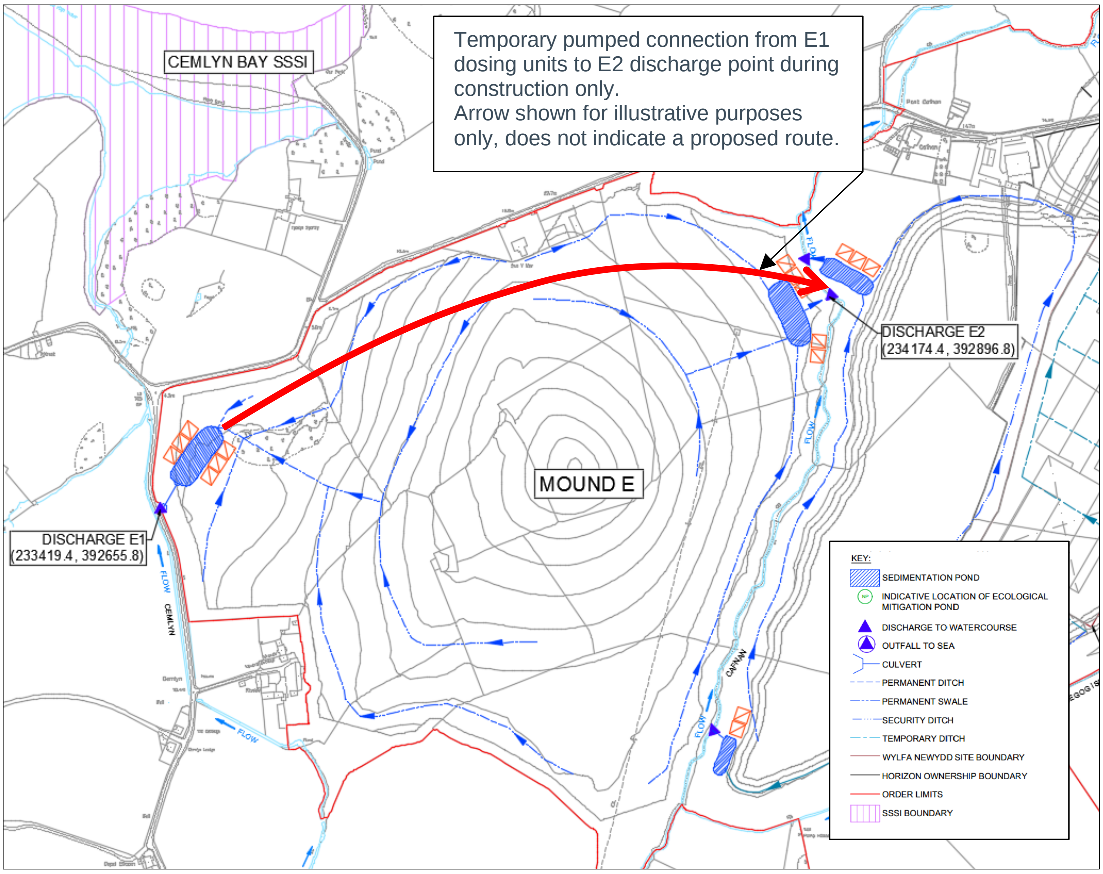

Figure 2-8 Mound E Site Location

2.2.5.1. Discharge E1

To maximise the control of surface water quality and in addition to the treatment pond and swales, reeds and natural habitat will be planted within the pond and swales. This approach increases the likelihood of maintaining current water quality conditions of Cemlyn Bay on SSSI/ SAC.

Following HNP discussions with NRW, it has been agreed that during construction of the western face of Mound E there will be no use of Discharge E1. The drainage system from catchment E1 will discharge to Pond E1 (with associated dosing units) but the discharge will be pumped to outfall E2 (downstream of the E2 dosing units). This arrangement only applies during the construction of the western face of Mound E; once vegetation has become established then Discharge E1 will be utilised. Any related impacts from the catchment transfer from the temporary pumping arrangements discussed above have not been assessed and will need to be reviewed prior to detailed design.

Following on from the construction period, drainage from the western side of Mound E will discharge to Cemlyn Bay lagoon, via Nant Cemlyn. To mitigate against potential impacts of the scheme on the SSSI, it is planned to complete all associated earthworks on the western side of Mound E within the first earthworks season of the construction programme (assuming favourable weather conditions), or a full year working within the drier months only. The works would include the reinstatement of topsoil and re-establishment of vegetation.

Furthermore, vegetation on the western side of Mound E will be accelerated through the implementation of appropriate surface binding techniques, such as hydroseeding, or impregnated matting, thereby reducing the likelihood of elevated and uncontrolled sediment runoff from unvegetated surfaces.

There is an aspiration, post construction, to remove the drainage systems associated with discharge E1, with land being returned to its original and natural form. However, to enable this it is important that the existing flow regime is matched as far as reasonably practicable and this can only be confirmed during the detailed design stage.

A summary of discharge E1 is provided in table 2-8.

Table 2-8 Discharge E1

Catchment	Cemlyn
Receiving watercourse (Freshwater/ Coastal)	Nant Cemlyn **Freshwater Discharge**
Grid Reference	233419.4, 392655.8
Catchment area (ha)	14.58
Combined inlet rate (30yr return period) (l/s)	976.9
Outlet rate (30yr return period) (l/s)	960.6
Cumulative volume (m^3/ day) (30yr return period)	3928.2
Estimated no. of dosing units required	6

Catchment based TSS limit: No net increase in downstream sediment concentration (Jacobs, 2018).

2.2.5.2. Discharge E2

A summary of discharge E2 is provided in table 2-9.

Table 2-9 Discharge E2

Catchment	Afon Cafnan
Receiving watercourse (Freshwater/ Coastal)	Afon Cafnan **Freshwater Discharge**
Grid Reference	234174, 392897
Catchment area (ha)	14.68
Combined inlet rate (30yr return period) (l/s)	860.4
Outlet rate (30yr return period) (l/s)	769.5
Cumulative volume (m^3/ day) (30yr return period)	3022.1
Estimated no. of dosing units required	5

Catchment based TSS limit: A **40mg/l** limit for TSS is proposed and will be achieved, as required, with dosing during construction activities (Jacobs, 2018).

2.2.6. Platform Area

A summary of the platform area, located within the Power Station catchment is shown in figure 2-9 and table 2-10.

During the Construction Phase earthwork plateaus will be drained by a system of transverse and perimeter ditches that discharge into two sedimentation ponds. Further treatment will be provided by a polyelectrolyte coagulant dosing system when required. The manner in which dosing will be used will be in accordance with the strategy outlined in Section 1.2.2. Three discharge points (referred to as PA, PB and PC) will be used to drain the platform area. The use of these discharge points will vary dependant on the sequence of construction and therefore may be subject to change. However, at this stage it is anticipated that discharge PA would be used initially with PB developed to allow marine works (dependent on the deep excavation sequence); PC would be the final discharge brought into use for the remainder of construction and would be retained as a permanent discharge point.

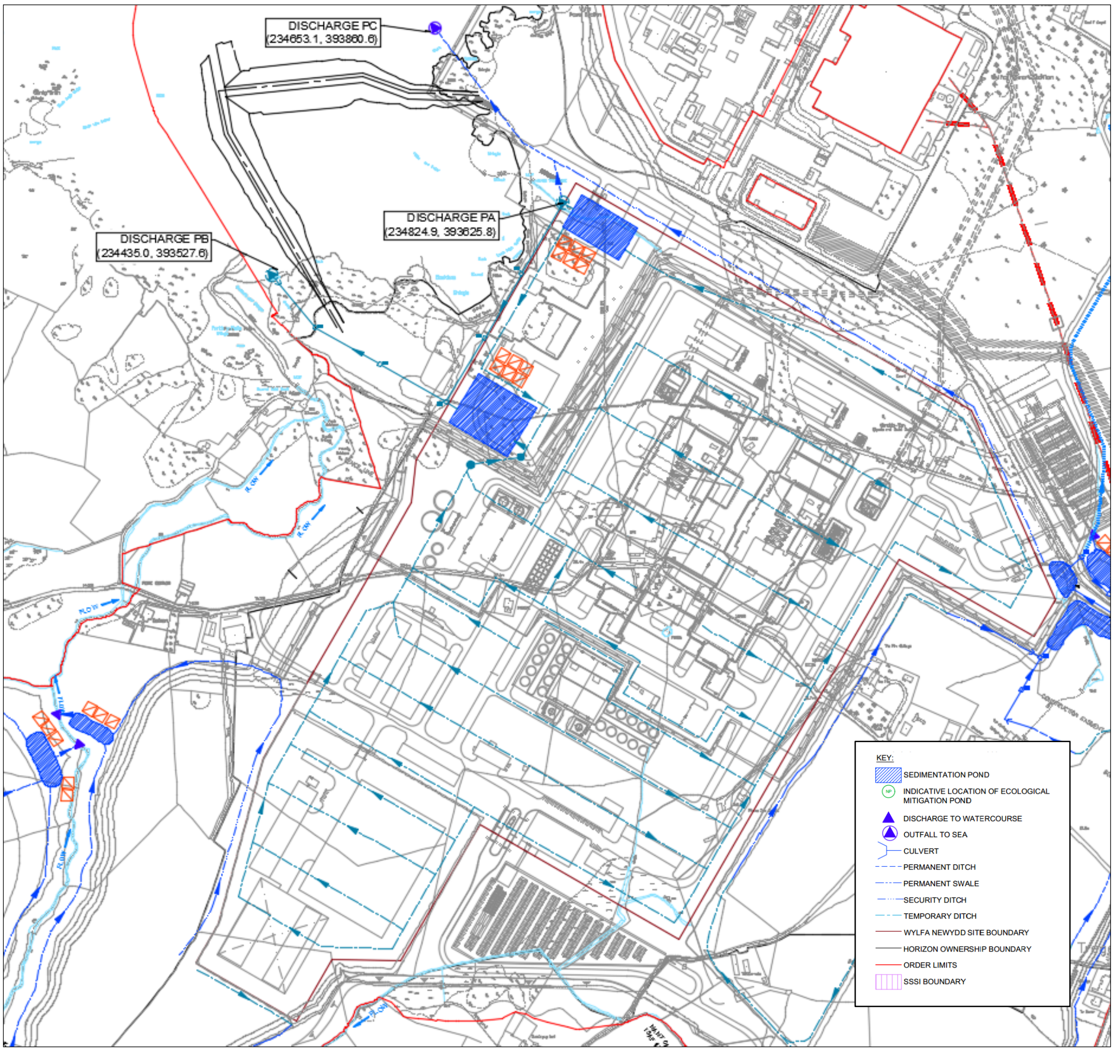

Figure 2-9 Platform Area Location

A summary of discharges from the platform area is provided in table 2-10.

Table 2-10 Platform Area Discharge

Catchment	Power Station
Receiving watercourse (Freshwater/ Coastal)	PA – Existing drainage (Freshwater) PB and PC – Porth-y-pistyll (Coastal)
Grid Reference	PA – 234824.9, 393625.8 PB – 234435.0, 393527.6 PC - 234653.1, 393860.6
Catchment area (ha)	70
Combined inlet rate (30yr return period) (l/s)	N/A
Outlet rate (30yr return period) (l/s)	1174.6
Cumulative volume (m^3/ day) (30yr return period)	16.623.7
Estimated no. of dosing units required	12

Catchment based TSS limit: A preliminary **70mg/l** limit is proposed for this catchment pending output of modelling (Jacobs, 2018).

2.3. Nitrates

Nitrate is a naturally occurring form of nitrogen in soil; the levels of nitrate can be changed through the addition of organic matter. The Construction Phase of the scheme will require existing topsoil from the site to be stripped and temporarily stockpiled and this operation has the potential to release nitrates into the aquatic environment. Aside from any areas treated by hydroseeding, the scheme will not be adding nitrates into the WNDA.

Existing nitrate data from long term water quality monitoring is limited and further ongoing monitoring will be required. Mitigation measures will be confirmed by the detailed design stage however measures to completely restrict livestock from the WNDA during the Construction Phase, localised stockpiling of topsoil (including re-use within the same catchment) and management of runoff will have positive effects on the release of nitrates into the environment.

2.4. Phosphates

Phosphorus is one of the three nutrients generally added to soils in fertilisers. As with nitrates, proposed bulk earthwork operations have the potential to increase the levels of phosphorous within the aquatic environment. Aside from any areas treated by hydroseeding, the scheme will not be adding phosphates into the WNDA.

Existing phosphate data from long term water quality monitoring is limited and further ongoing monitoring will be required. Notwithstanding this the following measures are expected to substantially control the release of phosphates into the environment:

- Control of surface water runoff as outlined in Section 1 of this report.
- Restrictions on livestock within the WNDA during the Construction Phase (preventing them from entering watercourses), however it is noted that there may be some areas where grazing occurs during the Construction Phase (e.g. Wylfa Head, Tre'r Gof SSSI and areas where landscaping is completed early on in the development).

- No application of fertilisers within the WNDA during the Construction Phase.

2.5. Exceedance Events

As discussed, the treatment of TSS will be undertaken using a number of features incorporated into the drainage system to achieve permit limits up to and including the 1 in 2 year return period storm event. The use of features such as silt fences, silt traps and sedimentation ponds will serve to remove the majority of suspended sediments from flow; polyelectrolyte chemical dosing will be undertaken to ensure that fine soil particles are removed to the required level.

A 1 in 2 year return period has been selected for the design event of the dosing units for the following reasons:

1. Risk based: It is anticipated that dosing units will only be required during bulk earthwork operations until vegetation on mounds has become established. As such, the annual probability of a large return period storm (e.g. 1 in 30 year event) being experienced is considered low; the 1 in 2 year event is therefore considered representative of the rainfall event that is likely to be experienced prior to the establishment of the mound vegetation.
2. Available Space: Multiple dosing units will be provided to treat surface water runoff at every proposed outfall from the drainage system. The number of units required has been estimated based on the design event considered. Notwithstanding this there will be limited space within the construction area, adjacent to drainage outfalls and ponds, within which to site a large number of dosing units to treat runoff from higher frequency storm events.
3. Availability and Cost: There are practical limits to the number of units that can be provided. Dosing units are specialised items of equipment and there are expected to be a finite number that are available nationally to serve the project; employing larger numbers treat higher frequency storm events is therefore likely to be impractical and cost prohibitive.
4. Exceedance: On the occasions when the 1 in 2 year return period event is exceeded, the dosing units will continue to operate at their maximum capacity (having been sized to treat the peak 1 in 2 year return period discharge rate) thus limiting the impact on the environment. The drainage system and pond treatments will continue to operate as designed during these periods of exceedance; due to the larger volumes of surface water the dosing units will provide a reduced level of treatment to the flow being discharged at outfalls.

3. Forward Actions

3.1. Water Quality Monitoring

To ensure the drainage design system is functioning as designed it is necessary to undertake regular sampling and monitoring within the identified catchments. It is envisaged that this will be an automated system that retains and adapts, where feasible, the current monitoring regime to suit the detailed design. The following are necessary features of any future monitoring system:

- Continuous water level and turbidity monitoring at all outfall locations as a minimum, upstream monitoring is also recommended, with additional storm event triggered auto-samplers. It is recommended that the system is set up to provide live access to the data.
  - Monthly spot-sampling at the outfall, with corresponding upstream and downstream sampling for a period of one year or up to the start of construction. Data should be reviewed monthly.
  - Monitored water quality parameters should correspond to those currently undertaken, i.e. physio-chemical parameters, nutrients, major ions, and suspended solids.
  - Flow monitoring at the outlet by a V-notch weir, or similar, at all discharge outfalls, at the same frequency as spot sampling water quality monitoring.

3.2. Soil Management

To support the management of surface water runoff, and levels of nitrate and phosphate in the aquatic environment a soil management plan will be developed prior to the commencement of bulk earthwork operations.

4. References

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