

1.0 Introduction

The Greencore site at Boston is seeking to appraise their untreated effluent as a consequence of their production process at the Greencore Boston located Marsh Lane, Boston, PE21 7PJ ('Site').

The effluent is composed of food grade cleaning and disinfectant products used to clean the manufacturing plant as well as residues from the processing of raw materials for preparation of Greencore prepared salads and vegetables. The Trade Effluent Discharge Consent, agreed between the Site and Anglian Water, allows the Site to discharge treated effluent originating from the following processes: i) Clean in Place and general sanitising of factory after the preparation and washing of salads and vegetables, ii) tray washing, iii) boiler blowdown, iv) softener backwash, vi) compressor condensate.

The effluent is discharged to sewer under a Trade Effluent Discharge Consent issued by Anglian Water (Document Reference: TECO-0156-2022). The effluent is treated on Site prior to discharge to sewer and further treatment by Anglian Water at their Boston WwTW. The final receiving water body is the surface waters of the River Haven.

2.0 On-Site Effluent Management

After removal of some solids by filtration (e.g., drain catch pots), process effluent is received in either one of two 25m³ concrete drainage sumps; the low care sump east of the facility or high care sump located on the west.

From the sumps, effluent was pumped through a solids separation screen (2mm) which removes process debris (salads), the debris discharges into dolav collection bins and enters an appropriate waste stream. The two 'screened' effluent streams are then mixed as they enter a 40m³ double skinned polypropylene buffer tank, with cascade aeration. This balance tank provides a method of balancing and homogenising the effluent. Effluent is pumped to drain over a calibrated 'v' notch to measure flow volume. Prior to discharge, the effluent passes through a 4-bottle auto sampler to allow for effluent chemistry monitoring.

The sludge formed is emptied and the treated effluent ultimately discharges to Anglian Water's Boston's Wastewater Treatment works (GR: 52.964541, -0.010042). Following further treatment stages, treated sewage is discharged by Anglian Water into the River Haven under the terms of their environmental permit.

3.0 Screening Assessment Methodology

The aim of this screening assessment is to appraise the potential effect of emissions to water from the permitted facility.

A surface water pollution risk assessment has been undertaken for the Site in accordance with government guidance prepared by both the Environment Agency (EA) and the Department for Environment, Food & Rural Affairs (DEFRA). This surface water pollution risk assessment involves three stages:

- 1) Identification of pollutants released from the plant;

- 2) Gathering of data on pollutants released from plant; and,
- 3) Screening tests on data.

The following section will document the assessment methodology and the associated findings within each of these stages.

4.0 Screening Assessment

The following assessment was conducted on data provided by the Site in relation to their liquid inventory and records of the chemical characteristics of the effluent produced by the Site. The aim of the assessment is to evaluate key potential pollutants within the chemical inventory and effluent to determine whether they pose a potential risk to surface waters upon discharge.

4.1 Identification of Pollutants

EHS was provided with a chemical inventory of liquid products used at the Site, which may have the potential to enter the effluent or may be considered chemical constituents of the effluent itself. This screening stage included the examination of Material Safety Data Sheets (MSDS) to identify priority pollutants as determined by the EA and other substances that exhibit eco-toxicological hazard statements. A summary of potentially toxic constituents is presented in the following list, and further quantified as Table 1.

Table 1: Summary of Ecotoxicological Substances

Product Name	Description	Compounds of Concern	Ecotoxicological Hazard Statement/ Rationale
Perbac	Biocide, acidic process cleaner	Acetic acid (30%)	H410 – Very toxic to aquatic life with long lasting effects.
		Hydrogen peroxide (30%)	
		Peracetic acid (10%)	
Chlorofoam	Detergent	Sodium Hydroxide (10%)	H400 - Very toxic to aquatic life and H412 - Harmful to aquatic life with long lasting effects
		Sodium hypochlorite (5%)	
		Alkyl dimethyl amine oxide (5%)	
		Sodium aryl sulphonate (5%)	
Sodium hypochlorite	Detergent and disinfectant	Sodium hypochlorite solution (16%)	H400 - Very toxic to aquatic life and H411 - Toxic to aquatic life with long lasting effects
Holquat	Disinfectant	EDTA (20%)	H400 - Very toxic to aquatic life H411 - Toxic to aquatic life with long lasting effects Product contains EA freshwater priority substance.
		Alkyl benzyl dimethyl ammonium chloride (10%)	
		Alcohol ethoxylate (5%)	
Causbrite	Detergent	Potassium hydroxide (30%)	H412 - Harmful to aquatic life with long lasting effects

		Alkyl dimethyl amine oxide (5%)	
Chlordet	Detergent	Sodium hydroxide (30%)	H400 - Very toxic to aquatic life and H412 - Harmful to aquatic life with long lasting effects
		Sodium hypochlorite (10%)	
Nipac	Detergent	Nitric acid (60%)	Potentially polluting substance used in a high volume (40 tonnes/year)
		Phosphoric acid (5%)	
TWH	Detergent	Sodium hydroxide (30%)	Potentially polluting substance used in a high volume (17.5 tonnes/year)

The review in Section 4.1 above has identified a schedule of substances that require further evaluation to determine emissions to water. All other chemical constituents have been discounted for further consideration as they are not included on the EA priority substance list and do not register an eco-toxic hazard code on the MSDS, do not contain EA Freshwater Priority Substances, or are not potentially polluting substances that are released in high quantities.

4.2 H1 Screening Test EDTA

The review in Section 4.1 above has identified a schedule of substances that require further evaluation to determine emissions to water. All other chemical constituents have been discounted for further consideration as they are not included on the EA priority substance list, do not register an eco-toxic hazard code on the MSDS, or are not potentially polluting substances used in high volumes.

Of the substances listed in Section 4.1, EHS has identified that EDTA is present within the EA's H1 screening tool and have published Environmental Quality Standards (EQS) to aid the assessment.

The concentration of EDTA within process water was determined using the maximum concentration within Holquat listed on the MSDS (20%); the annual usage figure for Holquat (74 000 kg) and the measured average daily volume of effluent discharged from Site (575 m³/ day).

Test 1

Test 1 identifies whether or not the effluent concentrations are less than 10% of the EQS. The output of Test 1 is presented within Figure 1 below. As shown below in Figure 4.1, concentration of EDTA discharged to surface water was found to exceed 10% of the EQS and therefore failed Test 1.

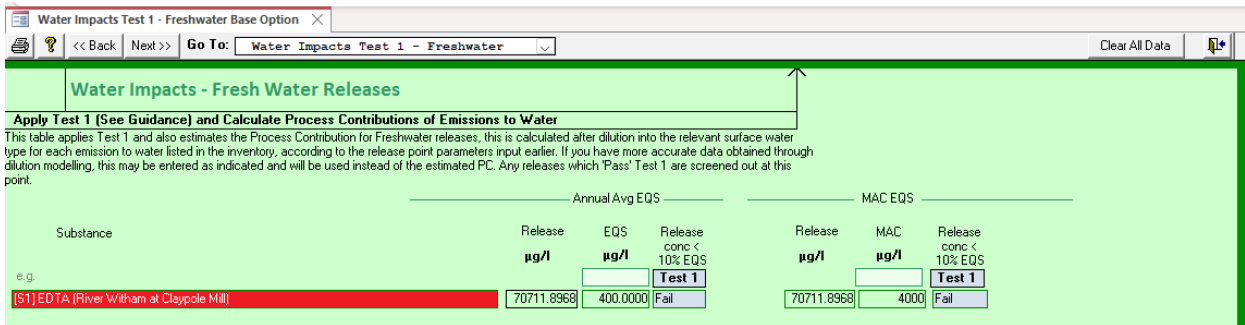


Figure 4.1: Output from H1 Screening Assessment Test 1

Test 2

This test introduces the dilution available in the receiving water in order to determine whether the process contribution (PC) of EDTA to the receiving water is greater than 4% of the EQS. The dilution factor specified for use in the H1 tool is the 95% Exceedance (Q95)

Due to an absence of publicly available flow data from the River Haven, a request for appropriate data was made to the EA (enquiries@environment-agency.gov.uk) on the 17th of November 2022. The EA were unable to provide data for the Haven and suggested treating the discharge as estuarine. As the Boston WwTW is discharging to the low water channel in the upper parts of an estuary where the water is mainly fresh, Tests 2 onwards follows the freshwater methodology. The most appropriate upstream data was identified as the River Witham at Claypole Mill; Q95 flow rate is 0.385m³/s [https://nrfa.ceh.ac.uk/data/station/meanflow/30001]. This flow rate is far lower than that of the Haven. Therefore, the dilution effect used here is a significantly less than the true dilution occurring in the Haven.

Nevertheless, the calculated annual average emission calculated 162.31% PC of the EQS value. As this is more than 4% Test 2 was 'Fail'. Test 2 is presented within Figure 4.2 below.

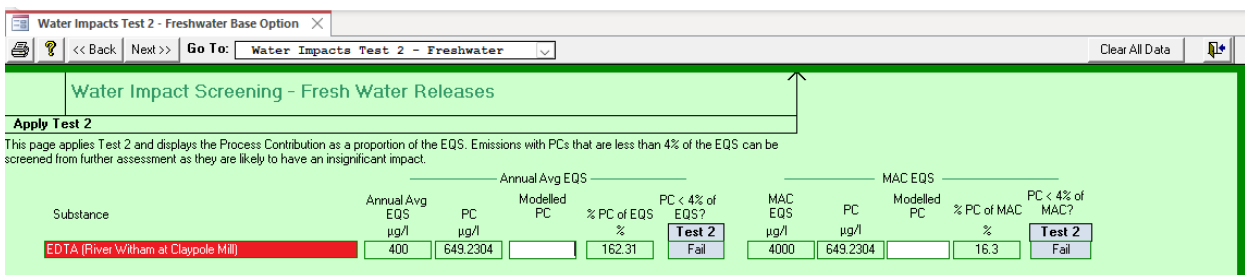


Figure 4.2: Output from H1 Screening Assessment Test 2

Tests 3, 4a and 4b

These tests use the supplied previously supplied data, and in the absence of measured data follow the EA’s guidance on SWRA to assume the Background Concentration (BC) of EDTA in the River Witham is 50% of the EQS value (200 µg/l), to calculate Predicted Environmental Concentrations (PEC) in relation to BC. As can be seen in Figure 4.3 below, as Tests 3 and 4a were 'Fail', while Test 4b was 'Pass'.

Number	Substance	Bkgnd Conc. µg/l	Annual Avg EQS				MAC EQS					
			PC	PEC	(PEC - BC)/EQS	PEC - BC >10% AA EQS	% PEC of EQS	PEC >100% AA EQS	PC	PEC	% PEC of MAC	PEC >100% MAC
1	EDTA (River Witham at Claypole Mill)	200	649	849	162.3%	Fail	212	Fail	649	849	21.3	Pass

Figure 1: Output from H1 Screening Assessment Test 3, Test 4a and Test 4b

As the substance analysed did not pass all of Tests 3, 4a and 4b within the EA's test of insignificance, the emission of EDTA from the Boston Site to the River Haven could not be screened out. However, it is important to note that due to inaccurate river flow data the dilution factor is significantly underestimated.

Furthermore, this assessment is based on the 'worst case' assumptions that firstly, 100% of the EDTA used on Site enters the site drainage system and that, secondly, none of this released EDTA is removed via effluent treatment at the Boston Site.

While the emission of EDTA can not be screened as insignificant through the H1 tool, once all mitigating factors and inaccuracies are considered, it is unlikely that the site's emission of EDTA will have a significant detrimental impact on the receiving water quality.

4.3 Screening Tests of Other Potential Pollutants

The remaining constituents of concern identified during the initial screening of the chemical inventory are screened within this section. These potential pollutants do not have EQS screening values as either freshwater priority or priority pollutants under the EA guidance. They do not feature within the H1 screening tool.

However, for completeness these compounds have been assessed in accordance with the EA methodology to determine the potential effect of these emissions to water.

The chemicals are as follows:

- Sodium Hypochlorite
- Sodium Hydroxide
- Acetic acid
- Hydrogen peroxide
- Peracetic acid
- Potassium hydroxide
- Amines, C12-14 alkyl dimethyl, N-oxides
- Sodium aryl sulphonate (SAS)
- Phosphoric acid
- Nitric acid

4.3.1 Methodology

In order to appraise the emission rates, EHS evaluated the chemical inventory to determine annual product use and concentration to estimate the mass of each chemical constituent of concern that may be emitted to water. The assessment methodology has used worst case inventory values to be conservative.

The mass of each constituent of concern was calculated via either direct measurement from effluent monitoring data or evaluating the mass of the chemical constituent within the chemical inventory. This data was derived from the MSDS. Where a concentration range was provided, EHS has used the highest potential concentration to ensure a precautionary approach. The emission rate was then calculated using the measured average daily volume of effluent discharged from Site (575 m³/ day).

Effluent is discharged to sewer under Trade Effluent Discharge Consent with Anglian Water (TECO-0156-2022). It is understood that effluent discharges to Anglian Water Boston's Wastewater Treatment works (GR: 52.964541, -0.010042). Following further treatment stages, treated sewage is discharged by Anglian Water into the River Nene under the terms of their environmental permit. As such, 'Sewage Treatment Reduction Factors' (STRF) are considered for each constituent of concern as the additional treatment step may result in further reduction of chemicals within the discharge.

It is understood that the Boston WwTW comprises various stages of treatment including screening to remove large and fine items of debris within the wastewater stream. The treatment process uses filters and activated sludge treatments to treat wastewater prior to discharge to the River Haven.

On this basis, EHS has applied sewage reduction factors (STRF) to the relevant compounds being assessed to appraise reductions of concentrations as a consequence of the wastewater treatment works stage prior to discharge. The STRF applied are those published by the EA for an activated sludge plant. The STRF calculation is as follows. The total predicted releases are presented in Table 2 below.

$$(3.1) \text{ Concentration of component discharged} = \text{emission rate} \times \text{STRF}$$

See Table 2 for a summary of these calculations.

Table 2: Summary of Emission Rates and Sewage Treatment Reduction Factors

Constituent of Concern	Emission Rate [mg/l]	Sewage Treatment Reduction Factor (STRF)	Total release concentration to freshwater [mg/l] = Emission Rate*RF
EDTA	71	0.63	44.55
Sodium Hypochlorite	38.34	0	0.00
Sodium Hydroxide	254.91	0	0.00
Acetic acid	32.81	0	0.00
Hydrogen peroxide	32.81	0	0.00
Peracetic acid	10.94	0	0.00
Potassium hydroxide	0.03	0	0.00

Amines, C12-14 alkyl dimethyl, N-oxides	37.38	0.04	1.50
Sodium aryl sulphonate (SAS)	2.02	0.01	0.02
Phosphoric acid	9.56	0	0.00
Alcohol Ethoxylate	18	0.01	0.18
Nitric acid	115	0	0.00

EHS note that published sewage reduction factors are not available for all the constituents of concern. As such, a qualitative assessment has been made.

Firstly, there are a number of acids and alkalis found within food grade cleaning chemicals including sodium hydroxide, sodium hypochlorite, hydrogen peroxide and various acids. Greencore consider that these compounds have a short lifespan, and their pollution potential is likely to be mitigated through reaction during the cleaning processes, neutralisation through in line dosing, and balancing at the permitted facility. Furthermore, due to the instability and highly reactive nature of these substances, they will disappear very rapidly during activated sludge treatment at the Boston WwTW.

There are no published STRF values for these chemicals, but their behaviour would result in a high likelihood of complete removal. As such, Greencore therefore consider that no significant emissions would occur beyond the wastewater treatment works. As such, these compounds are not considered to present a significant risk to the water environment and have therefore been discounted from further assessment.

Amines and associated compounds are former derivatives of ammonia found within food grade cleaning chemicals used at the Site. They are typically reactive with acids and may therefore neutralise in contact with acidic cleaning products and / or pH correction at the effluent treatment plant. It is considered that they would be unlikely to be detectable within emissions to water. Peer reviewed studies have demonstrated removal rates within industrial wastewater of at least 96 %^[1].

Sodium aryl sulphates (SAS) are water-soluble salts that can be used in detergents, dish washing liquids, shower gels, shampoos, hair conditioners and fabric softeners. They are toxic for freshwater fish, however, do not concentrate in the food chain. Branched alkenes are resistant to degradation by bacteria and hence linear alkyl sulfonates are used in detergents. A peer reviewed assessment by HERA in 2005 stated 'SAS is removed readily in sewage treatment plants mostly by biodegradation (ca. 83%) and by sorption to sewage sludge (ca. 16%). Only around 1% of the mass load from sewage is discharged into surface water and readily biodegraded in river as well^[2]. Based on the high removal rates of Amines and SAS, and the relatively low emission rates from Site, the Site's emissions of neither are considered to present significant risk to freshwater environments.

Alcohol ethoxylates (AE) are a common non-ionic surfactant employed in consumer and industrial detergents worldwide. Commercial AE are typically complex mixtures composed of > 100 homologous compounds with varying alkyl chain lengths and varying numbers of ethylene oxide (EO) units. A recent study of AE removal rates in several types of sewage treatment works determined that all AE homologues are effectively removed (>99%) in the most common treatment types.^[3]

The detergent products within the effluent do not have a STRF or EQS value and further assessment under the EA methodology is not possible. Further consultation is recommended with the EA to determine whether they have concerns relating to these food grade detergent products and whether modelling or monitoring would be required.

5.0 Findings and Conclusions

The permitted facility generates effluent wastewater as a by-product of the salad production process. This effluent comprises production wastewater following cleaning and processing works and contains a predominance of cleaning water and residual food grade cleaning chemicals used during the Site processes. The effluent is treated on Site prior to discharge to sewer and further treatment by Anglian Water at their Boston WwTW. The final receiving water body is the surface waters of the River Haven.

Of the chemical inventory reviewed only EDTA has published STRF and EQS values. As the substance analysed did not pass all of Tests 3, 4a and 4b within the EA's test of insignificance, the emission of EDTA from the Boston Site to the River Haven could not be screened out. However, once all mitigating factors and inaccuracies are considered, it is unlikely that the site's emission of EDTA will have a significant detrimental impact on the receiving water quality.

The remaining chemical constituents do not feature on the EA priority substance or freshwater EQS schedule. Greencore has performed a qualitative risk appraisal of those compounds to appraise potential risks. This assessment has concluded that the food grade cleaning product's (i.e., acids, alkali, amines) pollution potential would be readily mitigated through on-Site processing and effluent treatment, and further removed at the Boston WwTW via reaction with organic substances during filtration and sludge treatments.

The detergent products within the effluent do not have a STRF or EQS value and further assessment under the EA methodology is not possible. Further consultation is recommended with the EA to determine whether they have concerns relating to these food grade detergent products and whether modelling or monitoring would be required. This assessment and evidence from relevant peer-reviewed literature leads EHS to the conclusion that effluent does not pose a significant threat to the environmental quality of the River Haven

References:

^[1] Sanderson, H., Tibazarwa, C., Greggs, W., Versteeg, D.J., Kasai, Y., Stanton, K. and Sedlak, R.I., 2009. High production volume chemical amine oxides [C8–C20] category environmental risk assessment. *Risk Analysis: An International Journal*, 29(6), pp.857-867.

^[2] HERA., 2005. Human & Environmental Risk Assessment on ingredients of household cleaning products - Secondary Alkane Sulfonate (SAS).

^[3] Morrall, S.W., Dunphy, J.C., Cano, M.L., Evans, A., McAvoy, D.C., Price, B.P. and Eckhoff, W.S., 2006. Removal and environmental exposure of alcohol ethoxylates in US sewage treatment. *Ecotoxicology and environmental safety*, 64(1), pp.3-13.