Bleak Hill Landfill: Hydrogeological Risk Assessment Review

31 March 2021

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Bleak Hill Landfill: Hydrogeological Risk Assessment Review

Prepared for

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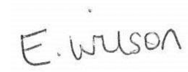
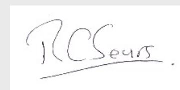
Author	Elizabeth Wilson	
Checked by	Rob Sears	
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1	16/03/2021	Draft	Draft issued to client	EMW	RCS	RCS
2	31/03/2021	Final		EMW	RCS	RCS

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1 Introduction

1.1 Background

This report has been prepared by Stantec UK Ltd (Stantec) at the request of CEMEX UK Materials Limited (CEMEX). It presents the results of a review of the hydrogeological risk assessment (HRA) for the Bleak Hill Landfill site (the Site).

The Site comprises an original landfill which is referred to here as Bleak Hill 1 and an extension which is referred to here as Bleak Hill 2. Further to the south of Bleak Hill 1 lie a number of older landfills which generally accepted a wider range of wastes than Bleak Hill 1 or 2. Many of these older landfills have had their licences surrendered, but there is one area which is still permitted, although it has been closed for many years. This latter landfill is referred to as Hamer Warren Landfill. The locations of the various landfills are shown on Figure 1.1. The excavations removed sand and gravel of the Plateau Gravels and partially removed some sand horizons within the Bagshot Beds. In Bleak Hill 2 some Bagshot Beds clay from below the sand and gravel deposits was also removed.

The original HRA for Bleak Hill 1 (ESI, 2004) was submitted in support of a Pollution, Prevention and Control (PPC) permit (now Environmental Permit) application as part of the process to transition existing landfills from the previous Waste Management Licensing (WML) regulations to the Environmental Permitting regulations. This application was determined on 19 April 2005 (Table 1.1).

In December 2010, an application was made to vary the permit to include the extension area, Bleak Hill 2. This application was supported by an updated HRA (ESI, 2010) which included the increased area and volume of landfill and this permit was determined on 23 August 2011.

The Site (NGR 413100, 110885) lies just inside the western boundary of Hampshire, approximately 5.5 km north-northeast of Ringwood and 4 km south-southwest of Fordingbridge (Figure 1.1). It is approximately square in shape, 580 m long along its east – west axis and 610 m along its north – south axis, with an area of 31.6 ha. A bridleway runs east – west approximately midway through the Site and this separates Bleak Hill 1 to the south from Bleak Hill 2 to the north.

Landfilling commenced on the eastern boundary of Bleak Hill 1 and progressed westwards. Landfilling of Bleak Hill 1 was originally carried out under a previous Waste Management Licence (WML) No. EAWML 23693. A Pollution Prevention and Control (PPC) permit was issued for Bleak Hill 1 on 19th April 2005. A variation notice (No. WP3433MK) was issued on 27th March 2007 by the Agency. A subsequent variation notice, which includes Bleak Hill 2, was issued on 23rd August 2011 (No. EPR/FP3498SZ/V003). The latest EP variation, which was issued solely to reflect the changing of the registered office for CEMEX UK Materials Limited, was issued on 16th January 2019 (No. EPR/FP3498SZ/V004).

Landfilling at Bleak Hill 1 stopped in 2015 as the remaining part of the area that is permitted for landfill is required for operational purposes e.g. lagoons, offices, etc. It is intended that the remaining area that is permitted for landfill will be filled at the end of site operations. Landfilling operations then moved on to Bleak Hill 2. Bleak Hill 2 is dewatered on an intermittent basis when excavation from the bottom of the Site is required, or preparation of the base of the Site prior to landfilling.

With the commencement of sand and gravel extraction at Bleak Hill 2 (which is now complete), a new groundwater abstraction point was created (BL2DIS as shown on Figure 1.1). However, it is noted that this location is indicative only, as samples are taken from pump inlet which is moved from phase to phase within the base of the excavation). Water that is pumped from the abstraction point can be discharged either into the on-site lagoons in Bleak Hill 1 or into the restored surface water lake to the south of Bleak Hill 1, via the licensed discharge point BL1DIS. When the water level in the surface water lake is high enough it overtops via a piped culvert into Hamer Brook.

1.2 Scope of work

Stantec has been instructed by CEMEX to review the Bleak Hill Landfill Hydrogeological Risk Assessment (HRA) as required by Environmental Permit (EP) EPR/ FP3498SZ as varied by Variation Notice EPR/FP3498SZ/V003 dated 23 August 2011.

Condition 3.1.3 of the Environmental Permit specifies the requirement for the HRA to be reviewed on a periodic basis. In line with current permitting requirements an HRA review is required every 6 years. Previous HRA reviews were undertaken in 2015 (ESI, 2015) and 2008 (ESI, 2008). These previous reviews showed that there were no significant changes to the conceptual understanding of the Site and that the HRA remained fit for purpose. The principal objective of this HRA review is to demonstrate that the Site remains in compliance with the relevant objectives of the Environmental Permitting (England and Wales) Regulations 2010 and subsequent updates. This HRA is due by April 2021.

This HRA Review follows the template set out in Environment Agency (EA) – 'hydrogeological risk assessment for landfills – four[1] yearly review template' document[2].

This report acts to provide:

- a summary of the Site operational history;
- a review of the available site monitoring data;
- a review of the existing hydrogeological Conceptual Site Model (CSM) to assess whether it remains fit for purpose on the basis of the Site setting and management / monitoring data;
- a review of the existing HRA to assess whether it remains fit for purpose on the basis of the CSM; and
- recommendations for further work if necessary.

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[1] The requirement for four yearly reviews has subsequently been changed to six yearly reviews as detailed in the current permit.

[2] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/321636/HRA_review_29_4_09.pdf

1.3 Improvement conditions

The Site permit number EPR/FP3498SZ has been varied several times as shown in Table 1.1. The latest variation is EPR/FP3498SZ/V004, which was issued in January 2019. However, variation EPR/FP3498SZ/V003 has been used as the basis for the current HRA review.

Table 1.1 Permit and variation numbers

Detail	Date	Comments
Application CP3235PE (EAWML 23963)	Duly made 07/05/04	
Additional Information Received	11/02/05	
Additional Information Received	15/02/05	
Permit determined EPR/CP3235PE	19/04/05	
Operator name change	22/07/05	
Variation EPR/CP3235PE/V002 determined	19/09/06	
Variation EPR/CP3235PE determined	27/03/07	
Application EPR/FP3498SZ/V003 (reference 210007)	Duly made 01/12/10	
Additional Information Received (60311 JLightfoot002.docx)	08/03/11	
Additional Information Received (60311 JLightfoot003Rev2.docx)	30/03/11	
Additional Information Received (Bleak Hill Revised Figures)	31/03/11	
Variation EPR/ FP3498SZ determined	23/08/11	
Notified of change of Company Registered office	05/12/18	Registered office changed to Cemex House, Evreux Way, Rugby, Warwickshire, CV21 2DT.
Variation issued EPR/FP3498SZ	16/01/19	Varied permit issued to CEMEX UK MATERIALS LIMITED.

There are no improvement conditions outstanding for the Site.

Figure 1.1 Site location plan

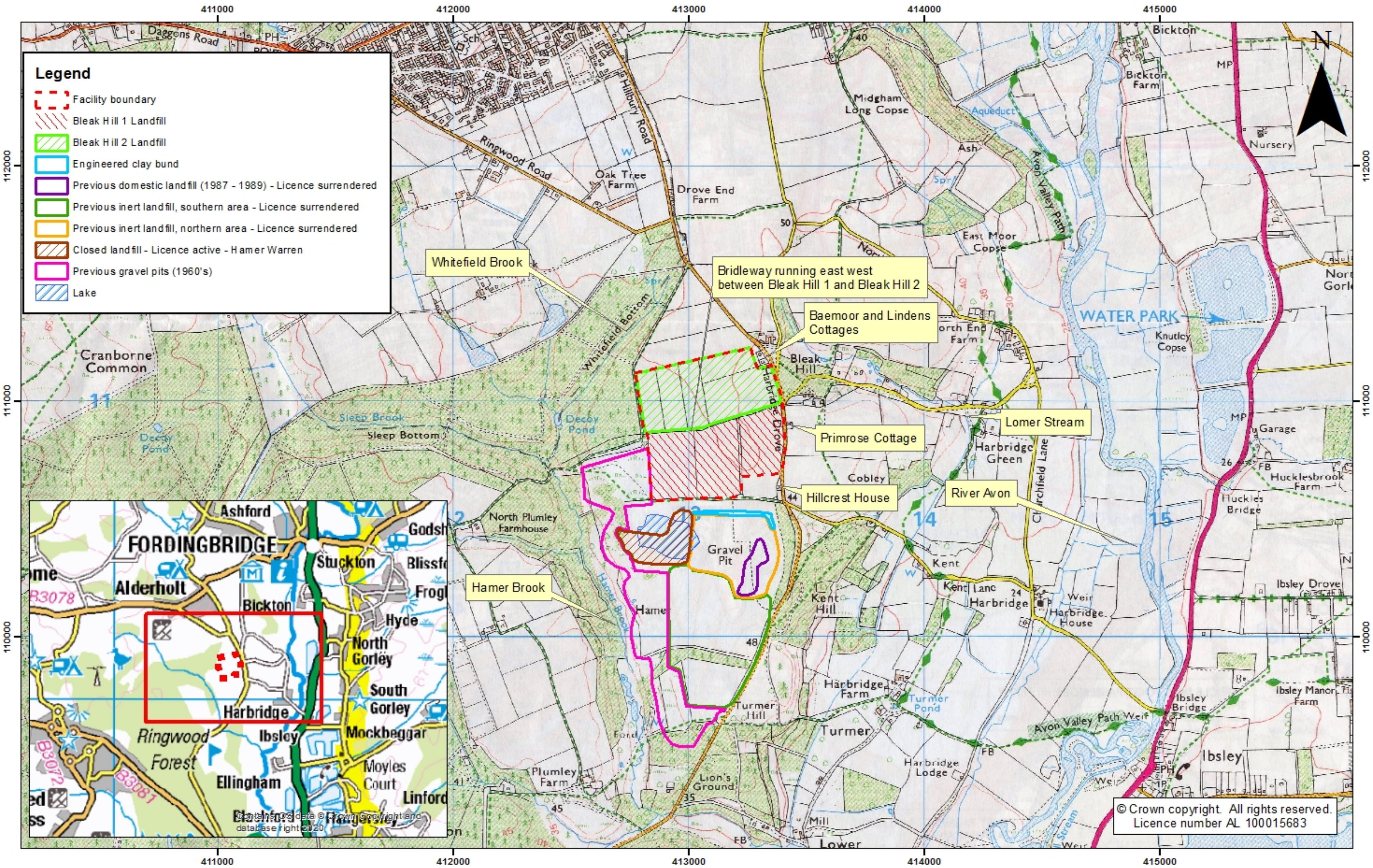
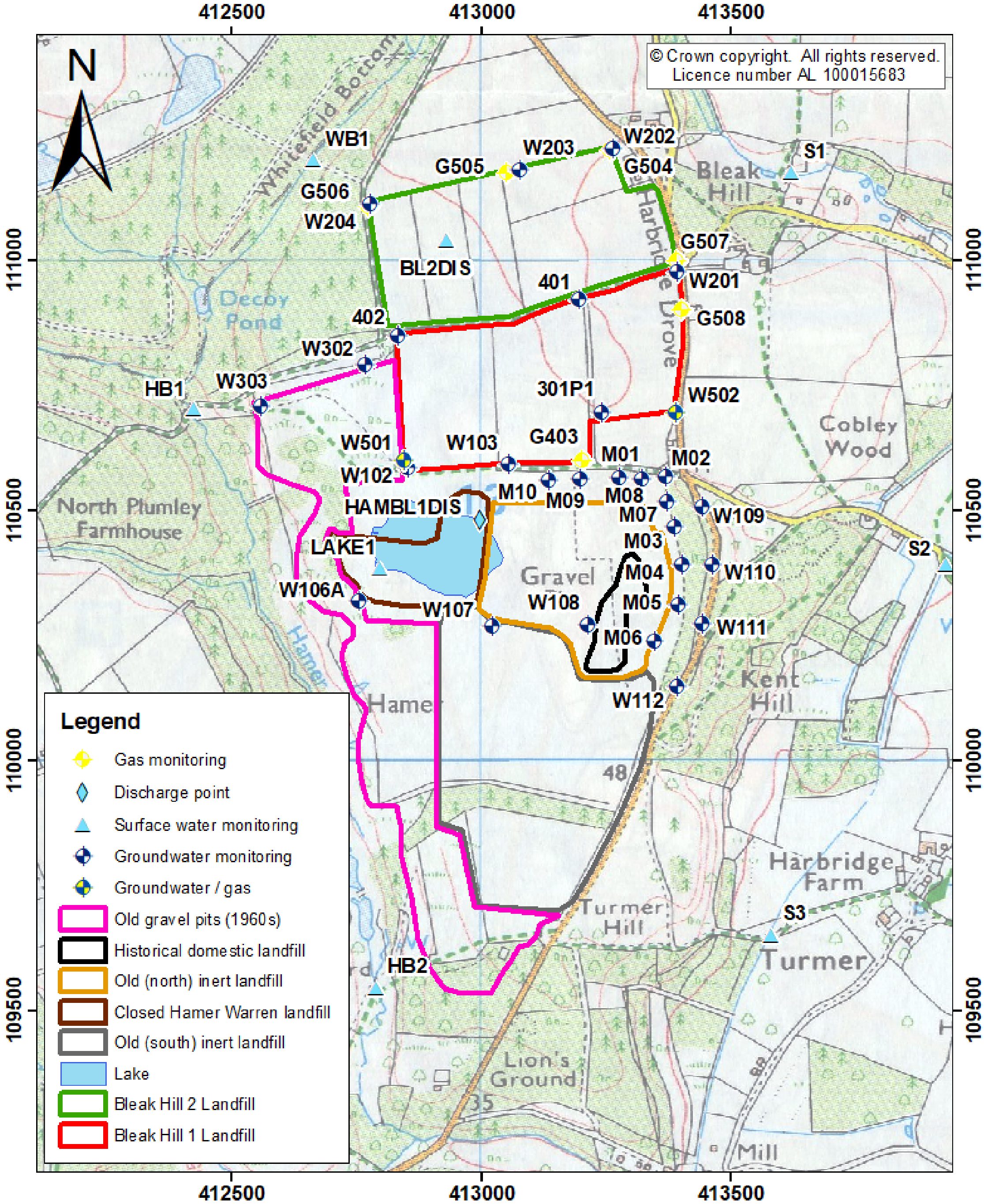


Figure 1.2 Site layout



2 Monitoring data

2.1 Introduction

This section reviews the groundwater and surface water monitoring undertaken at the Site and compares the data with the relevant requirements set out in the permit. The locations of current monitoring points are displayed in Figure 1.2.

2.2 Groundwater

2.2.1 Groundwater level

Figure 2.1 shows the water levels for all boreholes from January 2008 to February 2021 to compare the current reporting period (December 2014 – February 2021) with the previous reporting period (September 2008 - November 2014). Whilst there are a lot of data on this graph, which makes it difficult to read individual borehole hydrographs, what it does show is that water levels in the Site vary from approximately 32 mAOD to 48 mAOD. The data also show long-term seasonal variations, with a clear indication that the maximum groundwater levels achieved on the Site were in the spring of 2014, after the extremely wet winters of 2013/2014. Most years show a slight seasonal variation, with water levels higher in the spring than in the autumn. Some boreholes show more seasonal variability than others. There has been no significant change in the pattern of groundwater levels since the last HRA review was conducted in 2014 and, in particular, there have not been any significant changes since excavations commenced in Bleak Hill 2 in 2009.

Figure 2.2 shows the water levels from selected monitoring boreholes roughly on a north to south transect through the Site for the period 2008 to 2021. This gives a better idea of the local long-term changes in water levels that have occurred within the Site, as working areas and practices have changed.

The highest water levels have been consistently at W203P1 and W203P2 which are upper and lower piezometers in one of the most northerly boreholes on the northern boundary of Bleak Hill 2. The upper piezometer (P1) has a typical level of about 46 mAOD.

The lowest water levels on Figure 2.1 were recorded in the southeast of the Site, and southernmost points monitored, W111 and W112 at 32 - 33 mAOD. During the previous reporting period, groundwater levels at M05 recorded similar levels to W111 and W112 and hence also recorded the lowest water levels. However, since March 2017, groundwater levels at M05 have increased and returned between 33.2 - 33.4 mAOD no longer recording the lowest water levels.

The borehole with the lowest water levels on Figure 2.2 has continued to be at W107 which is approximately 320 m south of the Permit boundary of the Bleak Hill 1 area. This has been the case since 2008 as there has been little or no impact from dewatering of sand excavations during this time. The water level here has been generally between 38 and 40 mAOD.

Figure 2.2 shows that levels at 301P1 and M09 have stabilised since the end of the previous reporting period in 2011 following a water level increase from 2007 to 2010. During the current reporting period, water levels at both boreholes have remained consistent with those from 2011 varying between 41.2 and 43.6 mAOD in the last six years. The other borehole on this graph

401P1 is on the boundary between the Bleak Hill 1 and 2, and the water level here has been consistently intermediate between the northern and southern boreholes. The water levels at this borehole have been fairly stable between 43 and 45 mAOD.

Figure 5.2 of the 2008 HRA review (ESI, 2008) shows indicative groundwater contours for December 2009. Figure 2.3 to Figure 2.8 of this report show indicative contours for 2015 to 2020. These plots show that groundwater flow has not changed during the reporting period as there are no changes in groundwater levels at the Site. The Site lies on a groundwater divide with groundwater on the western side discharging to Hamer Brook and Whitefield Bottom and groundwater on the eastern side discharging to Lomer Stream and the River Avon.

Cross sections based on borehole logs from the Site were presented in the original HRA (ESI, 2004). These are re-presented here as Figure 2.9 and Figure 2.10. Figure 2.9 shows one north to south and two west to east sections through the Site and Figure 2.10 shows the groundwater divide at the Site with westwards flow towards Homer Brook and eastwards flow to the River Avon (and Lomer Stream).

Figure 2.1 Historical groundwater elevation data

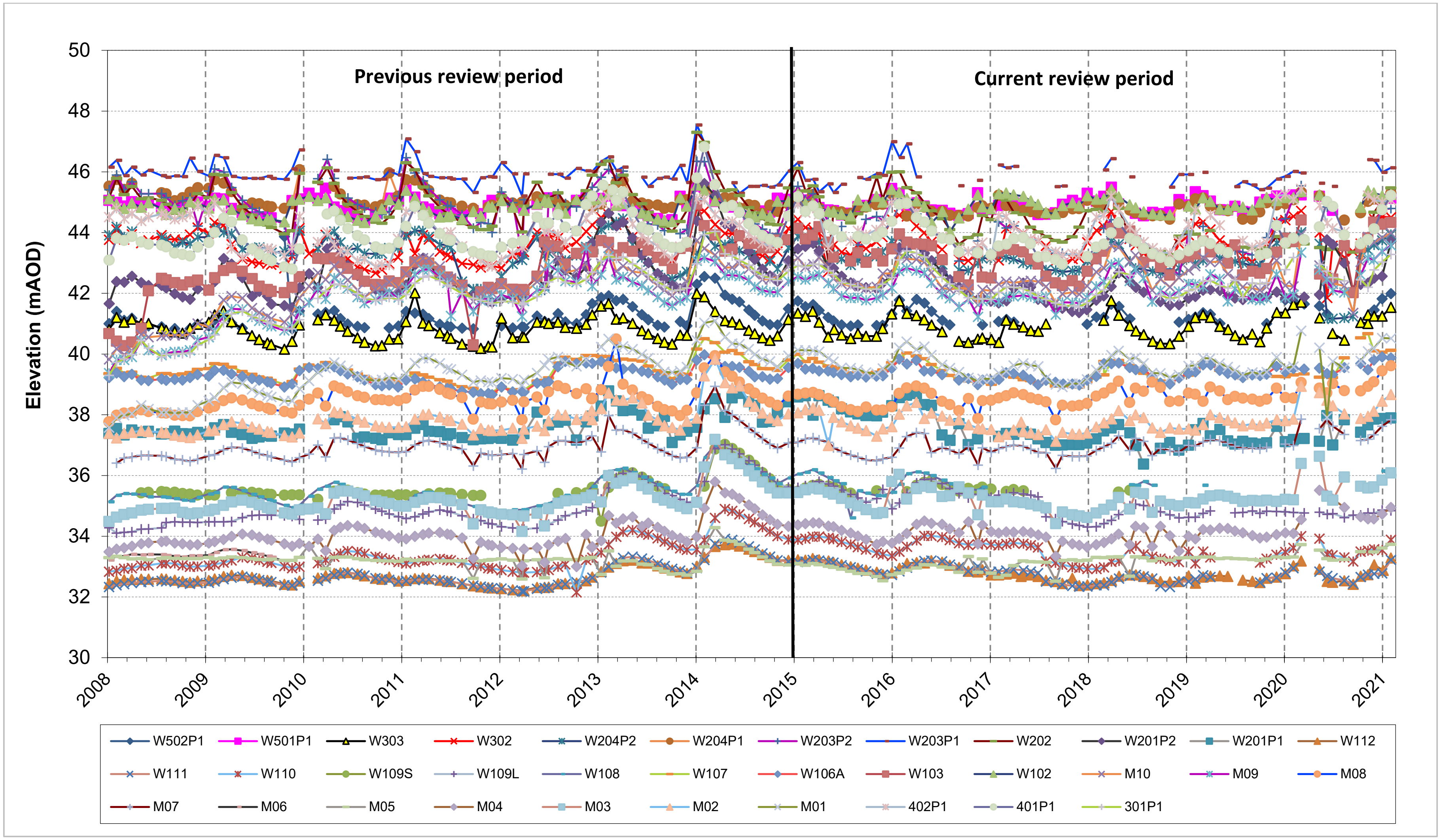


Figure 2.2 Historical groundwater elevation along south to north transact

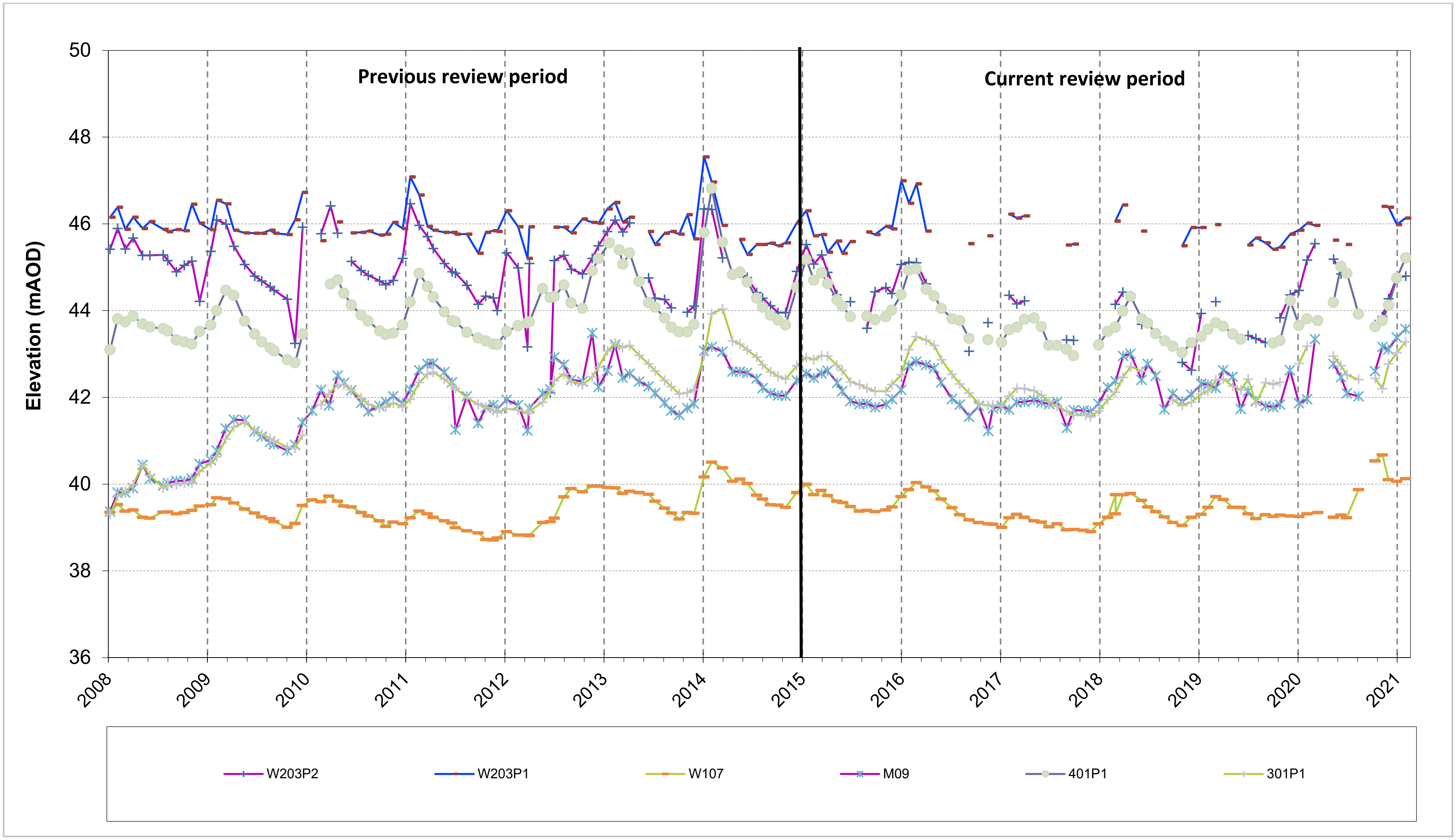


Figure 2.3 Groundwater contour plot (April 2015)

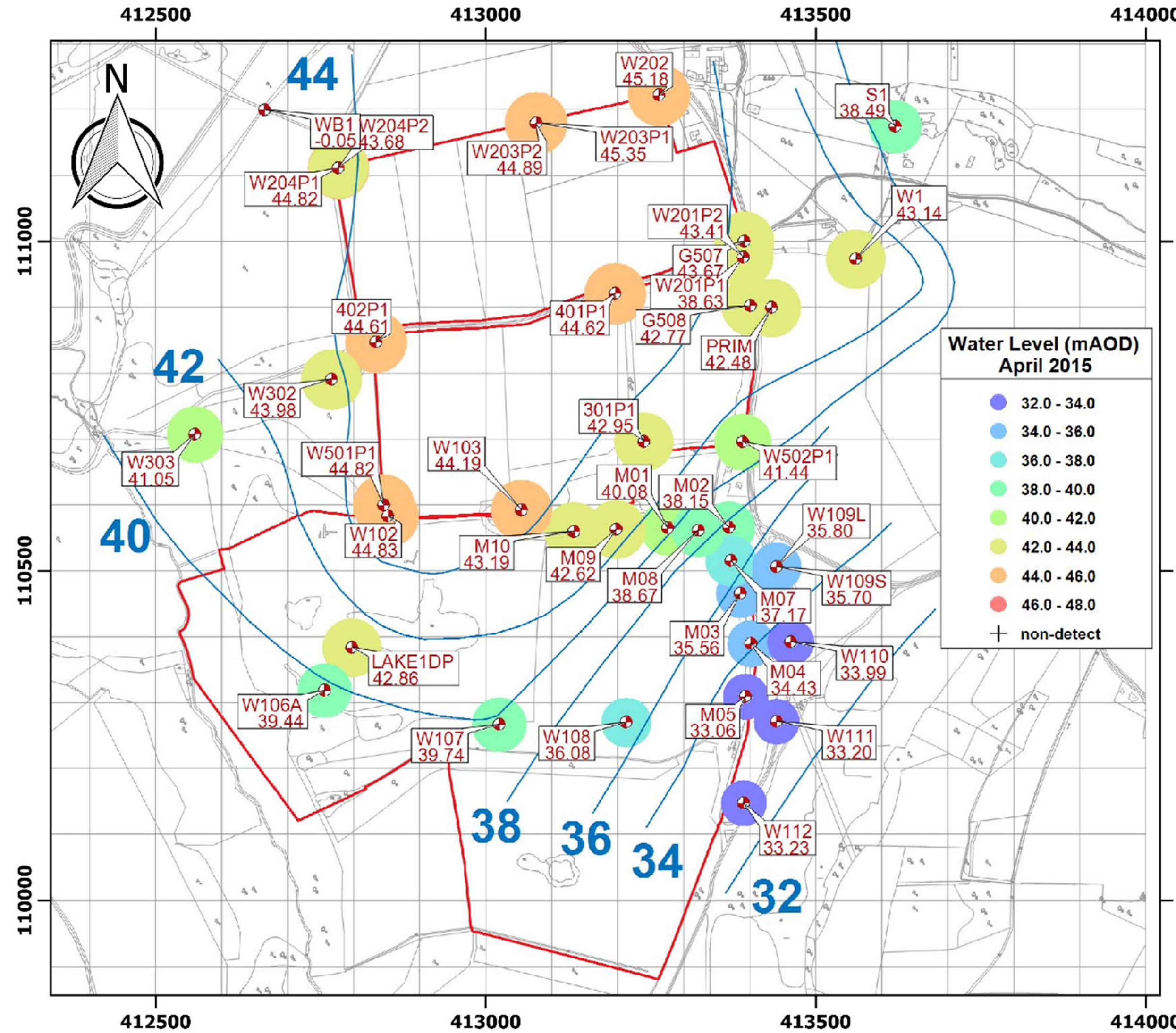


Figure 2.4 Groundwater contour plot (April 2016)

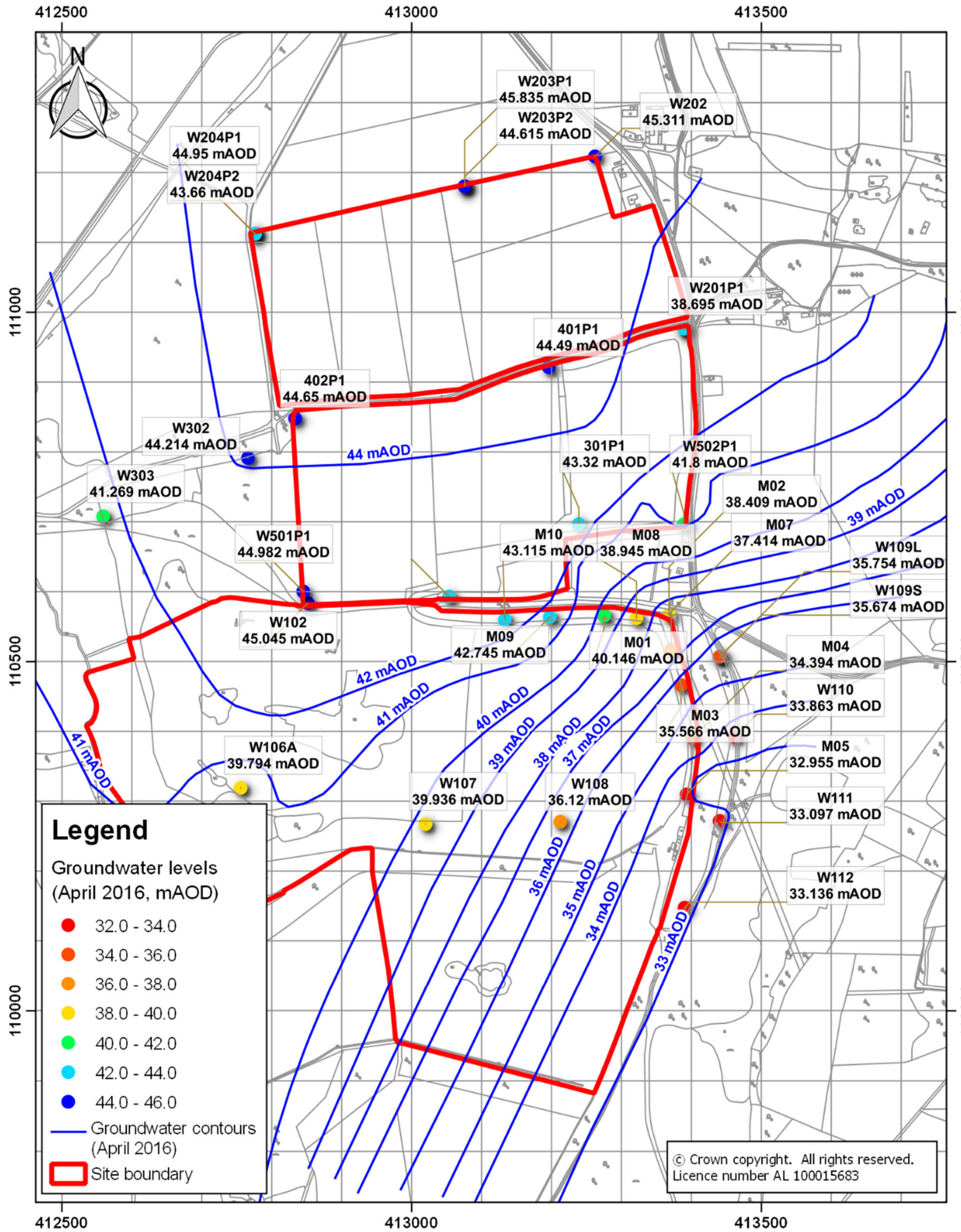


Figure 2.5 Groundwater contour plot (April 2017)

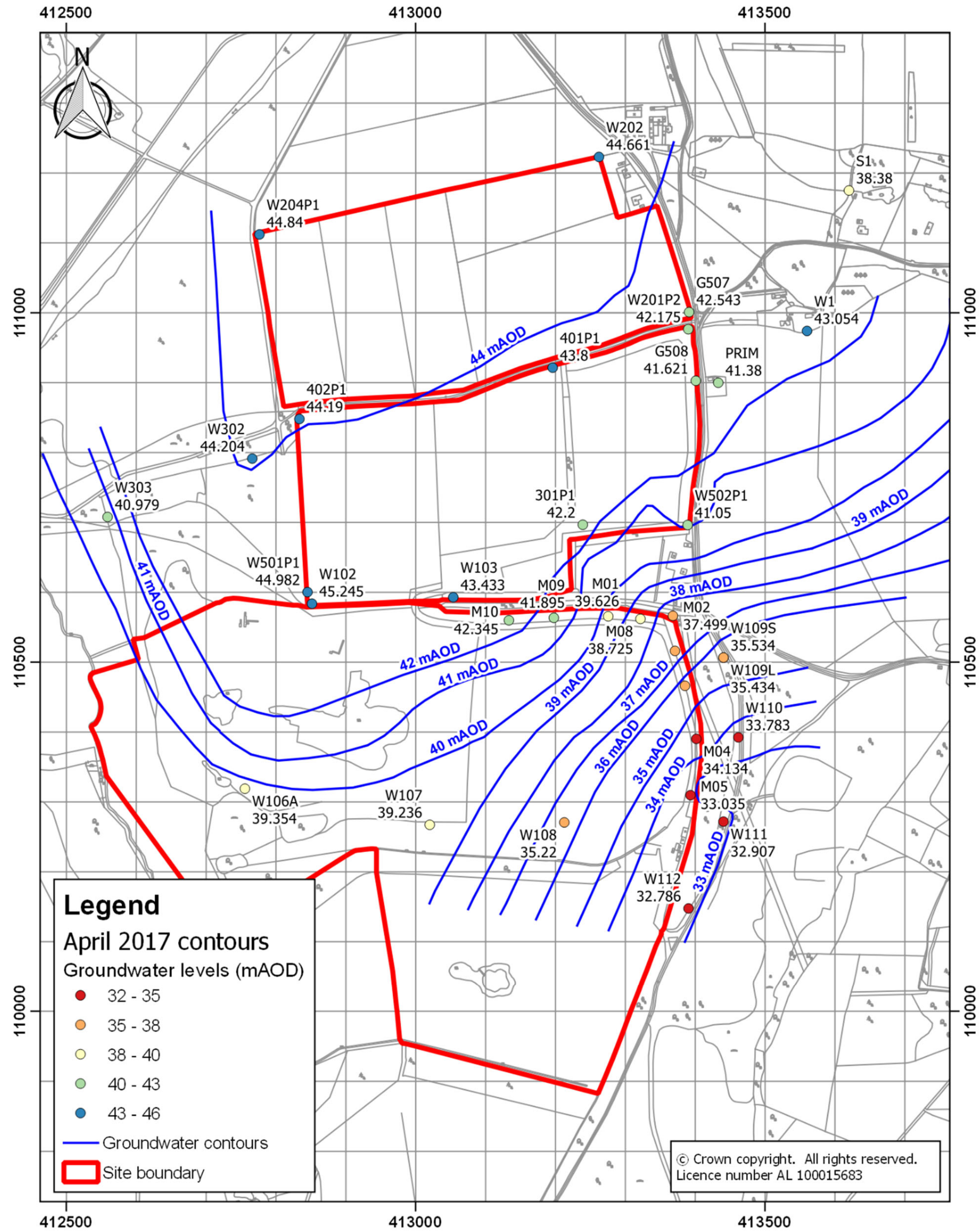


Figure 2.6 Groundwater contour plot (April 2018)

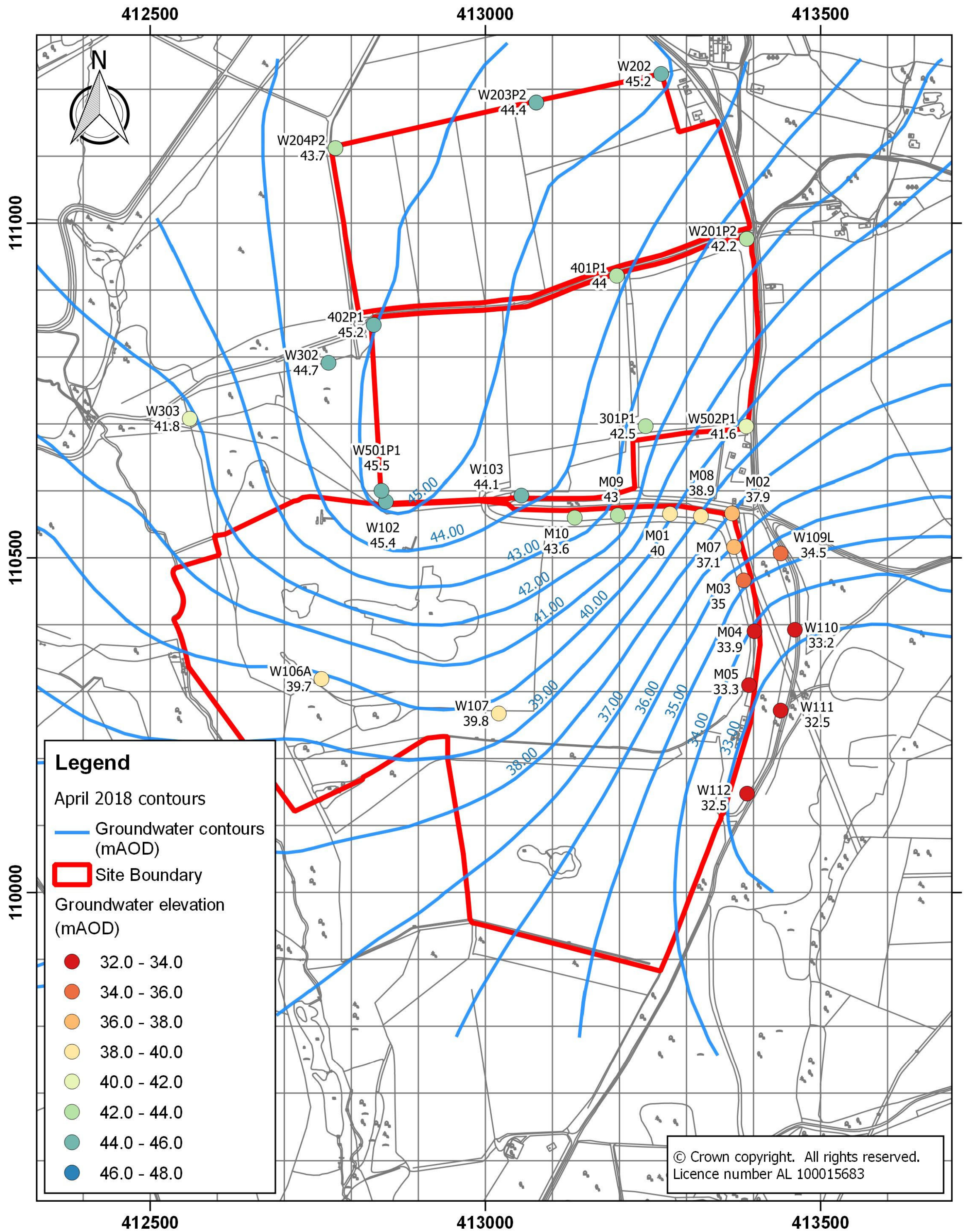


Figure 2.7 Groundwater contour plot (December 2019)

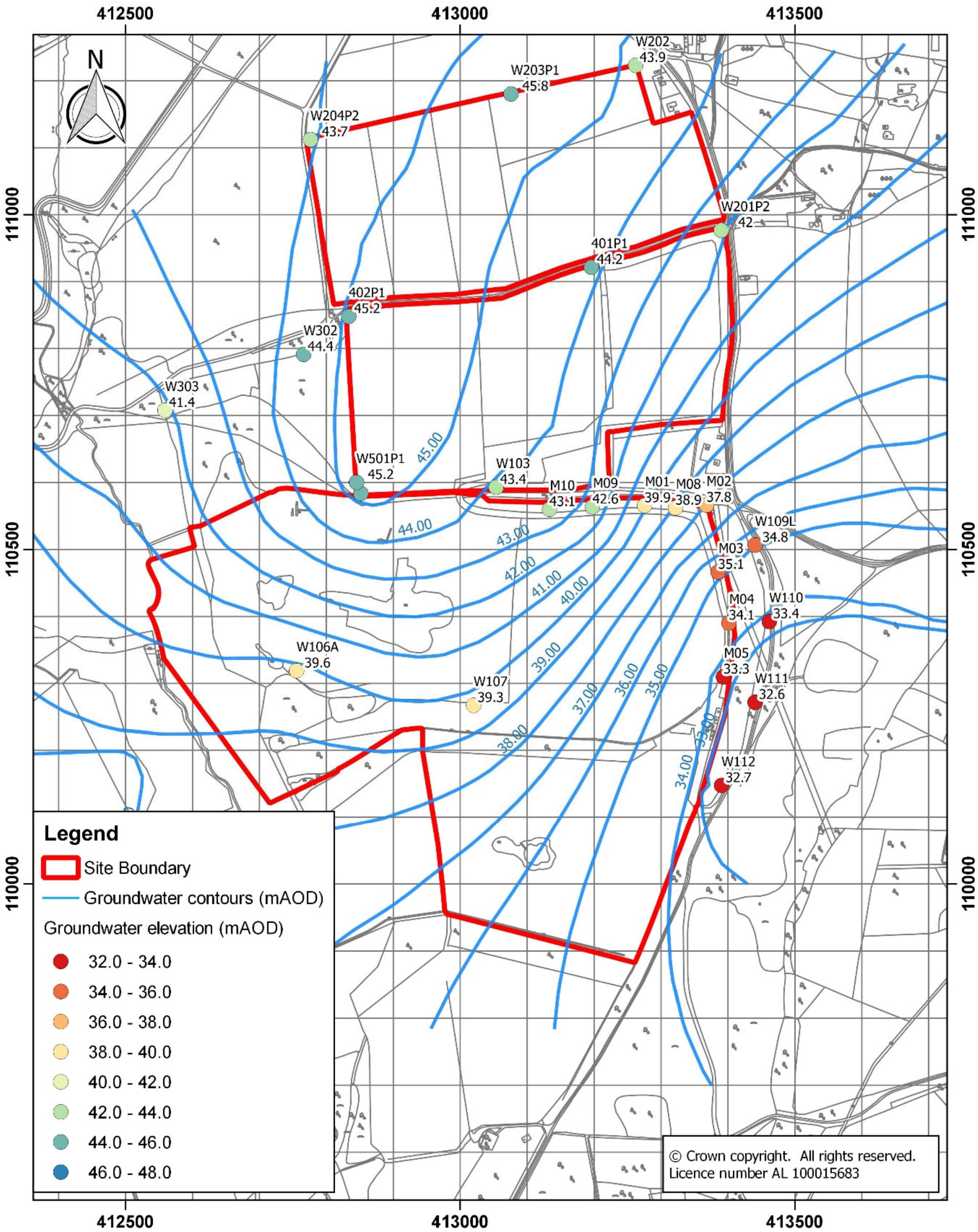


Figure 2.8 Groundwater contour plot (December 2020)

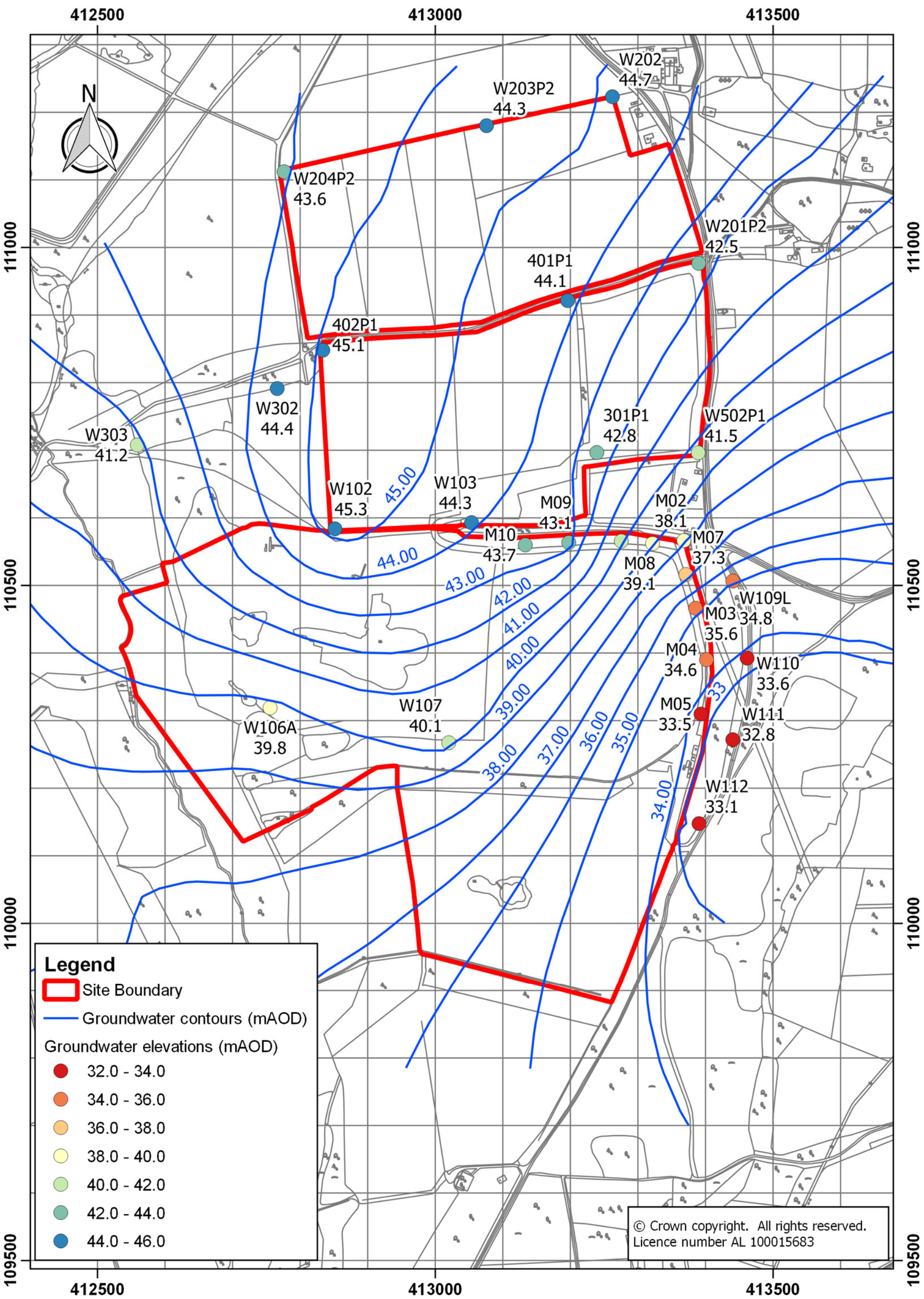


Figure 2.9 Cross sections of the Site

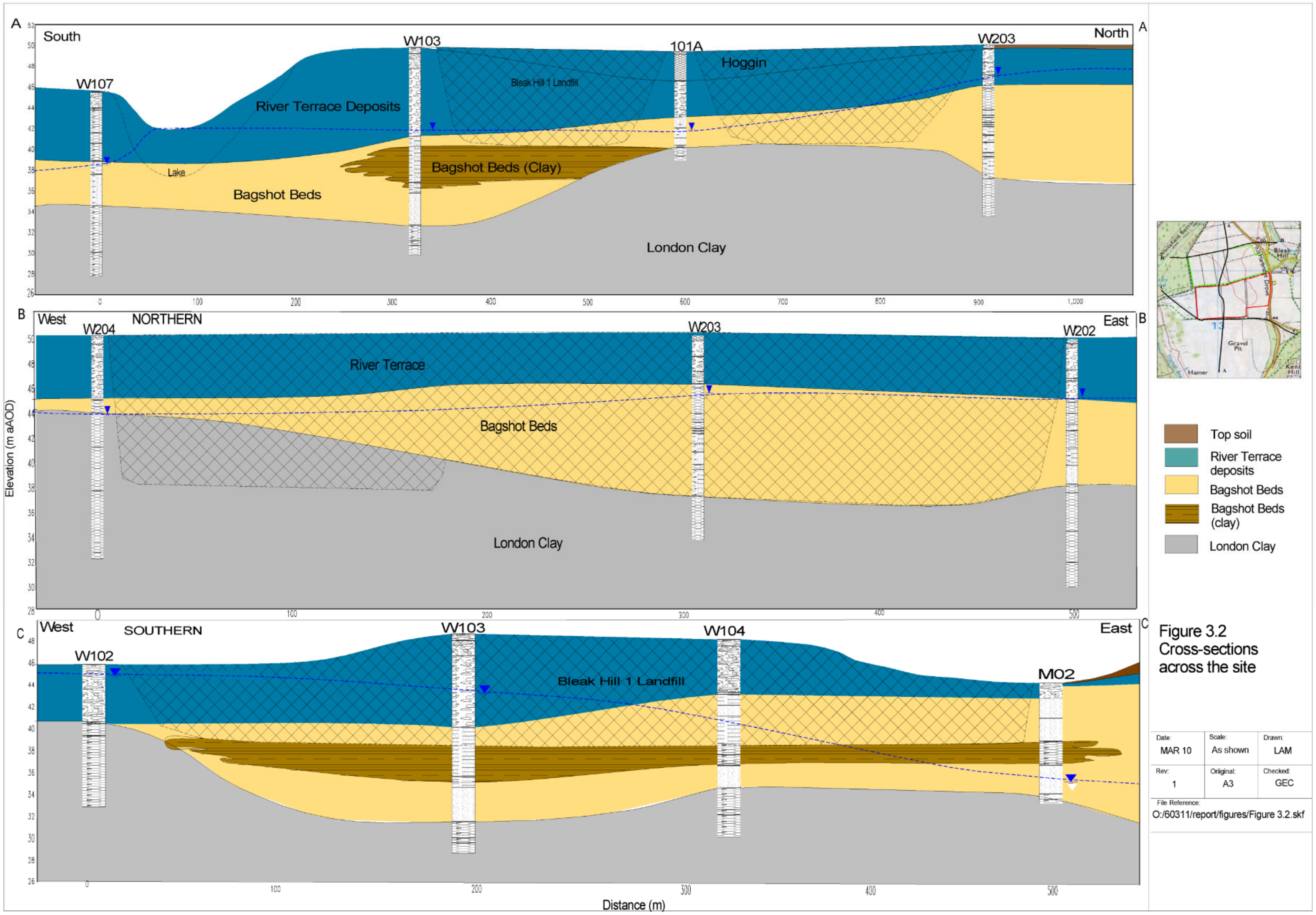
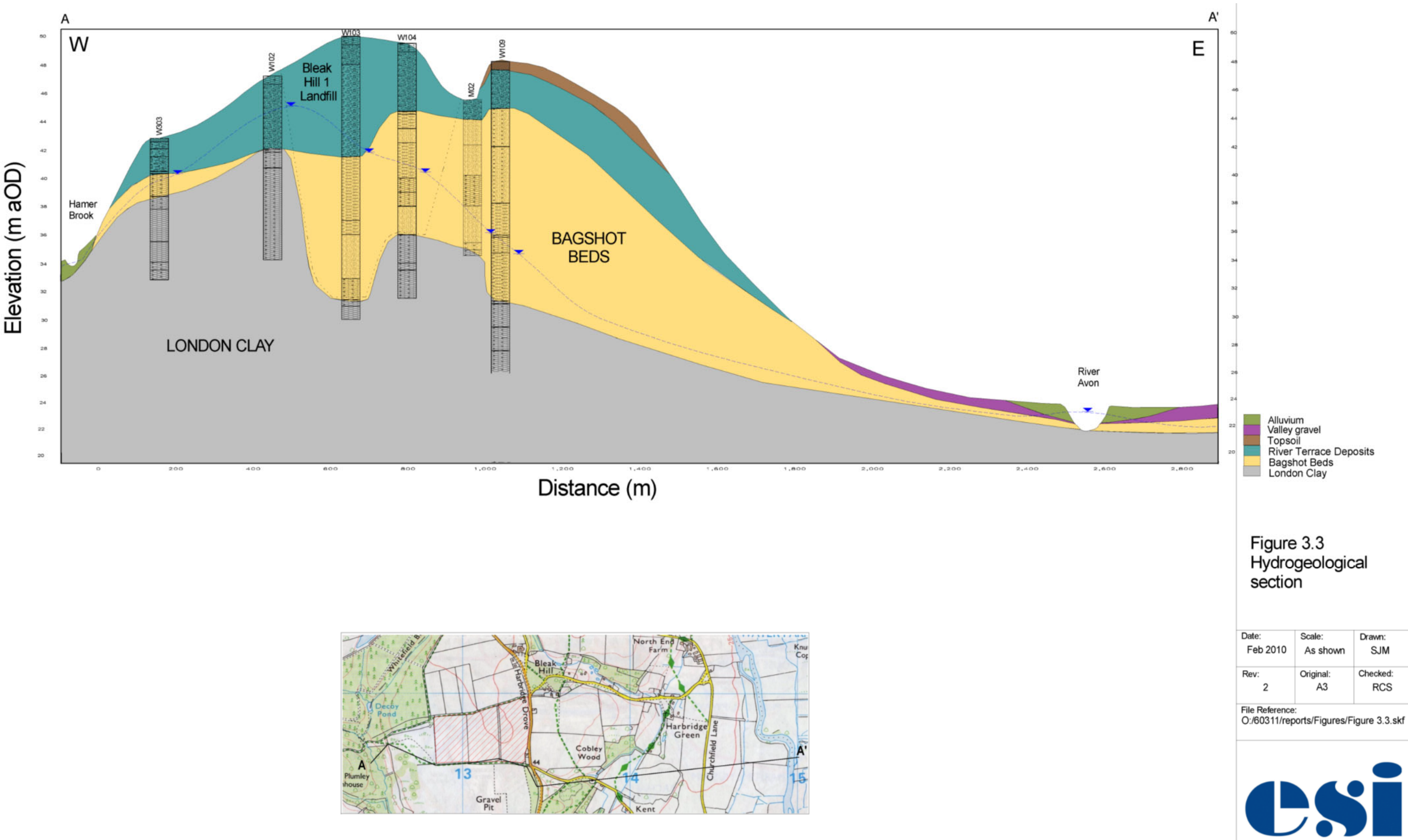


Figure 2.10 Hydrogeological west to east cross section



2.2.2 Groundwater quality

Groundwater quality at the Site is described in detail in the annual reports. A summary of all groundwater quality results between December 2014 and February 2021 is presented in Table 2.2 and a brief discussion presented below. Table 2.3 presents parameters measured at the Bleak Hill 2 Discharge (BL2DIS) in order to allow comparison. However, it is noted that there are only six samples from BL2DIS as it can only be sampled when there is a discharge. For some parameters at BL2DIS there are only two results from 3 December 2015 and 2 March 2016.

For those determinands that were selected to represent the source term in the HRA model, additional detail and time series graphs are presented.

Table S3.1 in the permit outlines groundwater quality compliance limits for W501P1, W103, M02, M09 and BL2DIS. Statistics from December 2014 to February 2021 are compared against these compliance limits in Table 2.1 and show that average concentrations at all locations are well below the limits for chloride, ammoniacal nitrogen and zinc. Further discussion on these determinands is provided in the annual reports that have been submitted to the EA.

Field parameters

Mean electrical conductivity (EC) is generally low at the Site but is slightly higher at BL2DIS compared to the groundwater boreholes. However, the 95th percentiles are more similar at around 750 µS/cm for field readings and 600-650 µS/cm for laboratory results. Conductivity readings are similar between field and laboratory methods. M04 continues to record the highest conductivities at 600 – 1000 µS/cm compared to most other locations recording below 400 µS/cm.

Mean pH is greater in groundwater than at BL2DIS with an average pH of 6.3-6.8 compared to 3.6-4.1. pH values are similar between field and laboratory methods. Groundwater pH is slightly acidic, which is typical of groundwater within the Bagshot Beds.

Mean temperature is also typical for groundwater but is slightly higher in groundwater than BL2DIS which is affected by surface temperatures.

Major Ions

Major ion concentrations in groundwater are generally low, with no results being above the UK Drinking Water Standards (DWS) for any of these determinands. ESI (2014) noted that the sole sample from BL2DIS for alkalinity gave a result that was below the detection limit whereas the mean value for the groundwater monitoring wells was 51.4 mg/l. During the current reporting period alkalinity has only been analysed on two further occasions at BL2DIS and was not detected on either occasion.

Figure 2.11 shows time series chloride concentrations in groundwater. Chloride concentrations generally remain low and stable during the current reporting period. The average chloride concentration for the current reporting period was 24.2 mg/l compared to a historic mean of 22.4 mg/l showing concentrations are comparable to historic concentrations. Concentrations at M04 have stabilised at around 30 mg/l since 2014 compared to the decline in concentrations during the previous reporting period. Concentrations at 301P1 and W501P1 have declined compared to the elevated concentrations between early 2010 and late 2013 at 301P1 and 2014 and 2015 at W501P1.

Figure 2.12 shows time series calcium concentrations in groundwater. As with other determinands, concentrations are highest at M04. Location 301P1 shows more stable concentrations at around 60 mg/l excluding the decline in December 2020. Calcium concentrations are generally consistent with previous data with a mean value of 37.5 mg/l for the current reporting period compared to a historic mean of 36 mg/l (1995 – 2014).

Figure 2.13 shows time series potassium concentrations in groundwater. As with other determinands concentrations are highest at M04 excluding elevated concentrations at 402P1 in December 2019 and March 2020. There are also single elevated concentrations at M09 and 301P1, but the times do not coincide. Average potassium concentrations during the current reporting value are at 2.2 mg/l compared to a historic average of 2.63 mg/l showing similar concentrations are still recorded.

Landfill Parameters

Mean ammoniacal nitrogen concentration for groundwater is 0.67 mg/l as N, which is above the UK Drinking Water Standard (DWS) concentration of 0.39 mg/l. The 95th percentile maximum concentration is 5.11 mg/l and the maximum concentration is 15.2 mg/l indicating that there is a significant proportion of higher ammoniacal nitrogen results in the dataset. However, this is a slight decline compared to a historic average of 0.77 mg/l as N, 95th percentile of 6.9 mg/l and maximum concentration of 18.3 mg/l.

Figure 2.14 shows time series concentrations for ammoniacal nitrogen in groundwater. This shows that almost all of the elevated ammoniacal nitrogen records have occurred at M04, due to the impact of Hamer Warren Landfill. However, concentrations at this borehole have decreased during the current reporting period to between 4 and 6 mg/l. M09 recorded its highest concentration in June 2020 at 15.2 mg/l but this reduced to 1.14 mg/l in the following monitoring round. A slight increase in concentrations have been observed at 301P1 since 2012.

Ammoniacal nitrogen concentrations at BL2DIS have all been at or below the limit of detection.

Chemical Oxygen Demand (COD) is generally low, and the maximum value of 275 mg/l is likely to be an outlier as the 95th percentile concentration is 43.9 mg/l.

Suspended solids in the Bleak Hill 2 discharge are low.

Total Organic Carbon (TOC) concentrations are generally low. The elevated maximum concentration in groundwater (56 mg/l with a 95th percentile concentration of 12.8 mg/l) is attributed to higher concentrations at M04 which is impacted by Hamer Warren Landfill to the south and 402P1 which recorded elevated peaks in December 2019 and March 2020 to 56 mg/l. The current dataset is comparable to historic concentrations which had a 95th percentile of 12.4 mg/l.

Minor Ions

Minor ion concentrations are generally low in groundwater, although iron and manganese are elevated. These determinands are known to be found naturally at elevated concentrations in Bagshot Beds groundwater. 1% of lead detections and 1.6% of nickel detections were recorded above the UK DWS.

Figure 2.15 shows time series iron concentrations in groundwater. As with other determinands, iron is highest at M04 and all other locations show low and stable concentrations. A decrease in 95th percentile concentrations is recorded during the current reporting period (4 mg/l) compared to historical data (11.5 mg/l).

Figure 2.16 shows time series zinc concentrations in groundwater. Concentrations remain low and stable and there are few concentrations above 0.1 mg/l. W201P1 recorded the greatest variation in concentrations which is consistent with historic data. The average and 95th percentile zinc concentrations have slightly declined during the current reporting period (0.016 mg/l and 0.05 mg/l respectively) in comparison with historical data (0.028 mg/l and 0.1 mg/l respectively).

There were no or very few detections of antimony, cadmium, chromium, lead and zinc during the current reporting period. There have been no chromium detections since 2017.

The most frequently detected metals were manganese and nickel, which were detected in 97% and 62% of analysed samples respectively. Of these, manganese was reported as being above its respective UK DWS value in 67% of samples, although this may be naturally elevated in background groundwater in the shallow sand and gravel aquifer, as evidenced by the fact that concentrations have been recorded above the UK DWS both up-gradient (W203P2) and down-gradient (W112) of the landfill.

<u>Organic compounds</u>

Hydrocarbon compounds have been analysed for in groundwater for 27 samples. C21-C40 was recorded in groundwater samples above the limit of detection on eight occasions between W103 and W501P1 in 2016 – 2019. Two detections of C21-C40 were recorded in BL2DIS in 2015/2016. However, these were very low concentrations. One detection of C6-C8 was recorded in groundwater samples at W103 in September 2020.

Table 2.1 Groundwater quality compared to compliance limits (Dec 2014 to Feb 2021)

Determinand	Location	Unit	Compliance limit	Count	Min	Max	Mean	95th percentile
Ammoniacal nitrogen	W501P1, W103, M09, M02	mg/l	5	86	<0.06	15.2	0.547	2.06
Chloride		mg/l	100	85	11.9	181	30.6	49.9
Zinc		mg/l	1	85	<0.018	0.08	n.d.	n.d
Ammoniacal nitrogen	BL2DIS	mg/l	5	6	<0.06	0.06	0.035	0.0525
Chloride		mg/l	100	6	11.5	14.3	12.5	14.2
Zinc		mg/l	1	2	0.235	0.311	0.273	0.307

Table 2.2 Statistical summary of groundwater quality over reporting period (December 2014 – February 2021)

Determinand	No. of Results	Unit	Min	Max	Mean	Median	Standard Deviation	5th Percentile	95th Percentile	# > LOD	% > LOD	UKDWS No. Exceeding	UKDWS % Exceeding	UKDWS Action Level
Field / lab parameters														
Conductivity- Electrical (Field)	410	µS/cm	87	1845	313	270	195	121	758	410	100	0	0	-
Conductivity- Electrical 20deg	424	µS/cm	106	854	283	251	149	126	649	424	100	0	0	-
pH	424	pH	4.2	7.9	6.34	6.4	0.63	5.3	7.3	424	100	0	0	-
pH (Field)	411	pH	4.46	16.5	6.85	6.86	0.872	5.68	7.9	411	100	0	0	-
Temperature (Field)	411	deg c	7.8	21.9	12.5	12.4	2.14	9.35	16.2	411	100	0	0	-
Major ions														
Alkalinity as CaCO3	424	mg/l	<2.8	461	52.6	24.1	82.7	5.4	307	421	99.3	0	0	-
Calcium	187	mg/l	5.98	129	37.5	34.9	26.5	7.95	104	187	100	0	0	-
Chloride	424	mg/l	7.3	181	24.2	21.5	13.2	12	40.7	424	100	0	0	250
Magnesium	187	mg/l	1.1	12	4.26	3.6	2.47	1.4	9.67	187	100	0	0	-
Potassium	187	mg/l	0.33	22	2.22	1.08	3.32	0.493	10.2	187	100	0	0	-
Sodium	187	mg/l	4.64	66.4	13.3	12.4	6.57	6.38	20.7	187	100	0	0	200
Sulphate as SO4	424	mg/l	<4.4	182	53.6	44.4	36.4	14.1	121	417	98.3	0	0	250
Minor ions														
Antimony	112	mg/l	<0.0016	<0.0016	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	0.005
Arsenic	113	mg/l	<0.0002	0.0068	0.000814	0.0005	0.00108	n.d.	0.00304	62	54.9	0	0	0.01
Cadmium	187	mg/l	<0.0006	0.0033	n.d.	n.d.	n.d.	n.d.	n.d.	7	3.74	0	0	0.005
Chromium	187	mg/l	<0.002	0.015	n.d.	n.d.	n.d.	n.d.	n.d.	4	2.14	0	0	0.05
Copper	187	mg/l	<0.009	0.038	n.d.	n.d.	n.d.	n.d.	0.012	21	11.2	0	0	2
Iron	187	mg/l	<0.23	38.5	1.17	n.d.	4.31	n.d.	4	47	25.1	47	25.1	0.2
Lead	187	mg/l	<0.006	0.022	n.d.	n.d.	n.d.	n.d.	0.006	11	5.88	2	1.07	0.01
Manganese	**187**	**mg/l**	**<0.007**	**1.37**	**0.198**	**0.079**	**0.252**	**0.0083**	**0.71**	**181**	**96.8**	**125**	**66.8**	**0.05**

Determinand	No. of Results	Unit	Min	Max	Mean	Median	Standard Deviation	5th Percentile	95th Percentile	# > LOD	% > LOD	UKDWS No. Exceeding	UKDWS % Exceeding	UKDWS Action Level
Nickel	187	mg/l	<0.003	0.025	0.00512	0.004	0.00404	n.d.	0.012	115	61.5	3	1.6	0.02
Selenium	112	mg/l	<0.0006	0.0028	n.d.	n.d.	n.d.	n.d.	0.0012	13	11.6	0	0	0.01
Zinc	424	mg/l	<0.018	0.261	0.0163	n.d.	0.0216	n.d.	0.05	96	22.6	0	0	-
Nitrogen species														
Ammoniacal Nitrogen as N	425	mg/l	<0.06	15.2	0.669	0.08	1.65	n.d.	5.11	233	54.8	100	23.5	0.39
Nitrate as N	112	mg/l	<0.7	14.4	1.51	n.d.	2.35	n.d.	6.86	37	33	1	0.89	11
Nitrite as N	112	mg/l	<0.006	0.114	0.00927	n.d.	0.0189	n.d.	0.0285	29	25.9	5	4.46	0.03
Nitrogen (total oxidised) as N	424	mg/l	<0.7	14.7	1.72	n.d.	2.27	n.d.	6.8	199	46.9	0	0	-
Landfill parameters														
COD (Total)	424	mg/l	<11	275	14.7	11	18.1	n.d.	43.9	217	51.2	0	0	-
TOC (filtered)	424	mg/l	<0.7	56	3.44	2.1	4.56	n.d.	12.8	401	94.6	0	0	-
Hydrocarbons														
C10-C12 Diesel range organics	27	mg/l	<0.01	<0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	-
C12-C16 Diesel range organics	27	mg/l	<0.01	<0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	-
C16-C21 Diesel range organics	27	mg/l	<0.01	<0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	-
C21-C40 Diesel range organics	27	mg/l	<0.01	0.057	0.0142	n.d.	0.0209	n.d.	0.0516	8	29.6	0	0	-
C6-C8 Petroleum Range Organics	27	mg/l	<0.01	0.064	n.d.	n.d.	n.d.	n.d.	n.d.	1	3.7	0	0	-
C8-C10 Diesel range Organics	27	mg/l	<0.01	<0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	-
TPH>C6-C40 6Split	27	mg/l	<0.01	0.064	0.0162	n.d.	0.023	n.d.	0.0619	9	33.3	0	0	-
Other parameters														
D.O. concentration	421	mg/l	<0.5	13.4	3.33	2.4	2.73	n.d.	8.4	360	85.5	0	0	-
Ionic balance	184	%	-9	9.8	-2.30924	-2.7	3.73	-7.47	5.2	184	100			

Note: if significant number of results exceed action limit row is coloured as follows: 10 - 25% pale red, 25 - 50% darker red, >50% dark red. n.d. statistic not determinable. Mean statistics for non-detects are calculated at half the limit of detection.

Table 2.3 Statistical summary for BL2DIS (December 2014 – February 2021)

												UKDWS		
Determinand	**No. of Results**	**Unit**	**Min**	**Max**	**Mean**	**Median**	**Standard Deviation**	**5th Percentile**	**95th Percentile**	**# > LOD**	**% > LOD**	**No. Exceeding**	**% Exceeding**	**Action Level**
Field / lab parameters														
Conductivity- Electrical (Field)	6	µS/cm	478	780	613	601	101	500	749	6	100	0	0	-
Conductivity- Electrical 20deg	2	µS/cm	427	605	516	516	126	436	596	2	100	0	0	-
pH	6	pH	3.1	5.2	3.58	3.25	0.813	3.1	4.8	6	100	0	0	-
pH (Field)	6	pH	2.8	5.8	4.14	4	1.03	3	5.5	6	100	0	0	-
Temperature (Field)	6	deg c	2.4	10	6.32	6.2	2.59	3.13	9.45	6	100	0	0	-
Major ions														
Alkalinity as CaCO3	2	mg/l	<2.8	<2.8	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	-
Chloride	6	mg/l	11.5	14.3	12.5	11.9	1.19	11.6	14.2	6	100	0	0	-
Sulphate as SO4	2	mg/l	130	190	160	160	42.4	133	187	2	100	0	0	-
Minor ions														
Iron	4	mg/l	3.7	9.5	5.6	4.6	2.68	3.75	8.86	4	100	0	0	-
Zinc	2	mg/l	0.235	0.311	0.273	0.273	0.0537	0.239	0.307	2	100	0	0	-
Nitrogen species														
Ammoniacal Nitrogen as N	6	mg/l	<0.06	0.06	0.035	n.d.	0.0122	n.d.	0.0525	1	16.7	0	0	-
Nitrogen (total oxidised) as N	2	mg/l	1.2	4.4	2.8	2.8	2.26	1.36	4.24	2	100	0	0	-
Landfill parameters														
COD (Total)	2	mg/l	<11	<11	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	-
TOC (filtered)	2	mg/l	0.8	0.8	0.8	0.8	0	0.8	0.8	2	100	0	0	-
Hydrocarbons														
C10-C12 Diesel range organics	5	mg/l	<0.01	<0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	-
C12-C16 Diesel range organics	5	mg/l	<0.01	<0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	-
C16-C21 Diesel range organics	5	mg/l	<0.01	<0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	-
C21-C40 Diesel range organics	5	mg/l	<0.01	0.025	0.011	n.d.	0.00894	n.d.	0.023	2	40	0	0	-

Determinand	No. of Results	Unit	Min	Max	Mean	Median	Standard Deviation	5th Percentile	95th Percentile	# > LOD	% > LOD	UKDWS No. Exceeding	UKDWS % Exceeding	UKDWS Action Level
C6-C8 Petroleum Range Organics	5	mg/l	<0.01	<0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	-
C8-C10 Diesel range Organics	5	mg/l	<0.01	<0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	-
TPH>C6-C40 6Split	5	mg/l	<0.01	0.025	0.011	n.d.	0.00894	n.d.	0.023	2	40	0	0	-
Other parameters														
D.O. concentration	2	mg/l	5	10.1	7.55	7.55	3.61	5.26	9.85	2	100	0	0	-
Solids, Suspended	6	mg/l	3	18	12.7	14	5.43	5	17.5	6	100	0	0	-

Note: if significant number of results exceed action limit row is coloured as follows: 10 - 25% pale red, 25 - 50% darker red, >50% dark red. n.d. statistic not determinable. Mean statistics for non-detects are calculated at half the limit of detection.

Figure 2.11 Time series chloride concentrations in groundwater since 2008

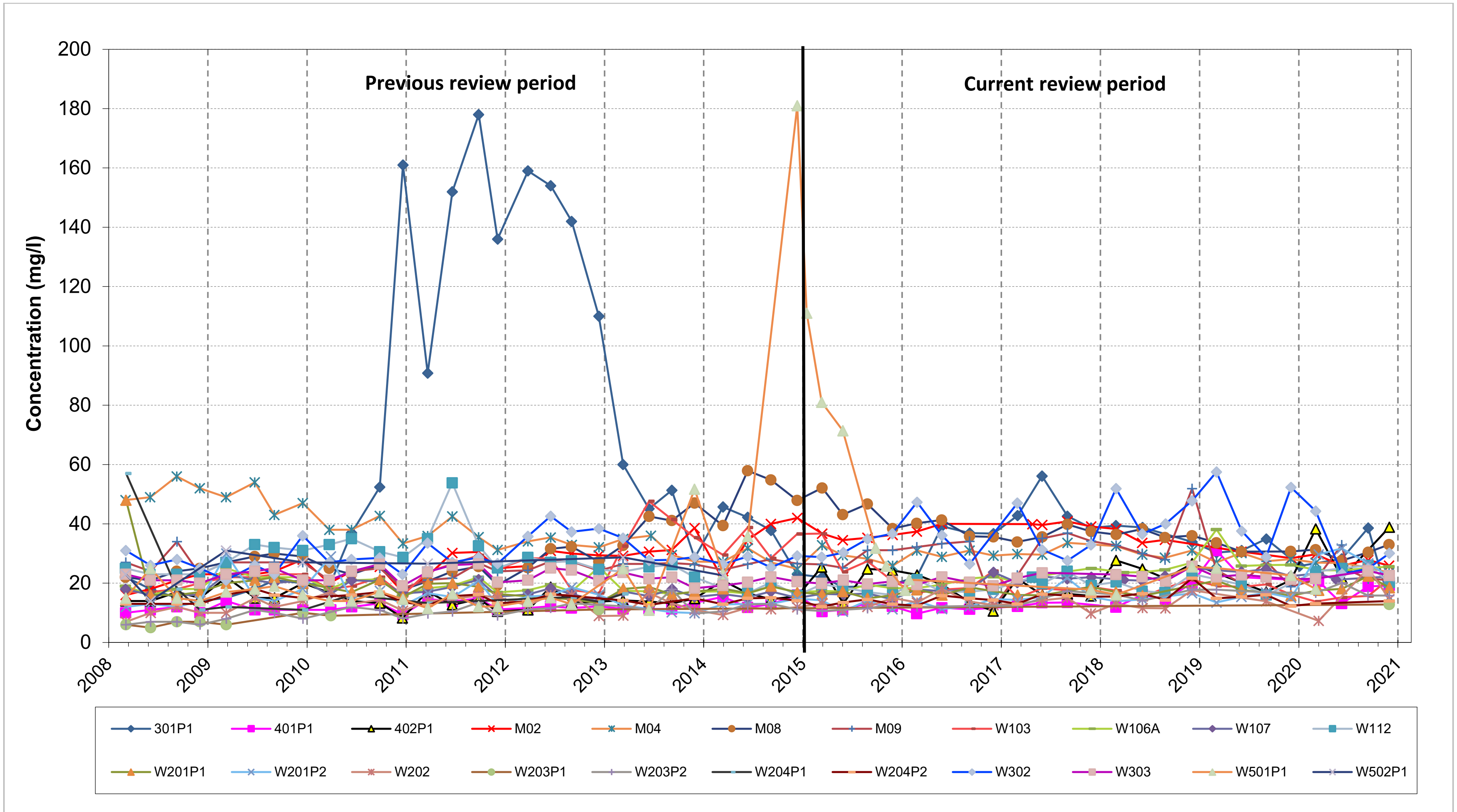


Figure 2.12 Time series calcium concentrations in groundwater since 2008

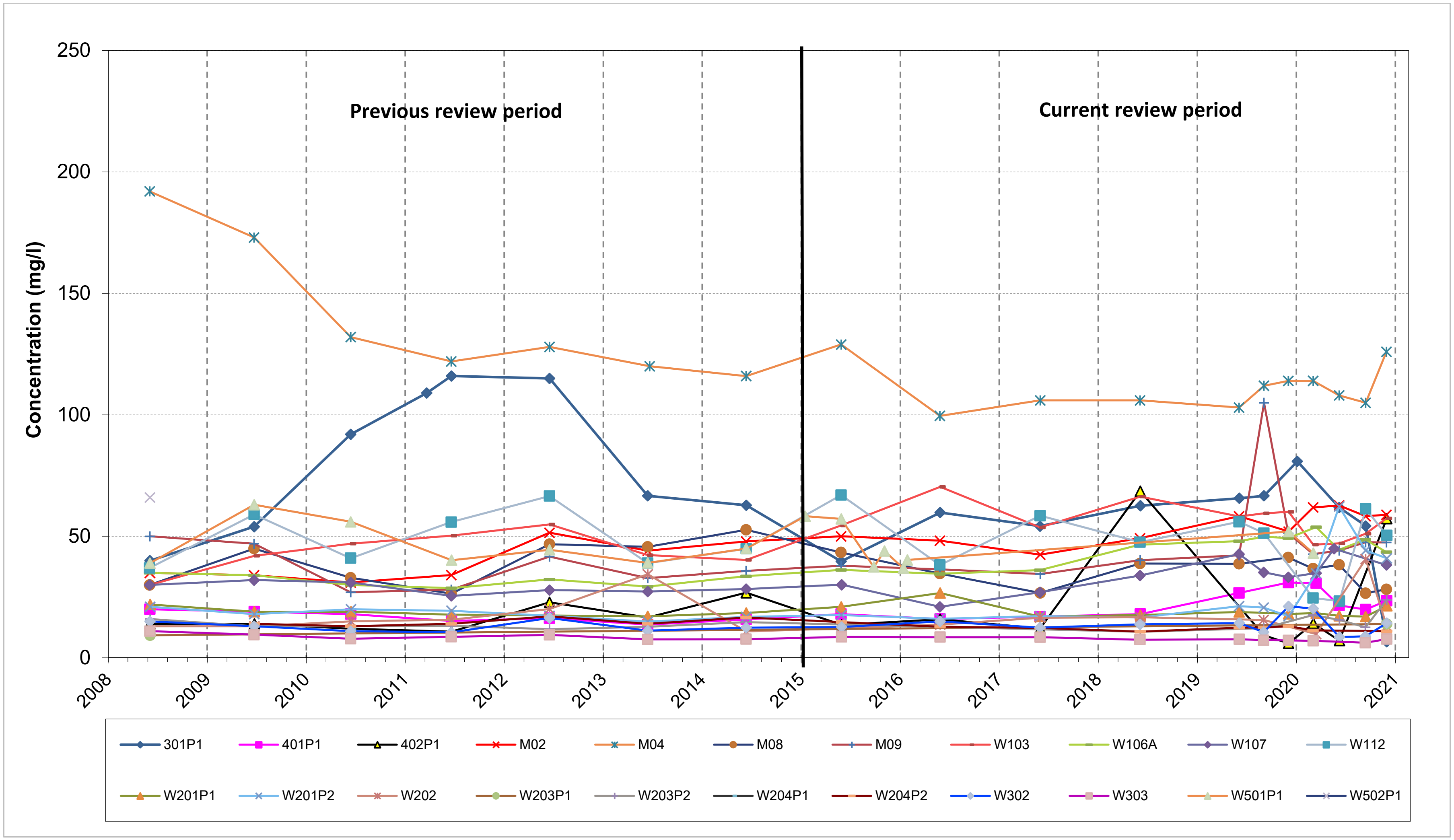


Figure 2.13 Time series potassium concentrations in groundwater since 2008

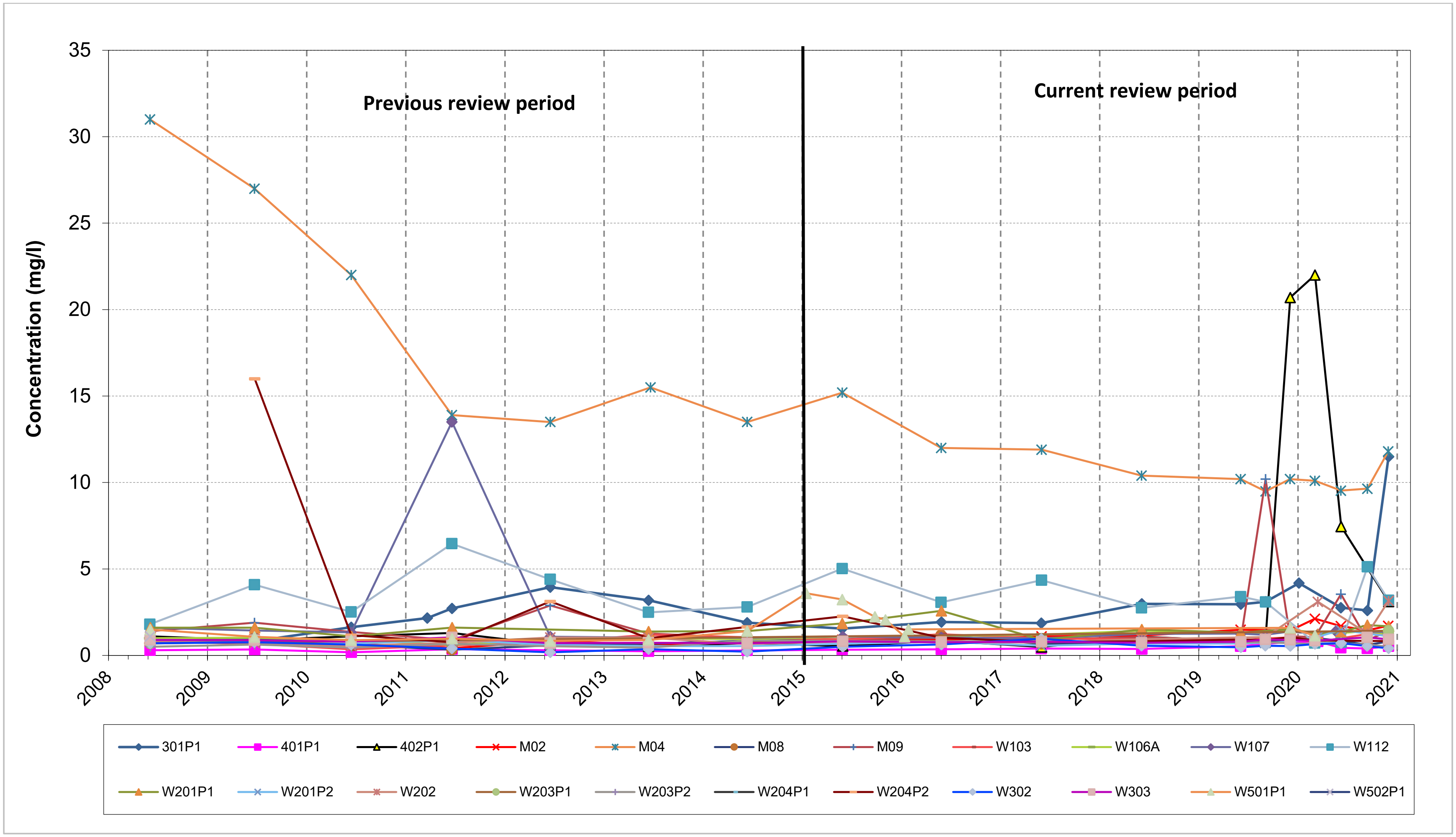


Figure 2.14 Time series ammoniacal nitrogen concentrations in groundwater since 2008

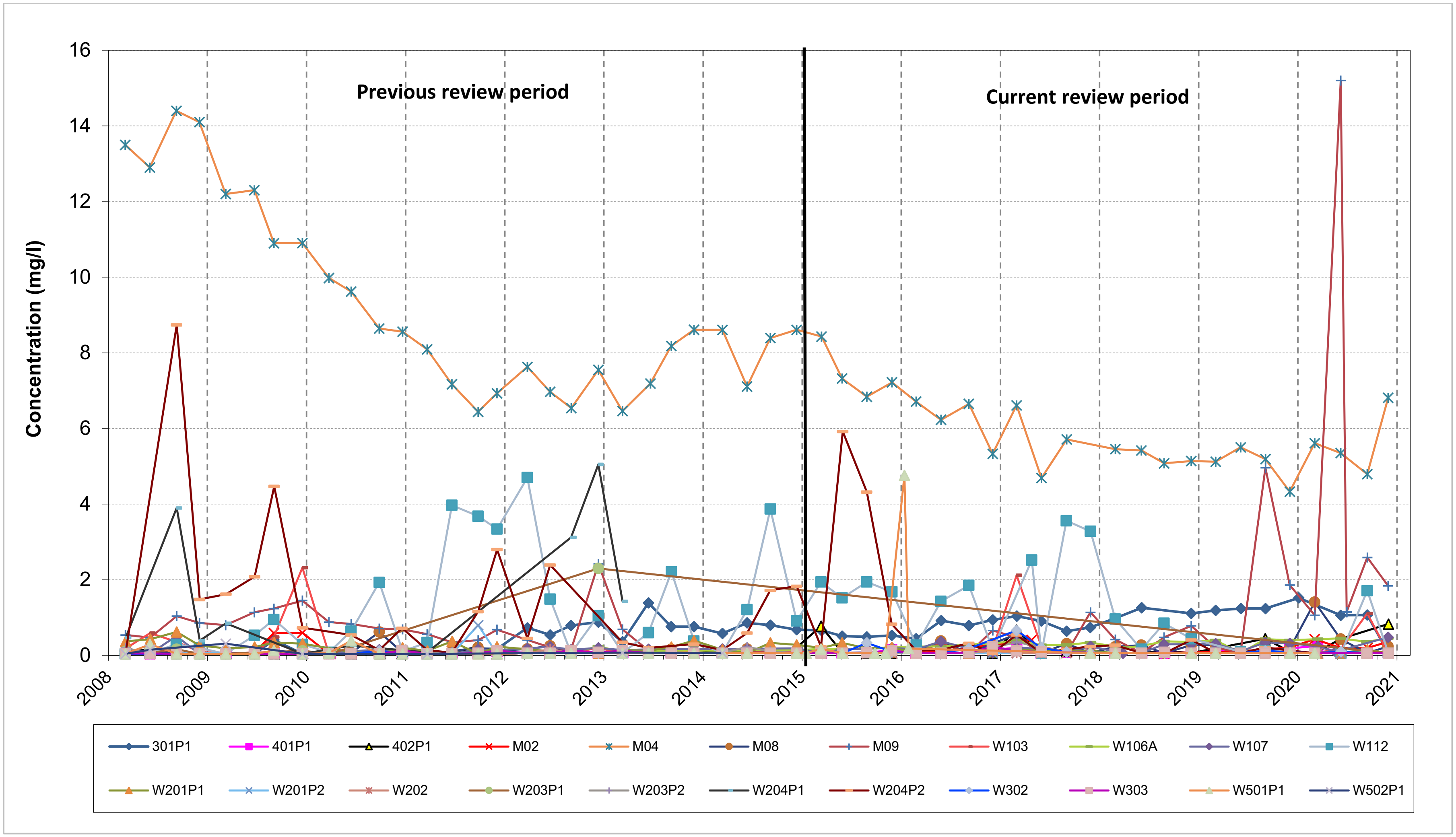


Figure 2.15 Time series iron concentrations in groundwater since 2008

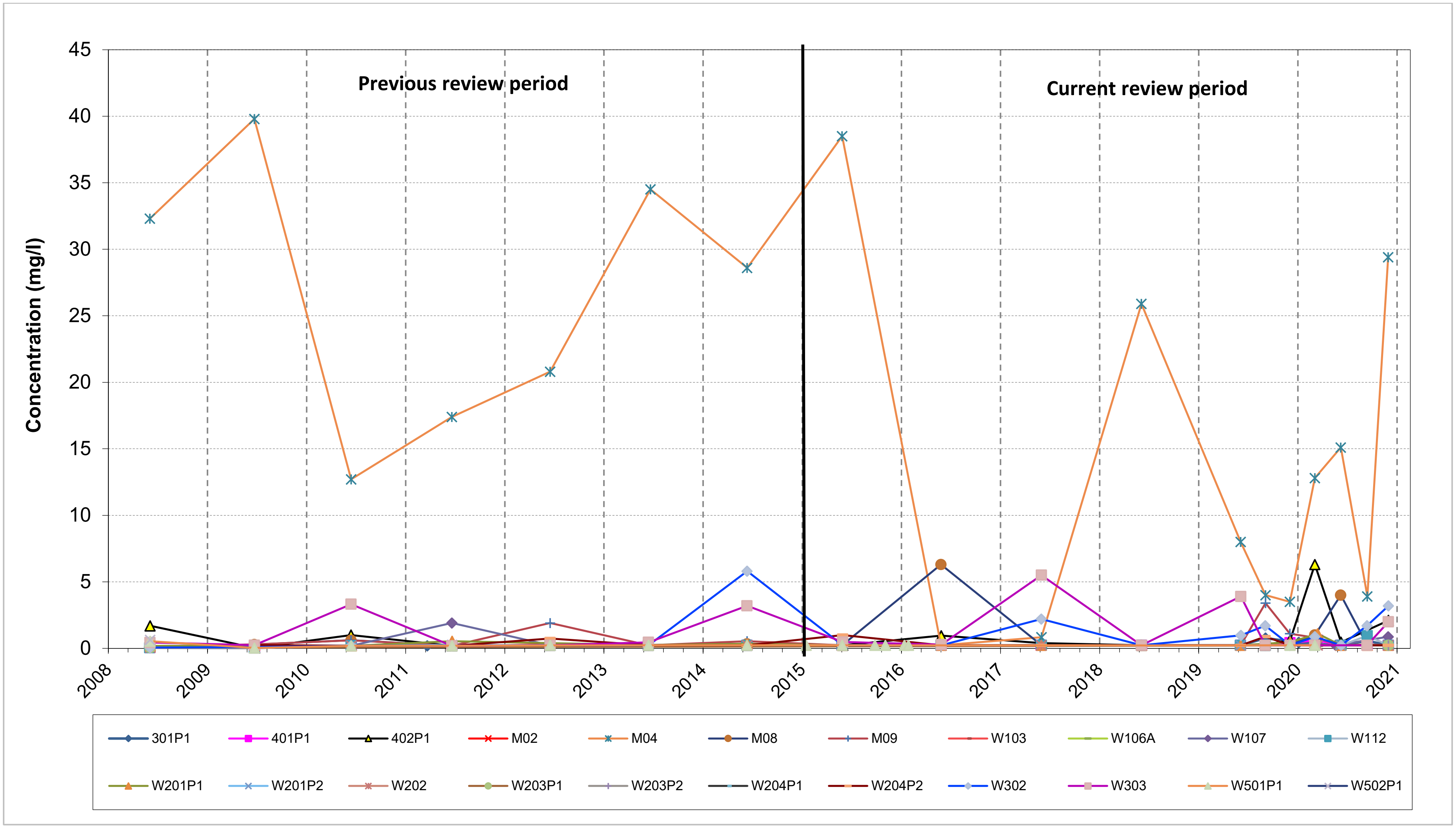
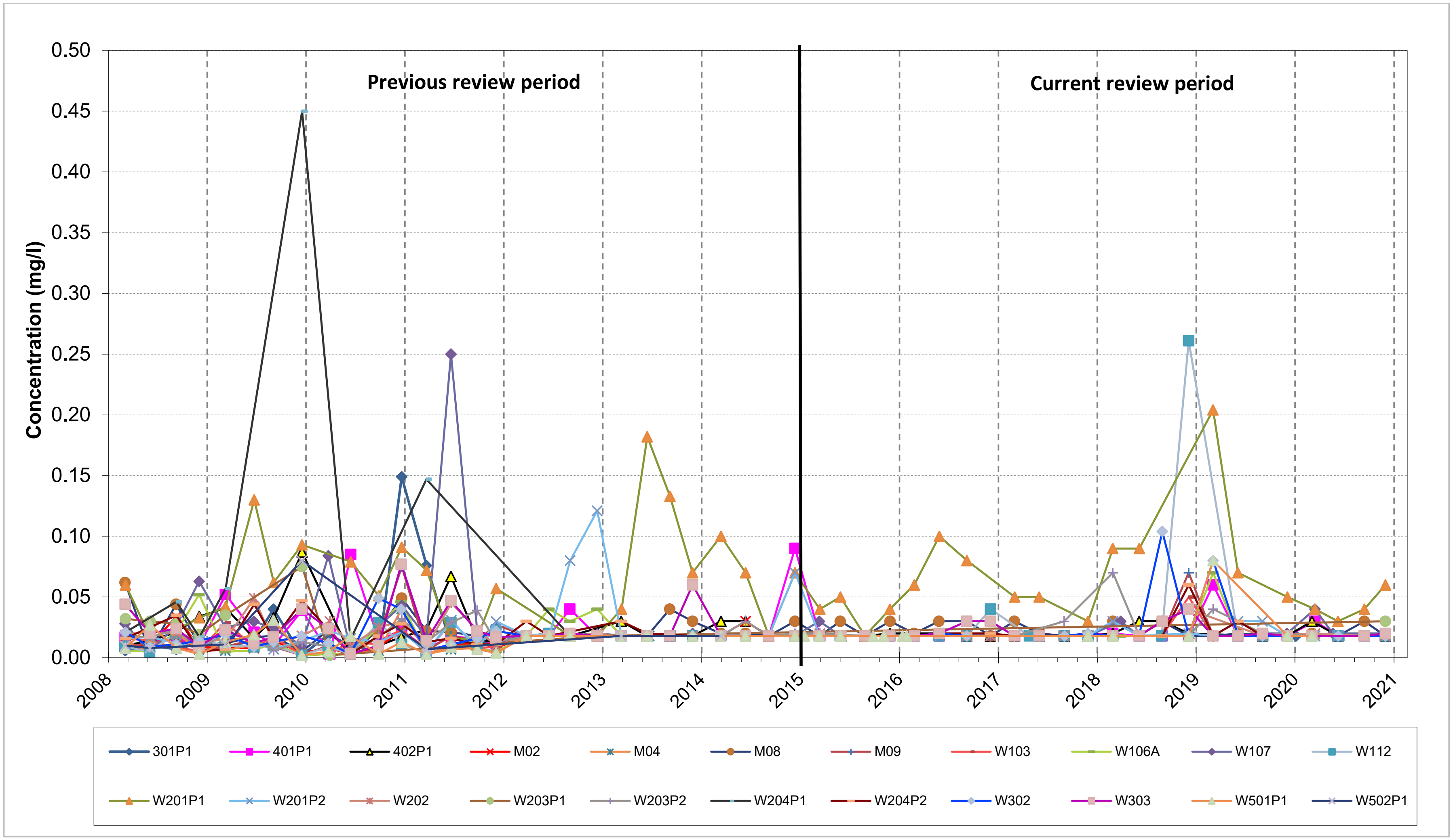


Figure 2.16 Time series zinc concentrations in groundwater since 2008



2.3 Surface water

Surface water is monitored at the following locations (Figure 1.2):

- Two locations, HB1 and HB2, in the Hamer Brook stream to the west of the Site;
- LAKE1 – the restored lake in the Hamer Warren part of the Site;
- WB1 – a location on the stream known as Whitefield Bottom to the north-west of Bleak Hill; this stream is a tributary to the Hamer Brook and is up-stream of HB1;
- At three locations, S1, S2 and S3, in the small stream to the east of the Site, known locally as the Lomer Stream;
- HAMBL1DIS – the surface water discharge from the dewatering of the sand excavation into LAKE1; and
- BL2DIS – abstraction point for Bleak Hill 2; water discharged may be to either on-site lagoons in Bleak Hill 1 or into LAKE1.

WB1 and S1 are the upstream locations for the Bleak Hill 2 landfill on these two surface water systems.

Table 2.4 shows a statistical summary of the surface water quality data (excluding BL2DIS). Results have been compared to the Environmental Quality Standards for Fresh Waters (EQS FW). These data show a good quality surface water. Electrical conductivity is moderate, and pH is neutral which is consistent with historical data. LAKE1 has recorded an increase in conductivity from 2014 to 2018 reaching a maximum value of 403 µS/cm at this location, followed by a decline during 2019 and the start of 2020. Major ions are present at modest concentrations.

The mean ammoniacal nitrogen concentration is low at 0.067 mg/l. HB1 has mostly recorded the highest concentrations in recent years at up to 0.68 mg/l which is reflected in the 95th percentile concentration which is 0.24 mg/l. These values are similar to those historically recorded.

Chloride concentrations are generally low. Concentrations were on average 22.1 mg/l, with a maximum concentration of 43.9 mg/l. These are considered to be normal for local surface waters, and the data are very similar to that from previous years with a historic mean of 22.3 mg/l and maximum of 114 mg/l.

BOD, COD and TOC are all present at low concentrations.

Metal concentrations are generally low. Lead, cadmium, chromium and antimony have not been detected since December 2014 and the present day. Copper, iron and zinc were recorded above the EQS but on less than 10% of occasions. Manganese and nickel recorded concentrations above the EQS on 11% and 29% of occasions respectively. All the higher manganese concentrations were recorded at WB1 which recorded the maximum concentration of 1.79 mg/l in September 2019 and similarly the higher nickel concentrations were predominantly recorded at HB1 and WB1.

In comparison to surface water quality statistics calculated in the last HRA review, major ion concentrations have remained similar or have slightly declined except for sulphate. This is due to the increasing trend at LAKE1 recorded from 2014 to 2018 as shown on Figure 2.17. The increase of sulphate at LAKE1 is likely to be due to the pumping of the dewatering water from the excavation at Bleak Hill 2 into the lake which has previously been in contact with the Bagshot Clays. Sulphate follows the same trend as electrical conductivity at LAKE1. Concentrations have since declined throughout 2019 and the start of 2020 but a sharp increase was observed from June to August 2020 from 75.5 mg/l to 94.1 mg/l. However, this still shows a decrease in concentrations compared to 2017, 2018 and 2019. The highest concentration of sulphate to date on Site was 189 mg/l in HAMBL1DIS in December 2015.

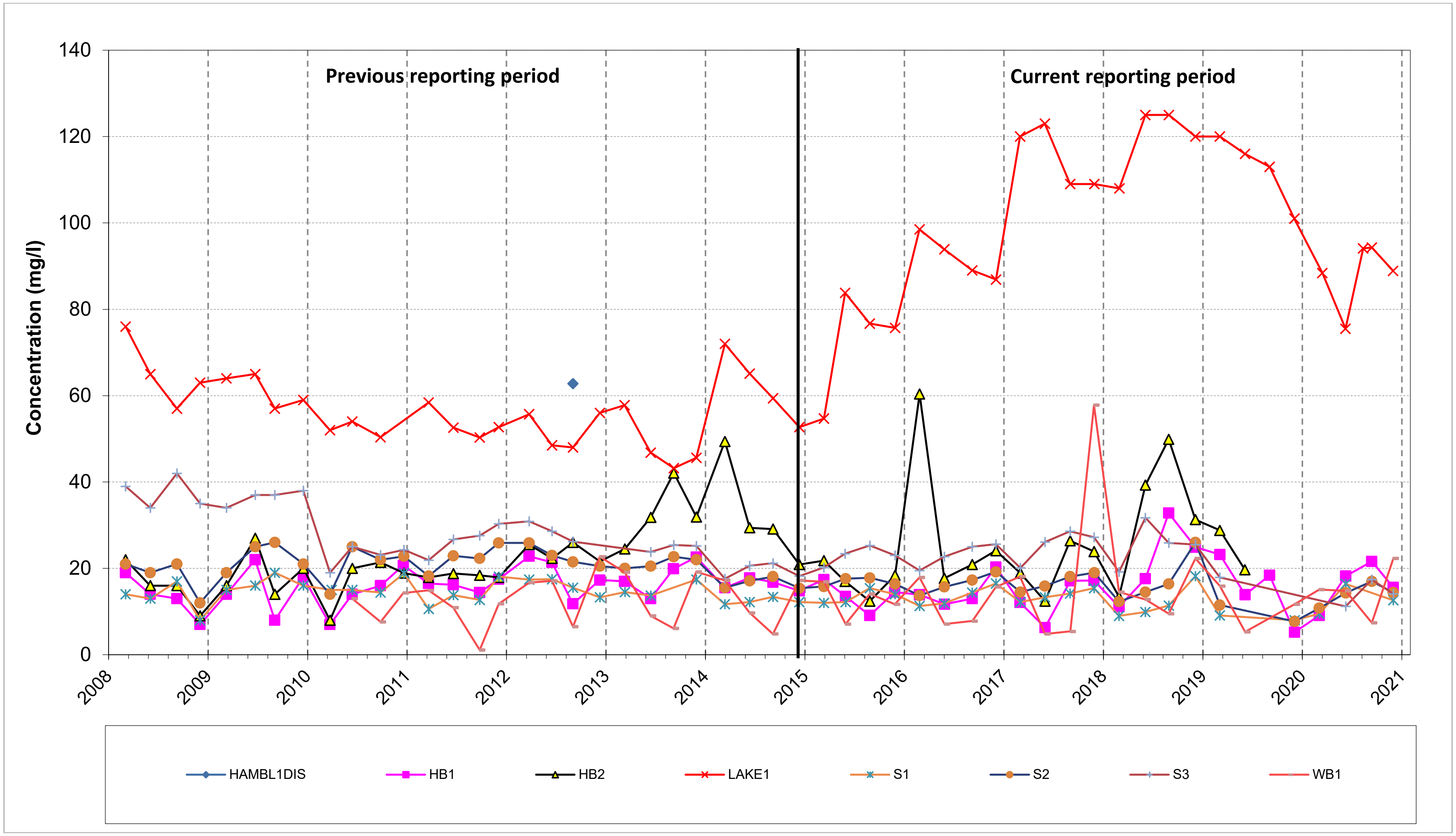
Table 2.4 Statistical summary for surface water quality over reporting period (December 2014 – February 2021)

Determinand	No. of Results	Unit	Min	Max	Mean	Median	Standard Deviation	5th Percentile	95th Percentile	# > LOD	% > LOD	EQS FW No. Exceeding	EQS FW % Exceeding	Action Level
Field / lab parameters														
Conductivity- Electrical (Field)	458	µS/cm	103	1382	260	241	114	135	435	458	100	0	0	-
Conductivity- Electrical 20deg	464	µS/cm	120	437	228	231	64.5	146	361	464	100	0	0	-
pH	464	pH	5.3	9.5	7.34	7.3	0.588	6.4	8.1	464	100	0	0	-
pH (Field)	458	pH	4.98	12.2	7.58	7.6	0.901	6.2	8.8	458	100	0	0	-
Temperature (Field)	458	deg c	1.5	101	11.9	11.7	6.05	5.1	19.2	458	100	0	0	-
Major ions														
Alkalinity as CaCO3	160	mg/l	3.2	95.2	43.6	41.7	26	8.2	77.2	160	100	0	0	-
Calcium	62	mg/l	7.66	55.8	29.7	36.2	15.9	8.81	50.6	62	100	0	0	-
Chloride	464	mg/l	11.2	43.9	22.1	21.6	5.43	13.9	32.8	464	100	0	0	250
Magnesium	62	mg/l	1.7	4.5	2.86	2.65	0.718	1.9	4.2	62	100	0	0	-
Potassium	62	mg/l	<0.18	5.05	1.57	1.51	0.877	0.405	2.94	61	98.4	0	0	-
Sodium	62	mg/l	4.71	15.2	9.85	10.2	2.32	6.29	13.3	62	100	0	0	-
Sulphate as SO4	161	mg/l	<4.4	125	30.3	17.4	31.8	7.4	109	160	99.4	0	0	400
Minor ions														
Antimony	34	mg/l	<0.0012	<0.0016	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	-
Arsenic	35	mg/l	<0.0002	0.00082	0.000458	0.0005	0.00017	n.d.	0.00073	26	74.3	0	0	0.05
Cadmium	62	mg/l	<0.0006	<0.0006	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	0.00008*
Chromium	62	mg/l	<0.002	<0.002	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	-
Copper	62	mg/l	<0.009	0.025	n.d.	n.d.	n.d.	n.d.	0.00975	4	6.45	4	6.45	0.001*

												EQS FW		
Determinand	**No. of Results**	**Unit**	**Min**	**Max**	**Mean**	**Median**	**Standard Deviation**	**5th Percentile**	**95th Percentile**	**# > LOD**	**% > LOD**	**No. Exceeding**	**% Exceeding**	**Action Level**
Iron	464	mg/l	<0.23	9	0.282	n.d.	0.465	n.d.	0.716	182	39.2	6	1.29	1
Lead	62	mg/l	<0.006	<0.006	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	0.0012*
Manganese	62	mg/l	<0.007	1.79	0.0925	0.024	0.258	n.d.	0.406	45	72.6	7	11.3	0.123
Nickel	62	mg/l	<0.003	0.007	0.00353	0.003	0.00157	n.d.	0.006	37	59.7	18	29	0.004
Selenium	34	mg/l	<0.0006	0.00067	n.d.	n.d.	n.d.	n.d.	n.d.	1	2.94	0	0	-
Zinc	62	mg/l	<0.018	0.02	n.d.	n.d.	n.d.	n.d.	0.0194	4	6.45	4	6.45	0.0109
Nitrogen species														
Ammoniacal Nitrogen as N	464	mg/l	<0.06	0.68	0.0671	n.d.	0.0903	n.d.	0.237	139	30	0	0	-
Nitrate as N	34	mg/l	<0.7	7.4	2.34	1.7	2.08	n.d.	6.12	22	64.7	0	0	-
Nitrite as N	34	mg/l	<0.006	0.025	0.00676	n.d.	0.00684	n.d.	0.0217	10	29.4	0	0	-
Nitrogen (total oxidised) as N	161	mg/l	<0.7	10.6	2.62	1.9	2.36	n.d.	7.4	123	76.4	0	0	-
Landfill parameters														
BOD + ATU (5 day)	464	mg/l	<1	53	1.65	n.d.	3.45	n.d.	4	190	40.9	0	0	-
COD (Total)	161	mg/l	<11	59	21.4	20	10.7	n.d.	37	139	86.3	0	0	-
TOC (filtered)	154	mg/l	1.9	24.2	6.85	6.25	3.53	2.47	13.4	154	100	0	0	-
Other parameters														
D.O. concentration	157	mg/l	<0.5	14.5	8.22	8.5	2.6	3.16	11.8	150	95.5	0	0	-
Solids, Suspended	430	mg/l	<1	21300	156	9	1141	2	381	429	99.8	0	0	-

*Note: if significant number of results exceed action limit row is coloured as follows: 10 - 25% pale red, 25 - 50% darker red, >50% dark red. n.d. statistic not determinable. Mean statistics for non-detects are calculated at half the limit of detection. * = limit of detection is greater than action level.*

Figure 2.17 Historical sulphate concentrations in surface water since 2008



3 Review of original site conceptual model

In this section the original site conceptual model for Bleak Hill 1 as described in ESI (2004) and the updated conceptual model for Bleak Hill 2 as described in ESI (2010) are compared against the site data that was reviewed in Section 2 of this report.

The HRA focusses on the post-closure period and provides predictions of future groundwater quality following cessation of waste activities. The model in ESI (2010) uses a hydraulic gradient that is appropriate for time periods when no dewatering is occurring. During the current reporting period no significant dewatering has occurred and therefore the hydraulic gradient used is still applicable. However, it also effectively informs the landfill performance for the operational phase (as the effects of dewatering are relatively minor) as well as the post-closure phase.

3.1 Site operations

During the previous HRA review in 2014, landfilling at Bleak Hill 1 had stopped as the landfill was full and operations had moved into Bleak Hill 2, although inert waste disposal had not yet commenced other than for minor preparatory works to an access ramp. Since this time, extraction at Bleak Hill 2 is now complete and there will be no further extraction work until planning permission for the next Phase of workings to the north is granted.

3.2 Geological setting

No additional geological data have been collected since the 2014 HRA review. As such this element of the conceptual CSM remains unchanged.

3.3 Source-pathway-receptor linkages

3.3.1 Sources

The source of the contamination is leachate generated within the inert waste. As Bleak Hill is an inert landfill, there is no requirement to collect leachate quality data. The Site has only accepted inert wastes (as defined by the EWC waste codes) that do not require compliance testing. Furthermore, as the Site is being filled in order to restore a quarry void, only the narrower range of wastes that do not incur landfill tax have been accepted.

The source term meets the permitting regulations outlined in EPR/FP3498SZ/V003 and has not changed. On this basis it is considered that the source term used in the previous HRA model remains valid.

3.3.2 Receptors

The receptors described and modelled in the original HRA and extension variation include both groundwater and surface water receptors. Receptors were defined as: groundwater adjacent to Whitefield Brook, Whitefield Brook, groundwater adjacent to Homer Brook, Homer Brook, Hamer Warren Lake, groundwater adjacent to Lomer Stream, groundwater adjacent to the River Avon drainage ditch, groundwater at the southern limit of the 20 m standoff between Bleak Hill 1 and the adjacent old waste of Hamer Warren landfill and private water supply wells.

As shown in Section 2.2.1, the groundwater flow direction (groundwater divide to east and west) and rate (0.011 compared to 0.015 in original HRA) at the Site has not significantly changed, and therefore it is considered that no change is believed to be needed to the previously identified receptors.

3.3.3 Pathways

In the HRA model, a number of the source, pathway, receptor linkages are grouped together and the most conservative (shortest travel distance) considered. A total of four source, pathway, receptor linkages were taken forward for assessment in the quantitative model. These are briefly summarised below.

- Leachate discharge from the western side of the landfill into the Bagshot Beds, followed by transport within the Bagshot Beds to the nearest watercourse which is Whitefield Brook. The concentration in groundwater adjacent to the Brook is considered using the drinking water standard (DWS) concentrations as the environmental assessment limit (EAL).
- Leachate discharge from the western side of the landfill into the Bagshot Beds, followed by transport within the Bagshot Beds to the nearest watercourse which is Whitefield Brook, followed by dilution within the Brook. The concentration in the Brook is considered using the Environmental Quality Standard (EQS) concentrations as the environmental assessment limit (EAL).
- Leachate discharge from the eastern side of the landfill into the Bagshot Beds, followed by transport within the Bagshot Beds to the nearest watercourse which is Lomer Stream. The concentration in groundwater adjacent to the Stream is considered using the drinking water standard (DWS) concentrations as the environmental assessment limit (EAL).
- Leachate discharge from the southern part of Bleak Hill 1 into the Bagshot Beds, followed by transport to the south. The receptor is taken to be the southern edge of the 20 m strip which separates Bleak Hill 1 from Hamer Warren landfill.

These pathway segments are considered to remain applicable.

3.4 Lifecycle phases

During the filling phase of the landfill below the watertable, the Site is intermittently dewatered. During this phase, there will be an inwards hydraulic gradient and it will not be possible for contamination to migrate into the wider environment. Once dewatering ceases, landfilling will be continued above the watertable and surface water ingress controlled by careful management. Once filling is complete, restoration soils will be placed on the waste and some infiltrating water will be lost to the Site perimeter as interflow within the restoration soils. These lifecycle phases have not changed compared to those considered by the original HRA model.

3.5 Summary of changes to the conceptual model

In summary, it is considered that there have been no significant changes to the Site conceptual model that would warrant a review of the modelling approach undertaken in the original model developed for Bleak Hill 1 or the extension model developed for Bleak Hill 1 and 2.

4 Hydrogeological Risk Assessment

4.1 Numerical modelling

In the original HRA a generic quantitative modelling approach (as defined in Environment Agency, 2011) was undertaken. This approach is considered to remain valid.

4.1.1 Justification for modelling approach and software

In the original HRA, ESI's RAM software modelling tool was used. This tool is considered to remain appropriate for a below watertable inert landfill.

4.1.2 Model parameterisation

All the model parameters in the original model and the extension model were checked and remain valid. The reader is referred to the original HRA report (ESI, 2004) for full details of all the parameters used in the model. As significant dewatering has not occurred in recent years the mean groundwater head previously used is still applicable with no obvious changes to groundwater levels except seasonal variation. In the original model and the extension model, a hydraulic gradient of 0.015 was applied for the Bagshot Beds. However, during the previous HRA review (ESI, 2015) a gradient of 0.0076 was measured. As no obvious changes in groundwater levels have been recorded this hydraulic gradient is still deemed appropriate.

4.2 Emissions to groundwater

During the previous HRA review, the model was rerun with the updated hydraulic gradient of 0.0076 and this showed that the concentrations resulting from each phase still remained below the relevant EALs.

A review of groundwater and surface water quality data has been undertaken (Sections 2.2.2 and 2.3) and this confirms that there has not been any impact from the landfill on controlled waters.

4.3 Review of technical precautions

As the landfill is inert, there is no leachate control and no engineered cap. The geological barrier at the base of the landfill is the London Clay (or clays present within the Bagshot Beds in the case of Bleak Hill 1). An artificially enhanced geological barrier (AEGB) is required to be constructed along the base and sides of Bleak Hill 2 (one metre thick with a maximum permeability of $1x10^{-7}$ m/s). Construction of the AEGB is detailed in Arup (2020) for the most recent phase. However, no reliance is placed upon the AEGB within the HRA. Thus, it is considered that all technical precautions remain as in the original HRA.

5 Requisite surveillance

The requisite surveillance for groundwater and surface water that is considered necessary and appropriate for the Site is presented in the following sections.

5.1 Groundwater monitoring

It is recommended that the current monitoring of groundwater levels and quality be continued in line with the existing permit and its variations. The groundwater monitoring as required by the current permit is presented in Table 5.1 below. The monitoring locations and parameters are considered to remain appropriate as monitoring covers up hydraulic and down hydraulic gradient locations, between Bleak Hill 1 and 2 as well as further down gradient to monitor groundwater quality that may be impacted by the older landfills including Hamer Warren.

Table 5.1 Groundwater monitoring requirements

Monitoring Location	Parameter	Frequency
W103, W106A, W107, W108, W109, W110, W111, W112, W201, W202, W203, W204, 401P1, 402P1, 301, W302, W303, W501, W502, W102, M01, M02, M03, M04, M05, M06, M07, M08, M09, M10.	Groundwater level (maOD)	Monthly
W103, W106A, W107, W112, W201P1, W201P2, W202, W203P1, W203P2, W204P1, W204P2, W302, W303 301P1, 401P1, 402P1, W501P1, W502P1, M02, M04, M08, M09, BL2DIS.	Ammoniacal nitrogen, chloride, zinc	Quarterly
W103, W106A, W107, W112, W201P1, W201P2, W202, W203P1, W203P2, W204P1, W204P2, W302, W303 301P1, 401P1, 402P1, W501P1, W502P1, M02, M04, M08, M09, BL2DIS.	Ammoniacal nitrogen, chloride, zinc, alkalinity, cadmium, calcium, chromium, COD, electrical conductivity, copper, dissolved oxygen, iron, lead, magnesium, manganese, nickel, TON, pH, potassium, sodium, TOC, sulphate	Annually

5.2 Groundwater compliance limits

Groundwater compliance limits are defined in Table 5.2 at four down gradient boreholes to the landfill and the surface water discharge from Bleak Hill 2. There have only been three breaches since the previous HRA review, once of the ammoniacal nitrogen limit (M09 on 16/06/2020 at 20 mg/l) and twice of the chloride limit (W501P1 on 16/12/2014 and 20/01/2015 at 181 mg/l and 111 mg/l respectively) as shown on Figure 5.1 and Figure 5.2. The compliance limits are consistent with background groundwater quality at the Site which has not significantly changed since the previous HRA review. Therefore, it is considered that the groundwater compliance limits remain appropriate.

Table 5.2 Groundwater compliance limits

Monitoring Location	Parameter	Limit (mg/l)
W103, W501P1, M02, M09, BL2DIS.	Ammoniacal nitrogen	5
W103, W501P1, M02, M09, BL2DIS.	Chloride	100
W103, W501P1, M02, M09, BL2DIS.	Zinc	1

Figure 5.1 Ammoniacal nitrogen concentrations in groundwater at compliance locations

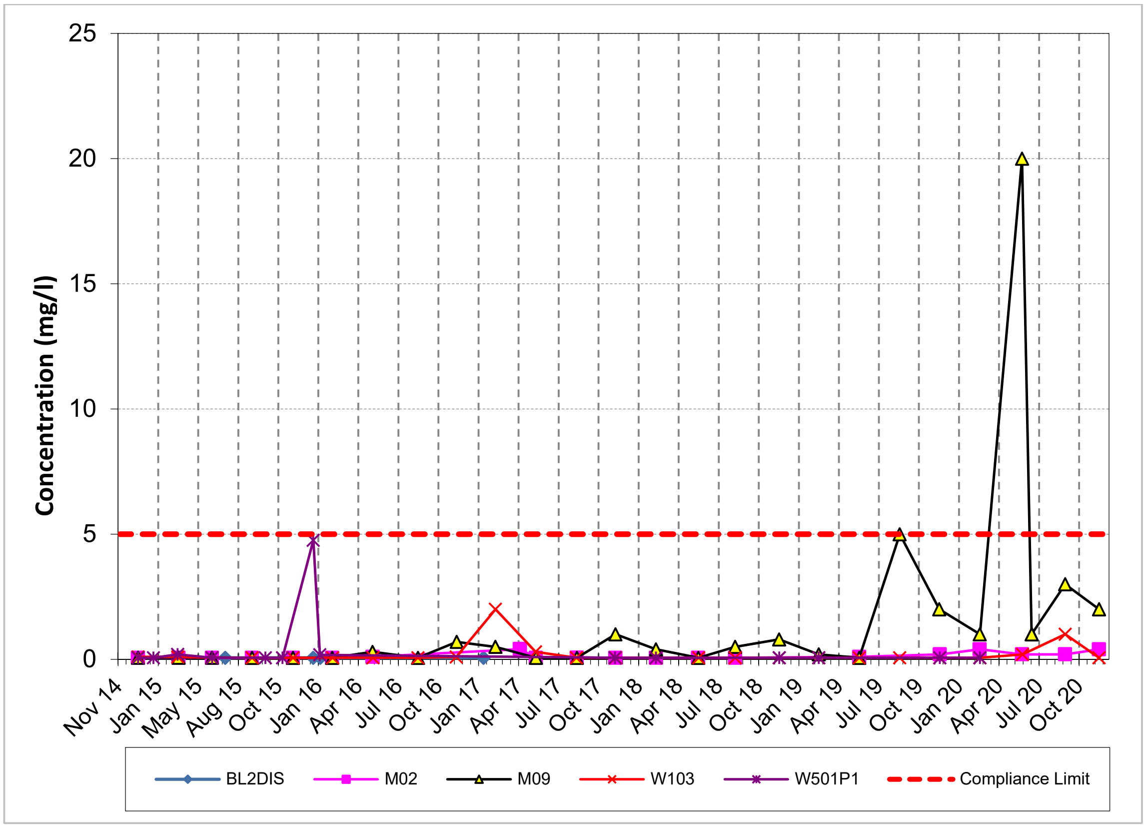
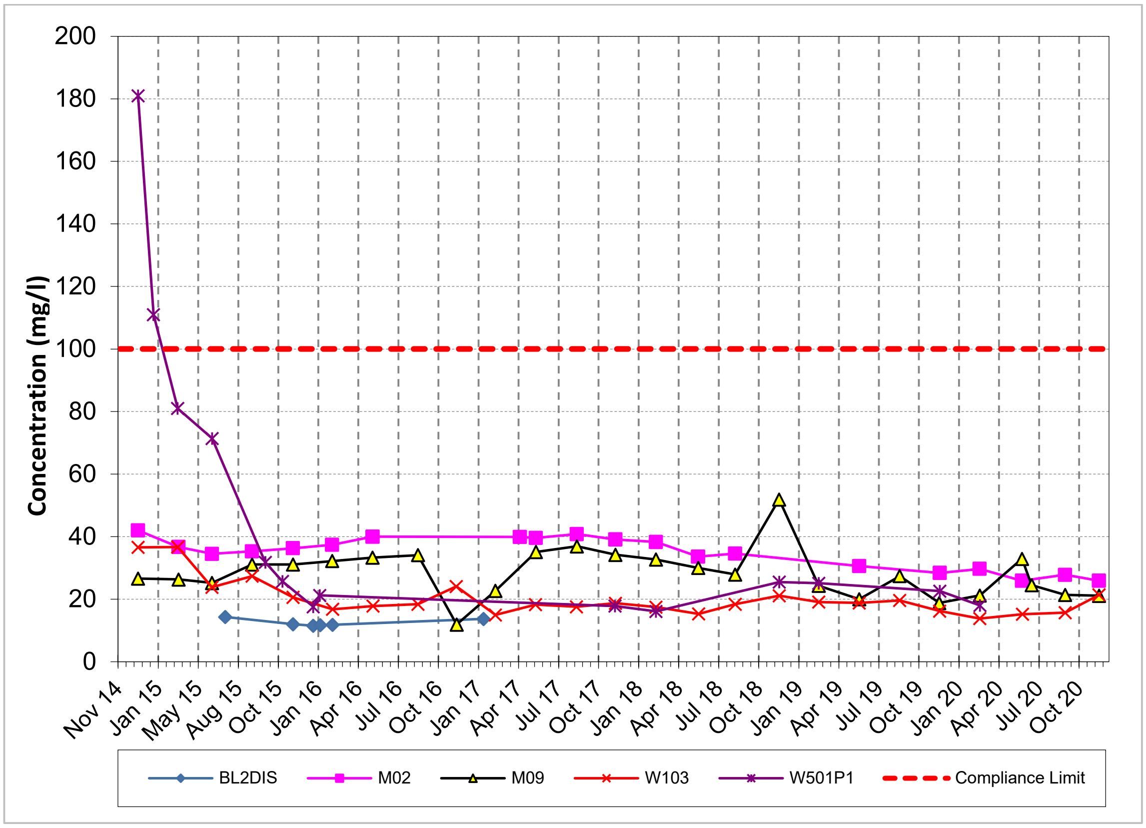


Figure 5.2 Chloride concentrations in groundwater at compliance locations



5.3 Surface water monitoring

It is recommended that the current monitoring of surface water quality be continued in line with the existing permit and its variations. The surface water monitoring as required by the current permit is presented in Table 5.3 below. These locations are considered to remain appropriate for monitoring of surface water adjacent to the Site.

Table 5.3 Surface water monitoring requirements

Monitoring Location	Parameter	Frequency
HB1 HB2 LAKE 1 HAMBL1DIS WB1 S1 S2 S3	Ammoniacal nitrogen, chloride, suspended solids	Quarterly
	COD, dissolved oxygen, BOD, pH, alkalinity, TOC (filtered), TON, sulphate, iron, lead, magnesium, manganese, nickel, potassium, sodium, cadmium, chromium, copper, zinc, calcium, electrical conductivity, suspended solids	Annually

6 Conclusions

The original Hydrogeological Risk Assessment (ESI, 2004) and variation to include the extension area (ESI, 2010) undertook a generic quantitative risk assessment to ascertain whether the Site was likely to impact on controlled waters receptors. These assessments demonstrated that the Site was likely to comply with the Landfill Directive.

In this report, recent monitoring data over the six-year period has been reviewed for groundwater level data and it is concluded that there have not been any significant changes to the groundwater flow regime. The groundwater and surface water quality has also been reviewed and it is concluded that there have not been any significant changes to water quality. There is no evidence that the Site is currently having any impact on controlled waters receptors.

The conceptual model, modelling methodology and mathematical model used in the previous HRAs have all been reviewed. It is concluded that these models remain fit for purpose.

7 References

Arup, 2020. Bleak Hill 2 Landfill CQA Validation Report for Phase 12 (north east) Basal Geological Barrier. August 2020.

ESI, 2004. Hydrogeological Risk Assessment for Bleak Hill 1 Landfill, Ringwood, Hampshire. ESI Report No. 6466R1. May 2004.

ESI, 2008. Bleak Hill Quarry: 4-Year Hydrogeological Risk Assessment Review. ESI Report No. 60080R2. September 2008.

ESI, 2010. Bleak Hill Variation: Hydrogeological Risk Assessment. ESI Report No. 60311R1. June 2010.

ESI, 2015. Bleak Hill Landfill: Hydrogeological Risk Assessment Review. ESI Report No. 60080ABR1Rev1. August 2015.

Environment Agency, 2011. Additional guidance for hydrogeological risk assessments for landfills and the derivation of groundwater control levels and compliance limits. Horizontal guidance note H1 – Annex J 3.

Appendices

Appendix A

Groundwater elevation data

Report Reference: 330201712R1

Report Status: Final Report

Appendix B

Groundwater quality data

Report Reference: 330201712R1

Report Status: Final Report

Appendix C

Surface water quality data

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