

**EAST WASTE  
MANAGEMENT SITE,  
LLANWERN STEELWORKS**

**PERMIT EAWML / 30003**

**2017 Annual Review of  
Environmental  
Monitoring**

*Report Number 1680r1v1d0218*

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## **Executive Summary**

Monitoring of groundwater and surface water around the landfill has revealed that shallow groundwater continues to be impacted by seepage from the unlined waste mass at Llanwern East Waste Management Site. Drainage ditches around much of the perimeter of the site control shallow groundwater levels, intercept leachate and direct it to the works treatment facility. Along the eastern flank, potential leachate breakout has been observed and as this poses a direct risk to surface water quality Tata has informed NRW and is managing mitigation measures.

Restoration capping works are currently on hold whilst the quality, of imported soil is being inspected by Tata. During this time, the site is not accessible.

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# 1 INTRODUCTION

Llanwern East Waste Management Site (LEWMS) is a land raise occupying an area of some 200,000m<sup>2</sup> at the eastern end of the Tata Steel (UK) Ltd, Llanwern Steelworks. The site is maintained and operated by Tata Steel (UK) Ltd (Tata). The landfill has accepted approximately 2.5 million tonnes of non-hazardous industrial and commercial wastes from the steel plant since its inception in 1978 until 2008 under a Waste Management Licence (Licence numbers 007/77 (EAWML/30003)).

In 2003, Tata (then Corus (UK) Ltd) applied to the Environment Agency (now Natural Resources Wales or NRW) for a Pollution Prevention and Control (PPC) Permit for the landfill as it still had a significant void space available within its planning consent. However, the permit application was refused. As the Permit was refused, NRW served a Closure Notice on 14 November 2006 requiring a series of risk assessments to be undertaken to inform the closure process. At the time, Corus expressed a desire to continue waste acceptance for a limited period of 12 months to allow the landfill landform to be completed and the site restored (see Geotechnology report 525.1/0/0207). As the Application was refused and the time for additional waste deposition lapsed, NRW issued a second Closure Notice (No. GR/EM4/01) on 25 February 2008. The Closure Notice specified that the landfill must cease accepting waste for disposal at landfill as of 31 March 2008 and that the landfill must be maintained, monitored and controlled as required by the conditions of the authorisation numbered 007/77.

A Closure Report was submitted to NRW in April 2008 (Geotechnology Report Reference 663.1/1/0408) which detailed the restoration plan proposed for the landfill. The Plan included a sequence of work including the installation of gas wells, geomembranes and soils to fully restore the surface of the landfill. The restoration scheme included full management of any evolved landfill gas, collection and treatment of surface waters and the vegetation of the placed restoration soils. This capping and restoration scheme is currently ongoing and due to be completed by 2018. To date, approximately one third of the site has been covered with a combination of geomembranes and capping soils.

This annual report brings together all of the environmental monitoring data gathered to date since issue of the 2008 Closure Report which included an Aftercare Monitoring Plan (AMP).

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## 2 SITE SETTING AND ACTIVITY

### 2.1 Location and Description of the Site

Llanwern Eastern Waste Management Site is located at Ordnance Survey Grid Reference No. ST 397 864, as shown on Figures 1 and 2. The site lies at the eastern edge of the Tata Llanwern Steelworks and has accepted steelmaking and general wastes from the Llanwern site for four decades. The waste management site is a land raise, with wastes being deposited initially into very shallow excavations (circa 1 metre) onto natural ground. Disposal has developed a raised landform that now reaches 15m above Ordnance Datum (AOD), or some 10m above surrounding ground level.

The site occupies an area of 197,835m<sup>2</sup> (19.78 Ha) and is fully occupied by deposited wastes. The landform of the site comprises a steep sided plateau, with only 1m of relief across the top of the land raise. LEWMS measures approximately 830m long by 300m wide with the long axis oriented north to south. In the northern half of the site, the boundary tapers to a point whilst the southern half of the site boundary is a uniform rectangle measuring 300m wide by 400m long.

### 2.2 Historical Landfilling

An examination of past disposal records shows that only a very small proportion of the waste stream is biodegradable. The remainder of the wastes comprise steel making wastes and demolition rubble. A breakdown of the most recent wastes to have been landfilled is provided in Table 2-1.

**Table 2-1 Waste Breakdown**

|                             |   |                              |        |
|-----------------------------|---|------------------------------|--------|
| Biodegradable               | - | Canteen Waste                | 0.18%  |
|                             | - | Office Waste/General Rubbish | 15.58% |
|                             | - | Horticultural Waste          | 0.14%  |
|                             | - | Timber                       | 0.45%  |
| Non-Biodegradable           | - | Steel (BOS) Slag             | 32.4%  |
| Inert Cover                 |   |                              | 12.7%  |
| Dusts                       |   |                              | 1.71%  |
| Demolition Rubble           |   |                              | 18.82% |
| Other Non-degradable Wastes |   |                              | 18.02% |

The existing waste mass has been placed by mixing all waste streams. This gives a diffuse distribution of biodegradable wastes intermixed with very high permeability steelmaking wastes (principally slag based).

### 2.3 Ongoing Capping and Restoration

#### 2.3.1 Scheme Design

The restoration of LEWMS comprises the construction of a cap. Due to the size of the landfill cap area the restoration will be completed on a piecemeal basis. This is likely to comprise three annual phases of capping work. All works are currently on hold pending an investigation of soil quality.

The capping work will involve the removal of all existing vegetation; the placement of a regulating layer; placement of gas vents and gas collection geomembrane; placement of a

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1mm HDPE geomembrane; placement of infiltration water collection geomembrane and pipe work and finally the restoration soils.

The initial works will involve the clearance of vegetation on the existing waste surfaces. This vegetation is generally scrub and is therefore amenable for shredding and re-use as compost for mixing with the restoration soils. Once vegetation clearance is completed the over-steep slopes will be re-graded to an angle of 1 in 3.5 (v/h) generally and 1 in 3 adjacent to the road. The flat plateau will also require some earthworks re-grading in order to encourage more rapid surface water run-off as currently it is too flat.

Once the slopes have been re-graded and rolled, the regulating layer will be placed, or re-dressed where suitable material already exists. The regulating layer will comprise sub-dredgings on the plateau cap and more granular slag dust on the flanks.

Once the final landform is completed, a passive gas extraction system will be installed on the cap which will comprise a gas geocomposite membrane with shallow piped aggregate trenches. The landfill gas collected from the piped system will be passively vented and monitored. The vents will be located on the crest of the slopes and at the high elevation points on the cap.

If monitoring was to reveal the presence of viable quantities of gas, the vents could be adapted to actively collect the gas and take it to a central location for flaring. Gas volumes were shown to be marginal in the original Closure Plan and as the landfill has not been capped for a further 7 years since, it is likely that insufficient volumes exist for successful flaring. However, this can only be ascertained once the cap and vents are fully in place.

The completion of the gas collection system described will allow the main capping membrane to be placed on top. This will comprise 1mm double rough sided and smooth HDPE. The former will be used on the slopes for enhanced frictional capabilities and the latter on the cap.

The capping membrane will be sealed onto the gas vents to ensure complete gas encapsulation. The surface water collection geomembrane will lie directly on the capping membrane and together with the underlying gas geomembrane will function as a protective layer to it.

A geomembrane will collect infiltrated water once the restoration soils are in place in order to prevent saturation and instability and will feed into a series of shallow piped ditches placed around the perimeter of the landfill. These ditches or trenches will collect surface water running overland on top of the restored soil surface.

The placement of the restoration soils will be closely followed by a program of vegetation placement via a combination of hydro-seeding and application of the compost generated by the original vegetation clearance.

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## **3 ENVIRONMENTAL SETTING**

Key features and receptors are identified on Figure 2.

### **3.1 Surrounding Areas**

To the east, the landform slopes gently down to the steelworks boundary at Hundred Perches Reen, a slow flowing man-made ditch draining the surrounding levels. Mature vegetation has established itself along the eastern batter of the landfill, forming a tree and vegetation screen to the land raise. The western and southern boundaries of the site are steep waste slopes which drop from the waste plateau to site roads within the steel plant. These boundaries have leachate collection ditches running along 50% of their length, set between the toe of the waste slope and the site roads. Surface water flows within the open collection ditches are directed into Drain 10 of the works effluent treatment system, as shown in Figure 3.

The northeastern boundary of the site is marked by a shunting spur to the works railway system. Between the toe of the waste slope and the railway, a ditch has been excavated to collect leachate moving through the slag starter layer beneath the waste. Leachate from this ditch is piped into Drain 9 of the works effluent treatment system.

With the exception of the eastern batter, each of the existing slopes comprise waste materials (principally steel slag) with a thin, impersistent covering of site won dredgings from the water courses around the plant. Vegetation is locally established on these flanks, comprising mainly invasive species such as Buddleia and Thistle.

The land surrounding LEWMS is flat lying and forms part of the Gwent levels. This is an area of reclaimed coastal marshland that extends through several counties surrounding the Severn Estuary. The site is 3.5km from the current estuary boundary which is due to extensive land drainage and sea flood defences maintenance since Roman times. Land use comprises low grade arable and grazing land in a system of fields separated by drainage ditches or reens. The reens form an inter-bedded network of drainage ditches with levels controlled by a series of sluices at the sea defence to the south of the site. Surface water discharges at low tide and at periods of high water the sluices are closed to prevent seawater incursion into the reen system. The nominal elevation of the ground surface surrounding the site is 5m AOD with a reen water level of 2.3m AOD.

The site lies in a remote area. There are five dwellings within 500m of the site, one warehouse and an industrial building (on the Llanwern site). Several public roads lie within 500m of the site as does the main South Wales to London railway line. All the land surrounding the perimeter of the eastern end of the Llanwern site is designated a SSSI, part of the Gwent levels SSSI.

### **3.2 Geology**

Through a combination of desk study and site investigation the site has been found to be underlain by a very uniform sequence of marine (estuarine) clays, freshwater peat, gravels and Mercia Mudstone bedrock. Some of the investigation locations are indicated on Figure 4. Based on the observations made at these positions a series of interpretive geological cross sections are presented in Figure 5. In each of the boreholes and trial pits the sequence summarised in Table 3-1 was encountered.

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**Table 3-1 Lithological sequence beneath landfill**

| Lithology          | Thickness / m |
|--------------------|---------------|
| Made Ground (Fill) | 1.90 - 4.50   |
| Upper Clay         | 1.85 - 2.60   |
| Peat               | 1.40 - 2.55   |
| Lower Clay         | 1.35 - 3.50   |
| Gravel             | 0.45 - 2.00   |
| Bedrock            | >10           |

With a ground surface elevation typically of 5 to 7m AOD the upper clay lies just above Ordnance Datum (i.e. mean sea level). All other strata, including the peat horizon, lie below mean sea level.

The geological deposit - known as the Wentlooge Formation - that was formed beneath the Levels is a series of alternating layers or beds of mainly blue-green silt and brown-black peat that total 10-15 metres thick in most places. The deposit represents tidal mudflats and different types of tidal-freshwater marsh. Locally, the beds are interrupted by silted-up tidal creeks, called palaeochannels. Because of coastal erosion, the layers are visible at countless places on the shores of the Levels, but ditch-cleaning, boreholes and development activities show that they also range far inland beneath the surface of the Levels.

The Wentlooge Formation (i.e. the Upper Clay, Lower Clay and the Peat) has been deposited over a flat rock surface of Mercia Mudstone (or Keuper Marl as it is commonly known). The flat ground reflects the flat lying Wentlooge Formation but some 1km to the north, the ground surface rises to a series of low hills at the village of Bishton. The available geological plan reveals that the hills comprise Blue Lias, a sequence of limestone with calcareous clay bands. Above the lias, near the hilltops is a sequence of clays with limestone bands. This more erosive resistant sequence has formed the higher ground around which the Wentlooge Formation clays and peats have been deposited.

### 3.3 Hydrogeology

Ground conditions around the site have been investigated through drilling and the installation of groundwater wells. Therefore, groundwater can be monitored and sampled at several locations around the perimeter of the site (see Figure 6). The wells are screened in the shallow waste deposits (shallow groundwater) and in the deeper bedrock.

Groundwater in the waste is typically encountered at shallow depths (typically 1 to 2 metres) at an elevation of between 3.9m AOD and 4.6m AOD. The water lies within the highly permeable fill materials, which comprise principally steel making slag. Permeabilities in this material have been previously found to be approximately  $10^{-4} \text{ ms}^{-1}$ . The water body in the fill materials has been found to be perched on the Upper Clay layer. This has been found to have permeability values of  $3.9 \times 10^{-10}$ ,  $4.2 \times 10^{-10}$  and  $9.2 \times 10^{-10} \text{ ms}^{-1}$ , indicating a stratum of consistently very uniform low permeability.

An examination of the cross sections in Figure 5 and the conceptual hydrogeological model in Figure 7 shows that the fill materials have been placed into a shallow excavation in the clay. This is consistent with historical information which indicates that the site was previously used for water settlement lagoons. The lagoons were dug and embankments constructed around them to contain the water. When the lagoons were decommissioned, they were backfilled with steel slag wastes and thus the water body in the made ground is contained by the clay materials.

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Beneath the upper clay layer, damp peat has been found in each of the boreholes previously drilled with no discernible water strikes. Based on field measurements, the peat has been previously found to have low permeability, ranging from  $7.2 \times 10^{-6}$  to  $4.83 \times 10^{-7} \text{ ms}^{-1}$  with an average of  $2 \times 10^{-6} \text{ ms}^{-1}$ .

In every borehole a second, lower clay layer was previously encountered beneath the peat horizon. Samples of the clay have been subjected to simple classification tests to compare its physical composition to that of the upper clay layer. This revealed that the two clay layers are almost identical in composition, grading and strength and therefore the likelihood is that the permeability of the lower clay layer will also be very similar to the upper clay.

Beneath the lower clay, Mercia Mudstone bedrock was encountered in each of the previous boreholes. In each case it was overlain by a thin layer of sub-rounded gravels with localised clays and silts forming the matrix. Recharge to the gravel layer is almost certainly due to the underlying bedrock aquifer, nevertheless, permeability tests were undertaken which revealed permeabilities averaging  $3.6 \times 10^{-5} \text{ ms}^{-1}$ . The underlying bedrock was investigated by three deep boreholes (16m) drilled by rotary methods. Surprisingly, permeability tests revealed a stratum permeability ranging from  $1.5 \times 10^{-6}$  to  $2.9 \times 10^{-4}$ , with an average of  $1.3 \times 10^{-4} \text{ ms}^{-1}$ . Geotechnology considers that this is most likely due to fracture flow or secondary permeability rather than primary permeability related to porosity, which is known to be low in the Mercia Mudstone.

The second principal water body beneath the site was encountered in the Mercia Mudstone bedrock. Water levels rose rapidly upon intersecting the bedrock or the directly overlying gravels during drilling to an elevation of 2.9m AOD in Borehole 1 (north of the site) to 2.64m in Borehole 6 and 2.63m in Borehole 4 (south of the site).

### **3.4 Groundwater Flow**

#### **3.4.1 Shallow Groundwater**

Groundwater flow in the shallow fill has been historically examined by contouring the piezometric surface, as shown using historical data in Figure 8. The levels, based upon 6 boreholes and 5 trial pits, reduce in elevation from east to west and from centre to north and south. This is not unexpected. A surface water drain, transmitting water from nearby parts of the plant follows the western edge of the landfill at a level controlled by a weir at Drain 10. This water, destined for the works effluent treatment plant is considered to act as a fixed head in the fill materials, controlling the rise of groundwater above this level. This mechanism, therefore, also provides an opportunity for groundwater lowering by reducing the fixed head.

On the southern and northern corners of the site, ditches have been excavated to collect groundwater. From these ditches it is piped into effluent drains 9 and 10 for treatment. These ditches also act as fixed heads controlling groundwater levels in the near surface fill.

With heads controlled on the western, southern and northern edges of the site and no formal control system on the eastern boundary, groundwater levels are elevated in the east. At the time of the previous assessments, this was not problematic for surface water as the elevation of the water surface (4.6m AOD) is less than the elevation of the clay layer between the land raise and Hundred Perches Reen (5.3m AOD). There is also a low permeability bund constructed along the eastern boundary that was used to contain the original water settlement ponds. Consequently, a steady state flow system may be

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established from east to west due to the combination of infiltration recharge through the wastes and the head maintenance at the ditches.

The water flowing in the fill is recharged by infiltration through the waste mass. This is considered to be leachate formed as a result of precipitation, infiltration and subsequent mounding within the waste mass. With the head distribution and flow pattern shown on Figure 8 there is no lateral recharge and therefore the fill through which the leachate flows could reasonably be considered to be the leachate drainage blanket.

### **3.4.2 Deeper Groundwater**

Groundwater flow in the Mercia Mudstone aquifer has been previously established by drilling three piezometers into the rock and measuring the piezometric head. The groundwater levels are sub-artesian and are confined by the lower clay layer. Upon piercing the lower clay and the clayey basal layer, groundwater was seen to rise to 2.9m AOD in the north of the site to 2.6m AOD in the south. Consequently, a very shallow groundwater gradient from north to south was previously detected, as shown on Figure 8.

Groundwater flow and movement between the upper shallow leachate body and the Mercia Mudstone aquifer is poorly understood. The presence of layers of contrasting permeability is likely to have resulted in a degree of groundwater stratification.

## **3.5 Groundwater Quality**

The overall risk from the site to groundwater and environmental receptors was previously described in the Hydrogeological Risk Assessment (HRA) submitted as part of the original Closure Report (see Geotechnology report 525.1/0/0207). The LandSim model identified that at no time do List 1 substances reach groundwater below the facility. Therefore, the site is not predicted by the model to pose a risk to groundwater quality from hazardous substances throughout the facilities full life cycle and complies with the requirements of the Groundwater Directive. With respect to non-hazardous pollutants, all predicted concentrations at the compliance point were below the established Environmental Assessment Levels, indicating that there is no significant deterioration in groundwater quality.

To ensure that the LandSim predictions are calibrated and that the risks posed are continually monitored, a groundwater monitoring programme was developed.

## **3.6 Leachate**

As the landfill is not lined and has no formal leachate collection and management system there is no way of directly monitoring leachate within the waste.

During 2016, samples have started to be collected from the leachate collection ditches at positions EL1 and EL2, as shown on Figure 6.

## **3.7 Surface Water**

Due to the inclusion of a low permeability bund on the eastern side of the landfill there is a very low risk of surface run-off entering the re-en system to the east. However, to ensure

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that the situation is monitored, two sample points have been identified upstream (SW1) and downstream of the landfill (SW2).

### **3.8 Landfill Gas**

A landfill Gas Risk Assessment (GRA) has been carried out to quantify the gas emissions profile from the existing waste mass (see Geotechnology report 525.1/0/0207). The assessment was carried out using the quantitative landfill gas generation model GasSim. The GRA established the risks to receptors, including the global atmosphere from gases evolved due to the degradation of the wastes that are currently placed.

The Landfill Regulations requires that gases evolved at landfill sites are subject to energy recovery, principally by electrical power generation and where this is not technically feasible, are flared. As the site produces insufficient gas for energy recovery, the EA Guidance on the Flaring of Landfill Gas applies.

The net rated thermal input for the gases evolved at LEWMS peaked in 2001 and has already fallen from 3.8 MW to 2.3 MW. Flaring is stated in the guidance to be practical only when gas yields exceed 100m<sup>3</sup>/hr at 50% methane concentration, i.e. a net thermal input 0.5 MW. Gases evolved at a slower rate than this cannot be practically treated by flaring or by energy recovery plants. For this reason, the GasSim simulations were undertaken with a flare which becomes active at a gas flow rate of 100m<sup>3</sup>/hr and inactive below this.

The site is expected to continue to evolve gases at a rate that could be potentially treatable by batch flaring until 2020, when yields are dropping as the waste stabilises. Outside these periods, the self-sustained thermal treatment of gas by flaring is not a viable option. In the absence of a viable self-sustaining thermal treatment process there are few options for gas treatment. The options available were reviewed in the previous Closure Report (see Geotechnology report 525.1/0/0207). The conclusion of the previous assessment was that a bio-filter was the only potential option for landfill gas treatment.

As the site is progressively capped from the south to the north, a gas drainage and collection infrastructure will be placed within the cap. By covering with a gas drainage blanket, surface emissions from the waste will be collected although these are not expected to be of significance. Monitoring of landfill gas has been undertaken during 2016 at GM1, GM2 and GM3.

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## 4 REGULATORY FRAMEWORK

### 4.1 Aftercare Monitoring Plan

As part of the 2008 Closure Report, an Aftercare Monitoring Plan (AMP) was presented (see Geotechnology report 663.1/0/0408). The plan provided details of the monitoring proposed during the aftercare period. Frequent monitoring of groundwater and surface water by Tata during 2014 and 2015 enabled a good dataset to be developed and in the previous annual report a modified, rationalised monitoring programme was suggested by Geotechnology (see Table 4-1). This modified programme was initially implemented during 2016 as it was more closely aligned to the AMP. The analytical parameters analysed are summarised in Table 4-2.

**Table 4-1 Proposed Monitoring Schedule**

| Monitoring Parameter  | Monitoring Location                                                                                 | Frequency              | Type of Monitoring Point                 | Monitoring Point Reference                   |
|-----------------------|-----------------------------------------------------------------------------------------------------|------------------------|------------------------------------------|----------------------------------------------|
| Leachate              | In ditches on SE, N and W sides of landfill                                                         | Quarterly for one year | Pre-formed open ditch                    | L1 and L2                                    |
| Groundwater           | Groundwater at boundary of landfill, with concentration to the hydraulically down gradient side – S | Quarterly              | 50mm diameter piezometer wells           | BH1 to BH7 inclusive excluding BH4 & BH6     |
| Surface water         | Surface-water on eastern and southern side of site                                                  | Monthly                | Surface water body comprising reens      | SW1 and SW2                                  |
| Gas                   | Internally within the landfill                                                                      | Quarterly              | Gas Well/Vent – gas tap on side          | GM1, GM2 and GM3                             |
| Dust and Particulates | As required                                                                                         | As required            | Dust gauges as required                  | Referenced in number and chronological order |
| Odour                 | As required                                                                                         | As required            | Subjective assessment in particular area | Referenced in number and chronological order |
| Settlement            | Landfill surface following restoration                                                              | Annual                 | Topographic survey of settlement plates  | Settlement Plates                            |
| Stability             | Landfill embankments                                                                                | Annual                 | Visual observation                       | All flanks                                   |

**Table 4-2 Analytical Programme**

| Measurement                 | Groundwater, surface Water and Leachate Characterisation Suite   | Groundwater, surface Water and Leachate Indicator and Field Suite |
|-----------------------------|------------------------------------------------------------------|-------------------------------------------------------------------|
| <b>Monitoring Positions</b> | All surface water, groundwater and leachate monitoring locations |                                                                   |
| <b>Frequency</b>            | Annually                                                         | All other times                                                   |
| Water Level                 | •                                                                | •                                                                 |
| Temperature                 | •                                                                | •                                                                 |
| pH                          | •                                                                | •                                                                 |
| Electrical Conductivity     | •                                                                | •                                                                 |
| Dissolved Oxygen            | •                                                                | •                                                                 |
| Ammoniacal Nitrogen         | •                                                                | •                                                                 |
| Total Oxidised Nitrogen     | •                                                                |                                                                   |
| Total Suspended Solids      | • (surface water only)                                           | • (surface water only)                                            |
| BOD                         | •                                                                |                                                                   |
| COD                         | •                                                                |                                                                   |
| Total Organic Carbon        | •                                                                |                                                                   |
| Aluminium                   | •                                                                |                                                                   |
| Arsenic                     | •                                                                |                                                                   |
| Antimony                    | •                                                                | •                                                                 |
| Boron                       | •                                                                |                                                                   |
| Cadmium                     | •                                                                | •                                                                 |
| Chromium                    | •                                                                |                                                                   |
| Chromium (vi)               | •                                                                |                                                                   |
| Copper                      | •                                                                | •                                                                 |
| Iron                        | •                                                                |                                                                   |
| Lead                        | •                                                                | •                                                                 |
| Manganese                   | •                                                                |                                                                   |
| Mercury                     | •                                                                |                                                                   |
| Molybdenum                  | •                                                                |                                                                   |
| Nickel                      | •                                                                |                                                                   |
| Phosphate                   | •                                                                | •                                                                 |
| Silica                      | •                                                                |                                                                   |
| Titanium                    | •                                                                |                                                                   |
| Tin                         | •                                                                |                                                                   |
| Vanadium                    | •                                                                |                                                                   |
| Zinc                        | •                                                                |                                                                   |
| Calcium                     | •                                                                | •                                                                 |
| Magnesium                   | •                                                                |                                                                   |
| Nitrate                     | •                                                                |                                                                   |
| Nitrite                     | •                                                                |                                                                   |
| Sodium                      | •                                                                |                                                                   |
| Potassium                   | •                                                                |                                                                   |
| Selenium                    | •                                                                |                                                                   |
| Sulphate                    | •                                                                |                                                                   |
| Total Alkalinity            | •                                                                | •                                                                 |
| Chloride                    | •                                                                | •                                                                 |
| Organohalogens (VOCs)       | •                                                                |                                                                   |
| Semi VOCs                   | •                                                                |                                                                   |

---

The AMP indicated that the analytical data should be reviewed to identify parameters from the characterisation suite that should be included in the indicator suite. The parameters listed as part of the Indicator suite may, therefore, be subject to change to ensure the monitoring programme is tailored to site specific data requirements. The AMP also indicated that the suitability of the analytical suites should be reviewed annually.

## **4.2 Control and Trigger Levels**

At this stage, Geotechnology is not aware of any formal control and trigger levels established for the assessment of surface water and groundwater monitoring data. Geotechnology suggests that these should be formally developed once the capping and restoration works are complete as these activities may influence the monitoring results in the short-term.

## 5 MONITORING PROGRAMME

### 5.1 Integrity of Monitoring Infrastructure

The full monitoring network available to Tata is shown in Figure 6 and summarised in Table 5-1.

**Table 5-1 Monitoring Point Locations**

| Monitoring Reference Point | Purpose                                   | Monitoring Interval          | Type                   | Safety/ Access                                                              |
|----------------------------|-------------------------------------------|------------------------------|------------------------|-----------------------------------------------------------------------------|
| BH1                        | Up gradient Groundwater Monitoring        | Shallow and Deep Groundwater | Borehole               | Require permit to sample - walk/vehicular access                            |
| BH2                        | Up gradient Groundwater Monitoring        | Shallow and Deep Groundwater | Borehole               | Off road/High Vis. Jacket - walk/vehicular access                           |
| BH 3                       | Up gradient Groundwater Monitoring        | Shallow and Deep Groundwater | Borehole               | In wooded area on eastern flank – walk on access                            |
| BH 4                       | Down gradient Groundwater Monitoring      | Shallow and Deep Groundwater | Borehole               | On corner of lorry access – walk/vehicular access                           |
| BH 5                       | Down gradient Groundwater Monitoring      | Shallow and Deep Groundwater | Borehole               | Next to exit point of Drain 10                                              |
| BH7                        | Down gradient Groundwater Monitoring      | Shallow and Deep Groundwater | Borehole               | In rear of lorry park - walk/vehicular access                               |
| EL1                        | Leachate quality monitoring               | Surface water                | From water body itself | Close proximity to strongly alkaline open ditch with potentially deep water |
| EL2                        | Leachate quality monitoring               | Surface water                | From weir system       | Close proximity to strongly alkaline open ditch with potentially deep water |
| SW1                        | Surface water quality                     | Surface water/Run-off        | From water body itself | Close proximity to deep water of Hundred Perches Reen                       |
| SW2                        | Surface water quality                     | Surface water/Run-off        | From water body itself | Close proximity to deep water of Hundred Perches Reen                       |
| GM1                        | Measure internal gas presence in landfill | Landfill Gas                 | Gas Well               | On landfill cap                                                             |
| GM2                        | Measure internal gas presence in landfill | Landfill Gas                 | Gas Well               | On landfill cap                                                             |
| GM3                        | Measure internal gas presence in landfill | Landfill Gas                 | Gas Well               | On landfill cap                                                             |

Note: Geotechnology suggest that each groundwater well is inspected to ensure monitoring interval is still accessible

Each time samples are collected by Geotechnology the monitoring infrastructure is inspected.

#### 5.1.1 Leachate Monitoring

Leachate monitoring currently comprises a walkover survey of the landfill edge, to examine for the presence of any leachate breakout and sampling from the perimeter ditches at positions EL1 and EL2, as shown on Figure 6.

Suspected leachate breakout has been observed on the eastern flank of the site and reported to Tata. Tata rapidly implemented the construction of a low permeability bund to trap the breakout and the situation is being actively monitored.

---

### **5.1.2 Groundwater Monitoring Infrastructure**

Groundwater monitoring boreholes are available to monitor water levels and chemistry within the shallow groundwater within the waste and the underlying deep groundwater encountered in the Mercia Mudstone.

The monitoring positions available (BH's 1 to 7) are shown on Figure 6. All positions are currently inspected quarterly to ensure that they provide suitable monitoring infrastructure.

At this stage, the headworks of each well are in good condition but the access to BH3 should be improved as the vegetation is very dense, particularly during the summer months. Each headworks are unlocked but the site is secure.

### **5.1.3 Surface Water Monitoring Infrastructure**

No further improvements are required. All samples are collected with a teleseopic sampling rod to avoid personnel coming into close contact with water.

### **5.1.4 Internal Gas Monitoring Infrastructure**

Landfill gas monitoring infrastructure comprises three dedicated gas wells on the surface of the landfill which incorporate gas taps.

Each well is surrounded by a concrete ring preventing damage from plant. Each well has been protected during the ongoing restoration works and extended through the new layer of restoration soil.

Limited monitoring has been undertaken during 2017 as the site has not been accessible whilst soil quality is being inspected.

### **5.1.5 External Gas Monitoring Infrastructure**

There is no external gas monitoring infrastructure.

## **5.2 Analytical Testwork**

All aspects of the analytical and monitoring programme are directly managed by Tata Environment Department. Under the direction of the Environment Department, Geotechnology and Testing Solutions Wales (the analytical laboratory) undertake several aspects of the sampling and analysis. These include surface water and groundwater laboratory analysis and measurement of groundwater levels. Tata Environmental Department undertakes all other monitoring aspects when required. All analysis is undertaken by Testing Solutions Wales based at the Engineering Centre for Manufacturing and Materials (ECM) in Margam, adjacent to the Port Talbot steelworks.

## **5.3 Actions required**

- Suspected seasonal leachate breakout on eastern flank of site should continue to be monitored
- Access to BH3 should be improved and maintained.

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## **6 TOPOGRAPHIC SURVEY AND SETTLEMENT MONITORING PROGRAMME**

Once the landfill surface is restored and capped, the final surface topography will be surveyed and settlement monitoring plates installed. The plates will then be surveyed at regular intervals to assess for waste settlement.

---

## **7 LEACHATE LEVEL AND QUALITY**

### **7.1 Level**

Over the next few years, as the landfill is cleared of vegetation, reprofiled and then capped, waste which has not been exposed for several years will be temporarily open to oxidation and leaching prior to capping. During this time, there is a possibility that the leachate elevation and quality will change.

### **7.2 Leachate Collection Ditches**

As the landfill is not formally lined, the only way of indirectly monitoring leachate quality is to sample the leachate collection ditch that runs along the western toe of the landfill. This started to be monitored in 2016.

As anticipated, the monitoring reveals that surface water running in the leachate collection ditch is dominated by leaching of slag wastes and is characterised by high pH, alkalinity and calcium and low metals. The mobility of many metals will be reduced under the strongly alkaline conditions. In 2017, pH was persistently over 12 and EC typically over 4000 microS/cm. Ammonia and phosphate were frequently elevated. In August 2017, 0.08 mg/l cadmium was reported by the laboratory but less than 0.0001 mg/l was found on all other monitoring occasions.



Plate 1. Leachate Collection Ditch at southwest corner of site

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## **8 GROUNDWATER LEVEL AND QUALITY**

### **8.1 Groundwater Flow**

Historic groundwater monitoring data (although incomplete) has indicated that head loss, and therefore water movement, has been predominantly from the east to the west. With the benefit of more recent data from BH3 (when accessible through dense vegetation) the scenario is a little more complicated.

Based on available monitoring data from the last few years it would appear that the hydraulic gradients are shallow and sometimes lowest in the east at BH3 in both the shallow and deep aquifers (see Figures 9 and 10). Interestingly, in September 2017, the reverse was true in the deep aquifer. An outbreak of leachate has been observed on the eastern side of the site (just south of BH3) and this would appear to be coincident with the low point in the system. Tata is closely monitoring this position and has already informed NRW (who has also visited the site). A temporary bund to protect the adjacent reed has been constructed.

Groundwater levels and flow patterns are likely to change as the site is progressively capped. Time series plots of current groundwater levels are included in Appendix 1.

### **8.2 Shallow Groundwater**

As expected, sampling of shallow groundwater in close proximity to the site reveals that it is impacted by infiltration that has passed through the unlined waste body and the surrounding exposed areas. As these areas are dominated by mixed wastes and slag, the shallow groundwater is characterised by elevated pH, electrical conductivity and alkalinity (see time series charts in Appendix 1). The water chemistry shares several similarities with that detected in the leachate collection ditches.

The situation is, however, complex as shown by the selected hydrochemical contour plots presented in Appendix 1 from 2016 and 2017. This analysis suggests that some contaminants are potentially influenced by groundwater flow (ammonia) whilst others (e.g. calcium and alkalinity) may also be influenced by other (more localised) factors. These variations may be partly because of the analytical technique used to present the data (mathematical interpolation of few data points) and may also reveal that groundwater chemistry is influenced by leaching of slag based materials outside of the site boundary, particularly on the western side of the site, and mixed wastes that contain slag below the site.

As noted previously, groundwater in close proximity to the landfill typically contains low levels of non-hazardous substances which infrequently exceed Environmental Quality Standards. During 2017, the levels observed were comparable to, or lower than, those noted previously. As noted previously, there are short-term variations and in 2017, 0.09 mg/l copper was detected at BH2S in December 2017. Earlier in the year concentrations of copper were below the limit of analytical detection at BH2S and 0.005 mg/l was the highest concentration detected at any point in shallow groundwater. At BH3S, 0.138 mg/l antimony was detected in the sample collected in January but at all other times the limit of detection was not breached and the concentration never exceeded 0.014 mg/l at any other position. The cause of these short-term variations is unclear but there is no data to suggest that shallow groundwater quality is deteriorating in terms of trace metal content. The variations

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could be due to variable leaching of the waste mass prior to capping and the occurrence of oxyanions in the high pH environment.

During 2016, no inorganic hazardous substances were detected. However, in 2017, cadmium was detected at 0.0007 mg/l at BH1S and 0.00015 mg/l at BH5S. On all other occasions the concentrations were below analytical detection limits.

### **8.3 Deep Groundwater**

The levels of non-hazardous and hazardous substances in the deep groundwater is similar to that observed in the shallow groundwater i.e. low and rarely in excess of EQS values. However, the deep groundwater is distinct in terms of pH as pH is significantly lower at approximately pH 8. As this pH is lower than that encountered in the shallow groundwater, the data suggests that there is limited hydraulic connection between the two water bodies, as would be expected due to the low permeability sequence of sediments present. However, the two water bodies (shallow and deep) have similar mineralised content with several dominant ions, including alkalinity, ammonia and chloride at comparable concentrations and sometimes higher in the deeper groundwater. Interestingly, the highest concentration of alkalinity detected in deep groundwater is at BH1 but this position has one of the lowest concentrations of alkalinity in the upper made ground.

In this context, the data from BH7 appears anomalous as the pH at BH7 is similar to that in the made ground. Geotechnology has checked this installation to ensure that the headworks are in satisfactory condition and there were no obvious visual surface defects. The geological logs and borehole depths have also been verified. The data from this point, therefore, appears indicative of potential connection between groundwater perched in the made ground and underlying groundwater. The cause of this connection is unclear. Consideration could be given to decommissioning and replacing, as suggested previously.

---

## 9 SURFACE WATER

### 9.1 Reen Hydrochemistry

The results of the surface water monitoring are presented in Appendix 2.

With one position upgradient (SW1) and one position downgradient (SW2), one of the aims of the surface water monitoring programme is to detect any influences leaching of the waste mass may be having on local surface water between these two points (see Figure 6).

The latest monitoring data continues to indicate that upgradient and downgradient surface water chemistry is generally very similar. However, there are times when there are abrupt changes in several parameters including pH and alkalinity. Subtle differences in the concentration of sodium, potassium, chloride, sulphate and alkalinity are also apparent and as leachate has been observed along this flank and as the waste in the landfill is being exposed during the restoration works, this aspect of the monitoring programme should continue to be closely scrutinised. Recent inspection of the adjacent reen indicates that the reen is cut into low permeability deposits and that there are no obvious visual signs of staining indicative of leachate (see Plate 2). At this stage, there is no clear evidence that the reen quality is being impacted by the landfill.



Plate 2. Reen flowing from right to left along eastern side of site.  
Landfill can be seen in background beyond tree.

Continued scrutiny of upstream influences is also required as observations in December 2016 (see Plate 3) suggest that there are upstream sources of suspended solids.



Plate 3. Suspended solids in surface water upstream of site

## **9.2 Contingency Actions Taken**

No specific contingency actions were required but Tata is actively managing and observing the potential leachate breakout along the eastern flank in order to identify if further measures are needed to ensure the adjacent ree is not impacted.

---

## 10 LANDFILL GAS

Internal landfill gas monitoring started in 2015. During 2017, monitoring has only been undertaken on two occasions as access to the site has been restricted whilst the quality of imported soils is inspected.

The relatively small amount of data gathered to date indicates that the waste is consuming oxygen and generating moderate levels of methane and carbon dioxide (<20% v/v) at variable concentrations but flow is low (<0.1 l/h). At GM3, high levels of hydrogen sulphide have been detected previously (up to 583 ppm) but during 2017 less than 1ppm was detected. Personnel involved with the restoration works are already aware of the potential gas risks at the site.

The gas wells will continue to be monitored as the restoration works progress. During this process the gas wells are being connected to the capping systems, as shown in Plate 4. However, as the gas is still free to vent to the atmosphere, only when the site is fully capped can a more representative assessment be made.



Plate 4. Construction of Gas Vents through Capping Systems

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## **11 AMENITY ISSUES**

There have been no complaints received and no specific additional requirements for any dust, noise or odour monitoring or investigations during 2016. As part of the restoration works, air quality observations are made daily and monitoring undertaken when necessary.

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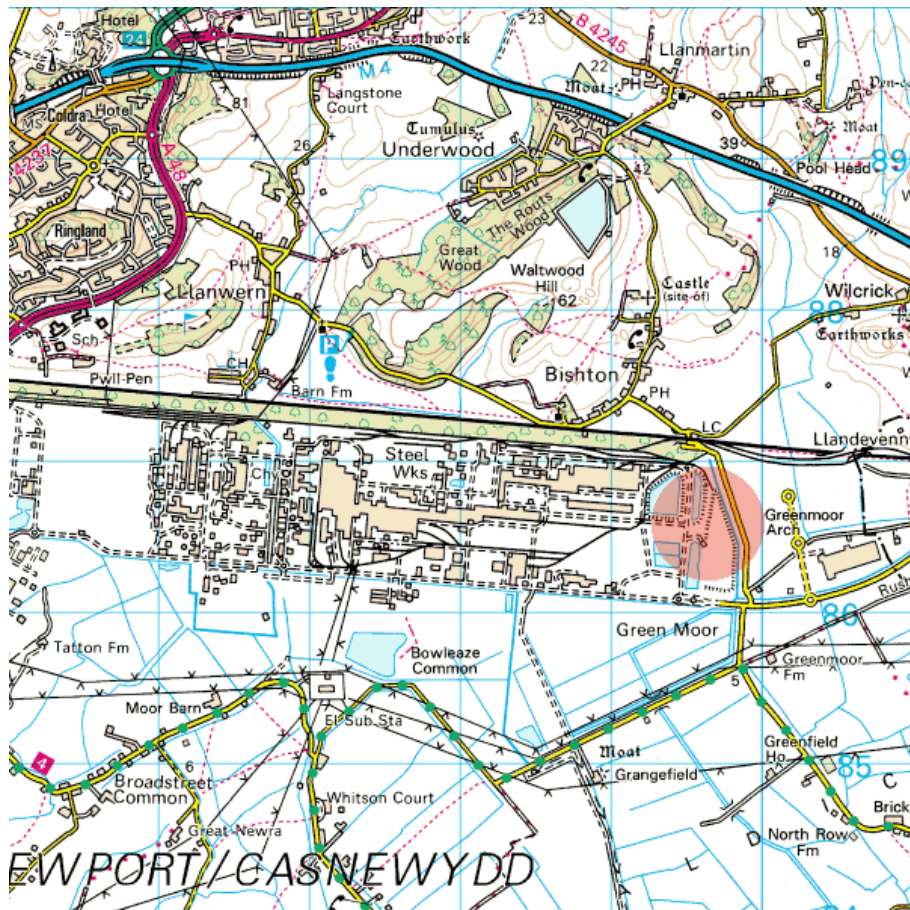
## **12 SUMMARY AND RECOMMENDATIONS**

### **12.1 Evaluation and Summary**

The current monitoring programme has confirmed historical observations; shallow groundwater is impacted by leachate from the unlined waste mass. Due to the network of shallow drainage ditches around the landfill shallow leachate is being intercepted and directed to the works effluent treatment plant. Potential leachate breakout has been observed on the eastern edge of the landfill and as this could potentially impact surface water, Tata is monitoring and improved surface drainage in this area.

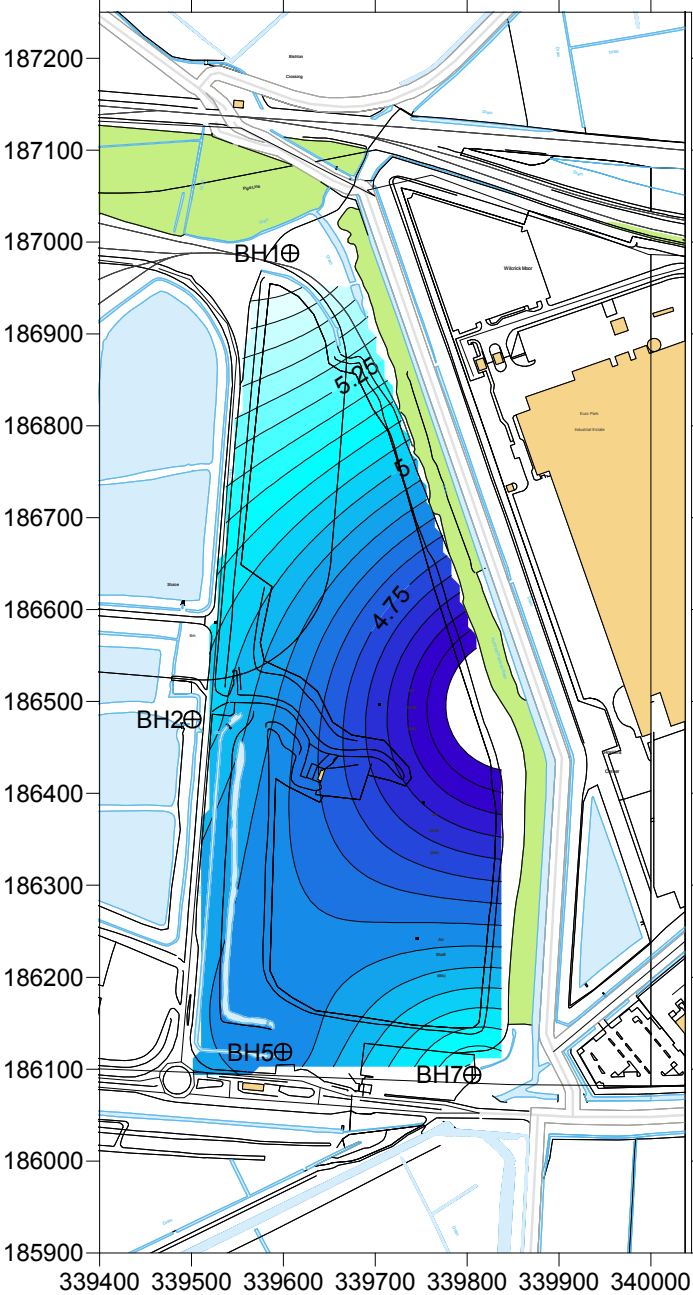
### **12.2 Actions Required**

- Suspected leachate breakout on eastern flank of site should continue to be monitored
- Vegetation in the vicinity of several sampling points requires routine clearance to enable continual safe access.
- Access to BH3 should be improved and maintained.

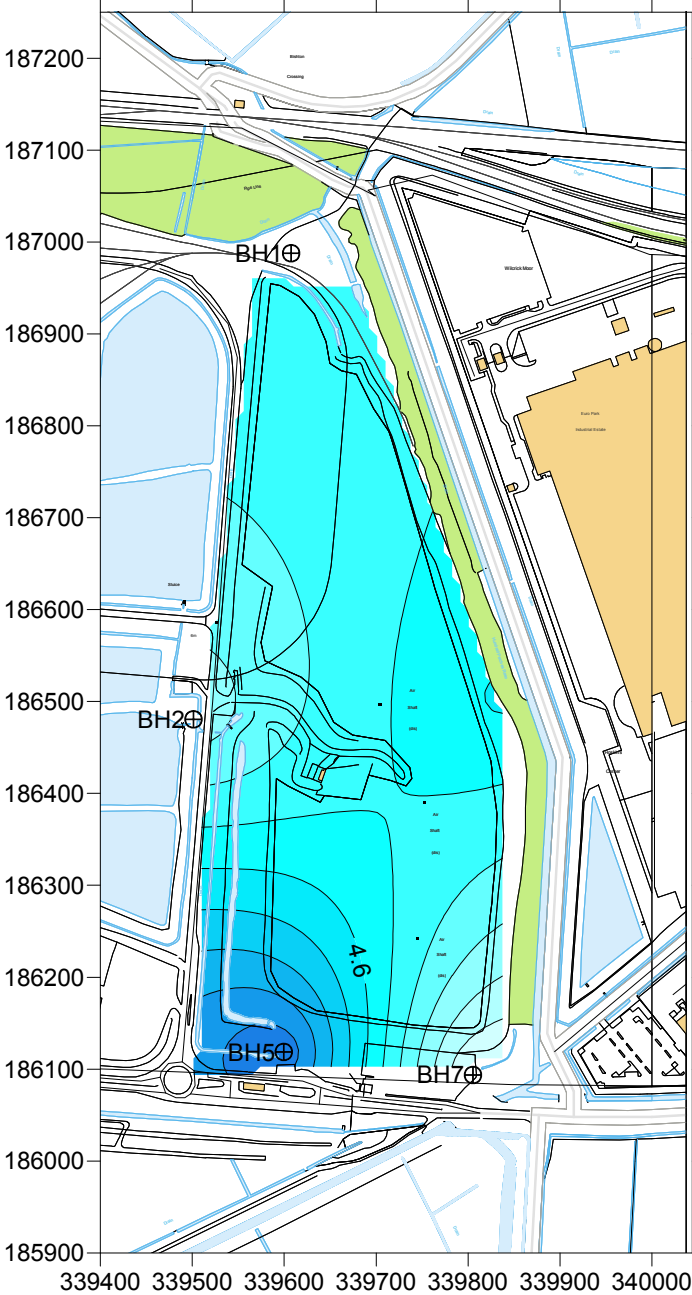


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Figure 10. Groundwater Levels September 2017 (mAOD)



Shallow Groundwater Surface September 2017



Deep Groundwater Surface September 2017

Figure 2 Environmental Setting

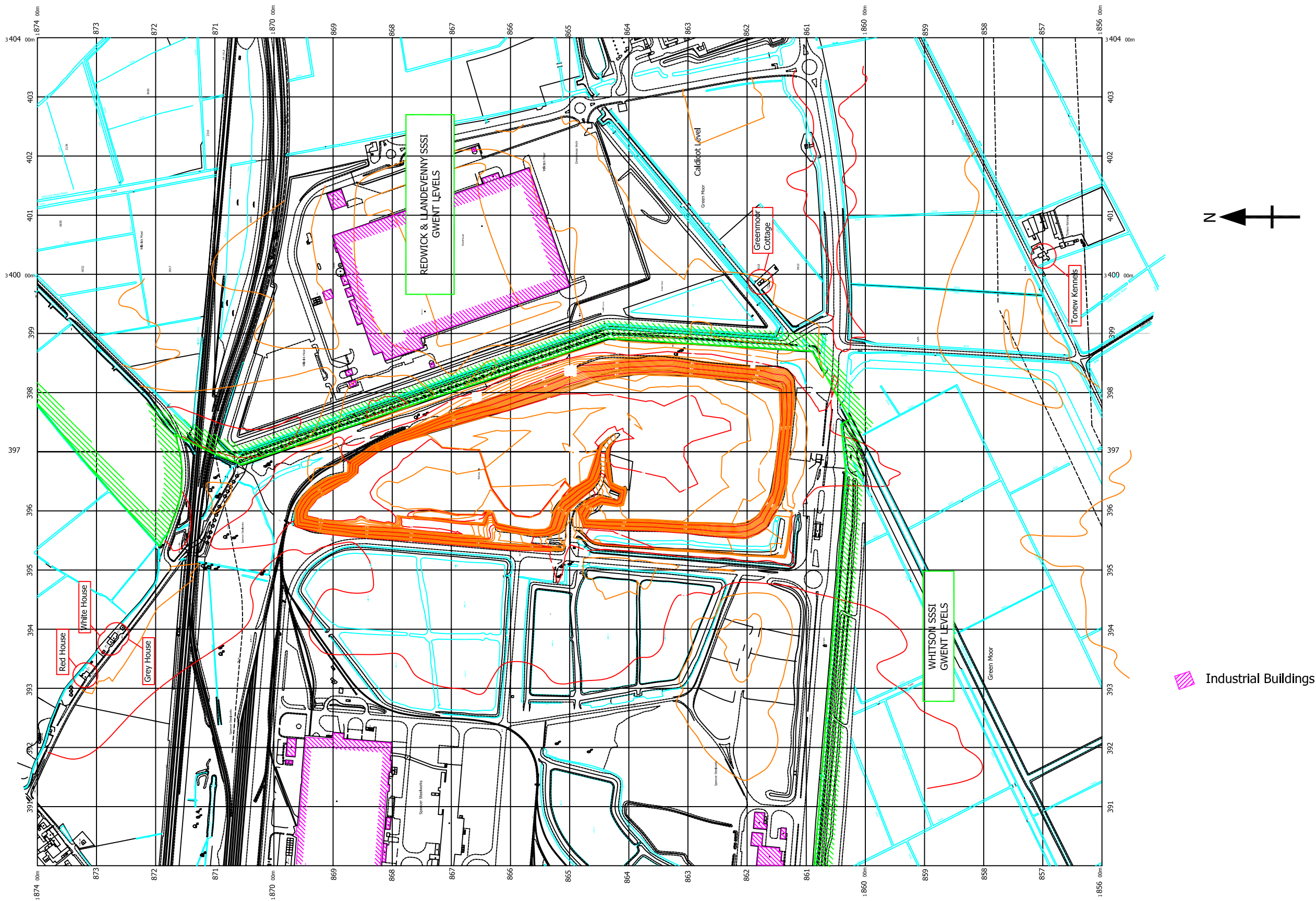


Figure 3 Hydrology

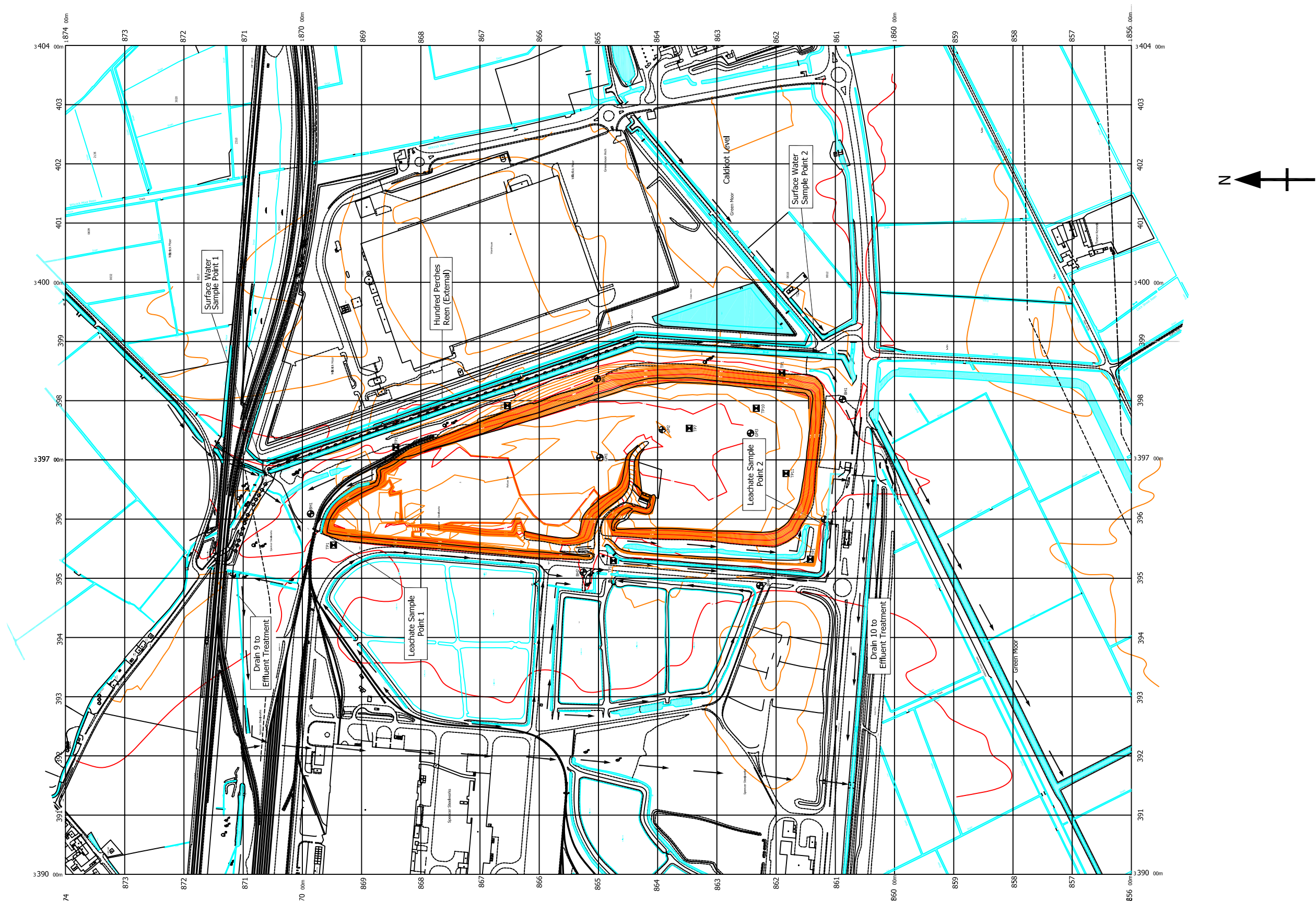


Figure 4 Site Investigation Locations



Figure 5 Geological Cross Sections

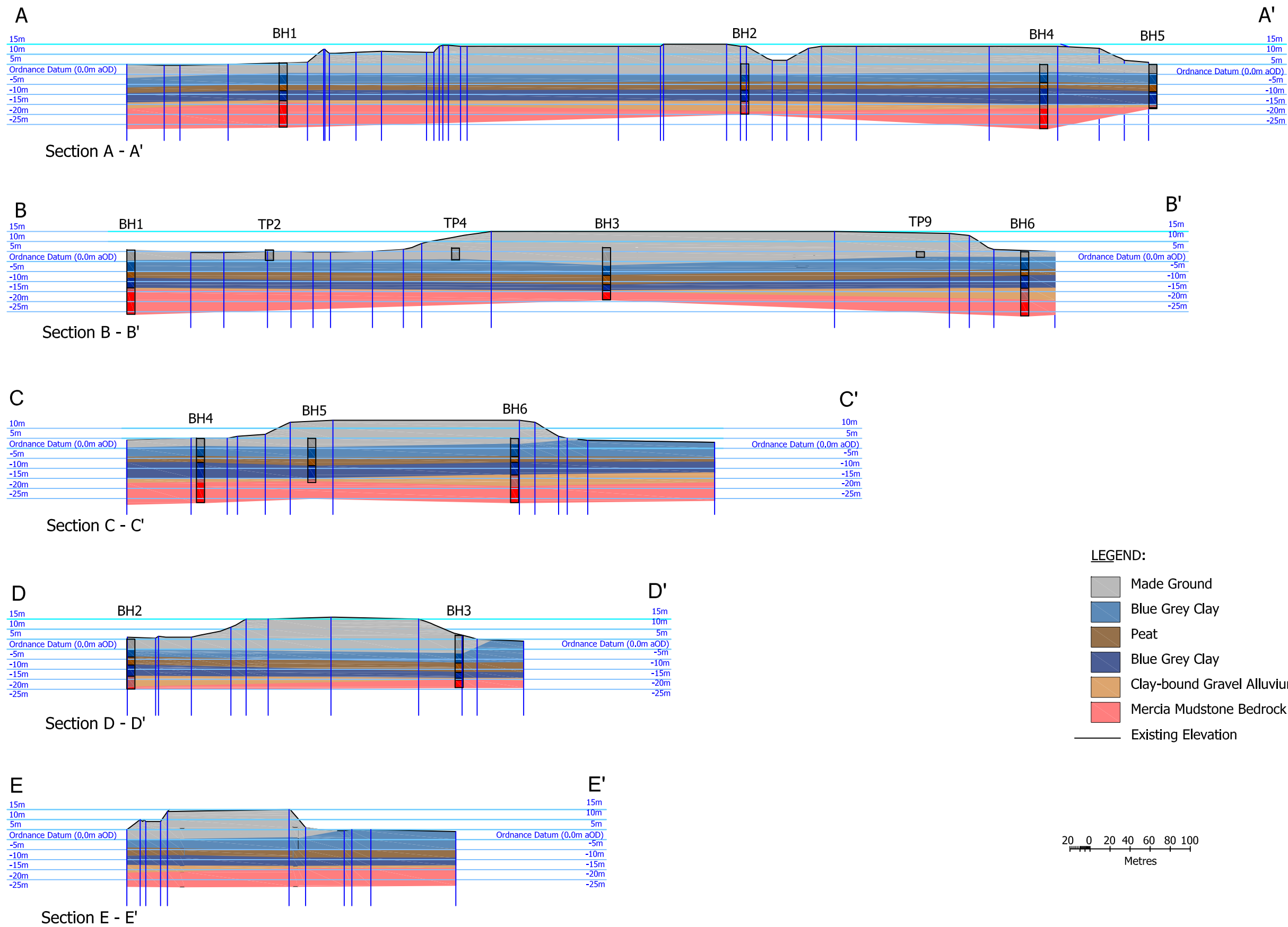


Figure 6 Available Monitoring Newtownk

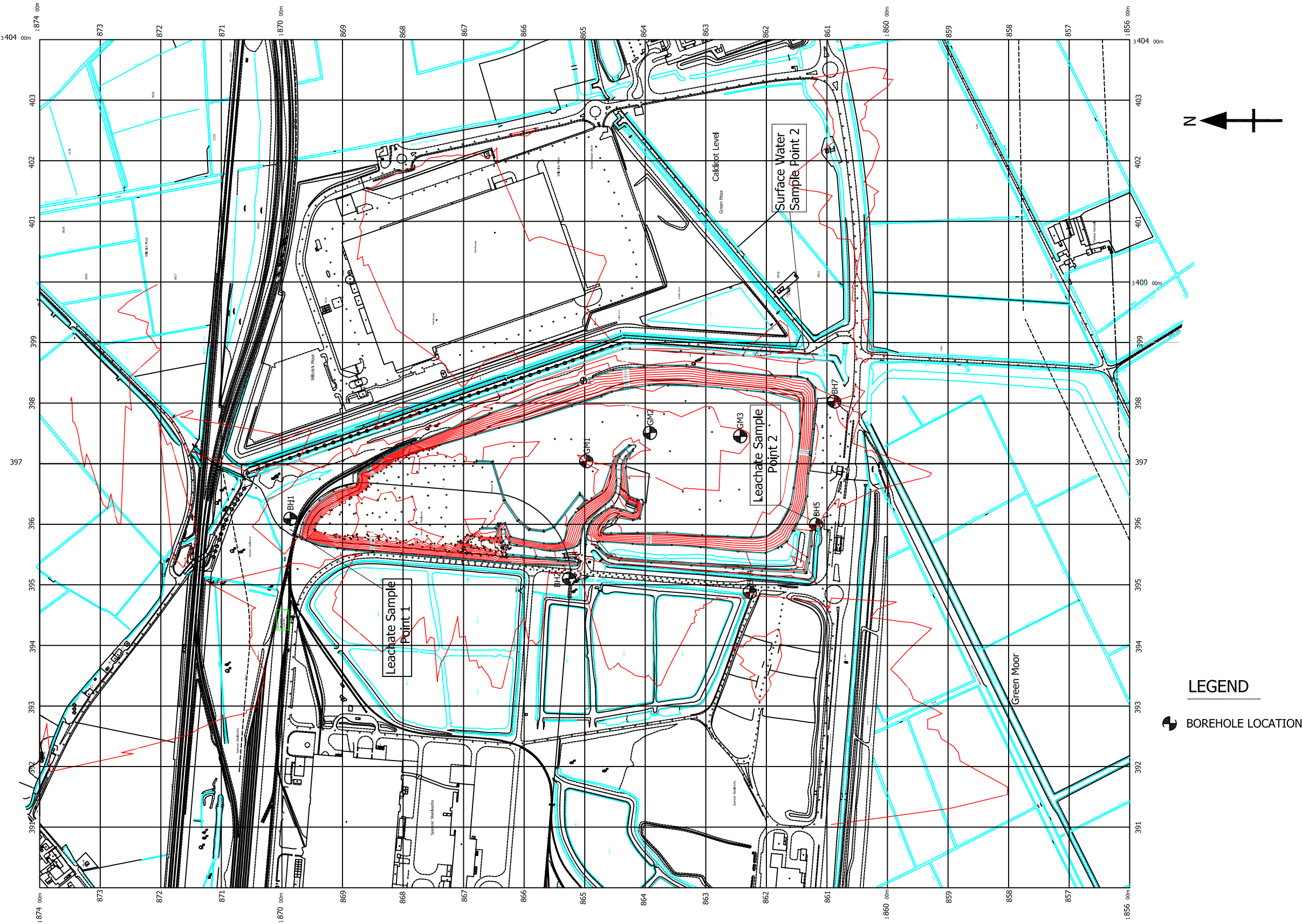


Figure 7 Hydrogeological Conceptual Site Model

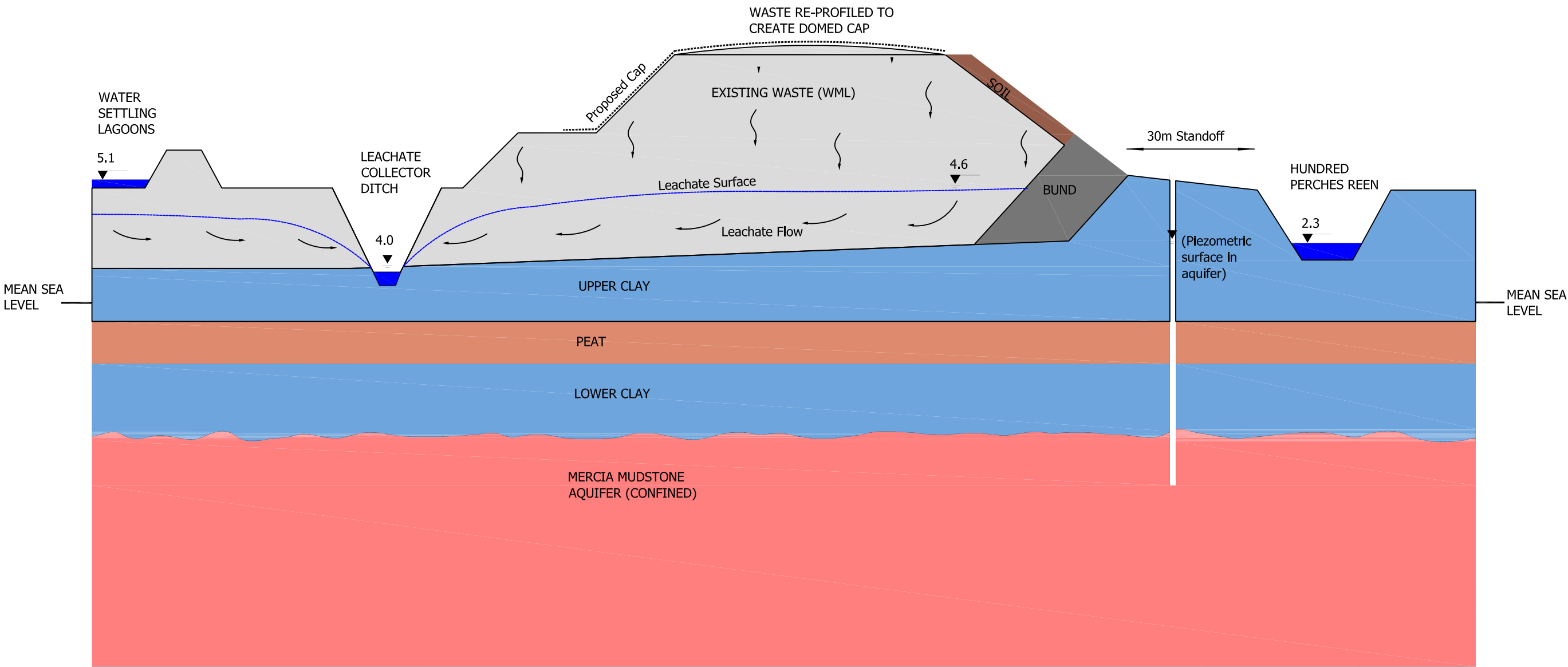
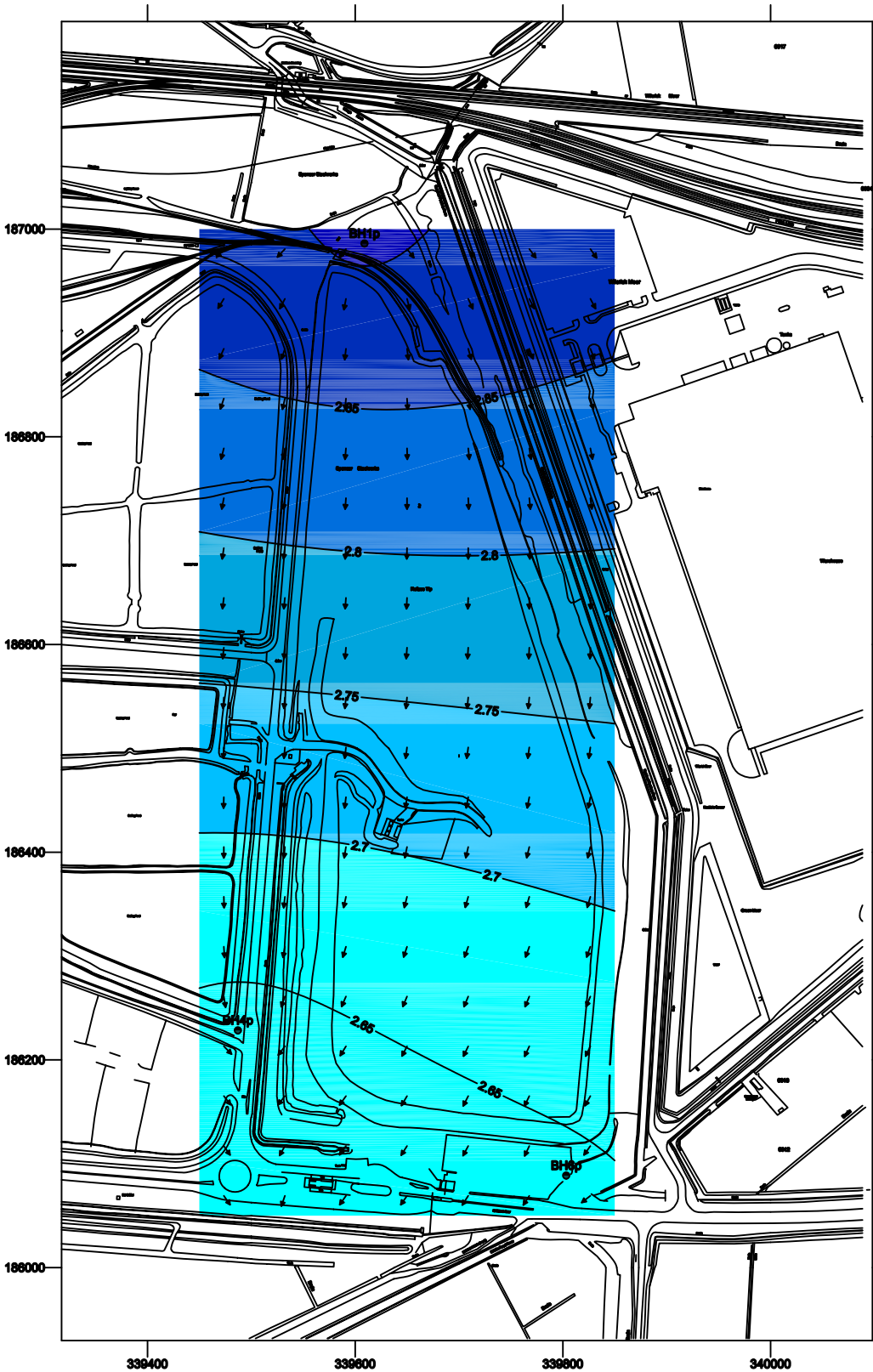
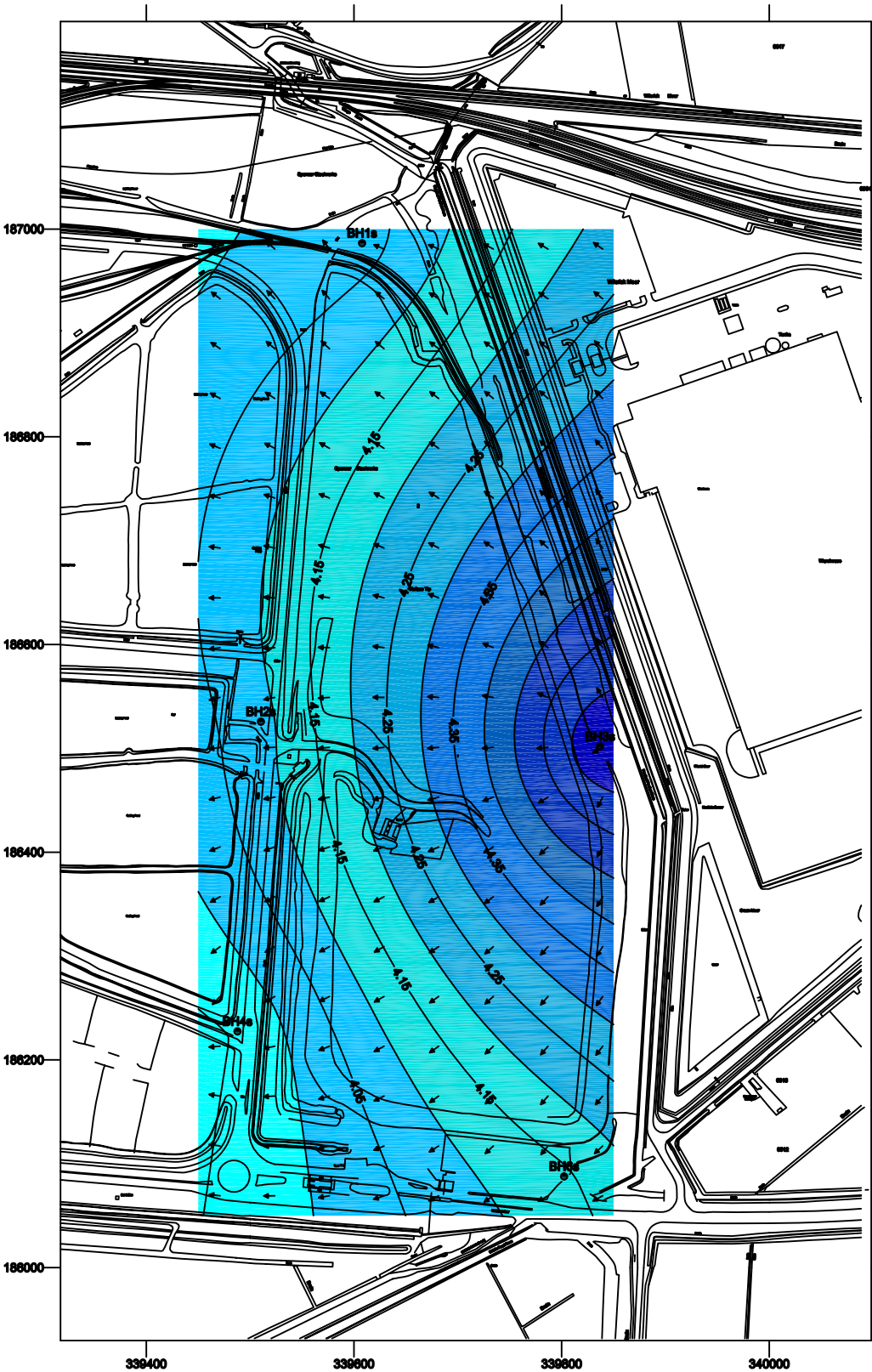


Figure 8 Historical Groundwater Levels

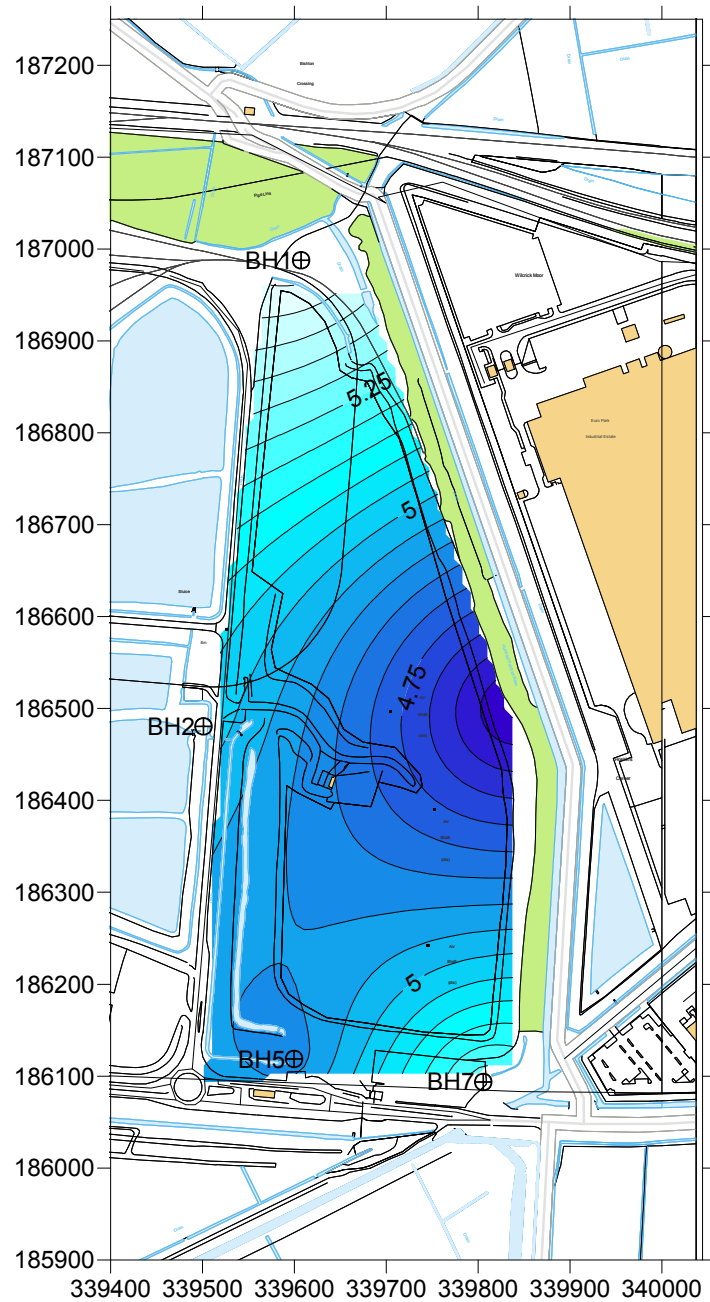


AQUIFER FLOW

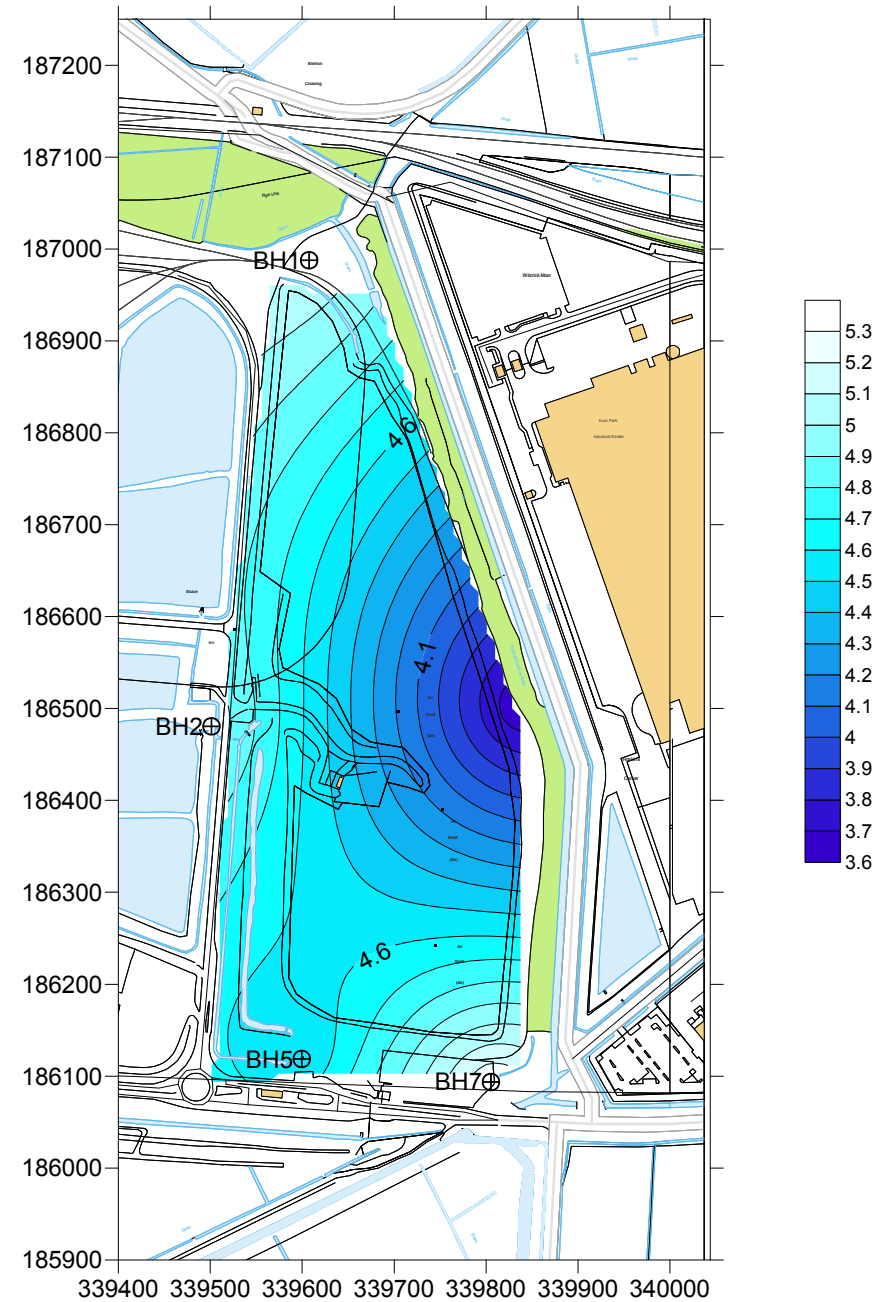


LEACHATE FLOW

**Figure 9. Groundwater Levels April 2016 (mAOD)**



**Shallow Groundwater Surface April 2016**



**Deep Groundwater Surface April 2016**

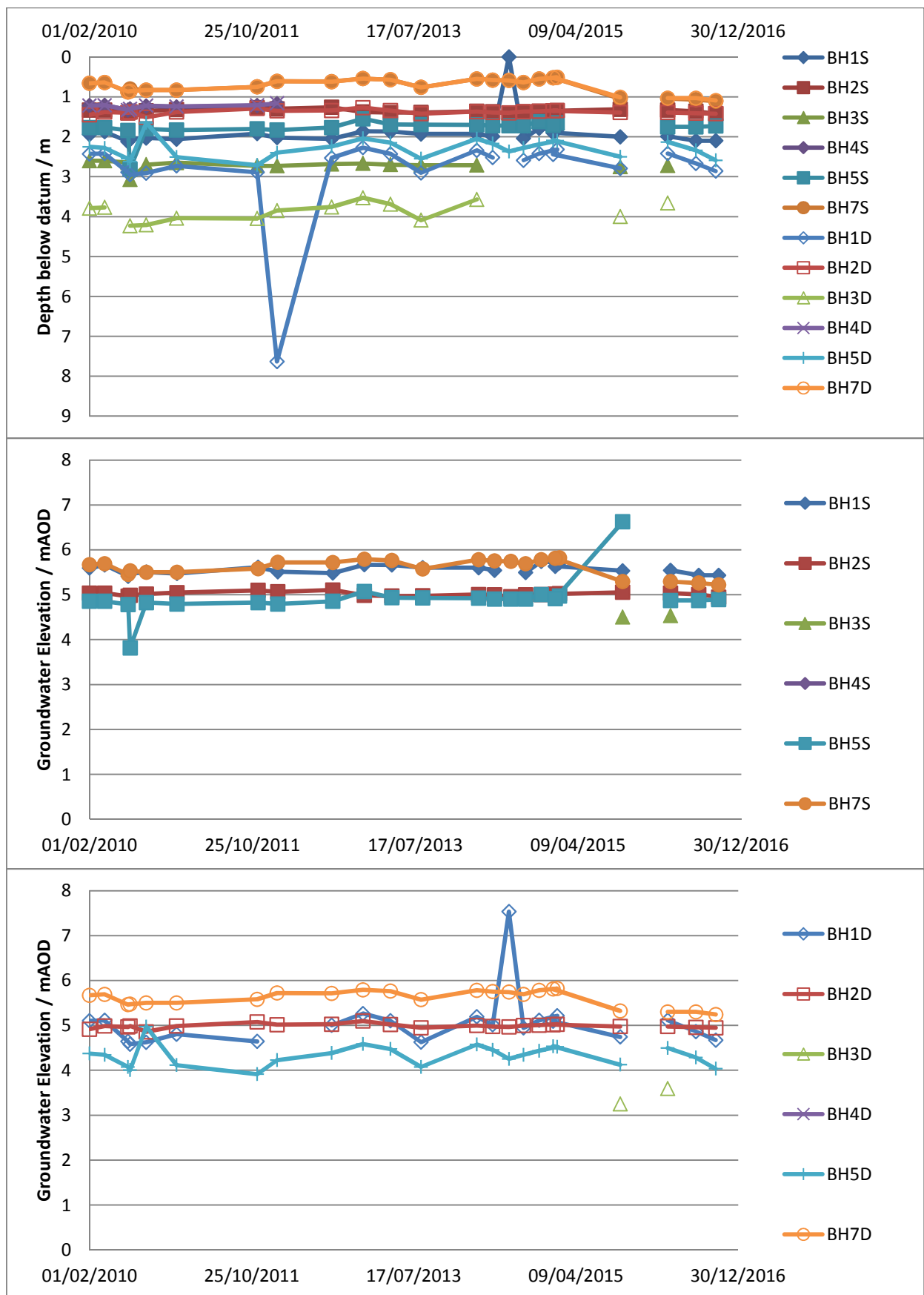
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LLANWERN STEELWORKS**

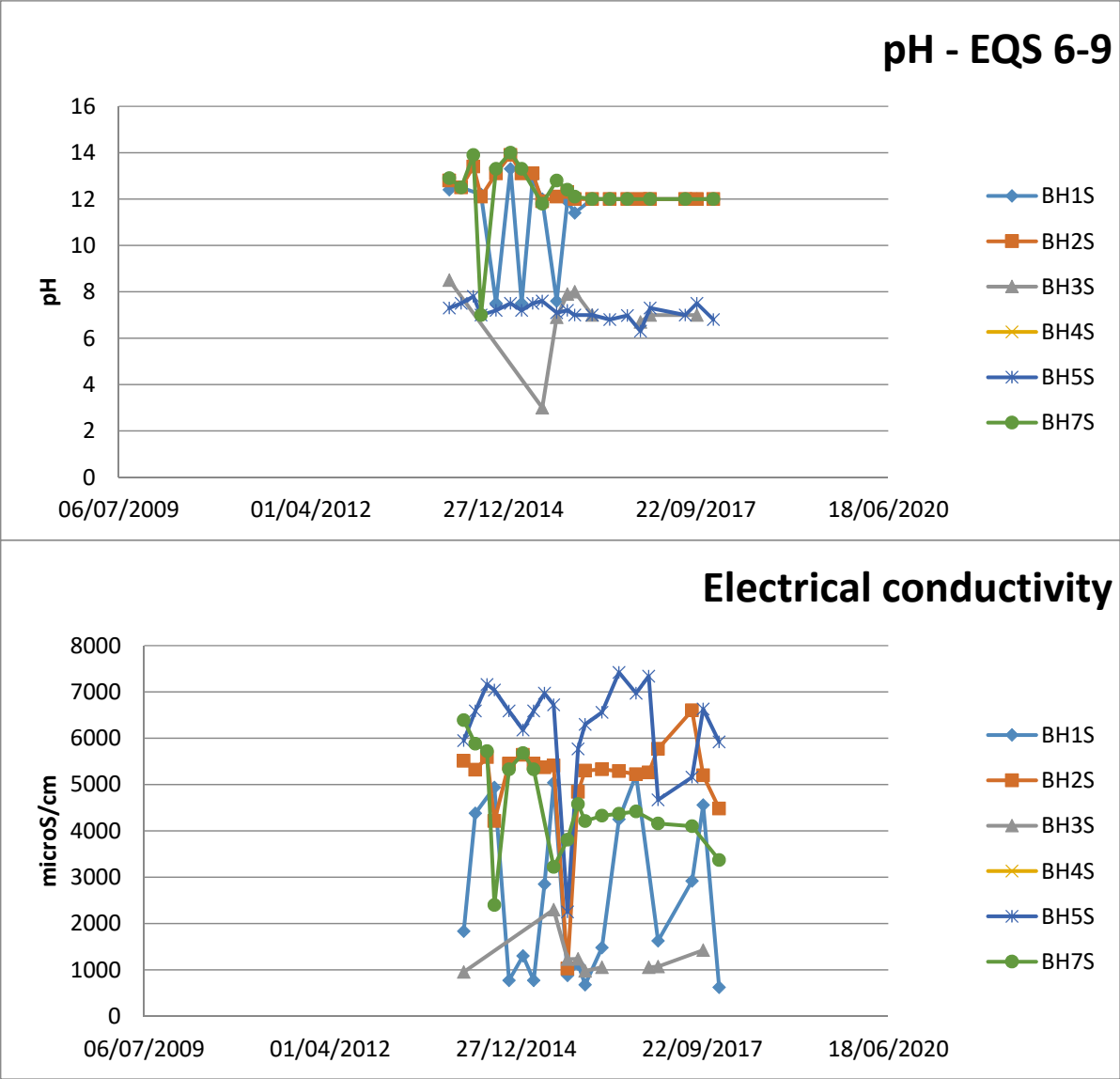
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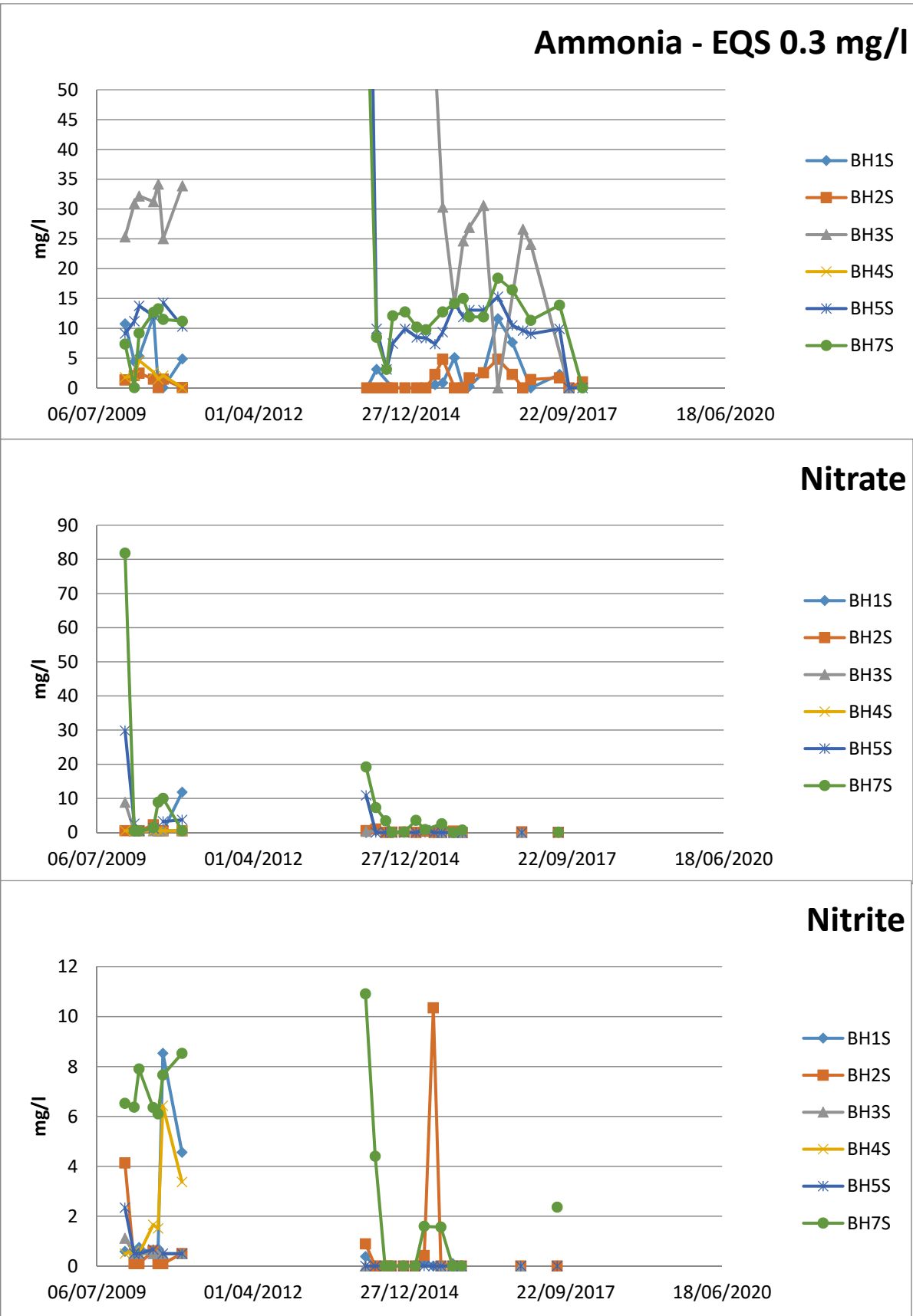
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Environmental  
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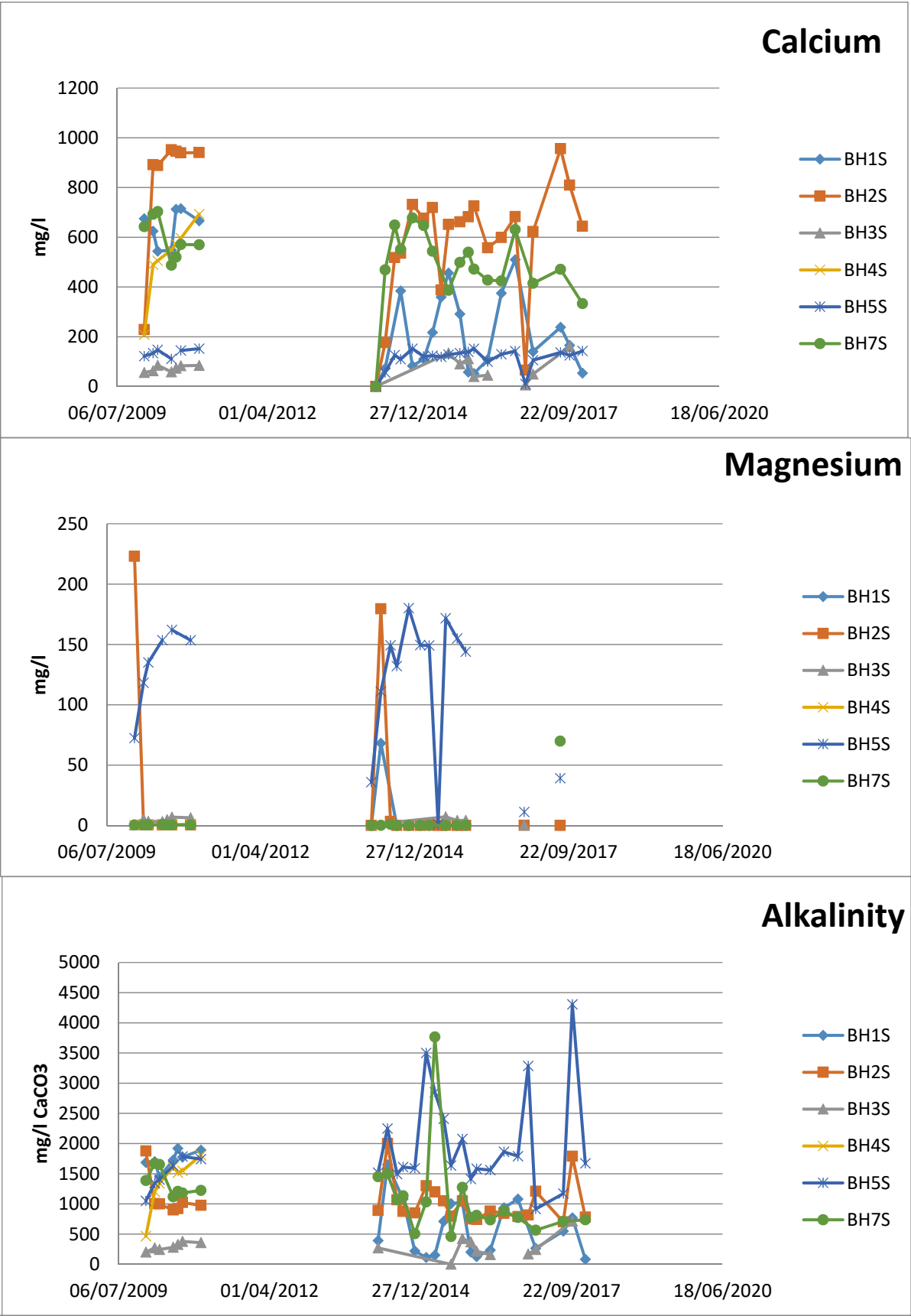
**Appendix 1  
Groundwater Levels  
and Chemistry**

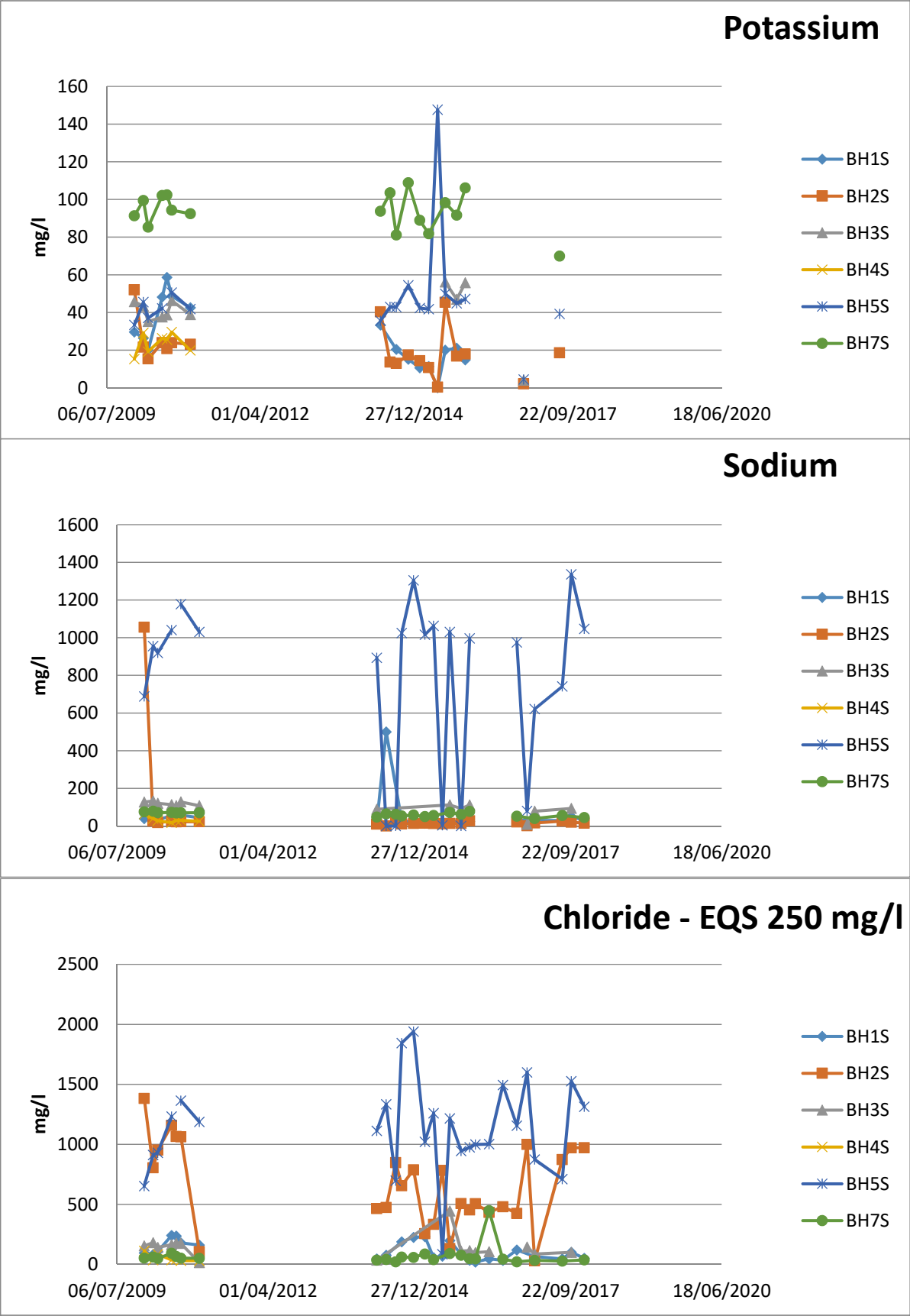
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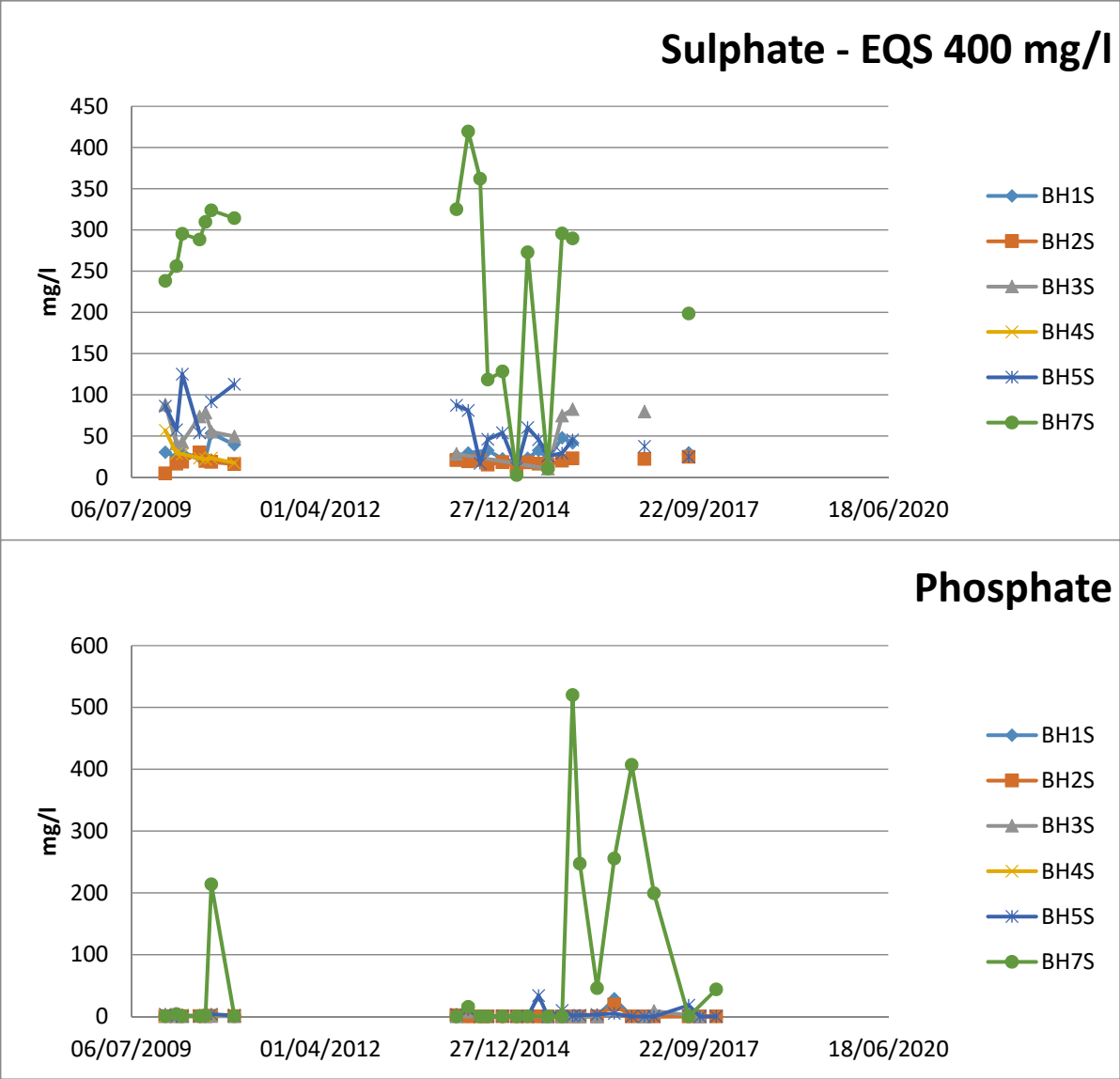


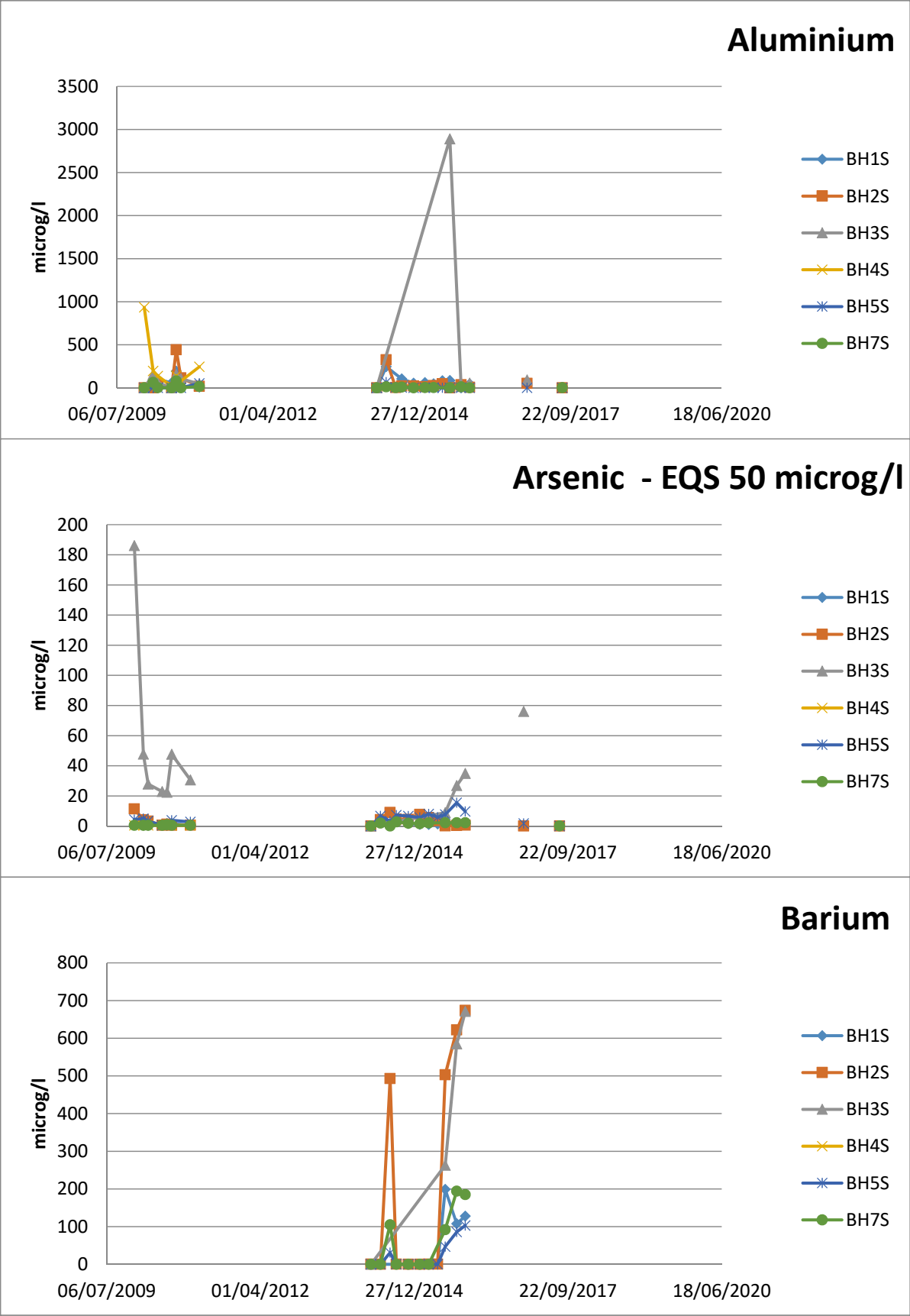


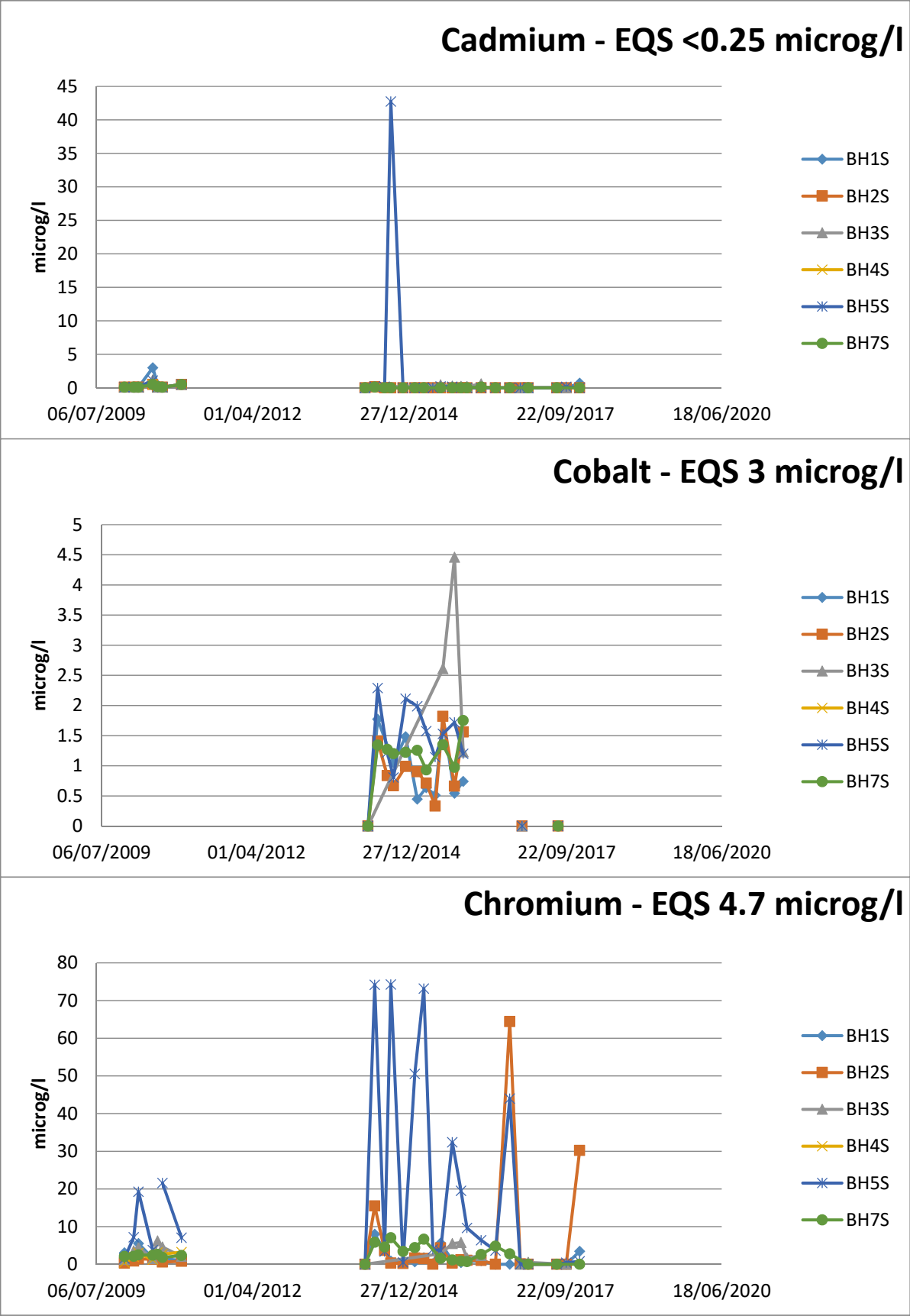


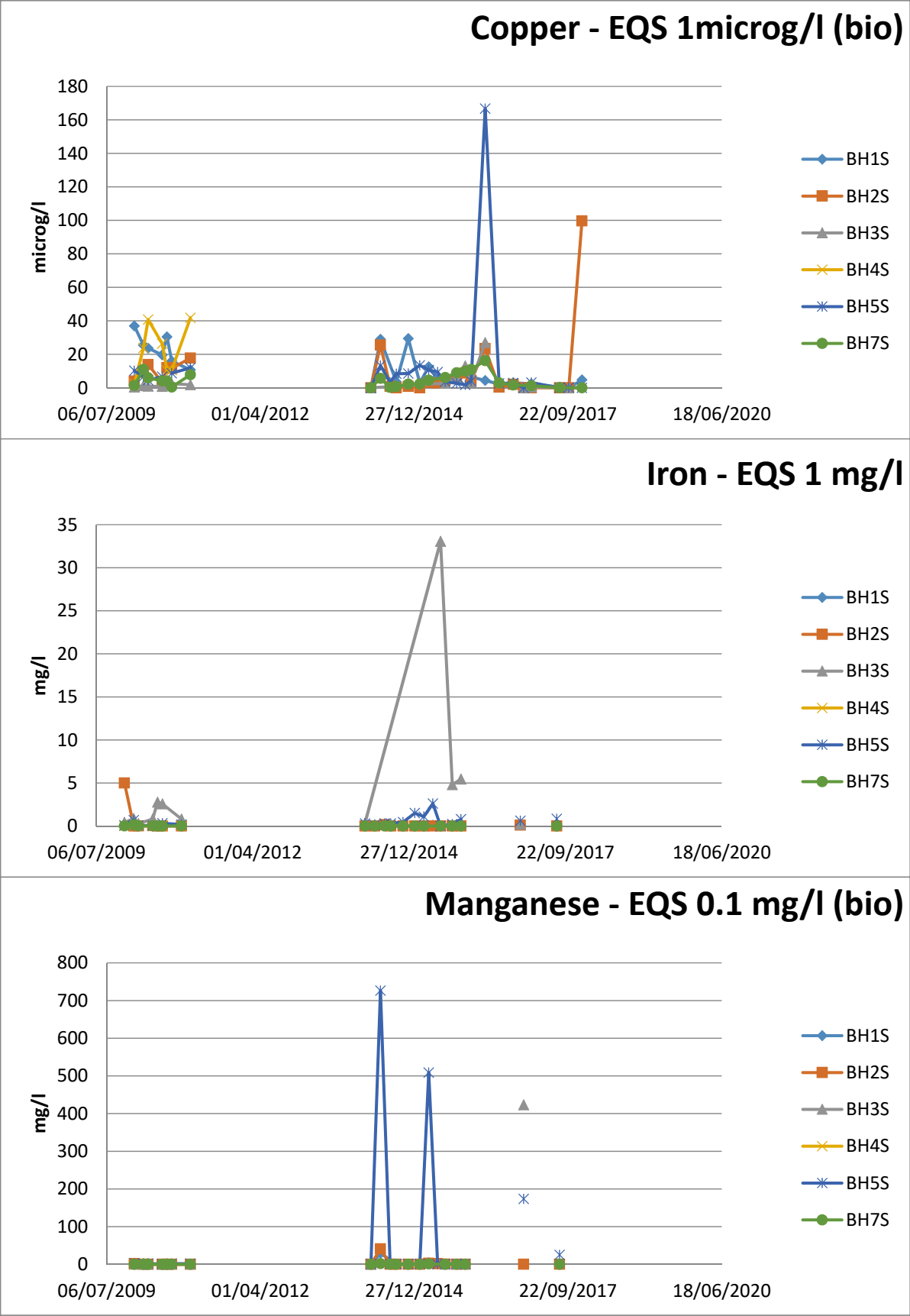


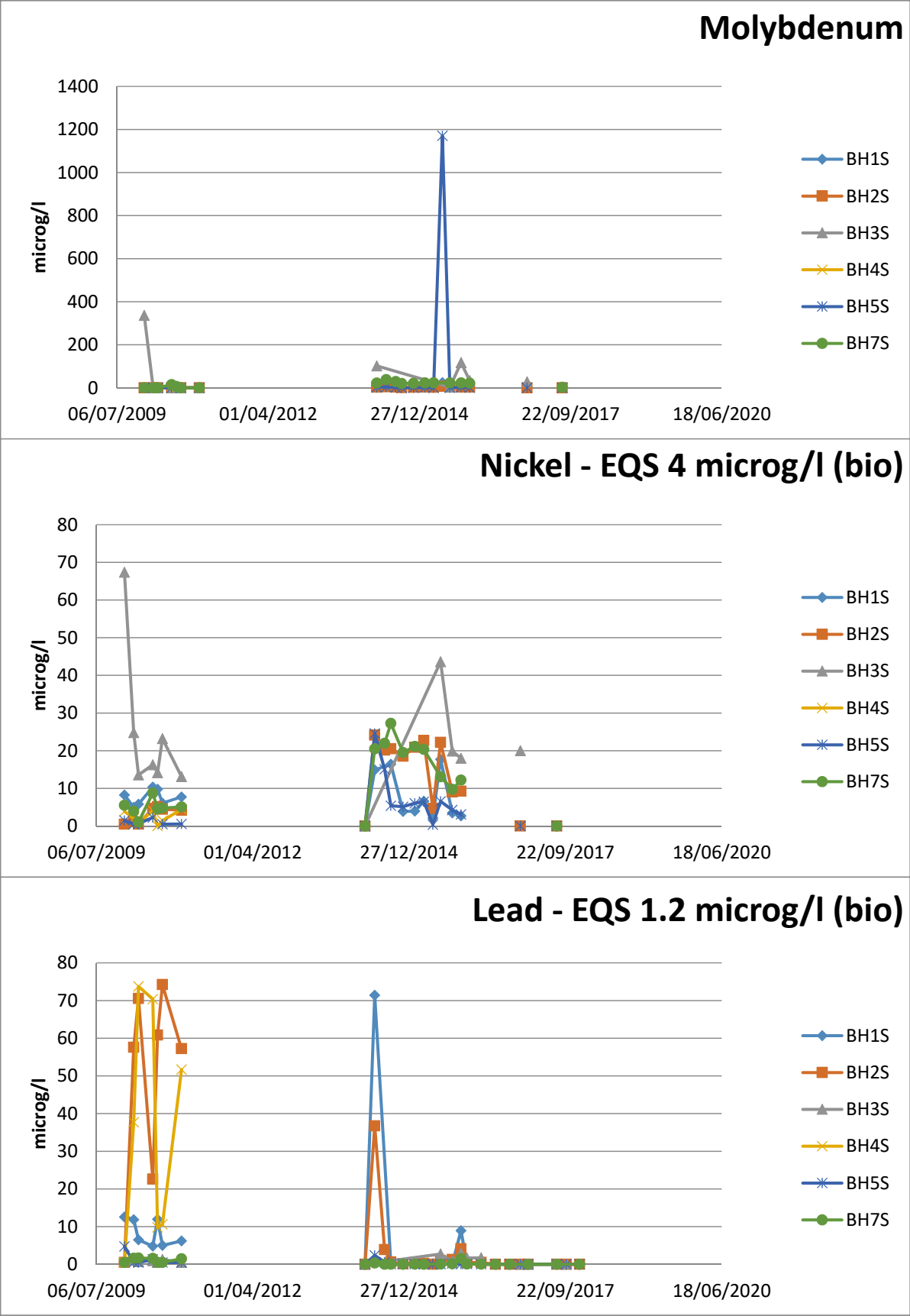


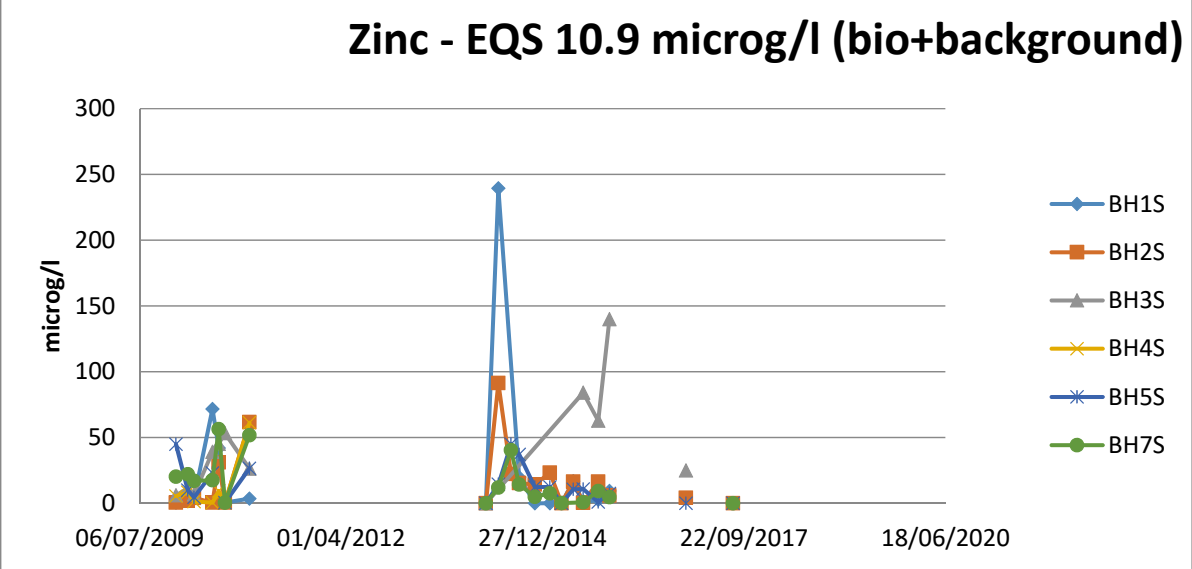
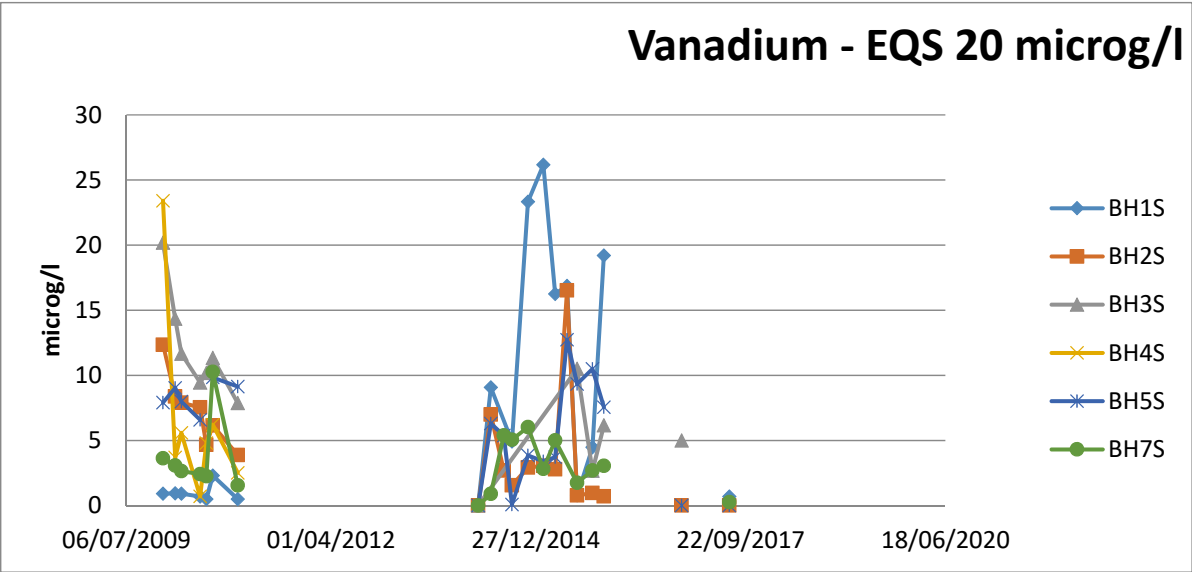
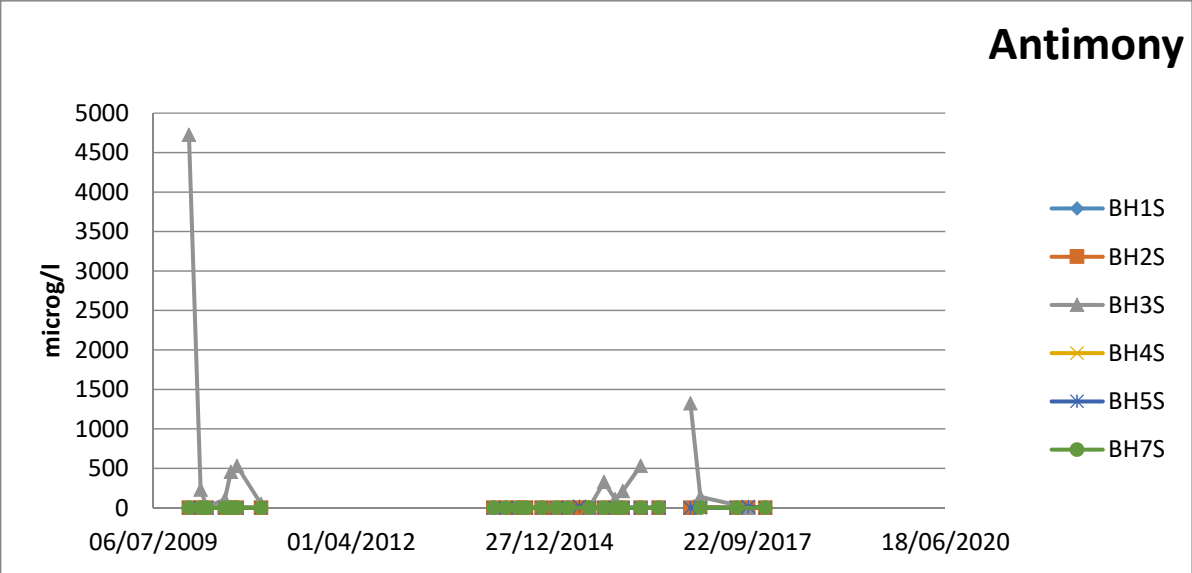


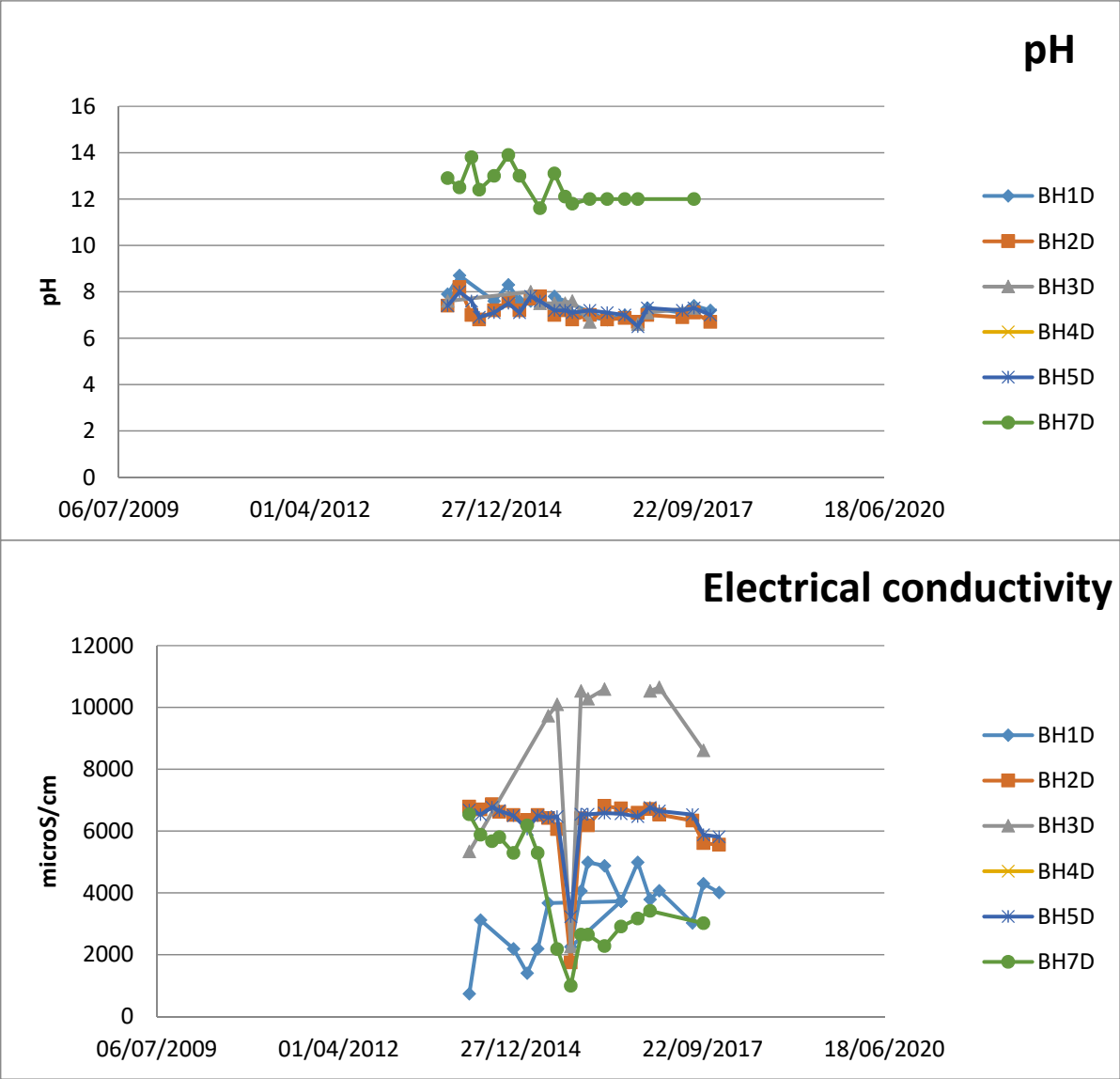


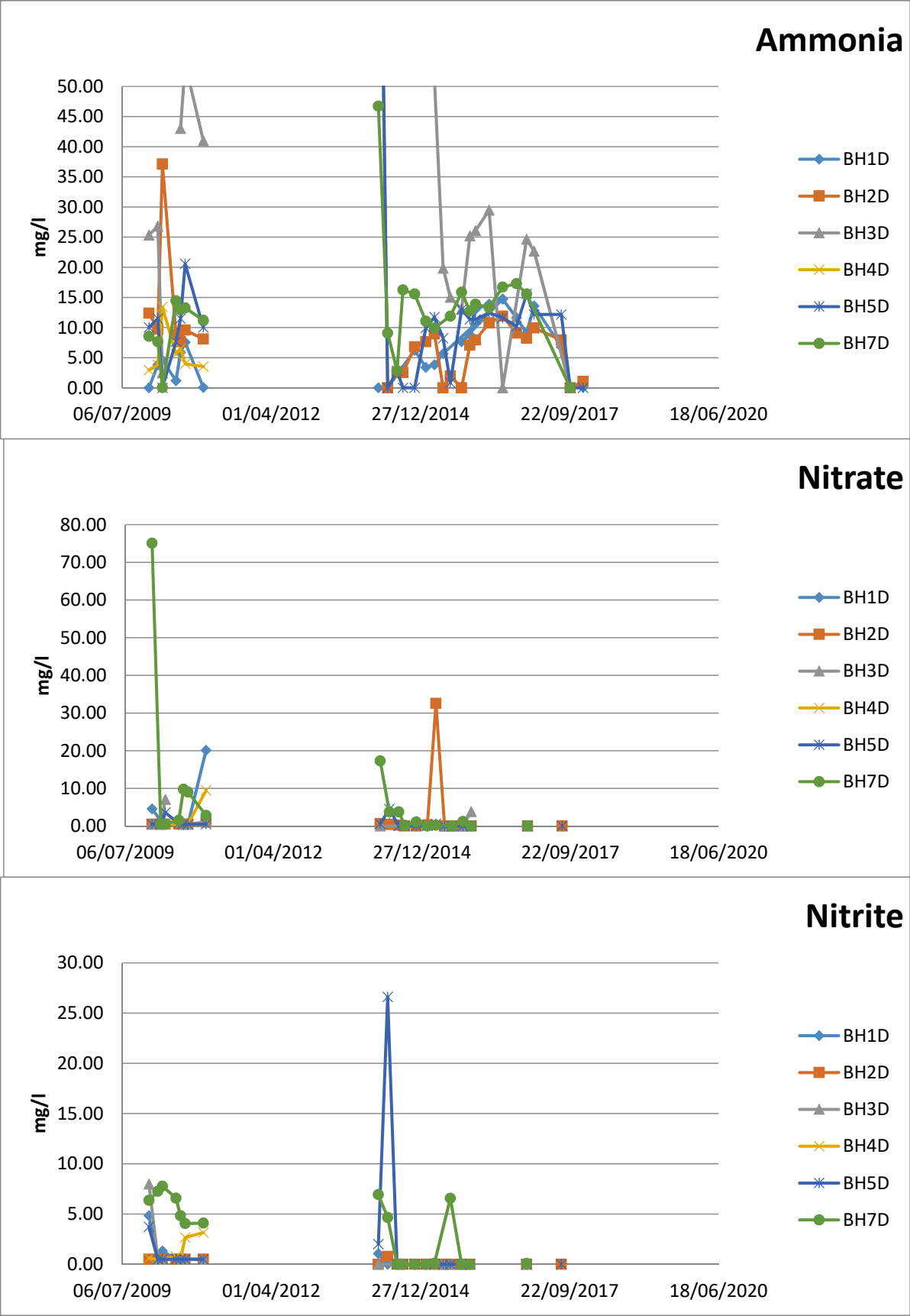


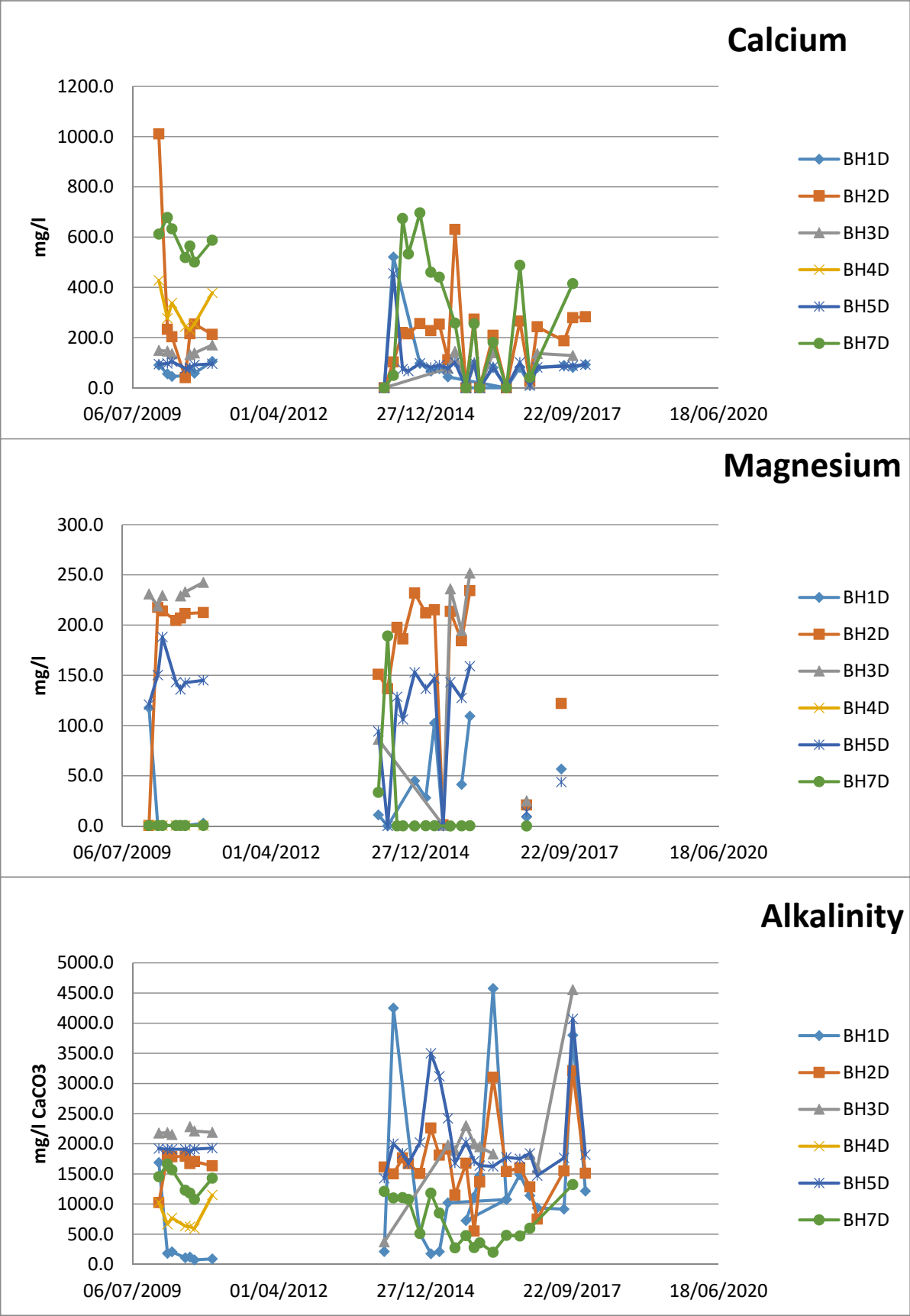


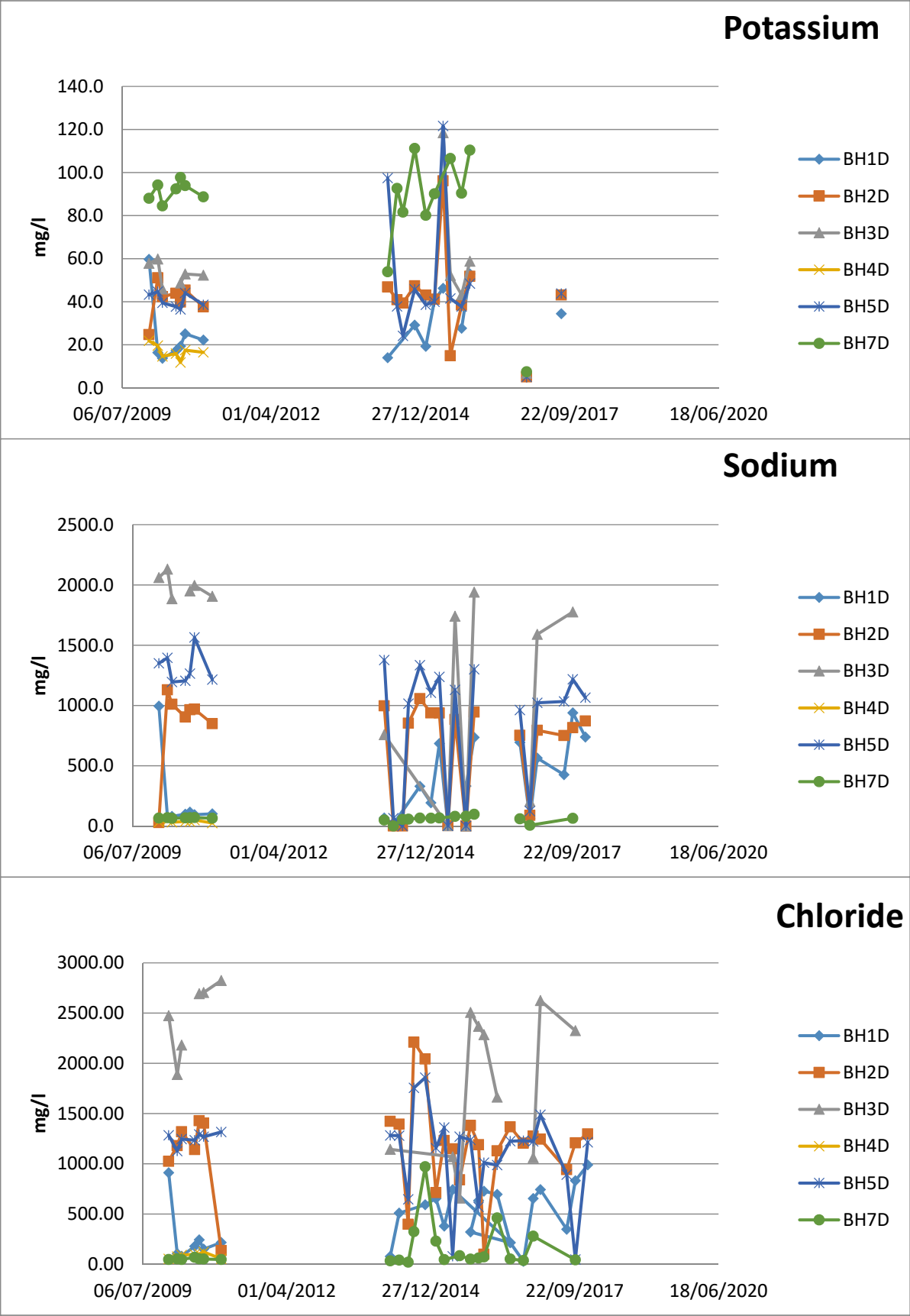


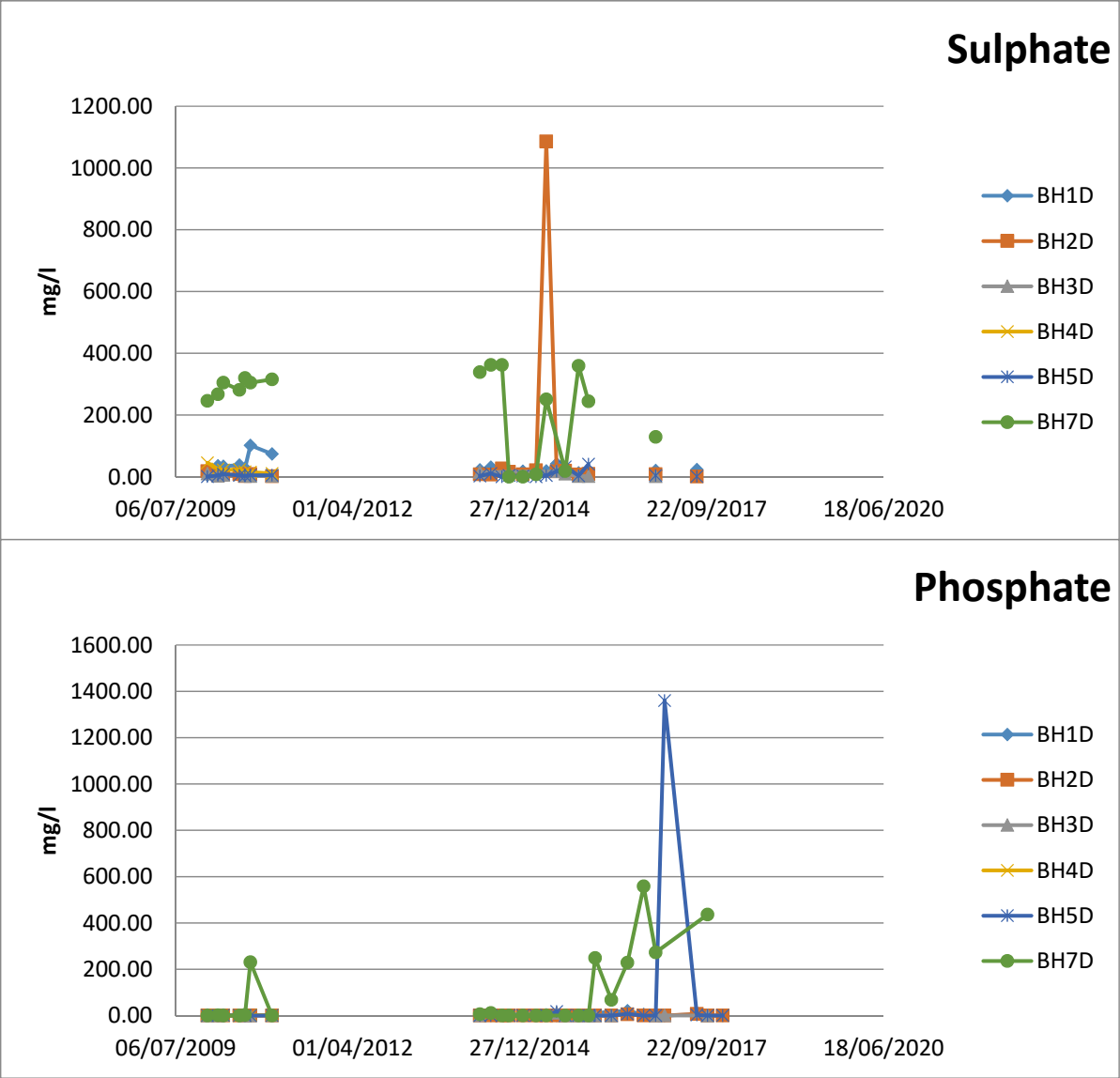


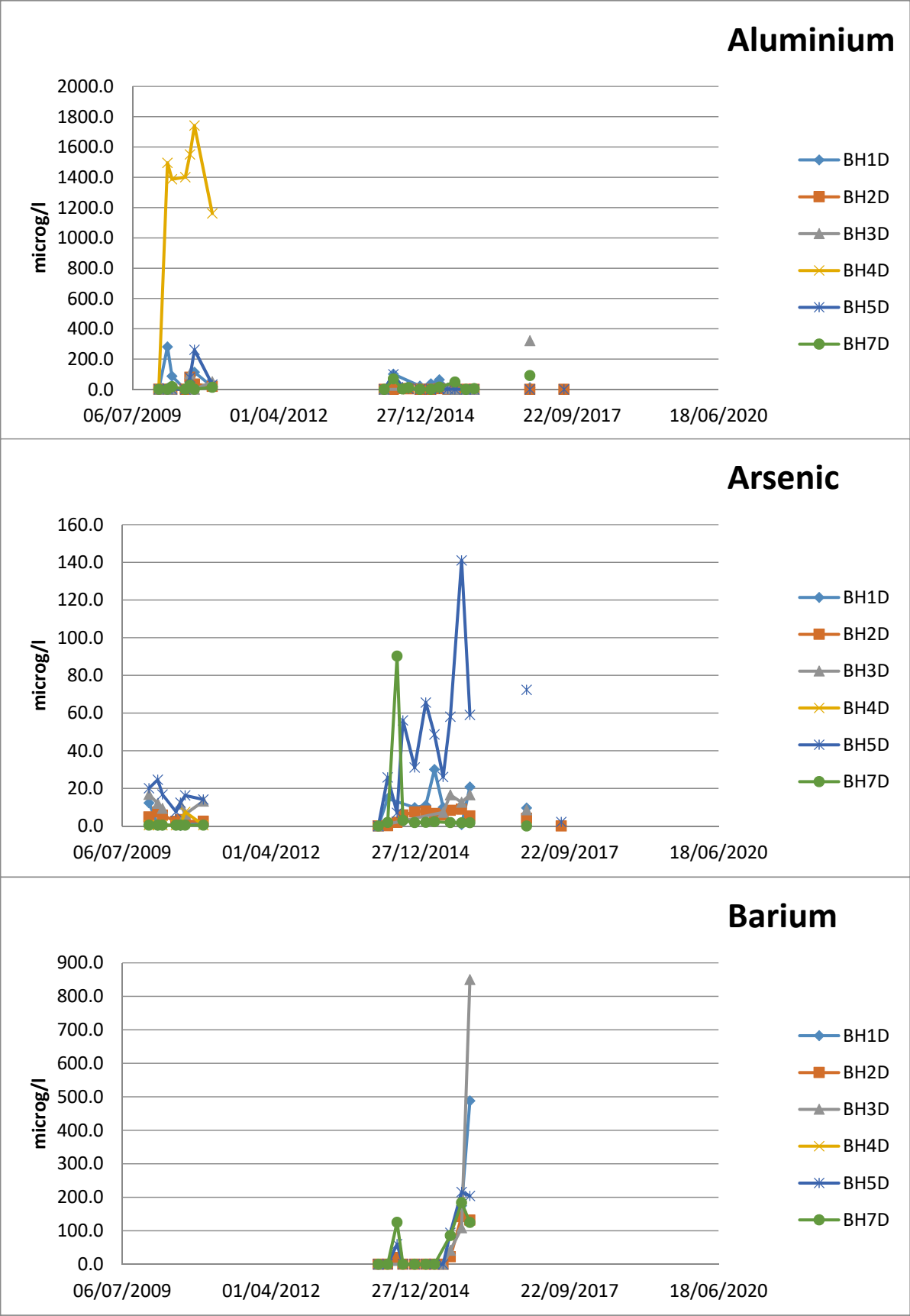


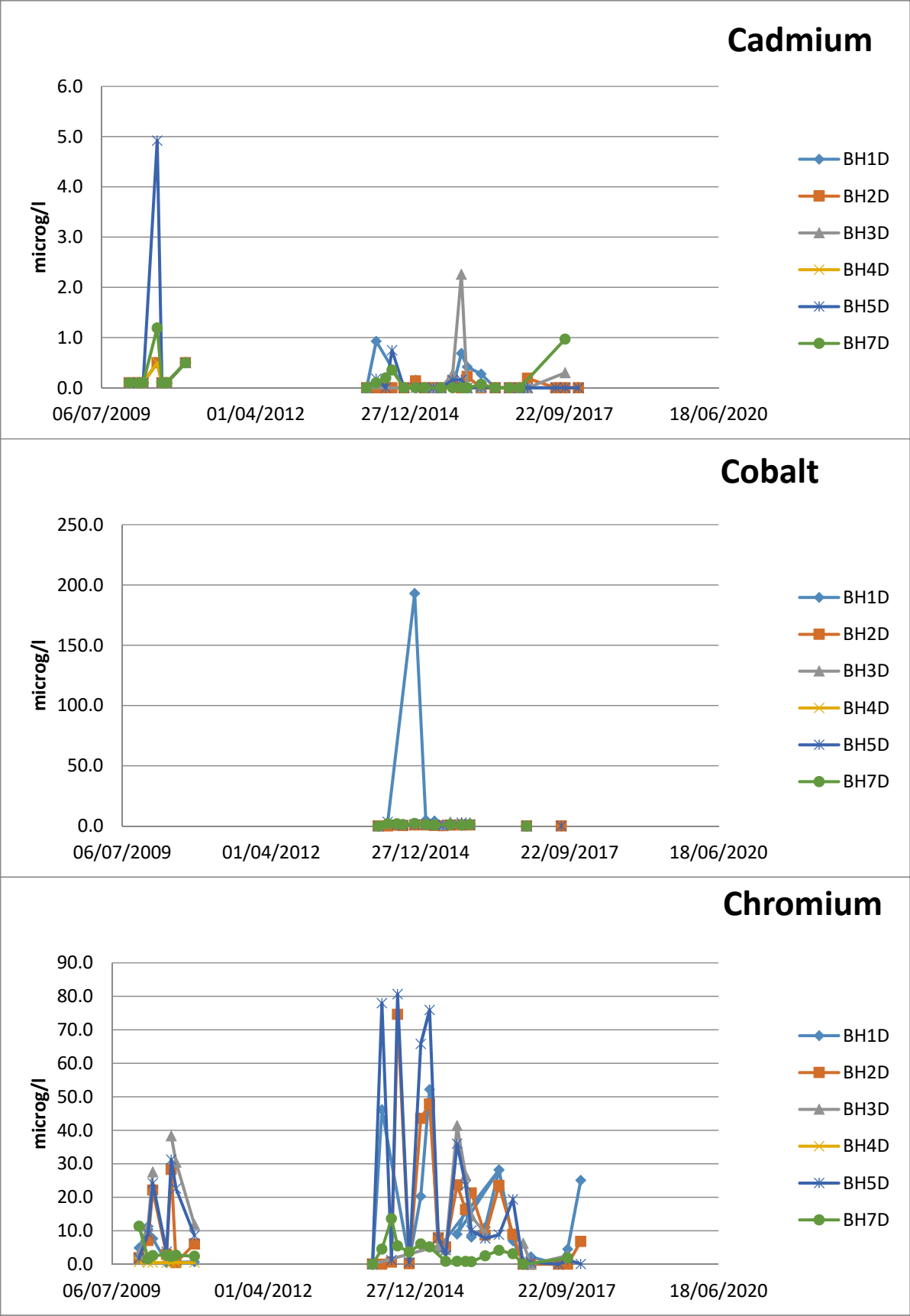


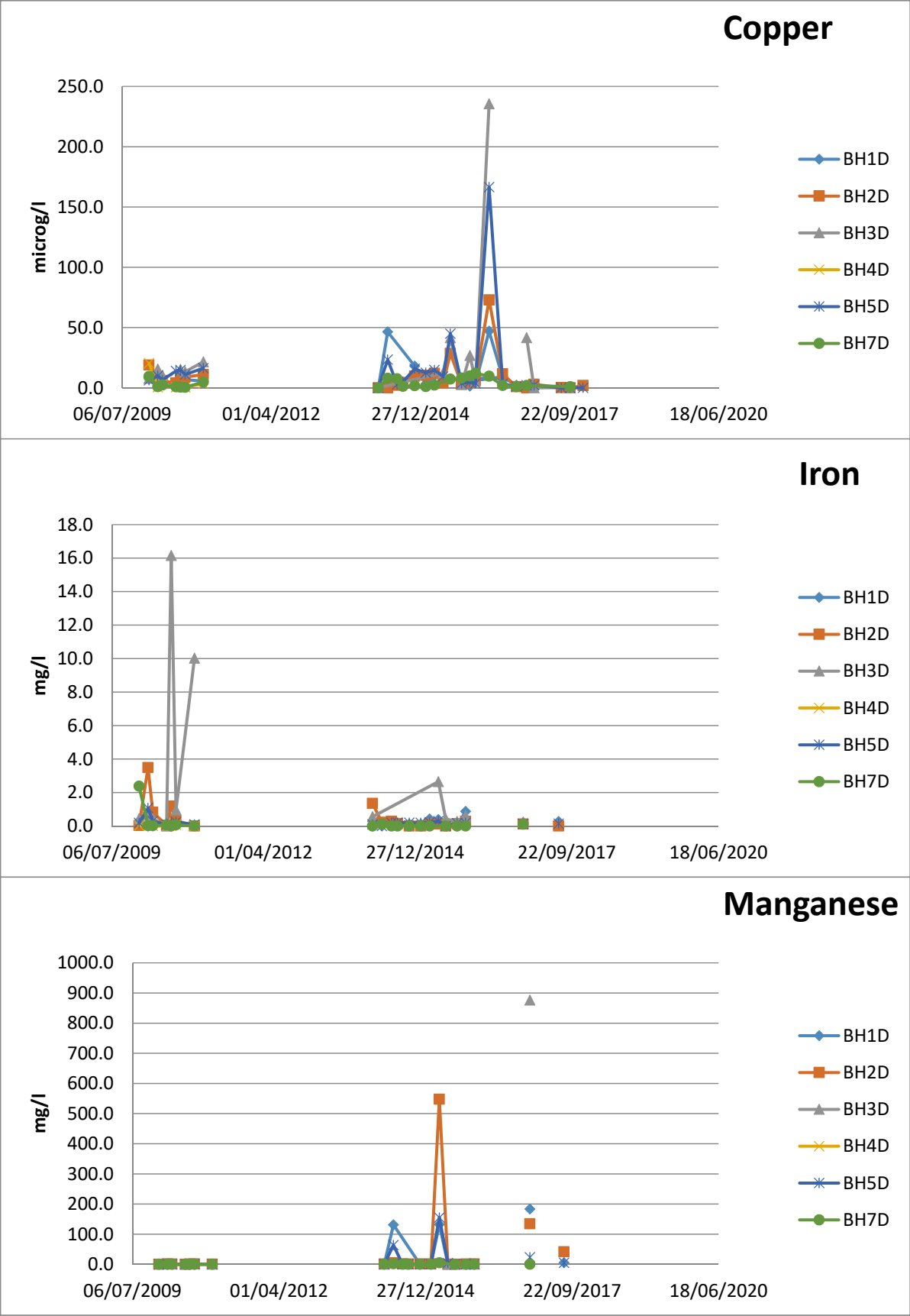


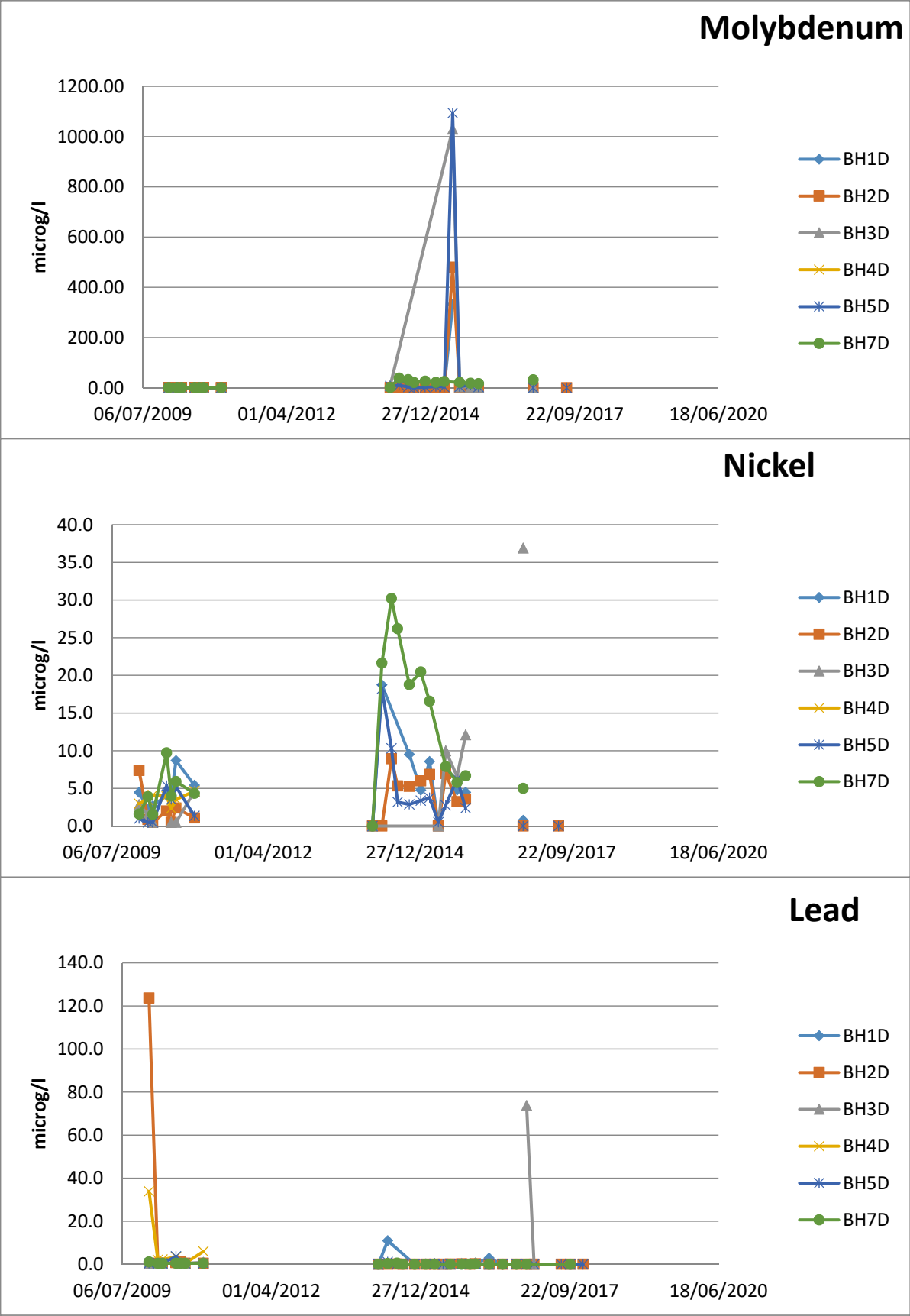


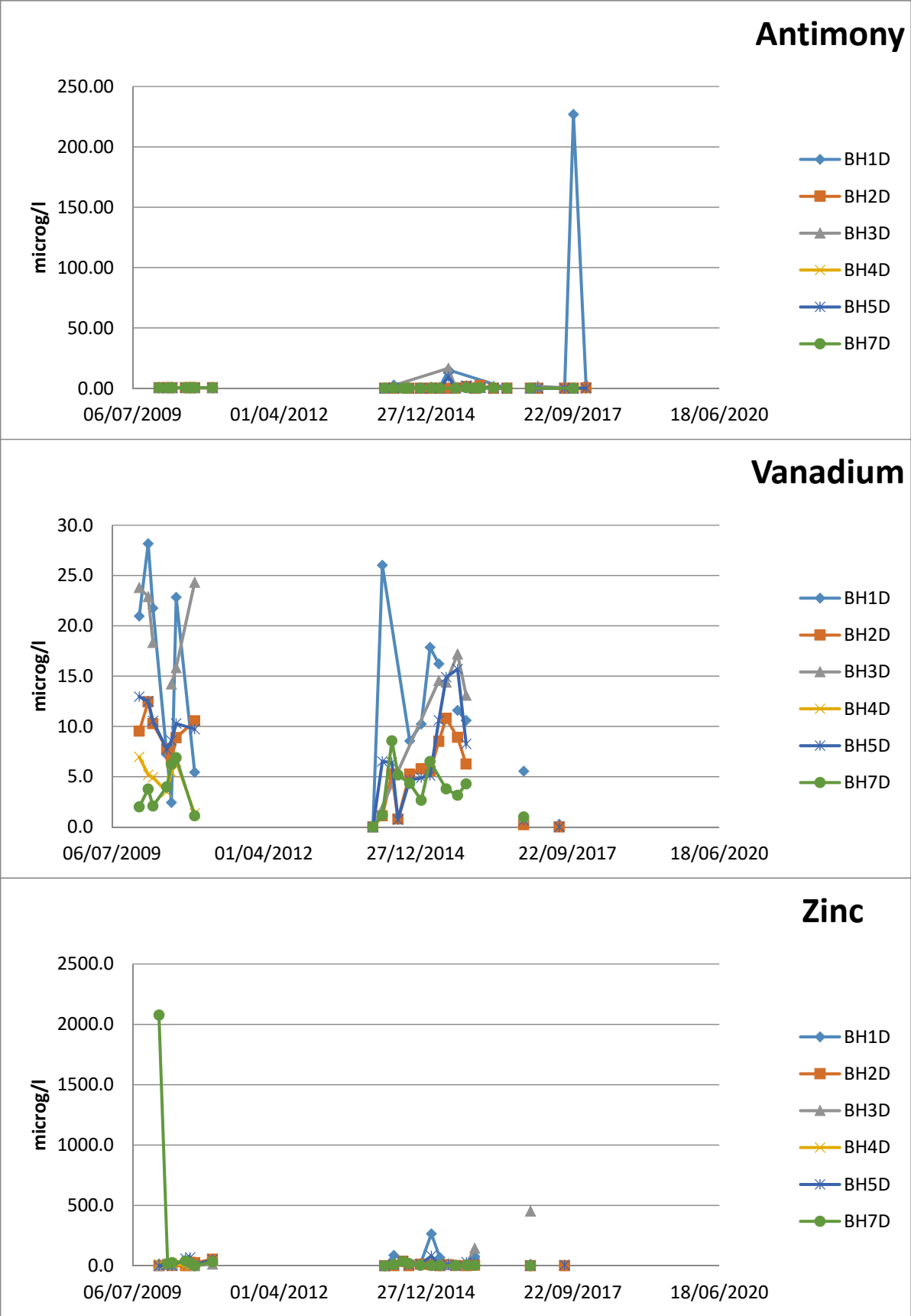




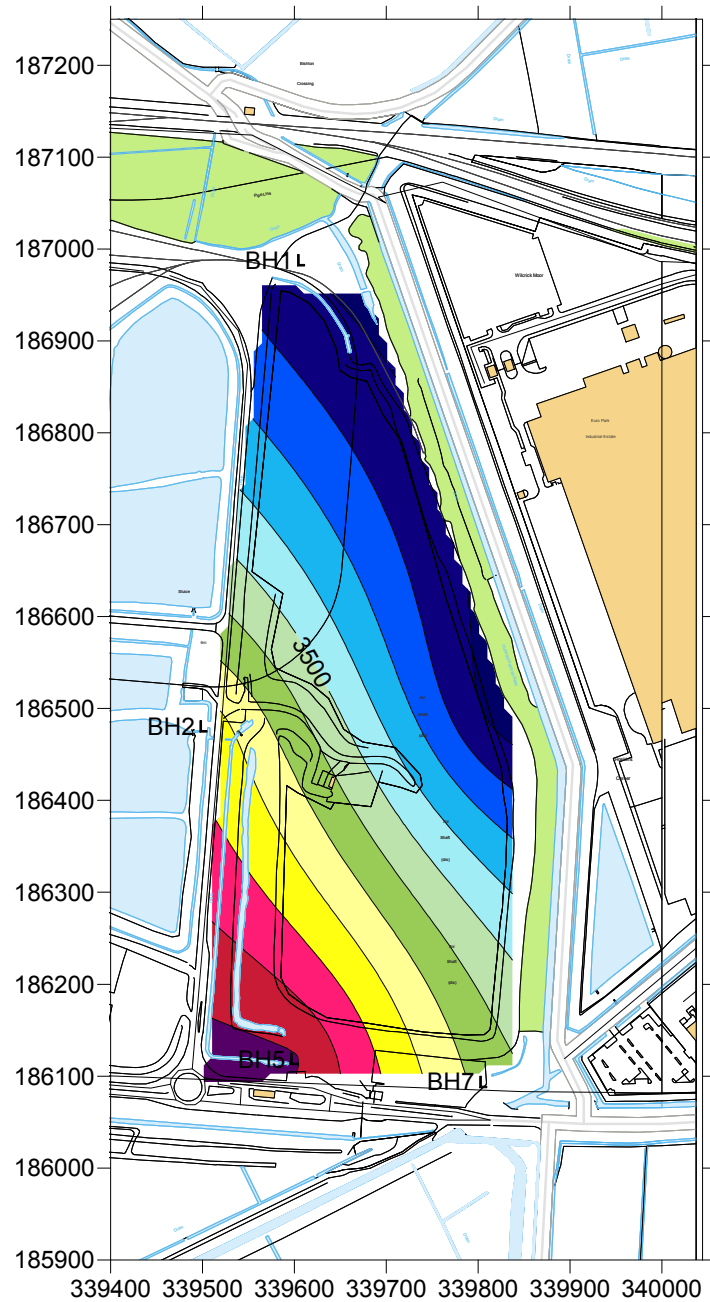




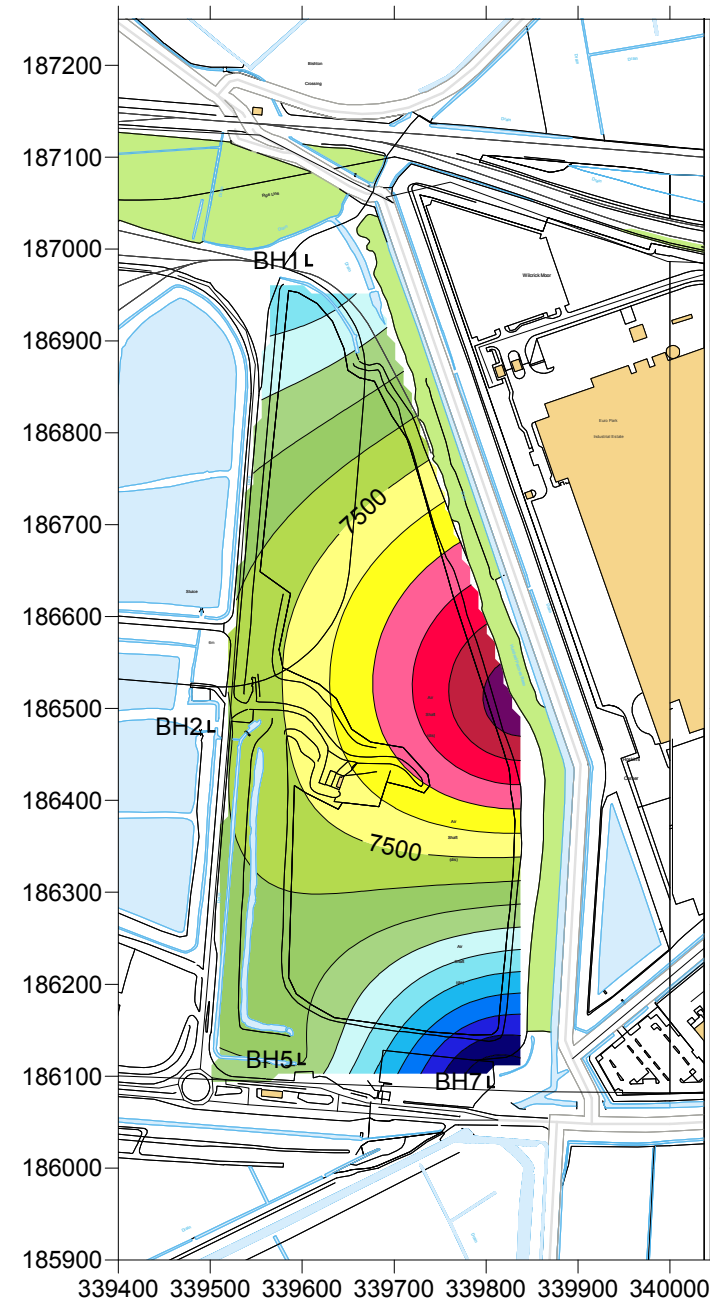




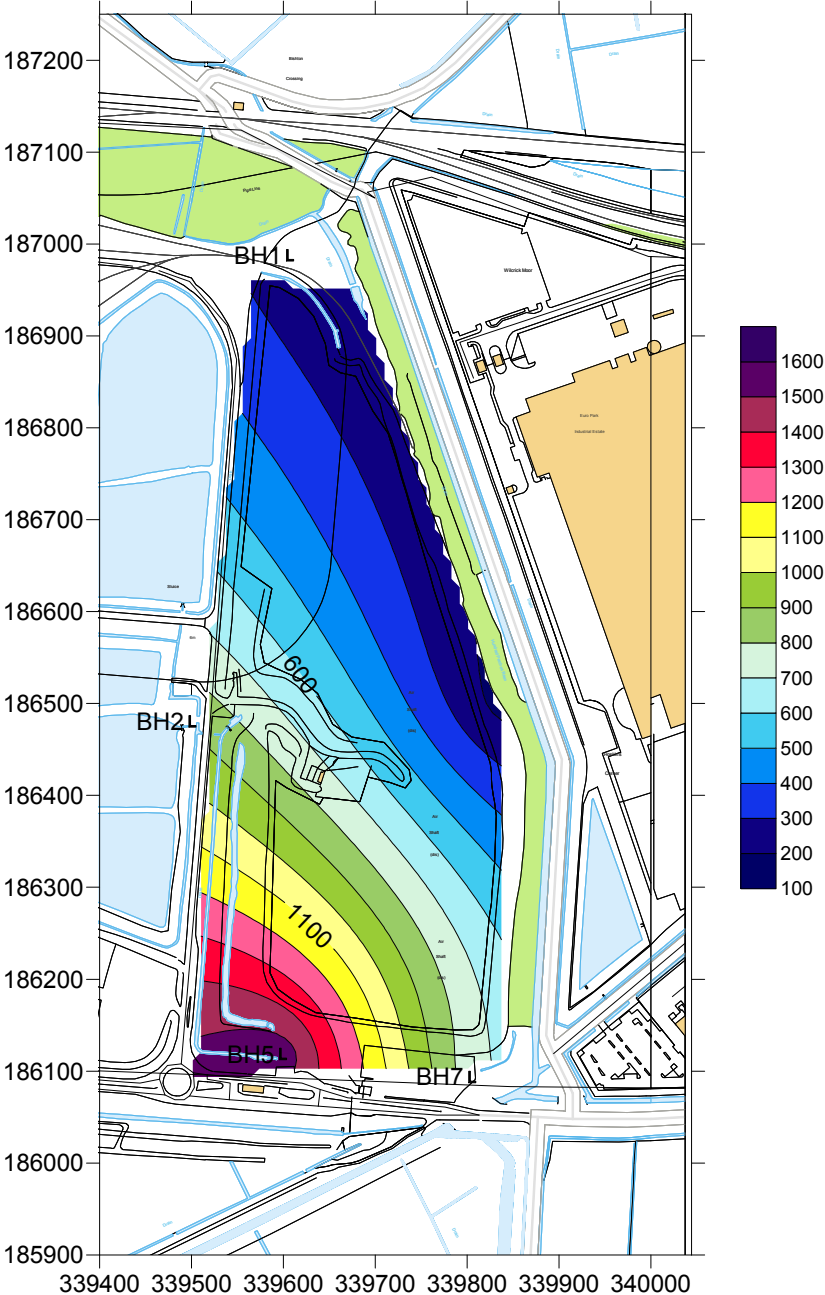
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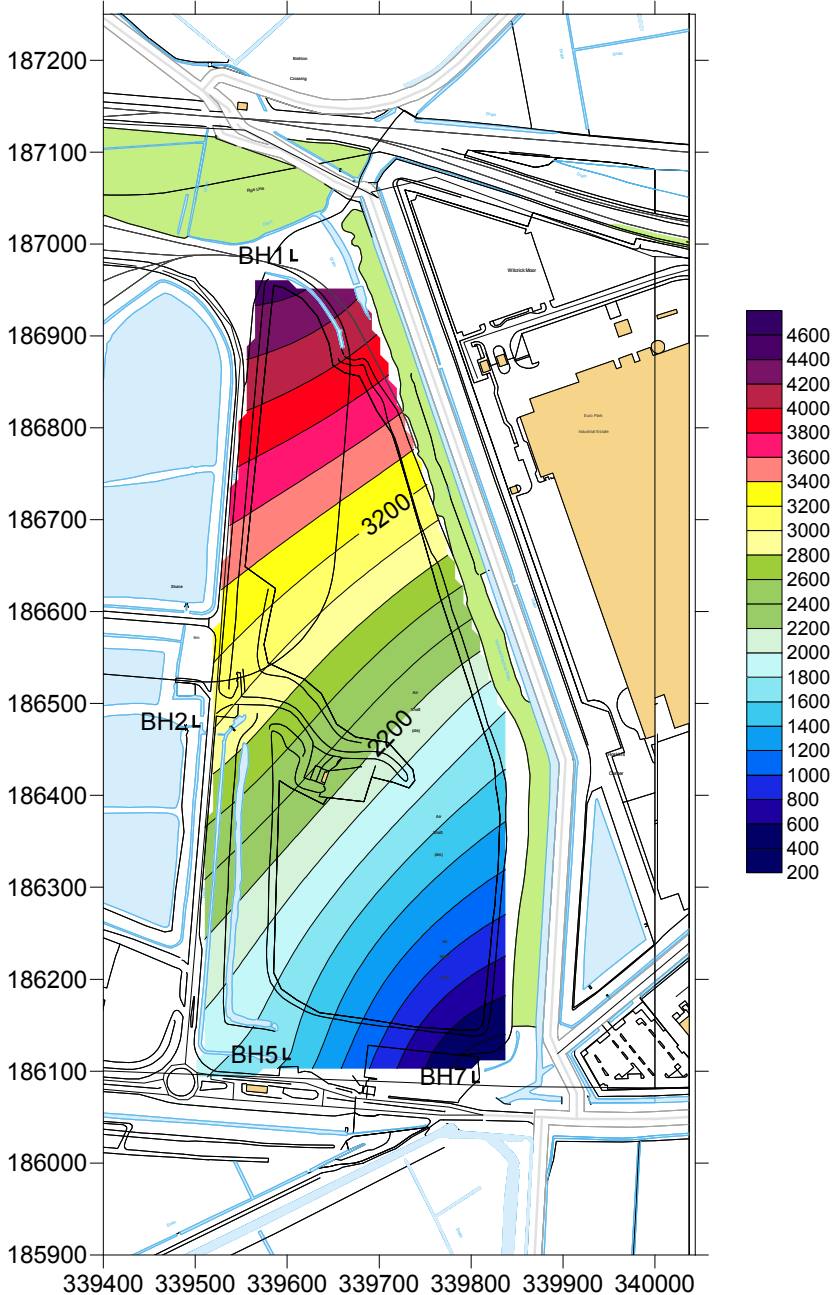
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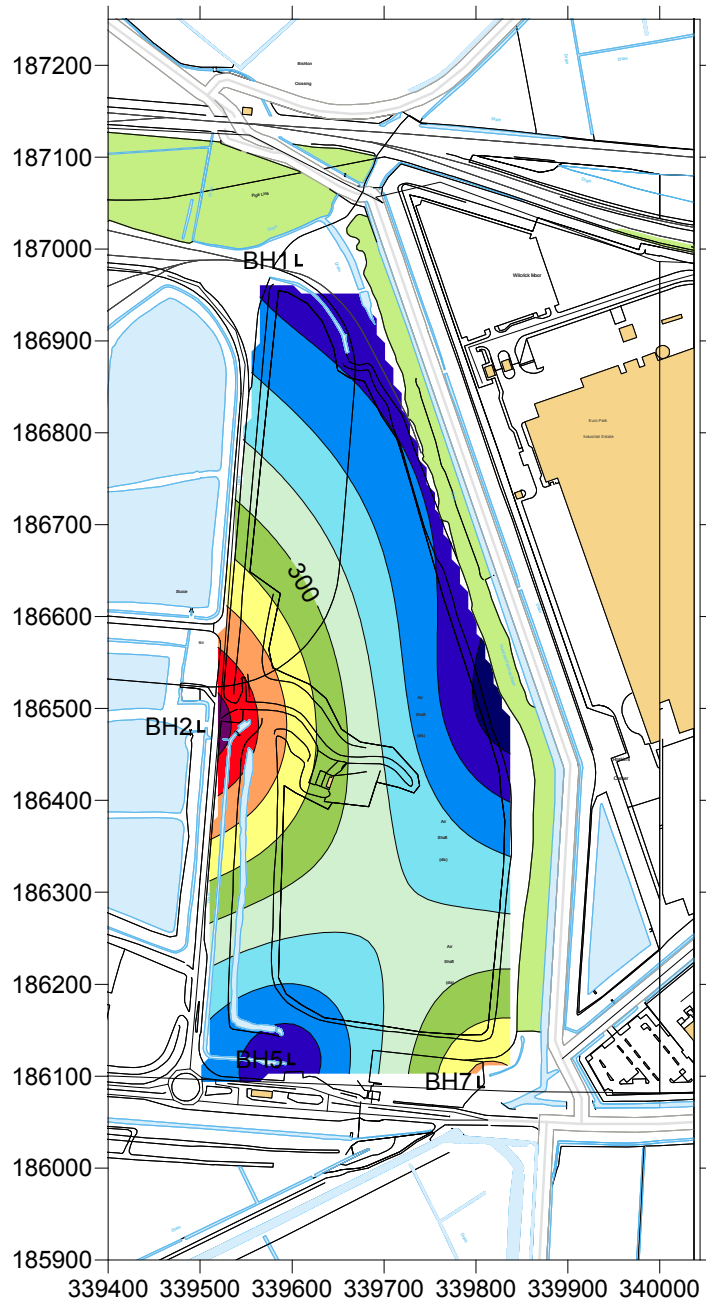
**Electrical Conductivity in  
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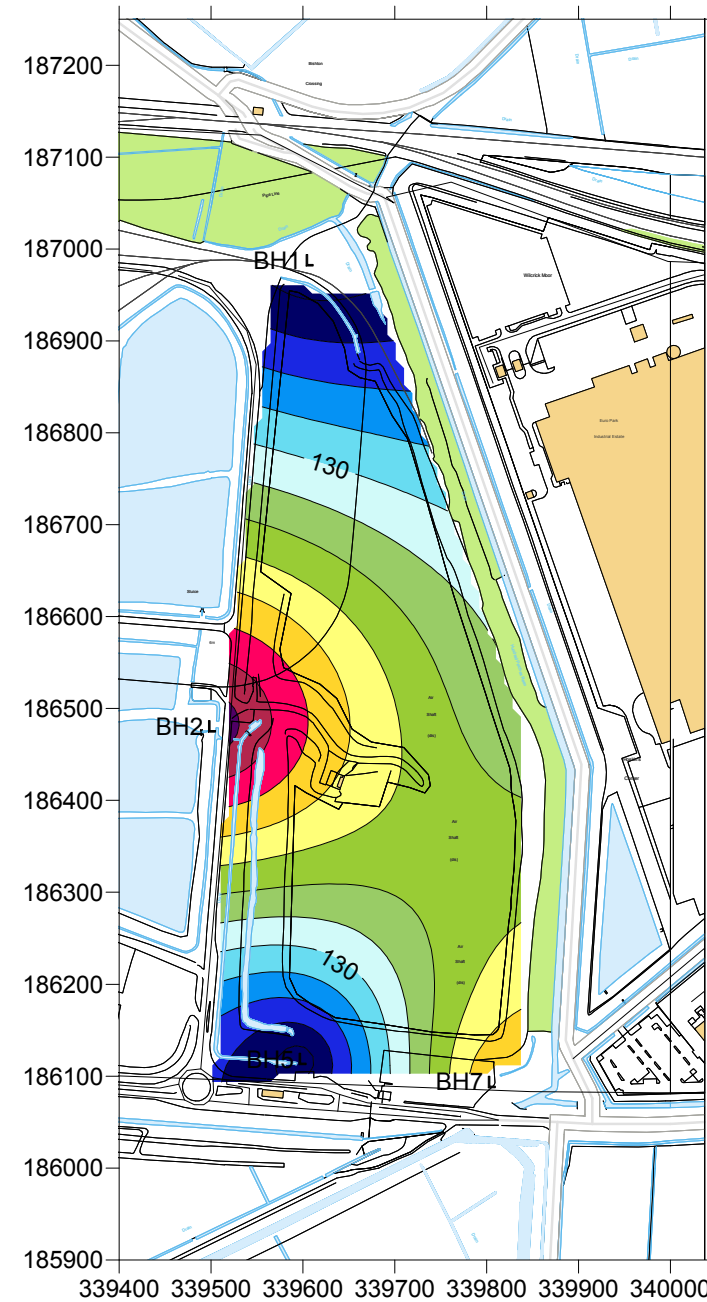
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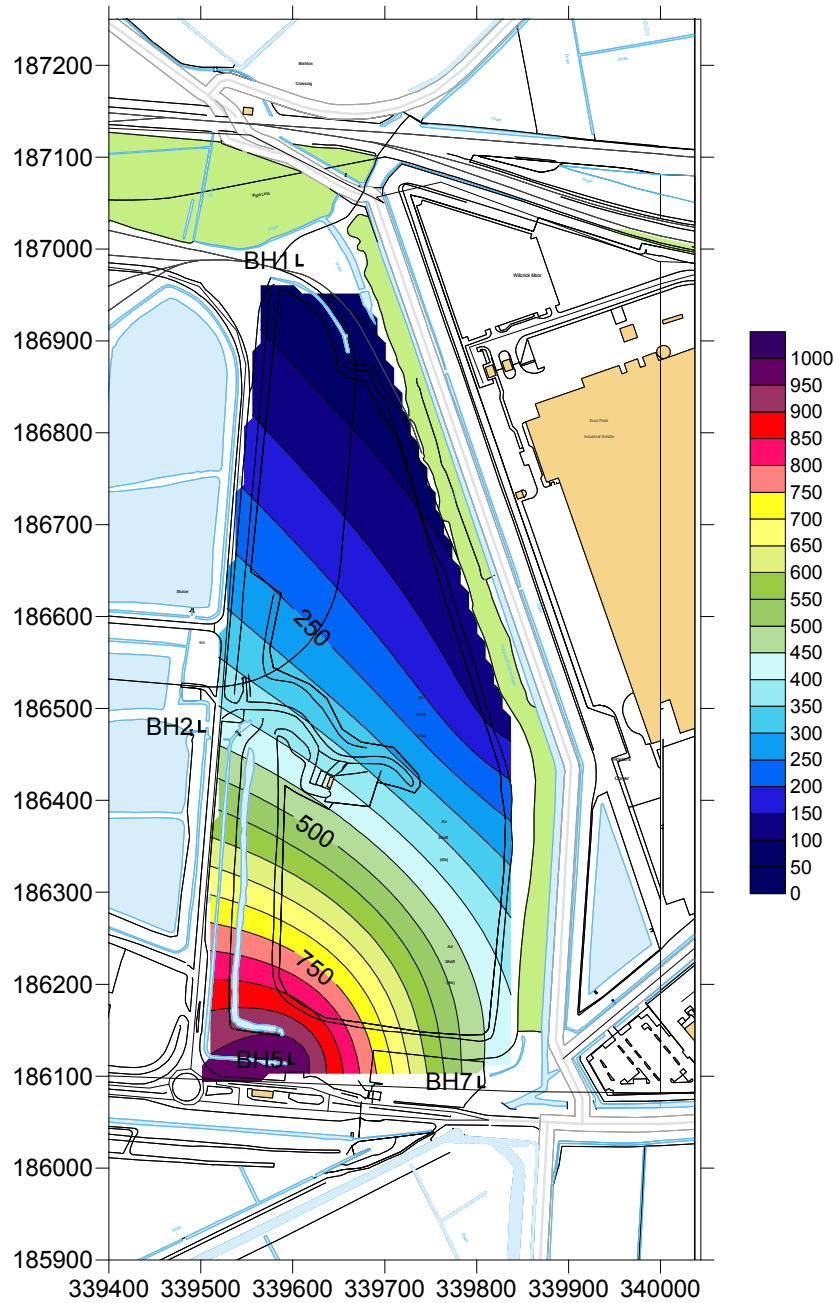
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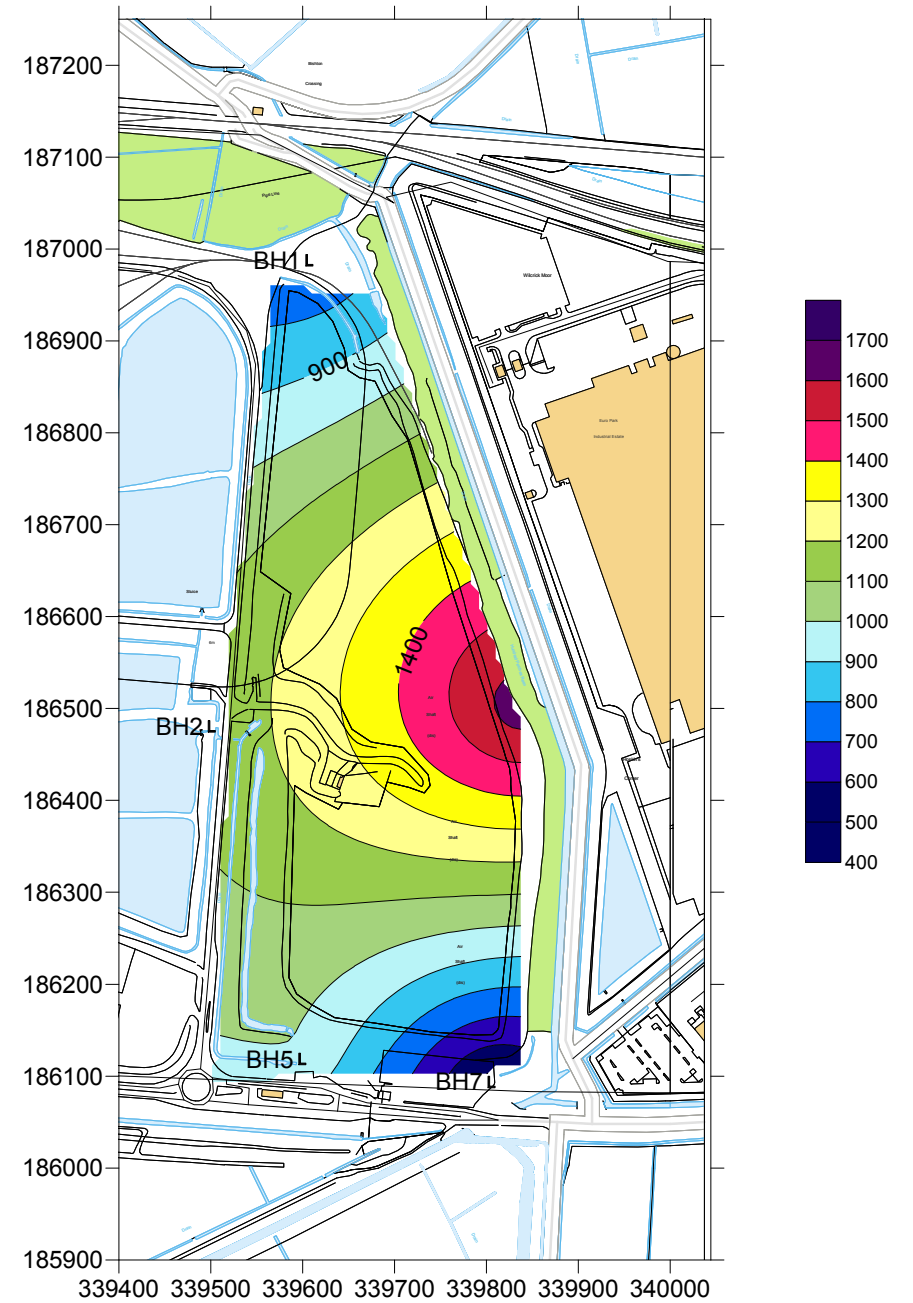
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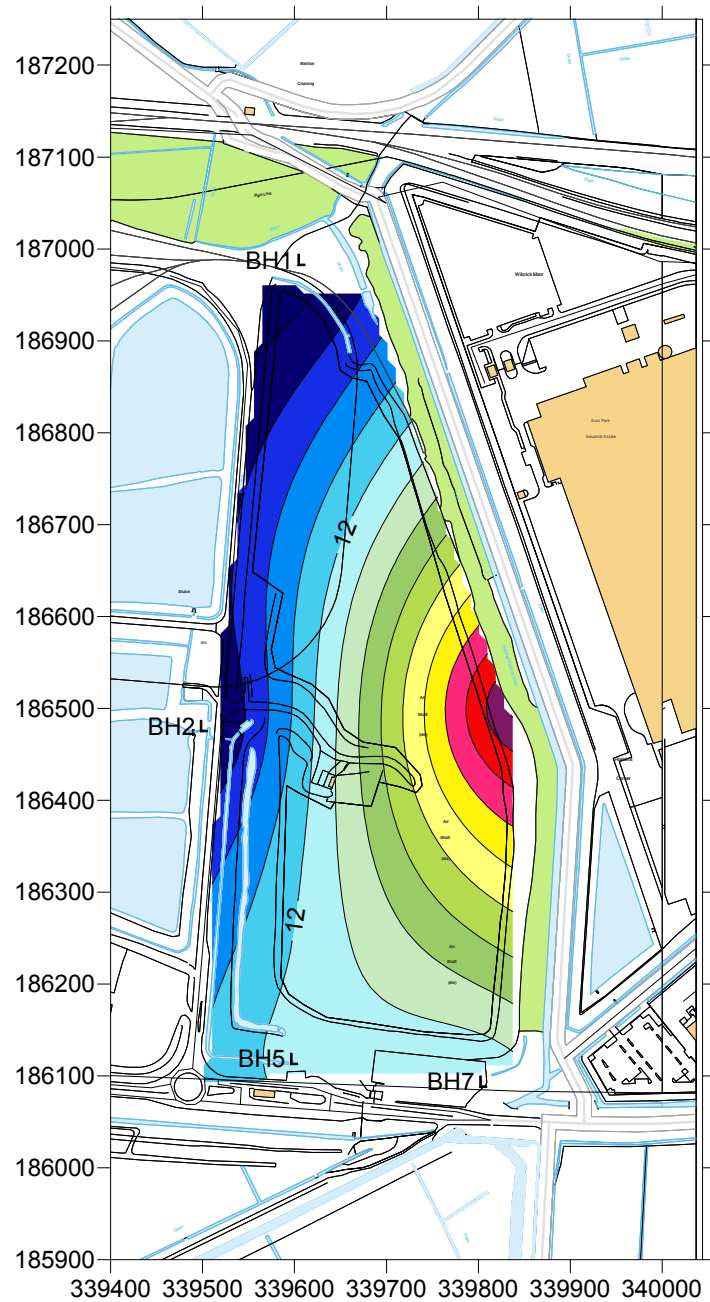
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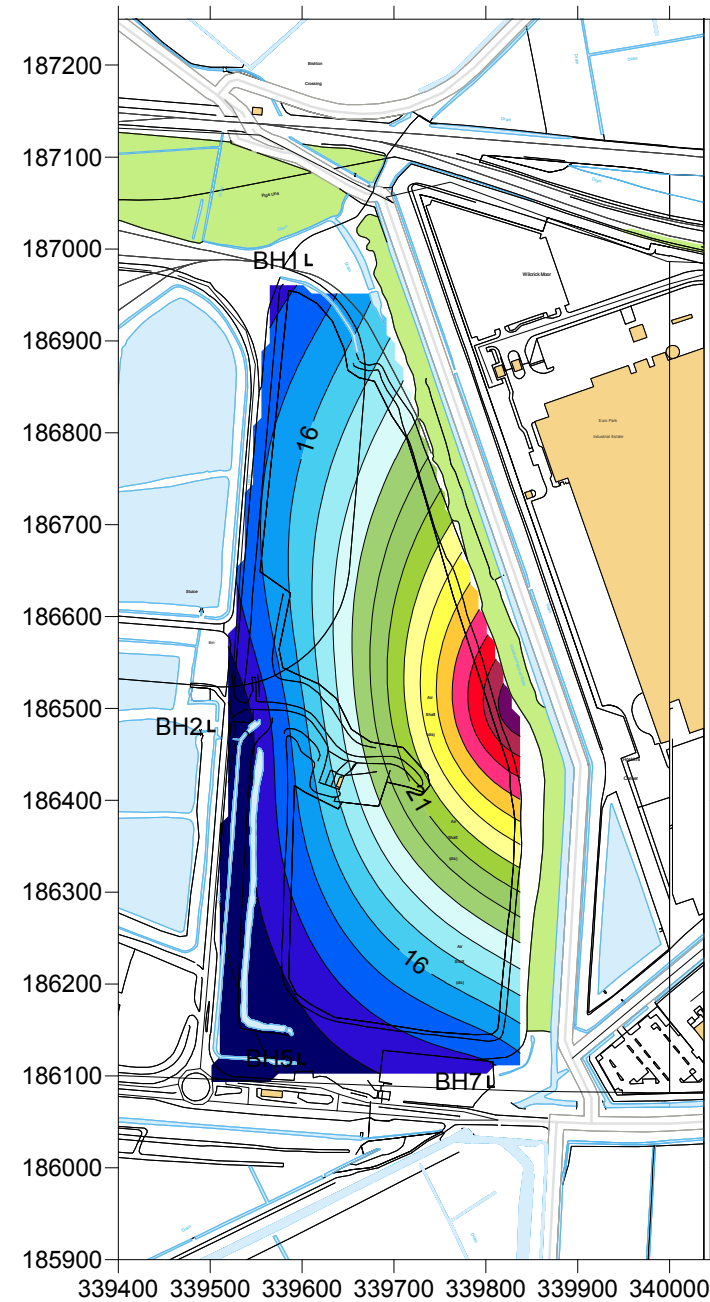
Chloride in Shallow Groundwater April 2016



Chloride in Deep Groundwater April 2016

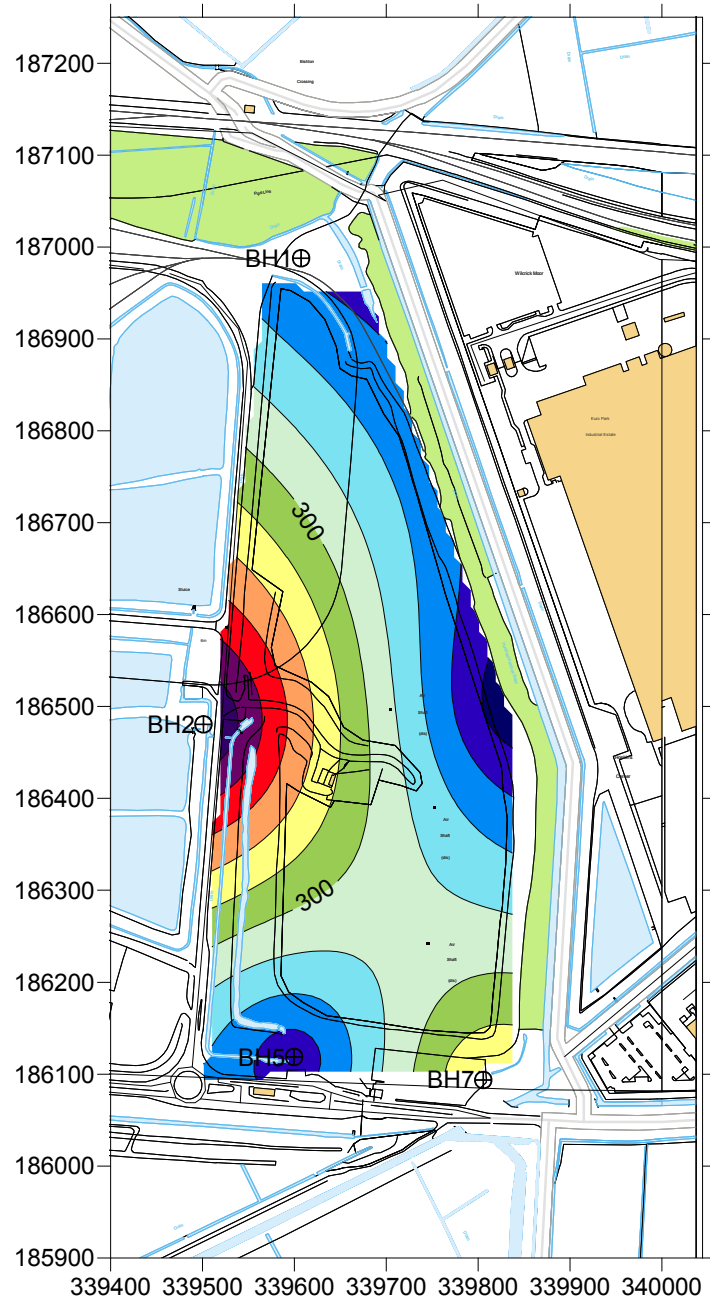


Ammonia in Shallow Groundwater April 2016

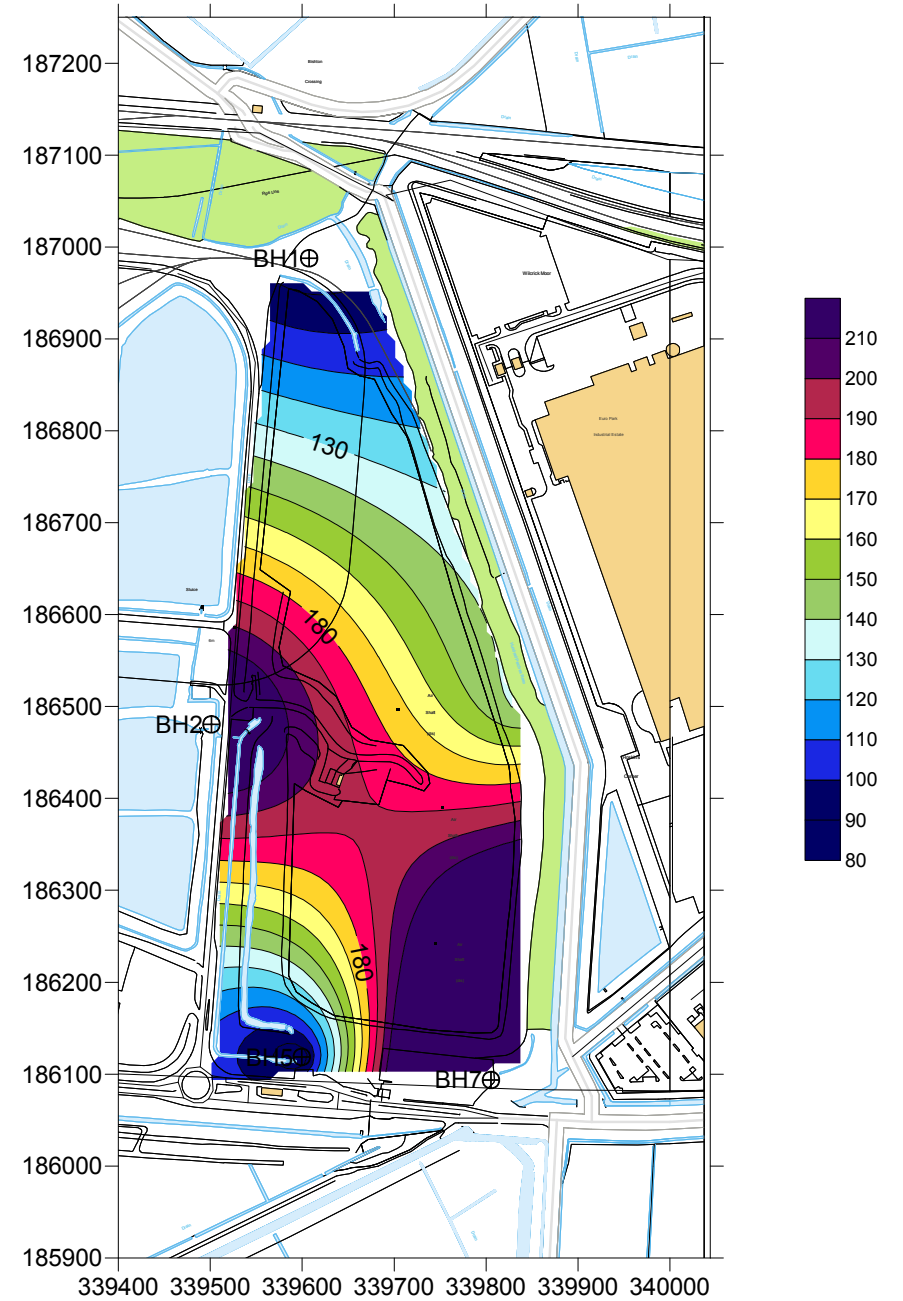


Ammonia in Deep Groundwater April 2016

# Calcium in Groundwater September 2017 (mg/l)

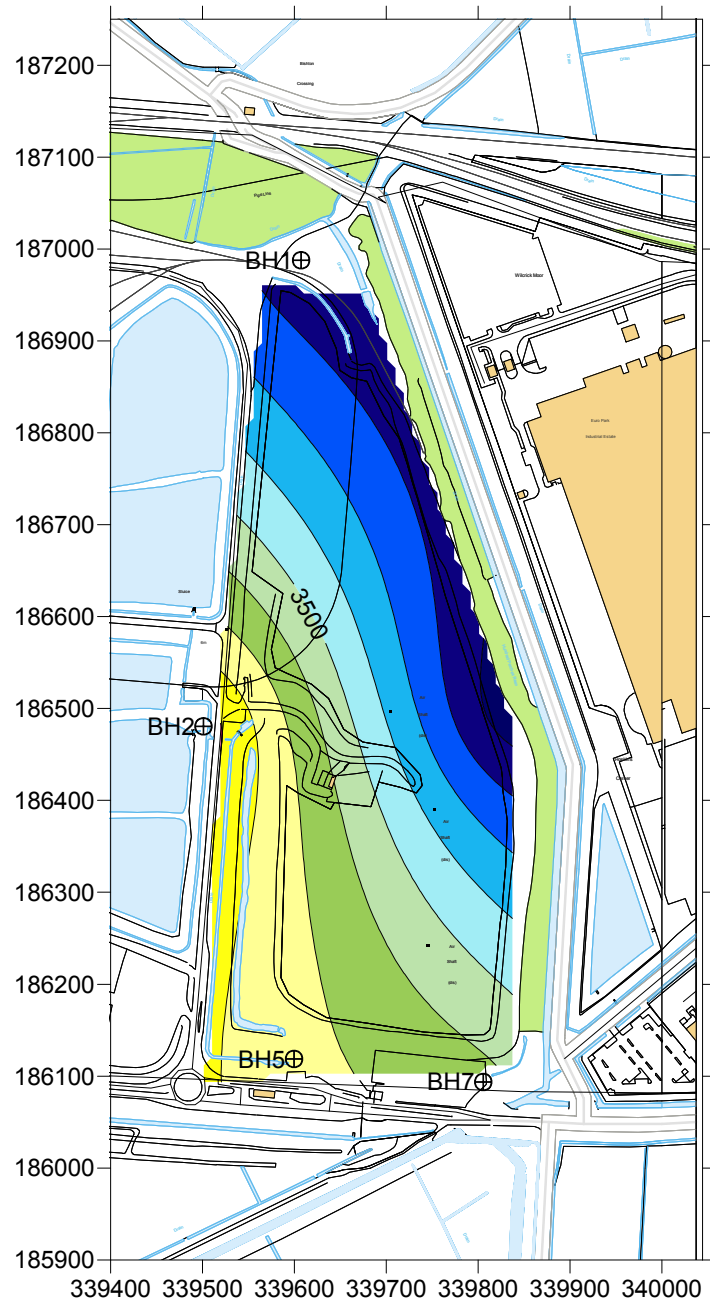


Calcium in Shallow Groundwater

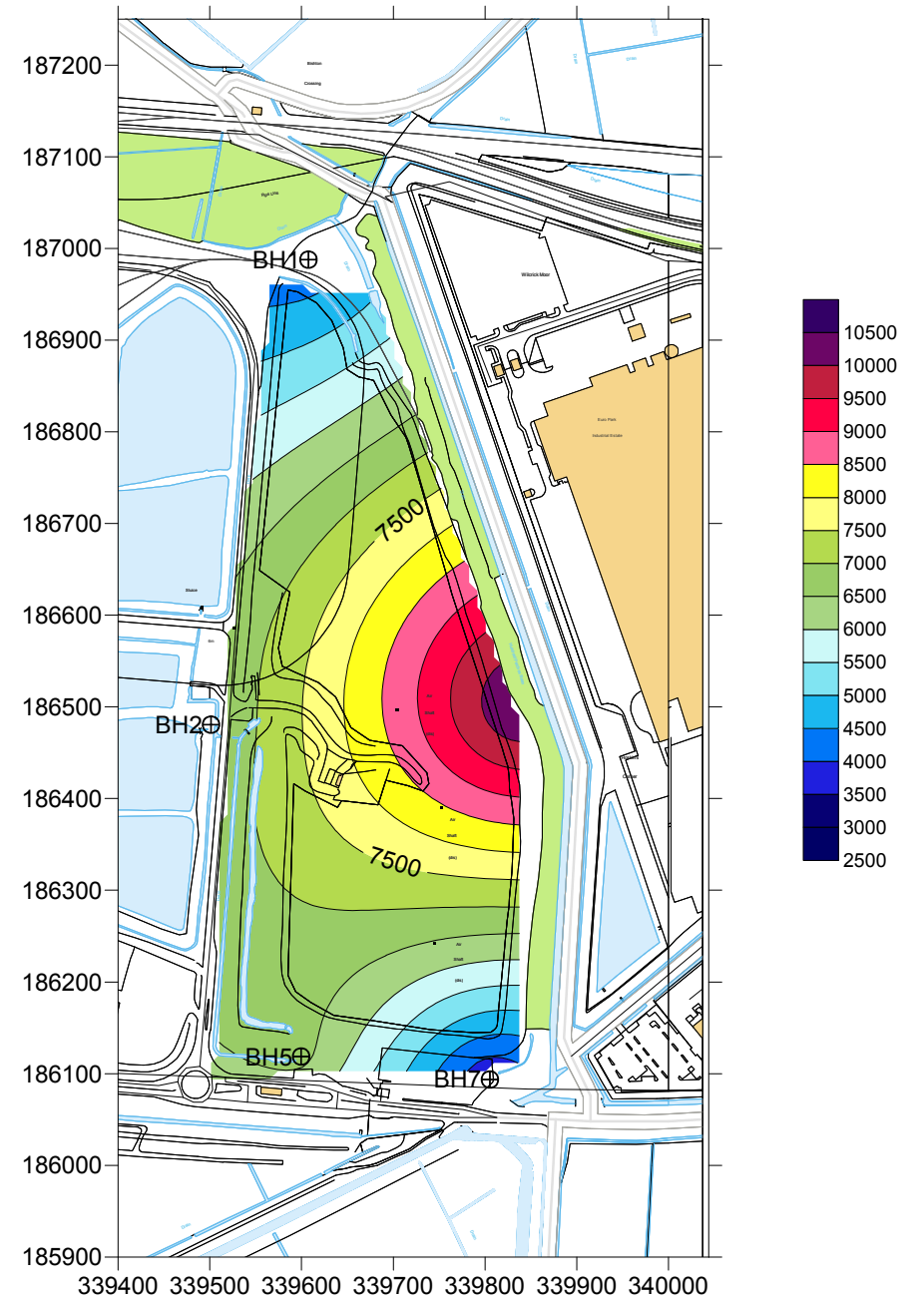


Calcium in Deep Groundwater

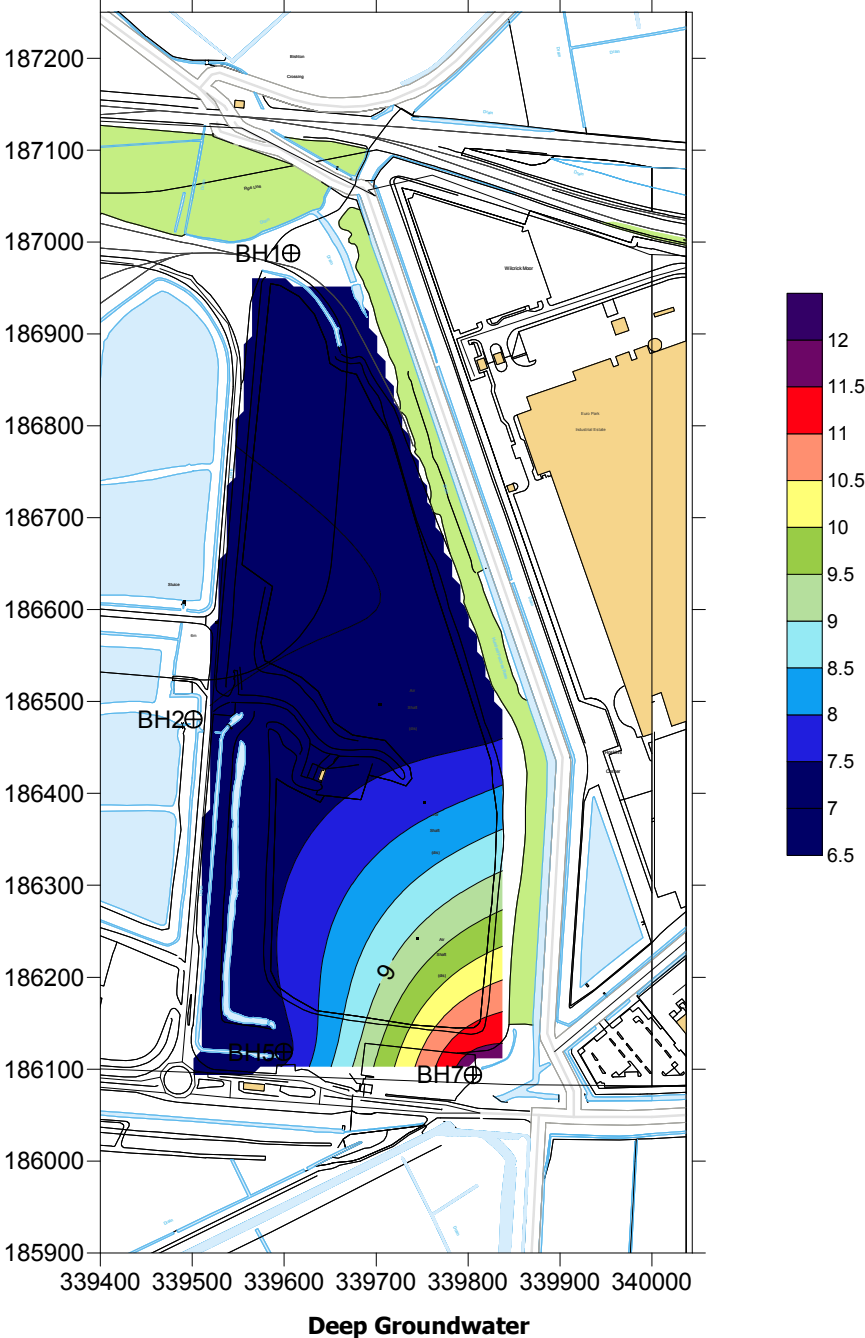
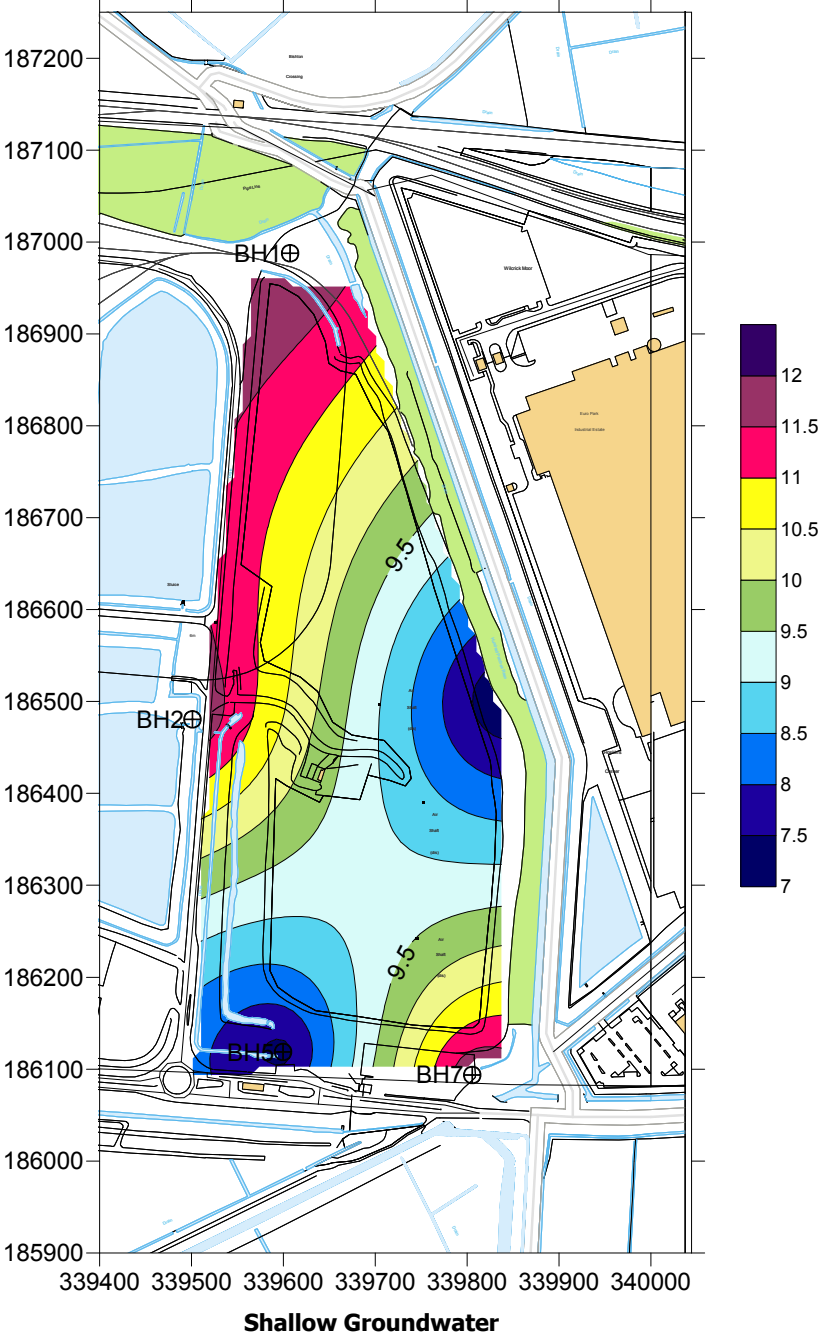
# Electrical Conductivity in Groundwater September 2017 (microS/cm)

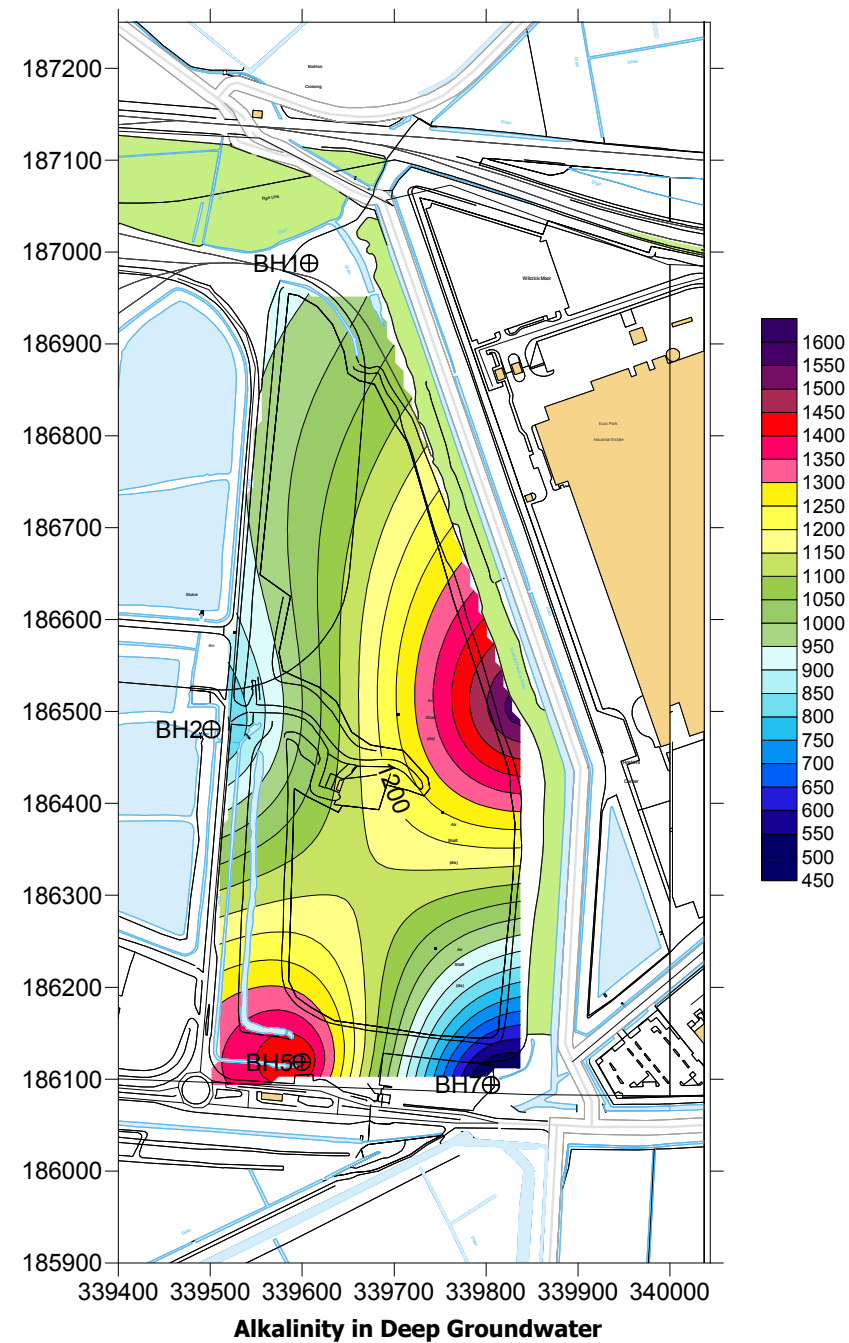
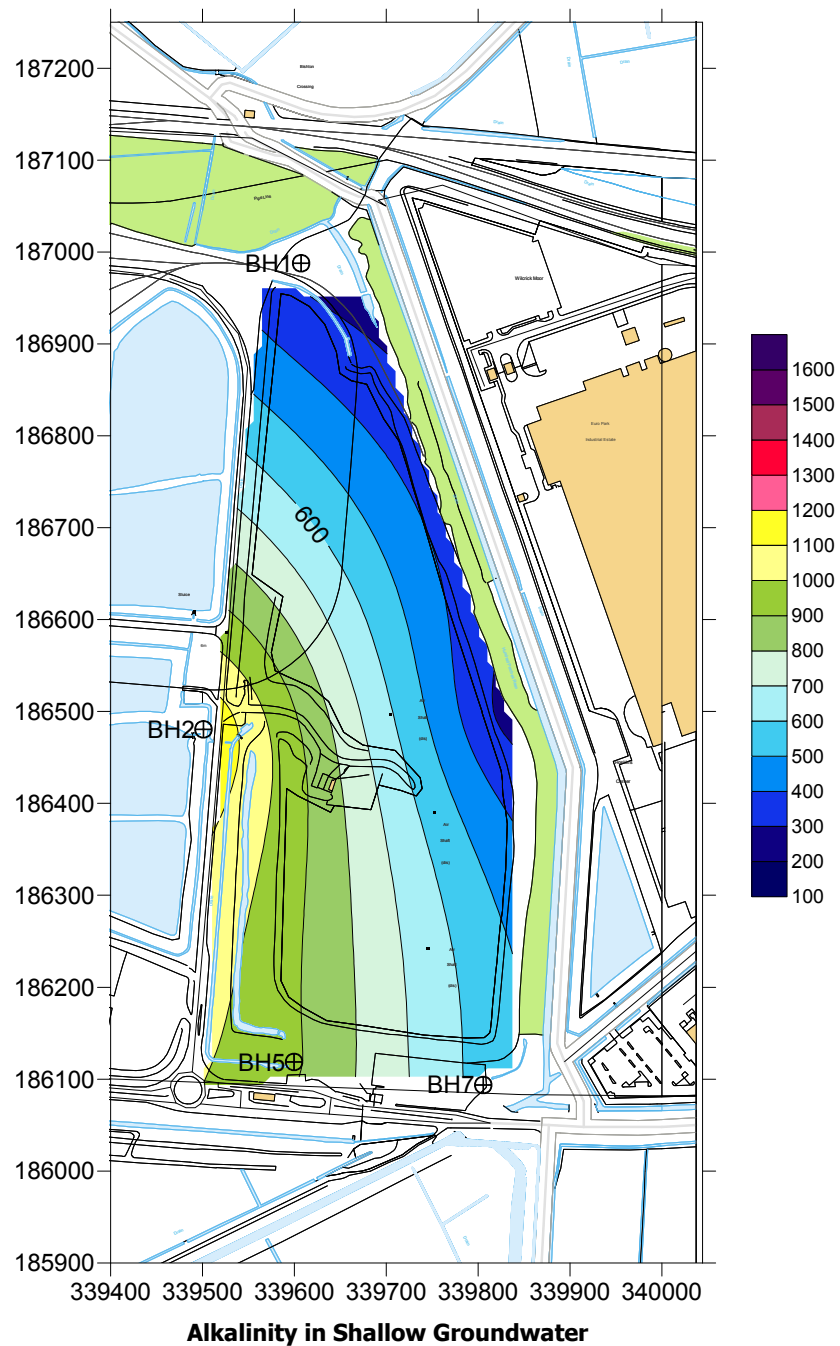


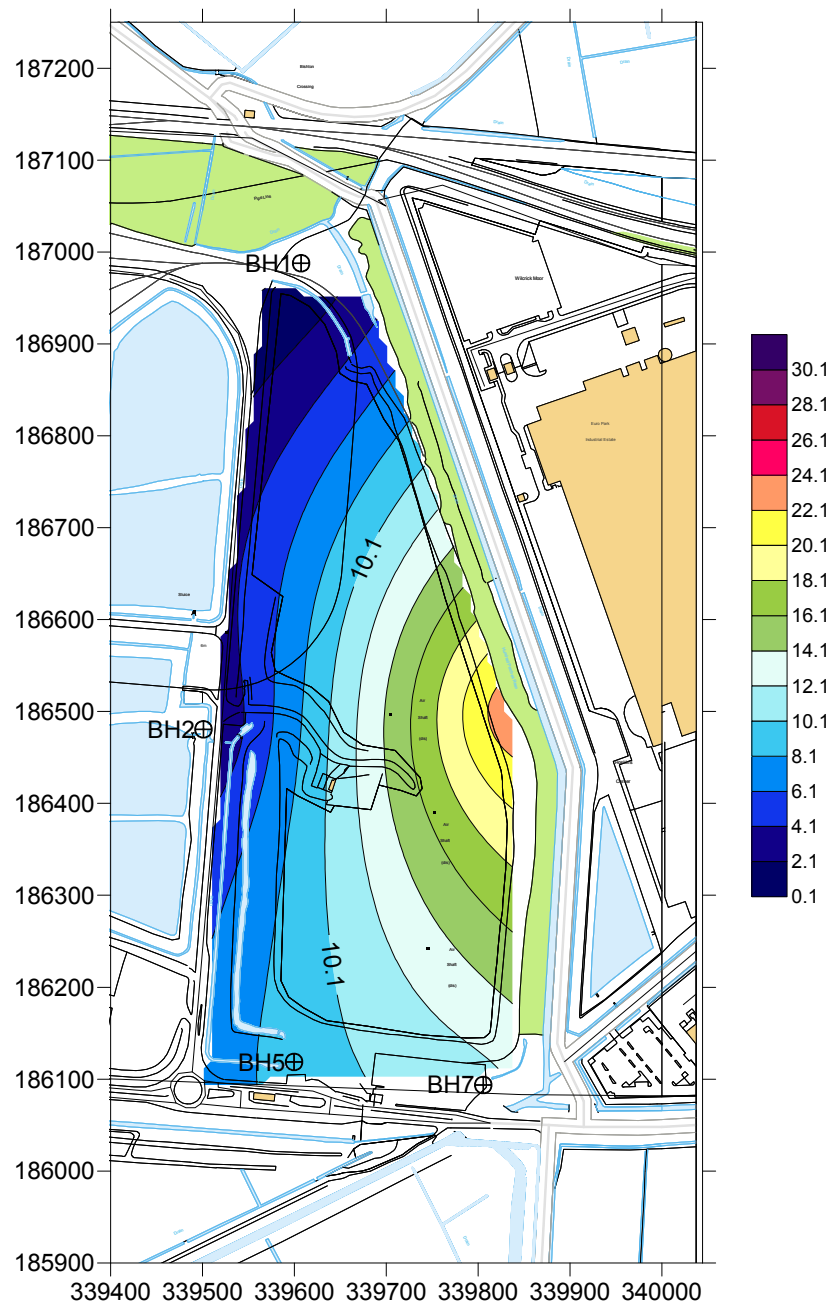
**Electrical Conductivity in  
Shallow Groundwater**



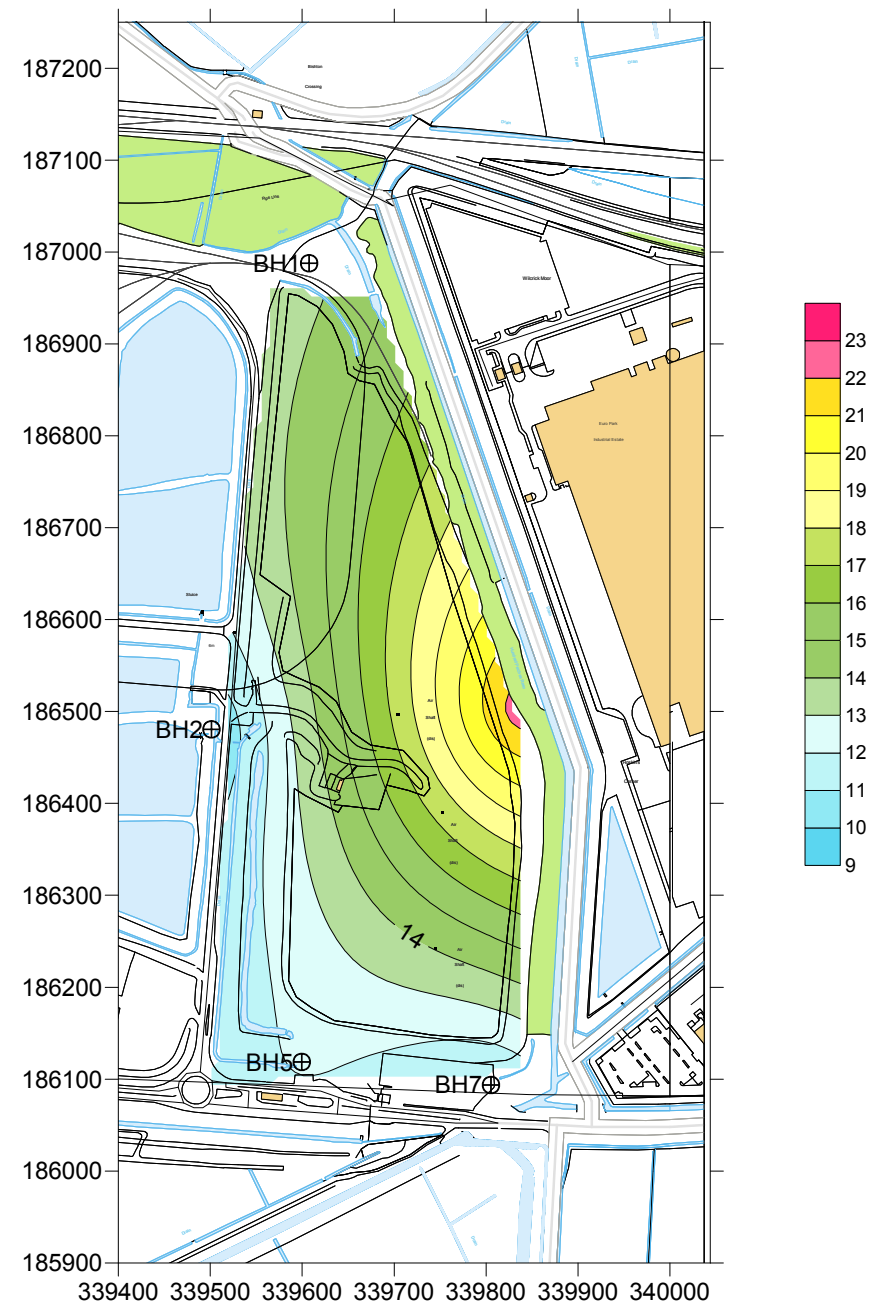
**Electrical Conductivity in  
Deep Groundwater**



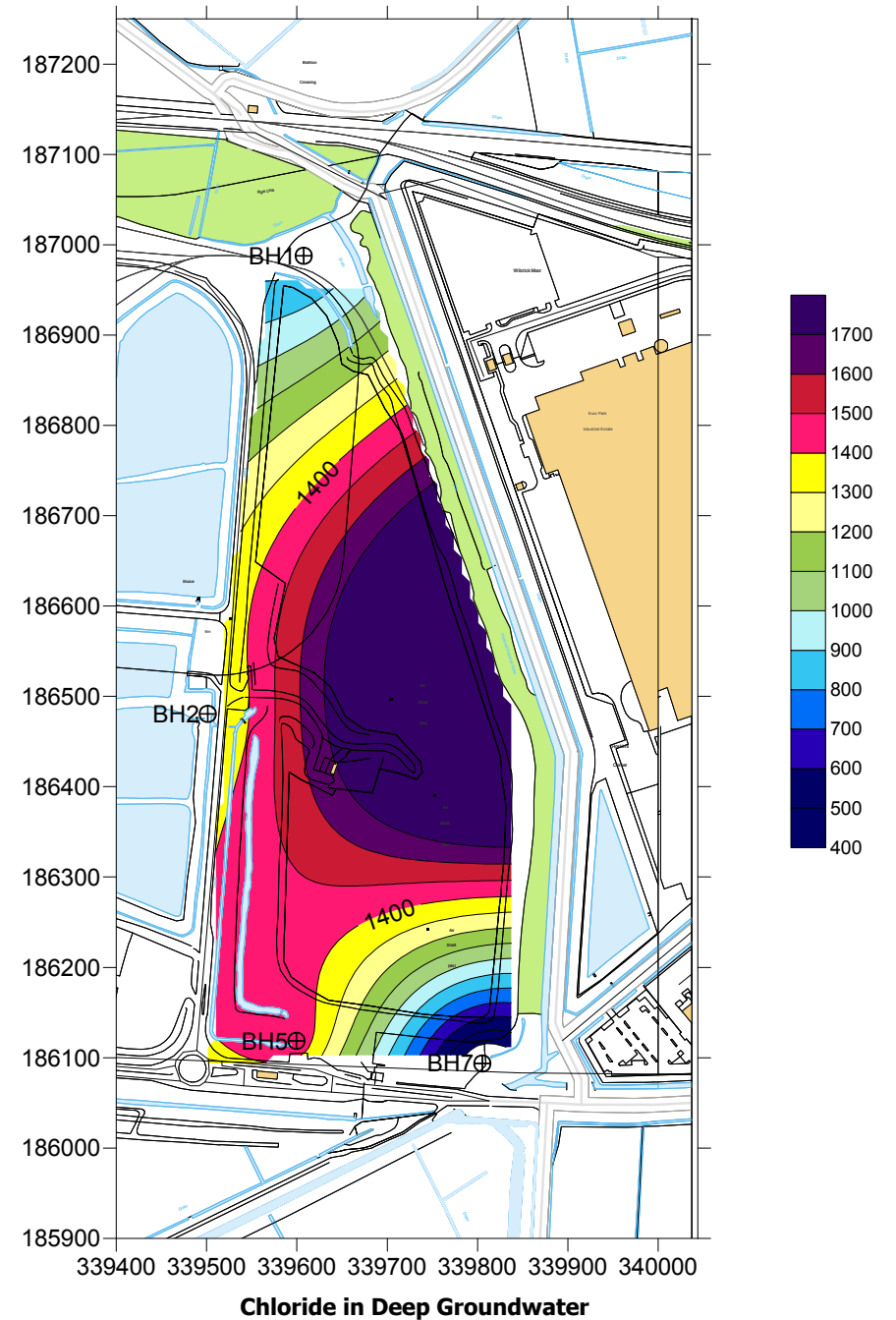
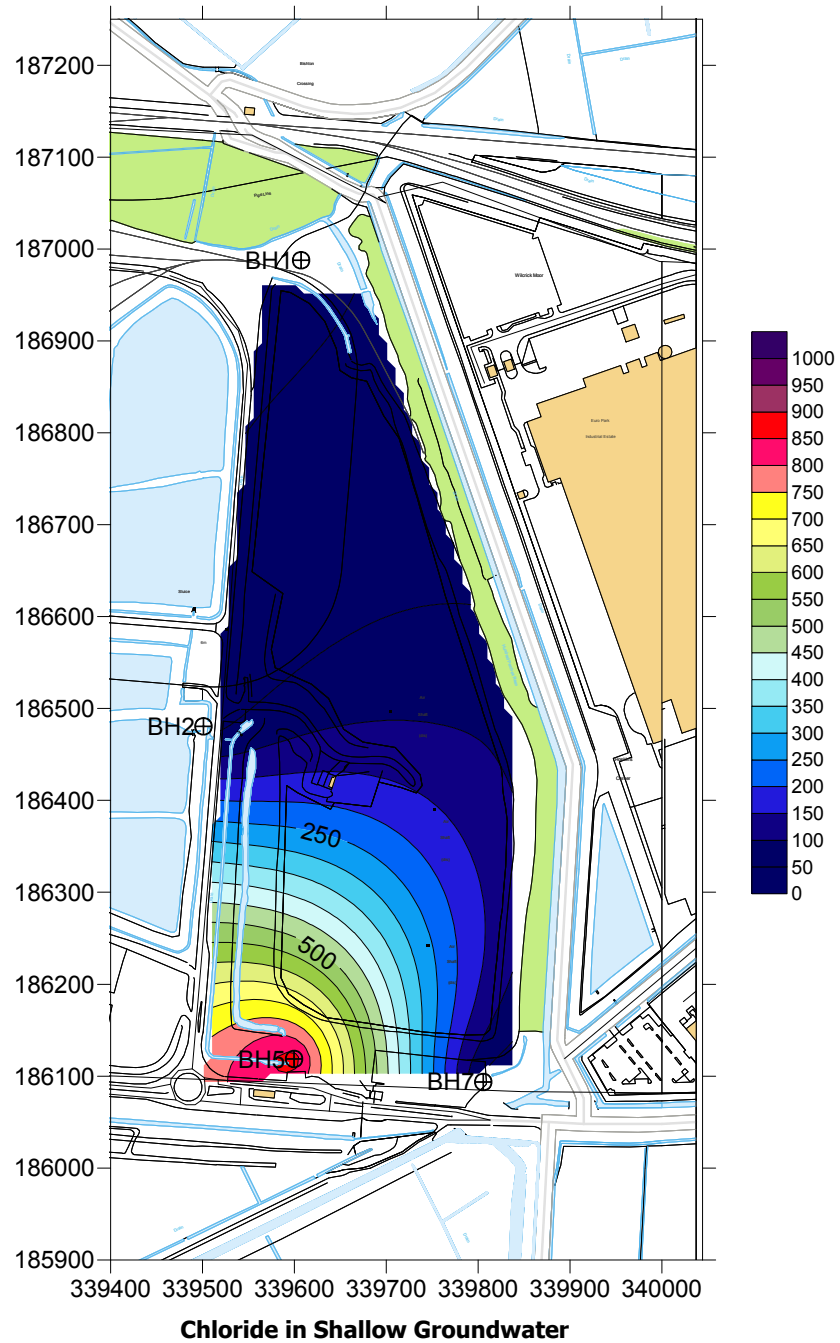


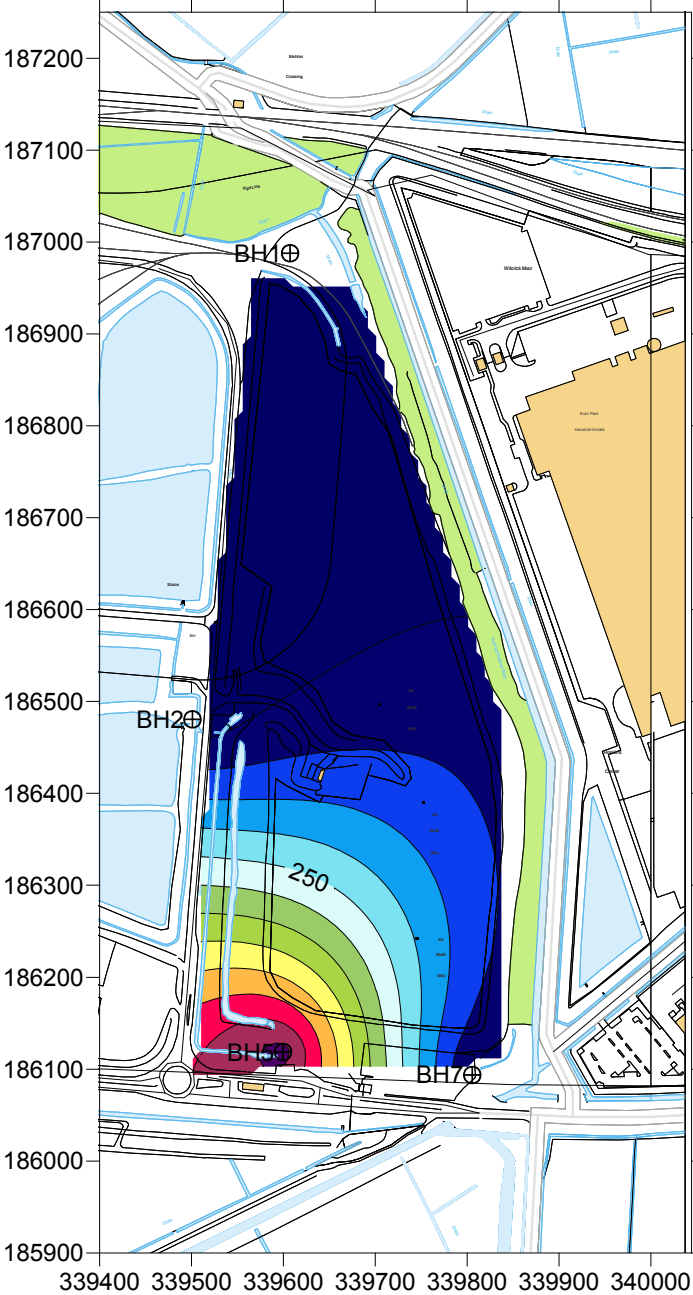


Ammonia in Shallow Groundwater September 2017

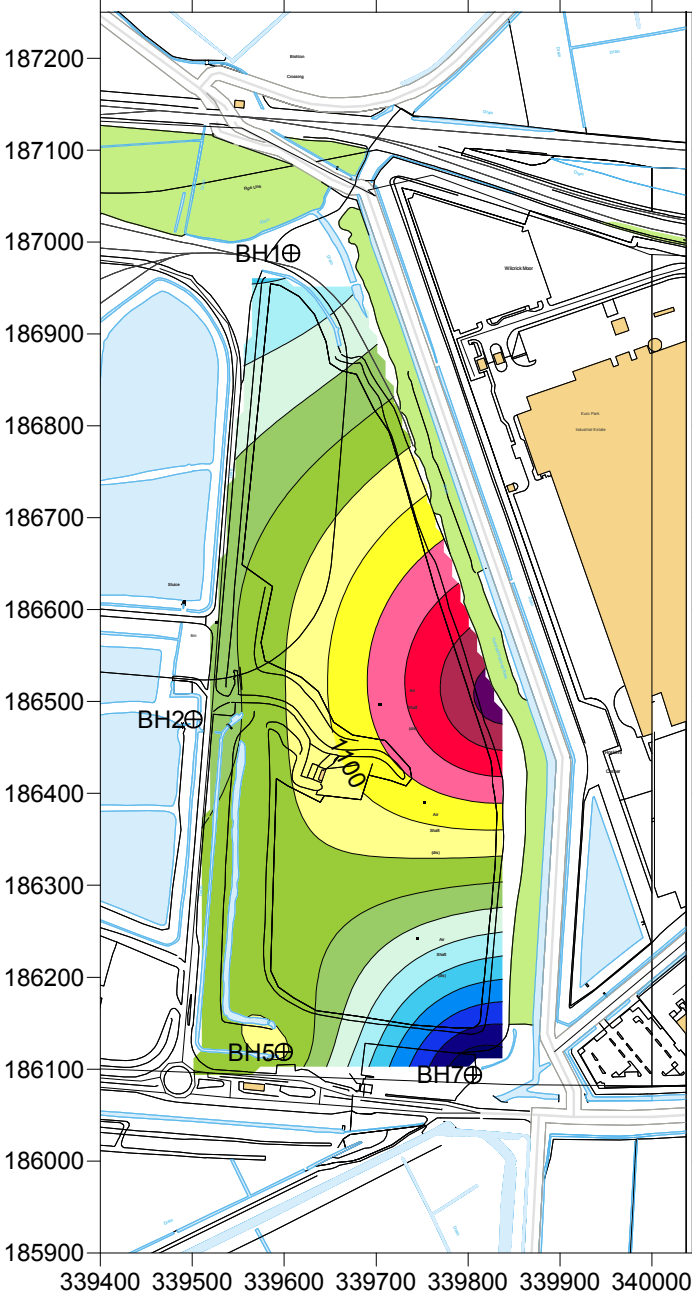


Ammonia in Deep Groundwater Sept 2017





Shallow Groundwater



Deep Groundwater

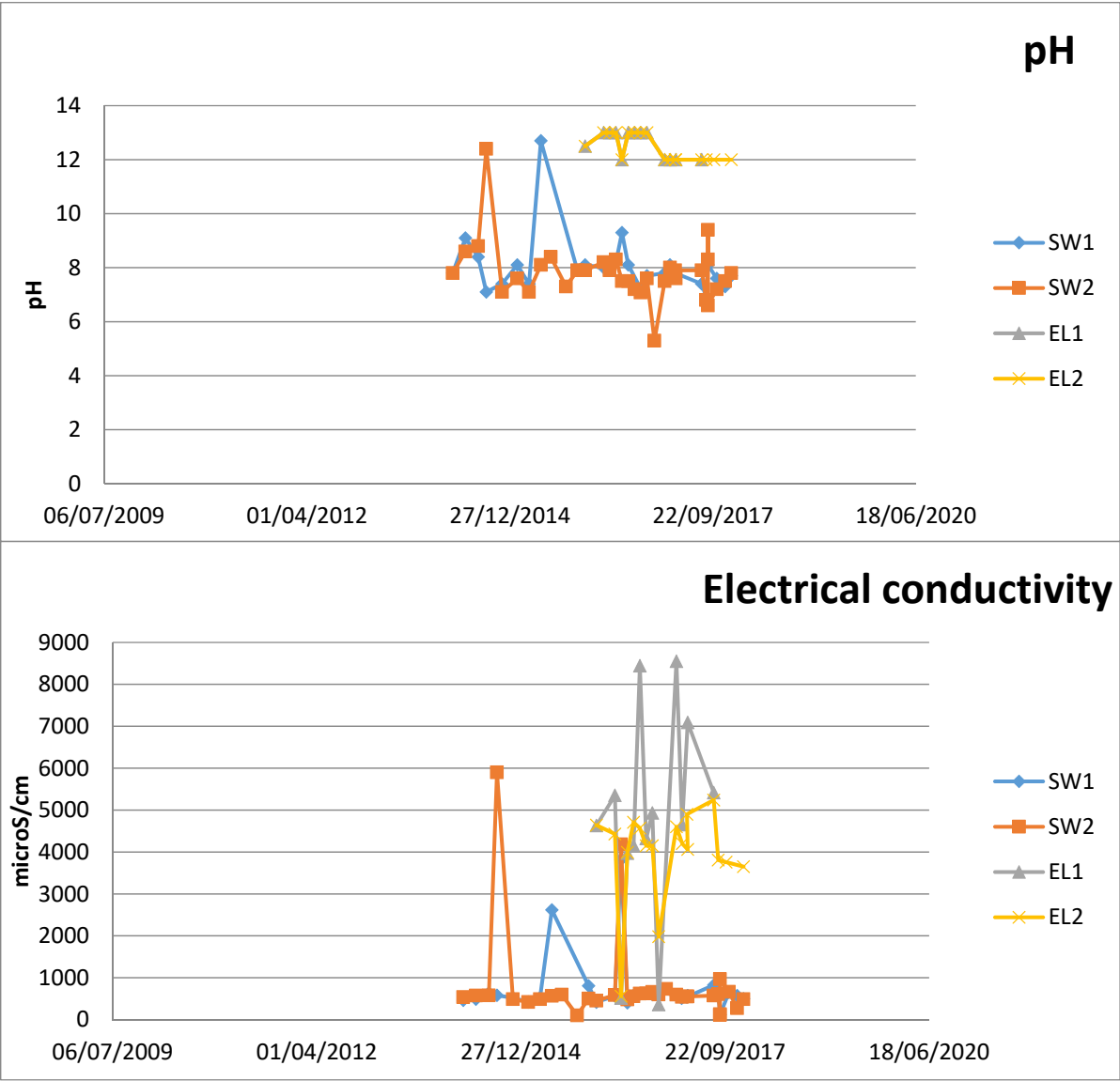
**EAST WASTE  
MANAGEMENT SITE,  
LLANWERN STEELWORKS**

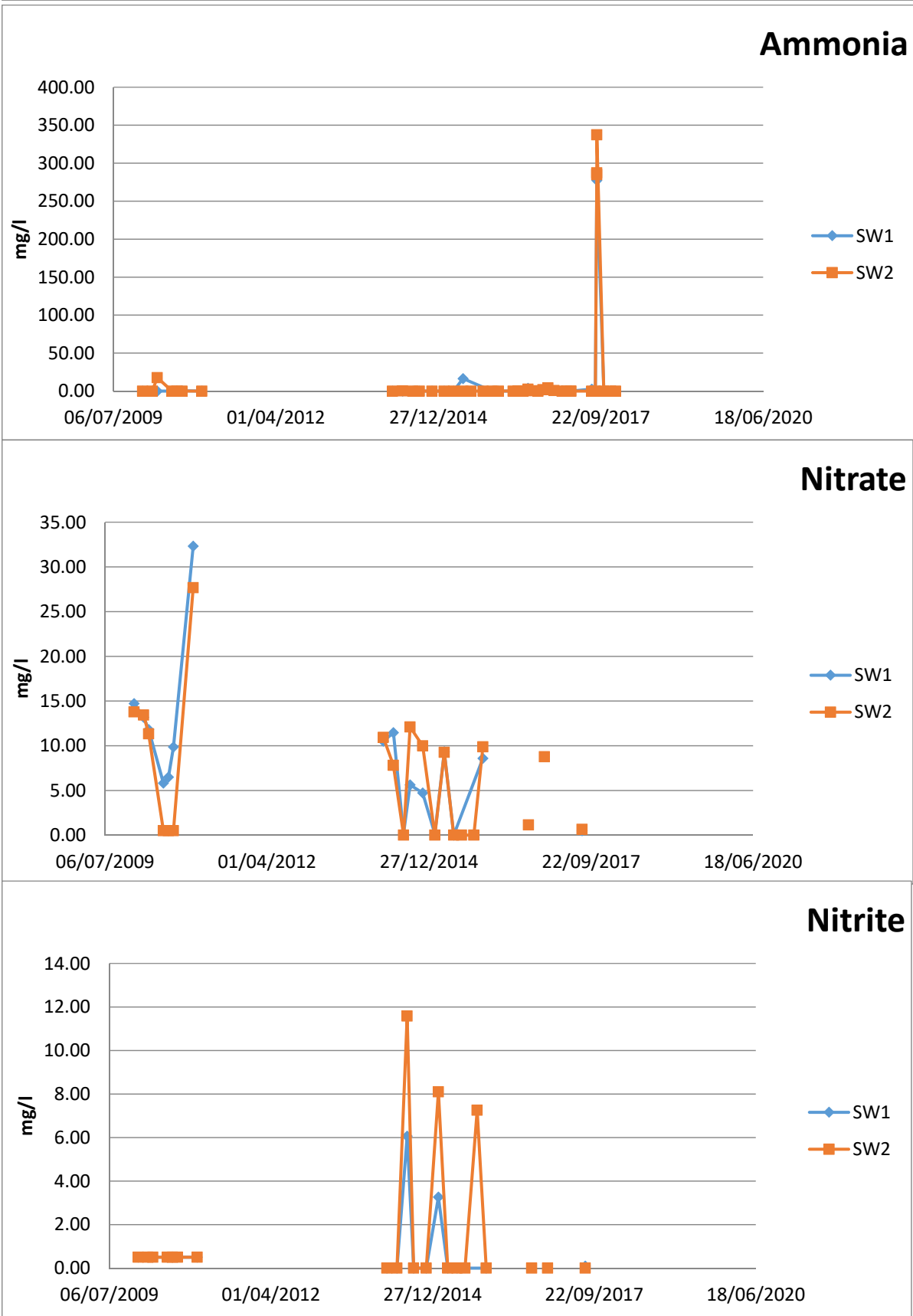
**PERMIT EAWML/30003**

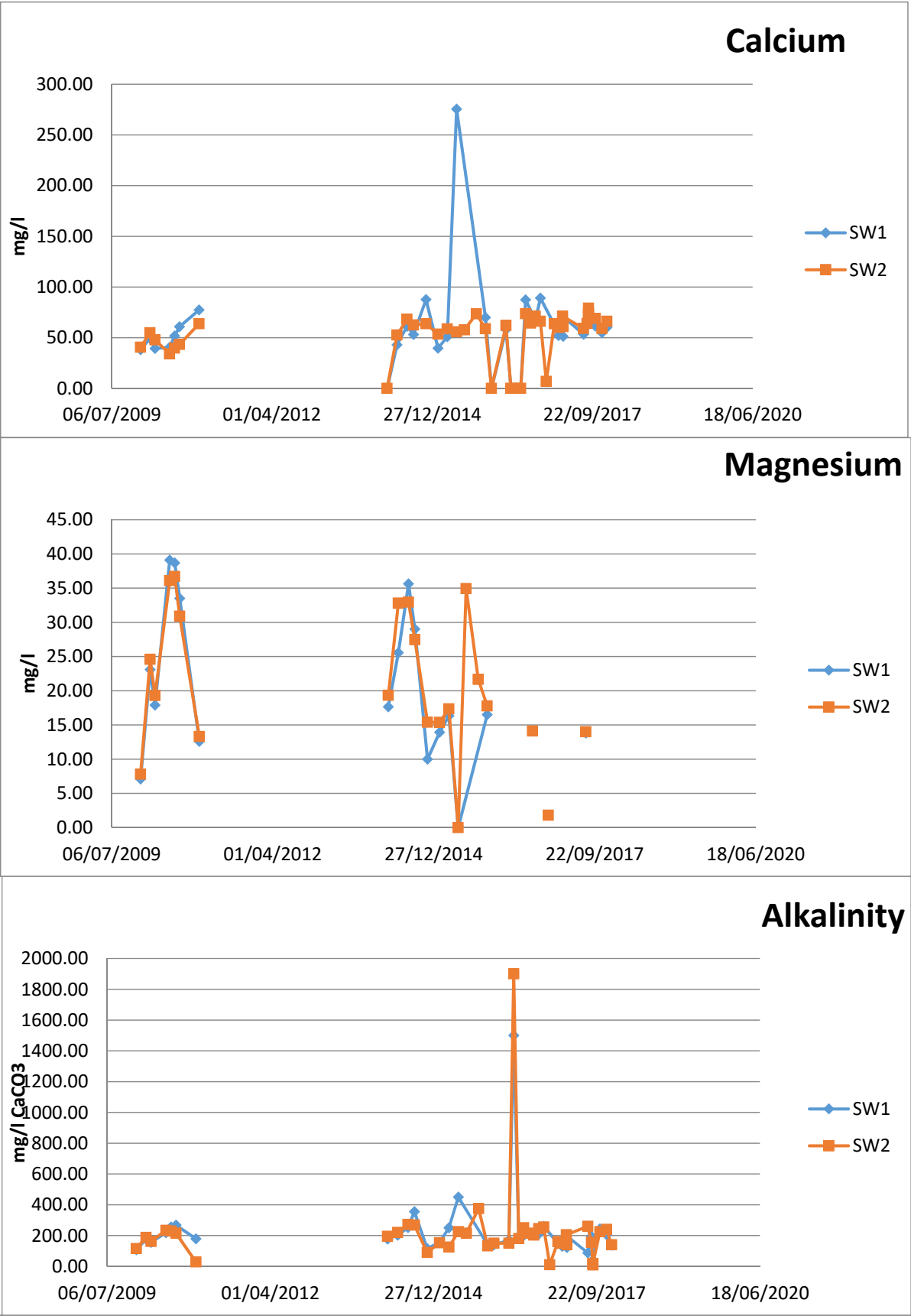
**2017 Annual Review of  
Environmental  
Monitoring**

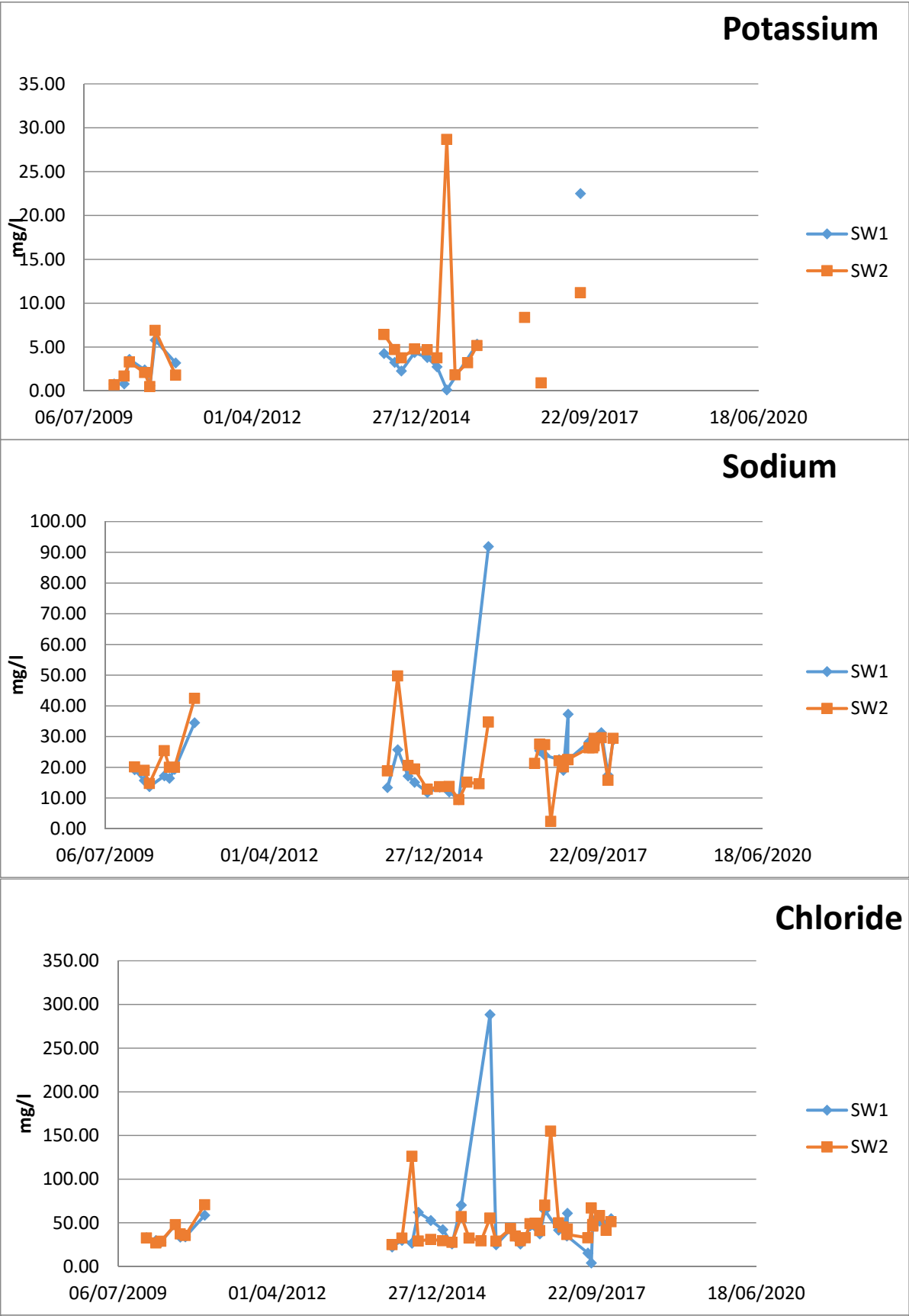
**Appendix 2  
Surface Water  
Chemistry**

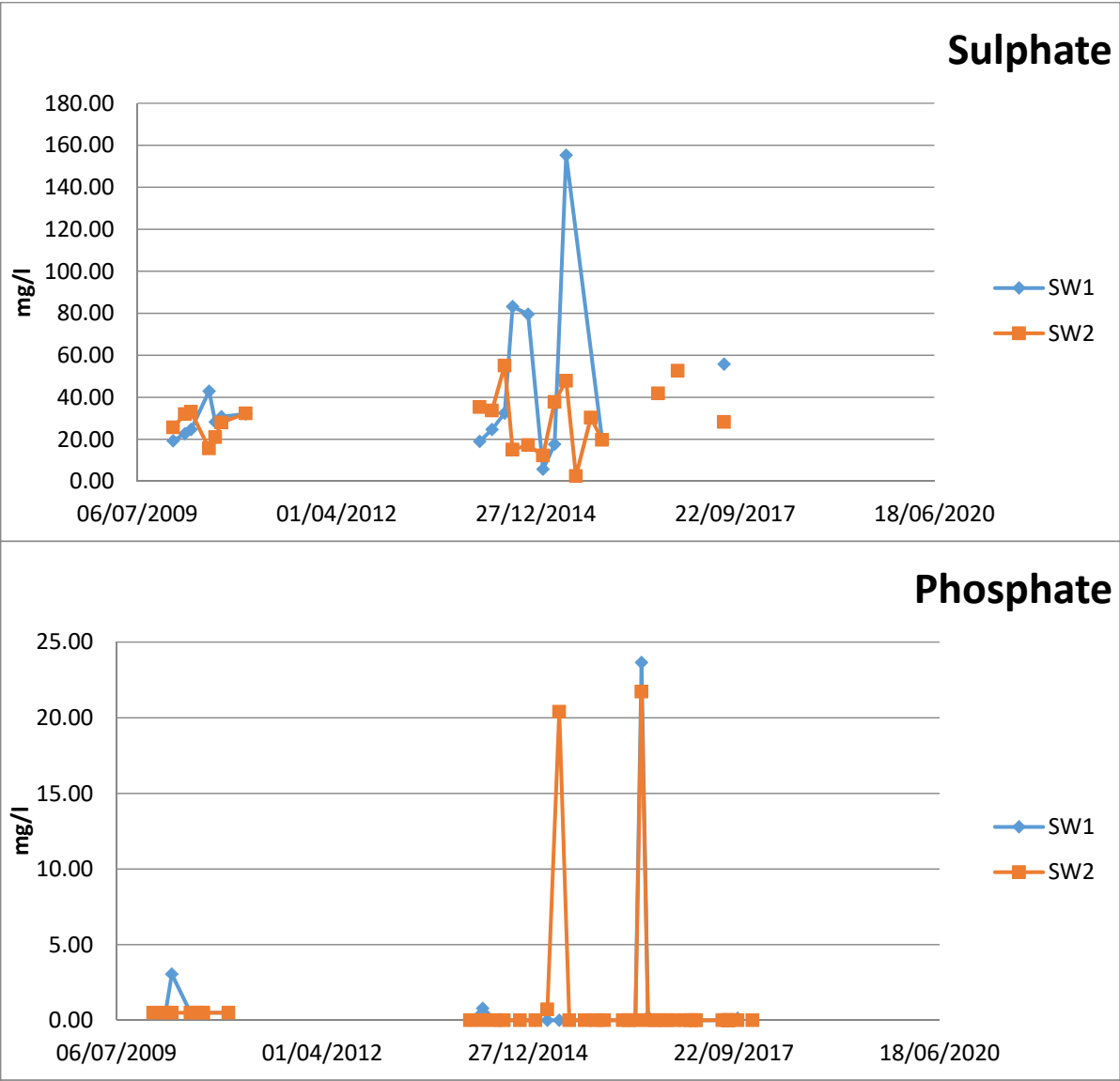
*Report Number 1680r1v1d0218*

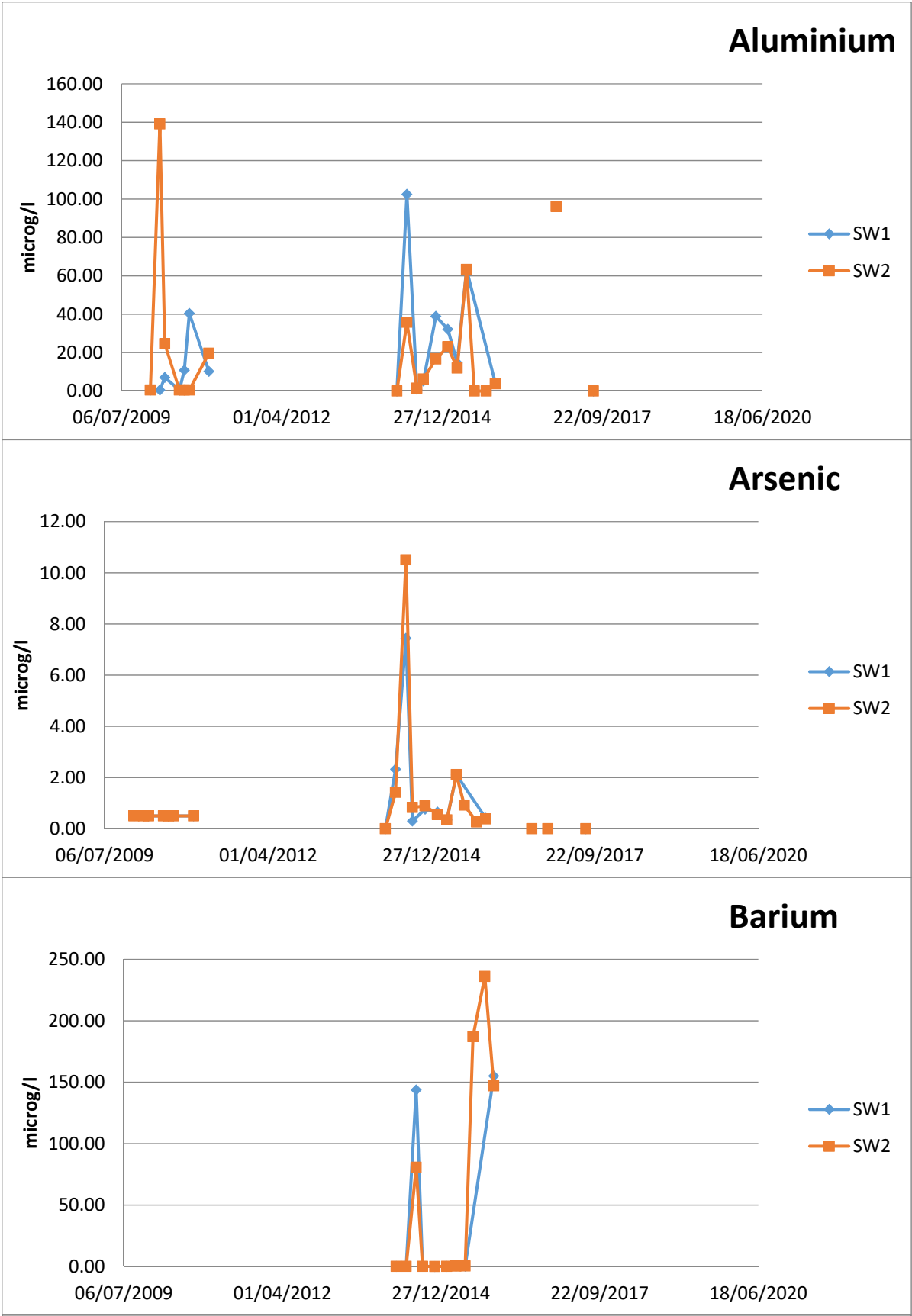


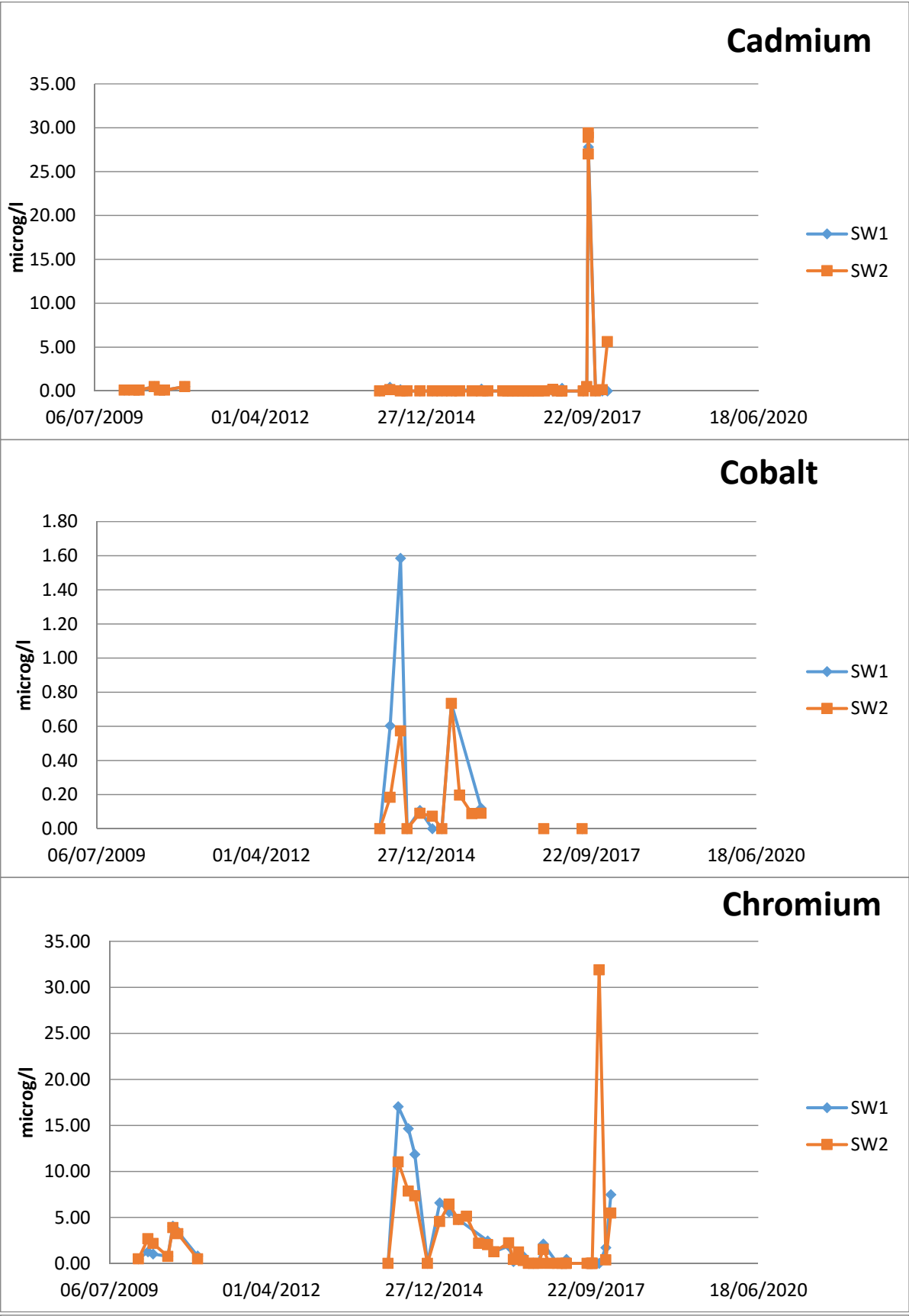


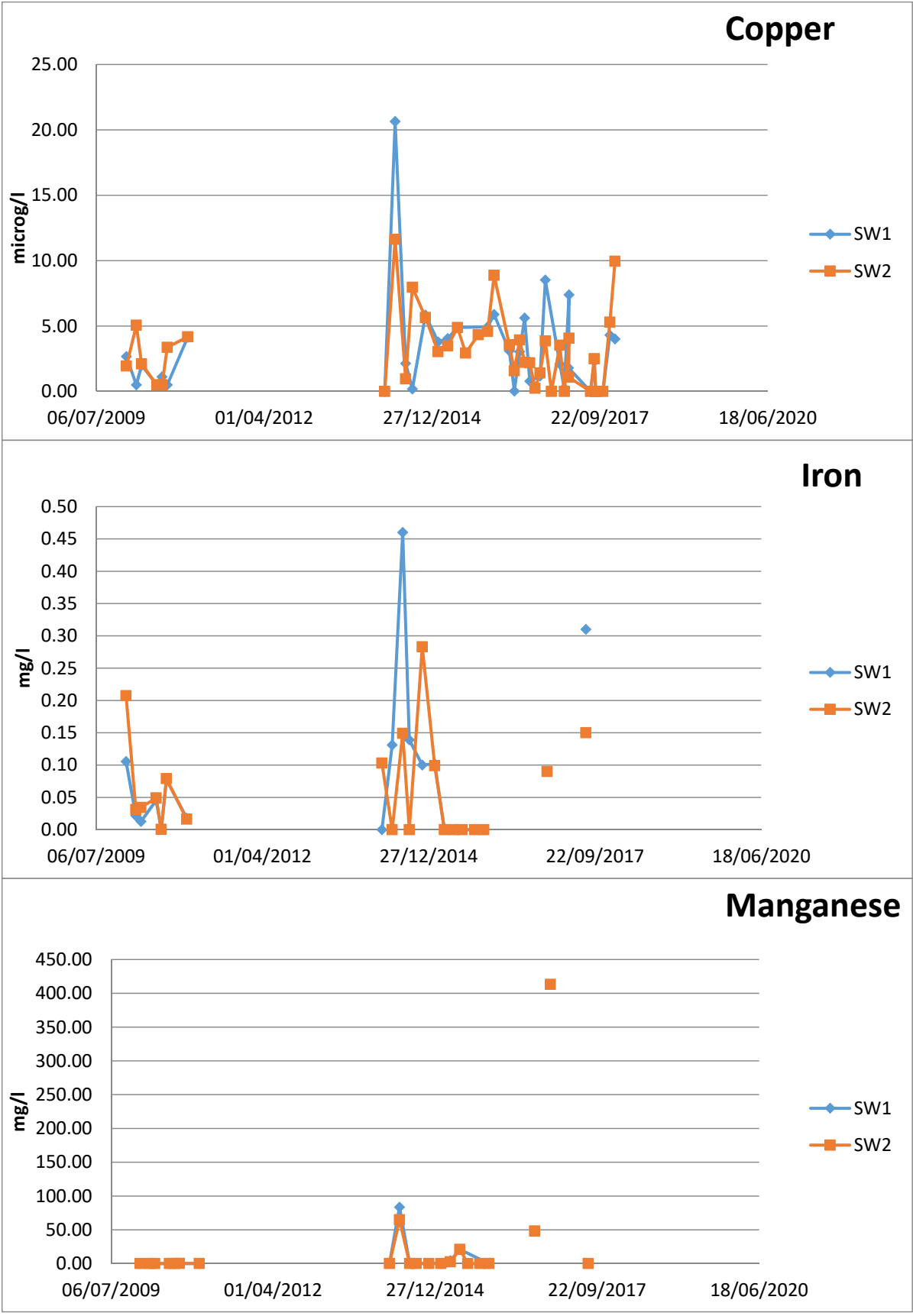


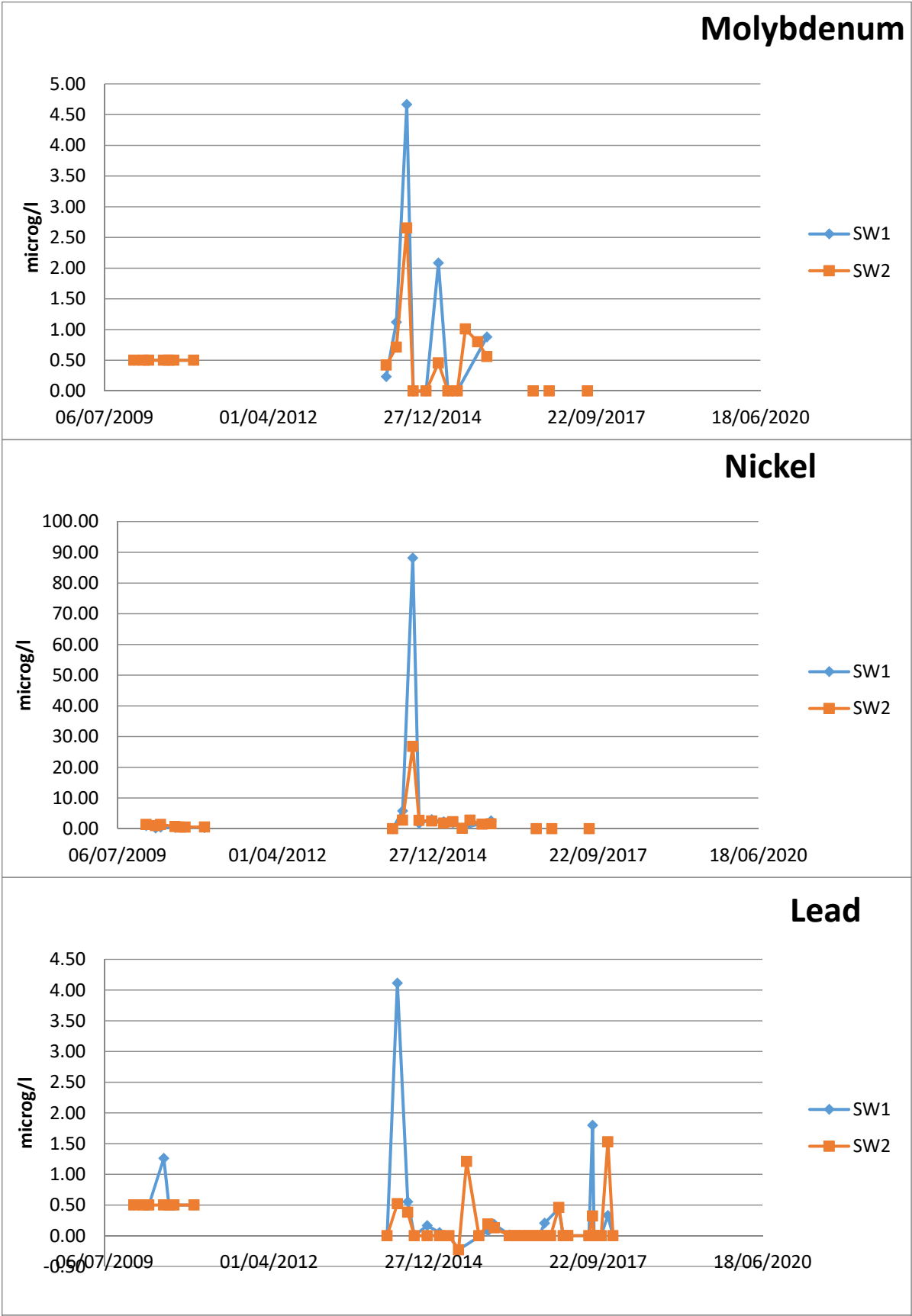


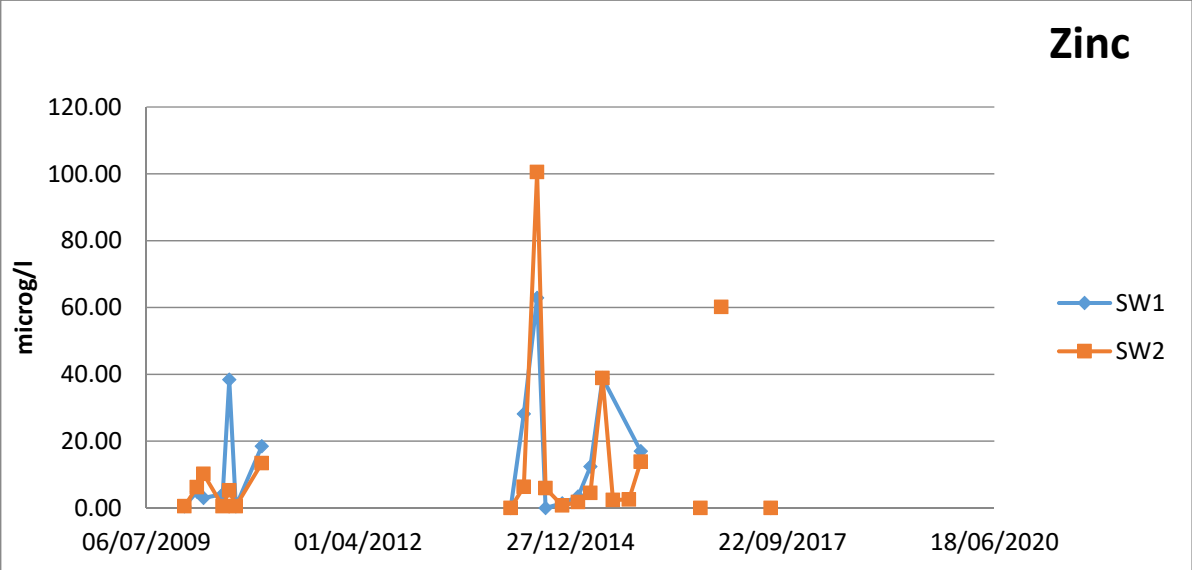
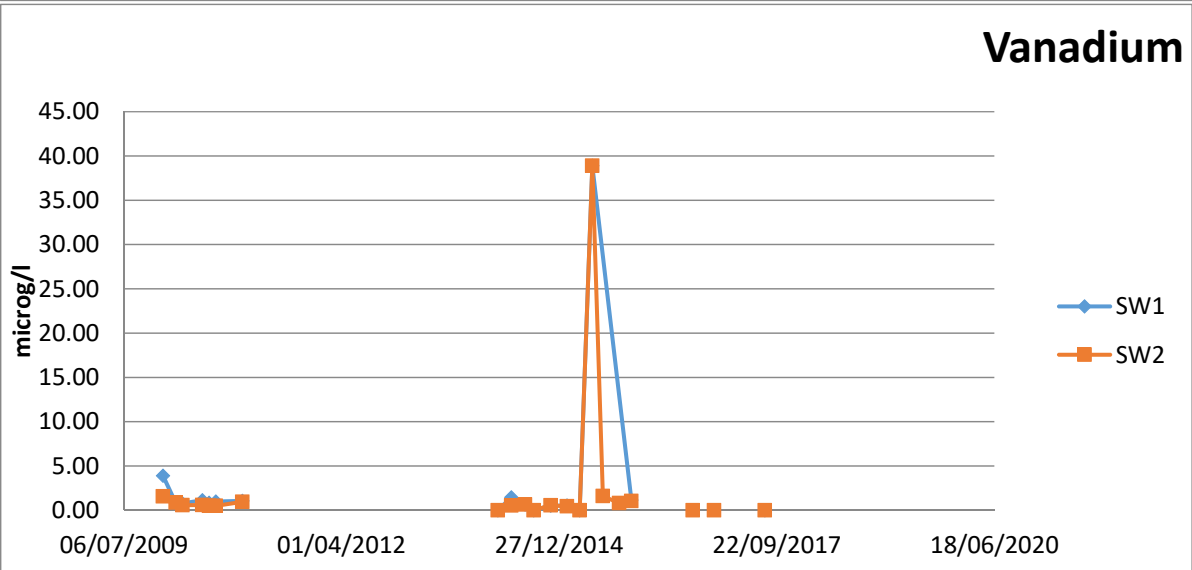
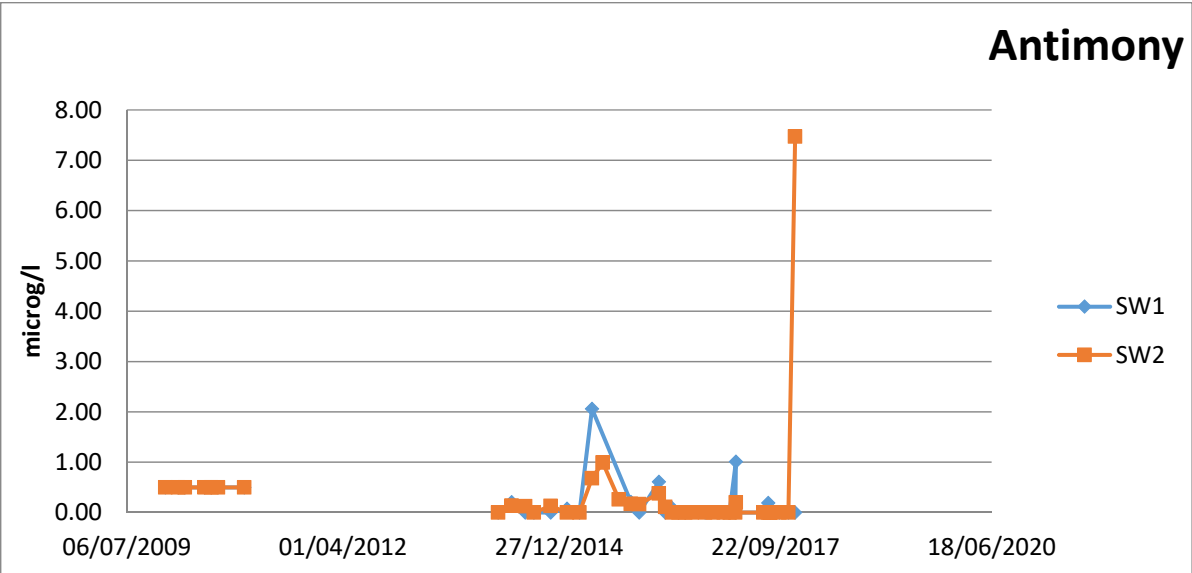














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