2021 Annual Performance Report

Aberthaw Quarry Ash Disposal Site

Permit Number: BP3339BH

March 2022

RWE

The energy to lead

Summary

This document gives details on the performance of Aberthaw Quarry Ash Disposal Site over 2021, as required by condition 4.2.1 of the site's Environmental Permit (EP), BP3339BH.

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1. Operational Update

Aberthaw Quarry Ash Disposal Site was designed to be constructed and filled with Pulverised Fuel Ash (PFA) in four distinct phases (see Appendix A).

- Phase 1 was constructed in 2008, filled between Quarter 4 2008 to Quarter 4 2010 and then capped and hydroseeded in Spring 2011.
- Phase 2 was constructed in 2009/10 with filling commencing from Quarter 4 2010. Phase 2 East was filled until Quarter 3 2013 before being capped and hydroseeded whilst Phase 2 West was filled until Quarter 4 2014 before being capped and hydroseeded.
- Phase 3A (east) was constructed in 2012/13 with filling commencing in Quarter 3 2013 and remained the working phase throughout 2014 to 2015. The construction of Phase 3B (west) was completed in 2014 with filling commencing in Quarter 2 2015. These phases continued to be worked until the formal closure of Aberthaw Power Station.

Aberthaw Power Station formally closed in March 2020. The main coal-fired generating units ceased generation in December 2019 with only the gas turbines remaining available for Quarter 1 of 2020 before eventual full site closure. Ash disposal routes remained open throughout the station decommissioning period, however, the last time Aberthaw Quarry received PFA from Aberthaw Power Station was during Quarter 3 2019.

2. Review of Results for Emission Monitoring

Monitoring has continued where possible during 2021, however the site has had to manage sampling visits within the evolving Coronavirus Pandemic restrictions. The four groundwater sampling visits, undertaken by specialist contractor, were spread throughout the year, taking account of changing working requirements and access to external accredited laboratory provision. The four visits were undertaken:

- 27th April 2021 (Q1 Visit)
- 30th June 2021 (Q2 Visit)
- 1st September 2021 (Q3 Visit)
- 19th October 2021 (Q4 Visit)

2.1. Hydrogeological Risk Assessment HRA Review

In accordance with the BP3339BH Permit requirement a 6-yearly review of the HRA was carried out during late 2017 and into 2018. The purpose of the review was to determine whether there had been any significant change in conditions at the site and whether the site remained in compliance with the Environmental Permitting Regulations. The review was carried out by an external specialist consultant Caulmert Ltd. The review process included an initial meeting between the consultant and RWE staff followed by a detailed review by the consultant of monitoring data gathered since the previous review.

The main conclusion from the review was that there is a discernible presence of PFA identifier species e.g. Molybdenum, Boron, Ammonia in both surface and groundwater but that the higher concentration in the surface water suggests the source of contamination is mainly driven by surface water run off which then effects the groundwater in some, but not all, boreholes. Work has historically been completed at the Quarry site to try to mitigate this effect by constructing new drainage ditches and channels. It was also recognised in the review that the final restoration plan should ensure all surfaces would be capped and seeded to consolidate the PFA and ensure any runoff would be free of contamination.

Due to the early closure of Aberthaw Power Station, the final restoration plans for the Quarry are currently under review by RWE. As a part of this process a HRA review for the site will be undertaken by external consultants prior to a formal application, to modify the current approved plan, being made.

2.2. Groundwater Quality Review

Monitoring Objective

To carry out routine monitoring of groundwater to monitor the performance of the ash disposal site by measurement of absolute levels and concentrations and trends relative to relevant criteria including background levels and concentrations, control levels and compliance limits.

Number and Location of Monitoring Points

A summary of the monitoring boreholes is provided in Table 1 below and the locations are shown in Appendix A. Historically in January 2015, borehole improvement works were completed to improve water sampling. E05-03 and E06-01 were re-drilled and the top hat cover was replaced on E06-05. In addition, a new borehole was installed above Phase 3B, E15/1 to improve the understanding of groundwater quality potentially flowing into the site from the south-east. In total, there are 12 monitored boreholes in natural ground, all completed in the Porthkerry Member limestone.

Groundwater flow beneath the ash disposal site is directed towards the cement work lagoons and the River Thaw to the west. Hence, monitoring boreholes, E09-01A, E09-01B, E09-02A and E09-02B on the north-eastern site boundary (approximately 200m apart) are upgradient. Borehole E15/1 on the south site boundary is also classed as upgradient.

Monitoring boreholes along the western site boundary (E05-03, E05-04 and E06-01) with an average spacing of 100m are downgradient of the Pulverised Fuel Ash (PFA) disposal area (Phase 1 and 2). Along the south-western site boundary, two of the monitoring boreholes with an average spacing of 100m (E06-02 and E06-03) are downgradient of the last active PFA disposal area (Phase 3A & 3B) and the non-utilised area (Phase 4). Whilst the two remaining boreholes (E06-04 and E06-05) with an average spacing of 100m are located downgradient of the unworked Phase 4.

Table 1: Summary of Monitoring Boreholes

Monitoring Borehole	Formation Sampled	Lithology Type – Natural (N)	Response Zone Depth (m b GL)	Designation
E09-01A	Limestone	N	18-24	Upgradient
E09-01B	Limestone	N	24-30	Upgradient
E09-02A	Limestone	N	21-27	Upgradient
E09-02B	Limestone	N	27-33	Upgradient
E15-1	Limestone	N	17-29	Upgradient
E05-03	Limestone	N	3 - 15	Downgradient Phase 1&2 Active Area
E05-04	Limestone	N	2.5 - 20	Downgradient Phase 1&2 Active Area
E06-01	Limestone	N	3 - 15	Downgradient Phase 1&2 Active Area
E06-02	Limestone	N	2 - 10	Downgradient Phase 3A & 3B Active Area
E06-03	Limestone	N	2 - 10	Downgradient Phase 3A & 3B Active Area
E06-04	Limestone	N	2 - 10	Downgradient Potential Phase 4
E06-05	Limestone	N	2 – 8	Downgradient Potential Phase 4

m b GL – metres below ground level

Monitoring Measurements

The groundwater monitoring analytical suite contains a range of parameters which are monitored in accordance with the Environmental Permit on a quarterly basis, along with the groundwater level and standard field measurements. An independent external contractor is responsible for the sampling of the groundwater boreholes and they utilise an independent external accredited laboratory for analysis of the samples.

Figure 1 shows the recorded groundwater elevations for the previous 15 years which vary between +17 (E05-03) to +35m OD (E09-02B). Upgradient groundwater elevations are characterised by larger amplitude seasonal water level fluctuations with annual winter influxes of rainfall recharge. Downgradient groundwater elevations fluctuate only slightly due to the effect of dewatering from the Quarry which maintains groundwater at near-constant elevations.

Figure 1: Groundwater Hydrograph

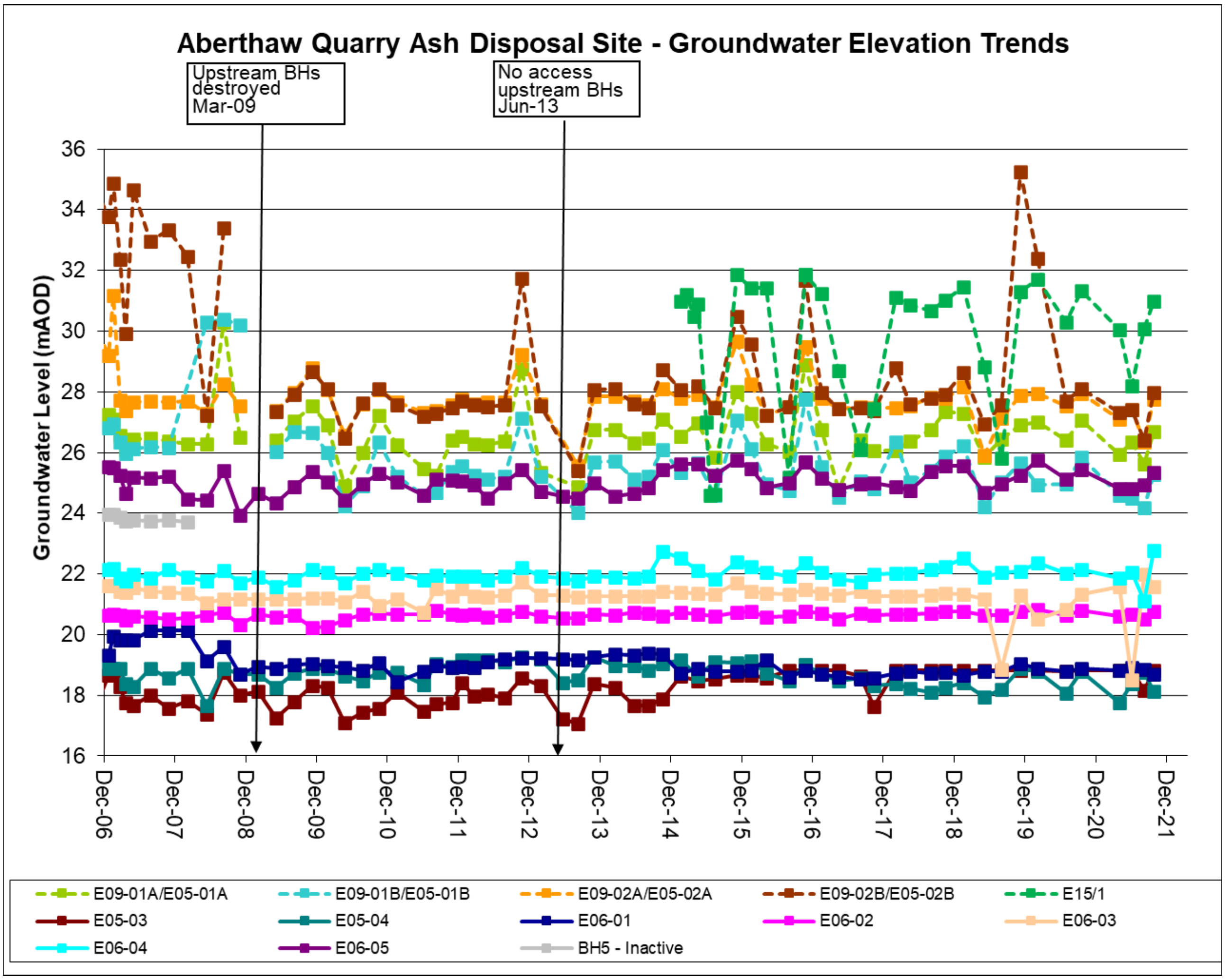


Figure 2 shows the general groundwater quality for the major ions in each of the site's boreholes. Natural groundwater quality varies between upgradient and downgradient locations. Calcium is depleted in some of the downgradient boreholes and correlated with elevated sodium, suggesting ion exchange reactions are occurring along the groundwater flow path. Whilst in other downgradient boreholesmajor ion chemistry is distinctly different with elevation of calcium, magnesium and sulphate, suggesting a natural geological or quarry-related source in or upgradient of this area.

Figure 3 shows the groundwater control charts with concentrations of all downgradient boreholes plotted as well as the average upgradient concentration (representing concentrations in boreholes E09-01A, E09-01B, E09-02A, E09-02B and E15/1, i.e. background groundwater quality). It should be noted that the compliance limits apply to boreholes E05-03, E05-04 and E06-01 whilst the control levels (where defined) apply to all downgradient boreholes. An exceedance is defined as a result above the compliance limit or control level for 3 consecutive sampling events. Quarry Phase average trends are now also included within Figure 3.

Please note that the historic datasets for all the borehole locations have been treated slightly differently this year when plotting the individual graphs. For many of the parameters a significant proportion of the results (especially for the upgradient locations) have been reported by the external accredited laboratories as being below the limit of detection (LOD), the value of which generally decrease as individual methods are developed/improved over time. Historically the <LOD results have been automatically plotted by Excel as 'zeros' which has resulted in a significant skewing of the trends. In line with other RWE sites, and in accordance with available guidance[1], consideration has been given to how these <LOD results should be handled. The main options considered were:

- Remove <LOD results from the dataset or replace with a zero value – discounted as this heavily skews the dataset.
- Replace <LOD results with the LOD value – As early LOD values can be higher than current analysis trends direct substitution with the LOD value does result in unrealistic skewing of the dataset.
- Replace <LOD results with half of the LOD value – this generally accepted approach ultimately provides better representation as it reduces the unavoidable skewing effect of the substitution.

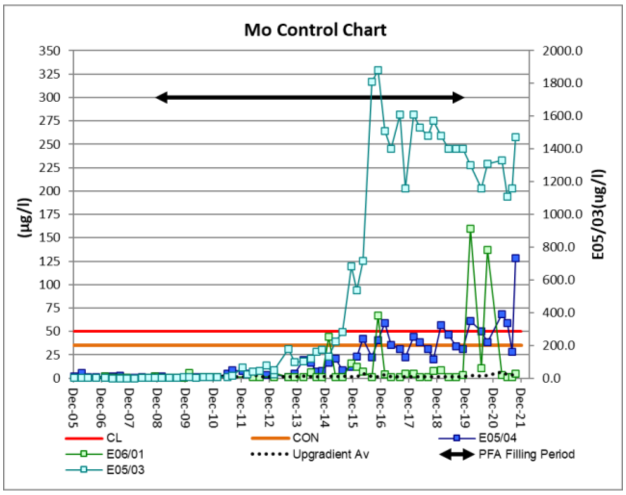
For the purposes of this this report all <LOD values have therefore been substituted with values of half the LOD applicable at the time of analysis.

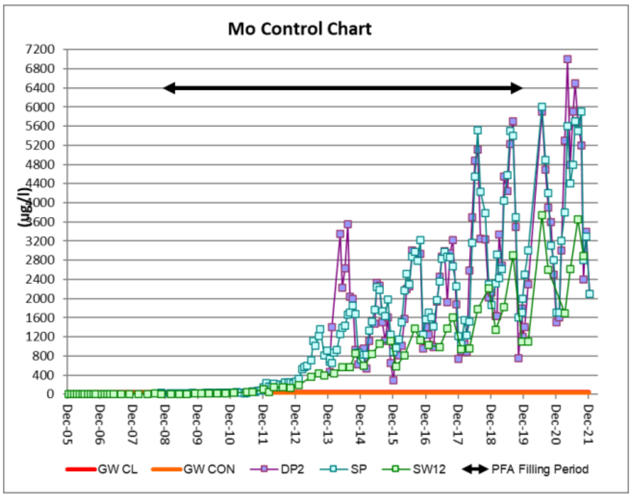
In 2021 there was a continued exceedance of the compliance limit and control level for Molybdenum at borehole E05-03, however the upward trend initially observed from 2012 peaked at 1880 ug/l in November 2016 and, although still high, has been on a general downwards trend since then. There were also elevated Molybdenum levels in boreholes E05/04 & E06/01 during 2021. It is noted that that elevated values observed in E06/02 last year have not been repeated in 2021.

Figure 4 shows the control chart for molybdenum for E05-03 and the two other boreholes closest to it, E05-04 and E06-01, as well as the surface water monitoring points (note there are no surface water compliance limits or control levels for molybdenum). The boreholes are located to the west of and adjacent to Phase 1 and are downgradient of the PFA fill. Natural background concentrations of molybdenum in the Porthkerry Formation are <3µg/l and the average pre-filling concentration for the cement works lagoon (SW12) is around 4µg/l.

[1] UK Technical Advisory Group on the Water Framework Directive Groundwater Trend Assessment, Section 4.2, UKTAG, 2012.

Figure 4: Molybdenum concentrations





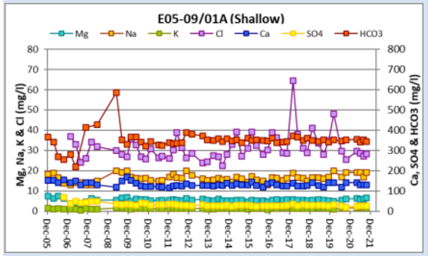
Molybdenum concentrations in E05-03 initially increased from around January 2012, about a year after Phase 1 was completed. After reviewing the subsequent data it appears there is a co-association of increasing concentrations in other indicative PFA leachate parameters; boron, sulphate and ammoniacal-nitrogen, suggesting PFA was the source of contamination. During site investigations in 2014, three possible sources were identified; discharges from the wheel wash pipe into an unlined ditch close to the borehole; surface water discharges of eroded PFA areas around the wheel wash pipe into the unlined ditch; and/or; leakage from adjacent cement works lagoon. In 2015, the wheel wash discharge pipe was re-routed into Settlement Pond 1, the unlined ditch cleaned out and the eroded areas smoothed. Since the improvements, molybdenum concentrations continued to increase until Q1 2017 when the results started to show a decrease. Boron, Ammoniacal Nitrogen and Sulphate have remained relatively consistent across the boreholes and stable within borehole E05-03 (where boron remains consistently below the Compliance Limit.

In borehole E05-04, molybdenum concentrations were approximately double the natural background concentrations until March 2014. Since then concentrations have slowly increased up to an unexpected peak of 128µg/l in October 2021. The trend appears seasonal with higher results in the winter months. Prior to 2015, the molybdenum concentrations in E06-01 consistently reflected the natural background concentrations, since February 2015, results have been sporadically above the natural background concentrations. During 2021 the elevated concentrations observed during 2020 were not repeated, and E06-01 has appeared to return back to reflecting background concentration. E06-02 has also continued to come down since its Mo peak of 340µg/l in 2019, and all four Mo results recorded in 2021 were below the control limit.

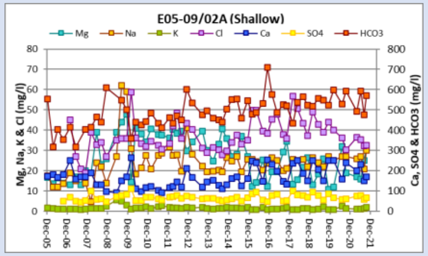
As in E05-03, molybdenum concentrations in the settlement ponds (SP) have been increasing since January 2012, however, since 2013, concentrations have been characterised by large amplitude seasonal fluctuations, with the highest concentrations in the summer and the lowest in the winter. This seasonal fluctuation is also reflected in DP2 which collects surface water and groundwater from the site. The water from the settlement ponds is discharged periodically into the cement works lagoon (SW12) where molybdenum concentrations have also been rising steadily since January 2012.

Figure 2: General Groundwater Quality Charts

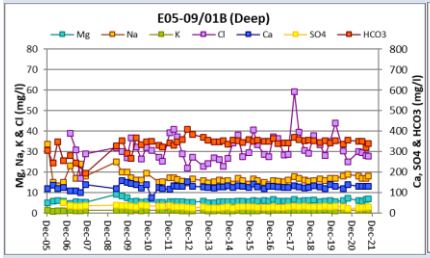
Upgradient Boreholes



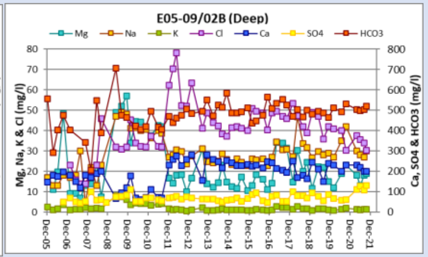
All analytes low and concentrations remain steady



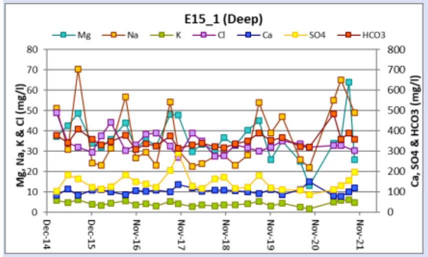
All analytes low but fluctuating.



All analytes low and concentrations remain steady

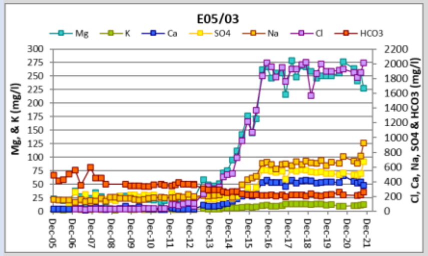


All analytes low but fluctuating.

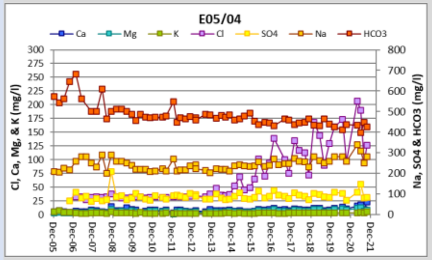


All analytes low and concentrations steady (n/b Sep-21 Na 130mg/l & Cl 200mg/l results removed from trend as spurious).

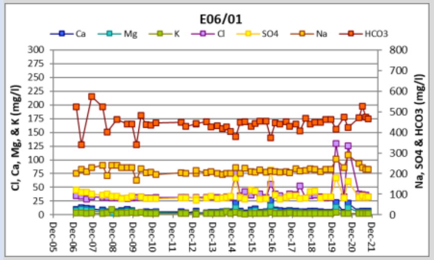
Downgradient Boreholes Phase 1/2



All analytes relatively steady since mid-2015 (n/b Mar-21 HCO3 1055mg/l result removed from trend as spurious)

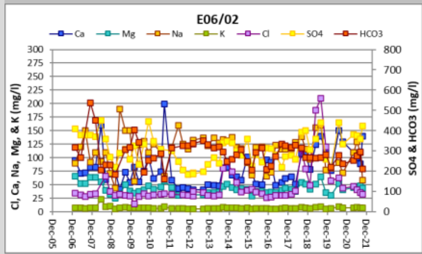


All analytes relatively steady, although Cl showing a gradual upwards trend since 2013.

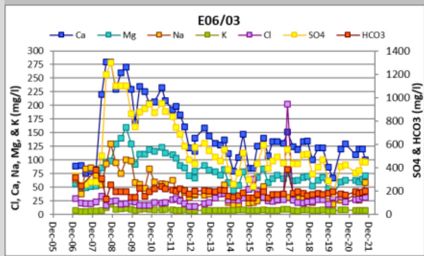


All analytes realtively steady. Cl spikes seen in 2020 not repeated during 2021.

Downgradient Boreholes Phase 3/4

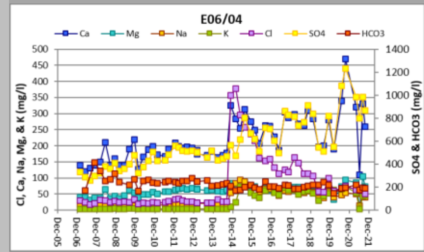


All analytes generally low but fluctuating.

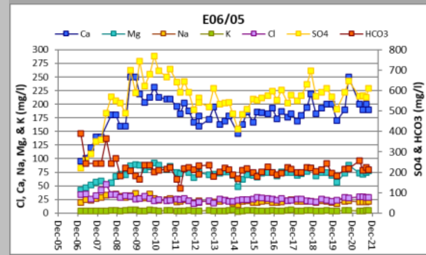


All analytes generally low, Mg, Ca & SO_4 showing a gradually decreasing trend.

Downgradient Boreholes Unworked Phase 4



Analytes generally steady, although Ca & SO4 are gradually trending upwards.

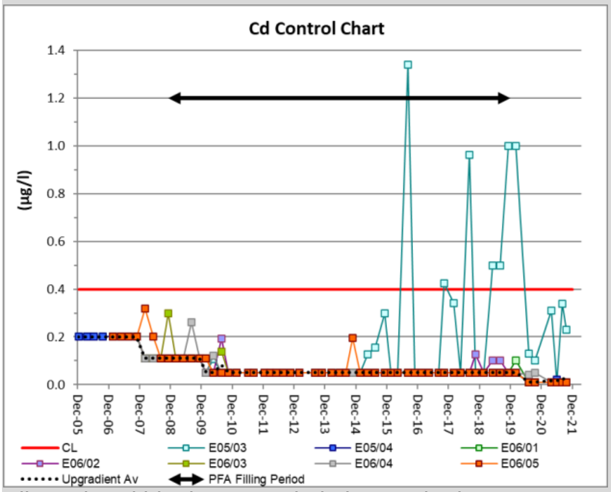


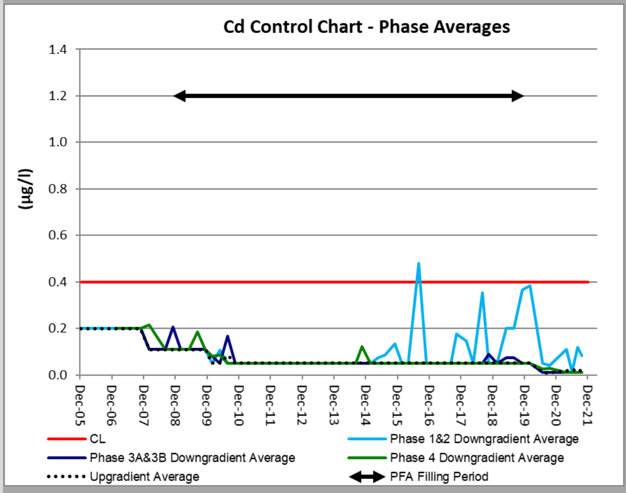
All analytes generally steady.

Figure 3: Control charts & Phase Averages for Down-gradient Groundwater boreholes
(CL – Compliance Limit, CON – Control Level)

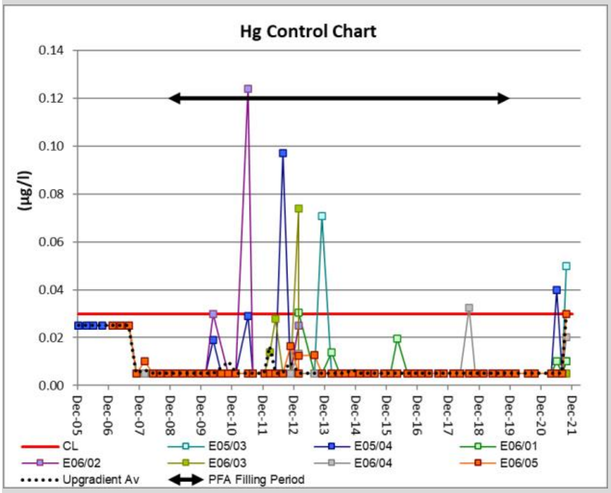
Down-gradient Boreholes against Average Up-gradient

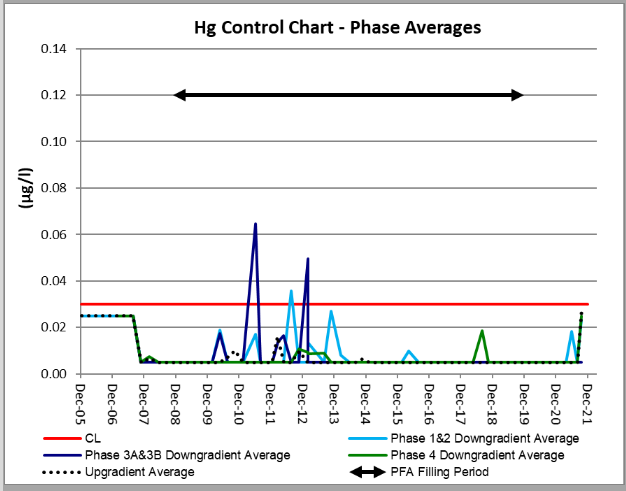
Down-gradient Site Phase averages



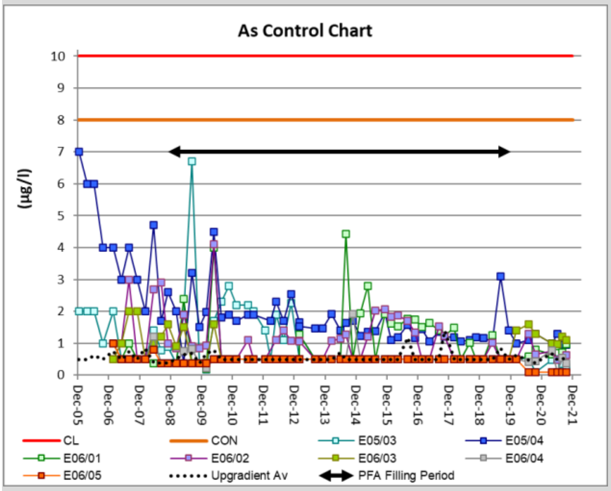


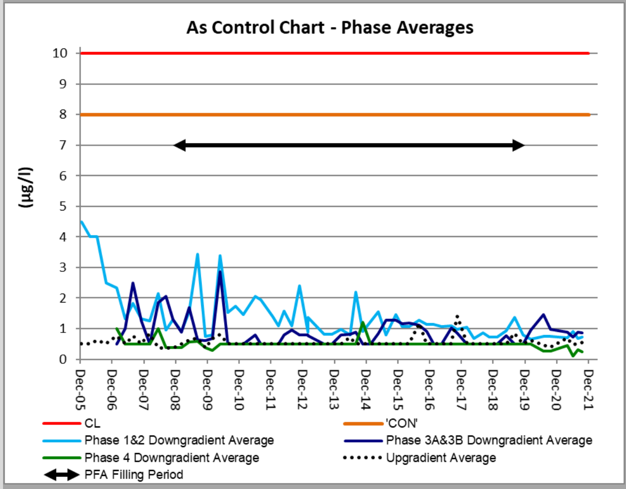
All results within the Control Limit over the last year.



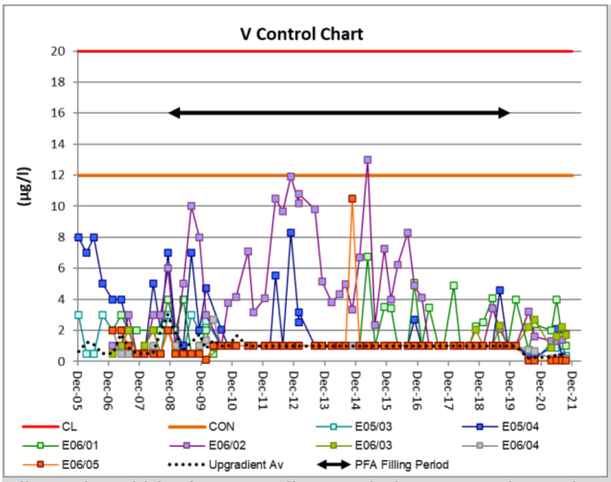


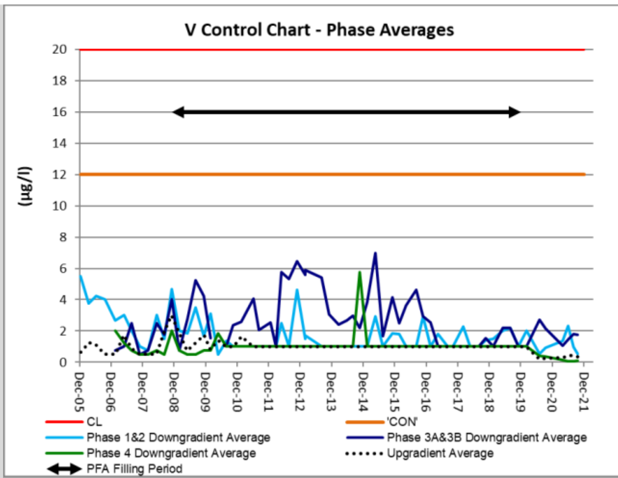
E05/04 (Jun-21), E05/03 & E05/05 (both Oct-21) recorded elevated results during 2021. However it is also noted that three upstream boreholes were also elevated during Oct-21.



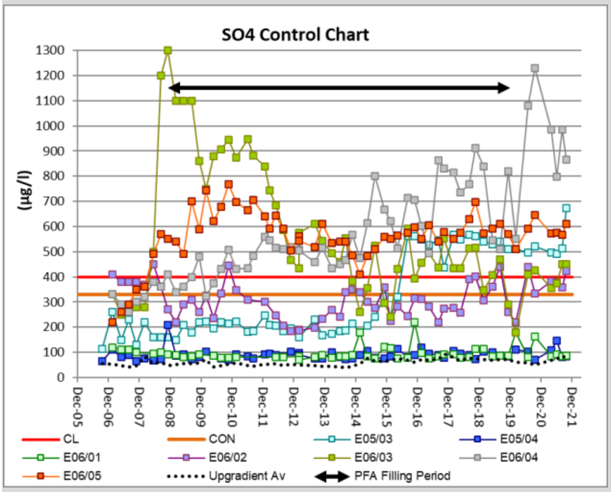


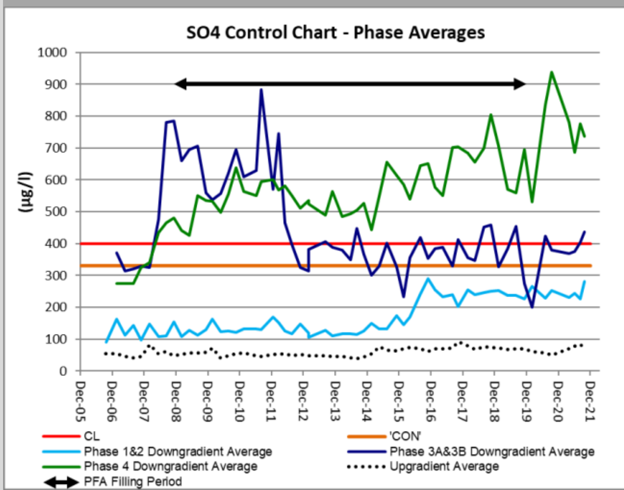
All results within the Compliance Limit & Control Level over the last year.



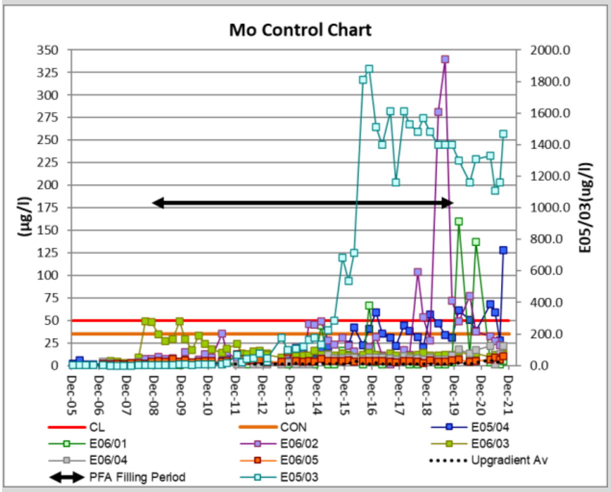


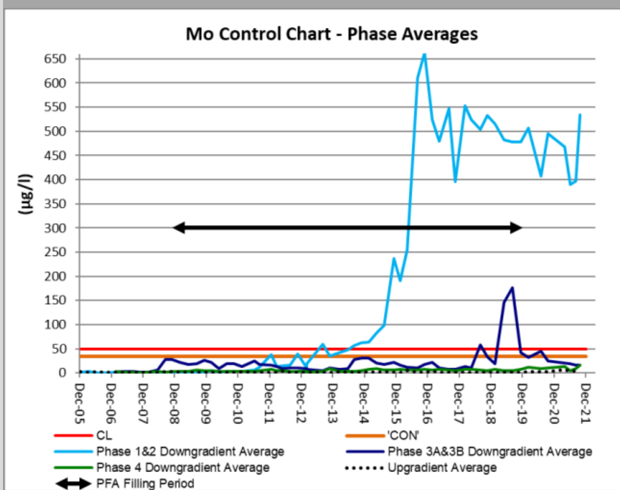
All results within the Compliance Limit & Control Level over the last year.



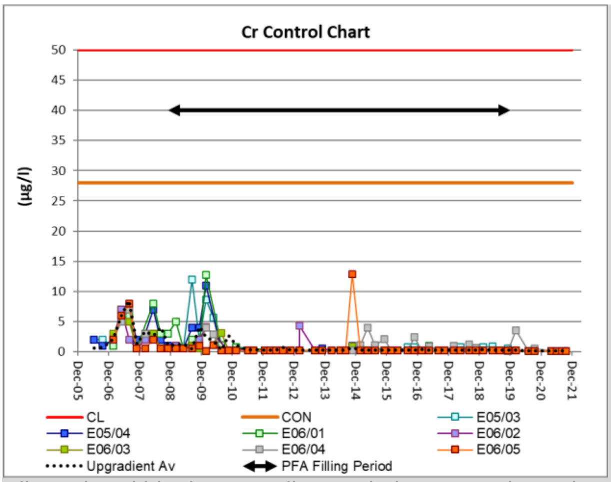


All trends generally steady, although E06/04 still appears to be increasing on average and E06/03 is consistently above the control level and compliance limit.

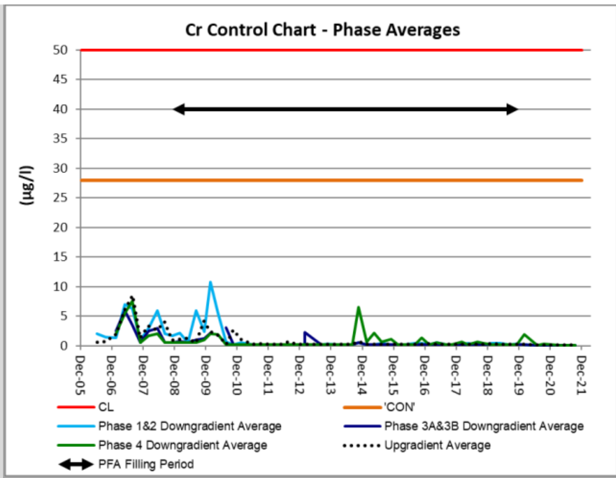


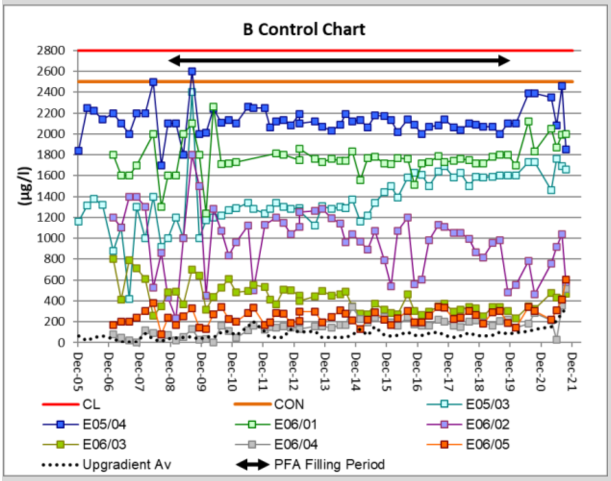


As discussed in Section 2.2 above, E05/03 is gradually decreasing, whilst E05/04 has also had some results above the Control & Compliance limits in 2021. Other locations remain consistently low.

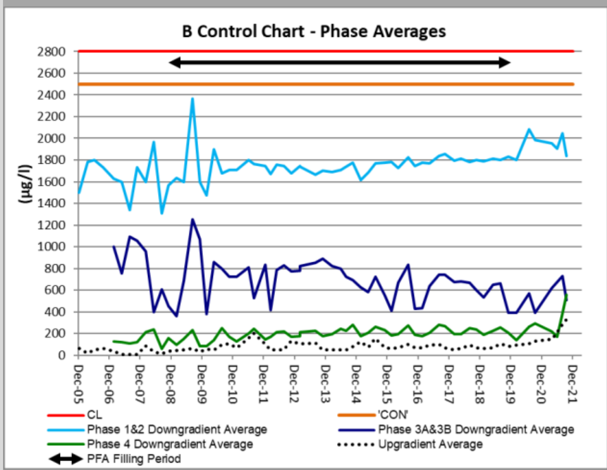


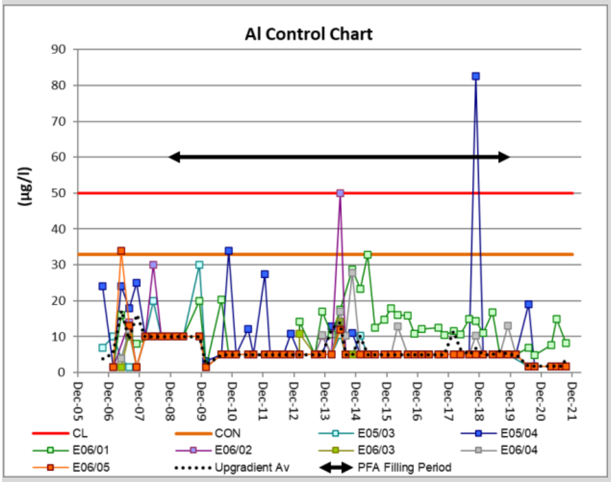
All results within the Compliance Limit & Control Level over the last year.



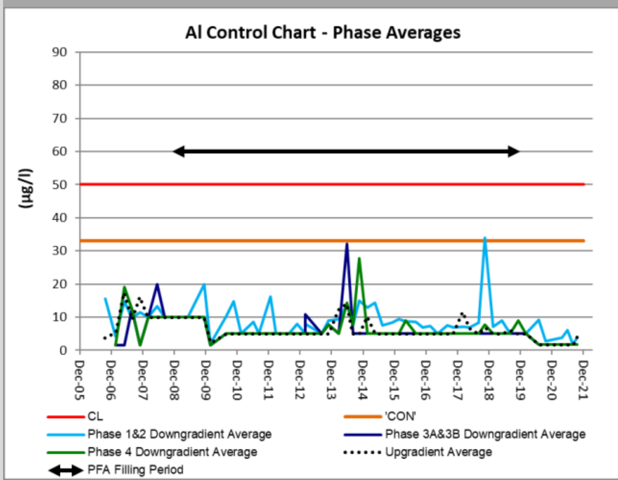


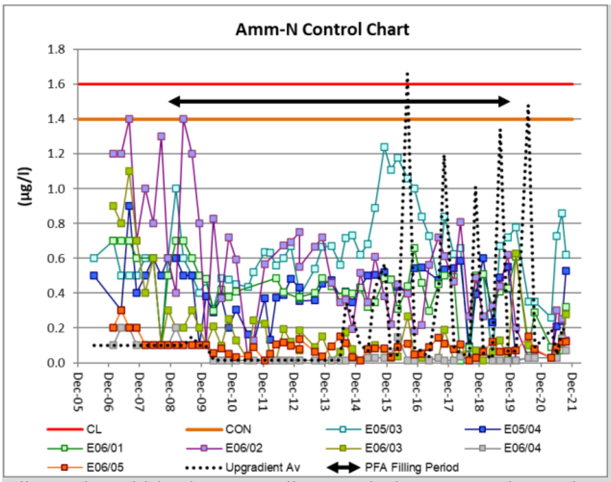
All results within the Compliance Limit & Control Level over the last year.



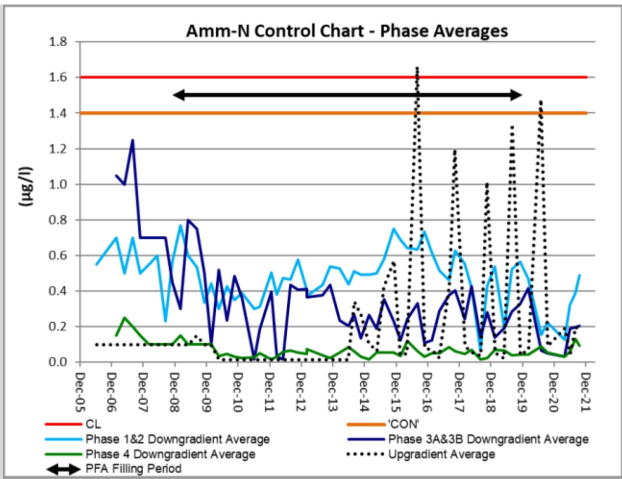


All results within the Compliance Limit & Control Level over the last year.





All results within the Compliance Limit & Control Level over the last year.



A summary of the average groundwater quality for all monitoring parameters between 2006 and 2021 is provided in Appendix B with a comparison of pre- and post-fill concentrations. The key trends in the data have been discussed above, however, it can be summarised that there may be some elevation of some identified parameters potentially due to surface water contact with PFA surfaces.

The external contractor reported that the duplicate samples collected during 2021 showed good repeatability and were within the expected laboratory error levels.

2.3. Surface Water Quality Review

Monitoring Objective

To carry out routine monitoring of surface water to;

- monitor the performance of the ash disposal site by measurement of absolute levels and concentrations and trends relative to relevant criteria including background concentrations and control levels; and;
- identify and quantify effects on surface water receptors.

Number and Location of Monitoring Points

A summary of the surface water monitoring points is provided in Table 3 below and the locations are shown in Appendix A. As detailed in a letter to NRW dated 13th June 2014 a new surface water monitoring point, DP2, was added to monitor the composition of water from the under-drainage. Routine monitoring of DP2 began in May 2014.

Table 3: Summary of Surface water monitoring points

Monitoring Point	Description	Direction from site	Designation
SW12	East shore of cement works lagoon in NW area	West	Surface water Receptor
Settlement Ponds (SP)	Two concrete ponds collecting groundwater and surface water	South-west	
DP2	Surface water and groundwater drainage channel at base of Phase 1 and 2	West within site	

A proportion of the upstream and underlying groundwater will be collected in the groundwater drainage layer and directed towards the two settlement ponds along with any water that has infiltrated through the PFA and the barrier/attenuation layer. Surface water from runoff is also directed into the two settlement ponds via a series of perimeter ditches and toe drains. The settlement ponds are constructed on the quarry floor, contained by concrete and butyl lined 3m high bunds, and are designed to allow suspended solids to settle out before the water is discharged through penstocks into the nearby cement works lagoon (SW12).

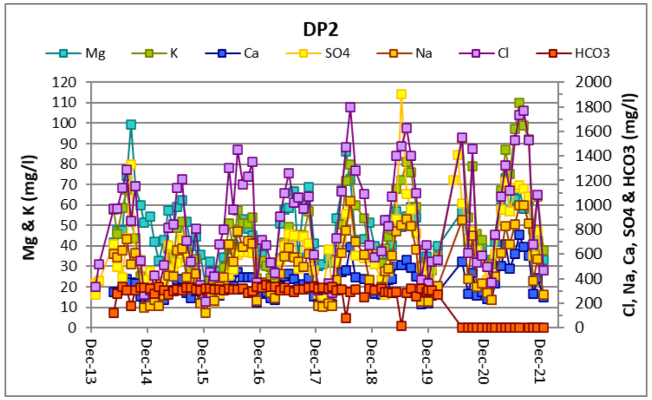
Monitoring Measurements

The surface water monitoring analytical suite contains a range of parameters which are monitored in accordance with the Environmental Permit on a quarterly basis for SW12 and a monthly basis for the SP and DP2. Trained in-house operatives are responsible for the sampling of the SP and DP2 and an independent external contractor is responsible for the sampling of SW12 (undertaken during the wider groundwater monitoring rounds). An independent external accredited laboratory is responsible for the analysis of the samples (usually ALS).

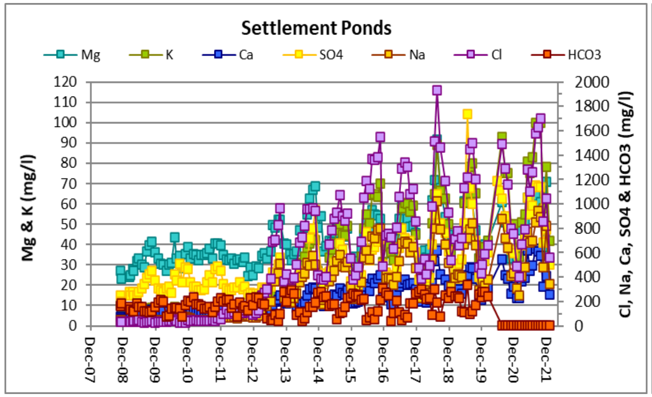
Figure 5 shows the general surface water quality for the major ions. Calcium, magnesium and sulphate concentrations appear naturally elevated in the cement works lagoon and the settlement ponds (i.e. prior to any PFA deposition. Concentrations appear to be seasonably variable in the settlement ponds and the cement works lagoon with highs in July to December and lows in February to June except for HCO_3 with lows in July to December and highs in February to June. When routine monitoring began in DP2 in May 2014 this seasonal pattern in concentrations was also evident. The seasonal pattern is much more marked in 2013-2021 with much higher chloride concentrations than seen previously.

Please note that RWE are have had discussions with ALS (the external accredited laboratory who undertake the monthly analysis for DP2 & Settlement Ponds) as it has become apparent that we have an issue with the Total Alkalinity analysis for these locations. It was suspected, and the lab has now confirmed, that they were not titrating the samples to the required pH target value, due to an incorrect classification of the sample matrix. This has resulted in a significant step change to lower alkalinity values which ultimately impacted the HCO_3 calculations for these locations (Jul-20 – Feb-22). Given that the SW12 samples have remained consistent (undertaken via our GW contractor) it is felt that the recent HCO_3 trends for DP2 & the Settlement Ponds are unlikely to reflect the true values of the site. The laboratory matrix/analysis method specified for the Quarry has now been corrected by ALS (Mar-22) and RWE are not expecting to have any further issues going forwards. At the end of 2022 the dataset will again be reviewed and the unrepresentative analysis removed from the trends if appropriate.

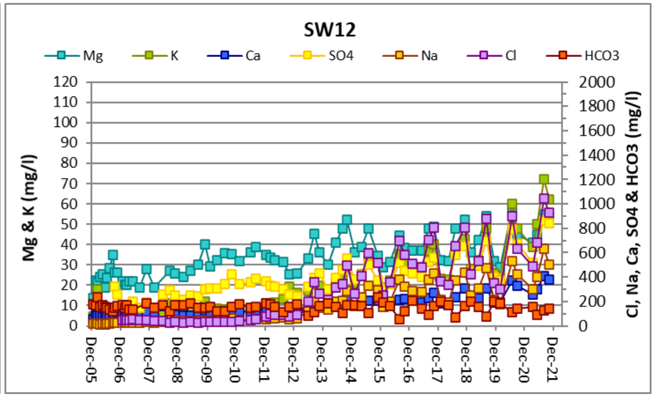
Figure 5: General Surface Water Quality Charts



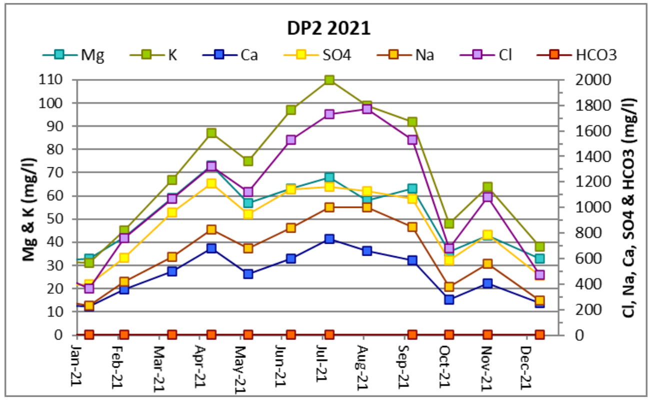
Fluctuations in SO4, Na & Cl with high concentrations in summer and low concentrations in winter.

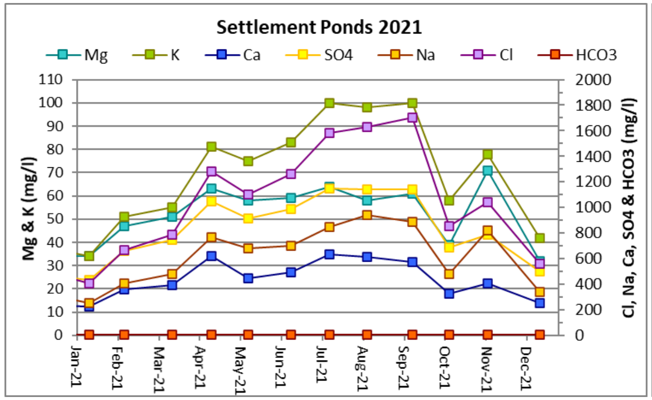


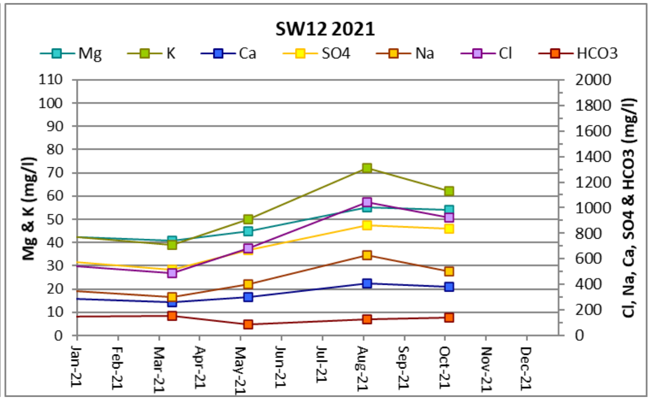
From 2013 fluctuations in Mg, K, Ca, SO4, Na & Cl with high concentrations in summer and low concentrations in winter.



From 2013 fluctuations in Mg, K, SO4, Na & Cl with high concentrations in summer and low concentrations in winter.







Please ref. HCO3 discussion in Section 2.3 above.

Figure 6 shows the surface water control charts. It should be noted that the compliance limits apply to the discharge from the settlement ponds whilst the control levels (where defined) apply to both the discharge from the settlement ponds and SW12. An exceedance is defined as a result above the compliance limit or control level for 3 consecutive sampling events.

In 2021, there were no exceedances of the compliance limit or control level for any critical parameter, except for:

- Boron – the majority of results have been recorded above the Control Level for all three locations during 2021, and overall, there also appears to be a general upwards trend across all three locations. DP2 and the Settlement Ponds also recorded a few results above the Compliance Limit (x4 and x1 respectively) with corresponding max results of 2000ug/l and 2200ug/l respectively. A per the previous year the trend appears seasonal with results returning below the Control Level during winter. However 2021 peak within SW12 (1,520ug/l) is lower than that recorded in 2020 (1,790ug/l).
- Chromium – briefly spiked above the Control Level in the early part of the year for DP2 (Apr, May & Jul) and the Settlement Ponds (Mar, Apr & May) with peaks of 44ug/l and 36ug/l respectively for both locations. All results during 2021 remained within the Compliance Limit.
- Sulphate – all analysis results record during 2021 for all three surface water locations were recorded above the Compliance Limit of 400mg/l. A temporary approval of the elevated discharge is in place with NRW on the basis of no environmental impact and the understanding that the elevated concentrations are being caused by drainage into the site from the south-east. This has also been suggested by the HRA conducted in 2018.
- Ammonia – is also consistently above the Compliance Level for both the Settlement Ponds and DP2, although sufficient oxidation or stripping appears to take place by the time the discharge passes to the cement works lagoon (SW12) as concentrations are low, within target limits and not increasing. Ammonia was injected into the Power Station flue gas stream to increase the efficiency of the Electrostatic Precipitators, this will have resulted in the deposited Ash being slightly Ammoniated. This may be the source of the elevated Ammonia levels observed at DP2.

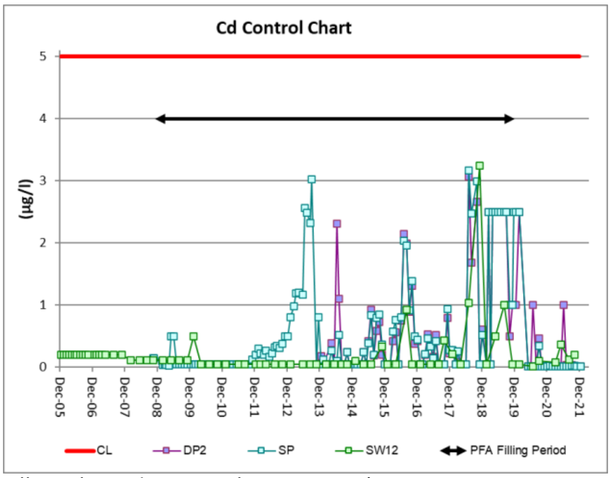
In general, Figure 6 shows that there are no increasing trends in critical parameter concentrations except for sulphate, boron and ammoniated nitrogen, as discussed above.

A summary of the average surface water quality between 2006 and 2021 is provided in Appendix B with a comparison of pre- and post-fill concentrations. The key trends in the data have been discussed above, however, it can be summarised that there may be some low-level contamination from surface water contact with PFA, which is considered to have not significantly impacted the surface water receptors.

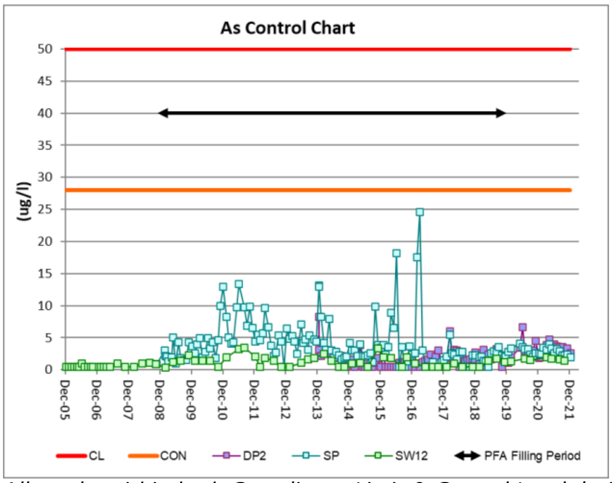
During late 2022 it is expected that an application to revise the site restoration plan will be made (in line with the closure of Aberthaw Power Station, taking account of the fact that no more PFA will be deposited at the quarry site). The site is currently under review and external specialist consultants have been contracted to assess both the hydrology and stability of the ash to inform the revised scheme. It is hoped that the planned reprofiling and restoration of the ash slope surfaces, predominantly within Phases 3a & 3b, will improve the surface water shedding (and also the potential groundwater impacts) of the site.

Figure 6: Surface Water Control Charts

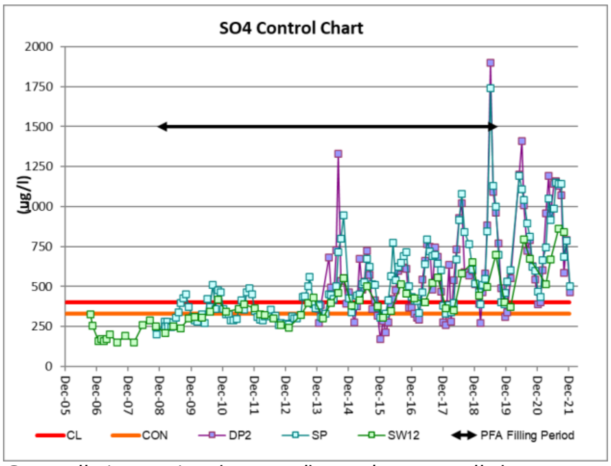
(CL – Compliance Limit, CON – Control Level)



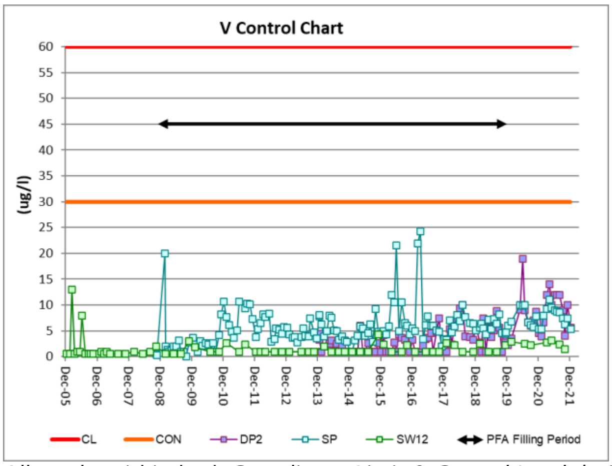
All results within Compliance Limit during 2021.



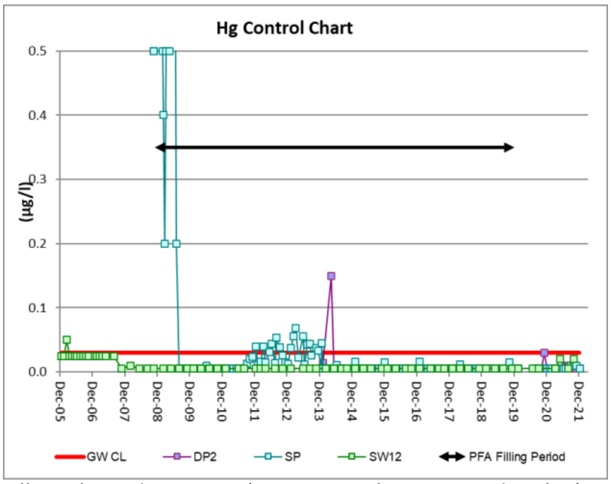
All results within both Compliance Limit & Control Level during 2021.



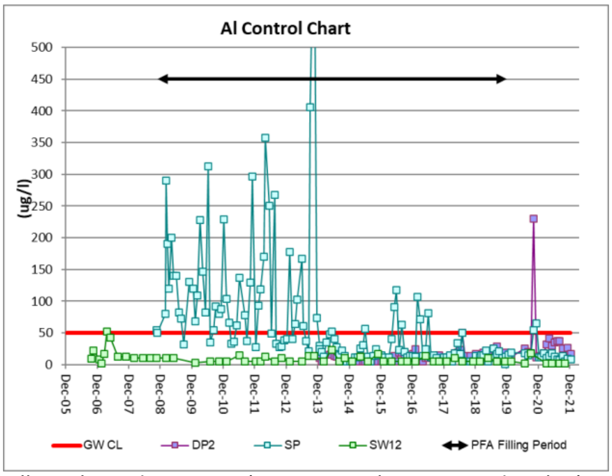
Generally increasing (seasonal) trends across all three locations. SO_4 continues to consistently exceed both target limits during 2021.



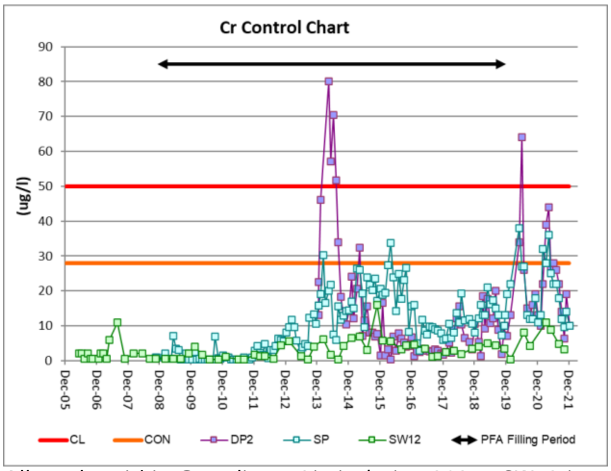
All results within both Compliance Limit & Control Level during 2021.



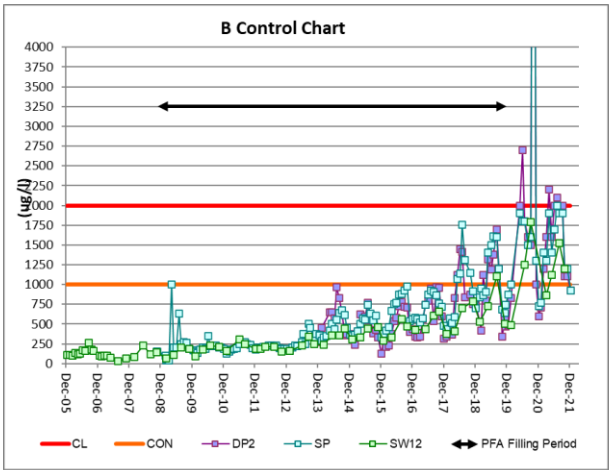
All results within Groundwater Compliance Limit (applied for comparison) during 2021.



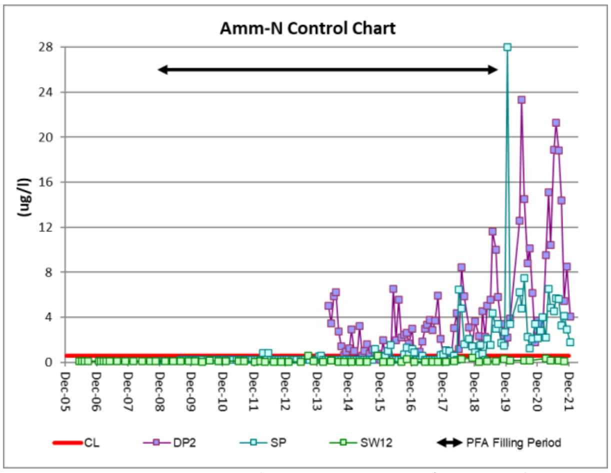
All results within Groundwater Compliance Limit (applied for comparison) during 2021.



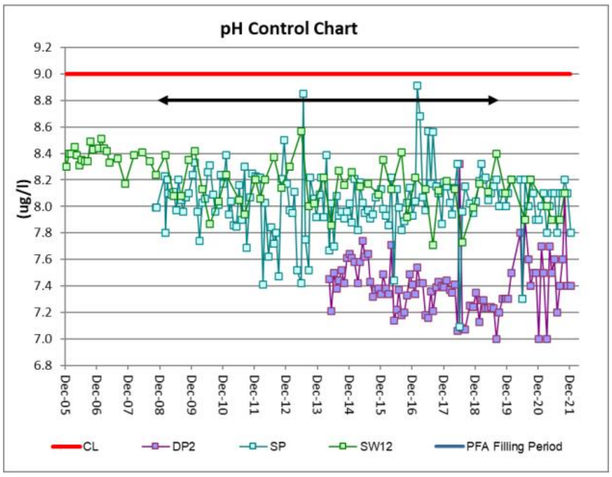
All results within Compliance Limit during 2021. SW12 is also within the Control Level through the year, although DP2 & the Settlement Ponds were above briefly in the early part of the year (3 results each).



As discussed above, the boron levels in surface water appear to be continuing to exhibit a general upwards trend.



Ammonia remains variable within DP2 and the Settlement Ponds and consistently above the Compliance Level for both locations (whilst SW12 remains within target).



pH levels have remained generally consistent across the three surface water locations.

3. Annual Production/Treatment Data

Table 5: Annual Production/Treatment Data(Table S5.2 EP)

Parameter	Value	Unit
Surface water disposed off site	0	m^3/yr
Groundwater disposed off site	0	m^3/yr

4. Contamination/Decontamination of Site

There have been no incidents or emissions which may have caused any site contamination during 2021, and, therefore, no requirement to decontaminate the site during 2021.

5. Topographical Survey

The last topographical survey to ordnance datum was carried out in July 2018 which is shown in Appendix C. It is expected that further topographical surveys of the site will take place to support any revised restoration plan/works agreed in the future.

6. Landfill Capacity

Table 6 below details the amount of PFA deposited at Aberthaw Quarry Ash Disposal Site during 2021 as reported to Natural Resources Wales via the Waste Return Form. It is estimated that around 2,478,843m^3 of void capacity remains (across Phases 1–4) although with the closure of Aberthaw Power Station this capacity will no longer be utilised for the disposal of PFA.

Table 6: PFA Deposited

Reporting Period	PFA Deposited (tonnes)
1st January – 31st December 2021	Nil

7. Waste Acceptance Compliance Testing

Aberthaw Quarry Ash Disposal Site is a mono-landfill site which is under the direct operational control of Aberthaw Power Station. All the ash was transported directly from the Power Station to the Quarry using lorries.

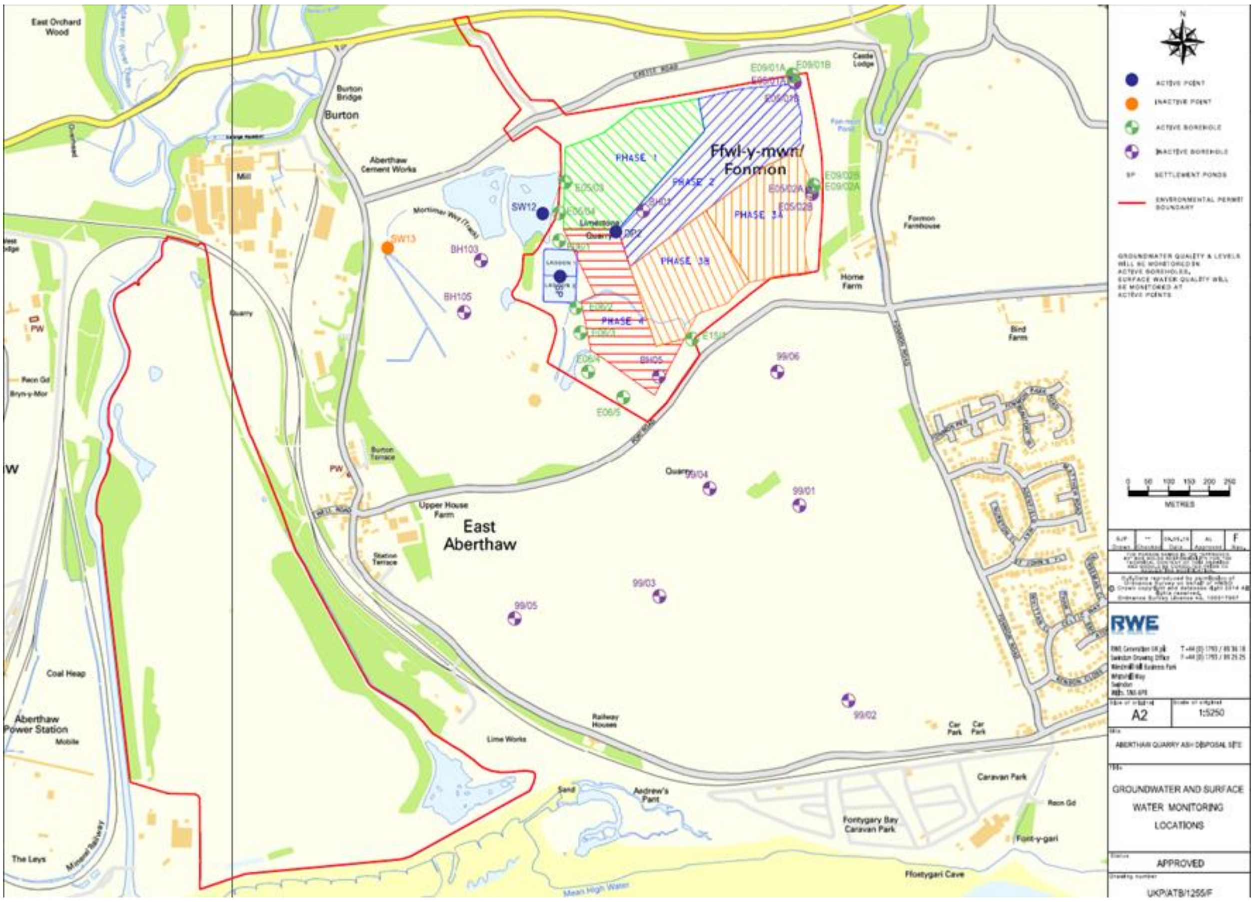
The exact composition of PFA was dependent upon the composition of the fuel utilised by Aberthaw Power Station. RWE has well established procedures which control the quality of fuel supplied to its stations.

Table 7 summarises the analytical data obtained for historic leachate tests performed on composite samples of conditioned PFA from Aberthaw Power Station between 2012 and 2017. The CEN two-stage method for leachate analysis was used (BS EN 12457-3:2002 Characterisation of waste – Leaching – Compliance test for leaching of granular waste materials and sludges of which Part 3).

Table 7: Summary of 10:1 Leachate Calculated Results (mg/kg)

Period	Jan-17	Apr-12 to Jan-17			
Analyte:	Latest Result	Minimum	Mean	Maximum	Number of results
Aluminium as Al (Dissolved)	8.1	2.4	21.9	75.4	15
Ammoniacal Nitrogen as N	156.6	4.2	83.5	158.1	15
Antimony as Sb (Dissolved)	0.192	0.020	0.163	0.256	15
Arsenic as As (Dissolved)	2.449	0.077	1.907	3.313	15
Barium as Ba (Dissolved)	1.4	0.1	2.5	5.9	15
Boron as B (Dissolved)	12.1	0.7	12.8	17.7	15
Bromide as Br	36.3	0.6	71.5	293.5	15
Cadmium as Cd (Dissolved)	0.0010	0.0004	0.002	0.0056	15
Chromium as Cr (Dissolved)	0.19	0.01	0.3	1.03	15
Copper as Cu (Dissolved)	0.010	0.004	0.015	0.028	15
Cyanide (Total) as CN	0.5	0.2	0.3	0.5	15
Dissolved Organic Carbon	25.5	2.2	22.6	43.3	15
Fluoride as F	21.7	2.3	23.5	45.1	15
Iron as Fe (Dissolved)	1.16	0.52	1.03	1.52	15
Lead as Pb (Dissolved)	0.043	0.013	0.034	0.083	15
Manganese as Mn (Dissolved)	0.025	0.006	0.066	0.174	15
Mercury as Hg (Dissolved)	0.0019	0.0004	0.0057	0.0132	15
Molybdenum as Mo (Dissolved)	8.1	0.7	9.4	17.8	15
Nickel as Ni (Dissolved)	0.040	0.003	0.028	0.062	15
Nitrate as N	4.6	2.3	3.1	4.6	15
Selenium as Se (Dissolved)	2.8	0.2	2.1	3.5	15
Sodium as Na (Dissolved)	327	9	821	2696	15
Total Dissolved Solids	6787	350	8888	21800	15
Total Nitrogen as N	162.7	5.0	92.1	166.0	15
Total Sulphur as SO4 (Dissolved)	3745	170	3422	4271	15
Vanadium as V (Dissolved)	3.59	0.40	2.39	3.59	15
Zinc as Zn (Dissolved)	0.17	0.01	0.14	0.57	15

Appendix A. Groundwater and Surface Water Monitoring Locations



Appendix B. Groundwater and Surface Water Quality 2006-2021

(Dark orange exceeds compliance limits, light orange exceeds EQS/DWS, blue exceeds background >25%)

	Aquifer	Response Zone Interval[1]	Al		Sb		As		B		Cd		Ca		Cr		Cu		Fe	
		m b GL	µg/l		µg/l		µg/l		µg/l		µg/l		mg/l		µg/l		µg/l		µg/l	
Background - Limestone			6.2		1.0		0.6		84		0.07		150		0.9		2.7		44	
Background - Seawater			256		<10		2		4166		0.07				1		12		<100	
GW EQS/DWL			200		5		10		2000		5.0		250		50		2000		200	
GW MRV							1				1.0									
GW CL			**50**				**10**		**2800**		**0.4**				**50**					
SW CL							**50**		**2000**		**5.0**				**50**					
Upstream Groundwater			**Average**		**Average**		**Average**		**Average**		**Average**		**Average**		**Average**		**Average**		**Average**	
E05-09_01A	Limestone	18-24	5.9		0.9		0.5		53		0.07		133		0.9		1.6		23	
E05-09_01B	Limestone	24-30	6.9		0.8		0.5		53		0.07		128		0.7		1.2		27	
E05-09_02A	Limestone	21-27	5.8		1.1		0.6		90		0.07		169		0.9		4.2		92	
E05-09_02B	Limestone	27-33	5.8		1.0		0.6		83		0.07		193		0.9		5.0		52	
E15_1	Limestone	17-29	5.4		0.6		0.7		245		0.04		104		0.2		1.5		17	
Downstream Active Filling Operations			**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**
E05_03	Limestone	3-15	8.0	5.6	2.1	0.7	1.2	0.9	1109	1424	0.18	0.19	37	208	2.8	0.9	6.5	1.3	38	22
E05_04	Limestone	2.5-20	15.3	8.7	3.9	1.1	4.1	1.6	2123	2127	0.18	0.05	6	9	3.7	0.7	4.5	1.0	42	18
E06_01	Limestone	3-15	9.3	12.1	2.9	0.9	0.6	1.1	1667	1781	0.17	0.05	10	8	4.3	0.8	0.8	0.9	53	16
E06_02	Limestone	2-10	11.2	6.0	4.1	0.7	1.6	1.0	1113	943	0.16	0.06	89	78	2.4	0.5	4.8	1.2	89	16
Downstream Future Filling Operations			**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**
E06_03	Limestone	2-10	6.5	5.2	2.0	1.2	1.2	0.7	561	404	0.16	0.06	131	150	2.9	0.3	1.8	1.5	77	15
E06_04	Limestone	2-10	7.0	6.3	1.8	0.7	0.7	0.5	57	168	0.16	0.06	147	228	2.9	0.7	5.1	2.7	59	22
E06_05	Limestone	2-8	11.4	5.1	3.1	0.6	0.6	0.4	224	255	0.20	0.06	129	190	2.8	0.5	1.5	1.8	41	15
Downstream Surface Water			**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**
DP2 Phase 2 West				15.9		0.6		2.0		962		0.57		346		14.8		2.9		15
Settlement Ponds				58.1		0.8		4.1		719		0.54		248		11.8		2.7		36
SW12 Lafarge Lagoon			15.7	7.1	2.1	0.5	0.7	1.4	124	492	0.18	0.23	86	193	1.8	3.6	1.4	1.5	33	15

1 Response zone interval for latest well where time series data are compiled from the original and replacement monitor well

2 Background - Limestone is mean of upstream boreholes (E05-09/1A,E05-09/1B, E05-09/2A, E05-09/2B)

3 Background - Seawater is mean of CW Inlet data collected 2011-12

	Aquifer	Response Zone Interval[1]	Mg		Mn		Hg		Mo		Ni		K		Se		Na		V	
		m b GL	mg/l		µg/l		µg/l		µg/l		µg/l		mg/l		µg/l		mg/l		µg/l	
Background - Limestone			17.5		21.9		0.01		1.9		2.9		1.9		0.8		23		1.0	
Background - Seawater					<20		0.02		<30		9		380		<1				<20	
GW EQS/DWL			50		50		1.00		70		20		12		10		200		60	
GW MRV							0.10													
GW CL							**0.03**		**50**										**20**	
SW CL																			**60**	
Upstream Groundwater			**Average**		**Average**		**Average**		**Average**		**Average**		**Average**		**Average**		**Average**		**Average**	
E05-09_01A		18-24	5.6		5.4		0.01		1.4		1.5		1.3		0.6		16		0.9	
E05-09_01B		24-30	5.9		5.0		0.01		1.6		1.2		1.3		0.7		17		0.9	
E05-09_02A	Limestone	21-27	26.4		43.2		0.01		1.6		3.8		1.7		0.9		24		1.0	
E05-09_02B		27-33	22.2		24.2		0.01		2.1		4.9		2.1		0.9		29		1.0	
E15/1		17-29	36.2		47.7		0.01		4.0		1.5		4.2		0.6		37		0.9	
Downstream Active Filling Operations			**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**
E05_03		3-15	24.2	134.4	10.5	37.6	0.018	0.007	1.1	651.8	2.2	1.5	3.5	7.7	0.9	0.5	149	407	1.5	1.1
E05_04	Limestone	2.5-20	4.0	6.5	5.9	4.7	0.018	0.008	1.8	22.8	2.3	0.7	3.7	3.0	1.3	0.8	241	245	4.2	1.8
E06_01		3-15	7.4	5.2	0.5	8.4	0.015	0.006	0.8	12.0	0.8	0.8	3.2	2.9	1.0	0.6	215	217	2.2	1.9
E06_02		2-10	56.1	40.7	18.0	7.0	0.014	0.008	2.9	33.1	4.3	1.6	9.9	7.0	1.6	0.7	109	114	1.7	4.5
Downstream Future Filling Operations			**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**
E06_03		2-10	62.4	80.5	10.1	9.4	0.014	0.007	10.9	16.2	4.9	2.6	7.3	8.3	4.9	1.4	70	42	1.1	1.1
E06_04	Limestone	2-10	41.9	63.0	4.7	20.5	0.014	0.006	2.5	6.4	4.2	3.5	3.7	29.6	2.3	0.6	17	39	0.8	1.0
E06_05		2-8	52.2	74.4	6.2	9.6	0.014	0.006	2.0	5.5	3.8	2.0	4.0	4.6	1.4	0.5	27	23	1.0	1.0
Downstream Surface Water			**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**
DP2 Phase 2 West				46.9		36.8		0.007		2505		14.8		45.3		19.9		489		4.3
Settlement Ponds				43.2		8.4		0.011		1731		10.3		34.6		11.7		357		6.1
SW12 Lafarge Lagoon			23.7	39.1	1.7	9.5	0.020	0.006	4	1009	2.2	4.4	6.1	26.4	1.5	1.7	26	227	1.4	1.6

		Response Zone Interval[1]	pH		EC		Bicarbonate		Sulphate		Ammoniacal Nitrogen as N		Total Oxidised Nitrogen as N		Nitrate		Chloride		Fluoride		Total Organic Carbon	
	Aquifer	m b GL			µS/cm		mg/l		mg/l		mg/l		mg/l		mg/l		mg/l		mg/l		mg/l	
Background - Limestone			7.4		825		410		60		0.20		10.1		11.0		35		0.2		4.3	
Background - Seawater			7.9				97		2396								16300		1.3			
GW EQS/DWL			8.5		2500		250		400		0.3				50		250		1.5			
GW MRV																						
GW CL									**400**		**1.6**											
SW CL			**9.00**						**400**		**0.6**											
Upstream Groundwater			**Average**		**Average**		**Average**		**Average**		**Average**		**Average**		**Average**		**Average**		**Average**		**Average**	
E05-09_01A	Limestone	18-24	7.4		670		350		32		0.04		5.4		9.3		31		0.1		3.5	
E05-09_01B		24-30	7.4		661		338		32		0.04		5.0		5.9		31		0.1		3.0	
E05-09_02A		21-27	7.3		926		492		68		0.42		10.9		11.6		37		0.2		4.4	
E05-09_02B		27-33	7.3		1054		479		72		0.40		23.7		21.8		41		0.2		5.9	
E15/1		17-29	7.6		823		354		145		0.19		2.4		2.2		34		0.2		1.8	
Downstream Active Filling Operations			**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**
E05_03	Limestone	3-15	8.5	7.7	977	3503	462	277	178	340	0.51	0.62	0.2	0.8	0.3	0.9	33	942	1.4	1.3	15.9	2.8
E05_04		2.5-20	8.8	8.4	1010	1017	564	463	79	92	0.53	0.37	0.3	0.2	0.8	0.1	31	73	6.4	5.4	18.6	3.2
E06_01		3-15	8.7	8.6	923	893	473	441	106	95	0.57	0.40	0.5	0.4	0.2	0.4	33	39	2.1	2.9	19.2	2.4
E06_02		2-10	8.4	7.8	1214	1047	336	281	390	299	1.09	0.46	0.8	0.7	0.6	0.6	38	49	0.6	0.5	4.3	3.5
Downstream Future Filling Operations			**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**
E06_03	Limestone	2-10	8.2	7.7	1224	1229	276	190	443	579	0.66	0.12	2.3	0.8	1.6	0.2	23	30	0.4	0.4	3.8	4.5
E06_04		2-10	8.0	7.6	930	1482	290	221	320	613	0.13	0.04	0.2	0.9	0.5	0.6	26	89	0.3	0.4	11.3	3.2
E06_05		2-8	8.1	7.6	1063	1246	289	208	363	586	0.17	0.08	0.4	0.2	3.3	0.2	37	25	0.3	0.4	8.3	1.2
Downstream Surface Water			**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**	**Prefill**	**Postfill**
DP2 Phase 2 West				7.4		3886		239		609		4.53		27.1		18.1		870		0.2		1.4
Settlement Ponds				8.0		2862		153		532		1.31		16.0		10.6		629		0.2		4.9
SW12 Lafarge Lagoon			8.4	8.1	710	2091	161	147	214	445	0.10	0.12	1.2	5.9	5.0	3.3	40	385	0.3	0.3	8.4	3.7

Please note, that for many of the parameters, a significant proportion of the results have been reported/recorded as being below the limit of detection (LOD). To prevent skewing of the data within the above assessment (e.g. as Excel views these as zeros/text cells), and in line with available guidance[2], the “<LOD” values have been replaced with half the reported LOD value (at the time of analysis). This has been applied on an individual result basis to take account of the <LOD values varying over time (predominantly due to the improvement of methods and laboratory standards since sampling commenced).

[2] E.g. UK Technical Advisory Group on the Water Framework Directive Groundwater Trend Assessment, Section 4.2, UKTAG, 2012.

Appendix C. Topographical Survey