

# The London Resort Development Consent Order

BC080001

**Environmental Statement** 

Volume 2: Appendices

## Appendix 18.11 – Peninsula Annual Report

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December 2020

Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 Regulation 5(2)(a)

The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 Regulation 12(1)

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Waste, Environment, Management

Swanscombe Landfills: South Pit Phase 3 Landfill South Pit & Surge Pile Landfill

**Annual Report 2019** 

SWANSCOMBE DEVELOPMENT LLP CMS Enviro

Hydrogeological consultancy has been provided by NSugg Ltd

2019 Annual Report for South Pit Phase 3 and South Pit Surge Pile Landfill(s) has been produced by CMS-Enviro, on behalf of LCR Ltd, in compliance with condition 4.2.2 of the Permit.

## Swanscombe Landfill(s) Site – Annual Report Document Control

Date	Detail	Initials	Approval
03.01.2019	Document review/LFG summary	RVT	RVT
06.01.2020	Hydrogeology review	NS	RVT
17.01.2020	RVT/BT technical review and LFG, executive summary, conclusions sections	RVT/BT	PC
27.01.2020	RVT/BT Review and submission draft to client	RVT/BT	RVT
31.01.2020	Submit to EA via drop box	RVT	PC

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Status log of the permit Description	Date	Comments
Permit determined as P/1/11A	14/06/1977	Original permit issued to the Associated Portland Cement Manufacturers Ltd
Modification issued	21/02/1984	Change of company name from the Associated Portland Cement Manufacturers Ltd to Blue Circle Industries Plc
Modification issued	01/06/1992	Condition 26 added – Environment Management Plan
Modification issued	27/11/1992	Condition 4 amended – Waste quantities for deposit: 900te of flue dust 100te of non-toxic and inert waste
Variation issued EAWML19373	05/05/1994	Condition 26.8 amended Conditions added: 27, 28,29
Closure Notice CN1	20/12/2005	Closure notice issued
Permit transfer EPR/KP3998HW/T001	08/11/2007	From: Blue Circle Industries Plc To: Lafarge Cement UK Plc (EAWML19373)
Closure Notice CN2	08/12/2008	Closure Notice
Notified of change of company name EPR/KP3998HW/V002	12/07/2012	Name changed to Lafarge Cement UK LIMITED
Variation issued EPR/KP3998HW/V002	30/07/2013	Varied permit issued to Lafarge Tarmac Cement UK LIMITED
Application for variation EPR/KP3998HW/V003 to change company name and registered office address	Duly made 23/09/2013	Name changed to Lafarge Tarmac Cement & Lime Limited
Variation issued EPR/KP3998HW/V003	22/11/2013	Varied permit issued to Lafarge Tarmac Cement and Lime LIMITED
Application for variation EPR/KP3998HW/V004 to change company name	Duly made 04/09/2015	Name changed to Tarmac Cement and Lime LIMITED
Variation issued EPR/KP3998HW/V004	19/10/2015	Varied permit issued to Tarmac Cement and Lime LIMITED
Application EPR/EB3802FX/T001 (full transfer of permit EPR/KP3998HW)	Duly made 14/11/2016	Application to transfer the permit in full to Swanscombe Development LLP
Transfer determined EPR/EB3802FX/T001	09/01/2017	Full transfer of permit complete
Notified of change of company details	07/03/2017	Registered office address changed to: Barton Hall, Copt Oak Road, Markfield LE67 9PJ
Variation issued EPR/EB3802FX/V002	20/03/2017	Varied permit issued to Swanscombe Development LLP
Definitely closed status confirmed	20/12/2016	CAR 19373/0276376 EA initiated permit variation to be issued

South Pit Phase 3 Permit number EPR/CP3238YX Status log of the permit						
Description	Date	Comments				
Application EPR/RP3039SZ/A001	Duly made 29/11/04	Received 10/11/04				
Permit determined EPR/RP3039SZ	04/11/05	Original permit issued to Lafarge Cement UK				
		PLC.				

Environment Agency Initiated Variation EPR/RP3039SZ/V002 Billing Ref: CP3433MC	Issued 29/02/08	
Variation application EPR/RP3039SZ/V003 Billing Ref: BP3033GY	Duly made 02/03/09	
Variation determined EPR/RP3039SZ	15/06/09	Change in the annual permitted tonnage from 10,000 to 40,000 and inclusion of revised monitoring trigger level.
Variation application EPR/RP3039SZ/V004	Duly made 12/07/12	Name changed to Lafarge Cement UK Limited.
Variation determined EPR/RP3039SZ	30/07/12	Varied permit issued to Lafarge Cement UK Limited.
Variation application EPR/RP3039SZ/V005	Duly made 23/09/13	Name changed to Lafarge Tarmac Cement and Lime Limited.
Variation determined EPR/RP3039SZ	22/11/13	Varied permit issued to Lafarge Tarmac Cement and Lime Limited.
Environment Agency Landfill Sector Review 2014 Permit reviewed Variation determined EPR/RP3039SZ/V006 Permit issued EPR/RP3039SZ	28/05/14	Varied and consolidated permit issued in modern condition format. Also incorporates an administrative application to reduce the annual tonnage of hazardous waste to zero but allow 9,400 tonnes per annum for restoration. Received 07/03/14.
Variation application EPR/RP3039SZ/V007 (variation and consolidation	Duly made 21/04/15	Application to add a leachate treatment activity, amend leachate assessment levels and groundwater monitoring points.  This application also incorporates an additional administrative application to change the operator name from Lafarge Tarmac Cement and Lime Limited. Received 04/09/15.
Additional Information – Response to Schedule 5 dated 01/07/15	Received 30/07/15	Additional details on the conceptual model, details of borehole EW7/14.
Additional Information – Response to Schedule 5 dated 29/07/15	Received 06/08/15	Detail of the design leachate treatment plant and leachate treatment.
Variation determined EPR/RP3039SZ/V007 Billing Ref: DP3234AQ	16/11/15	Varied and consolidated permit issued in modern condition format to Tarmac Cement and Lime Limited.
Application EPR/CP3238YX/T001 (full transfer of permit EPR/RP3039SZ)	Duly made 05/04/17	Application to transfer the permit in full to Swanscombe Development LLP.
Transfer and Environment Agency variation determined EPR/CP3238YX Billing Ref: CP3238YX	26/06/17	Full transfer and Environment Agency initiated variation

## 1. Executive Summary

This **2019 AMR** combines results of environmental monitoring undertaken at both **South Pit Phase 3** landfill and **South Pit and Surge landfill** into one document; fulfilling the requirement of Southpit phase 3 Permit EPR/RP3039SZ/V007 condition 4.2.2 and Southpit and Surge Pile EPR/KP3998HW Closure Report Issue 1 Rev A FINAL Nov 2016. Both landfill Sites are located on the Swanscombe Peninsula and share an identical environmental setting and deposited waste type, cement kiln dust which is outlined in the **EMP Volume 1 – Background information and Risk Assessment.** 

Monitoring suites and compliance parameters are different due to the Permitting regime they are regulated by, but sufficient similarities exist to make one document the preferred option.

The 2018 Annual Monitoring Report (AMR) for South Pit Phase 3 landfill concluded that the Site was in compliance with Permit Limits and work was continuing to commission the Leachate Treatment Plant (LTP). South Pit and Surge Landfill was confirmed as definitely closed in December 2016 and the requirements of the Environmental Management Plan/Closure Report (EMP/CR) have been fully implemented in 2017. The Hydrogeological Risk Assessment (HRA) Review carried out in June 2017 for South Pit Phase 3 landfill recommended assessment levels for a number of key parameters at SSW2 and EW5/14 and EW6/14; these have been implemented into CMS Reporting system.

Surface water remains consistent with previous years. Low rainfall and low flow in the surface water courses during 2019 have prevented sampling on a number of occasions at a number of points, including those introduced in 2017 following acceptance of the EMP/CR. Low rainfall and low flow conditions prevented samples being taken from some points on all monitoring occasions and some samples are concluded to be non-representative with little or no flow.

Leachate levels remained compliant throughout 2019 for both landfill units. Leachate quality is typical of a CKD waste leachate with elevated pH and high concentrations of potassium, chloride and sulphate. Leachate treatment is required for leachate collected in the perimeter drain at South Pit Phase 3 and is fully commissioned, closing IC8 of Table S1.3. For South Pit Phase 3 landfill the HRA, and its subsequent review in 2017, concluded that a leachate level compliance limit of 2.5m above the local groundwater level was appropriate. The revised mechanism for calculating leachate compliance has confirmed that leachate levels did not rise above this limit in 2019. For South Pit and Surge Pile landfill the leachate compliance limit is set at 4mAOD and this was not exceeded in 2019.

Groundwater quality beneath South Pit and Surge Pile and Phase 3 landfill in 2019 remained comparable to previous years with evidence of impact from saline intrusion at down-gradient boreholes.

Landfill gas (LFG) monitoring has continued at the in-waste points for both landfills and the results confirm that LFG is not an issue for either Site. LFG production is inhibited by the high pH and low carbon content of the CKD wastes. Monitoring of trace gas concentrations is carried out annually at South Pit Phase 3 landfill, in accordance with Permit conditions.

A leachate treatment plant (LTP) on South Pit Phase 3 has been constructed and collects leachate from the perimeter drain. A Construction Quality Assurance (CQA) Report was submitted in July 2017. The plant has had some minor issues throughout 2018 leading to the plant sporadically discharging in this reporting year. Since November 2018 the plant has been running automatically, working on leachate levels and treating as appropriate.

## 1.2 Limitations of the Review and Notable Restrictions to Monitoring

CMS-Enviro carry out the monitoring, collate and assess field and laboratory data for operational response and regulatory reporting. If it has not been possible to obtain a sample the reason is shown in table below. Laboratory results are provided by DETS and survey data is provided by JC White Geomatics Ltd.

Notable Restrictions to Monitoring 2019					
Point/Date	Comment				
Leachate	South Pit Phase 3 – samples taken annually no sample for IW3BR/14 or IW3CR/14 insufficient leachate. No hazardous substance analysis for these points.  South Pit & Surge Pile – IW1BR/14 no sample in March – insufficient leachate level. IW1CR/14 no sample in March, September or November				

	due to insufficient leachate. No hazardous substance analysis for these points.
Surface Water	SSW1 – no samples July, September – no flow SSW2 – no samples July - no flow SSW3 – no samples July - no flow SSW4 – no samples January, July, September - no flow SSW5 – no samples March, May, June, July, August, September SSW6 – no samples June, July, August, September
	SSW7 – no sample May, September
LTP	Discharge samples taken weekly if the LTP is discharging; not achieved 22 <sup>nd</sup> Jan, 26 <sup>th</sup> March, 1 <sup>st</sup> April, 10 <sup>th</sup> April, 30 <sup>th</sup> April to 6 <sup>th</sup> June, 8 <sup>th</sup> , 22 <sup>nd</sup> and 28 <sup>th</sup> August, 5 <sup>th</sup> 12 <sup>th</sup> , 25 <sup>th</sup> and 30 <sup>th</sup> September, 11 <sup>th</sup> November 2019.

#### 2 Site Characteristics

#### 2.1 Site Location

The landfills are located within the Swanscombe Peninsula, near Dartford, Kent, which sits on the south bank of the River Thames. The Sites are accessed from the A226 in Swanscombe via an internal road network.

Entry to the internal road network is via a manned security unit and all visits are recorded. A robust metal barrier further minimises unauthorised entry to the Site access road and is kept locked when access is not required. A series of padlocked gates control entry to the landfill areas preventing unauthorised access from the public footpath that transects the two landfills. Security guards and dog patrols regularly visit the access roads and all areas of Swanscombe Peninsula.

## 2.2 Installation Details

The South Pit Landfill complex is constructed upon reclaimed marshland on the Swanscombe Peninsula, Kent. The peninsula is surrounded towards the north, from the east side to the west side, by the River Thames, while to the south the area is bordered by the towns of Swanscombe, Northfleet and Greenhithe. The peninsula is protected by a river wall embankment, which has a maximum elevation of 6 – 7mAOD, and is intersected by drainage channels across the area. The peninsula includes areas of marshland, waste disposal Sites, redundant industrial infrastructure and a Port of London Authority radar station, accessed by a network of tracks and footpaths.

The original South Pit and Surge Pile landfill Site was developed in **three phases**, **Phase 1**, **Phase 2** and **Phase 3**. **South Pit Phase 3** has been re-Permitted and now operates in accordance with an environmental Permit, as described in **Section 2.2.3** below. **Phase 1** and **Phase 2** are regulated by the South Pit and Surge Pile Landfill Permit, details given in **section 3** below,

**Phase 3** was constructed on the low-lying marshland with an average ground level of just 4 to 5maOD. The area of the Site is approximately 7.9 hectares and the landraise extends to a maximum of 11 -13 mAOD. The Swanscombe Main Drain, which is classified as a main river, flows in a northerly direction adjacent to the western boundary of **Phase 3**. The original marsh drainage network located beneath the waste was infilled before landfill operations began. The Swanscombe Main Drain and marsh ditches meet at a point on the north west corner of **Phase 3** and flow through a culvert to a penstock valve and tidal flap discharge to the River Thames.

Phase 2, waste operations have not taken place on Phase 2 and this remains as an area of marshland. Phase 2 remains within the South Pit & Surge Pile Landfill boundary but is not considered within this Report.

Phase 1 is located to the west of South Pit Phase 3 landfill and is an infilled clay quarry with CKD waste surcharged above. The footprint of this area is approximately 7.5ha with a maximum height of 11 – 12 mAOD. A surface water drainage ditch is located on the eastern boundary and runs parallel to the Swanscombe Main Drain. This enters a pond which discharges to the Swanscombe Main Drain and ultimately the River Thames as described above.

Drawing LTCLLtd.EMP\_CR.3 – November 2016 shows the location of each phase and the Permit boundaries (Permit holder name and Permit references are to be updated).

## 2.3 Geology

Regional geology is shown on **BGS Geological Map 271 Dartford**. This indicates that the sequence of geology at the Site is as follows: Head and Coombe Deposits (Thanet Sands) above; Upper Chalk dipping gently to the south east. The area surrounding South Pit has been extensively used for chalk extraction and Site investigations around the margins of the waste have confirmed a variable thickness of Thanet Sand above the underlying Chalk.

Local geology, from Site investigations confirm that the geology of the Site consists of superficial deposits in the form of Pleistocene and recent Alluvium overlying Terrace Gravels which in turn overlies Cretaceous Upper Chalk. The Alluvium is overlain by Made Ground, which includes CKD waste.

The Alluvium comprises soft to very soft greenish grey organic clays with peat layers and occasional deposits of fine silty sand and gravel in the order of 5 to 13.5 metres thick.

The Terrace Gravels are described as medium dense to dense grey or brown sandy to coarse angular to rounded flint gravel with occasional cobbles. The Upper Chalk is described regionally as soft micro porous fissured limestone containing tabular and nodular flints. However, the Chalk encountered beneath the Site is described as moderately weathered weak with medium density and closely spaced fractures.

#### 2.4 Hydrogeology

The Landfills are underlain by Alluvium, which comprises predominantly clays and peats. The superficial deposits have been classified by the Environment Agency as a Secondary Aquifer (undifferentiated) which combines both former minor aquifer and non-aquifer properties. It is thought that this refers to the Alluvium (former non-aquifer) and the underlying Terrace Gravels (former minor aquifer). The Chalk (principal aquifer) underlies the Terrace Gravels. The Terrace Gravels and Chalk are hydraulically connected with each other and with the River Thames. Groundwater within the Terrace Gravels / Chalk aquifer is confined by the overlying, low permeability Alluvium. Previous Site investigations for the railway construction and the landfill boreholes indicate that any limited groundwater in the Alluvium is perched and possibly isolated in discrete horizons which are not laterally continuous.

Groundwater flow in the Chalk/Terrace Gravels is generally north / north-east towards the River Thames but is tidally influenced.

The Alluvium has a low permeability which limits potential downward migration of leachate. Swanscombe Peninsula has been defined by the Environment Agency as being within groundwater **Source Protection Zone 3 (SPZ3)** – Source Catchment Protection Zone for abstractions to the south/south-east. However, it is noted that background groundwater quality beneath the Site is poor suggesting saline intrusion and the inferred groundwater flow direction is away from the abstractions towards the River Thames.

#### 2.5 Local Hydrology

The River Thames is directly hydraulically connected to the Terrace Gravels and the Chalk. The ditches and minor surface water courses that surround the landfills are not considered to be hydraulically connected with the underlying aquifers due to the presence of a significant thickness of low permeability alluvial peat and clays. According to the Environment Agency Flood Map the whole peninsula has been designated as being within a flood risk area but benefits from sea or river defences.

Surface water drainage over the Swanscombe Peninsula is via a network of ditches across the marshes. The ditches discharge to a piped culvert in the northern-most corner of the Site adjacent to the sea wall. Water levels in these ditches are controlled by a variety of inputs and outflows and are not influenced by landfill activities.

**CAR RP3039SZ/0273906** issued 28<sup>th</sup> December 2016 required an action plan to be submitted by 20<sup>th</sup> February 2017 (submission date amended by agreement to 31<sup>st</sup> March 2017) to assess surface water quality and remediation proposals. The action plan was submitted and upon transfer of the Permit the requirement to carry out the works has been incorporated into the Permit, **Table S1.3 Improvement Programme Requirements (IC9).** This work relies on the ability to carry out clearance to Swansombe Main Drain which is a main river and, as such, requires a Flood Risk Assessment Permit which was issued in 2019. No works have yet been carried out and a revised completion date of 31 December 2020 is now agreed via CAR issues January 2020.

## 2.6 Conceptual Site Model

Table below presents the hydrogeological conceptual site model for Southpit Landfills and summarises the potential source-pathway-receptor.

Potential Ro	eceptor at Risk	Contaminant Source	Pote	Potential Pathway			Monitoring Priority	
Description	Vulnerability	Mechanism	Description	Travel Time	Mitigation	Measurements	Locations	Risk
Groundwater below and down-gradient of the Site	Low - local geology is Alluvium above confined Terrace Gravels and Chalk. Quality poor due to saline intrusion from tidal River Thames.	Leachate – leachate generated by infiltration through CKD waste. Characterised by high pH, potassium, chloride and sulphate concentrations.	Vertical flow through 5m to 12m of low permeability Alluvium beneath the Site to the underlying confined Terrace Gravels / Chalk aquifer. An outward hydraulic gradient exists from the Site to the aquifer and groundwater flow within the aquifer is towards the north, discharging to the River Thames.	Slow due to thickness of low permeability Alluvium	Dilution, degradation, retardation	Groundwater quality	South Pit Phase 3 - Boreholes G11 and EW7/14 on the down-gradient boundary South Pit & Surge Pile – EW5R/14 and EW6/14 on the down gradient boundary	Medium
Surface water - Swanscombe Main Drain, marsh drainage ditches	Medium – the landfill Sites have been developed in close proximity to the surface water courses.	Leachate –leachate generated by infiltration through CKD. Characterised by high pH, potassium, chloride and sulphate concentrations.	South Pit Phase 3 - Lateral seepage of leachate at the landfill surface around the perimeter of the landfill.  South Pit & Surge Pile – lateral seepages not noted	South Pit Phase 3 Rapid, in heavy rainfall conditions due to short pathway lengths and proximity of surface water course.	South Pit Phase 3 - a leachate collection drain to intercept perimeter seepages.	Surface water quality	South Pit Phase 3- SSW2 at confluence of Swanscombe main Drain downstream of Phase 3.  South Pit & Surge Pile – SSW6 Swanscombe Main Drain downstream of Phase 1 but upstream of Phase 3.	High
Atmosphere – surface emission of landfill gas	Low – significant volume of LFG not generated due to nature of waste.	LFG – characterised by elevated methane.	Emission of LFG via cracks and discontinuities in the surface and sides of the landfills.	NA	Non-required as LFG production inhibited by high pH and low carbon content of the waste	LFG quality at in waste points.	South Pit Phase 3 - IW3AR/14; IW3BR/14 & IW3CR/14 South Pit & Surge Pile - IW1AR/14, IW1BR/14 & IW1CR/14	Low

## 3 Permit & Closure Report Requirements

#### 3.1 Introduction

South Pit Phase 3 Landfill, **Condition 3.5 and Schedule 3 Tables S3.1 to S3.9** of the Permit detail the monitoring currently required.

Monitoring locations are shown drawings Reference: LTCCLLtd.MEPP 1-January 2017

South Pit and Surge Pile Landfill EMP/CR Section 5 details the monitoring regime currently required.

Monitoring locations are shown on drawing reference LTCLLtd.EMP\_CR.3 -November 2016

## 3.2 Leachate

#### 3.2.1 South Pit & Surge Pile EMP/CR Requirements

Leachate level and quality samples are taken at three Leachate/LFG combined chambers for the suite and frequency shown in table EMP/CR Table 12.

## 3.2.2 South Pit Phase 3 Landfill Permit Requirements

Leachate level and quality samples are taken at three Leachate/LFG combined chambers for the suite and frequency shown in Permit table S3.7

#### 3.2.3 South Pit Phase 3 Landfill Leachate Treatment Plant (LTP) Requirements

The Leachate Treatment Plant (LTP) was installed in 2014/2015 and commissioning /CQA Report submitted in March 2017. The Permit process monitoring requirements are shown in Permit Table S3.9.

## 3.2.4 Leachate Compliance Limits

		k Surge Pile Table 13		South Pit Phase 3 Table S3.1			
Monitoring Point	Frequency	Assessment Level	Compliance Limit	Monitoring Point	Frequency	Compliance Limit	
IW1AR/14 IW1BR/14 IW1CR/14	Quarterly	3.0mAOD	4.0mAOD	IW3AR/14 IW3BR/14 IW3CR/14	Monthly	2.5m above the average (arithmetic mean) groundwater potentiometric level calculated from boreholes G11 and EW7/14 as per NS_0111_39_FINAL 7 CMS-Enviro, South Pit Phase 3 Landfill — Schedule 5 Response July 2015	

## 3.3 Groundwater

#### 3.3.1 South Pit & Surge Pile EMP/CR Requirements

There are four groundwater monitoring points, three are routinely monitored for level and quality, and one for level only, shown in EMP/CR table 18.

## 3.3.2 South Pit Phase 3 Landfill Permit Requirements

There are 4 monitoring points SA5944 and G13 upgradient and G11 and EW7/14 downgradient. All are routinely monitored as shown in Permit Table S3.5.

## 3.3.3 Groundwater Compliance Limits

South P	South Pit & Surge Pile EMP/CR Table 20					South Pit Phase 3 Table S3.3			
Monitorin g Point	Frequency	Control Level C		Proposed Compliance Limit	Monitoring Point	Frequency	Compliance Limit		
			0.7	9		erly		G11	EW7/14
		рН	8.7				Cr(total)	0.007mg/l	0.050mg/l
EW5R/14	terly	Alkalinity	725mg/l	854mg/l	G11 9 9 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		K (total)	201mg/l	311mg/l
EW6/14	Quarterly	К	200mg/l	380mg/l		Quart	Sulphate	770mg/l	842mg/l
	Se (filtered)	n/a	0.02mg/l						
		As (filtered)	n/a	0.01mg/l			Se (total)	0.32mg/l	0.166mg/l

EW5/14 and EW6/14 have interim compliance limits due to lack of background data for arsenic with review after 12 months of monitoring. These remain in place until ditch works completed to enable the review to be incorporated into the SSW6 compliance limits review, at one time.

#### 3.4 Surface Water

#### 3.4.1 South Pit & Surge Pile EMP/CR Requirements

There are four surface water monitoring points; The locations are described in EMP/CR Table 16.

CMS sample ALL surface waters on a monthly frequency for full comparison, extending further than the varying Permit or EMP/CR requirements.

## 3.4.2 South Pit Phase 3 Landfill Permit Requirements

There are six surface water monitoring locations SSW1, SSW2, SSW3, SSW4, SSW5 and SSW6. The sampling points are located up and downstream of the landfill at points on the Swanscombe Main Drain and marsh ditch network. The location of the surface water monitoring points is described in Permit Table S3.8.

## 3.4.3 Surface Water Compliance Limits

So	South Pit & Surge Pile EMP/CR Table 17					South Pit Phase 3 Table 15 HRA Review 2017			
Monitoring Point	Frequency	Proposed Assessment Level	Proposed Compliance Limit		Monitoring Point	Frequency	Assessn	nent Level	
		рН	8.6	9.0			NH4-N	1.29mg/l	
		Cl	162mg/l	250mg/l			Cl	399mg/l	
SSW6	Quarterly	Sulphate	296mg/l	400mg/l	SSW2	Monthly	Phenol	7.7mg/l	
	,	As (filtered)	n/a	0.025mg/l			Sulphate	883mg/l	
			n/a 0.03mg/l				Selenium	0.01mg/l	
		Se (filtered)				Cr (VI)	0.002mg/l		

Table Note: South Pit & Surge Pile Compliance Limits (EMP/CR Table 17) requested to be reviewed after 12 months of monitoring atSSW6 but the action plan submitted March 2017 required works to be completed. CMS recommends review of compliance limits after completion of the ditch clearance works, now due in 2020.

#### 3.4 Landfill Gas (LFG)

## 3.4.1 South Pit & Surge Pile EMP/CR Requirements

LFG is monitored at three in waste locations on a quarterly basis. IW1AR/14, IW1BR/14 and IW1CR/14 as in EMP/CR table 14.

## 3.4.2 South Pit Phase 3 Permit Requirements

LFG is monitored at three in waste locations on a quarterly basis. IW3AR/14, IW3BR/14 and IW3CR/14 as in Permit Table S3.6.

#### 3.4.3 LFG Compliance Limits

	South Pit & Su	rge Pile EMP/CR Table 15	South Pit Phase 3		
Compliance Point	Action Level	Compliance Limit	Action Level	Compliance Limit	
In waste monitoring points IW1AR/14, IW1BR/14, IW1CR/14	Results are out of trend. CH <sub>4</sub> % v/v above previous annual maximum		NA	NA	

#### 3.6. Restored Surface Monitoring

#### 3.6.1 South Pit & Surge Pile EMP/CR Requirements

Due to dense vegetation on South Pit & Surge Pile settlement monitoring by direct comparison of topographical surveys is not proposed. Annual surveys of the survey pegs will be undertaken during the aftercare period and the data compared with the previous years and the 2010 Peg Survey. EMP/CR Table 21 outlines the restored Surface Infrastructure Monitoring Program.

## 3.6.2 South Pit Phase 3 Permit Requirements

Permit condition 3.5.3 outlines the survey and Reporting requirements with topographical survey required annually. With settlement review requirements in condition 4.2.2 to be covered in AMR. See section 4.6 of this report.

## 3.6.3 Restored Surface Compliance Limits

Compliance Limits do not apply to restored surface monitoring. An assessment level test is included within the South Pit & Surge Pile EMP/CR and Table 22. Further works are proposed to restore the perimeter areas of South Pit Phase 3 therefore an assessment level test for this Site is not currently proposed but is included in the Closure Report Table 22.

#### 3.7. Performance Parameters

#### 3.7.1 South Pit & Surge Pile EMP/CR Requirements

The South Pit & Surge Pile EMP/CR does not require any performance parameters to be reported.

#### 3.7.2 South Pit Phase 3 Permit Requirements

Schedule 4 of the Permit requires the following performance parameters to be reported. Table S4.2 is required by the end of February each year and Table S4.3 is included within this annual Report.

Permit Table S4.2: Annual Production/Treatment				
Leachate: Cubic metres/year				
Disposed of offsite	NA			
Disposed of to any onsite leachate treatment plant 4623				
'Disposed of offsite' = Volume of any leachate disposed of by tanker.				
'Disposed of to any onsite leachate treatment plant' = Volume of discharge from plant to sewer				

Permit Table S4.3 Performance Parameters						
Parameter Frequency of Annual total Unit assessment						
Energy used (including for leachate treatment)	Annually	N/A	MWh of electricity or natural gas			
Raw material usage	Annually	3 tonnes	tonnes or m3			
Treatment efficiency	Annually	1.6%	%			

#### 4 Monitoring Data Discussion

#### 4.1 Introduction

#### 4.1.1 Data and Graphical Representation

Data is presented in **Appendix 1**. Key parameters are included in this section, as agreed with the Environment Agency. All data required by the Permit and EMP/CR is submitted to the Environment Agency on a quarterly basis.

Within Appendix 1 results below the laboratory Reporting limit (LRL) are shown as blue font. The less than symbols are removed for graphical representation and statistical analysis as Excel will recognise these as formula and show the value as '0'.

#### 4.1.2 Operational Events

South Pit and Surge Pile Landfill is fully restored and definitely closed. South Pit Phase 3 is fully restored and in the process of ensuring compliance with all permit conditions in order to apply for definitely closed status. The issue delaying closure is that of fugitive leachate emissions which are to be addressed by the completion of the Surface Water Action Plan.

Operations at the landfills are limited to maintenance of the pollution control systems and environmental monitoring. Significant events are tracked using a variety of recording mechanisms, these include Exception Reports (ER) and Compliance Exception Reports (CER). A CER/ER index is included in Appendix 4.

#### 4.2 Landfill Gas

## 4.2.1 Perimeter Landfill Gas Monitoring

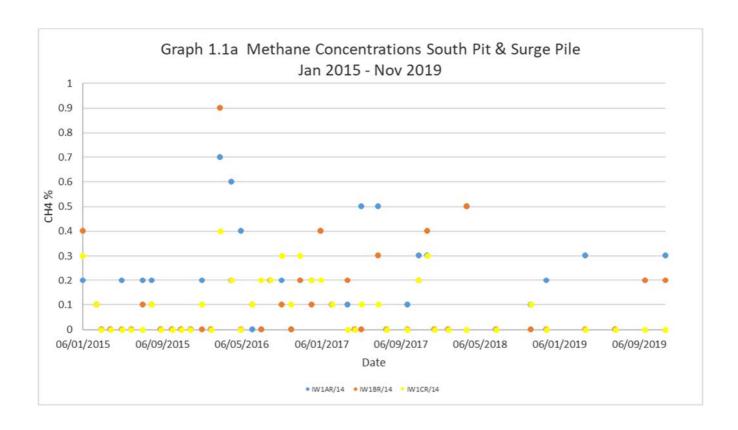
Monitoring of landfill gas at locations outside the waste mass is not required for either landfill. Perimeter monitoring was undertaken at adapted groundwater monitoring points from January 2006 to June 2014. Elevated levels of methane were recorded but not attributable to landfill gas generation within the waste mass. Therefore, discontinued for **South Pit Phase 3** and not included within the South Pit and Surge Pile closure requirements.

## 4.2.2 In-Waste Landfill Gas Monitoring

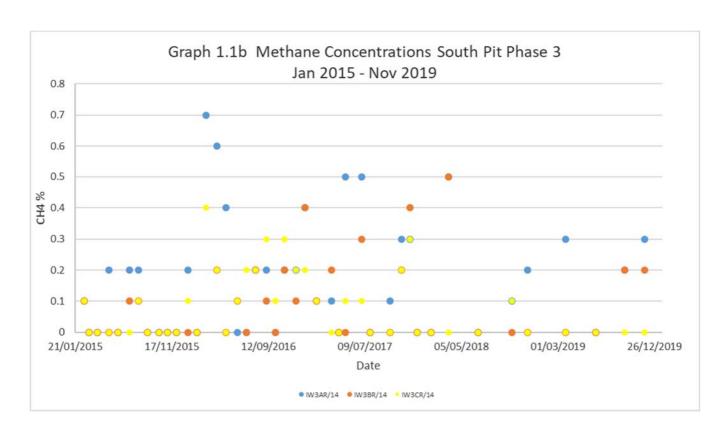
For the purposes of this report to illustrate the condition of the landfill Site and provide a comparison to assumptions and conclusions within the risk assessment, selected parameters only are included within this Section. Landfill gas monitoring is required quarterly, and all measurements were taken in 2019. All data is submitted to the Environment Agency on a quarterly basis.

Table 1.1 Landfill Gas monitoring Statistics 2019 - South Pit & Surge Pile							
Monitoring Point	Parameter	Count	Methane	Carbon Dioxide Oxy	Oxygen	Relative Pressure	Atmospheric Pressure
Tome	Units		% v/v	% v/v	% v/v	mb	mb
	Minimum		0	0	16.7	-1.4	994
IW1AR/14	Average	4	0	0.09	15.7	-0.34	1017
	Maximum		0	0.2	19.8	0.24	1036
Minimum		0	0	10	-0.52	995	
IW1BR/14	Average	4	0	0.11	15.85	-0.04	1014
	Maximum		0	0.4	16.7	0.26	1031
	Minimum		0	0	11.1	-0.6	1033
IW1CR/14	Average	4	0	0.11	15.9	0.00	1012
	Maximum		0	0.2	17.7	0.26	995

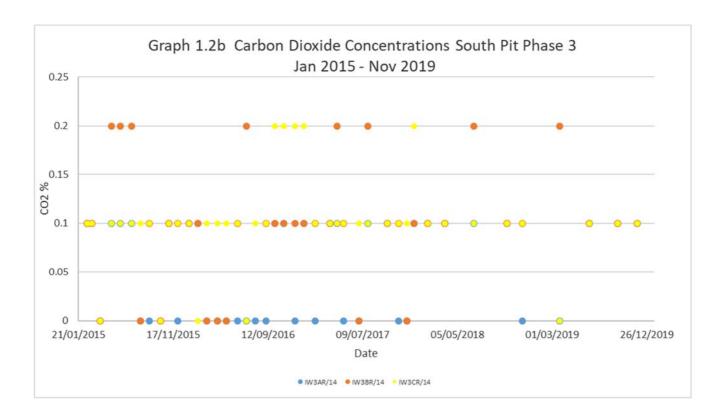
Table 1.2 Landfill Gas monitoring Statistics 2019 - South Pit Phase 3							
Monitoring Point	Parameter	Count	Methane Carbon Dioxide		Oxygen	Relative Pressure	Atmospheric Pressure
Foint	Units		% v/v	% v/v	% v/v	mb	mb
	Minimum		0	0	7.3	-0.76	994
	Average	4	0.05	0.11	15.7	0.05	1010
	Maximum		0.3	0.1	19.8	0.22	1033
	Minimum		0	0.1	18.9	-0.83	994
IW3BR/14	Average	4	0.05	0.12	16.4	0.09	1010
	Maximum		0.2	0.2	20.1	0.22	1033
	Minimum		0	0	5.7	-0.88	992
IW3CR/14	Average	4	0	0.11	15.7	0.2	1006
	Maximum		0	0.1	20	0.21	1031

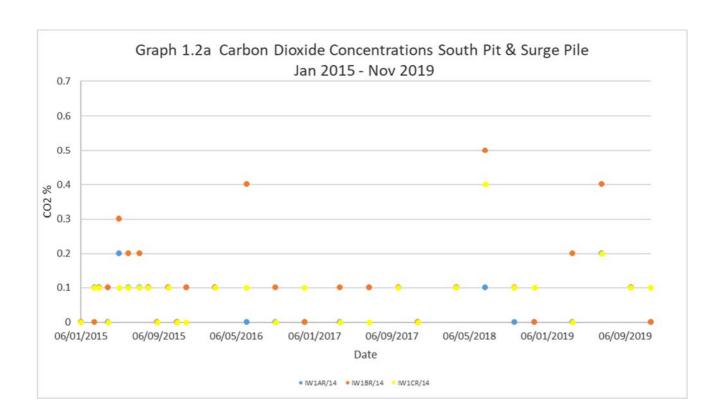


**Methane** – methane was not recorded at a concentration above 0.3% at either site during the reporting year. This is comparable to previous years and as expected due to waste type.

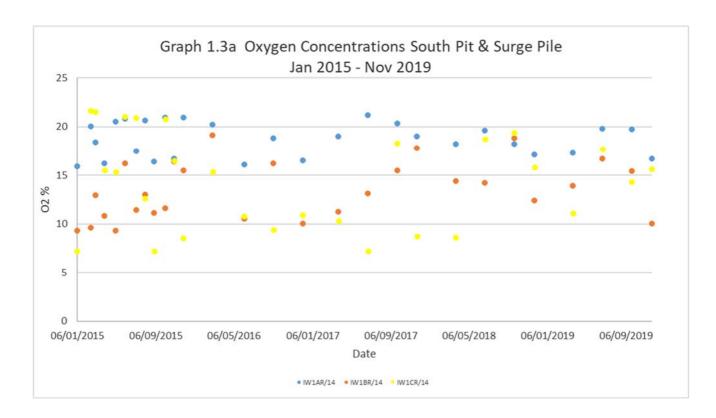


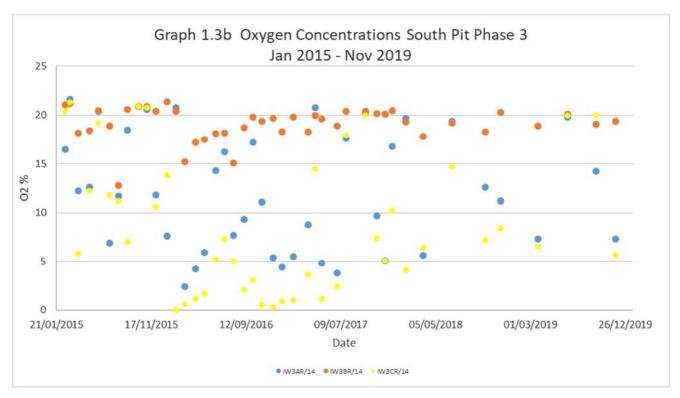
**Carbon dioxide** – carbon dioxide was not recorded at a concentration above 0.4% at either site during the Reporting year. As for methane this is comparable to previous years and as expected given the waste type.





**Oxygen** – depleted oxygen is evident in all internal monitoring points during the Reporting year and is within previously observed trends.





Hydrogen sulphide and hydrogen – Table S3.6 of the South Pit Phase 3 Permit requires quarterly monitoring of hydrogen sulphide and hydrogen. This is carried out using a calibrated handheld monitoring instrument. Only two results of 1ppm hydrogen sulphide was recorded during March 2019, all other results did not record the presence of hydrogen sulphide. Hydrogen is sampled quarterly via a High, Medium or Low result from a handheld gas analyser, all recorded low in 2019. Annually Hydrogen is tested for during the trace gas analysis, this had a result of 0%.

Trace gas analysis – trace gas analysis was carried out by Envirodat Ltd on 2<sup>nd</sup> December 2019. The Report is included in **Appendix 4**. Envirodat concluded that the levels of trace gas within the landfill were undetectable overall, except for a few notable examples. There were 1,1,1-trichloroethane and ethylbenzene.

## 4.2.3 Summary

Landfill gas is not an issue at Swanscombe landfills. The high pH and low carbon content of the CKD waste inhibit landfill gas production. Trace gas concentrations are not significant and as samples are taken from a sub-surface point within the landfill the results are not representative of actual or potential emission to atmosphere

#### 4.3 Leachate

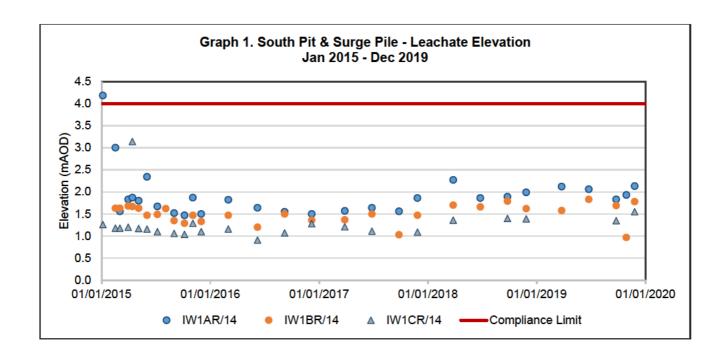
#### 4.3.1 Elevation

South Pit and Surge Pile – leachate levels are monitored quarterly at the three in waste points: IW1AR/14, IW1BR/14 and IW1CR/14. Elevated leachate levels present a risk of perimeter leachate seepages with the leachate level compliance limit of 4.0mAOD based on the site geometry and hydrogeological conceptual site model. The assessment limit of 3.0mAOD provides an early warning of increasing leachate levels.

Graph 2.1 below presents leachate level data for South Pit & Surge Pile from 2015 to 2019 and confirms that leachate levels in 2019 remained low and consistent with 2016 and 2017 data. Table 2.1 presents summary statistics for leachate levels in 2019. There were no exceedances of the leachate assessment or compliance limit in 2019, with a maximum recorded leachate level of 2.13mAOD (IW1AR/14, November 2019). Monitoring well IW1CR/14 was recorded as 'dry' on two of the five monitoring events.

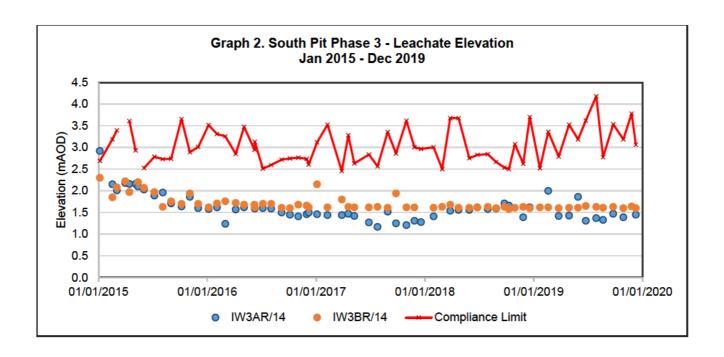
Table 2.1 – South Pit & Surge Pile: 2019 Leachate Elevation Statistics (Quarterly Monitoring)

Manitorina Doint	Compliance	2019 Leach	nate Elevation Statist	ics (mAOD)
Monitoring Point	Limit (mAOD)	Minimum	Mean	Maximum
IW1AR/14		1.83	2.01	2.13
IW1BR/14	4.00	0.97	1.57	1.83
IW1CR/14		<0.93	-	1.55



South Pit Phase 3 - the management of leachate levels within South Pit Phase 3 and the issue of historic perimeter leachate outbreaks are being addressed via a Leachate Management Project. The project has involved the construction of a perimeter leachate collection drain with leachate sumps pumping to a holding tank for subsequent treatment and discharge to sewer. The leachate management system was installed in 2014/15 and currently discharges approximately 12m³/day of treated leachate to foul sewer.

Leachate levels are monitored monthly at three in-waste points: IW3AR/14, IW3BR/14 and IW3CR/14. Monitoring point IW3CR/14 has consistently been reported as 'dry' since installation, representing a leachate level of <3.2mAOD. Leachate level compliance is based on a comparison of leachate level (mAOD) against average groundwater level (mAOD). The Hydrogeological Risk Assessment for the site derived a leachate level compliance limit of 2.5m above the average groundwater level. Average groundwater level is calculated as the arithmetic mean of groundwater level measurements at G11 and EW7/14 carried out on the same monitoring visit as the leachate level. Graph 2.2 below presents leachate level data for South Pit Phase 3 from 2015 to 2019.



In 2019, leachate was only present in IW3AR/14, with monitoring points IW3BR/14 and IW3CR/14 remaining dry or with very limited depth of leachate present (<0.05m). This confirms leachate levels of <1.6mAOD at IW3BR/14 and <3.2mAOD at IW3CR/14. Graph 2.2 confirms that leachate levels recorded at IW3AR/14 in 2019 were comparable to previous years and remained below the leachate level compliance limit. Summary statistics for IW3AR/14 in 2019 are included within Table 2.2.

Table 2.2 - South Pit Phase 3: 2019 Leachate Elevation Statistics (Monthly Monitoring)

Monitoring Doint	2019 Leachate Elevation Statistics (mAOD)					
Monitoring Point	Minimum Mean Maximu					
IW3AR/14	1.31 1.50 2.00					
IW3BR/14	Dry (leachate level <1.6mAOD)					
IW3CR/14	Dry (leachate level <3.2mAOD)					

#### 4.3.2 Leachate Quality - Key Parameters

South Pit and Surge Pile – Leachate quality is monitored quarterly at the three in-waste monitoring wells: IW1AR/14, IW1BR/14 and IW1CR/14, when sufficient depth of leachate is available. A more comprehensive annual monitoring schedule is also undertaken. In 2019 only one sample was obtained from IW1CR/14 and samples were only obtained from IW1BR/14 on just three occasions, due to insufficient depth of leachate. A summary of the 2019 quarterly leachate quality statistics is presented in Table 2.3 below.

Table 2.3 – South Pit and Surge Pile: 2019 Leachate Quality Statistics

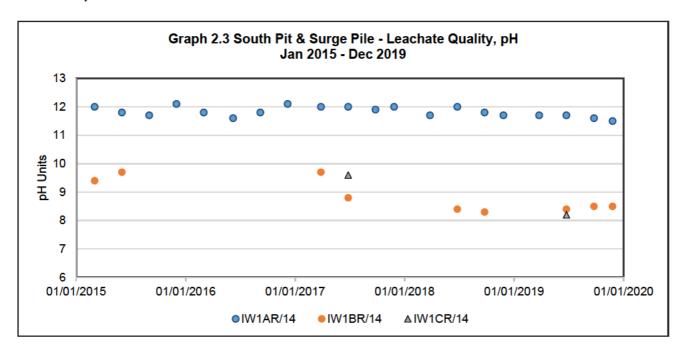
Monitoring Point: IW1AR/14					
Parameter	Count	Minimum	Mean	Maximum	
Potassium, filtered (mg/l)	4	5070	6460	7840	
Sodium, filtered (mg/l)	4	852	1371	1780	
pH (units)	4	11.5	11.6	11.7	
Electrical Conductivity (µS/cm)	4	26600	43800	81100	
Alkalinity as CaCO3 (mg/l)	4	1500	1713	1900	
Ammoniacal-Nitrogen as N (mg/l)	4	1.68	5.78	10	
Chloride (mg/l)	4	2900	4708	5630	
Sulphate as SO4 (mg/l)	4	2670	4123	5950	
BOD (mg/l)	4	<b>&lt;</b> 5	-	66	
COD (mg/l)	4	125	210	300	

Monitoring Point: IW1BR/14					
Parameter	Count	Minimum	Mean	Maximum	
Potassium, filtered (mg/l)	3	6320	7013	7440	
Sodium, filtered (mg/l) <sup>2</sup>	3	1010	1157	1310	
pH (units)	3	8.4	8.5	8.5	
Electrical Conductivity (µS/cm)	3	33400	53467	88900	
Alkalinity as CaCO3 (mg/l)	3	185	362	590	
Ammoniacal-Nitrogen as N (mg/l)	3	1.7	3.1	4.23	
Chloride (mg/l)	3	3000	4360	5460	
Sulphate as SO4 (mg/l)	3	2130	5483	7830	
BOD (mg/l)	3	<b>&lt;</b> 5	-	23	
COD (mg/l)	2	100	161	222	

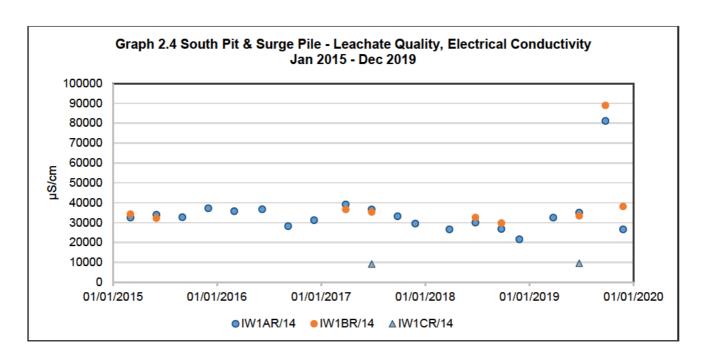
Monitoring Point: IW1CR/14					
Parameter	Count	Value			
Potassium, filtered (mg/l)	1	1600			
Sodium, filtered (mg/l)	1	422			
pH (units)	1	8.2			
Electrical Conductivity (µS/cm)	1	9550			
Alkalinity as CaCO3 (mg/l)	1	190			
Ammoniacal-Nitrogen as N (mg/l)	1	0.354			
Chloride (mg/l)	1	906			
Sulphate as SO4 (mg/l)	1	2190			
BOD (mg/l)	1	<b>&lt;</b> 5			
COD (mg/l)	1	23			

Time-series plots are presented below for concentrations of the following key parameters in leachate from 2015 to 2019: pH, electrical conductivity, potassium, sulphate, ammoniacal-nitrogen, chloride, alkalinity, arsenic and selenium. These parameters are either compliance parameters for groundwater and/or surface water, or noted to be indicative of CKD leachate quality.

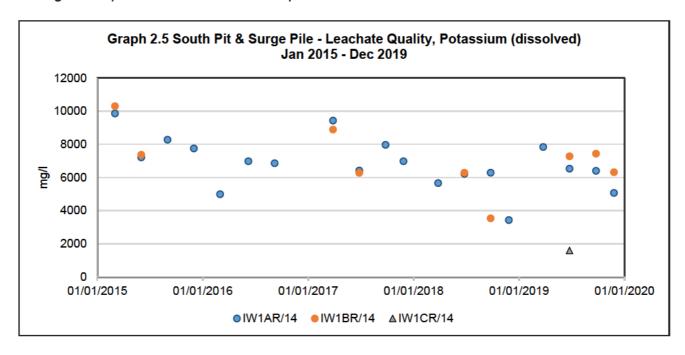
pH – Graph 2.3 presents the pH of leachate samples from 2015 to 2019. CKD leachate is characterised by high pH, usually above 12 and this is evident in samples taken from IW1AR/14 which reported an average pH of 11.6 in 2019. Leachate pH was notably lower, in the range pH8.0 - pH8.5, in the samples obtained at IW1BR/14 and IW1CR/14.



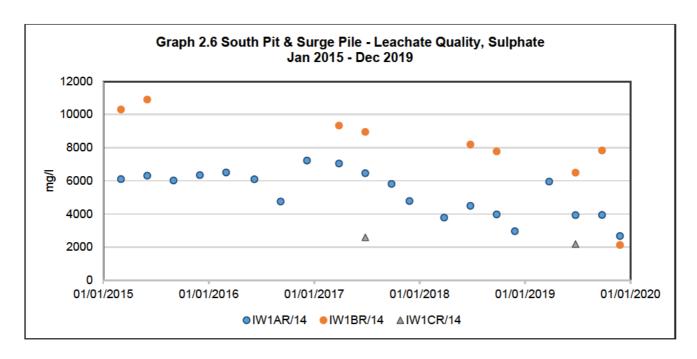
Electrical conductivity – Graph 2.4 presents electrical conductivity levels for leachate from 2015 to 2019. Electrical conductivity is extremely high in CKD leachate, indicative of high levels of inorganic dissolved solids. In 2019, the electrical conductivity of leachate was comparable to previous years and ranged from  $26,600\mu\text{S/cm}$  to  $38,100\mu\text{S/cm}$  at IW1AR/14 and IW1BR/14, with the exception of elevated results in September 2019 of >80,000 $\mu$ S/cm; these are isolated and likely to represent laboratory error. The 2019 leachate sample from IW1CR/14 recorded a significantly lower conductivity value of  $9550\mu$ S/cm; this monitoring point does not appear to be representative of the site leachate probably due to groundwater seepage / dilution.



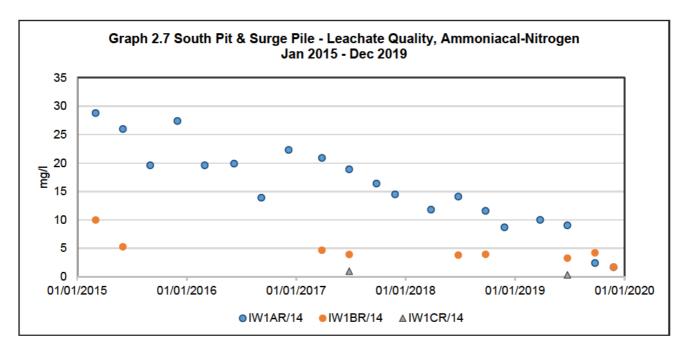
Potassium – Graph 2.5 presents potassium concentrations in leachate from 2015 to 2019. Potassium is a key CKD indicator parameter and is a compliance parameter for the groundwater compliance points. In 2019 potassium concentrations in leachate at IW1AR/14 and IW1BR/14 were comparable to recent years and ranged from 5070mg/l to 7840mg/l. Potassium concentrations rose sharply at the end of 2018 and gradually declined during 2019. As observed for other parameters, the potassium concentration recorded at IW1CR/14 was significantly lower and not considered representative of the site leachate.



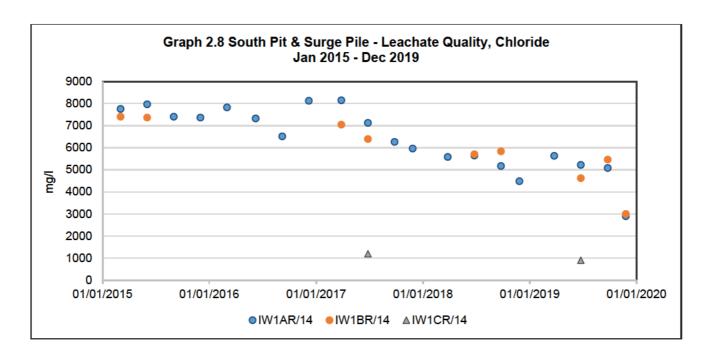
Sulphate – Graph 2.6 presents sulphate concentrations in leachate from 2015 to 2019. Elevated sulphate levels are another indicator of CKD leachate and concentrations at South Pit and Surge Pile ranged from 2190mg/l to 7830mg/l in 2019. As observed for potassium, sulphate concentrations rose at the end of 2018 and generally followed a declining trend in 2019.



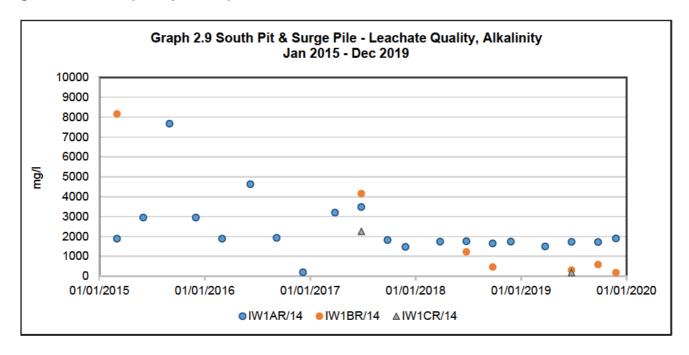
Ammoniacal nitrogen – Graph 2.7 presents ammoniacal-nitrogen concentrations in leachate from 2015 to 2019. Ammoniacal-nitrogen concentrations at IW1AR/14 in 2019 continued the general declining trend observed in recent years, with an average concentration in 2019 of 5.8mg/l compared to a 2018 average of 11.5mg/l. Concentrations at IW1BR/14 remained relatively low in 2019 (<5mg/l).



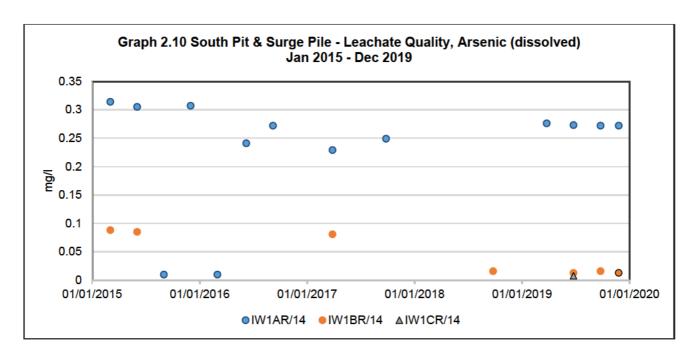
Chloride – Graph 2.8 presents chloride concentrations in leachate from 2015 to 2019. Chloride is elevated in CKD leachate and the average chloride concentration at IW1AR/14 in 2019 was 4708mg/l. Chloride concentrations at IW1BR/14 are comparable and both monitoring points display a gradual declining trend from 2017 – 2019. The 2019 chloride concentration recorded at IW1CR/14 was significantly lower (906mg/l) and uncharacteristic of CKD leachate.



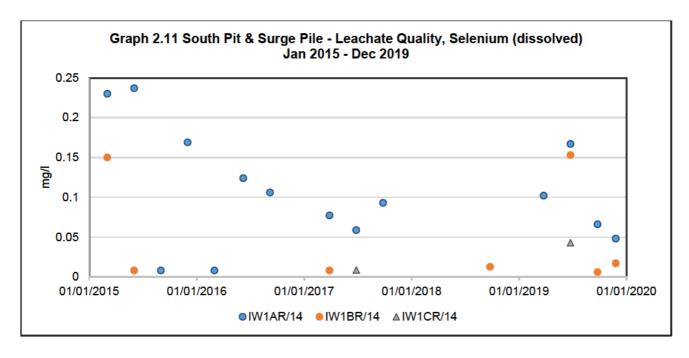
Alkalinity – Graph 2.9 presents the alkalinity of leachate from 2015 to 2019. The 2019 results at IW1AR/14 were in the range 1500mg/l – 1900mg/l and were comparable to the 2018 data. The results continued to show greater consistency than previous years.



Arsenic – arsenic has been included within the quarterly monitoring schedule during 2019 because it is a groundwater compliance parameter. Graph 2.10 presents the 2015 to 2019 dataset; the 2019 results for IW1AR/14 range from 0.272mg/l to 0.276mg/l and are comparable to previous years.



Selenium – selenium was also added to the quarterly leachate monitoring schedule in 2019 and the 2015 to 2019 dataset is presented on Graph 2.11. Selenium concentrations in 2019 were variable, ranging from 0.048mg/l to 0.167mg/l at IW1AR/14.



Hexavalent Chromium – concentrations of hexavalent chromium, a priority hazardous substance in South Pit and Surge Pile leachate, remained below the laboratory reporting limit of 0.02mg/l in 2019, as observed in 2018.

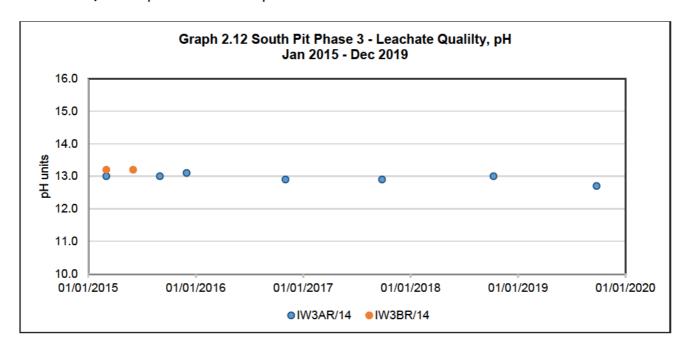
Hazardous Substances – leachate samples were taken for hazardous substance analysis from IW1AR/14 and IW1BR/14 on 25/09/2019. Only arsenic was detected above the relevant Environment Agency recommended laboratory reporting limit ( $10\mu g/l$  for volatiles and semi-volatiles;  $1\mu g/l$  for mercury). The concentrations are comparable to 2018 results.

```
Arsenic (filtered) 0.272mg/l (IW1AR/14)
Arsenic (filtered) 0.016mg/l (IW1BR/14)
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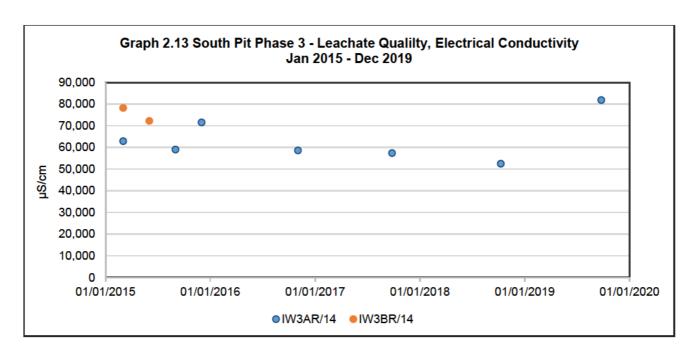
South Pit Phase 3 - in accordance with Permit, Table S3.7 requirements for a non-operational landfill, leachate quality samples are obtained annually at South Pit Phase 3. There are no permit compliance limits associated with leachate quality. Leachate samples could not be obtained from IW3BR/14 and IW3CR/14 in 2019 due to insufficient depth of leachate, as observed in previous years. Therefore, in 2019 a single leachate sample was obtained in September from IW3AR/14; the results are compared with previous years' data in the discussion below.

Time-series plots of the priority contaminants within Phase 3 leachate are presented below as Graphs 2.12 to 2.21. The graphs show concentrations of the following parameters from 2015 to 2019: pH, electrical conductivity, potassium, ammoniacal-nitrogen, chloride, alkalinity, sulphate, hexavalent chromium, arsenic and selenium.

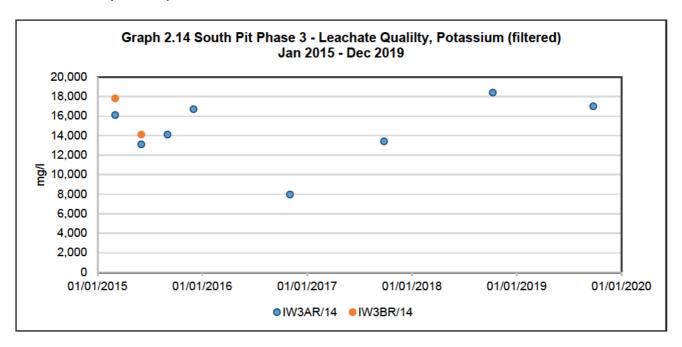
pH – Graph 2.12 presents the pH of leachate samples from 2015 to 2019 and confirms that the pH has remained consistent and elevated at around pH13, which is characteristic of CKD leachate. The pH of leachate from IW3AR/14 in September 2019 was pH12.7.



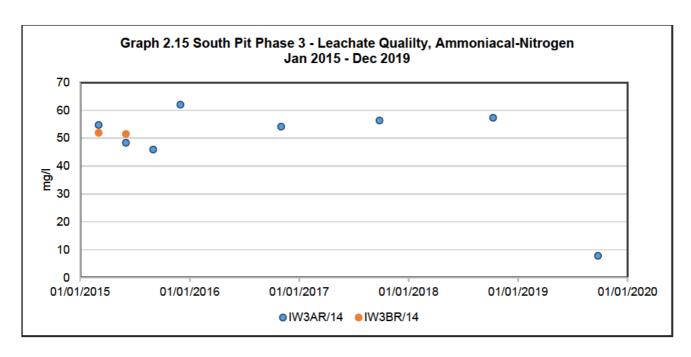
Electrical conductivity – Graph 2.13 presents the electrical conductivity of leachate, which is characteristically high in CKD leachate. The electrical conductivity of leachate at IW3AR/14 followed a gradual declining trend from 2015 to 2018 but rose to a five-year maximum in 2019 at 81,800μS/cm.



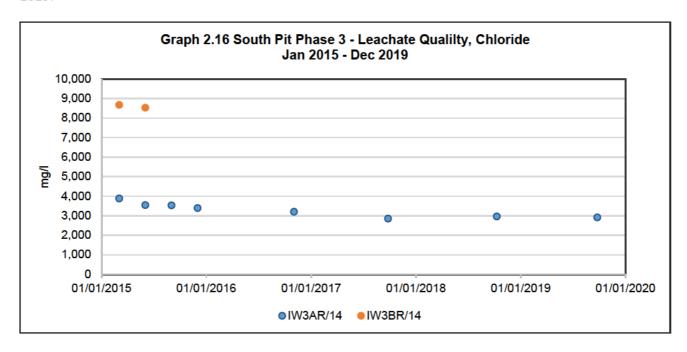
Potassium – Graph 2.14 presents potassium concentrations in leachate from 2015 to 2019; potassium is a key indicator of CKD leachate. The potassium concentration of leachate in 2019 was 17,000mg/l which is consistent with previous years.



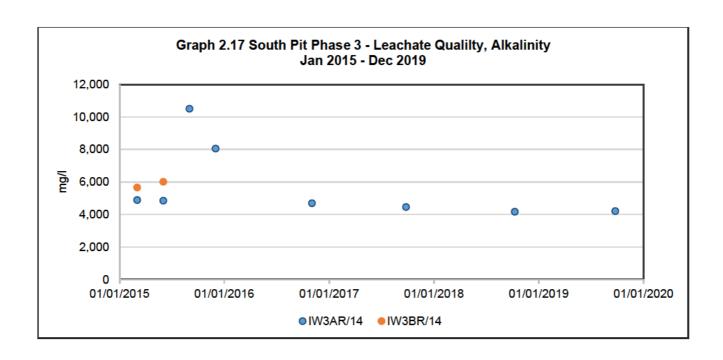
Ammoniacal-nitrogen – Graph 2.15 presents ammoniacal-nitrogen concentrations in leachate from 2015 to 2019. Ammoniacal-nitrogen concentrations from 2015 to 2018 were consistent and in the range 45mg/l to 65mg/l; the 2019 result was significantly lower at 7.8mg/l.



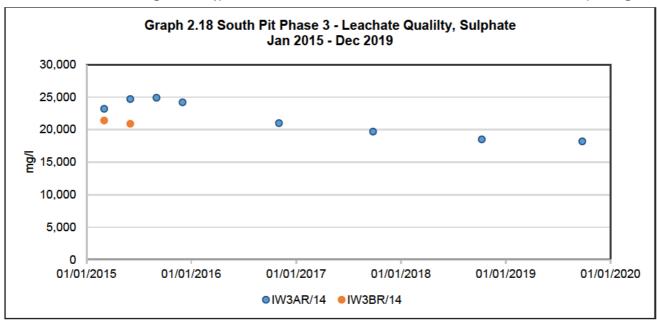
Chloride – Graph 2.16 presents chloride concentrations in leachate from 2015 to 2019 and confirm consistent, elevated concentrations at IW1AR/14 characteristic of CKD leachate. A value of 2910mg/l was recorded in 2019.



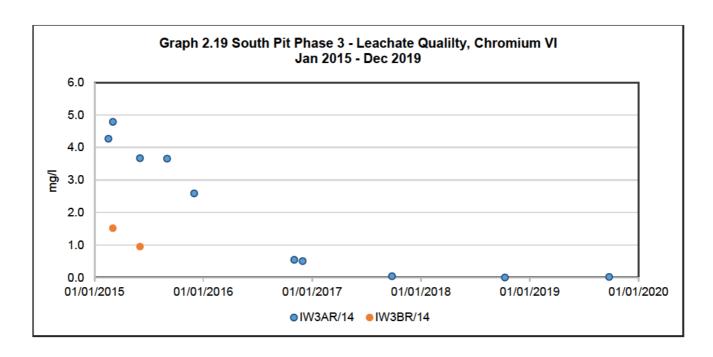
Alkalinity – Graph 2.17 presents the alkalinity of leachate samples from 2015 to 2019, with the 2019 result of 4210mg/l comparable to recent years.



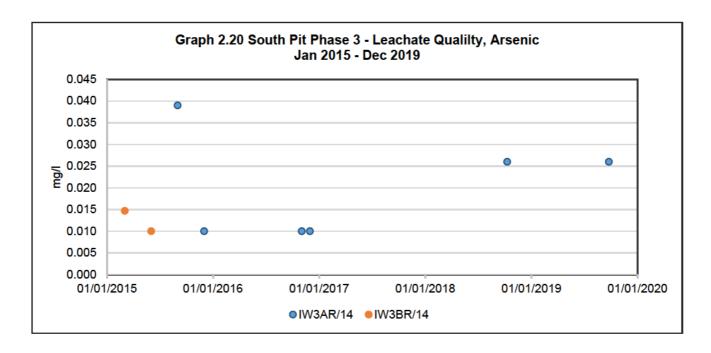
Sulphate – Graph 2.18 presents sulphate concentrations in leachate; CKD leachate is characterised by elevated sulphate. Although Phase 3 leachate displays a slight declining trend in sulphate levels since 2016, based on limited annual monitoring data only, the concentration recorded in 2019 remained elevated at 18,200mg/l.



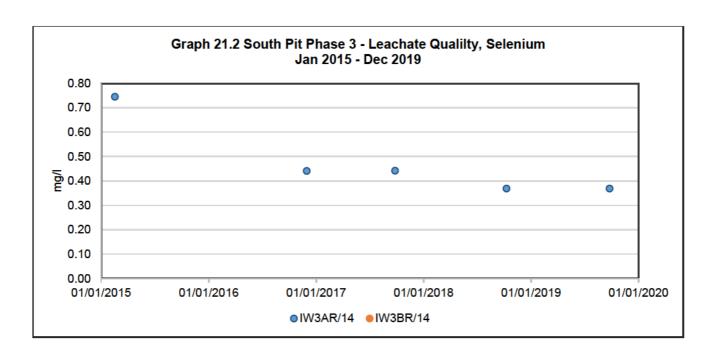
Chromium VI – Graph 2.19 presents hexavalent chromium concentrations in Phase 3 leachate from 2015 to 2019 and presents a clear declining trend since 2015. In 2019, hexavalent chromium was below the laboratory reporting limit (0.02mg/l) IW3AR/14, as observed in 2018.



Arsenic – Graph 2.20 presents arsenic concentrations in leachate from 2015 to 2019. Arsenic is a hazardous substance which has been occasionally detected at low concentrations above the 0.01mg/I LRL at IW3AR/14, with the 2018 result of 0.026mg/I comparable to recent results.



Selenium – Graph 2.21 presents selenium concentrations in Phase 3 leachate from 2015 to 2019. The data suggest a gradual declining trend in concentrations over the period; the 2019 result at IW3AR/14 was 0.369mg/l.



Hazardous Substances – a sample was taken from IW3AR/14 for a reduced hazardous substance analysis on 25/09/2019 and only arsenic was detected above the relevant recommended laboratory reporting limit  $(10\mu g/l)$  for volatiles and semi-volatiles and  $1\mu g/l$  for mercury). The recorded concentration of arsenic (filtered) of 0.026mg/l was comparable to 2018 data.

#### 4.3.3 Leachate Quality Summary

South Pit and Surge Pile: leachate quality is monitored quarterly when sufficient depth of leachate is present, with eight samples analysed during 2019. However, only the quarterly leachate samples obtained from IW1AR/14 are considered representative of the site leachate; significantly lower concentrations at the other monitoring points are indicative of groundwater seepage / dilution. The leachate quality at IW1AR/14 remained characteristic of CKD leachate with elevated pH, chloride, sulphate and potassium but concentrations of many parameters in 2019 continued to follow the declining trend observed in recent years.

South Pit Phase 3: leachate quality is monitored annually at South Pit Phase 3, with a single sample obtained in 2019 from IW3AR/14. The leachate remains characteristic of CKD leachate with concentrations of key indicator parameters comparable to previous years and reporting high alkalinity, high electrical conductivity and high concentrations of potassium, chloride and sulphate. Some of the trace indicator parameters including hexavalent chromium and selenium are reporting gradual declining concentrations over recent years. The 2019 leachate data remain within the concentration ranges assumed in the 2017 HRA Review for the priority contaminants: ammoniacal-nitrogen, chloride, sulphate, hexavalent chromium, phenol and selenium.

## 4.4 Surface Water Monitoring Data

## 4.4.1 Key Parameters

Surface water quality is monitored at the following locations around South Pit Landfills:

- **SSW1** upstream of Phase 1 and Phase 3 within Swanscombe Main Drain
- SSW2 entrance to the Swanscombe Main Drain culvert, downstream of both sites
- SSW3 on the eastern (midstream) boundary of Phase 3, within the eastern marsh drain
- **SSW4** upstream of Phase 3, within the eastern marsh drain
- SSW5 on the north-east (downstream) boundary of Phase 3, within the eastern marsh drain
- SSW6 downstream of Phase 1 (upstream of Phase 3), within Swanscombe Main Drain
- SSW7 within a site drainage ditch opposite (west of) SSW6 (downstream of Phase 1)

The Closure Report / EMP for **South Pit and Surge Pile** presents assessment and compliance limits for surface water quality at downstream compliance point **SSW6**, which were subject to review after 12 months (yet to be undertaken).

There are no surface water compliance limits for **South Pit Phase 3** and no compliance limits recommended in the 2017 HRA Review due to the difficulty in identifying impacts to surface water quality from Phase 3 in isolation from the other, adjacent CKD sources. However, the 2017 HRA Review recommended assessment limits for surface water at **SSW2**, to be used in conjunction with visual assessments of leachate seepages. **SSW2** assessment levels are to be fully implemented following the completion of the surface water drain clearance works which is due to be undertaken in 2020. The discussion below includes reference to **SSW2** assessment levels and provides information on the current situation.

Surface water graphs (**Graph 3.1 – 3.6**) presented below include data for all surface water monitoring points at South Pit Landfills (**SSW1** to **SSW7**) for the following priority leachate substances: pH, potassium, chloride, sulphate, ammoniacal-nitrogen and selenium. For the purposes of the graphs, values below the LRL are assumed to equal the LRL.

Due to low flow conditions it was not possible to take samples at all the points on every monitoring occasion.

In addition to the assessment and compliance limits, surface water quality data have been reviewed against freshwater environmental quality standards (EQSs) as detailed in **Table 3.1** below.

Table 3.1 Surface Water Emission Limits and Environmental Quality Standards					
Parameter	Assessment / Compliance Limits	Freshwater Environmental Quality Standard (EQS*)	Comment		
рН	SSW6: assessment: pH8.6; compliance: pH9.0	рН6 – рН9	UK Standards for protection of inland freshwaters		
Electrical conductivity		2500 <b>µ</b> S/cm	UK Drinking Water Standard		
Chloride	SSW2: 399mg/l (assessment limit) SSW6: assessment: 162mg/l; compliance: 250mg/l	250mg/l	Freshwater EQS (annual average)		
Sulphate	SSW2: 883mg/l (assessment limit) SSW6: assessment: 296mg/l; compliance: 400mg/l	400mg/l	Freshwater EQS (annual average)		
Arsenic	SSW6: compliance: 0.025mg/l	25 to 50µg/l	UK Standard for surface water quality and protection of aquatic life		
Ammoniacal-nitrogen	SSW2: 1.29mg/l (assessment limit)	0.2mg/l – 2.5mg/l	EQS after Environment Agency H1 Environmental Risk Assessment, Annex D, A5 – Table 3		
Phenol	SSW2: 7.7mg/l (assessment limit)	0.3mg/l	Freshwater EQS (maximum acceptable)		
Selenium	SSW2: 0.01mg/l (assessment limit) SSW6: compliance: 0.03mg/l	0.01mg/l	UK Drinking Water Standard		
Hexavalent Chromium	SSW2: 0.002mg/l (assessment limit)	-	-		

Table note: Assessment limits for SSW2 after Phase 3 2017 HRA Review (no permit compliance limits exist)
Assessment and compliance limits for SSW6 after South Pit & Surge Pile Closure Report and are due review.
Water quality standards after EA Chemical Standards Database.

Table 3.2 presents 2019 surface water quality monitoring statistics for the general chemistry and leachate indicator parameters.

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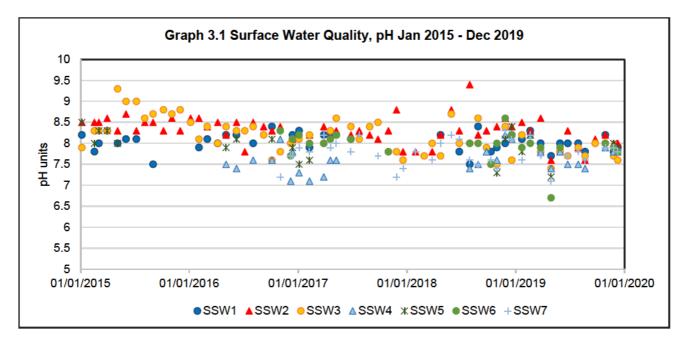
Monitoring Point: SSW1 (upstream)										
Parameter	Count	Minimum	Mean	Maximum						
Potassium, total (mg/l)	11	4.32	8.8	13.8						
Sodium, total (mg/l)	11	26	36.2	45.9						
pH (units)	11	7.7	8.0	8.3						
Electrical Conductivity (µS/cm)	9	519	628	721						
Alkalinity as CaCO3 (mg/l)	9	105	144	175						
Ammoniacal-Nitrogen as N (mg/l)	11	<0.05	-	0.274						
Chloride (mg/l)	11	42	53	66						
Sulphate as SO4 (mg/l)	11	55	77	94						
Selenium (total) (mg/l)	11	<0.0008	-	0.011						
Hexavalent Chromium (mg/l)	12	<0.001	-	<0.02						
Arsenic (total) (mg/l)	9	<0.005	<0.005	<0.005						
Phenols (mono) (mg/l)	11	<0.01	-	<0.1						
Monitoring Point: SSW2 (downstrea	m)			Monitoring Point: SSW2 (downstream)						
Parameter	Count	Minimum	Mean	Maximum						
Parameter Potassium, total (mg/l)	Count 12	Minimum 6.5	<b>Mean</b> 57.7	Maximum 274						
Potassium, total (mg/l)	12	6.5	57.7	274						
Potassium, total (mg/l) Sodium, total (mg/l)	12 10	6.5 27.6	57.7 66.4	274 144						
Potassium, total (mg/l) Sodium, total (mg/l) pH (units)	12 10 12	6.5 27.6 7.6	57.7 66.4 8.1	274 144 8.6						
Potassium, total (mg/l) Sodium, total (mg/l) pH (units) Electrical Conductivity (µS/cm)	12 10 12 10	6.5 27.6 7.6 593	57.7 66.4 8.1 961	274 144 8.6 1900						
Potassium, total (mg/l)  Sodium, total (mg/l)  pH (units)  Electrical Conductivity (µS/cm)  Alkalinity as CaCO3 (mg/l)	12 10 12 10 10	6.5 27.6 7.6 593 160	57.7 66.4 8.1 961 211	274 144 8.6 1900 300						
Potassium, total (mg/l)  Sodium, total (mg/l)  pH (units)  Electrical Conductivity (µS/cm)  Alkalinity as CaCO3 (mg/l)  Ammoniacal-Nitrogen as N (mg/l)	12 10 12 10 10 10	6.5 27.6 7.6 593 160 <0.05	57.7 66.4 8.1 961 211	274 144 8.6 1900 300 0.294						
Potassium, total (mg/l)  Sodium, total (mg/l)  pH (units)  Electrical Conductivity (µS/cm)  Alkalinity as CaCO3 (mg/l)  Ammoniacal-Nitrogen as N (mg/l)  Chloride (mg/l)	12 10 12 10 10 10 12 12	6.5 27.6 7.6 593 160 <0.05	57.7 66.4 8.1 961 211 -	274 144 8.6 1900 300 0.294 305						
Potassium, total (mg/l)  Sodium, total (mg/l)  pH (units)  Electrical Conductivity (µS/cm)  Alkalinity as CaCO3 (mg/l)  Ammoniacal-Nitrogen as N (mg/l)  Chloride (mg/l)  Sulphate as SO4 (mg/l)	12 10 12 10 10 12 12 12	6.5 27.6 7.6 593 160 <0.05 36	57.7 66.4 8.1 961 211 - 107 106	274 144 8.6 1900 300 0.294 305 244						
Potassium, total (mg/l)  Sodium, total (mg/l)  pH (units)  Electrical Conductivity (µS/cm)  Alkalinity as CaCO3 (mg/l)  Ammoniacal-Nitrogen as N (mg/l)  Chloride (mg/l)  Sulphate as SO4 (mg/l)  Selenium (total) (mg/l)	12 10 12 10 10 12 12 12 12	6.5 27.6 7.6 593 160 <0.05 36 54 <0.005	57.7 66.4 8.1 961 211 - 107 106	274 144 8.6 1900 300 0.294 305 244 0.007						

Monitoring Point: SSW3 (midstream)					
Parameter	Count	Minimum	Mean	Maximum	
Potassium, total (mg/l)	12	20.3	347	1470	
Sodium, total (mg/l)	10	48.2	181	662	
pH (units)	11	7.4	7.8	8.2	
Electrical Conductivity (µS/cm)	10	806	2196	6260	
Alkalinity as CaCO3 (mg/l)	10	220	353	700	
Ammoniacal-Nitrogen as N (mg/l)	12	<0.05	-	1.13	
Chloride (mg/l)	12	65	363	1230	
Sulphate as SO4 (mg/l)	12	53	377	1520	
Selenium (total) (mg/l)	12	<0.0008	-	0.011	
Hexavalent Chromium (mg/l)	12	<0.001	-	<0.02	
Arsenic (total) (mg/l)	10	<0.005	-	0.035	
Phenols (mono) (mg/l)	10	<0.01	<0.01	<0.01	
Monitoring Point: SSW4 (upstream)					
Parameter	Count	Minimum	Mean	Maximum	
Potassium, total (mg/l)	10	16	21.9	33.5	
Sodium, total (mg/l)	9	47.7	59.6	82.1	
11.7 11.3					
pH (units)	10	7.4	7.7	8.2	
pH (units)  Electrical Conductivity (µS/cm)	10 9	7.4 778	7.7 875	8.2 1000	
,					
Electrical Conductivity (µS/cm)	9	778	875	1000	
Electrical Conductivity (µS/cm) Alkalinity as CaCO3 (mg/l)	9	778 245	875	1000 330	
Electrical Conductivity (µS/cm)  Alkalinity as CaCO3 (mg/l)  Ammoniacal-Nitrogen as N (mg/l)	9 9	778 245 <0.05	875 283 -	1000 330 0.611	
Electrical Conductivity (µS/cm)  Alkalinity as CaCO3 (mg/l)  Ammoniacal-Nitrogen as N (mg/l)  Chloride (mg/l)	9 9 9 9	778 245 <0.05 63	875 283 - 95	1000 330 0.611 121	
Electrical Conductivity (µS/cm)  Alkalinity as CaCO3 (mg/l)  Ammoniacal-Nitrogen as N (mg/l)  Chloride (mg/l)  Sulphate as SO4 (mg/l)	9 9 9 10 10	778 245 <0.05 63 37	875 283 - 95	1000 330 0.611 121 87.1	
Electrical Conductivity (µS/cm)  Alkalinity as CaCO3 (mg/l)  Ammoniacal-Nitrogen as N (mg/l)  Chloride (mg/l)  Sulphate as SO4 (mg/l)  Selenium (total) (mg/l)	9 9 9 10 10	778 245 <0.05 63 37 <0.0008	875 283 - 95 60.2	1000 330 0.611 121 87.1 <0.005	

Monitoring Point: SSW5 (downstream)					
Parameter	Count	Minimum	Mean	Maximum	
Potassium, total (mg/l)	5	77.8	208	616	
Sodium, total (mg/l)	3	67.2	80.3	95.3	
pH (units)	5	7.2	7.8	8.2	
Electrical Conductivity (µS/cm)	3	1060	1220	1440	
Alkalinity as CaCO3 (mg/l)	3	245	263	280	
Ammoniacal-Nitrogen as N (mg/l)	5	<0.05	-	0.188	
Chloride (mg/l)	5	90	287	786	
Sulphate as SO4 (mg/l)	5	125	305	916	
Selenium (total) (mg/l)	4	<0.005	-	<0.008	
Hexavalent Chromium (mg/l)	4	<0.02	<0.02	<0.02	
Arsenic (total) (mg/l)	3	<0.005	<0.005	<0.005	
Phenols (mono) (mg/l)	3	<0.01	<0.01	<0.01	
Monitoring Point: SSW6 (downstrea	m)				
Parameter	Count	Minimum	Mean	Maximum	
Potassium, total (mg/l)	8	10.4	89.3	318	
Potassium, total (mg/l) Sodium, total (mg/l)	8	10.4 44.7	89.3 54.3	318 59.7	
Sodium, total (mg/l)	3	44.7	54.3	59.7	
Sodium, total (mg/l) pH (units)	3	44.7 6.7	54.3 7.8	59.7 8	
Sodium, total (mg/l)  pH (units)  Electrical Conductivity (µS/cm)	3 8 3	44.7 6.7 738	54.3 7.8 824	59.7 8 895	
Sodium, total (mg/l)  pH (units)  Electrical Conductivity (µS/cm)  Alkalinity as CaCO3 (mg/l)	3 8 3 6	44.7 6.7 738 200	54.3 7.8 824 233	59.7 8 895 255	
Sodium, total (mg/l)  pH (units)  Electrical Conductivity (µS/cm)  Alkalinity as CaCO3 (mg/l)  Ammoniacal-Nitrogen as N (mg/l)	3 8 3 6 8	44.7 6.7 738 200 <0.05	54.3 7.8 824 233	59.7 8 895 255 0.181	
Sodium, total (mg/l)  pH (units)  Electrical Conductivity (µS/cm)  Alkalinity as CaCO3 (mg/l)  Ammoniacal-Nitrogen as N (mg/l)  Chloride (mg/l)	3 8 3 6 8	44.7 6.7 738 200 <0.05 66	54.3 7.8 824 233 - 131	59.7 8 895 255 0.181 279	
Sodium, total (mg/l)  pH (units)  Electrical Conductivity (µS/cm)  Alkalinity as CaCO3 (mg/l)  Ammoniacal-Nitrogen as N (mg/l)  Chloride (mg/l)  Sulphate as SO4 (mg/l)	3 8 3 6 8 8	44.7 6.7 738 200 <0.05 66 71	54.3 7.8 824 233 - 131 133	59.7 8 895 255 0.181 279 328	
Sodium, total (mg/l)  pH (units)  Electrical Conductivity (µS/cm)  Alkalinity as CaCO3 (mg/l)  Ammoniacal-Nitrogen as N (mg/l)  Chloride (mg/l)  Sulphate as SO4 (mg/l)  Selenium (total) (mg/l)	3 8 3 6 8 8 8	44.7 6.7 738 200 <0.05 66 71 <0.0008	54.3 7.8 824 233 - 131 133	59.7 8 895 255 0.181 279 328 <0.005	
Sodium, total (mg/l)  pH (units)  Electrical Conductivity (µS/cm)  Alkalinity as CaCO3 (mg/l)  Ammoniacal-Nitrogen as N (mg/l)  Chloride (mg/l)  Sulphate as SO4 (mg/l)  Selenium (total) (mg/l)  Hexavalent Chromium (mg/l)	3 8 3 6 8 8 8 8	44.7 6.7 738 200 <0.05 66 71 <0.0008	54.3 7.8 824 233 - 131 133 -	59.7 8 895 255 0.181 279 328 <0.005 <0.02	

Monitoring Point: SSW7 (downstream)						
Parameter	Count	Minimum	Mean	Maximum		
Potassium, total (mg/l)	10	15.7	169	518		
Sodium, total (mg/l)	8	38.5	85.4	166		
pH (units)	10	7.1	7.7	8.2		
Electrical Conductivity (µS/cm)	8	733	1364	2460		
Alkalinity as CaCO3 (mg/l)	8	180	231	310		
Ammoniacal-Nitrogen as N (mg/l)	10	<0.05	-	0.482		
Chloride (mg/l)	10	62	160	356		
Sulphate as SO4 (mg/l)	10	83.5	179	397		
Selenium (total) (mg/l)	10	<0.0008	-	<0.005		
Hexavalent Chromium (mg/l)	9	<0.02	<0.02	<0.02		
Arsenic (total) (mg/l)	8	<0.005	-	0.021		
Phenols (mono) (mg/l)	8	<0.01	<0.01	<0.01		

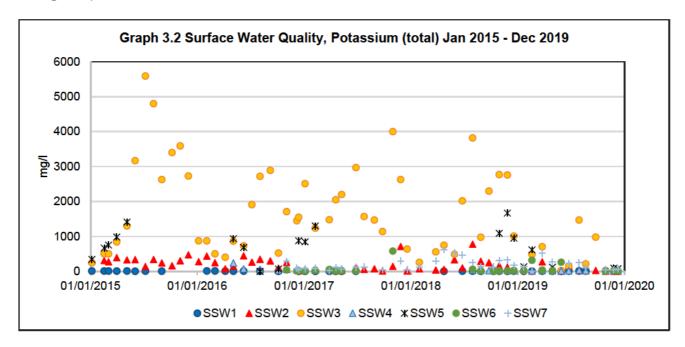
pH – Graph 3.1 presents the pH of surface water from 2015 to 2019. In 2019 the upstream pH, as monitored at SSW1 and SSW4, ranged between pH7.4 and pH8.3. South Pit CKD leachate is characterised by high alkalinity with pH in the range pH11 to pH13. In 2019, a single elevated pH value, above the upstream maximum of pH8.3, was recorded at SSW2 (pH8.6 in March 2019). The downstream surface water samples at SSW2 and SSW3 recorded slightly lower and more consistent pH in 2019 than in 2017/18. All 2019 data remained within the UK freshwater quality standard range of pH6-pH9 and there were no exceedances of the SSW6 assessment limit (pH8.6) or compliance limit (pH9).



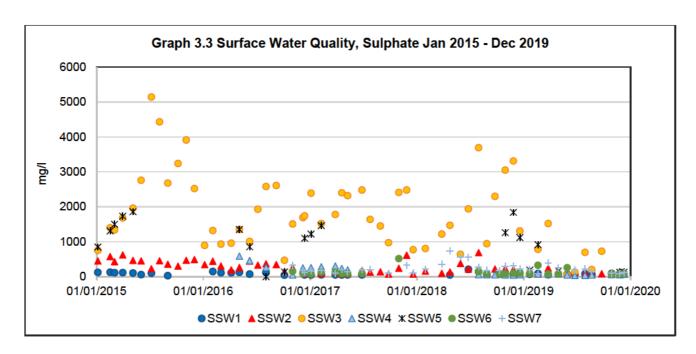
Potassium – Graph 3.2 presents potassium concentrations in surface water from 2014 to 2019. In 2019, the highest potassium concentrations are recorded at SSW3, as in previous years. However, the 2019 concentrations are significantly lower than in previous years, with an average potassium concentration of 347mg/l, compared to a 2018 average of 1611mg/l. Historically, elevated potassium concentrations at this location have been attributed to leachate outbreaks flowing over ground as a result of heavy rainfall and reaching the eastern marsh drain. Construction of the leachate collection system in 2014/15 aimed to reduce the incidence of leachate seepages from South Pit Phase 3 and peak concentrations subsequently reduced slightly. The data record shows a seasonal fluctuation in concentrations, with lower concentrations observed in winter months presumably due to higher surface water flow conditions affording greater dilution.

There are no assessment or compliance limits for potassium.

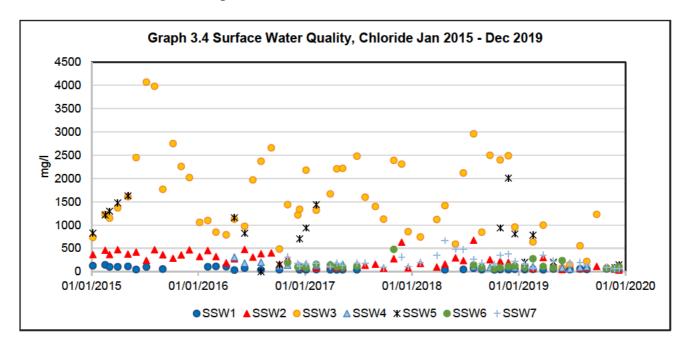
It is noted that the potassium analysis is for 'total' potassium and could be influenced by the inclusion of sediment in low flow conditions. Analysis of 'dissolved' potassium, alongside 'total' potassium, commenced during 2019; the results will be reviewed within the 2020 AMR.



Sulphate – Graph 3.3 presents sulphate concentrations in surface water from 2015 to 2019. The data follow similar trends as observed for potassium, with the highest concentrations recorded at midstream SSW3. As for potassium, concentrations of sulphate are significantly lower in 2019 at SSW3 than in previous years (2018 average: 1880mg/l; 2019 average: 377mg/l). 2019 concentrations at the downstream compliance points remained below the SSW2 assessment limit (883mg/l) and below the SSW6 compliance limit (400mg/l).

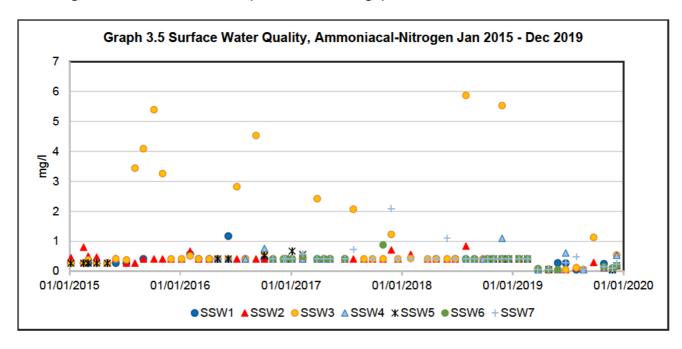


Chloride – Graph 3.4 presents chloride concentrations in surface water from 2015 to 2019; these follow comparable trends to sulphate and potassium. The highest concentrations in 2019 continued to be observed at mid-stream SSW3, although, as for other parameters, chloride concentrations were significantly lower than in previous years (2018 average: 1651mg/l; 2019 average: 363mg/l). Upstream concentrations at SSW1 and SSW4 remained relatively low in 2019 at <125mg/l. There was one slight exceedance of the SSW6 compliance limit (250mg/l) in February 2019, with a recorded concentration of 279mg/l; the repeat sample collected in March 2019 reported a concentration of 113mg/l, below both the assessment and compliance limits. It is noted that the SSW6 assessment limit (162mg/l) was exceeded again in May 2019 (239mg/l); all other 2019 results were below 120mg/l. The SSW2 assessment limit of 399mg/l was not exceeded in 2019, with a maximum concentration of 305mg/l.

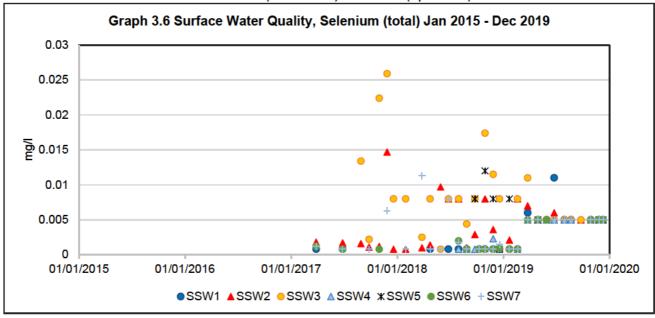


Ammoniacal-Nitrogen - Graph 3.5 presents ammoniacal-nitrogen concentrations in surface water from 2015 to 2019. The laboratory transition from ALS to DETS in March 2019 resulted in a reduction in the ammoniacal-nitrogen LRL from 0.41mg/l to 0.05mg/l. Despite this reduction, the majority of results in 2019 remained below the LRL of 0.05mg/l. Ammoniacal-nitrogen was recorded at low concentrations in surface water at all

monitoring points on at least one occasion in 2019, with comparable concentrations up-gradient and downgradient of the landfills. The highest ammoniacal-nitrogen concentration recorded in 2019 was 1.13mg/l at SSW3; this remains below the maximum freshwater quality standard of 2.5mg/l. The SSW2 assessment limit of 1.29mg/l was not exceeded in 2019 (maximum: 0.294mg/l).



Selenium – Graph 3.6 presents selenium concentrations in surface water from 2015 to 2019. The LRL for selenium was revised to 0.005mg/l in 2019 as a result of the laboratory transition and the majority of 2019 results were reported as below the LRL. Isolated, peak selenium concentrations recorded at SSW3 were lower in 2019 than in previous years and all concentrations at SSW2 and SSW6 remained below the relevant assessment and compliance limits. However, the UK Drinking Water Standard of 0.01mg/l was marginally exceeded in 2019 on one occasion at SSW3 (midstream) and SSW1 (upstream).



Arsenic – arsenic (filtered) is a compliance parameter for SSW6 with a compliance limit value 0.025mg/l. Historic surface water monitoring has been for total arsenic, rather than filtered content, with filtered analysis commencing in 2019. The 2019 results at SSW6 ranged from <0.005mg/l to 0.007mg/l, significantly below the compliance limit. In 2019 arsenic (filtered) was detected above the LRL at the majority of monitoring points on at least one occasion with the highest concentrations recorded at SSW3 (maximum: 0.027mg/l), SSW7

(maximum: 0.019mg/l) and **SSW2** (maximum: 0.016mg/l). A single result (**SSW3**, 0.027mg/l) marginally exceeded the most stringent UK standard for surface water quality of 0.025mg/l.

**Phenol** – the 2017 Phase 3 HRA Review recommended a preliminary assessment limit for phenol of 7.7mg/l at **SSW2**, to be reviewed after additional upstream monitoring data became available. In 2019, phenol was not detected above the LRL of 0.01mg/l at any monitoring point except upstream **SSW\$1** (maximum 0.021mg/l).

**Chromium (VI)** – the 2017 Phase 3 HRA Review recommended an assessment limit for hexavalent chromium of 0.002mg/l at **SSW2.** In 2019, as in 2018, all sample results for all monitoring points remained below the LRL of 0.001mg/l or 0.02mg/l.

#### 4.4.1 Surface Water Summary

Surface water quality in the perimeter drains at South Pit landfills is affected by very poor flow conditions and the historic land use of Swanscombe Peninsula. Lateral seepage and surface flow of CKD leachate can potentially impact surface water quality, and this is particularly evident at **SSW3**. Any visual evidence of leachate seepages is recorded during monitoring visits. 2019 monitoring data are generally comparable to previous years although peak concentrations at **SSW3** are lower than in recent years, possibly due to enhanced perimeter leachate collection within the Phase 3 leachate management system. The monitoring undertaken in accordance with the landfill Permit and CR/EMP is focussed on CKD leachate parameters but it is not possible to attribute individual incidents of elevated concentrations to a specific (regulated or pre-regulation) CKD disposal area. Recently introduced compliance and assessment limits are used to provide an indication of increasing concentrations above the background and initiate a response. The limits remain under review and will be fully implemented once works to improve the ditch network are completed; this work is due in 2020. In February 2019 there was a single, slight exceedance of the chloride compliance limit at **SSW6**; the repeat sample collected in March 2019 had a concentration below both the assessment and compliance limits.

Low rainfall and low flow conditions prevented samples being taken from some points on all monitoring occasions in 2019, as in previous years, and some samples are concluded to be non-representative with little or no flow. It is recommended that all metals continue to be analysed for dissolved content rather than total content to minimise the impact of any sediment collected during low flow conditions.

#### 4.5 Groundwater

#### 4.5.1 Elevation

**South Pit and Surge Pile** – groundwater levels are monitored quarterly at boreholes **EW4/12**, **EW5R/14**, **EW6/14** and **G13**. Groundwater levels from 2015 to 2019 are presented on **Graph 4.1**, with 2019 data summarised in **Table 4.1**.

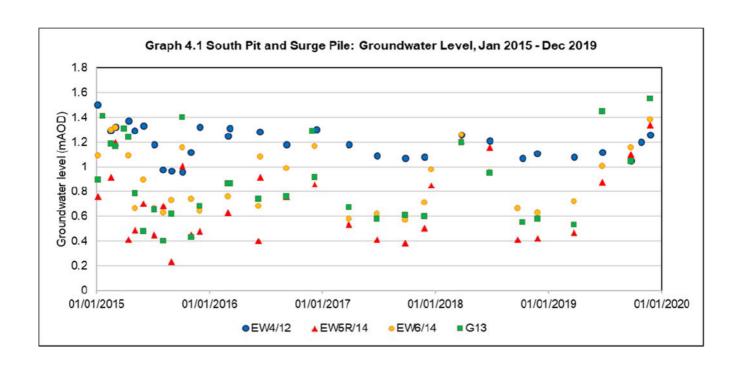


Table 4.1 – South Pit and Surge Pile: 2019 Groundwater Level Statistics (Quarterly Monitoring)

Manitoring Daint	2019 Groundwater Level Statistics (mAOD)				
Monitoring Point	Minimum	Mean	Maximum		
EW4/12	1.05	1.15	1.26		
EW5R/14	0.47	1.33	2.61		
EW6/14	0.72	1.41	2.51		
G13	0.53	1.15	1.55		

Groundwater levels in 2019 remained low, with mid and down-gradient boreholes influenced by the adjacent tidal River Thames. **EW4/12** is up-gradient of the site, beyond the limit of tidal influence of the river and records the most consistent groundwater levels. The 2019 groundwater level data are generally comparable to previous years.

South Pit Phase 3 – groundwater levels are monitored monthly at down-gradient boreholes G11 and EW7/14 and quarterly at up-gradient boreholes G13 and SA5944. The monthly results at G11 and EW7/14 are used to calculate an average groundwater level for leachate level compliance assessment. Groundwater levels from 2015 to 2019 are presented on Graph 4.2, with 2019 data summarised in Table 4.2. Previous studies have confirmed that groundwater levels at the down-gradient Phase 3 monitoring boreholes are tidally influenced by the River Thames. The monitoring aims to sample groundwater quality and record water levels within two hours after low tide to represent an outward groundwater flow direction from the site towards the river. However, this is not always possible due to tide times and sample collection logistics.

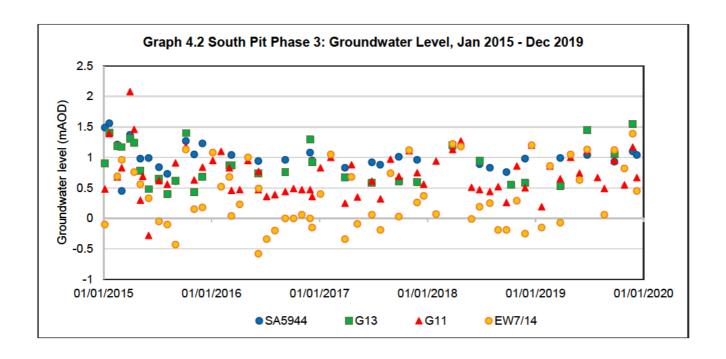


Table 4.2 - South Pit Phase 3: 2019 Groundwater Level Statistics

Monitoring Daint	2019 Groundwater Level Statistics (mAOD)							
Monitoring Point	Count Minimum Mean Maximu							
G13	4	0.53	1.15	1.55				
SA5944	5	0.93	1.02	1.10				
G11	12	0.19	0.75	1.17				
EW7/14	11	-0.15	0.66	1.39				

In 2019, as in previous years, borehole **EW7/14** shows the greatest variability in groundwater levels due to tidal influence, with the 2019 range reported as -0.15mAOD to 1.39mAOD. Groundwater levels are comparable with previous years and indicate a generally northerly flow direction towards the River Thames, with tidal influence beneath the northern part of the site.

## 4.5.2 Groundwater Quality - Key Parameters

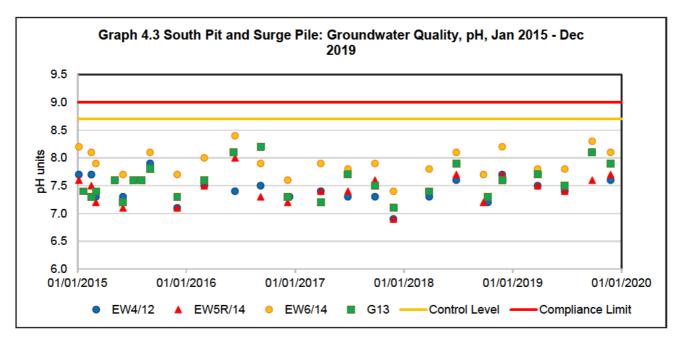
South Pit & Surge Pile – Groundwater quality is monitored quarterly within the four perimeter boreholes (EW4/12 located up-gradient of the site, G13 located mid-gradient and EW5R/14 and EW6/14 located downgradient of the site). 2019 statistics are presented in Table 4.3 below.

Table 4.3 – South Pit & Surge Pile: 2019 Groundwater Quality Statistics						
Monitoring Point: EW4/12 (up-gradi	ent)					
Parameter	Count	Minimum	Mean	Maximum		
Potassium, filtered (mg/l)	4	37.9	44.9	51.2		
Sodium, filtered (mg/l)	2	312	339	365		
pH (units)	4	7.4	7.7	8.1		
Electrical Conductivity (µS/cm)	4	2940	3015	3140		
Alkalinity as CaCO3 (mg/l)	4	690	736	790		
Ammoniacal-Nitrogen as N (mg/l)	2	1.34	1.85	2.36		
Chloride (mg/l)	2	492	534	575		
Sulphate as SO4 (mg/l)	4	318	353	383		
Selenium, filtered (mg/l)	4	<0.005	<0.005	<0.005		
Arsenic, filtered (mg/l)	2	<0.005	<0.005	<0.005		
Monitoring Point: G13 (mid-gradient	t)					
Parameter	Count	Minimum	Mean	Maximum		
Potassium, filtered (mg/l)	4	51.8	93.7	133		
Sodium, filtered (mg/l)	1	474	474	474		
pH (units)	4	7.5	7.8	8.1		
Electrical Conductivity (µS/cm)	4	2030	2705	3410		
Alkalinity as CaCO3 (mg/l)	1	485	485	485		
Ammoniacal-Nitrogen as N (mg/l)	2	0.203	1.34	2.47		
Chloride (mg/l)	2	291	559	826		
Sulphate as SO4 (mg/l)	4	133	203	250		
Selenium, filtered (mg/l)	4	<0.005	<0.005	<0.005		
Arsenic, filtered (mg/l)	4	0.006	0.013	0.02		
Monitoring Point: EW5R/14 (down-g	gradient)					
Parameter	Count	Minimum	Mean	Maximum		
Potassium, filtered (mg/l)	4	96.1	105	121		
Sodium, filtered (mg/l)	2	960	1070	1180		
pH (units)	4	7.4	7.6	7.7		
Electrical Conductivity (µS/cm)	3	8230	8810	9600		
Alkalinity as CaCO3 (mg/l)	4	515	579	720		
Ammoniacal-Nitrogen as N (mg/l)	2	2.57	4.4	6.3		
Chloride (mg/l)	2	2070	2105	2140		
Sulphate as SO4 (mg/l)	4	310	352	371		
Selenium, filtered (mg/l)	4	<0.005	<0.005	<0.005		
Arsenic, filtered (mg/l)	4	<0.005	<0.005	<0.005		

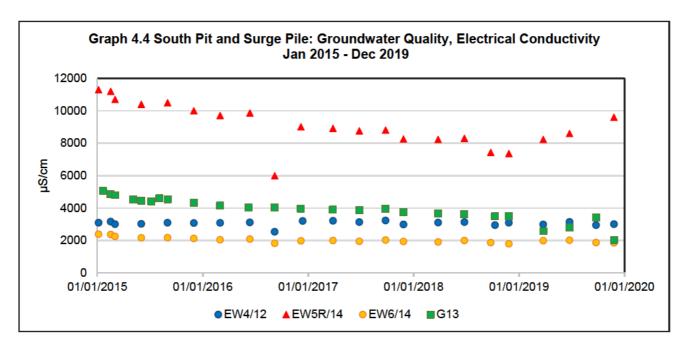
Monitoring Point: EW6/14 (down-gradient)					
Parameter	Count	Minimum	Mean	Maximum	
Potassium, filtered (mg/l)	4	18.4	20.1	21.7	
Sodium, filtered (mg/l)	2	213	240	266	
pH (units)	4	7.8	8.0	8.3	
Electrical Conductivity (µS/cm)	4	1850	1925	2010	
Alkalinity as CaCO3 (mg/l)	4	380	418	500	
Ammoniacal-Nitrogen as N (mg/l)	2	<0.05	-	0.134	
Chloride (mg/l)	2	307	318	328	
Sulphate as SO4 (mg/l)	4	158	182	197	
Selenium, filtered (mg/l)	4	<0.005	<0.005	<0.005	
Arsenic, filtered (mg/l)	4	<0.005	<0.005	<0.005	

Graphs 4.3 to 4.8 present concentrations in groundwater of the following key leachate indicator parameters: pH, electrical conductivity, potassium, sulphate, selenium (filtered), arsenic (filtered) and alkalinity. The EMP/CR introduced control levels and compliance limits for pH, potassium, selenium, arsenic and alkalinity at down-gradient boreholes EW5R/14 and EW6/14. Borehole EW4/12 is up-gradient of the site and representative of background groundwater quality. It is recognised that groundwater within the mid and down-gradient boreholes is strongly influenced by saline intrusion from the tidal River Thames. For the purposes of the graphs, values below the LRL are assumed to equal the LRL.

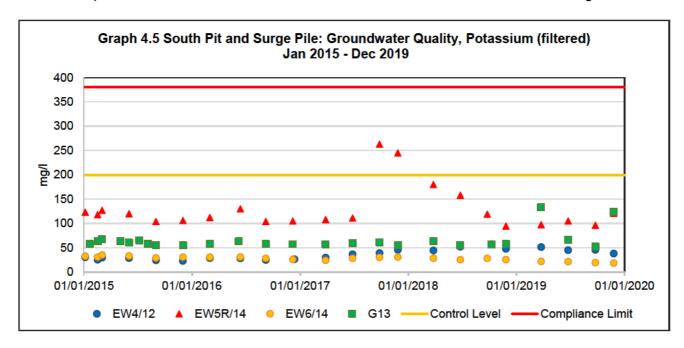
pH – Graph 4.3 presents the pH of groundwater samples from 2015 to 2019. In 2019 the pH of groundwater was slightly alkaline, ranging from pH7.4 to pH8.3, which is comparable to previous years. The highest pH is consistently recorded at down-gradient borehole EW6/14. In 2019, as in previous years, the results at the compliance boreholes EW5R/14 and EW6/14 were consistently below the EMP/CR control level (pH8.7) and compliance limit (pH9.0).



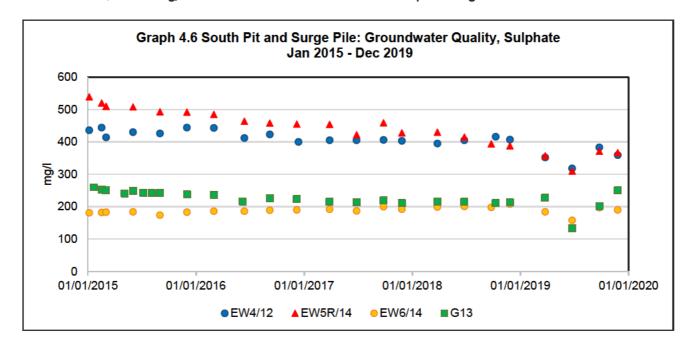
Electrical conductivity – Graph 4.4 presents the electrical conductivity of groundwater from 2015 to 2019. In 2019 electrical conductivity was consistently highest at EW5R/14, with a maximum of  $9600\mu$ S/cm; the declining trend observed in recent years did not continue in 2019, with conductivity gradually increasing during the year. Electrical conductivity of groundwater at up-gradient EW4/12 continued to be higher than the level recorded at down-gradient borehole EW6/14, indicating an off-site source. The electrical conductivity at down-gradient EW6/14 remains consistent, with an average value of  $1925\mu$ S/cm in 2018. Although there are no groundwater compliance limits for electrical conductivity, the conductivity of groundwater both up-gradient and down-gradient of the site frequently exceeded the UK Drinking Water Standard of  $2500\mu$ S/cm in 2019.



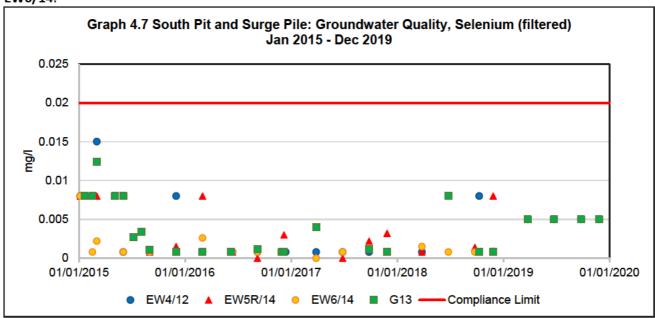
Potassium – Graph 4.5 presents the potassium concentrations in groundwater from 2015 to 2019. The elevated potassium concentrations recorded in 2018 at borehole EW5R/14 were not observed in 2019, with concentrations back to 2017 levels. In 2019 the highest potassium concentration was recorded at up-gradient borehole G13 (maximum: 133mg/l), with is a peak for the five-year dataset. A potassium control level of 200mg/l and a compliance limit of 380mg/l have been imposed by the EMP/CR at EW5R/14 and EW6/14. 380mg/l represents the typical concentration of potassium in seawater and therefore the background level for the tidally influenced boreholes. There was no exceedance of these assessment levels during 2019.



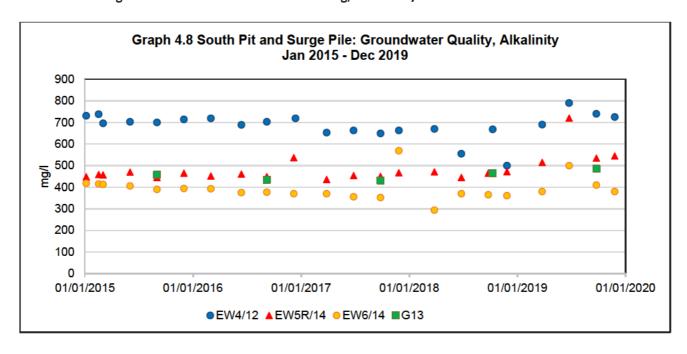
Sulphate – Graph 4.6 presents the sulphate concentrations in groundwater from 2015 to 2019. In 2019 the highest sulphate concentrations were recorded at upgradient EW4/12 (maximum: 383mg/l) and downgradient EW5R/14 (maximum: 371mg/l), as in previous years. These concentrations remain below the freshwater EQS of 400mg/l. There are no assessment limits for sulphate in groundwater.



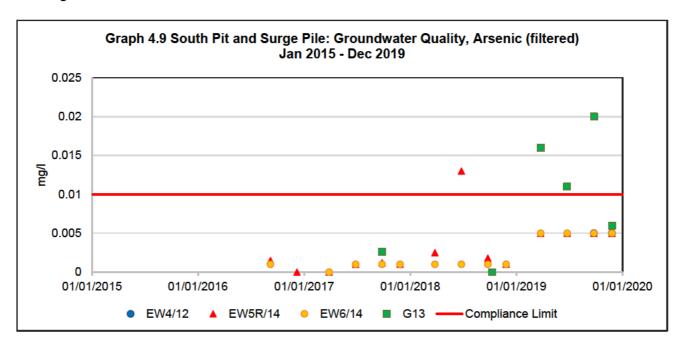
Selenium (filtered) – Graph 4.7 presents the selenium concentrations in groundwater from 2015 to 2019. The laboratory transition to DETS in 2019 resulted in a revision of the selenium LRL to 0.005mg/l. The 2019 data confirm that all selenium concentrations in groundwater remained below the LRL (<0.005mg/l) and therefore concentrations were below the compliance limit of 0.02mg/l at down-gradient boreholes EW5R/14 and EW6/14.



Alkalinity – Graph 4.8 presents the alkalinity of groundwater from 2015 to 2019 and confirms that 2019 data were generally comparable to recent years, with the exception of a peak in concentrations in all boreholes in June 2019. As in previous years, the highest alkalinity levels in 2019 were recorded at up-gradient borehole EW4/12 (maximum: 790mg/l). There was no exceedance of the groundwater control level (725mg/l) or compliance limit (854mg/l) at the down-gradient compliance boreholes in 2019. The maximum alkalinity recorded down-gradient of the site in 2019 was 720mg/l at EW5R/14 in June.



Arsenic – Graph 4.9 presents the arsenic (filtered) concentrations in groundwater from 2015 to 2019. In 2019 all concentrations remained below the LRL of 0.05mg/l in all boreholes except up-gradient G13. Concentrations at G13 ranged from 0.006mg/l to 0.02mg/l which are significantly higher than recorded in previous years. Arsenic was not detected at the down-gradient boreholes EW5R/14 and EW6/14; therefore there was no exceedance of the groundwater compliance limit of 0.01mg/l which is equivalent to the UK Drinking Water Standard.



Hazardous Substances – groundwater samples were collected for annual hazardous substance analysis on 25/09/2019 and the substances listed below were detected above the laboratory reporting limit. Arsenic has only been detected in up-gradient borehole G13. The remaining hazardous substances were detected at trace concentrations, only marginally above the LRL, generally in both up-gradient and down-gradient boreholes and therefore are not considered significant.

Arsenic (filtered) G13: 0.020mg/l
Arsenic (total) G13: 0.038mg/l

Pyrene EW5R/14: 0.03μg/l; G13: 0.02μg/l
 Fluoranthene EW5R/14: 0.02μg/l; G13: 0.01μg/l

Isophorone EW4/12: 0.2µg/l

# South Pit Phase 3

Groundwater quality is monitored quarterly within the four perimeter boreholes (up-gradient: G13 and SA5944; down-gradient: G11 and EW7/14). 2019 statistics are presented in Table 4.4 below.

Table 4.4 – South Pit Phase 3: 2019 Groundwater Quality Statistics

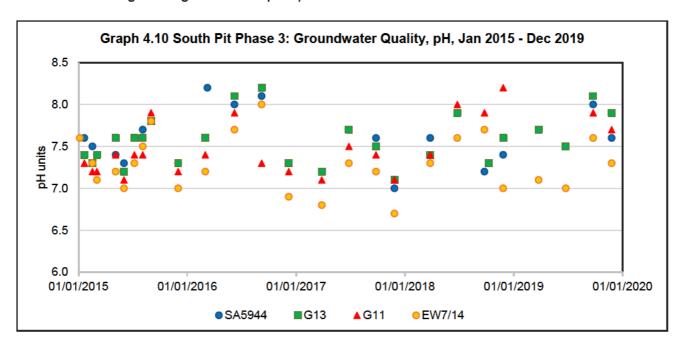
Monitoring Point: G13 (up-gradient)					
Parameter	Count	Minimum	Mean	Maximum	
Potassium, total (mg/l)	4	61	97.3	134	
Sodium, total (mg/l)	1	636	636	636	
pH (units)	4	7.5	7.8	8.1	
Electrical Conductivity (µS/cm)	4	2030	2705	3410	
Alkalinity as CaCO3 (mg/l)	1	485	485	485	
Ammoniacal-Nitrogen as N (mg/l)	2	0.203	1.34	2.47	
Chloride (mg/l)	2	291	559	826	
Sulphate as SO4 (mg/l)	4	133	203	250	
Selenium, total (mg/l)	4	<0.005	<0.005	<0.005	
Chromium, total (mg/l)	4	<0.005	-	0.006	
Monitoring Point: SA5944 (up-gradie	ent)				
Parameter	Count	Minimum	Mean	Maximum	
Potassium, total (mg/l)	2	54.9	56.2	57.5	
Sodium, total (mg/l)	1	1590	1590	1590	
pH (units)	2	7.6	7.8	8.0	
Electrical Conductivity (µS/cm)	2	2940	7770	12600	
Alkalinity as CaCO3 (mg/l)	1	880	880	880	
Ammoniacal-Nitrogen as N (mg/l)	2	0.267	0.30	0.332	
Chloride (mg/l)	2	2650	2880	3110	
Culphata as COA (mag/I)	4	366	427	481	
Sulphate as SO4 (mg/l)					
Selenium, total (mg/l)	4	<0.005	-	0.006	

Monitoring Point: G11 (down-gradient)						
Parameter	Count	Minimum	Mean	Maximum		
Potassium, total (mg/l)	2	30	31.4	32.8		
Sodium, total (mg/l)	1	1090	1090	1090		
pH (units)	2	7.7	7.8	7.9		
Electrical Conductivity (µS/cm)	4	6110	6443	6870		
Alkalinity as CaCO3 (mg/l)	1	530	530	530		
Ammoniacal-Nitrogen as N (mg/l)	2	3.14	3.15	3.16		
Chloride (mg/l)	2	1440	1485	1530		
Sulphate as SO4 (mg/l)	4	168	241	281		
Selenium, total (mg/l)	4	<0.005	-	0.008		
Chromium, total (mg/l)	4	<0.005	<0.005	<0.005		

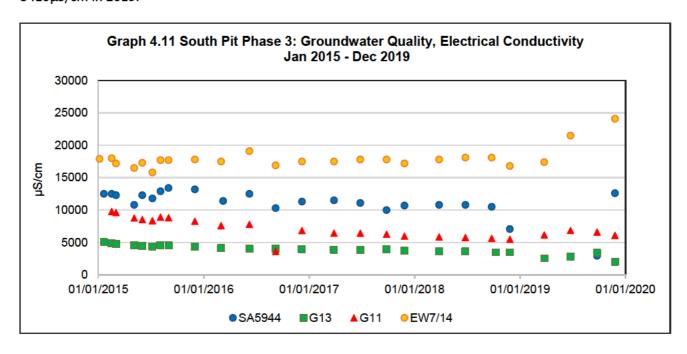
Monitoring Point: EW7/14 (down-gr	adient)			
Parameter	Count	Minimum	Mean	Maximum
Potassium, total (mg/l)	4	98.6	127	166
Sodium, total (mg/l)	1	2960	2960	2960
pH (units)	4	7.0	7.3	7.6
Electrical Conductivity (µS/cm)	3	17400	21000	24100
Alkalinity as CaCO3 (mg/l)	1	530	530	530
Ammoniacal-Nitrogen as N (mg/l)	2	7.47	8.99	10.5
Chloride (mg/l)	2	6180	6345	6510
Sulphate as SO4 (mg/l)	4	537	620	663
Selenium, total (mg/l)	4	<0.005	-	0.025
Chromium, total (mg/l)	4	<0.005	<0.005	<0.005

Graphs 4.9 to 4.14 present concentrations in groundwater of the following key leachate indicator parameters: pH, electrical conductivity, potassium (total), sulphate, selenium (total) and chromium (total). Monitoring boreholes G13 and SA5944 are up-gradient of the site and boreholes G11 and EW7/14 are the down-gradient compliance points with associated permit compliance limits. The influence of saline intrusion on groundwater quality increases with proximity to the River Thames. For the purposes of the graphs, values below the LRL are assumed to equal the LRL.

pH – Graph 4.10 presents the pH of groundwater from 2015 to 2019 and confirms that groundwater is near-neutral with pH ranging from pH 7.0 to pH 8.1 in 2019. This is comparable to previous years, with up-gradient and down-gradient boreholes displaying similar pH values with no evident impact of highly alkaline CKD leachate on down-gradient groundwater quality.

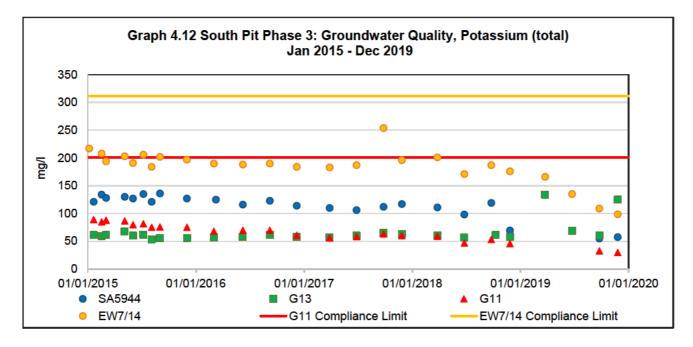


Electrical conductivity – Graph 4.11 presents the electrical conductivity of groundwater from 2015 to 2019. The electrical conductivity of groundwater has historically been consistent, however 2019 results display greater variation with increasing conductivity at down-gradient EW7/14 to a five-year maximum of 24,100μS/cm by November 2019. Groundwater quality at EW7/14 is strongly influenced by saline intrusion. The lowest electrical conductivity values are consistently recorded at up-gradient borehole G13, although values here frequently exceed the UK Drinking Water Standard of 2500μS/cm and ranged from 2030μS/cm to 3410μS/cm in 2019.

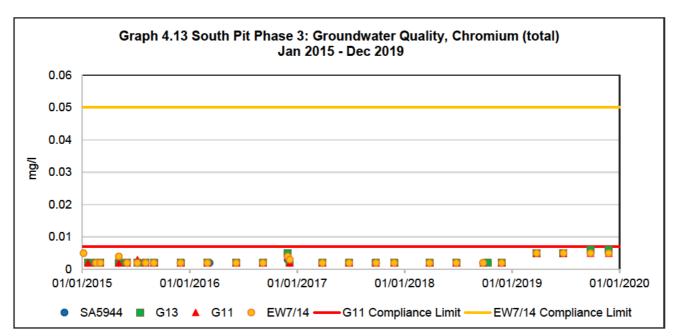


Potassium (total) – Graph 4.12 presents potassium concentrations in groundwater from 2015 to 2019. The 2019 potassium concentrations display greater variation than in previous years. Concentrations at downgradient borehole G11 remained relatively low (35mg/l) and the highest concentrations were generally recorded at down-gradient (tidal) borehole EW7/14, although concentrations fell during 2019 from 166mg/l to 98.6mg/l. It is noted that seawater has a typical potassium concentration of 380mg/l.

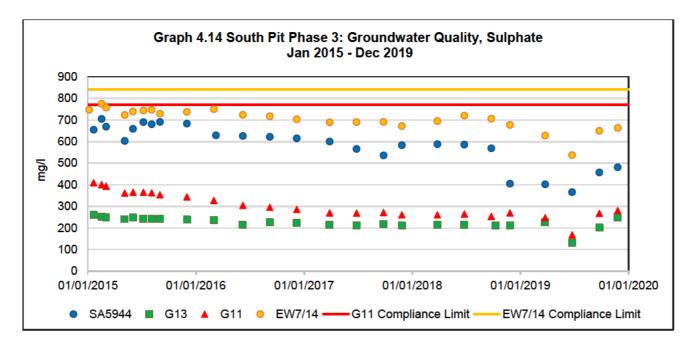
There was no exceedance of the permit compliance limits at boreholes G11 and EW7/14 in 2019.



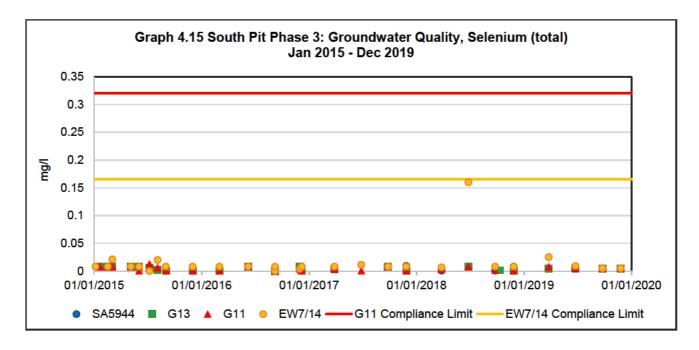
Chromium (total) – Graph 4.13 presents total chromium concentrations in groundwater from 2015 to 2019. In 2019, the LRL for chromium increased to 0.005mg/l as a result of the laboratory transition. All 2019 chromium concentrations in groundwater at the down-gradient boreholes remained below this LRL of 0.005mg/l; all results were therefore below the groundwater compliance limits of 0.007mg/l for borehole G11 and 0.05mg/l for borehole EW7/14. In 2019 chromium was only detected at up-gradient borehole G13 at low concentrations (0.06mg/l) on two occasions.



Sulphate – Graph 4.14 presents sulphate concentrations in groundwater from 2015 to 2019. Sulphate concentrations generally follow a similar trend to potassium and in 2019 all results remained below the groundwater compliance limits at G11 and EW7/14. The highest sulphate concentrations are recorded at EW7/14 (downgradient) and SA5944 (up-gradient), as previously observed. A slight, long-term downward trend in concentrations is observed at all boreholes.



Selenium (total) – Graph 4.15 presents total selenium concentrations in groundwater from 2015 to 2019. In 2019, the majority of results were below the laboratory reporting limit of 0.005mg/l and consistent with previous years. All results at G11 and EW7/14 were below the relevant groundwater compliance limits.



**Hazardous Substances** - groundwater samples were collected for hazardous substance analysis from all monitoring boreholes on 25/09/2019. The substances listed below were detected in groundwater at concentrations above the laboratory reporting limit.

Arsenic (filtered) G11: 0.007mg/l; G13: 0.020mg/l
 Arsenic (total) G11: 0.01mg/l; G13: 0.038mg/l

Fluoranthene
 Pyrene
 G13: 0.01µg/l
 G13: 0.02µg/l

The arsenic concentrations are comparable to 2018 data, with the highest concentrations recorded at upgradient **G13**. Concentrations of fluoranthene and pyrene at upgradient **G13** are at or marginally above the LRL and therefore are not considered significant.

## 4.5.3 Groundwater Summary

**South Pit and Surge Pile:** Groundwater quality beneath South Pit and Surge Pile landfill in 2019 remained generally comparable to previous years with evidence of impact from saline intrusion at down-gradient boreholes. There was no exceedance of the EMP/CR control levels and compliance limits at down-gradient boreholes **EW5R/14** and **EW6/14** in 2019.

**South Pit Phase 3:** Groundwater quality beneath South Pit Phase 3 remained generally comparable to previous years, with no exceedance of permit compliance limits in 2019. Groundwater quality is influenced by saline intrusion from the adjacent tidal River Thames and, as previously reported groundwater is not considered a primary receptor for the site.

## 4.6 Restored Surface Monitoring

#### 4.6.1 Settlement and stability

**South Pit and Surge Pile** – defects with the Site surface and slopes are Reported quarterly by exception and no issues were raised during the 2019 Reporting period. Survey of settlement pegs is carried out annually and comparison of levels shown below. Forty pegs were installed and surveyed in 2010 and of these 17 have been lost. Survey levels were taken for the points noted as rotten/broken and a programme for replacement and re-measure is in place. The maximum difference between 2019 and 2018 height measurement was 0.3m. **EMP/CR Table 22** has an assessment level +/-0.5m therefore no further action is required.

**South Pit Phase 3** – with regards to survey and settlement assessment the **South Pit Phase 3** Permit contains the following conditions:

- Condition 3.5.3(a) of the Permit requires an annual topographic survey and this was carried out in October 2019, drawing reference 1908046 Swanscombe Phase 3 October 2019-Sheet 1
- **Condition 4.2.2 (d)** requires the topographic survey to be included in the annual report. A copy has been included in the drawings section of this Report.
- Condition 4.2.2 (e) requires assessment of the void space used by waste deposit to be reported. This is not applicable for South Pit Phase 3.
- Condition 4.2.2 (f) requires assessment of settlement behaviour by comparison of levels between surveys. An Isopachyte drawing is included in this report, drawing reference 1908046 Swanscombe Phase 3 October 2019-Sheet 2. This shows that very little change in levels is evident. The 2019 isopachyte drawing compared data from 2019 topographic survey with data from the 2017 topographic survey. Results are shown as contours linking areas of lower, increased or no change in level. The majority of the site has remained at the same level and only minor changes (+/- 0.3m) noted elsewhere. Settlement pegs are also installed and monitored annually. It should be noted that a number of the pegs have been damaged or lost during works on South Pit and the measurements results of the remaining pegs may have been compromised. A review of the use of pegs as a settlement monitoring techniques will be undertaken

as part of the closure process. All results are below the nominal assessment level of -0.5m therefore settlement is not significant at **South Pit Phase 3**.

• Condition 4.2.2 (g) requires a calculation of remaining void space which is not applicable for South Pit Phase 3 landfill.

#### 5 Conclusions & Recommendations

#### 5.1 Landfill Gas

Landfill gas is not an issue at either of the South Pit landfills and results of monitoring at in waste monitoring points continues to confirm that LFG production is inhibited by the high pH and low carbon content of the waste.

Continue monitoring in accordance with **Permit** and **EMP/CR** requirements.

#### 5.2 Leachate

Leachate levels remained compliant throughout 2019 for both landfill units. Leachate quality is typical of a CKD waste leachate with elevated pH and high concentrations of potassium, chloride and sulphate. Leachate treatment is required for leachate collected in the perimeter drain at **South Pit Phase 3** and is fully commissioned, closing IC8 of Table S1.3.

Continue monitoring in accordance with **Permit** and **EMP/CR** requirements.

#### 5.3 Surface Water

Surface water is monitored at locations on the Swanscombe Main Drain and the marsh ditch network when sufficient flow is available for sampling. CKD leachate has impacted locations where rainfall has washed localised leachate emissions into the water course. Improvements to the perimeter of **South Pit Phase 3** have been proposed within a Surface Water Action Plan; this has been accepted by the Environment Agency with a Flood Risk Activity Permit issued in July 2019 and is due to be implemented in 2020. Monitoring should continue in accordance with **EMP/CR** and **Permit** requirements and Hydrogeological Risk Assessment Review recommendations.

The limited data set for those compliance parameters introduced in the **EMP/CR** remain in place for another year before formal review. The limits remain under review and will be fully implemented once works to improve the ditch network are completed. Low rainfall and low flow conditions prevented samples being taken from some points on all monitoring occasions and some samples are concluded to be non-representative with little or no flow.

## 5.4 Groundwater

Groundwater is not a primary receptor due to the influence of saline intrusion and historic land usage.

Continue monitoring in accordance with **Permit and EMP/CR** requirements. The limited data set for those compliance parameters introduced in the EMP/CR remain in place for another year before formal review. The limits remain under review and will be fully implemented once works to improve the ditch network are completed.

#### 5.5 Restored Surface

Restored surface monitoring involves a site inspection and survey results. Review of settlement peg monitoring for **South Pit and Surge Pile landfill** concludes that any change in measured levels is not significant (below the nominal assessment level of -0.5m). Settlement is assessed by isopachyte review of topographic surveys for **South Pit Phase 3** and no significant levels of settlement were noted.

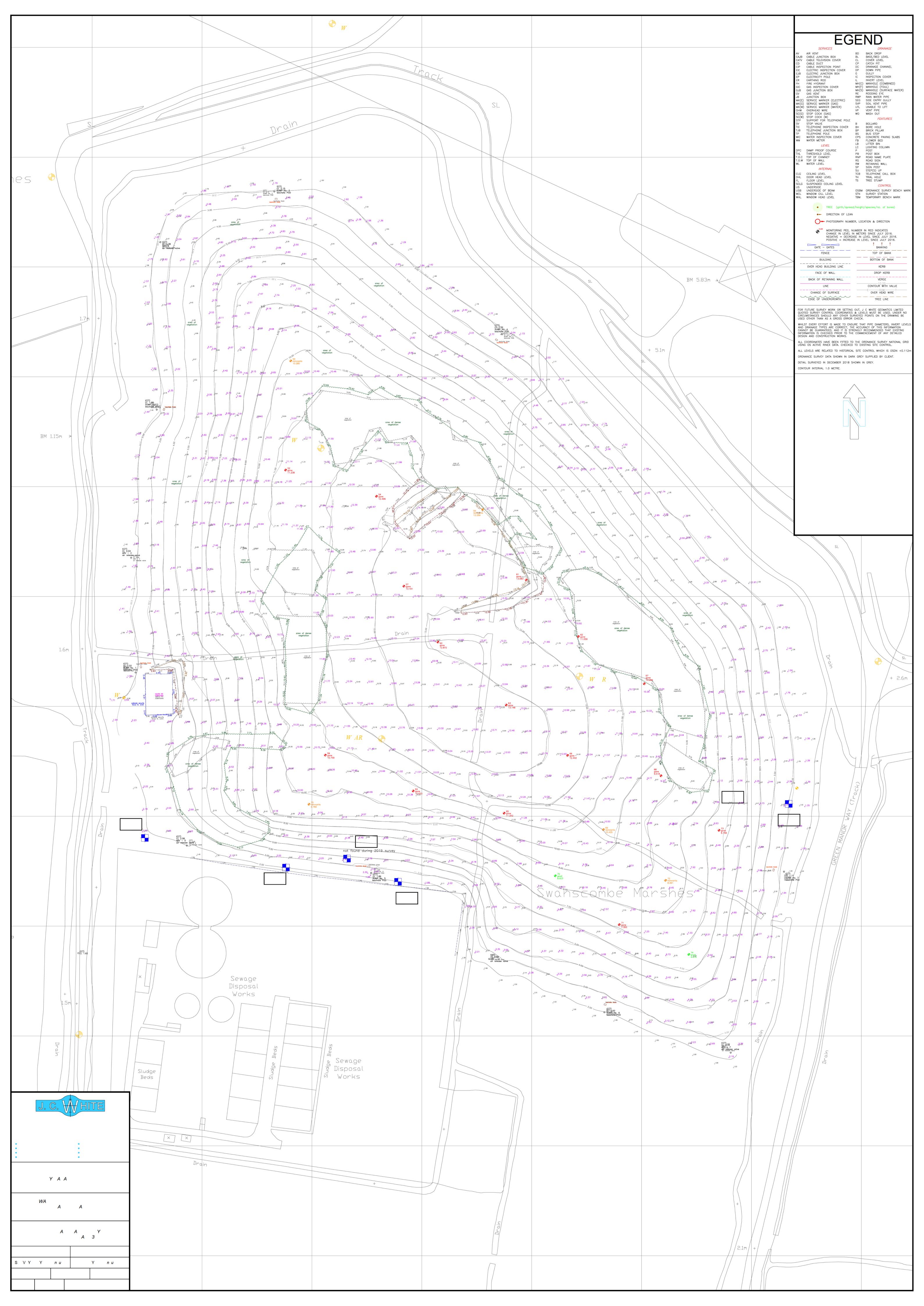
Replace and re-survey the damaged/lost settlement pegs on South Pit and Surge Pile landfill. Settlement monitoring to continue by use of settlement pegs only at this site. Annual topographic surveys and isopachyte drawings will continue at **South Pit Phase 3** landfill and the use of settlement pegs postponed until site is formally closed.

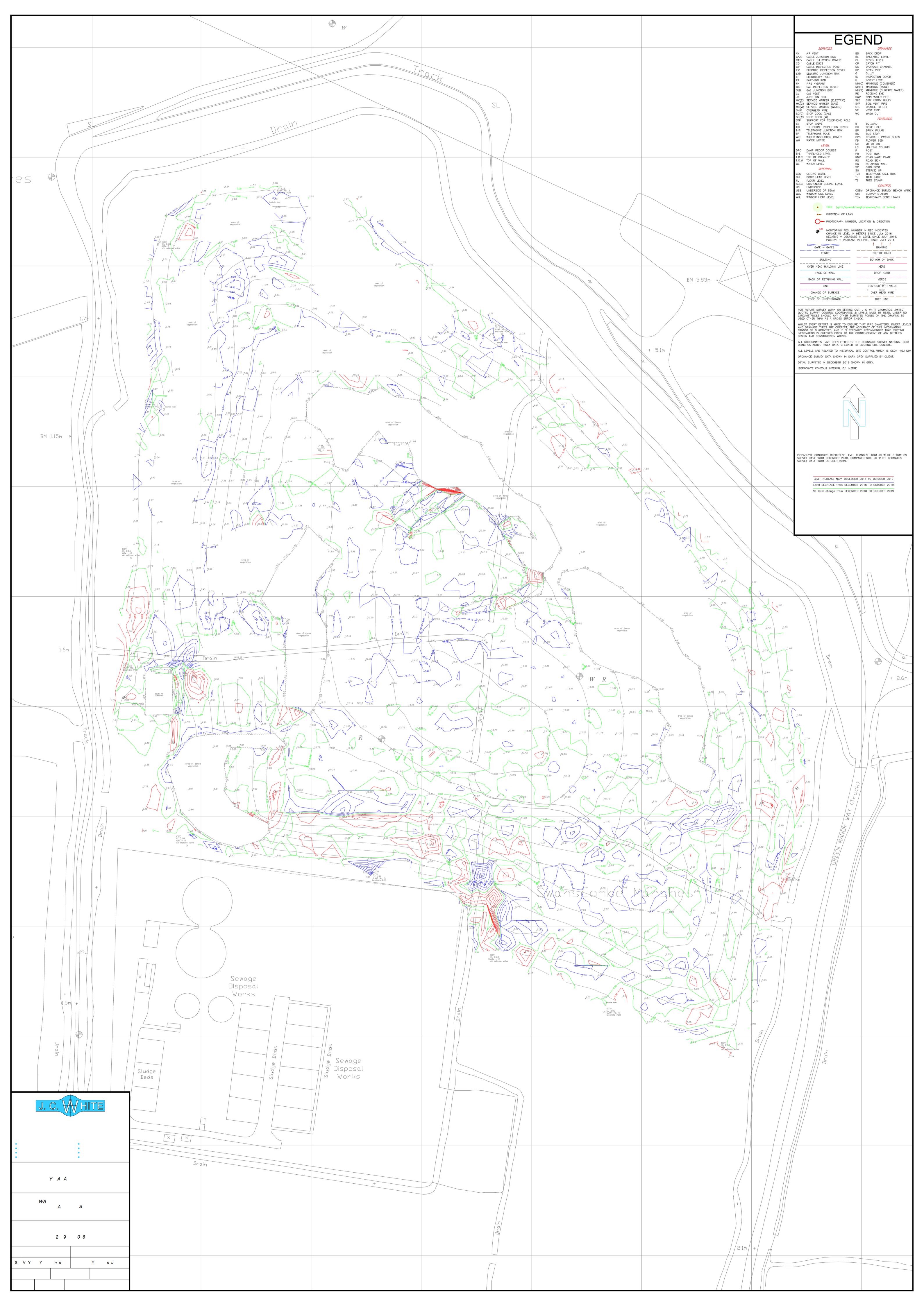
# **Drawings**

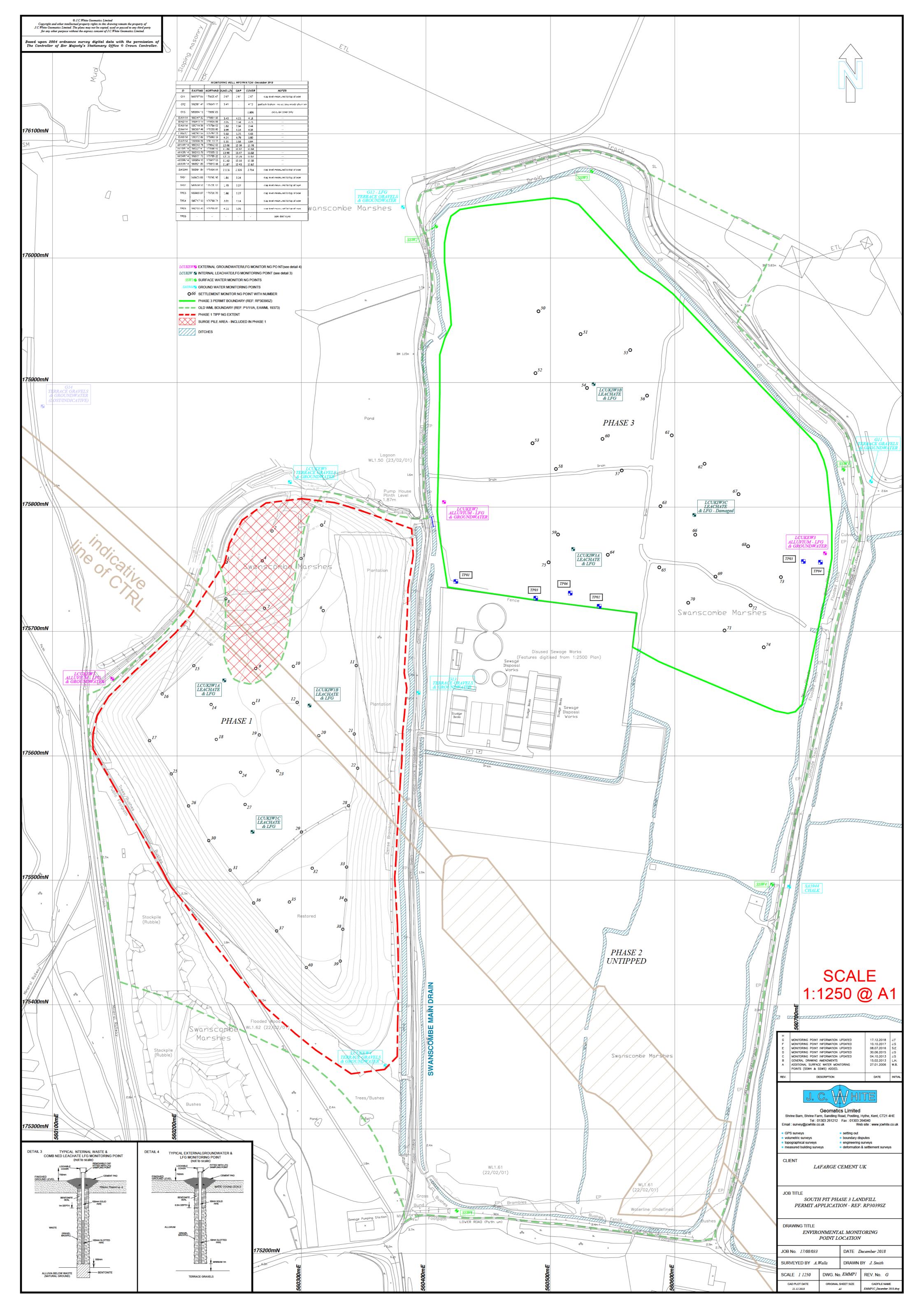
1908046 - Swanscombe 2019 - Sheet 1.Topo

1908046 - Swanscombe 2019 - Sheet 2.Isopachyte

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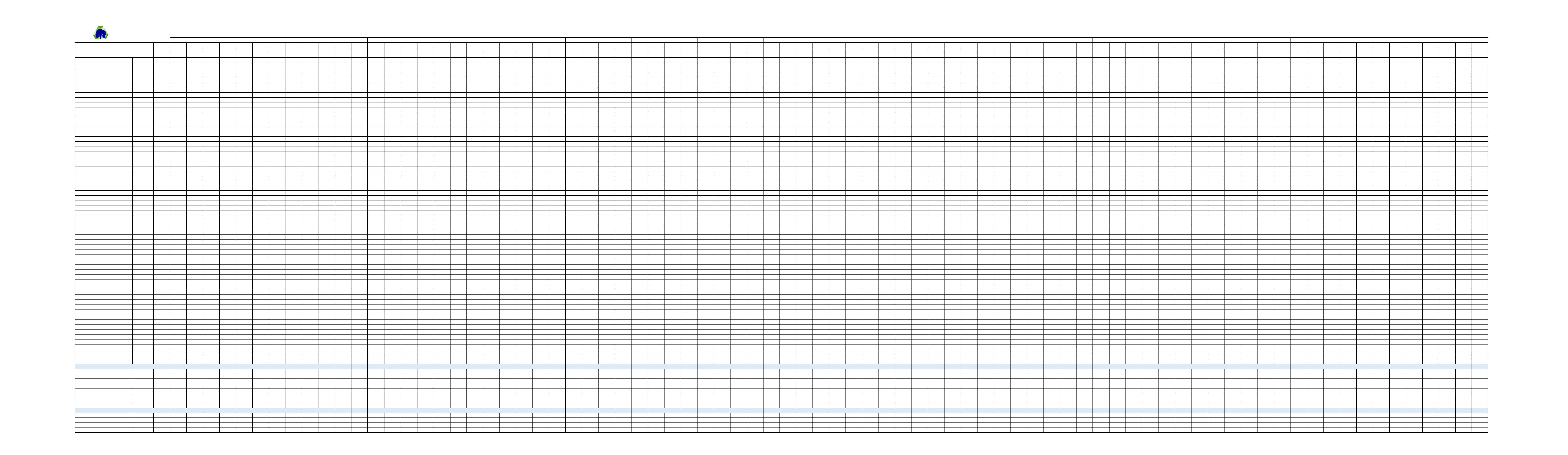


Appendix 1 – Raw Data (Hazardous substances displayed as laboratory raw data in the excel spreadsheet)	



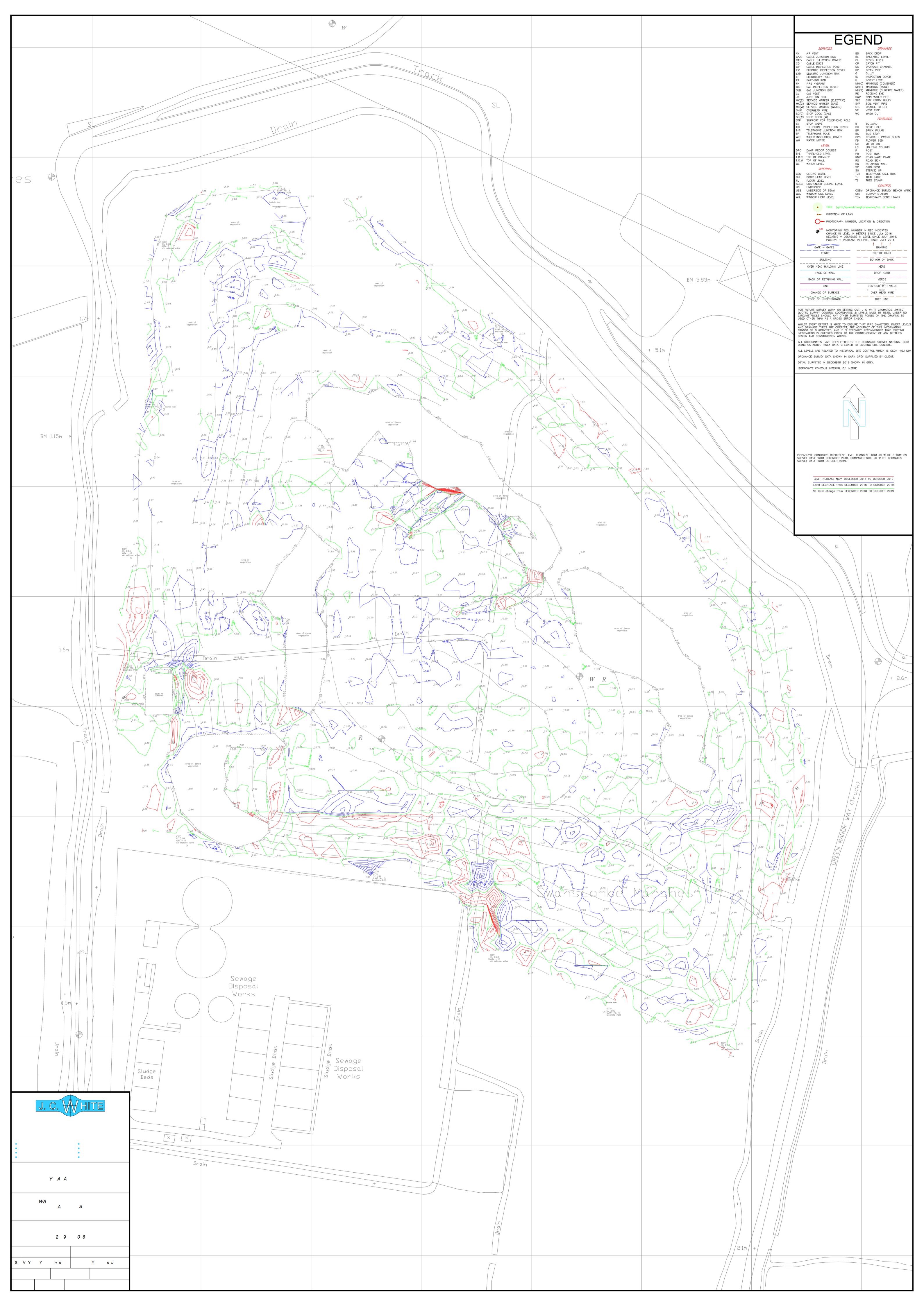
Date	Monitoring Point	Methane (CH4) %	Carbon Dioxide (CO2) %	Oxygen (O2) %	Rel Pressure (mb)	Atmospheric Pressure (mb)	H2S (ppm)
26/03/2019	IW1AR/14	0	(CO2) %	17.3	-0.84	1032	0
26/03/2019	IW1BR/14	0	0.2	13.9	-0.52	1031	0
26/03/2019	IW1CR/14	0	0.2	11.1	-0.6	1033	0
26/03/2019	IW3AR/14	0.3	0	7.3	-0.76	1033	1
26/03/2019	IW3BR/14	0.3	0.2	18.9	-0.83	1033	1
	•		0.2	6.5			1
26/03/2019	IW3CR/14	0			-0.88	1031	0
25/06/2019	IW1AR/14	0	0.2	19.8	0.24	1018	0
25/06/2019	IW1BR/14	0	0.4	16.7	0.26	1019	0
25/06/2019	IW1CR/14	0	0.2	17.7	0.21	1020	0
25/06/2019	IW3AR/14	0	0.1	19.8	0.22	1019	0
25/06/2019	IW3BR/14	0	0.1	20.1	0.22	1020	0
25/06/2019	IW3CR/14	0	0.1	20	0.21	1019	0
25/09/2019	IW1AR/14	0	0.1	19.7	0.21	1000	0
25/09/2019	IW1BR/14	0	0.1	15.4	0.19	1001	0
25/09/2019	IW1CR/14	0	0.1	14.3	0.21	1000	0
25/09/2019	IW3AR/14	0.2	0.1	14.2	0.17	1002	0
25/09/2019	IW3BR/14	0.2	0.1	19.1	0.21	1002	0
25/09/2019	IW3CR/14	0	0.1	20	0.1	1002	0
26/11/2019	IW1AR/14	0	0	16.7	0.21	994	0
26/11/2019	IW1BR/14	0	0	10	0.22	995	0
26/11/2019	IW1CR/14	0	0.1	15.6	0.26	995	0
26/11/2019	IW3AR/14	0.3	0.1	7.3	0.21	994	0
26/11/2019	IW3BR/14	0.2	0.1	19.4	0.22	994	0
26/11/2019	IW3CR/14	0	0.1	5.7	0.21	992	0

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Appendix 2 – Restored Surface	
Appendix 2 Restored Surface	



**South Pit & Surge Pile Condition Report** 

Date: 29.10.2019
Report carried out by: Beth Turner
Weather Conditions: Gld, Dy Amesphenic 1002 when
Any Other Notes:

Monitoring Point	Fit For Purpose?	Installed Depths	Dip	Base	Comments
achate Monitorin	g:				
IW1AR/14	yes	13 m	10.68	13.27	names need le winhis; lid works, no vegetat
IW1BR/14	yes	11.8m	DRY	11.52	names need we with lid works line work
IW1CR/14	yes	12 m	DRY	12.51	Re write name lid works get route cut back.
EW4/12	yes	16m	13.76	15.20	lid + partlock hare, pulled
EW5R/14	YUS	23.5m	5.2	23.12	lid + padoch on
EW6/14	yes	20 m	3.66	20.15.	71
her Monitoring:					
SSW1	yes	_	-	_	ion flow
SSW2	yes	e	_	_	Deep wake cut back okay
SSW3	No	-	-	-	no flow looks shagnant. Heavily swronnowed by reeds.
SSW4	No	_	-	-	no flow Swinned by reeds on all sides.
SSW5	No	_	-	-	very overgrown with reads - no flow, stagnant.
SSW6	No	_	_	_	no flow hearthy swrounded by reeds
SSW7	No	_	_	-	no flow havily swromded by

A		
Appendix 3 – Trace Gas Analysis		





# ANALYSIS OF THE TRACE LANDFILL GAS

#### **AT**

# South Pit, Phase 3 Landfill

Manor Way Swanscombe Dartford Kent, DA10 0LL

Commissioned by: Jess Woods

Of
CMS Enviro
No 1 The Roost
Ratling Road
Aylesham
Canterbury
Kent, CT3 3HL

Date of Survey: 2<sup>nd</sup> December 2019

Compiled By: David Godfrey

Project Scientist

# ANALYSIS OF THE TRACE LANDFILL GAS

#### **AT**

# South Pit, Phase 3 Landfill

Manor Way Swanscombe Dartford Kent, DA10 0LL

Commissioned by: Jess Woods

Of

## **CMS Enviro**

No 1 The Roost Ratling Road Aylesham Canterbury Kent, CT3 3HL

Date of Survey:	2 <sup>nd</sup> December 2019
Checked By:	Bruce Kester Team Leader MCerts Level II (TE1, 2, 3 & 4)
Signed:	

Dated: 2<sup>nd</sup> January 2020

## **CONTENTS**

- 1. INTRODUCTION
- 2. PLANT DESCRIPTION
- 3. SAMPLING PROCEDURES
- 4. RESULTS
- 5. DISCUSSION & CONCLUSION

#### **APPENDICES**:

APPENDIX A: Site Information & Preliminary Gas Measurements

APPENDIX B: Trace Gas Results

#### 1. INTRODUCTION

- 1.1 EnviroDat Limited was commissioned by Jess Woods, on behalf of CMS Enviro Ltd, to measure the trace gas, mercury, tetrachloroethane, tetrachloroethene and trimethylbenzene components from landfill gas located at South Pit, Kent. Sampling was performed on the 2<sup>nd</sup> December 2019.
- 1.2 The sampling was conducted in response to PPC Permit requirements (Permit No. EPR/RP3039SZ/V007). Monitoring was conducted with reference to the Environment Agency document 'Guidance for Monitoring Trace Components in Landfill Gas' (LFTGN 04).

#### 2. PLANT DESCRIPTION

2.1 Cement Kiln Dust waste has historically been deposited at South Pit Phase 3 landfill site.

#### 3. SAMPLING PROCEDURES

- 3.1 Trace gas sampling was performed from the well IW3CR14, with analysis for components identified in Table 1.1 of the EA LFTGN04 guidance note. General site information is presented in Appendix A.
- 3.2 Mixed bed, automated thermal desorption (ATD) tubes were used for sampling of the priority volatile organic species prior to analysis by gas chromatography with mass spectrometry (GC/MS), in accordance with EA recommendations and documented EnviroDat protocol, SPTGN04. Two tests and one blank were applied during the sampling. The results are

presented in Appendix B. The analytical component of the work was conducted at Marchwood Scientific Services (MSS), Manchester.

- 3.3 The LFTGN04 designated 'priority' carbonyl components (i.e. methanal and ethanal) were sampled dinitrophenylhydrazine (DNPH) impregnated, silica gel sorbent prior analysis by high performance liquid to chromatography (HPLC) incorporating an ultraviolet (UV) detection system, in accordance with EA recommendations and SPTGN04. Two tests and one blank were applied during the sampling. The results are presented in Appendix B. The analytical component of the work was conducted at MSS Ltd, Manchester.
- 3.4 Arsenic was sampled onto an activated charcoal sorbent tube prior to analysis by inductively coupled plasma/optical emission spectrometry (ICP/OES), in accordance with EA recommendations and SPTGN04. Two tests and one blank were applied during the sampling. The results are presented in Appendix B. The analytical component of the work was conducted at MSS Ltd, Manchester.
- 3.5 Hydrogen sulphide was sampled into a Tedlar bag with analysis by GC/MS (by CLS Ltd) in accordance with SPTGN04. Two tests were applied during the sampling. The results are presented in Appendix B.
- 3.6 Mercury was sampled onto 226-17 sorbent tube prior to analysis by CVAFS, in accordance with NIOSH method 6009. Two tests and one blank were applied during the sampling. The results are

- presented in Appendix B. The analytical component of the work was conducted at MSS Ltd, Manchester.
- 3.7 For bulk gases, gas was sampled into Tedlar bags in accordance with EnviroDat Ltd. documented procedure SPTGN04. The results are presented in Appendix A. Laboratory analysis was completed using GC-TCD instrumentation at MSS Ltd, Manchester.

## 4. RESULTS

- 4.1 Field measurements of the 'bulk gases' are given in Appendix A.
- 4.2 Measured concentrations of the EA 'priority' trace components for the trace gas are given in Appendix B.
- 4.3 All blank samples came back with no trace of any detectable compounds.

#### 5. DISCUSSION AND CONCLUSION

- 5.1 The aim of the survey was to measure trace components from the trace gas at South Pit Phase 3, Kent.
- 5.2 The levels of trace components within the landfill were undetectable overall, except for a few notable examples. These were 1,1,1-trichloroethane and ethylbenzene.

## **APPENDIX A**

**Site Information & Preliminary Gas Measurements** 

**TABLE 1a: Site Information & Preliminary Gas Measurements** 

Sample Position Details								
Date	02/12/19	Site	CMS Enviro – South Pit					
Ambient Temperature	7°C	Atmospheric Pressure	1030 mbar					
Monitoring Organisation (s)	EnviroDat Ltd	Analytical Laboratory	MSS Ltd					
Location of Sampling Point	Well 3C	Area of Influence of collection system sampled	All capped areas of the site					
Type of Sampling Point	Valve	Temperature of gas	11.6°C, at sample flow meter					
Vacuum on	Slight Negative	Type of waste	Cement Kiln Dust					
Sampling	Pressure (-0.07 mbar)	Age of Waste	-					
Status of Gas System	Fully Operational, Steady State	Other	-					
Parameter	Concentration	Units	Comments					
Methane*	0.0	%	-					
Carbon Dioxide*	0.2	%	-					
Oxygen*	8.2	%	-					
Nitrogen*	91.6	%	-					
Hydrogen Sulphide*	0	ppmv						

Notes: \* Raw result obtained from MCerts landfill gas analyser (Geotech 5000).

TABLE 1b: Bulk Gas Analysis from Laboratory

Parameter	Concentration (in %)				
Parameter	Test 1	Test 2			
Hydrogen	0.12	0.08			
Oxygen	8.0	8.9			
Nitrogen	91	91			
Carbon Monoxide	<0.01	<0.01			
Carbon Dioxide	1.0	0.04			
Methane	0.02	<0.02			
Hydrogen Sulphide	0.006	0.021			

## **APPENDIX B**

**Trace Gas Results** 

#### **TABLE 2a: Trace Gas Results, (Test 1)**

Test Duration	Flow Rate	Flowmeter	Volume	Ambient T	Barometric P	Volume
(min)	(ml/min)	CAL Factor	(I as sampled)	(°C)	(kPa)	(I @ STP)
30	200	0.9471	5.68	7	103	5.63
20	200	0.9471	3.79	7	103	3.75
30	200	0.9471	5.68	7	103	5.63
10	50	0.966	0.48	7	103	0.48
	(min) 30 20 30	(min)         (ml/min)           30         200           20         200           30         200	(min)         (ml/min)         CAL Factor           30         200         0.9471           20         200         0.9471           30         200         0.9471           30         200         0.9471	(min)         (ml/min)         CAL Factor         (l as sampled)           30         200         0.9471         5.68           20         200         0.9471         3.79           30         200         0.9471         5.68	(min)         (ml/min)         CAL Factor         (las sampled)         (°C)           30         200         0.9471         5.68         7           20         200         0.9471         3.79         7           30         200         0.9471         5.68         7	(min)         (ml/min)         CAL Factor         (I as sampled)         (°C)         (kPa)           30         200         0.9471         5.68         7         103           20         200         0.9471         3.79         7         103           30         200         0.9471         5.68         7         103

VOC (429611)	10	30	0.966	0.46	,	105	0.46
Compound	Mass of TG (ng)	LoD of TG (ng)	Concen		Units	Analysis Notes (See below)	Analysis UKAS Acredited (Y/N)
Arsenic (as As)		100	<	18	μg/m3	-	N
Acetaldehyde (Ethanal)		100	<	27	μg/m3	-	Y
Formaldehyde (Methanal)		100		27	μg/m3		Y
						-	
Mercury		10		1.78	μg/m3	-	N
Vinyl Chloride		10	<	21	μg/m3	-	N
1,3-Butadiene		10	<	21	μg/m3	-	N
Methanethiol		50		104	μg/m3	-	N
Chloroethane		10		21	μg/m3	-	N
1-Pentene		20			μg/m3	-	N
Furan		10	<	21	μg/m3	-	N
Ethanethiol		50			μg/m3	-	N
	100						
1,1-Dichloroethene	100	5		209	μg/m3	-	N
Dimethylsulphide	11	10		23	μg/m3	-	N
Dichloromethane	17	10		36	μg/m3	-	N
Carbon Disulphide	160	10		334	μg/m3	-	N
trans-1,2-dichloroethene		5	<	10	μg/m3	-	N
			-				
1,1-Dichloroethane	14	5	<b></b>	29	μg/m3	-	N
cis-1,2-dichloroethene		5			μg/m3	-	N
Propanethiol		40	<	84	μg/m3	-	N
Bromochloromethane		5			μg/m3	-	N
						-	N
Chloroform		5		10	μg/m3		
2,2-dichloropropane		5		10	μg/m3	-	N
1,2-dichloroethane		5	<	10	μg/m3	-	N
1,1,1-trichloroethane	1200	5		2507	μg/m3	С	N
1,1-dichloropropene	-2200	5	<	10		-	N
					μg/m3		
Carbon tetrachloride		5	<	10	μg/m3	-	N
Benzene	65	1		136	μg/m3	-	N
Dibromomethane		5	<	10	μg/m3	-	N
1,2-dichloropropane		5		10	μg/m3	_	N
						-	
Trichloroethylene		5		10	μg/m3	-	N
Bromodichloromethane		5	<	10	μg/m3	-	N
Butanethiol		40	<	84	μg/m3	-	N
cis-1,3-dichloropropene		5	<	10	μg/m3	-	N
Dimethyldisulphide		10		21		-	N
					μg/m3	+	
trans-1,3-dichloropropene		5		10	μg/m3	-	N
Butyric acid		10	<	21	μg/m3	-	N
1,1,2-Trichloroethane		5	<	10	μg/m3	-	N
Toluene	290	5		606	μg/m3	-	N
	230						
1,3-Dichloropropane		5			μg/m3	-	N
Chlorodibromomethane		5	<	10	μg/m3	-	N
Ethylbutyrate		10	<	21	μg/m3	-	N
1,2-Dibromomethane		5		10	μg/m3	-	N
		5		10		_	N
Tetrachloroethene					μg/m3		
1,1,1,2-tetrachloroethane		5	<	10	μg/m3	-	N
Chlorobenzene	14	5		29	μg/m3	-	N
Ethylbenzene	910	1		1901	μg/m3	С	N
-	750	2		1567			N
m/p-Xylene	730				μg/m3	-	
Bromoform		5			μg/m3	-	N
2-Butoxyethanol		10	<	21	μg/m3	-	N
Styrene	94	5	I	196	μg/m3	-	N
1,1,2,2-tetrachloroethane		5	<	10	μg/m3	-	N
	370		<del>                                     </del>				N
o-Xylene	270	1	<b></b>	564	μg/m3	-	
1,2,3-Trichloropropane		5	<	10	μg/m3	-	N
Isopropylbenzene	92	5		192	μg/m3	-	N
Bromobenzene		5	<	10	μg/m3	-	N
Propylbenzene	69	5	<del>                                     </del>	144	μg/m3	-	N
	69		<b>—</b>				
2-Chlorotoluene		5	<	10	μg/m3	-	N
4-Chlorotoluene		5	<	10	μg/m3	-	N
1,3,5-Trimethylbenzene	100	5		209	μg/m3	-	N
-			-			1	N
tert-Butylbenzene	252	5		10	μg/m3	<del>-</del>	
1,2,4-Trimethylbenzene	250	5		522	μg/m3	-	N
sec-Butylbenzene		5	<	10	μg/m3	-	N
1,3-Dichlorobenzene		5	<	10	μg/m3	-	N
1,4-Dichlorobenzene	10	5	· `	21	μg/m3	_	N
			<b>-</b>			+	
p-Isopropyltoluene	500	5		1044	μg/m3	С	N
1,2-Dichlorobenzene		5	<u> </u>	10	μg/m3	-	N
Butylbenzene		5			μg/m3	-	N
3-Chloro-1,2-dibromopropane		5		10	μg/m3	-	N
1,2,4-Trichlorobenzene		5	<u> </u>	10	μg/m3	-	N
Napthalene	3	1		6	μg/m3	-	N
Hexachloro-1,3-butadiene		5	<	10	μg/m3	-	N
1,2,3-Trichlorobenzene		5		10	μg/m3	-	N
1,2,3-THUMOTOBENZENE		3		110	µg/1113	<del>                                     </del>	
Compound	Concentration in ppm	LOD of TG (ppm)	Concen	itration	Units	Analysis Notes (See below)	Analysis UKAS Acredited (Y/N)
District of the second		10		04074		1	
Hydrogen sulphide*	60	10		91071	μg/m3	-	N

<sup>\*</sup>H2S value is equivalent to 60 ppm, values in highlighted box are expressed as ppm and not ng

<sup>(</sup>a) — Results have been blank corrected
(b) — Results should be considered a minimum due to detector saturation
(c) — Result is above the instrument calibration range.
Reference to UKAS (final column) relates to the accreditation status of the analysis only, sampling is covered under EnviroDat Accreditation scope.

#### **TABLE 2b: Trace Gas Results, Test 2**

Trace Gases - Test 2	3		*				
	Test Duration	Flow Rate	Flowmeter	Volume	Ambient T	Barometric P	Volume
	(min)	(ml/min)	CAL Factor	(I as sampled)	(°C)	(kPa)	(I @ STP)
Arsenic (8110917075)	30	200	1.0485	6.29	7	103	6.24
Aldehydes (8492102400)	20	200	1.0485	4.19	7	103	4.16
Mercury (3744001403)	30	200	1.0485	6.29	7	103	6.24
VOC (429612)	10	50	0.9926	0.50	7	103	0.49

VOC (423012)	10	30	0.5520	0.30	,	103	0.43
Compound	Mass of TG (ng)	LoD of TG (ng)	Concen	tration	Units	Analysis Notes (See below)	Analysis UKAS Acredited (Y/N)
Arsenic (as As)		100	<	16	μg/m3	-	N
Acetaldehyde (Ethanal)		100		24	μg/m3	-	Y
Formaldehyde (Methanal)		100		24	μg/m3	-	Y
, , ,						-	
Mercury		10		1.60	μg/m3		N
Vinyl Chloride		10		20	μg/m3	-	N
1,3-Butadiene		10	<	20	μg/m3		N
Methanethiol		50	<	102	μg/m3	-	N
Chloroethane		10	<	20	μg/m3	-	N
1-Pentene		20	<	41	μg/m3	С	N
Furan		10		20	μg/m3	-	N
Ethanethiol		50		102	μg/m3	-	N
1,1-Dichloroethene	34	5	`	69	μg/m3	-	N
	34						
Dimethylsulphide		10	<	20	μg/m3	-	N
Dichloromethane	26	10		53	μg/m3	-	N
Carbon Disulphide	150	10		305	μg/m3	-	N
trans-1,2-dichloroethene		5	<	10	μg/m3	-	N
1,1-Dichloroethane	5	5		10	μg/m3	-	N
cis-1,2-dichloroethene		5	<	10	μg/m3	-	N
Propanethiol		40		81	μg/m3	-	N
Bromochloromethane		5		10	μg/m3		N
		5				-	
Chloroform				10	μg/m3		N
2,2-dichloropropane		5		10	μg/m3	-	N
1,2-dichloroethane		5	<	10	μg/m3	-	N
1,1,1-trichloroethane	490	5		996	μg/m3	с	N
1,1-dichloropropene		5	<	10	μg/m3	-	N
Carbon tetrachloride		5	<	10	μg/m3	-	N
Benzene	140	1		285	μg/m3	-	N
Dibromomethane		5	<	10	μg/m3	-	N
1,2-dichloropropane		5	<	10	μg/m3	-	N
	20	5	`	79			N
Trichloroethylene	39				μg/m3	-	
Bromodichloromethane		5		10	μg/m3	С	N
Butanethiol		40		81	μg/m3	-	N
cis-1,3-dichloropropene		5	<	10	μg/m3	-	N
Dimethyldisulphide		10	<	20	μg/m3	-	N
trans-1,3-dichloropropene		5	<b>×</b>	10	μg/m3	-	N
Butyric acid		10	<	20	μg/m3	-	N
1,1,2-Trichloroethane		5		10	μg/m3	-	N
Toluene	22	5		45	μg/m3	-	N
1,3-Dichloropropane	22	5	<	10		-	N
				10	μg/m3	-	N
Chlorodibromomethane		5			μg/m3		
Ethylbutyrate		10		20	μg/m3	-	N
1,2-Dibromomethane		5		10	μg/m3	-	N
Tetrachloroethene		5		10	μg/m3	-	N
1,1,1,2-tetrachloroethane		5	<	10	μg/m3	-	N
Chlorobenzene		5	<	10	μg/m3	-	N
Ethylbenzene		1	<b>×</b>	2	μg/m3		N
m/p-Xylene		2		4	μg/m3	-	N
Bromoform		5		10	μg/m3	-	N
2-Butoxyethanol		10		20	μg/m3	-	N
Styrene		5		10	μg/m3	-	N
1,1,2,2-tetrachloroethane		5		10	μg/m3	-	N
o-Xylene		1		2	μg/m3	-	N
1,2,3-Trichloropropane		5	<	10	μg/m3	-	N
Isopropylbenzene		5	<	10	μg/m3	-	N
Bromobenzene		5	<	10	μg/m3	-	N
Propylbenzene		5		10	μg/m3	-	N
2-Chlorotoluene		5		10	μg/m3	С	N
4-Chlorotoluene		5		10	μg/m3	-	N
1,3,5-Trimethylbenzene		5		10	μg/m3	-	N
tert-Butylbenzene		5		10	μg/m3	-	N
1,2,4-Trimethylbenzene		5		10	μg/m3	-	N
sec-Butylbenzene		5			μg/m3	-	N
1,3-Dichlorobenzene		5	<	10	μg/m3	-	N
1,4-Dichlorobenzene		5		10	μg/m3	-	N
p-Isopropyltoluene		5		10	μg/m3	-	N
1,2-Dichlorobenzene		5		10	μg/m3	-	N
Butylbenzene		5		10		-	N
3-Chloro-1,2-dibromopropane					μg/m3		
		5		10	μg/m3	С	N
			ı <	10	μg/m3	-	N
1,2,4-Trichlorobenzene		5					
1,2,4-Trichlorobenzene Napthalene		1	<		μg/m3	-	N
1,2,4-Trichlorobenzene Napthalene Hexachloro-1,3-butadiene		1 5	< <	10	μg/m3	-	N
1,2,4-Trichlorobenzene Napthalene		1	< <			-	
1,2,4-Trichlorobenzene Napthalene Hexachloro-1,3-butadiene	Concentration in ppm	1 5	< <	10 10	μg/m3		N N Analysis UKAS Acredited
1,2,4-Trichlorobenzene Napthalene Hexachloro-1,3-butadiene 1,2,3-Trichlorobenzene		1 5 5 LOD of TG	< c	10 10	μg/m3 μg/m3	- Analysis Notes	N N Analysis UKAS

<sup>(</sup>a) — Results have been blank corrected
(b) — Results should be considered a minimum due to detector saturation
(c) — Result is above the instrument calibration range.

Reference to UKAS (final column) relates to the accreditation status of the analysis only, sampling is covered under EnviroDat Accreditation scope.