EAST WASTE MANAGEMENT SITE, LLANWERN STEELWORKS

PERMIT EAWML/30003

2014 Annual Review of Environmental Monitoring

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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 recently been observed and as this poses a direct risk to surface water quality, the root cause should be identified and remediated.

Suggestions are made to reduce the current monitoring frequency so that it is more closely aligned with the Aftercare Management Plan. These changes primarily involve reducing the monitoring frequency from bi-monthly to quarterly for groundwater but implementing monthly surface water monitoring.

1 INTRODUCTION

Llanwern East Waste Management Site (LEWMS) is a land raise occupying an area of some 200,000m^2 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.

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).

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 ST 397 864, as shown on Figure 1 and Figure 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^2 (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

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 which are scheduled for completion in 2018 having started in January 2015.

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 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. The latter is subject to ensuring that Japanese Knotweed is not present within the compost.

Tata are aware that the LEWMS landfill could contain volumes of recoverable materials, especially slag. It is proposed that some recovery of materials will occur during the restoration process. It is intended that the recovery process will be relatively minimal and will be led by the requirement for the acquisition of materials for the restoration process itself i.e. slag dust and aggregates.

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.

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, lies 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 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 3.9×10^{-10}, 4.2×10^{-10} and 9.2×10^{-10} 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.

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 x 10^{-6} to 4.83 x 10^{-7} ms^{-1} with an average of 2 x 10^{-6} ms^{-1}.

In every borehole a second, lower clay layer was previously encountered beneath the peat horizon. Samples of the clay has 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 x 10^{-5} 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 x 10^{-6} to 2.9 x 10^{-4}, with an average of 1.3 x 10^{-4} 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, reduced 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 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 considered 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, the groundwater monitoring programme described in this report 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.

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 reen system to the east. However, to ensure that the situation is monitored two sample points have been identified upstream and downstream of the landfill.

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^3/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^3/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.

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, with the key information summarised in Tables 4-1 to 4-4. At this stage, Tata is undertaking slightly more frequent monitoring than is suggested in the AMP to develop a current dataset and other aspects are not yet fully implemented.

Table 4-1 Monitoring Summary Table

Monitoring Parameter	Monitoring Location	Purpose	Type of Monitoring Point	Monitoring Point Reference
Leachate	In ditches on SE, N and W sides of landfill	Leachate quality	Pre-formed open ditch	L1 and L2
Groundwater	Groundwater at boundary of landfill, with concentration to the hydraulically down gradient side - S	Quality and level to be monitored Assurance that no List I substances are being discharged to groundwater	50mm diameter piezometer wells	BH1 to BH7 inclusive
Surface water	Surface-water on eastern and southern side of site	Impact on surface water quality on water courses in surrounding reens	Surface water body comprising reens	SW1 and SW2
Gas	Internally within the landfill	Assess the generation of any gas within the waste mass	Gas Well / Vent – gas tap on side	GM1, GM2 and GM3
Dust and Particulates	As required	Assess dust emissions during any earthworks/ soil importation	Dust gauges as required	Referenced in number and chronological order.
Odour	As required	Assess odour in response to complaint	Subjective assessment in particular area	Referenced in number and chronological order.
Meteorological Data	Site Offices	Weather Data	Proprietary weather station	N/a
Settlement	Landfill surface and embankments	Assess Waste Settlement	Topographic survey	Annual Topographic Survey

Table 4-2 Parameters to be Monitored in Leachate, Surface water and Groundwater

Determinant	Chemical Symbol	Unit of Measurement	Minimum reporting Value (MRV)	Field (F) / Laboratory (L) Tested
Temperature	Temp.	C	+/- 1	F
pH	pH	pH units	+/- 0.1	F
Electrical Conductivity	EC	microS/cm	2	F
Dissolved Oxygen	DO	mg/l	+/- 1	F
Ammoniacal Nitrogen	NH4 –N	mg/l	0.5	L
Total Oxidised Nitrogen	TON	mg/l	0.05	L
Total Organic Carbon	TOC	mg/l	0.5	L
Aluminium	Al	mg/l	0.01	
Arsenic	As	ug/l	0.5	L
Antimony	Sb	ug/l		L
Boron	B	ug/l	0.05	L
Cadmium	Cd	ug/l	0.2	L
Chromate	CrO3	mg/l CrO3		L
Chromium (vi)	Cr	ug/l Cr	2.0	L
Copper	Cu	ug/l	2.0	L
Iron	Fe	ug/l	10.0	L
Lead	Pb	ug/l	5.0	L
Manganese	Mn	ug/l	1.0	L
Mercury	Hg	ug/l	0.05	L
Molybdenum	Mo	ug/l		L
Nickel	Ni	ug/l	5.0	L
Phosphorous	Po	Mg/l	0.1	L
Selenium	Se	ug/l		L
Silica	Si O2	mg/l I SiO2		L
Titanium	Ti	ug/l	0.5	L
Tin	Sn	ug/l	10.0	
Vanadium	V	ug/l	5.0	L
Zinc	Zn	ug/l	10.0	L
Calcium	Ca	mg/l	0.01	L
Magnesium	Mg	mg/l	0.0001	L
Sodium	Na	mg/l	0.01	L
Nitrate		mg/l N	0.40	L
Nitrite		mg/l N	0.08	L
Potassium	K	mg/l	0.01	L
Phosphate				L
Sulphate	SO4	mg/l	0.01	L
Total Alkalinity	Ca CO3	mg/l Ca CO3	10.0	L
Chloride	Cl	mg/l	4.0	L
Organohalogens (VOCs)	Org Voc	ug/l	As per Laboratory detectable limit for individual speciate – generally between 2.0 - 10.0	L
Semi VOCs	Semi Voc	ug/l	As per Laboratory detectable limit for individual speciate – generally between 2.0 - 10.0	L

Table 4-3 Monitoring Suites for Water

Measurement	Groundwater, Surface Water and Leachate Characterisation Suite	Groundwater, Surface Water and Leachate Indicator and Field Suite
Monitoring Positions	All surface water, groundwater and leachate monitoring locations	
Frequency/Duration/Start Time	Year 1: First 4 Months and then quarterly Year 2+:Bi-annually	Commences after first 12 months
Field Parameters		
Water Level	•	•
Temperature	•	•
pH	•	•
Electrical Conductivity	•	•
Dissolved Oxygen	•	•
Laboratory Parameters		
Ammoniacal Nitrogen	•	•
Total Oxidised Nitrogen	•	
Total Suspended Solids	• (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	•	

Table 4-4 Parameters to be Measured in Gas Surveys

Determinant	Symbol	Unit of Measurement	Minimum reporting Value (MRV)	Field/Laboratory Tested
Oxygen	O_2	% Vol	+/- 0.1%	F
Carbon Dioxide	CO_2	% Vol	+/- 0.1%	F
Methane	CH_4	% Vol	+/- 0.1%	F
Carbon Monoxide	C_O	ppm	1	F
Hydrogen Sulphide	H_2S	ppm	1	F
Atmospheric Barometric Pressure	AmB	mBar	1mBar	F

Following the completion of the first 12 months of monitoring, the AMP indicated that the analytical data would 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 would be reviewed annually.

4.2 Control and Trigger Levels

At this stage, Gepotechnology 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.

5 MONITORING PROGRAMME

5.1 Monitoring Completed

The full monitoring network available to Tata is shown in Figure 6 and summarised in Table 5-1. From this network the monitoring programme summarised in Table 5-2 was implemented during 2014.

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
SW1	Surface water	Surface water/Run-off	From water body itself	Hundred Perches Reen
SW2	Surface water	Surface water/Run-off	From water body itself	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				

Table 5-2 Current Monitoring Schedule

	Sampling Positions	Monitoring Frequency	Lab analysis
2014 Monitoring	Surface water at SW1 and SW2 Shallow and Deep groundwater at BH1, BH2, BH3, BH5, BH7	Bi-monthly	Characterisation suite

5.2 Integrity of Monitoring Infrastructure

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

5.2.1 Landfill Monitoring

Leachate monitoring currently comprises a walkover survey of the landfill edge, to examine for the presence of any leachate.

Suspected leachate breakout or poor drainage has been observed on the eastern flank of the site and reported to Tata. This is currently being investigated.

5.2.2 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 bi-monthly 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. Each headworks are unlocked but the site is secure.

5.2.3 Surface Water Monitoring Infrastructure

To improve the safety of sampling personnel, fixed position hand rails should be installed at SW1 and SW2, where possible.

5.2.4 Internal Gas Monitoring Infrastructure

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

Once monitoring commences at these positions, the wells will be inspected and maintained.

5.2.5 External Gas Monitoring Infrastructure

There is no external gas monitoring infrastructure.

5.3 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. Following collection, all samples are transferred to the laboratory for cool storage and analysis. Geotechnology understands that since April 2012 the laboratory has not been fully UKAS accredited. At the moment, the laboratory is accredited for anions, pH, EC, COD, Alkalinity, ammonia, TDS, SS and metals by ICP. The laboratory has informed Geotechnology that they hope to get accreditation back for metals via ICP-MS by mid-2015.

5.4 Actions required

Suspected leachate breakout on eastern flank of site should be investigated and remediated.

Hand rails should be installed at SW1 and SW2.

Access to BH3 should be improved.

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

As the landfill is not formally lined there is no way of directly sampling leachate at the base of the waste.

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 quality will change.

8 GROUNDWATER LEVEL AND QUALITY

8.1 Groundwater Flow

Contour plans showing the piezometric surface obtained from the monitoring of shallow groundwater and bedrock groundwater are provided in Figure 9. Although the dataset is not complete due to the lack of data from BH3, Figure 9 still reveals that shallow groundwater generally moves from east to west, as previously noted. The data also suggests that a similar pattern of groundwater movement is present in the bedrock, which has not been observed previously. This may be because sub-artesian conditions are observed in several wells.

This situation will be more closely evaluated in next year’s annual review with the benefit of more data, particularly from BH3.

8.2 Shallow Groundwater

As expected, sampling of shallow groundwater in close primity to the site reveals that it is impacted by the passage of infiltration through the unlined waste body and into the made ground, which largely comprises slag waste. This seepage is characterised by elevated pH, electrical conductivity and alkalinity (see time series charts in Appendix 1). As noted previously, groundwater in close proximity to the landfill contains low levels of non-hazardous substances which infrequently exceed Environmental Quality Standards and on rare occasions cadmium is detectable, but at low concentrations (<0.02 microg/l).

Although there is currently limited data from BH3, the results suggest that it is less alkaline but has higher ammonia than the other shallow groundwaters. This data will be more closely evaluated as part of next year’s annual review when more data will be available.

8.3 Deep Groundwater

The levels of non-hazardus 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 any hydraulic connection between the two water bodies is limited, as would be expected due to the low permeability sequence of sediemnts present. In this context, the data from BH7 appears anomalous as the pH is similar to that in the made ground. Geotechnology will check this installation to ensure that the headworks are in satisfactory condition.

9 SURFACE WATER

9.1 Hydrochemistry

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

With one position upgradient (SW1) and one position downgradient (SW2) the surface water monitoring programme is designed to detect any influences the waste mass may be having on local surface water. At this stage, the monitoring data indicates that upgradient and downgradient surface water chemistry is generally very similar. However, in September there were 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 potentially been observed along this flank and as the landfill is being capped, this dataset will continue to be closely scrutinised.

9.2 Contingency Actions Taken

No specific contingency actions were taken but Tata is investigating the potential leachate breakout.

10 AMENITY ISSUES

There have been no requirements for any dust, noise or odour monitoring or investigations.

11 SUMMARY AND RECOMMENDATIONS

11.1 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 investigating the root cause.

11.2 Overview of Monitoring Programme

Bi-monthly monitoring by Tata has enabled a good dataset to be developed and there is now opportunity for rationalisation. Geotechnology suggests that the current monitoring should now be more closely aligned to the AMP and based on the schedule provided in Table 11-1. There is also opportunity to reduce the parameters routinely analysed and to implement the Indicator Suite. The suggested analytical parameters are provided in Table 11-2.

Table 11-1 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
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	Annual	Topographic survey of settlement plates	Settlement Plates
Stability	Landfill embankments	Annual	Visual observation	All flanks

Table 11-2 Analytical Programme

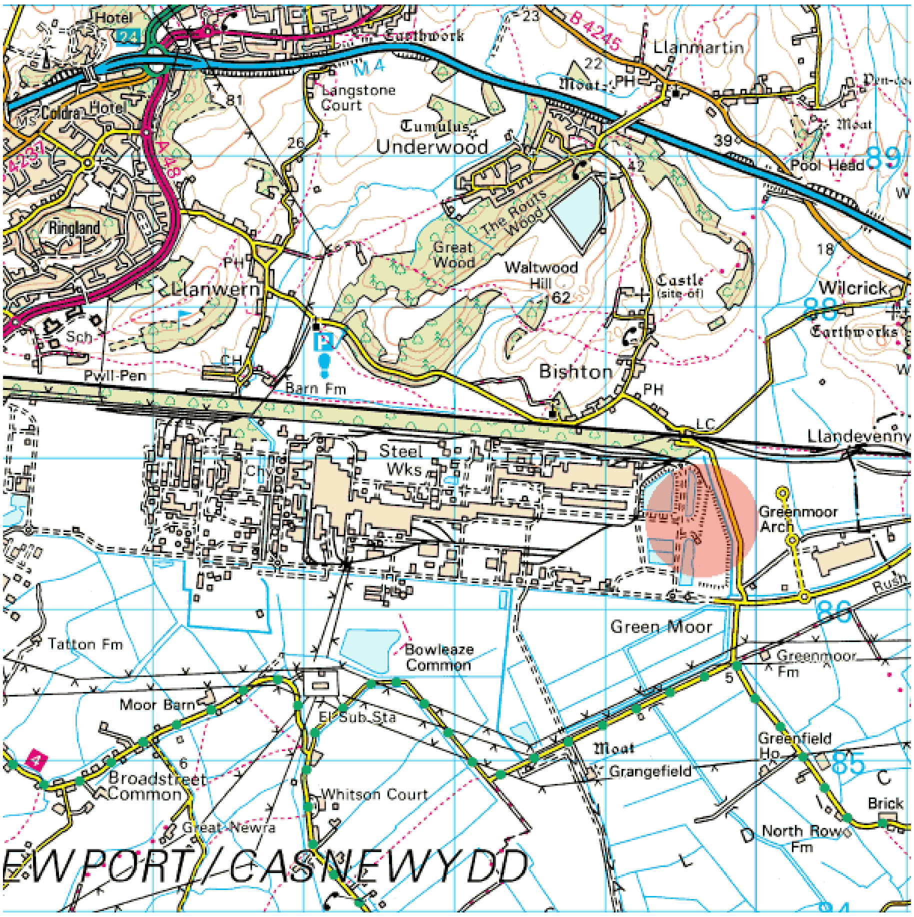
Measurement	Groundwater, surface Water and Leachate Characterisation Suite	Groundwater, surface Water and Leachate Indicator and Field Suite
Monitoring Positions	All surface water, groundwater and leachate monitoring locations	
Frequency	Annually	All other times
Water Level	•	•
Temperature	•	•
pH	•	•
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	•	

11.3 Actions Required

Implement the components of the monitoring programme not being done.

- Suspected leachate breakout on eastern flank of site should be investigated and remediated.
- Vegetation in the vicinity of several sampling points requires routine clearance to enable continual safe access.
- Hand rails should be installed at SW1 and SW2.
- Access to BH3 should be improved.

Figure 1 Site Location Plan



Reproduced from the Ordnance Survey Land Ranger Map
with the permission of The Controller of Her Majesty's Stationery Office

Industrial Buildings

N

Figure 2 Environmental Setting

1435r1v1d0315 Figure 2

Revision 1

Scale: As Shown

Figure 3 Hydrology

Revision 1

1435r1v1d0315 Figure 3

Scale: As Shown

Figure 4 Site Investigation Locations

Figure 5 Geological Cross Sections

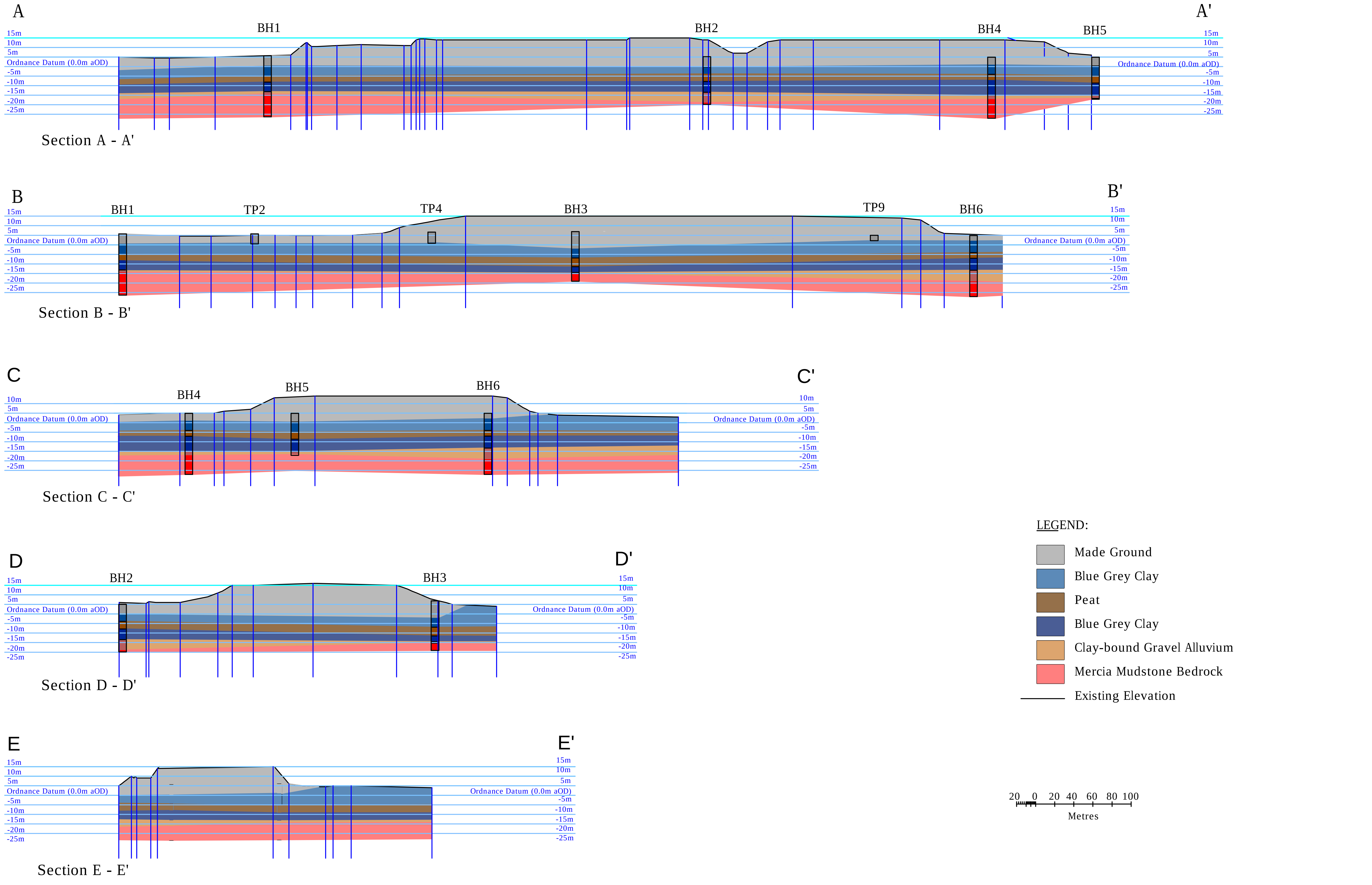


Figure 6 Available Monitoring Newtowk

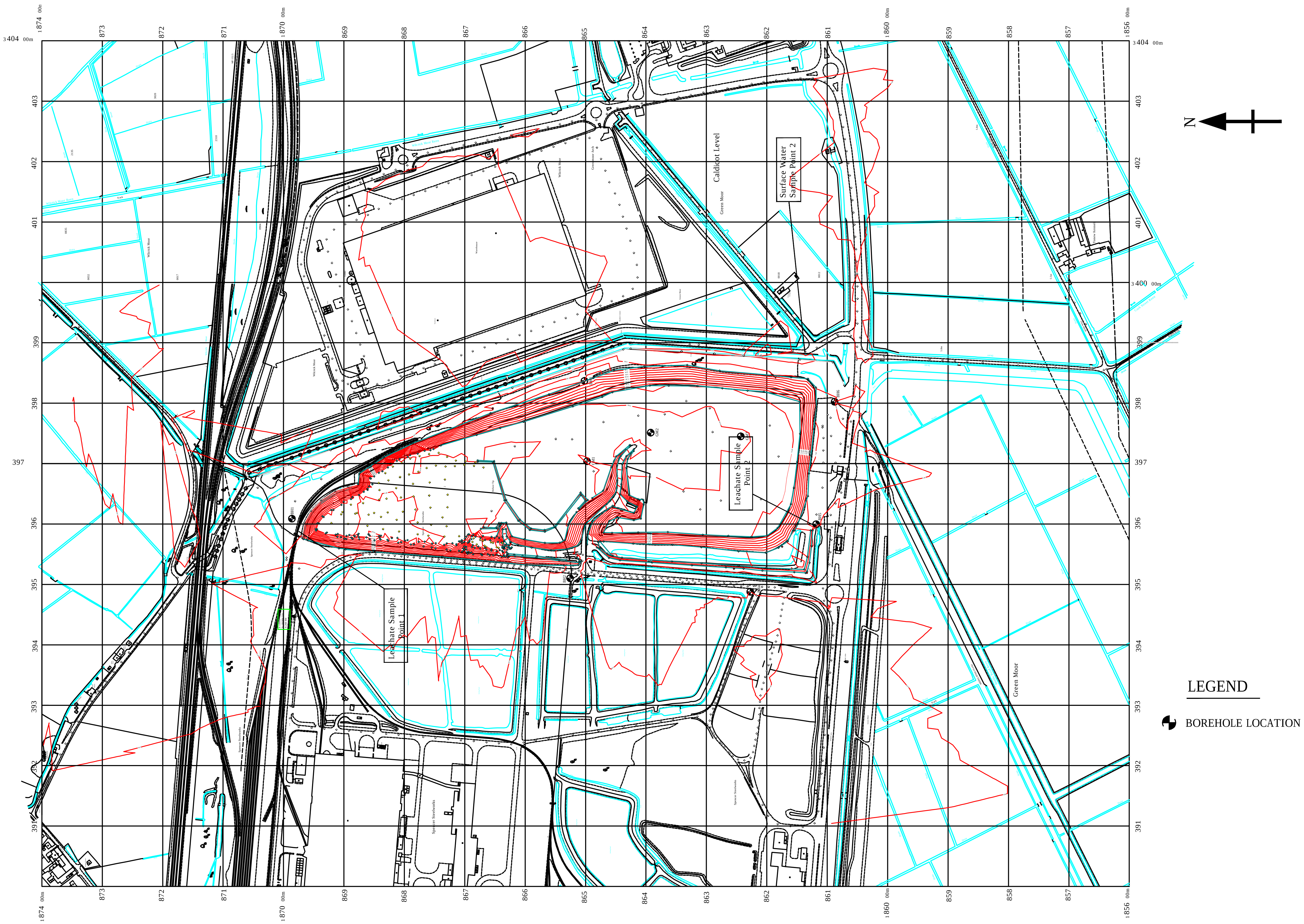
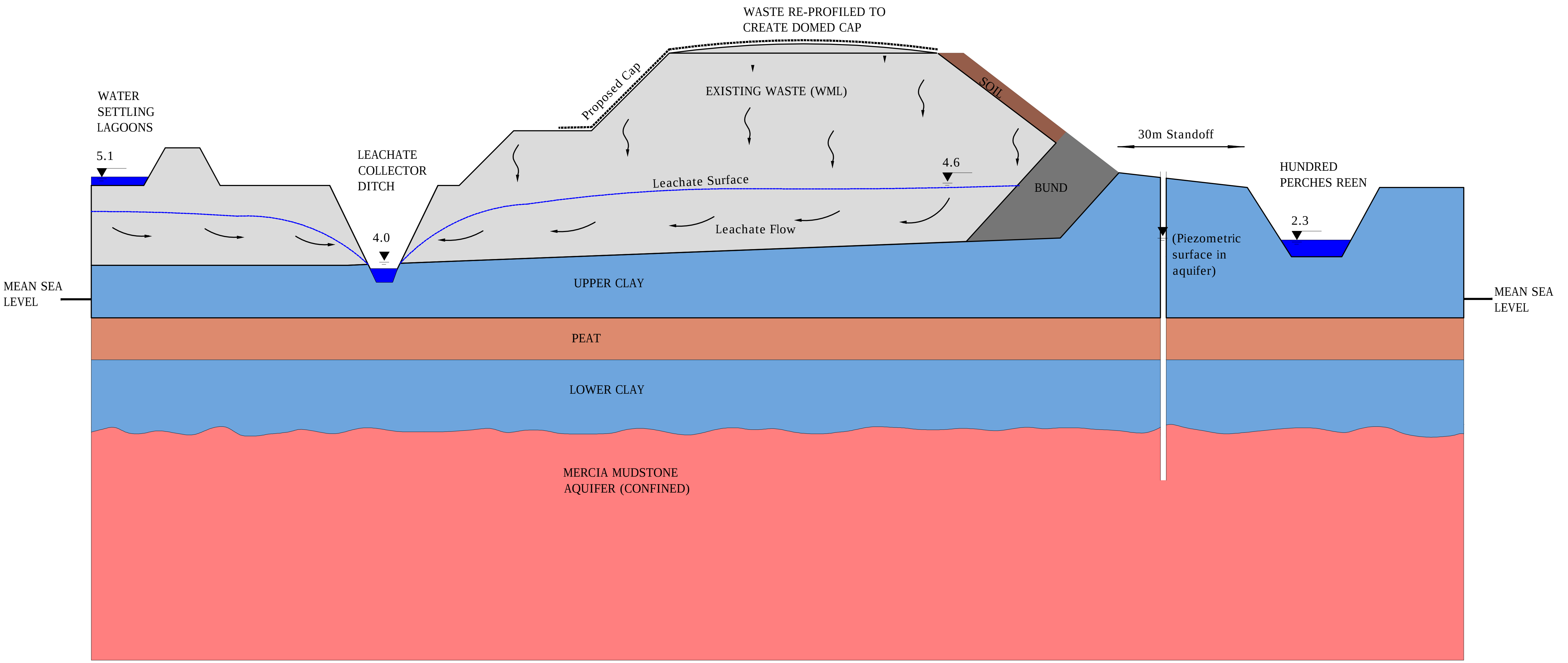
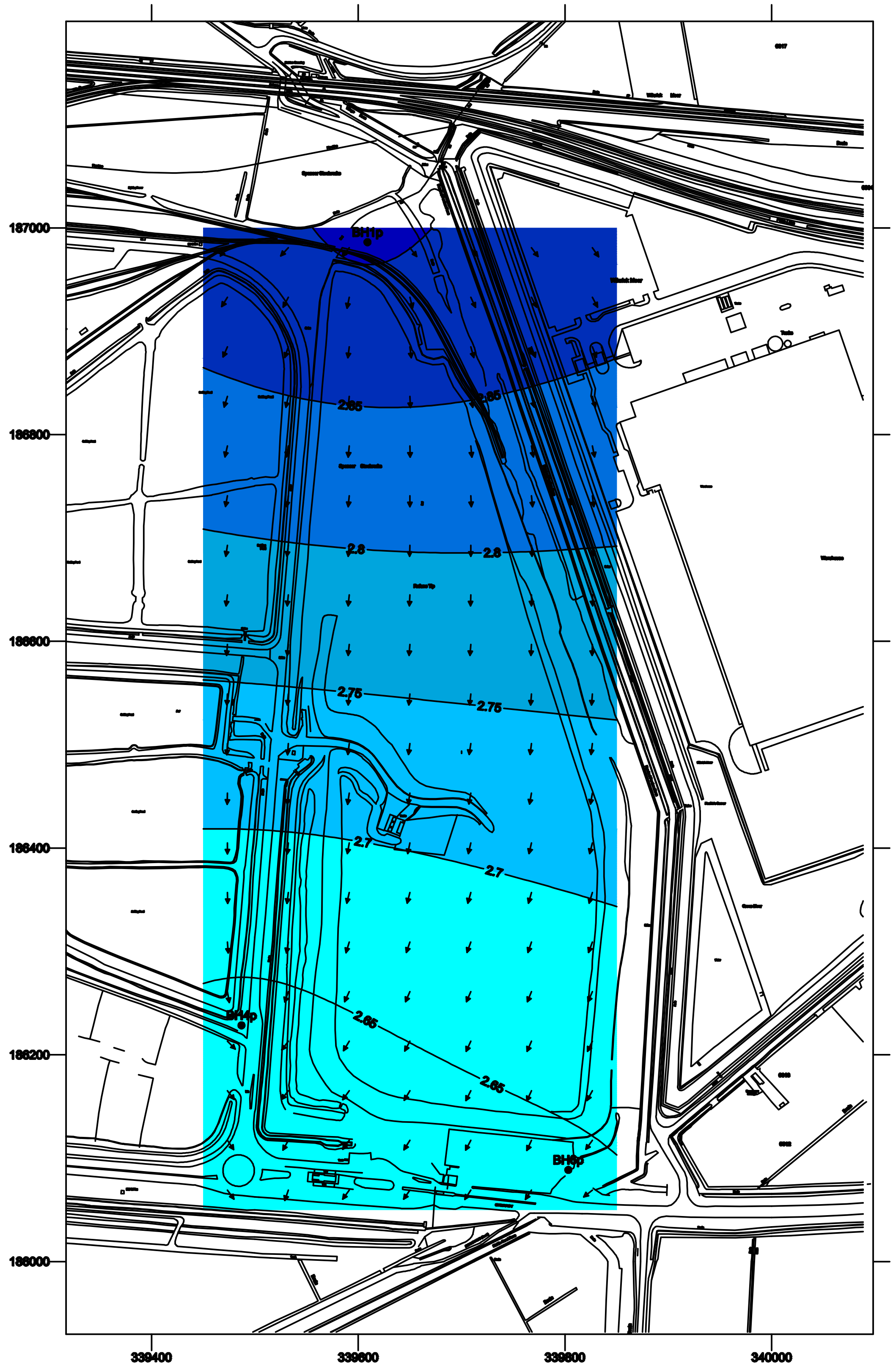
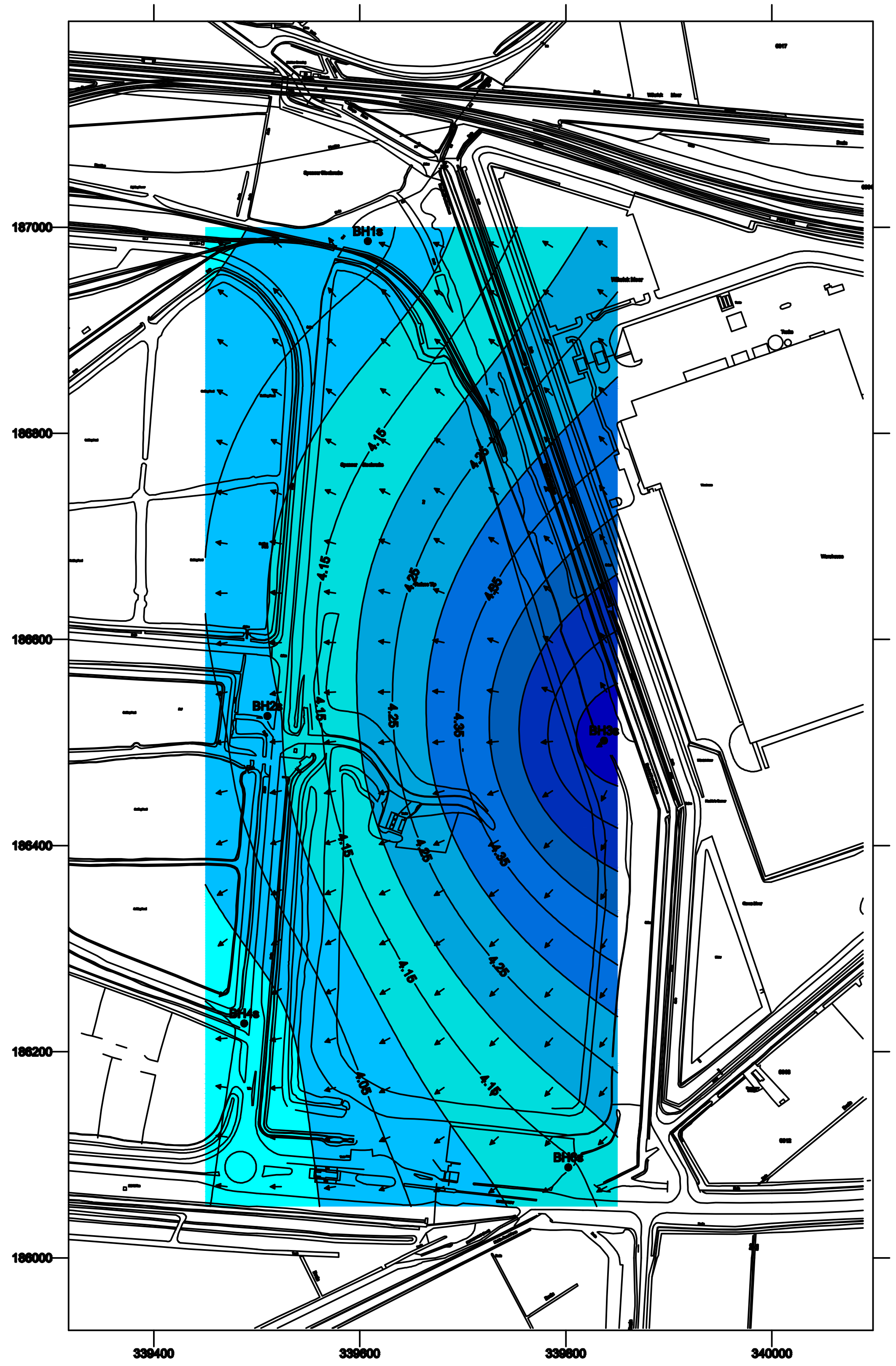


Figure 7 Hydrogeological Conceptual Site Model



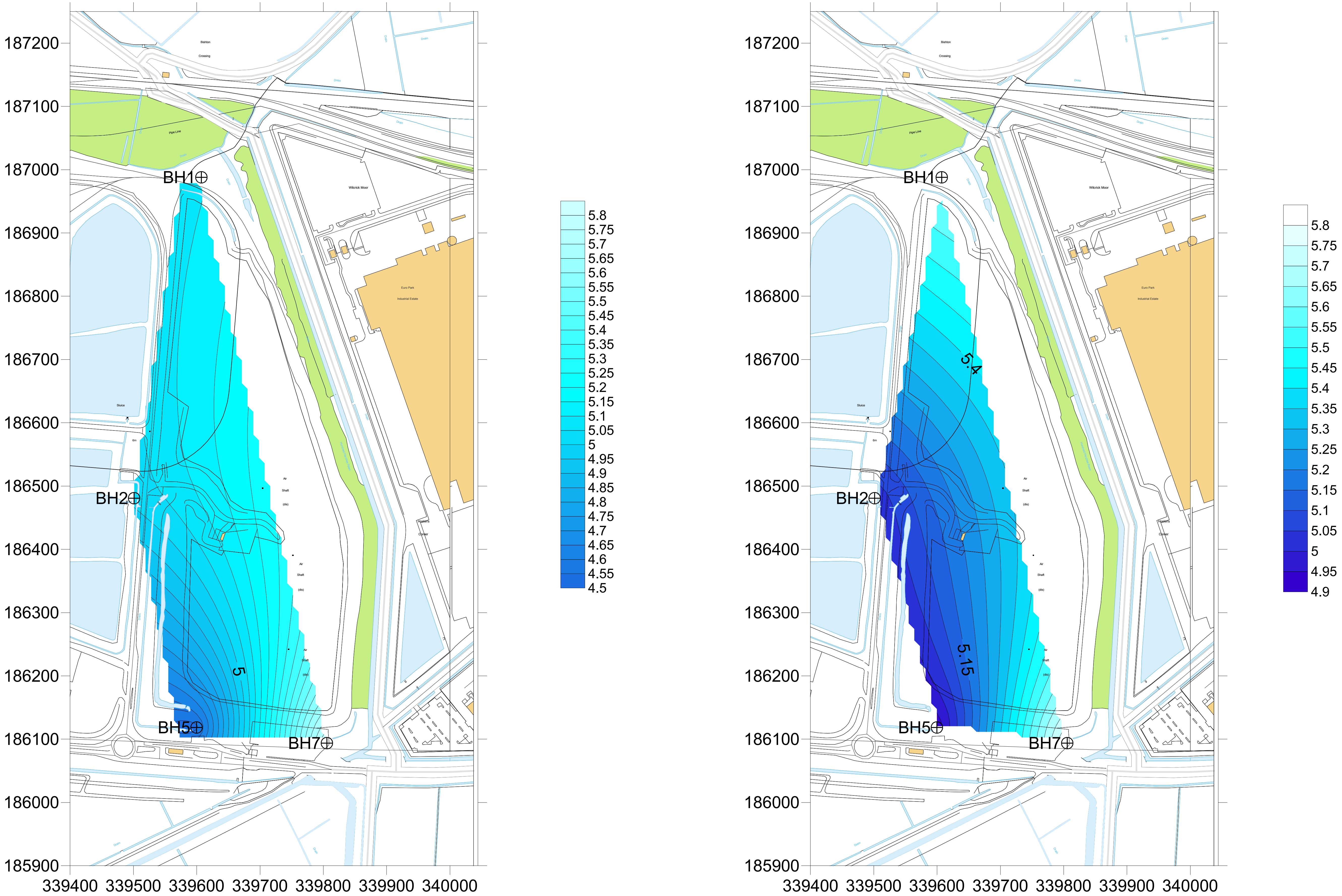


AQUIFER FLOW



LEACHATE FLOW

Figure 9 Recent Groundwater Levels



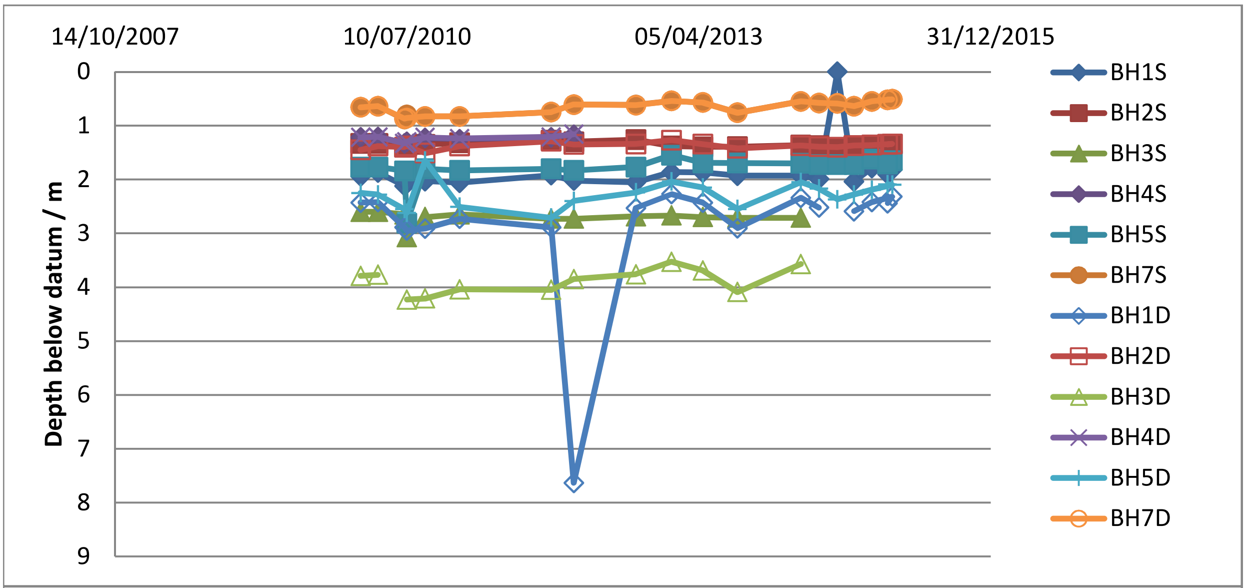
EAST WASTE MANAGEMENT SITE, LLANWERN STEELWORKS

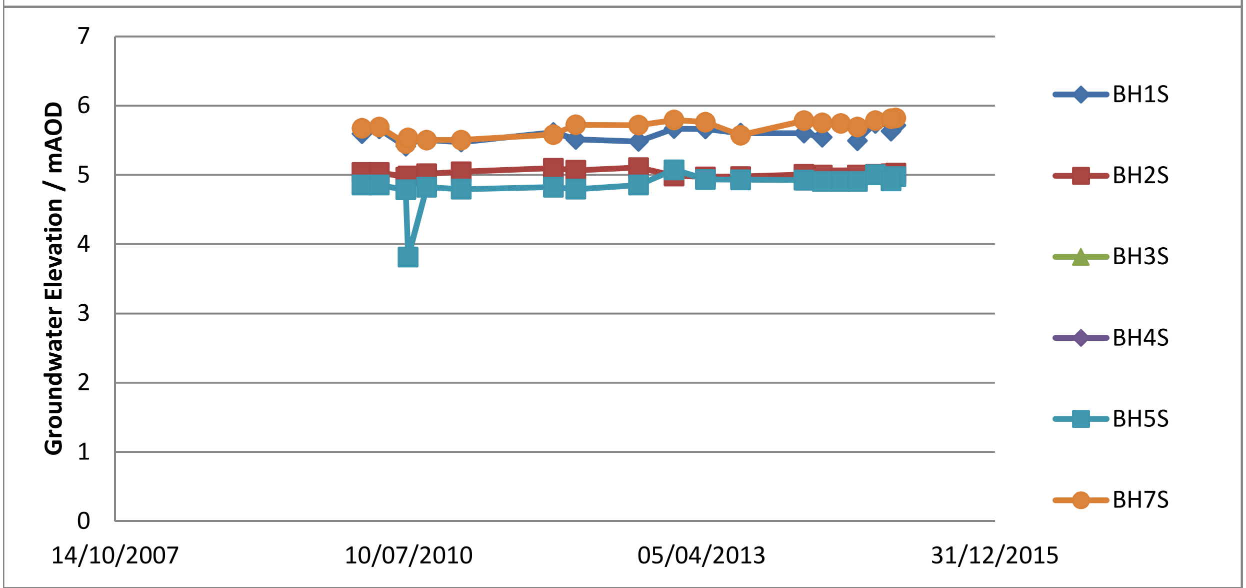
PERMIT EAWML/30003

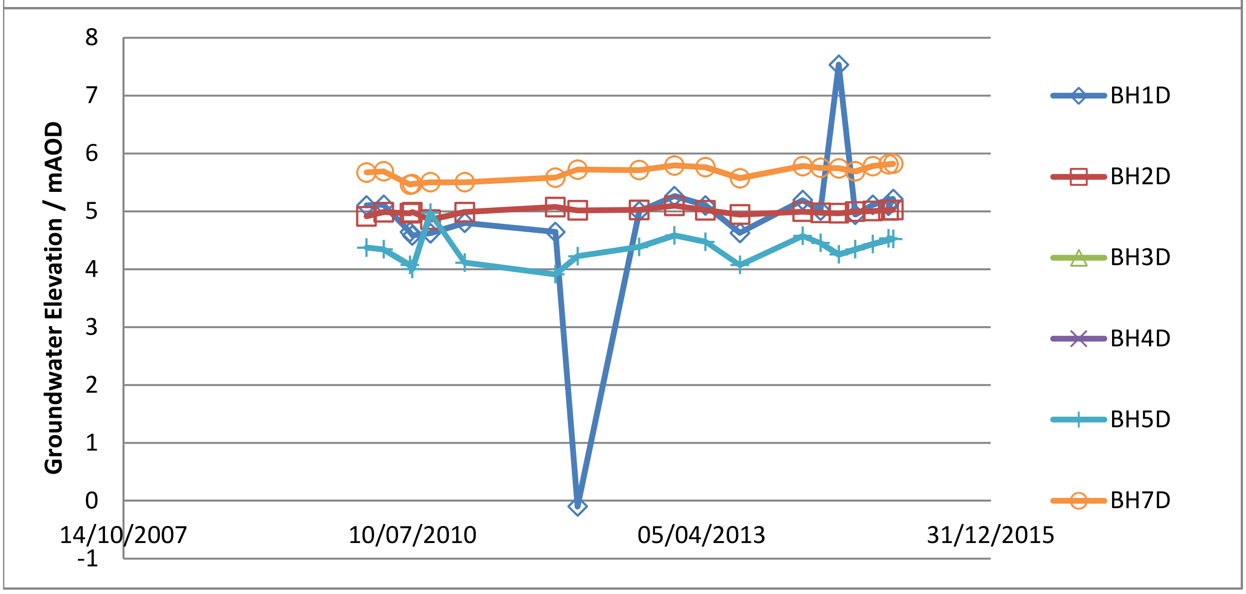
2014 Annual Review of Environmental Monitoring

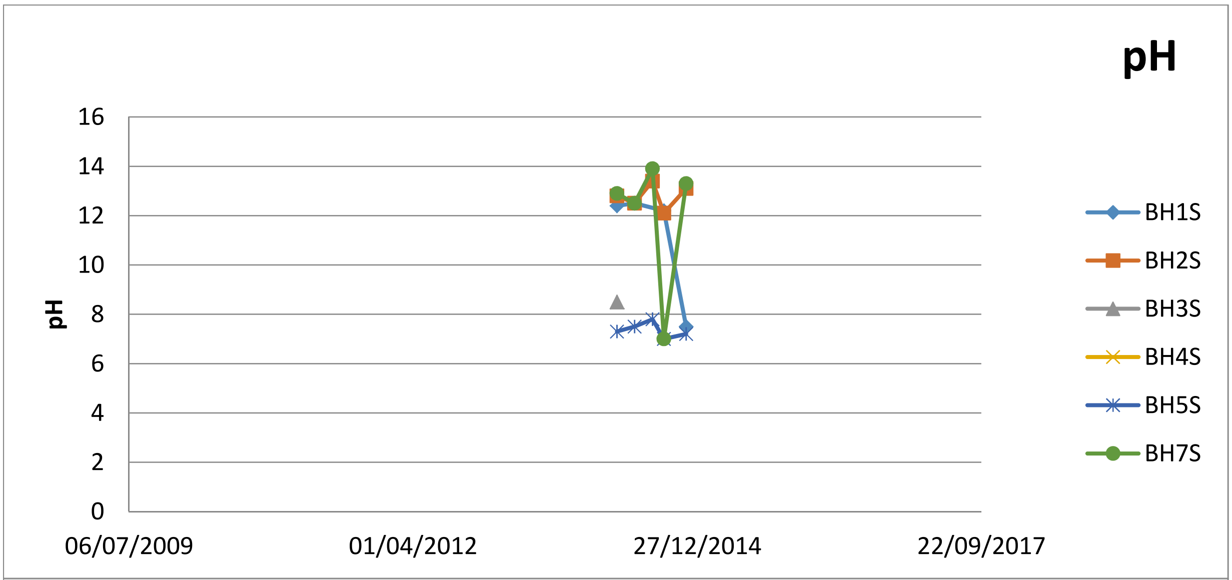
Appendix 1
Temporal Variation of Groundwater Levels and Chemistry

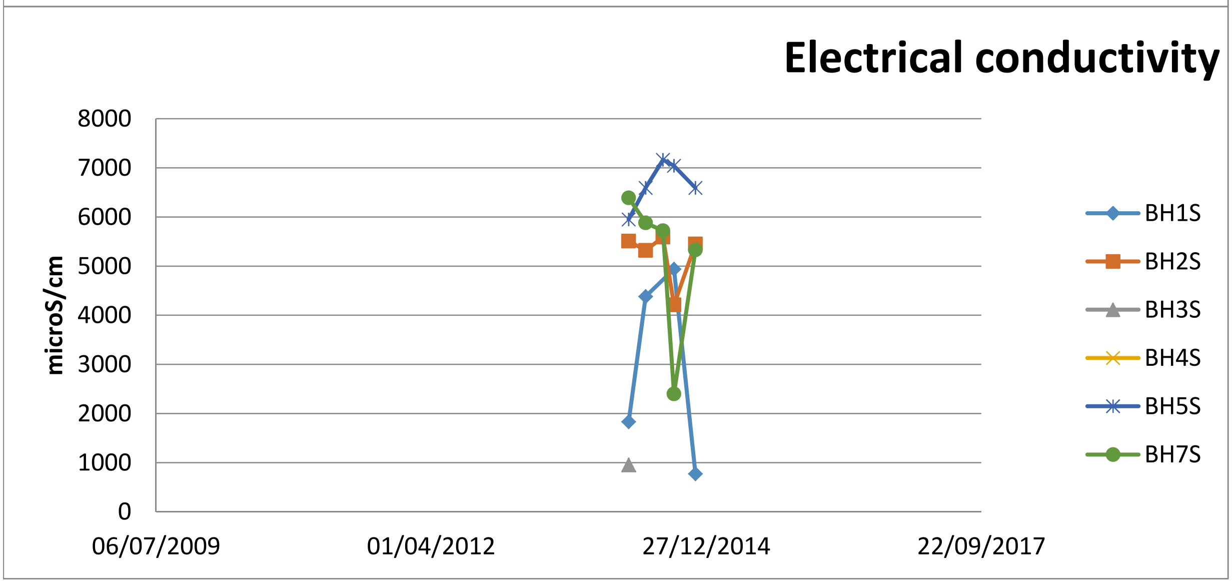
Report Number 1435r1v1d0315

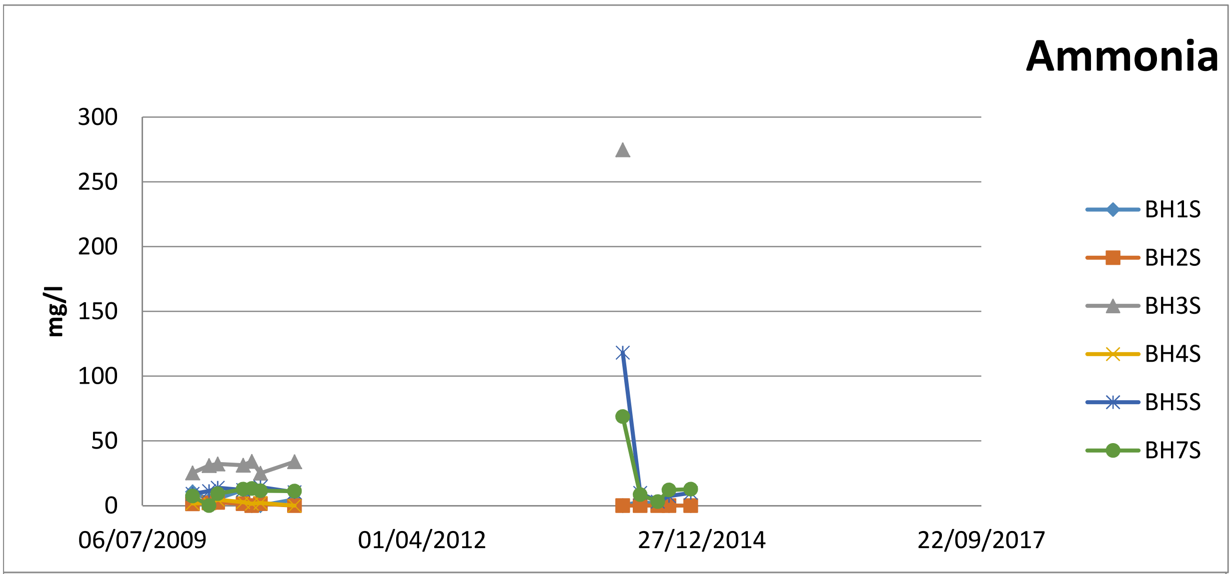

14/10/2007
10/07/2010
05/04/2013
31/12/2015
Depth below datum / m
0
1
2
3
4
5
6
7
8
9
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

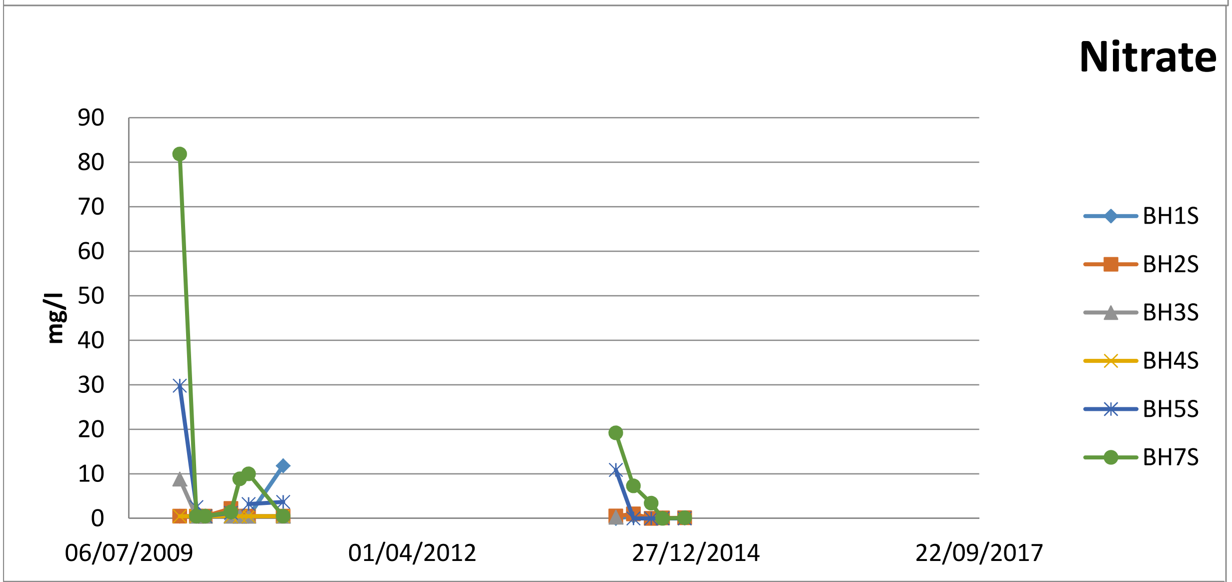

Groundwater Elevation / mAOD
7
6
5
4
3
2
1
0
14/10/2007
10/07/2010
05/04/2013
31/12/2015
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

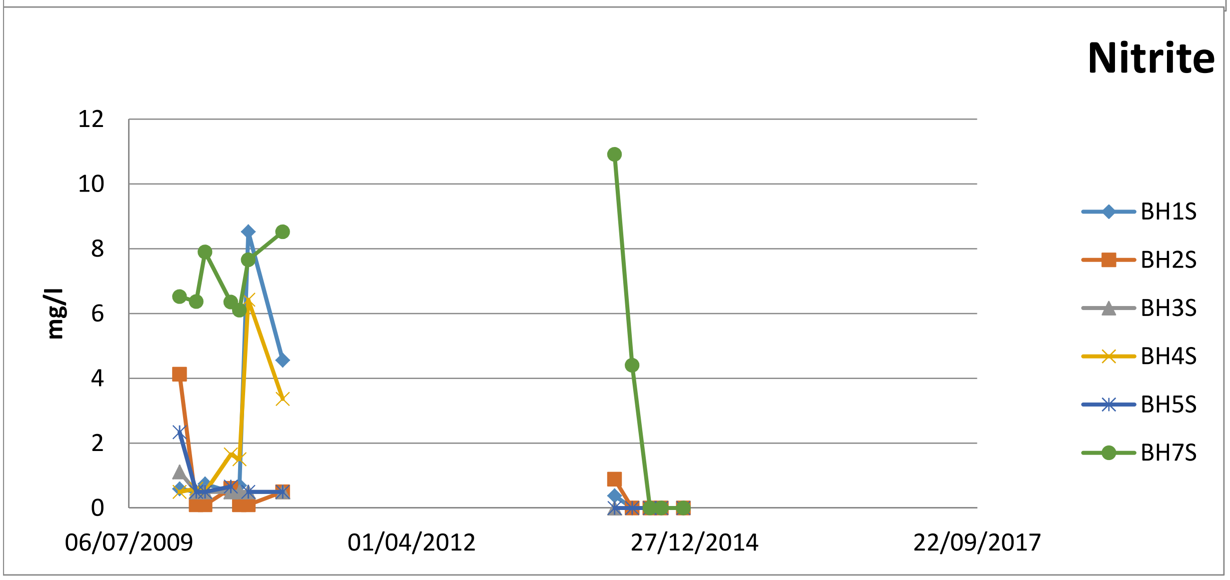

Groundwater Elevation / mAOD
8
7
6
5
4
3
2
1
0
-1
14/10/2007
10/07/2010
05/04/2013
31/12/2015
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

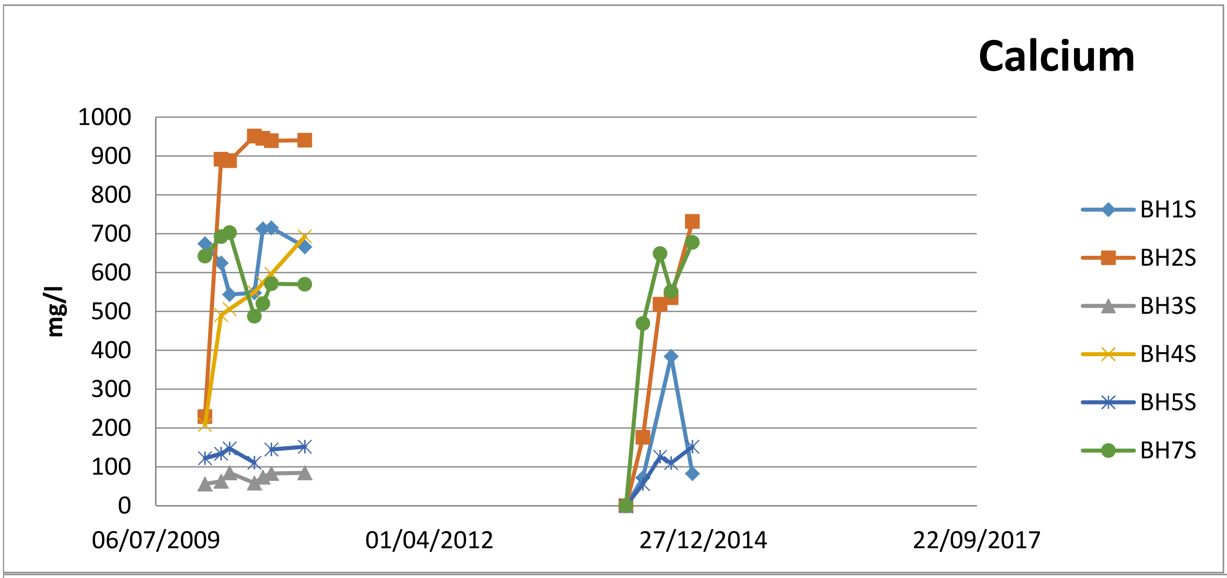

pH
16
14
12
10
8
6
4
2
0
pH
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

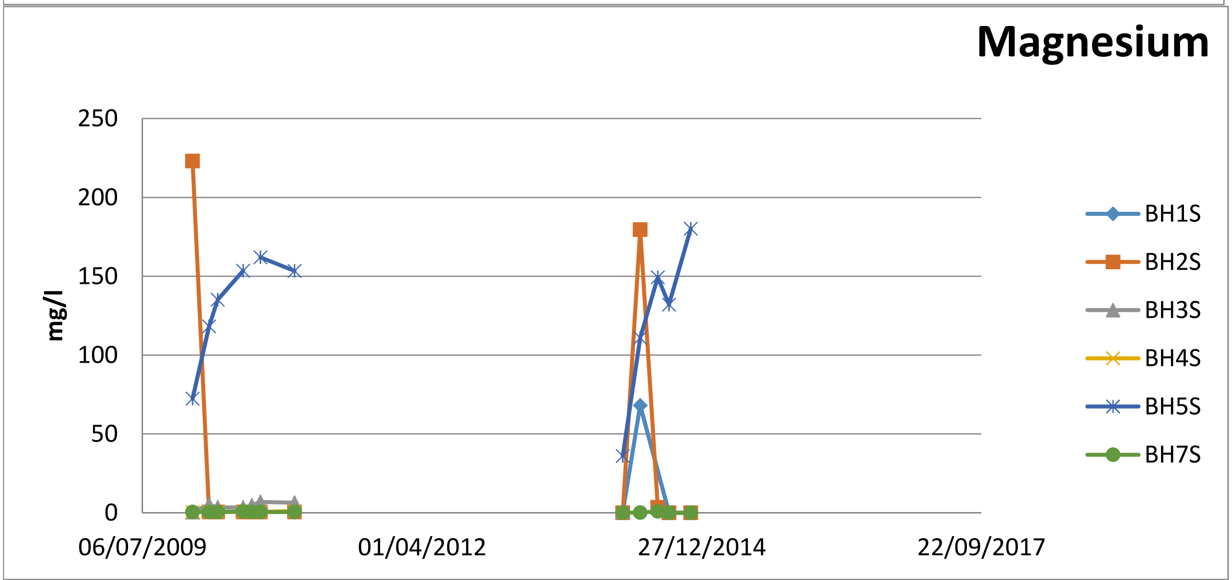

Electrical conductivity
8000
7000
6000
5000
4000
3000
2000
1000
0
microS/cm
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

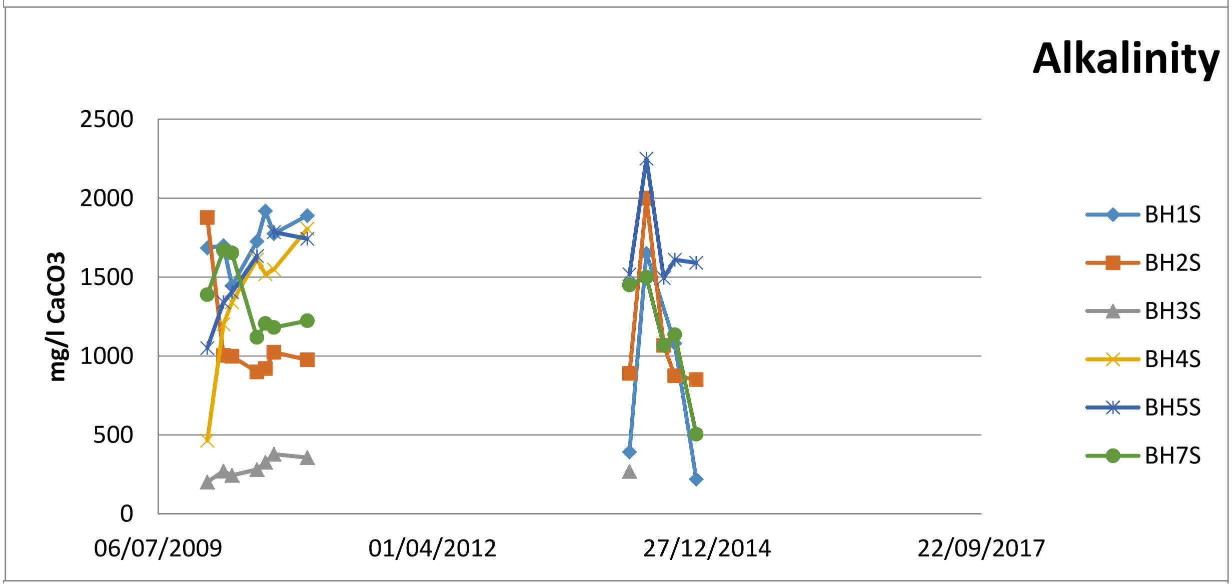

Ammonia
300
250
200
150
100
50
0
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

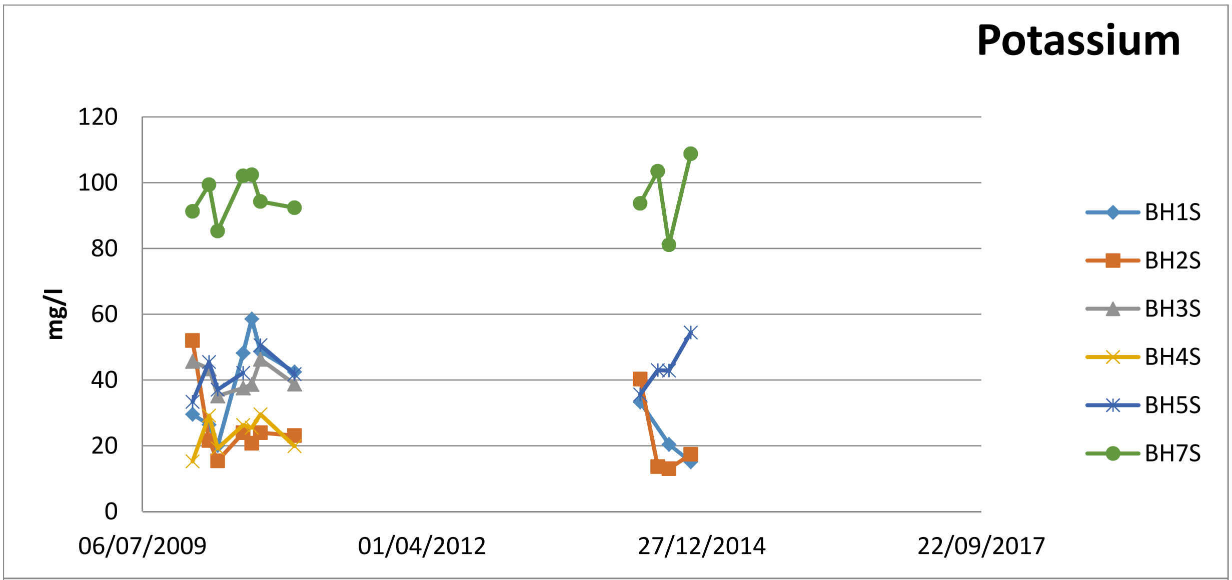

Nitrate
90
80
70
60
50
40
30
20
10
0
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

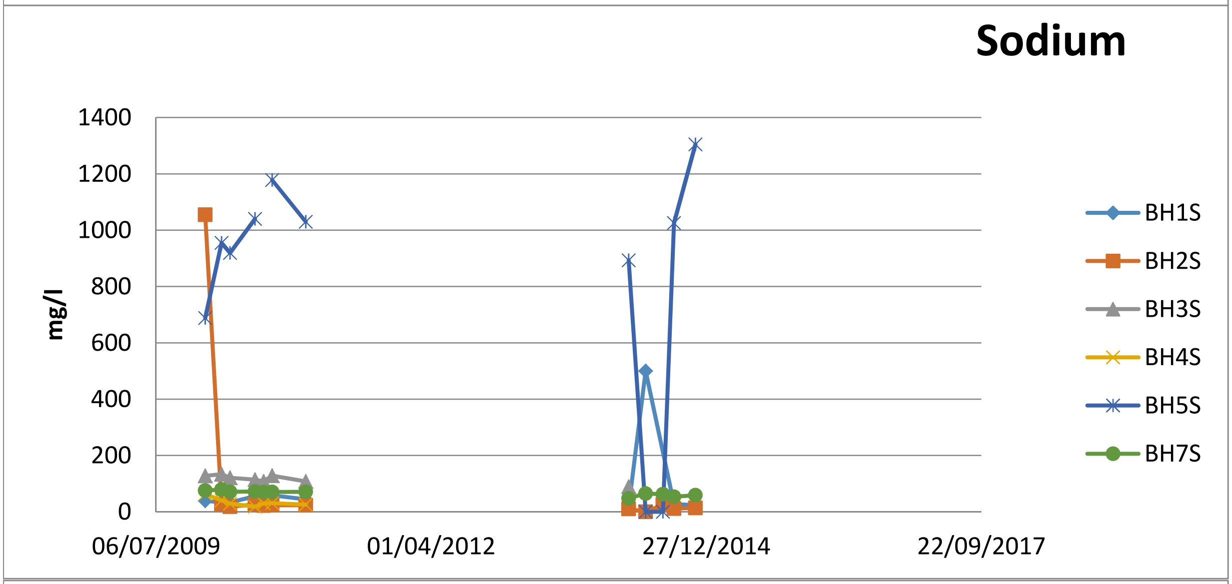

Nitrite
12
10
8
6
4
2
0
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

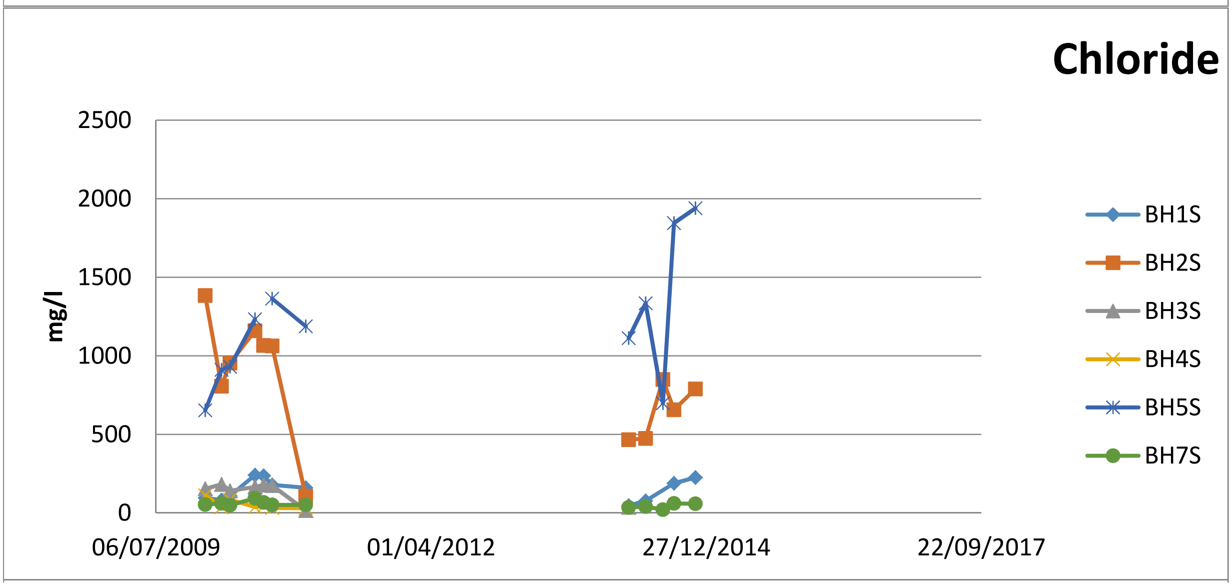

Calcium
mg/l
1000
900
800
700
600
500
400
300
200
100
0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

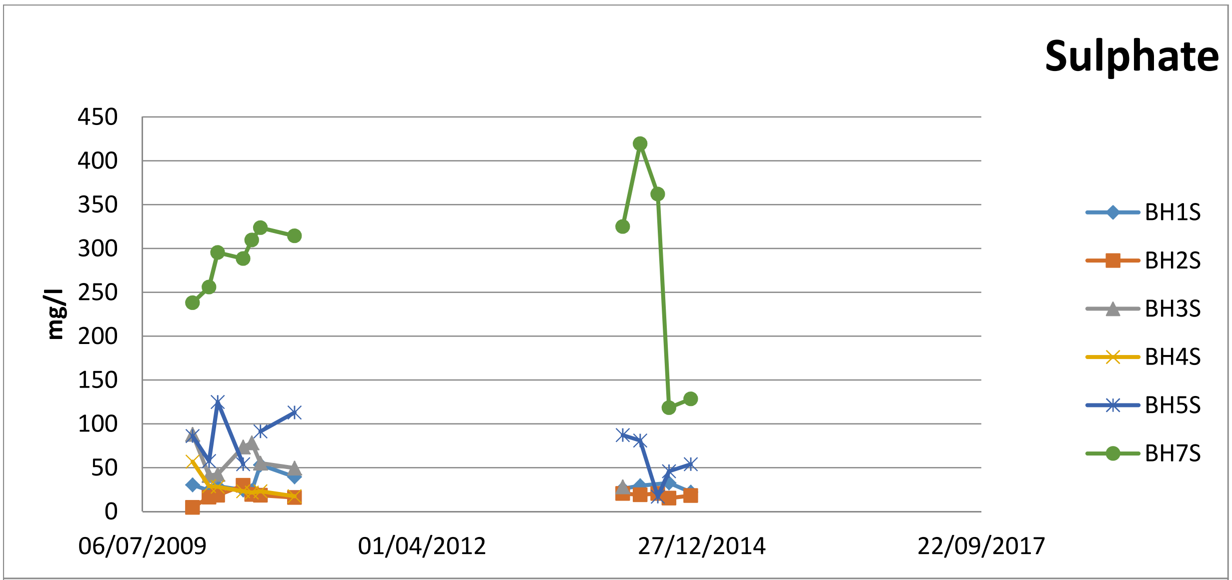

Magnesium
mg/l
250
200
150
100
50
0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

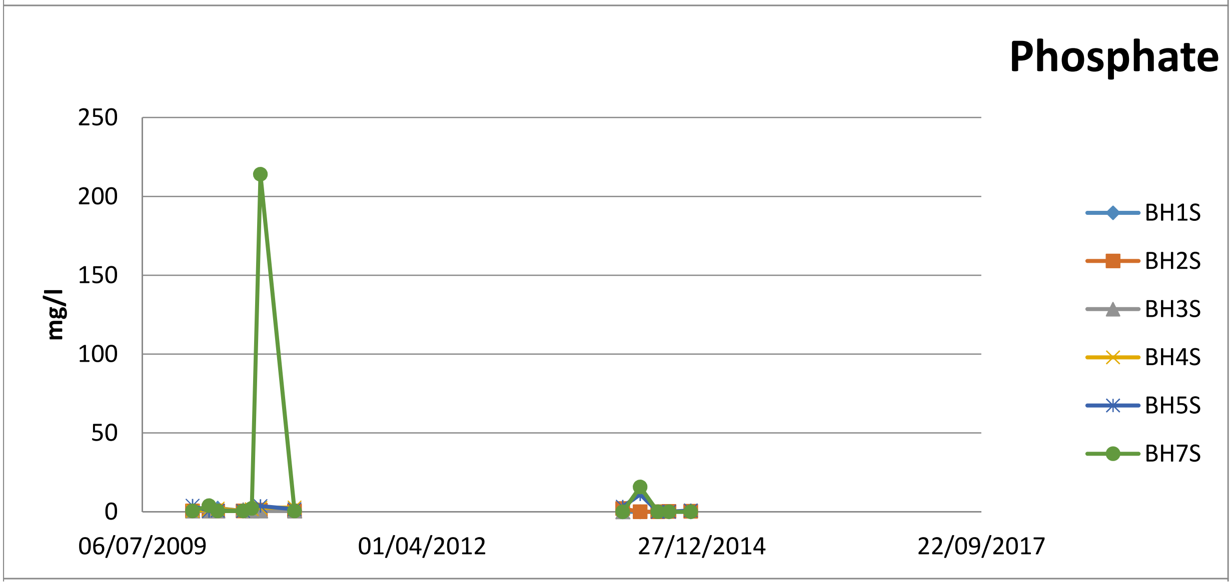

Alkalinity
mg/l CaCO3
2500
2000
1500
1000
500
0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

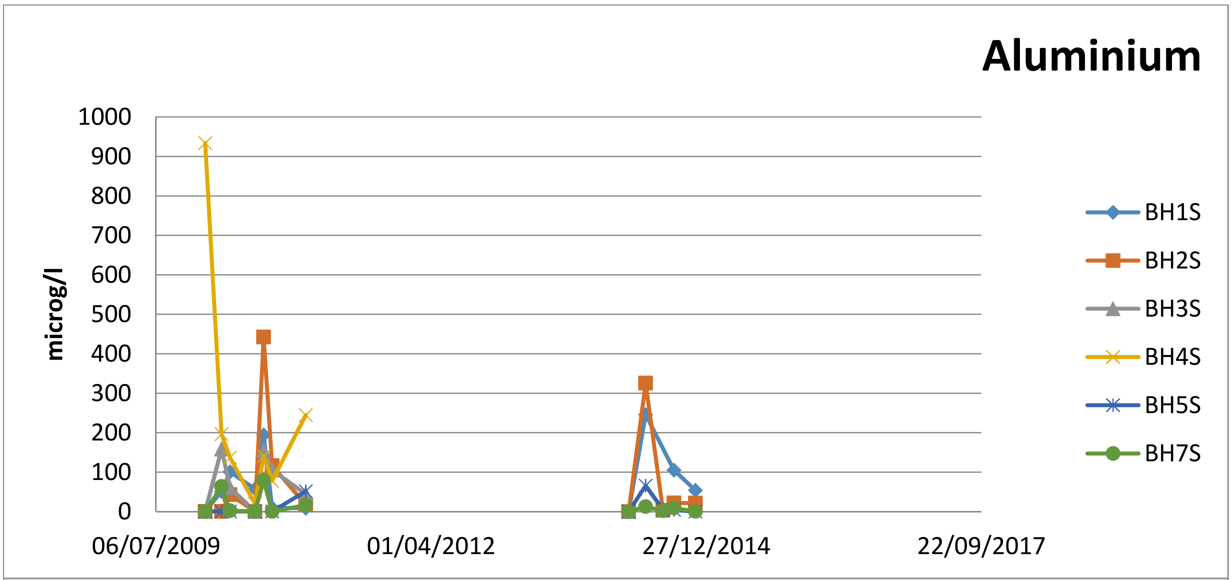

Potassium
mg/l
120
100
80
60
40
20
0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

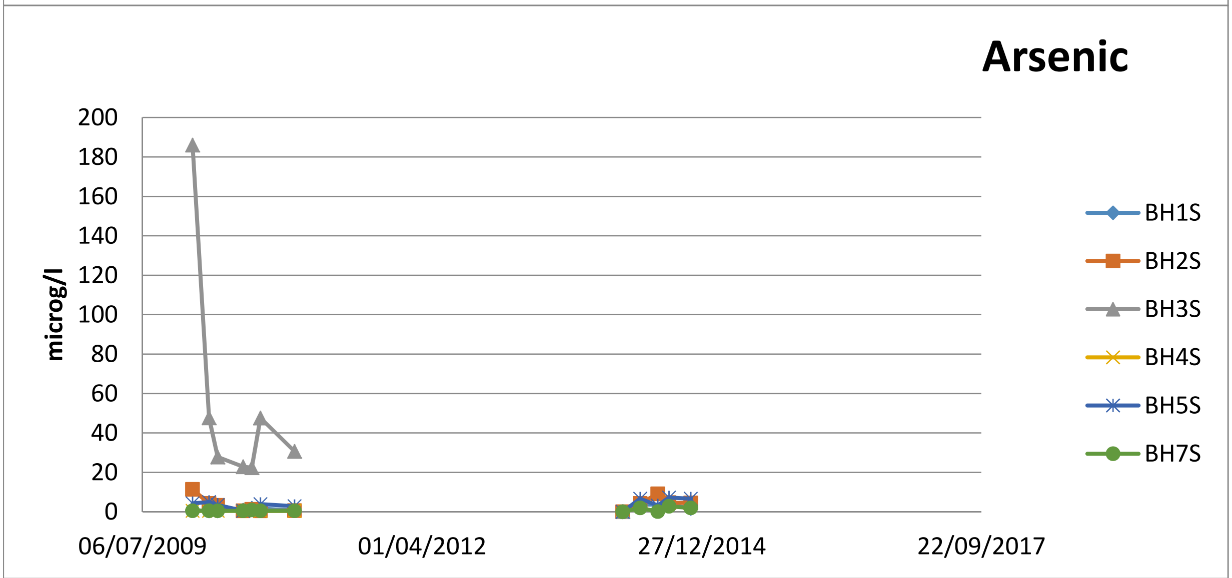

Sodium
mg/l
1400
1200
1000
800
600
400
200
0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

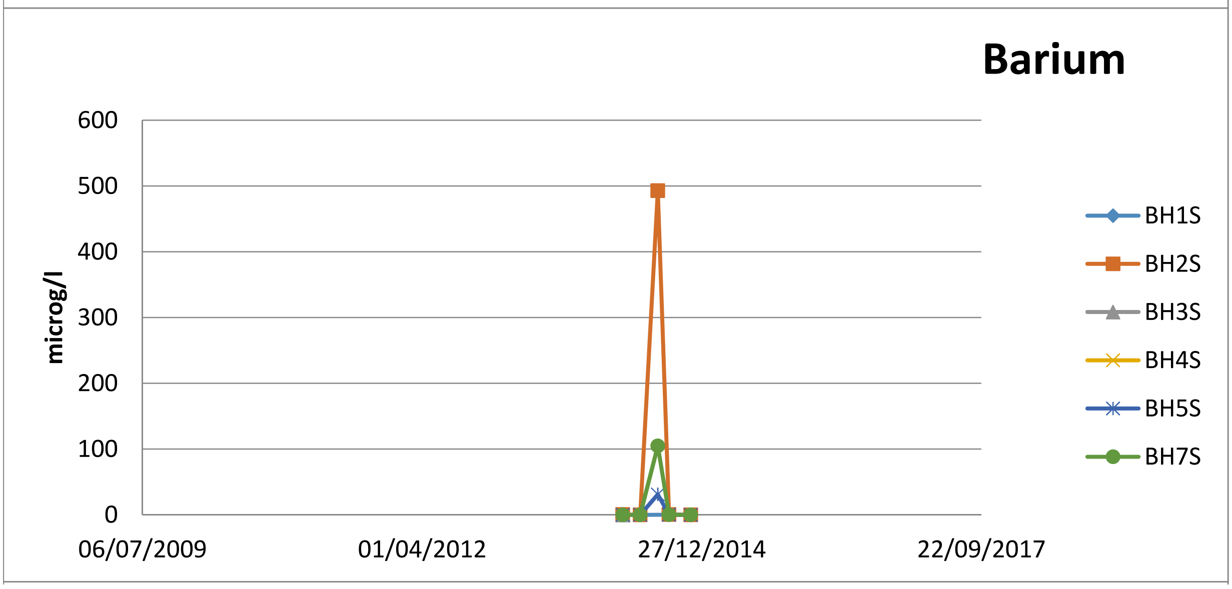

Chloride
mg/l
2500
2000
1500
1000
500
0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S


Sulphate
mg/l
450
400
350
300
250
200
150
100
50
0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S


Phosphate
mg/l
250
200
150
100
50
0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S


Aluminium
microg/l
1000
900
800
700
600
500
400
300
200
100
0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S


Arsenic
microg/l
200
180
160
140
120
100
80
60
40
20
0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S


Barium
microg/l
600
500
400
300
200
100
0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
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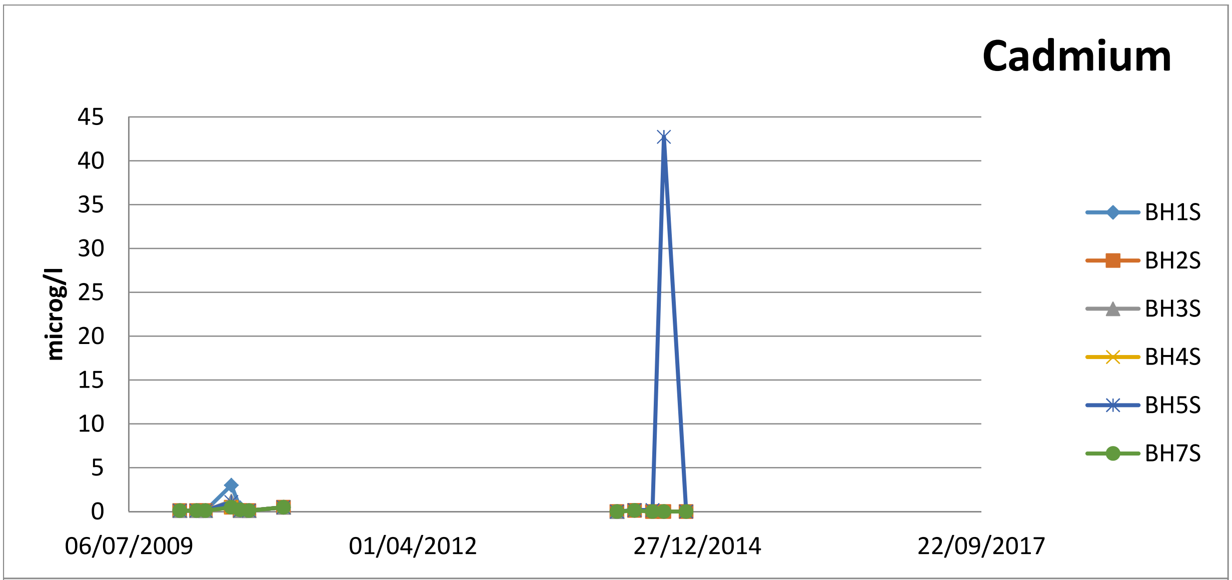
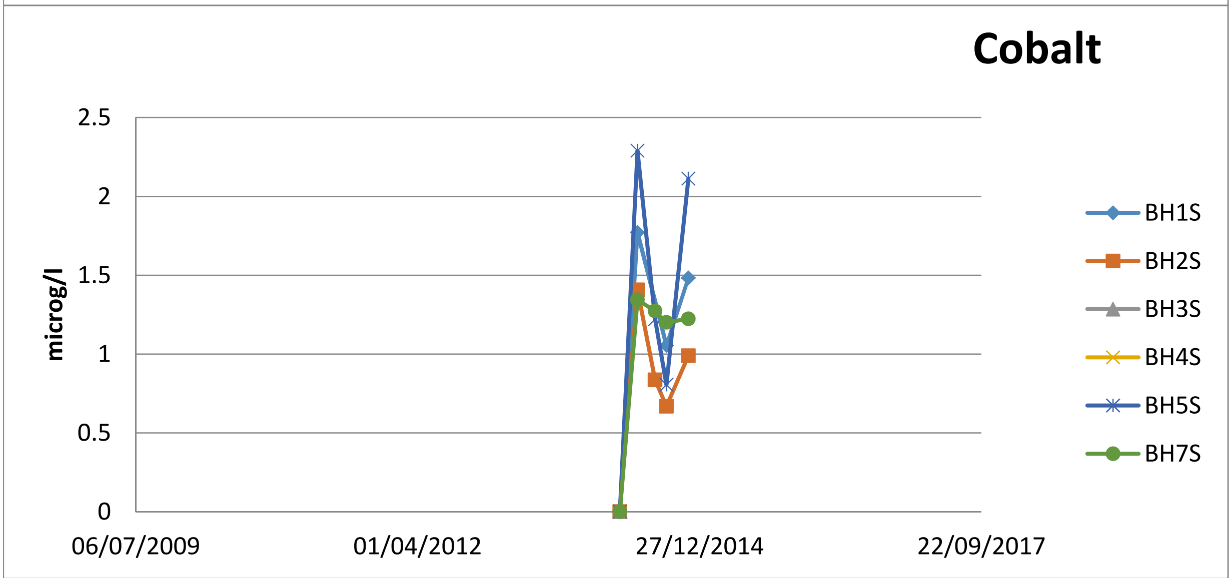
BH3S
BH4S
BH5S
BH7S


Cadmium
microg/l
45
40
35
30
25
20
15
10
5
0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S


Cobalt
microg/l
2.5
2
1.5
1
0.5
0
06/07/2009
01/04/2012
27/12/2014
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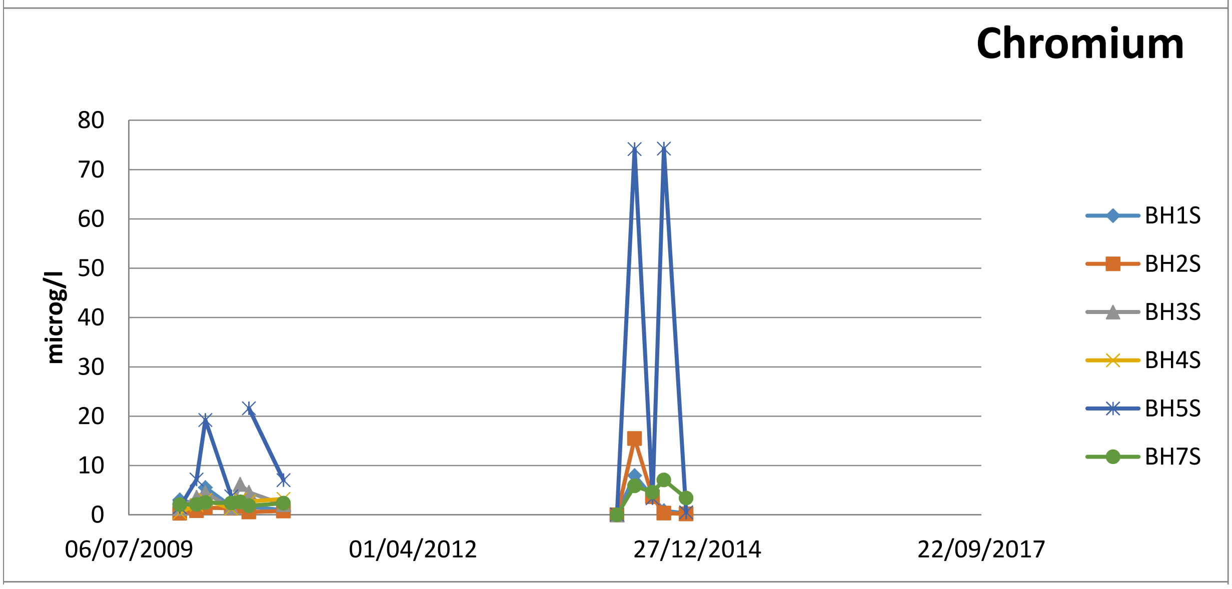
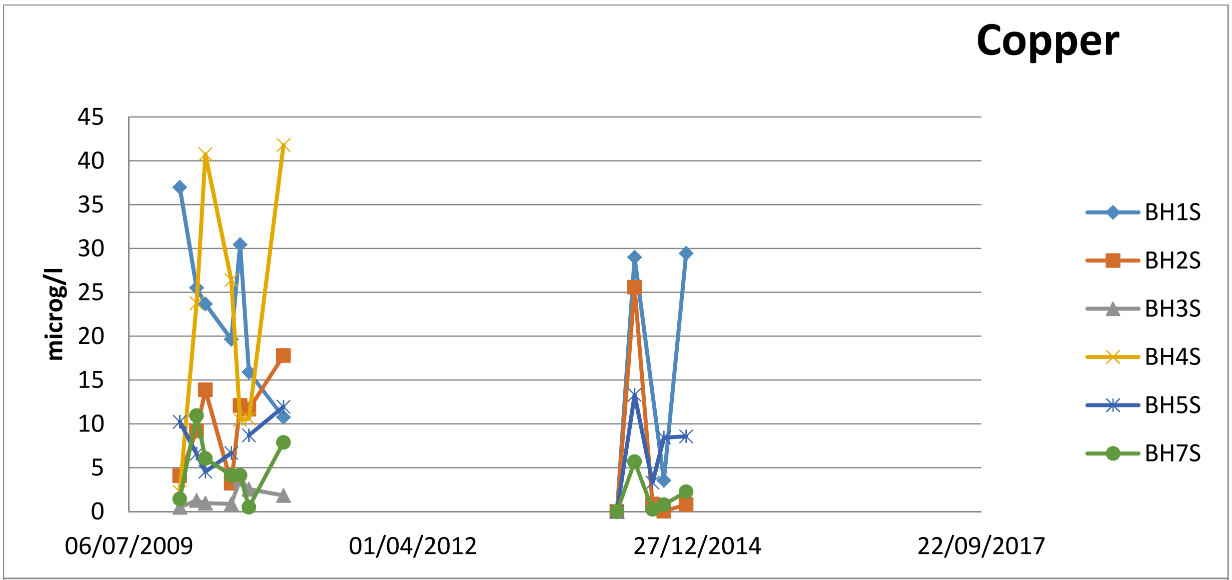
BH3S
BH4S
BH5S
BH7S


Chromium
microg/l
80
70
60
50
40
30
20
10
0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S


Copper
45
40
35
30
25
20
15
10
5
0
microg/l
06/07/2009
01/04/2012
27/12/2014
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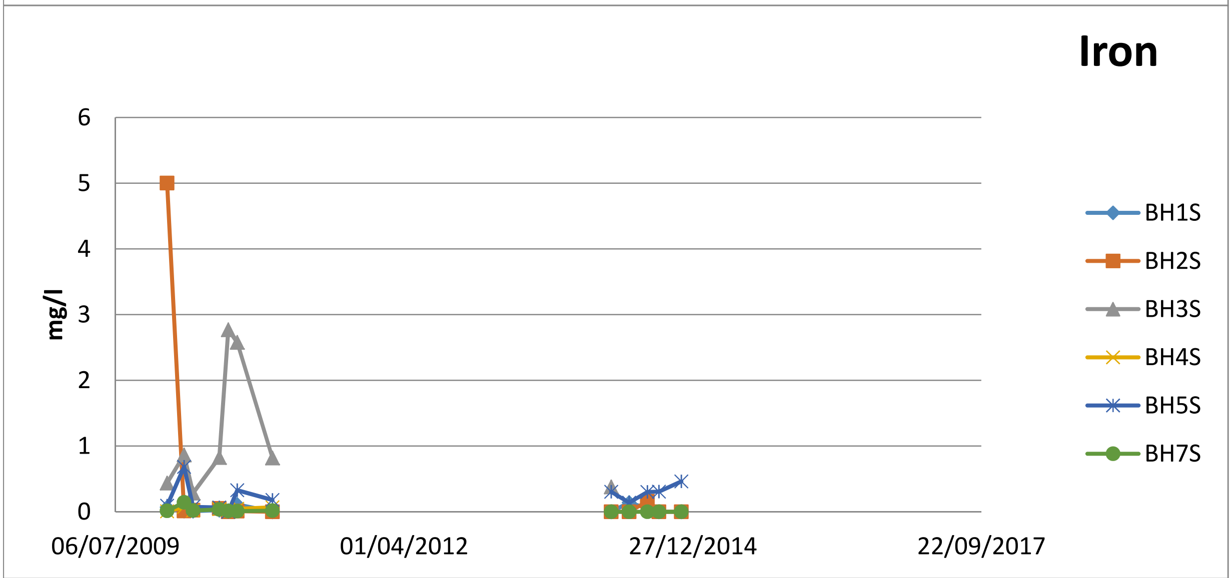
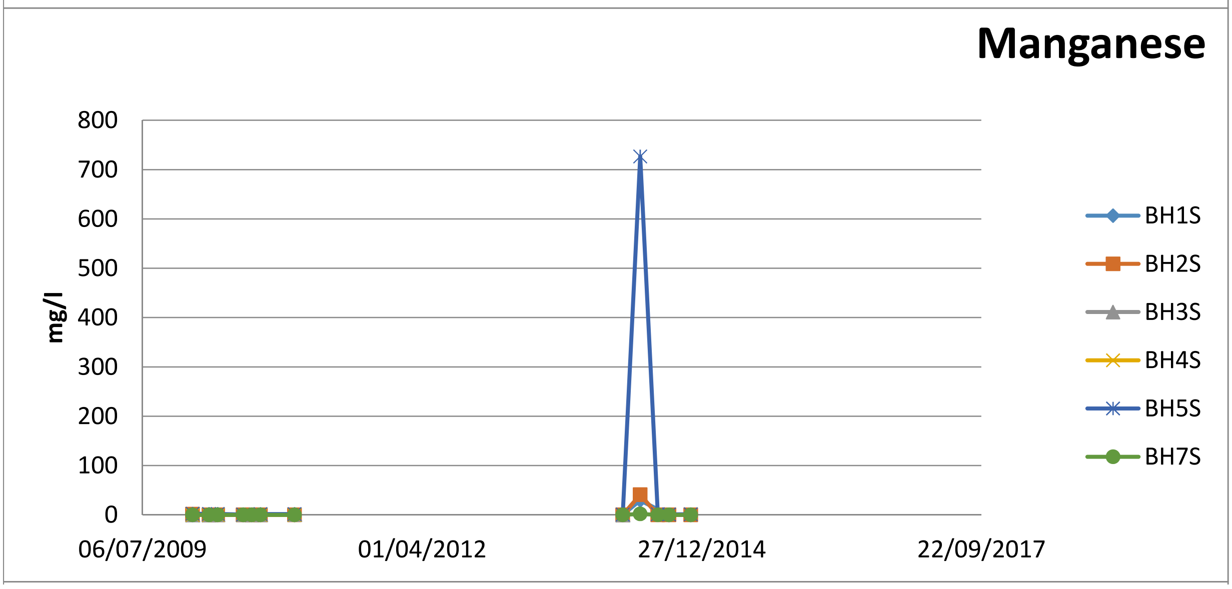
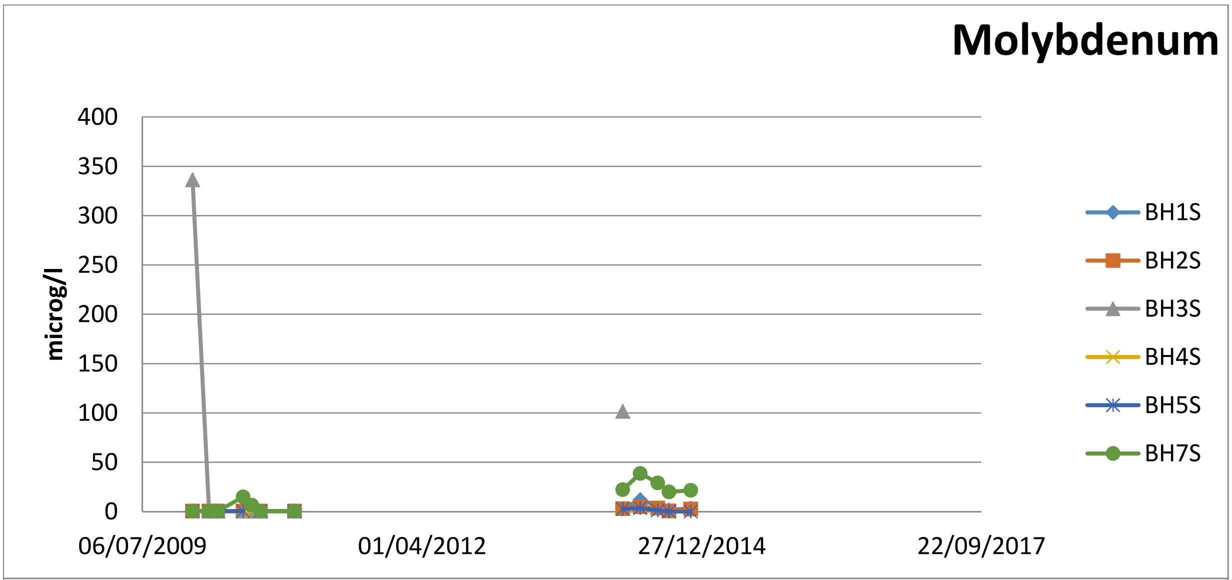
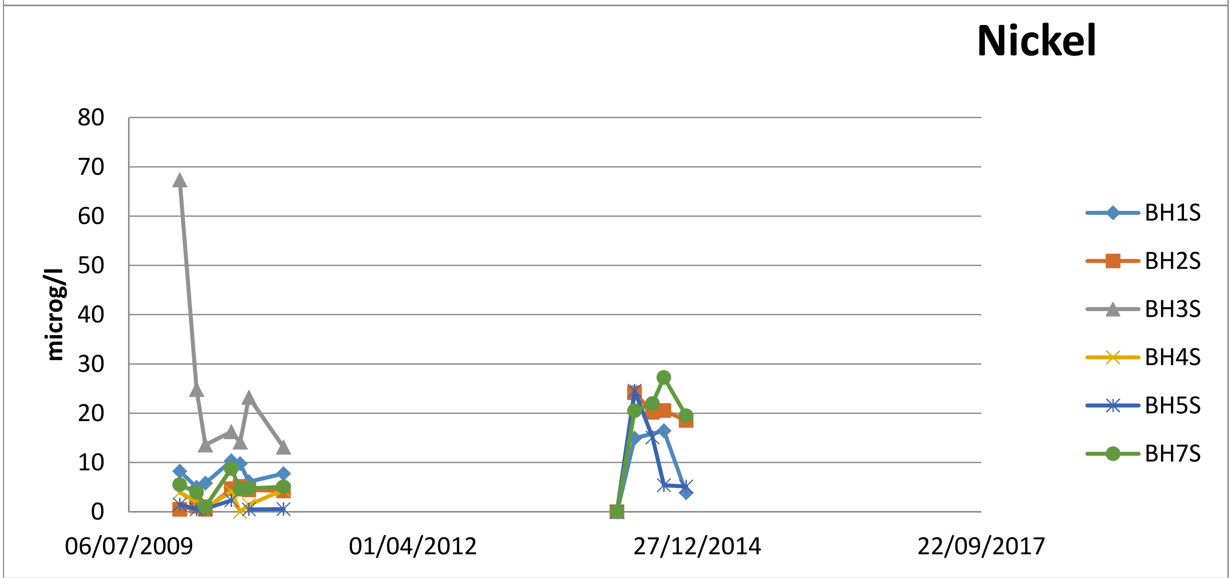
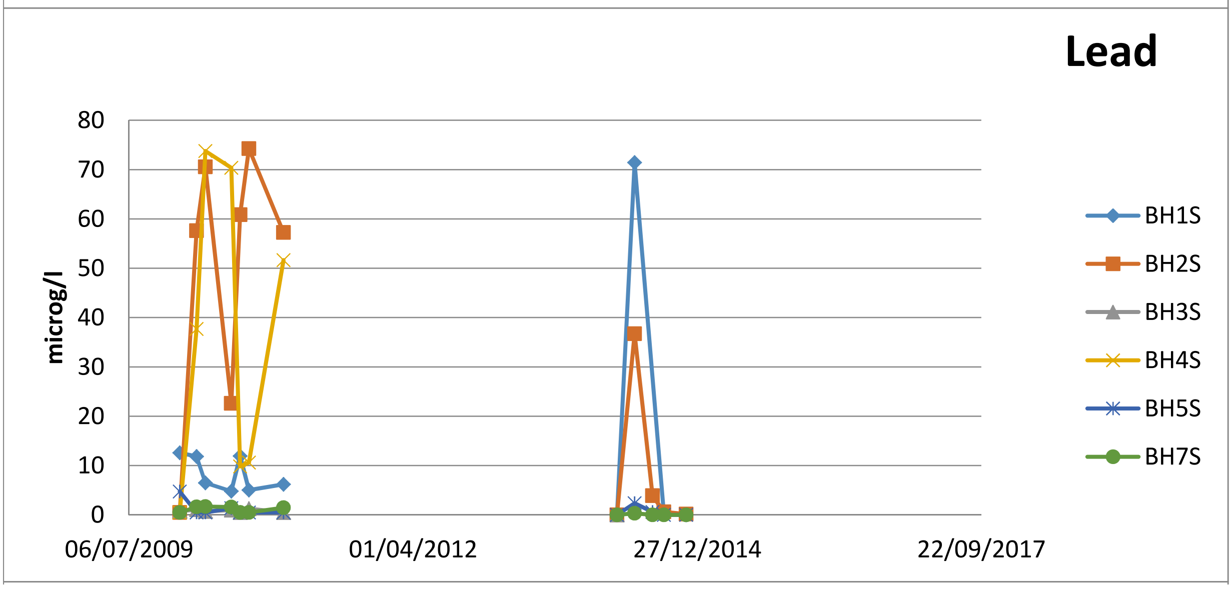
BH3S
BH4S
BH5S
BH7S

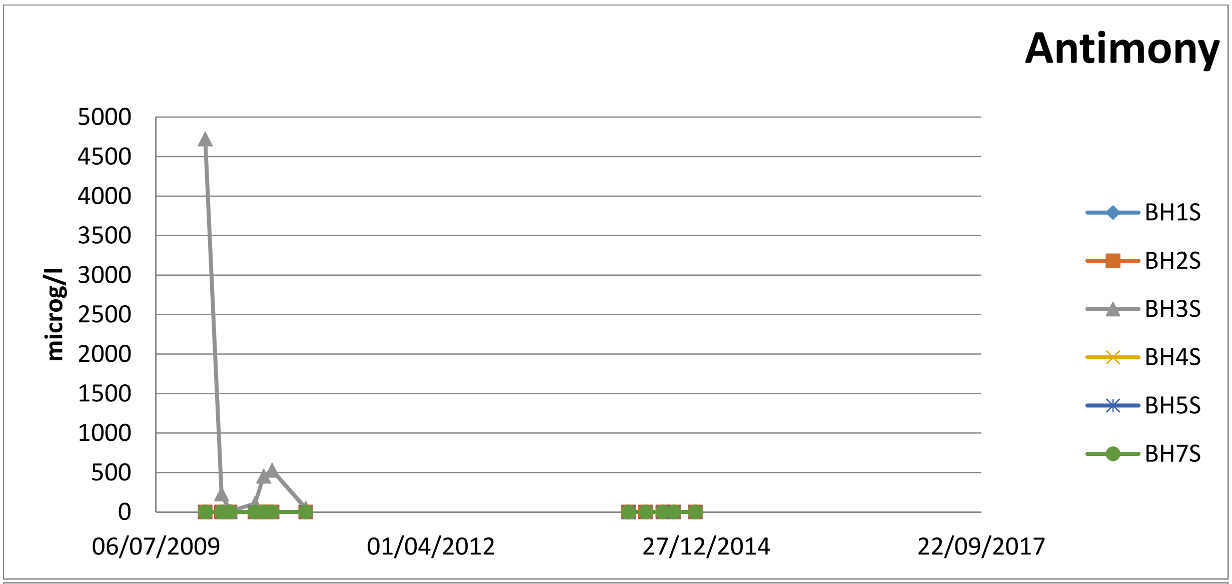

Iron
6
5
4
3
2
1
0
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

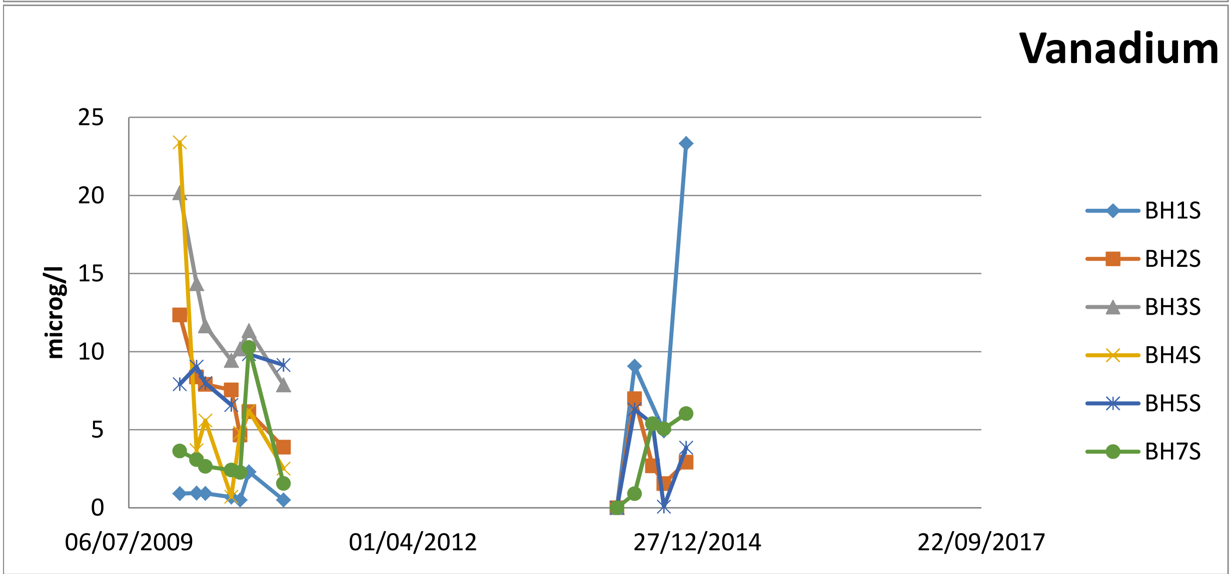

Manganese
800
700
600
500
400
300
200
100
0
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

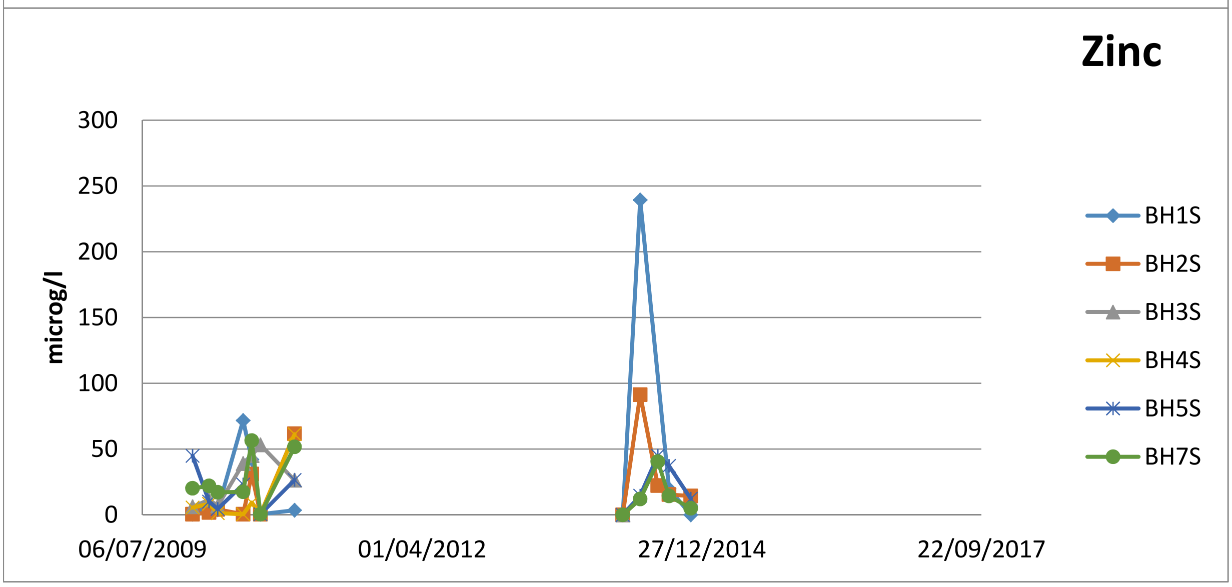

Molybdenum
400
350
300
250
200
150
100
50
0
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

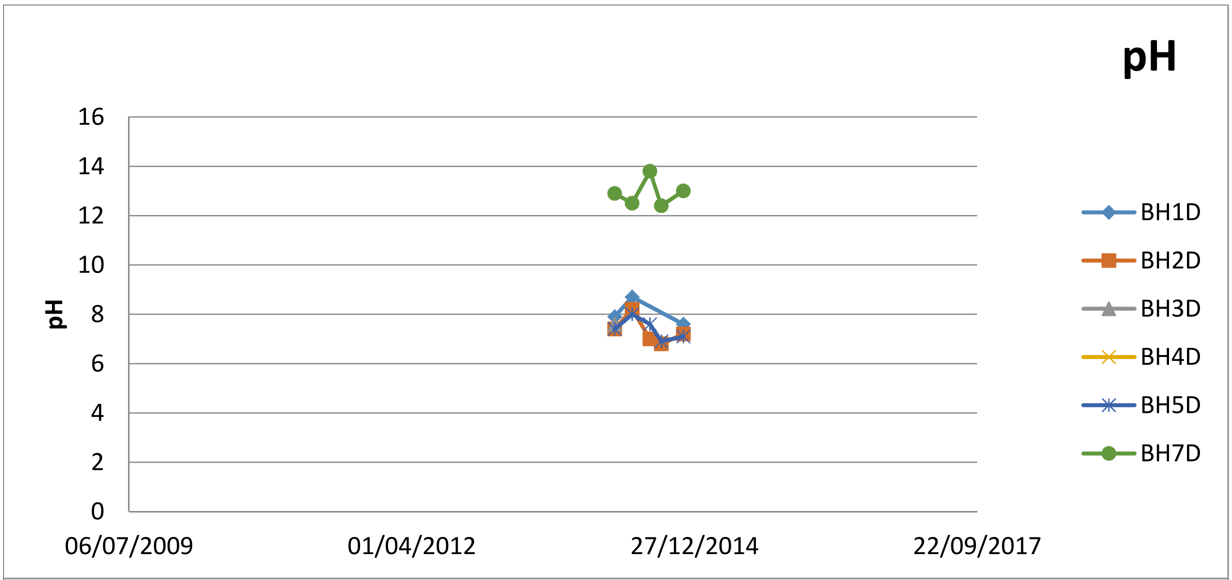

Nickel
80
70
60
50
40
30
20
10
0
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

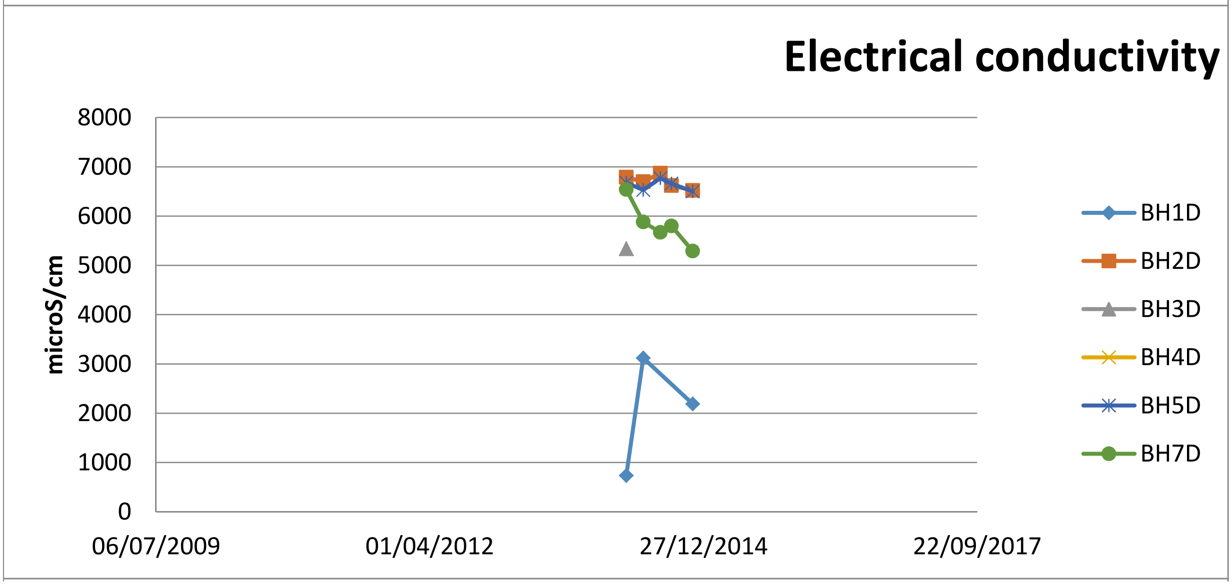

Lead
80
70
60
50
40
30
20
10
0
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

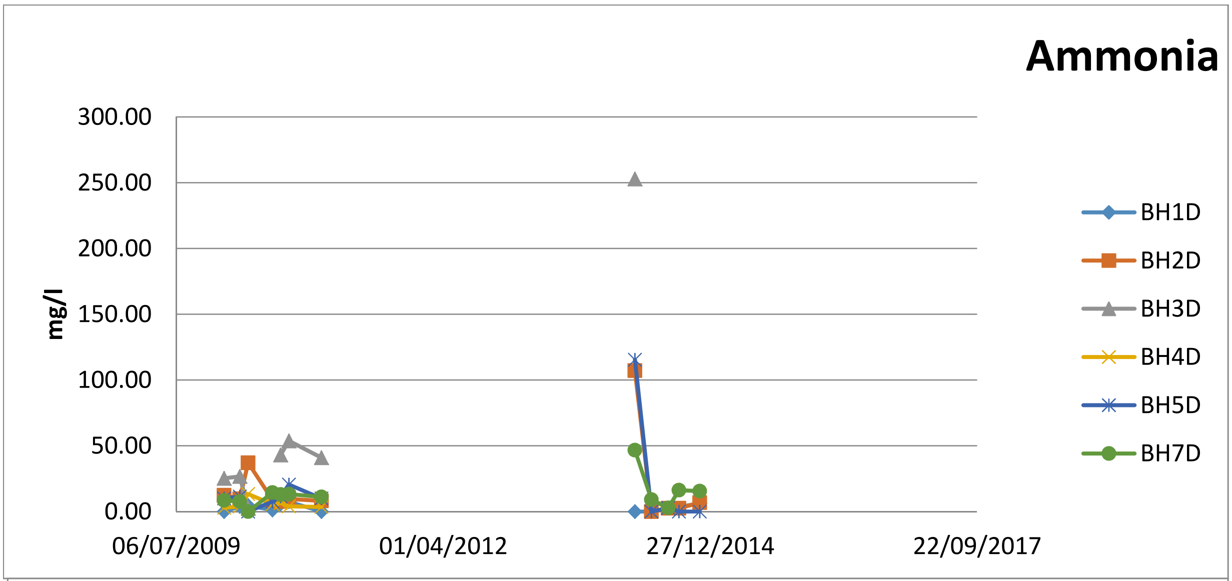

Antimony
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

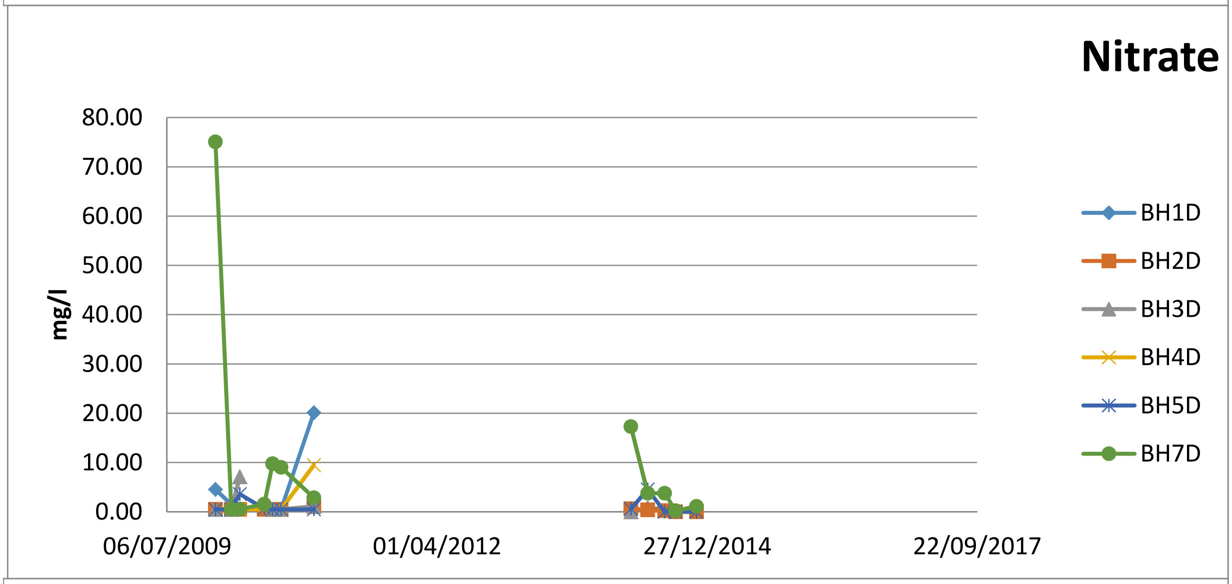

Vanadium
25
20
15
10
5
0
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

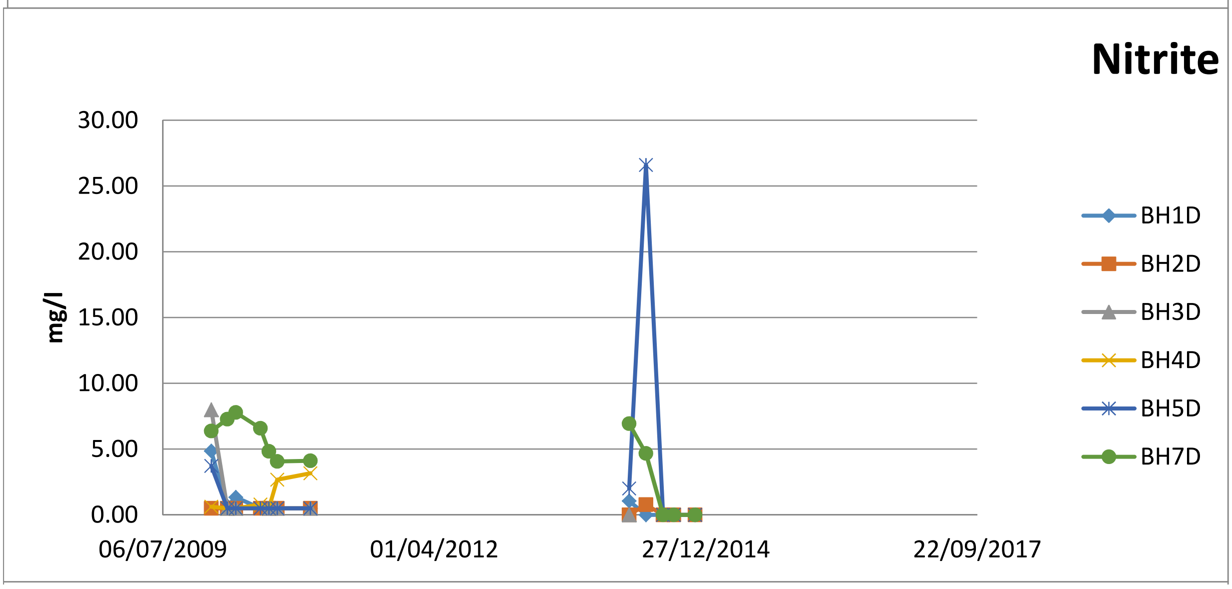

Zinc
300
250
200
150
100
50
0
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

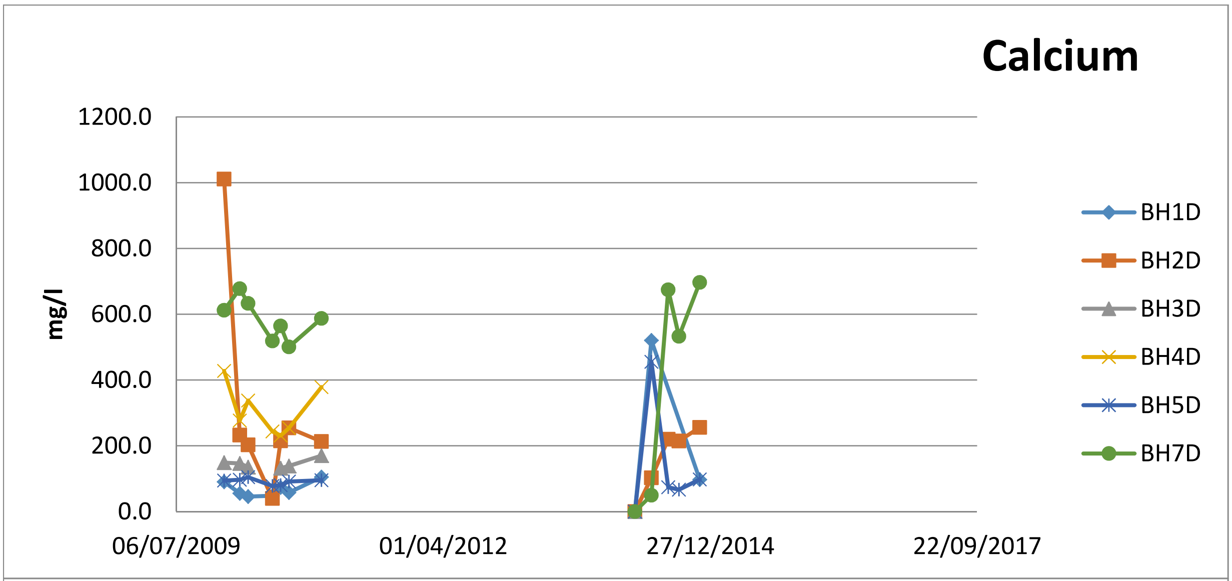

pH
16
14
12
10
8
6
4
2
0
pH
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

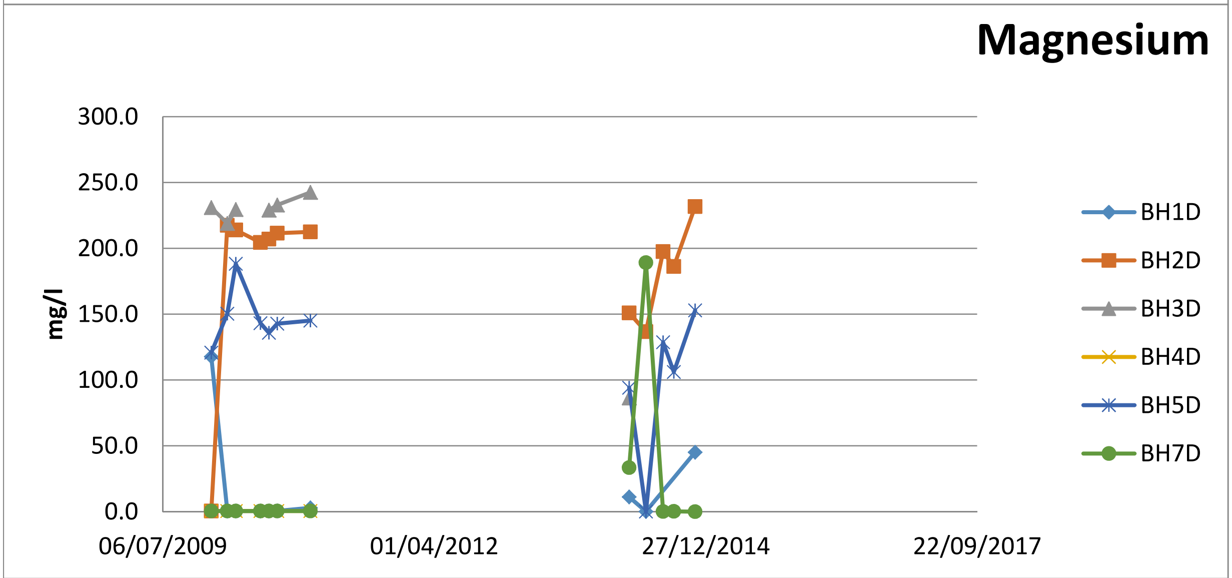

Electrical conductivity
8000
7000
6000
5000
4000
3000
2000
1000
0
microS/cm
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

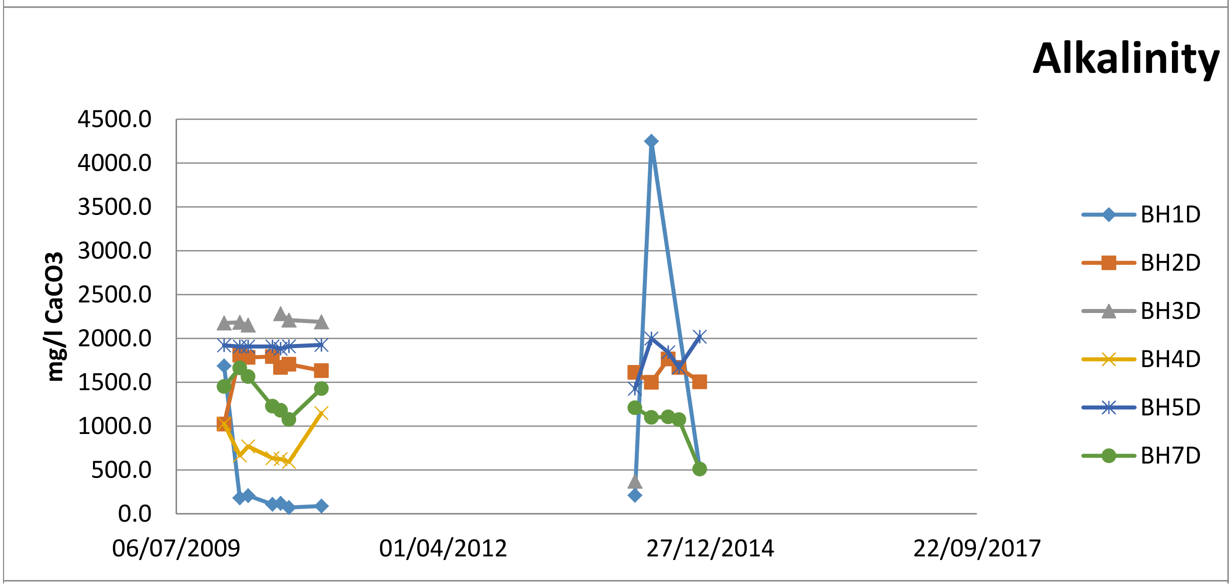

Ammonia
300.00
250.00
200.00
150.00
100.00
50.00
0.00
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

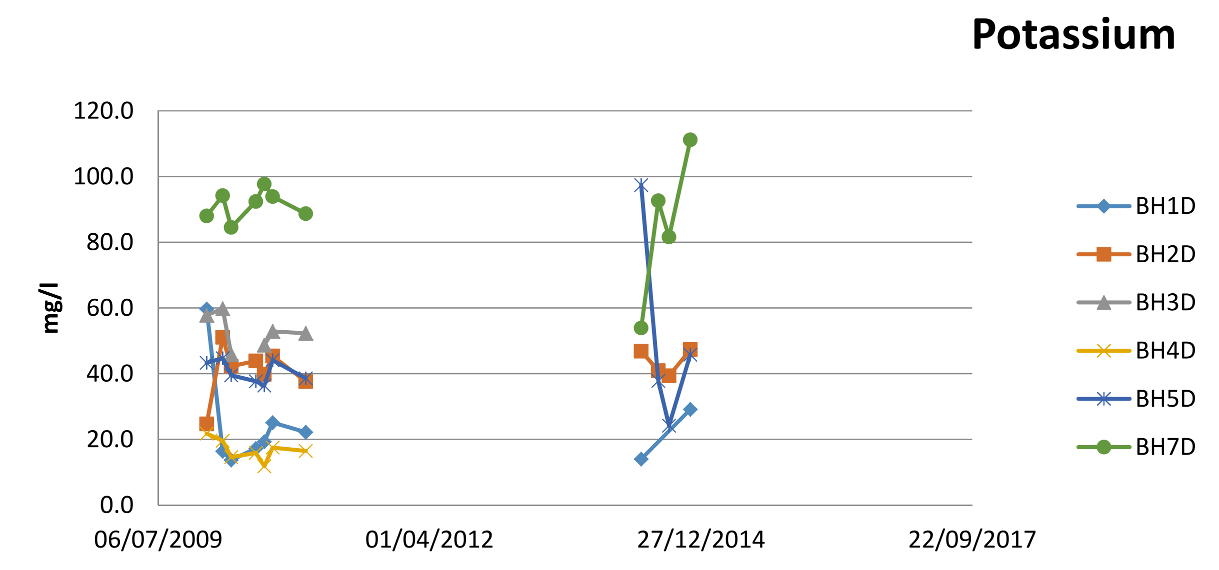

Nitrate
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

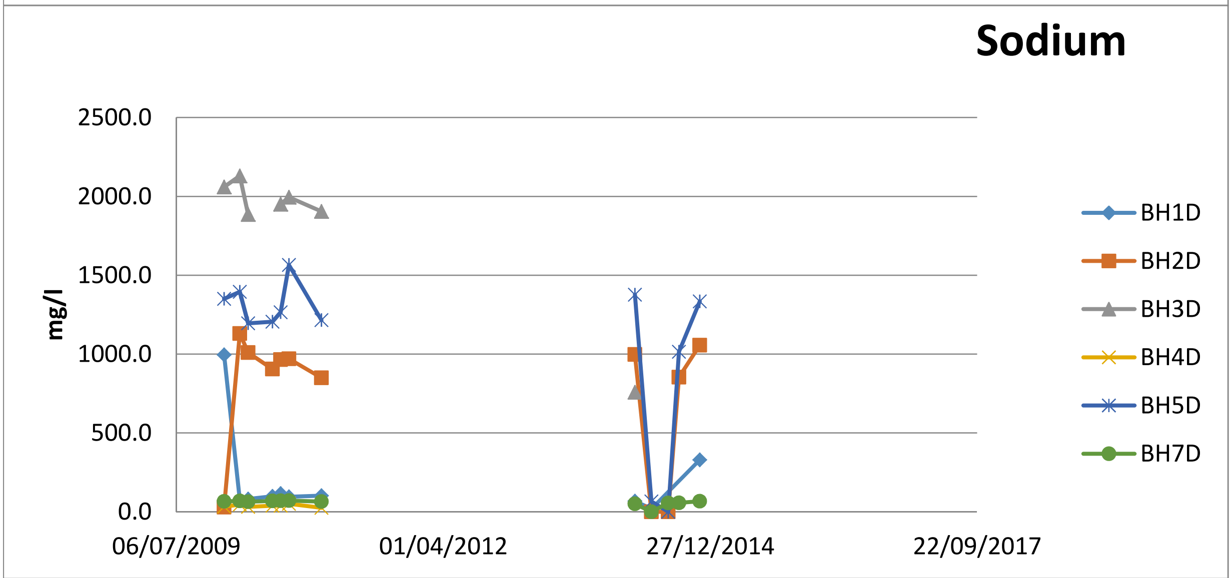

Nitrite
30.00
25.00
20.00
15.00
10.00
5.00
0.00
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

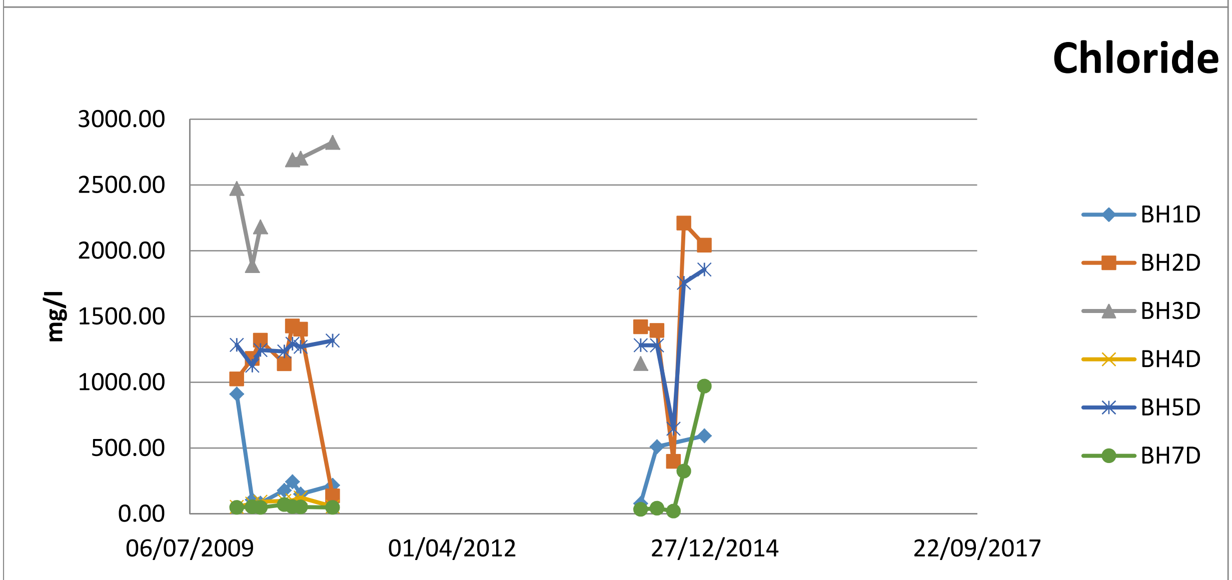

Calcium
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

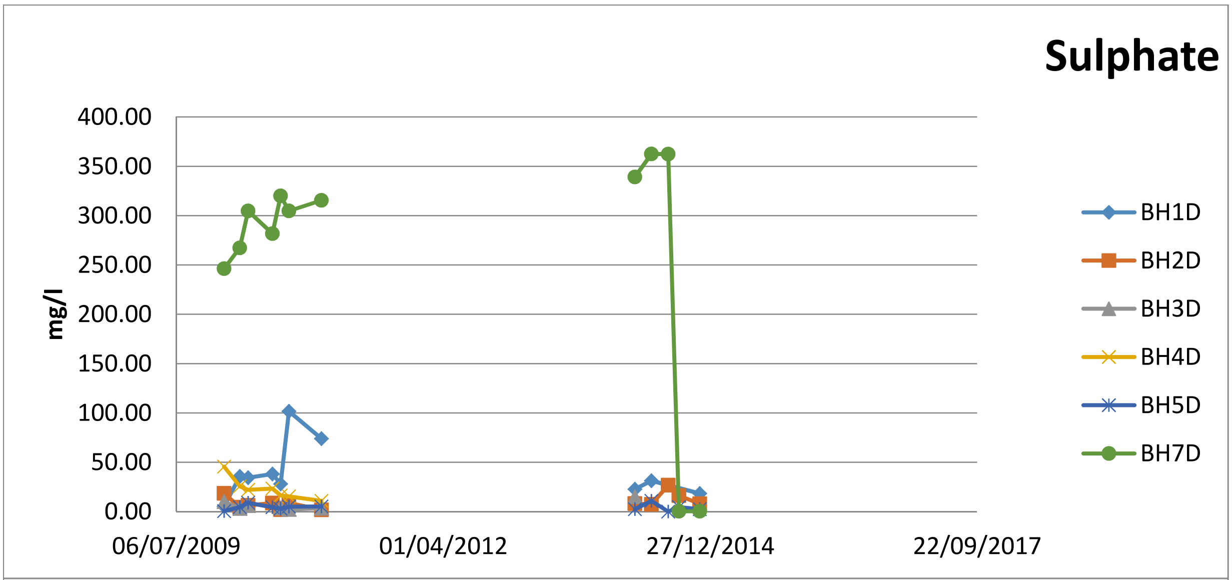

Magnesium
300.0
250.0
200.0
150.0
100.0
50.0
0.0
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

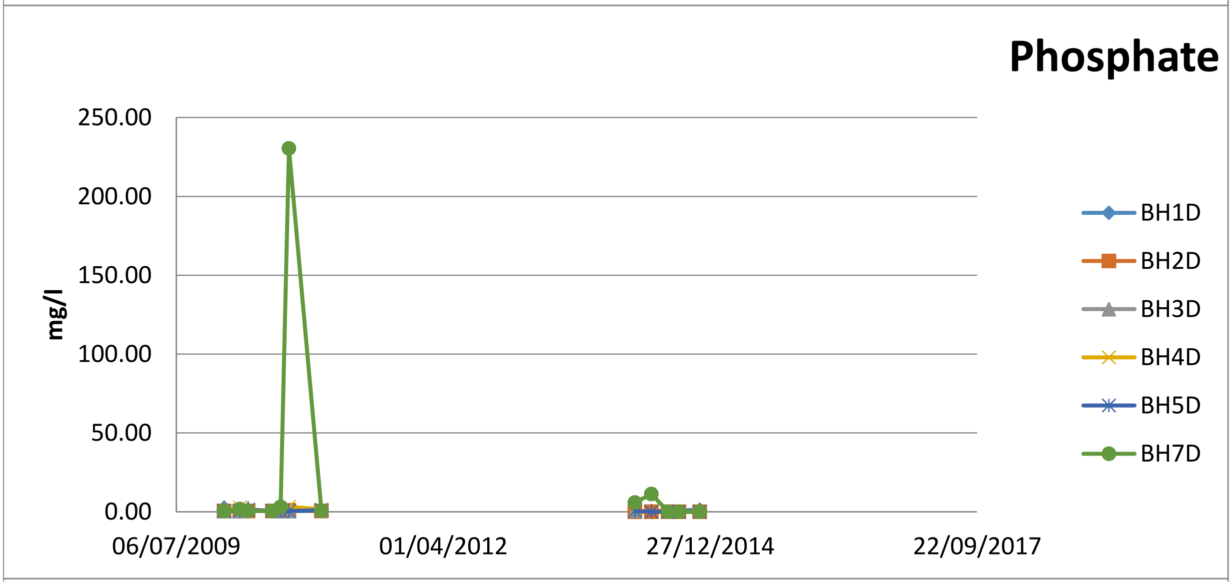

Alkalinity
4500.0
4000.0
3500.0
3000.0
2500.0
2000.0
1500.0
1000.0
500.0
0.0
mg/l CaCO3
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

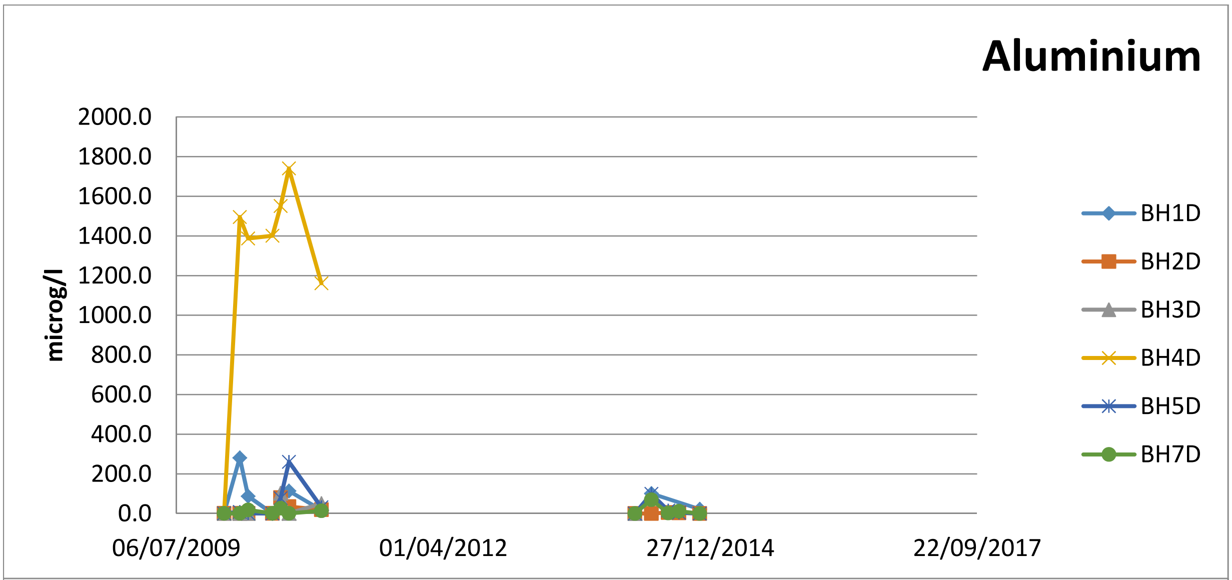

Potassium
120.0
100.0
80.0
60.0
40.0
20.0
0.0
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

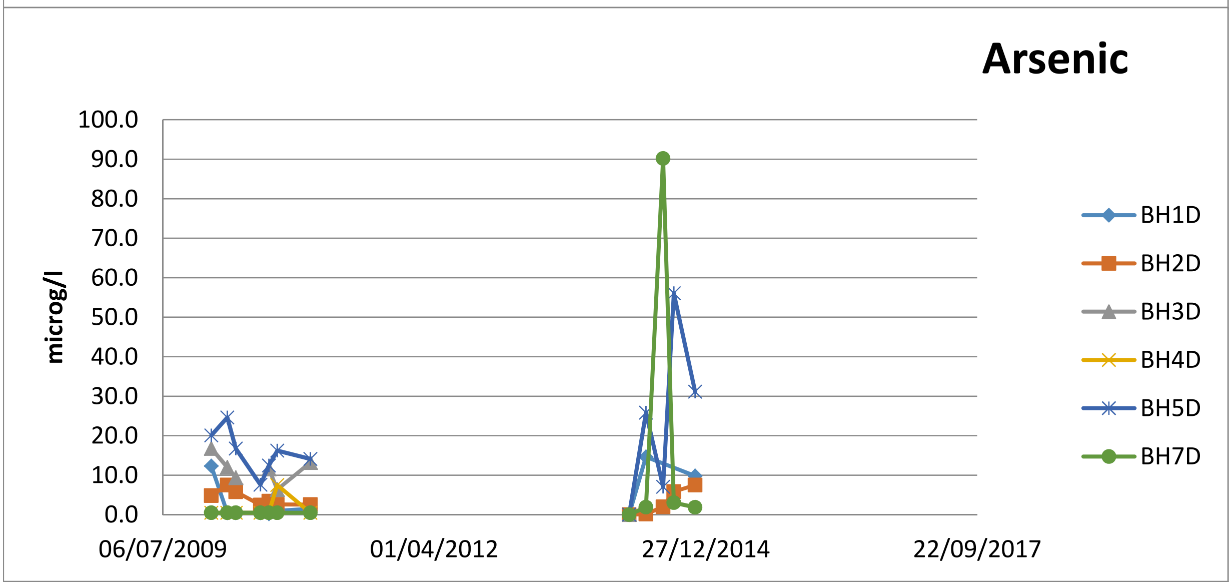

Sodium
2500.0
2000.0
1500.0
1000.0
500.0
0.0
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

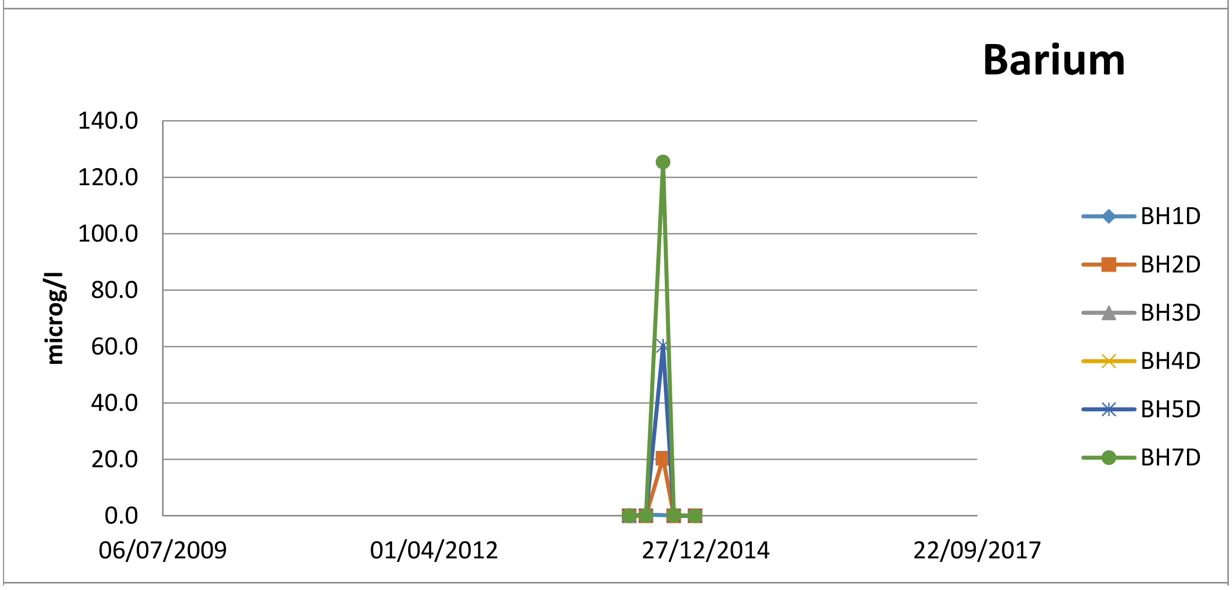

Chloride
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

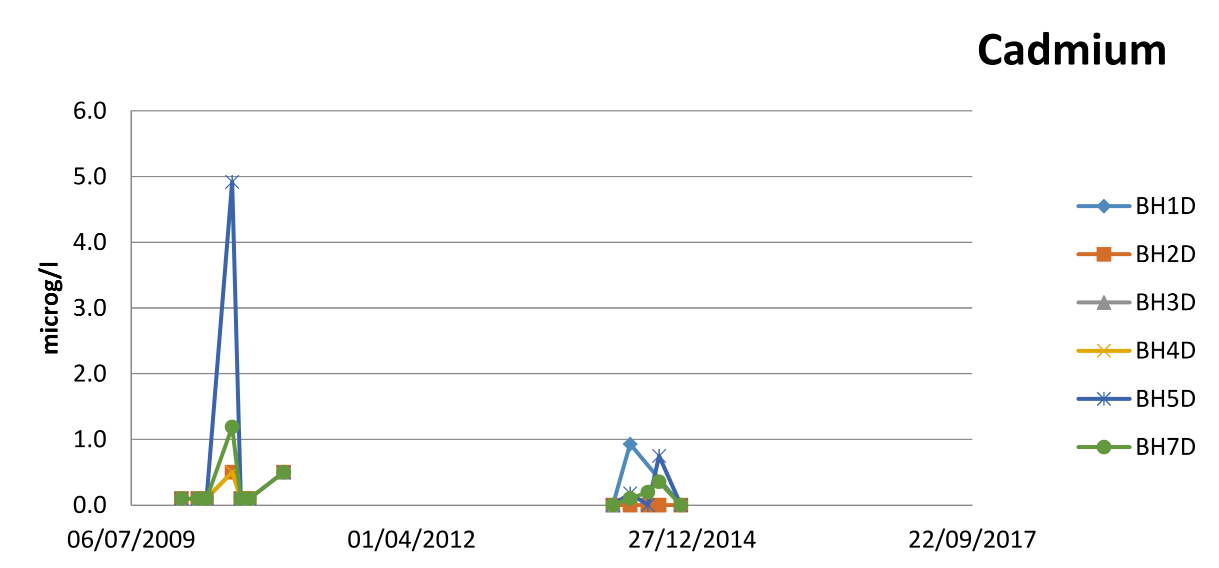

Sulphate
mg/l
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

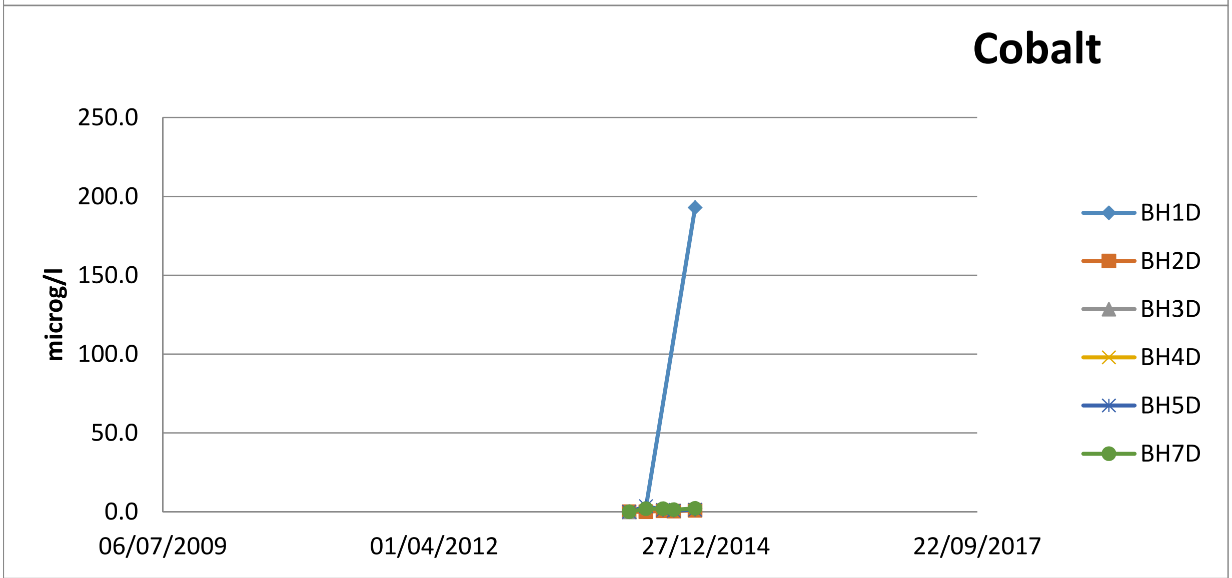

Phosphate
mg/l
250.00
200.00
150.00
100.00
50.00
0.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

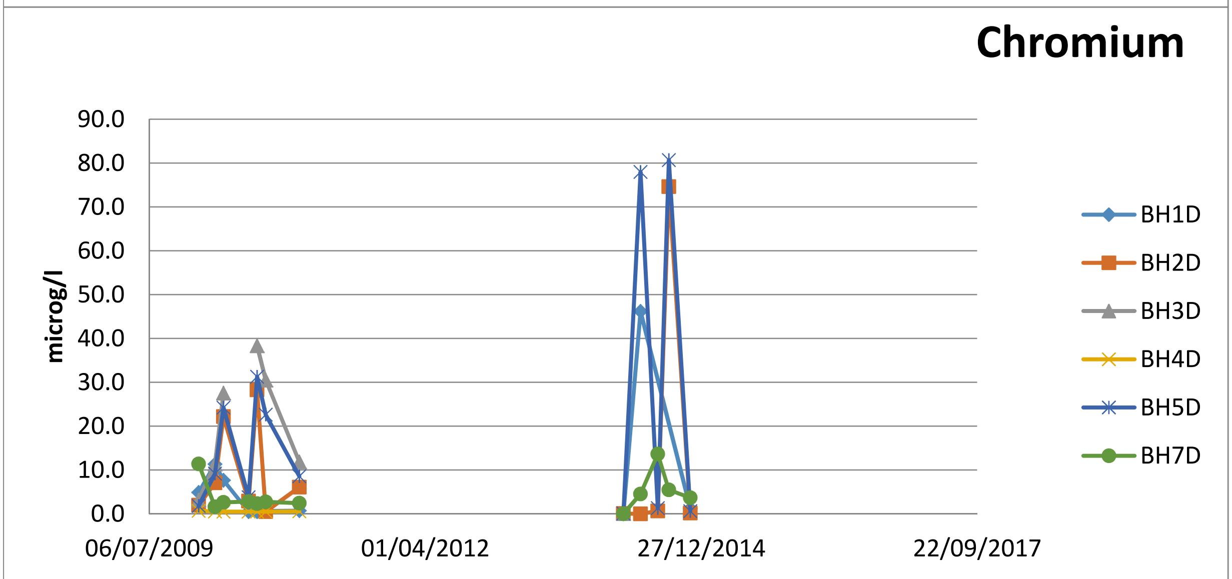

Aluminium
microg/l
2000.0
1800.0
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

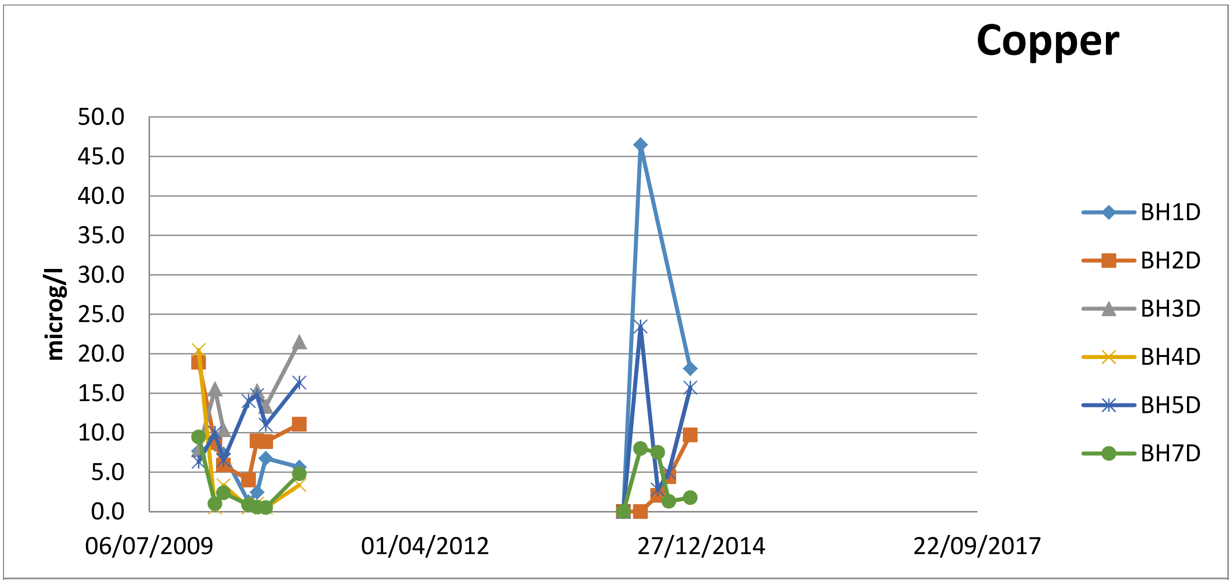

Arsenic
microg/l
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

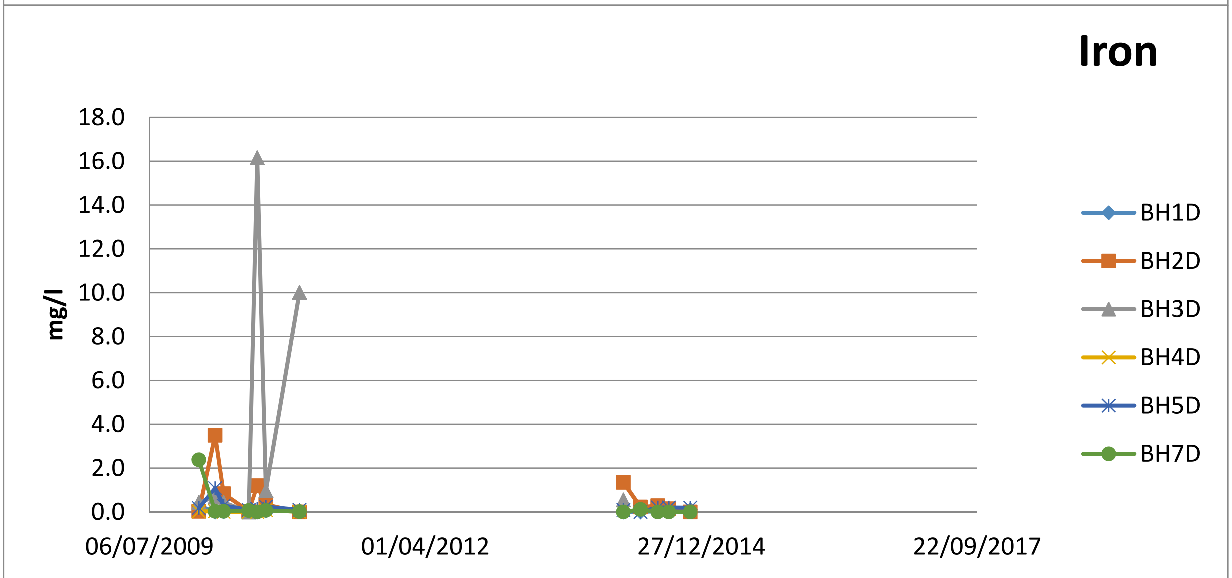

Barium
microg/l
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

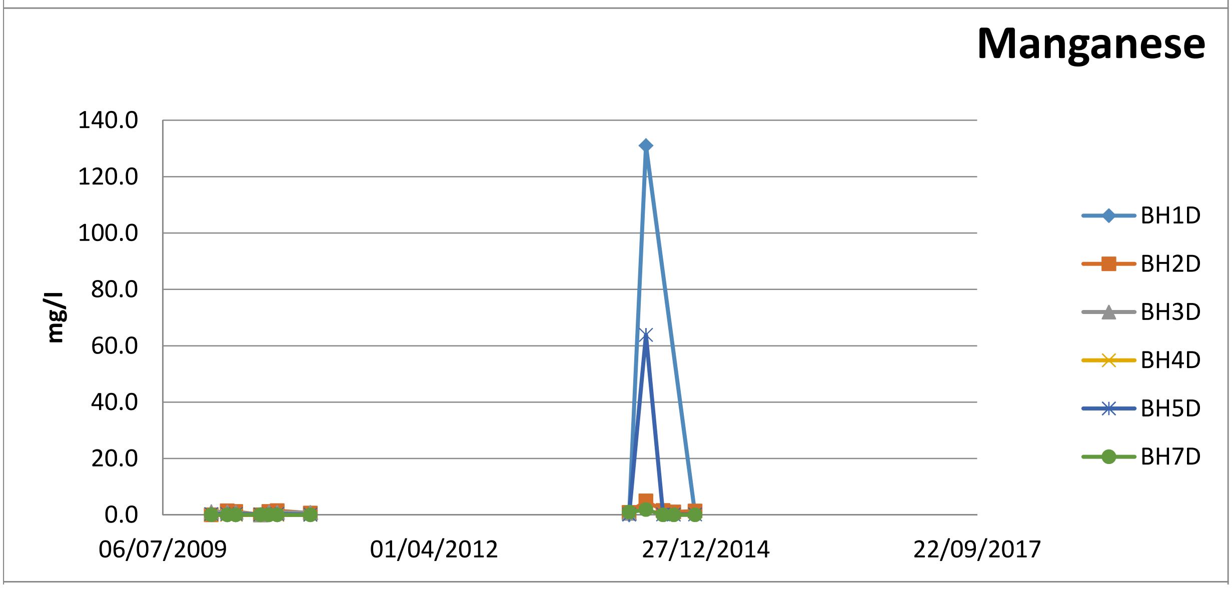

Cadmium
6.0
5.0
4.0
3.0
2.0
1.0
0.0
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

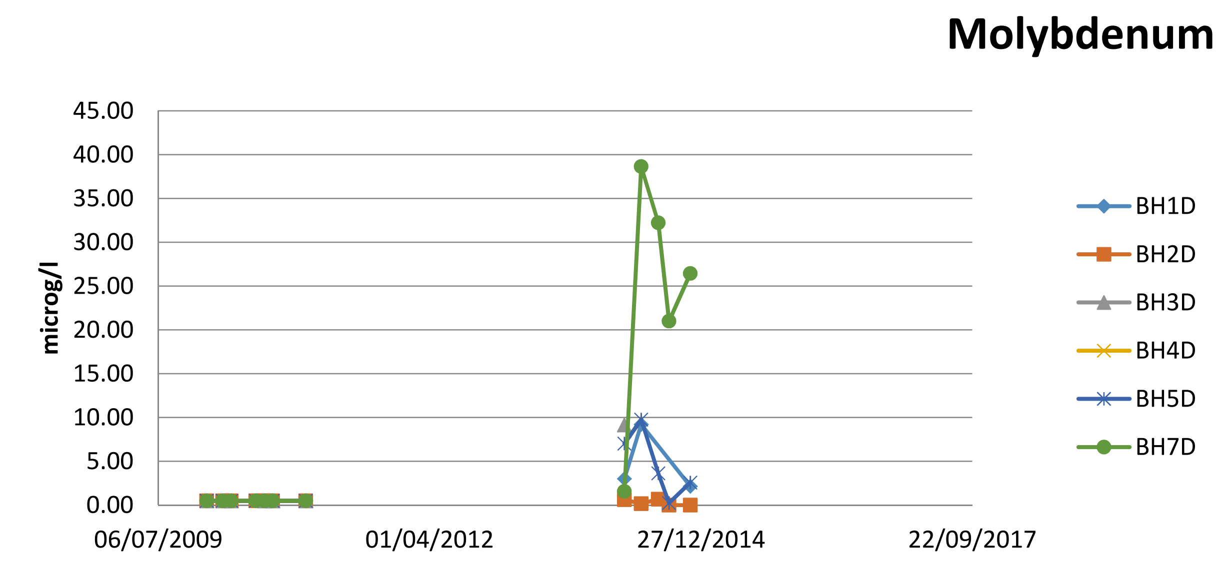

Cobalt
250.0
200.0
150.0
100.0
50.0
0.0
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

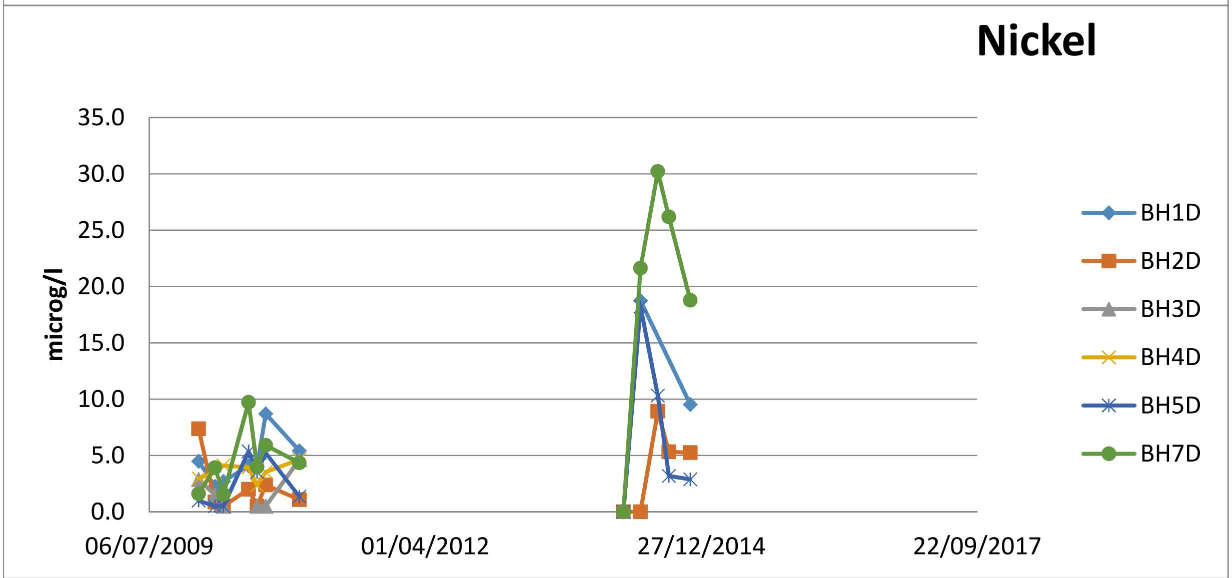

Chromium
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

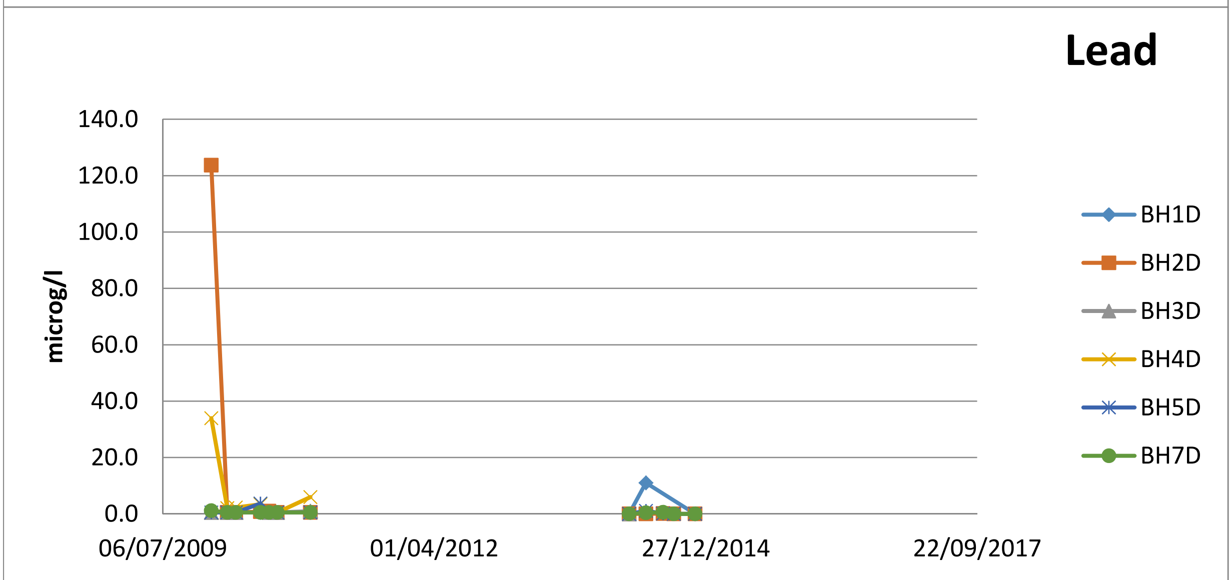

Copper
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

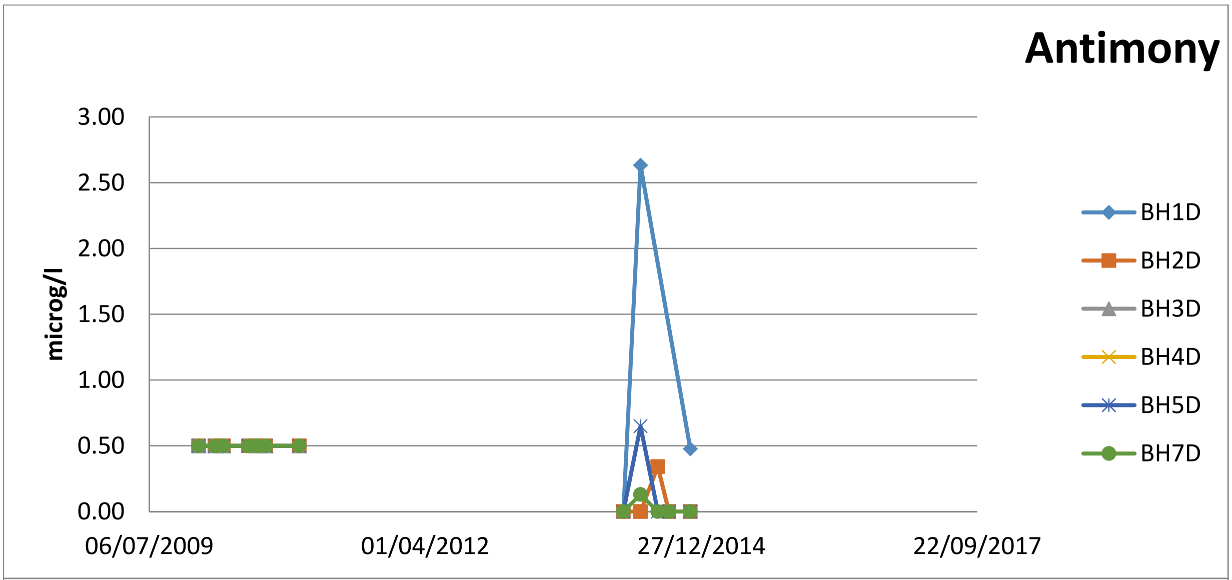

Iron
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

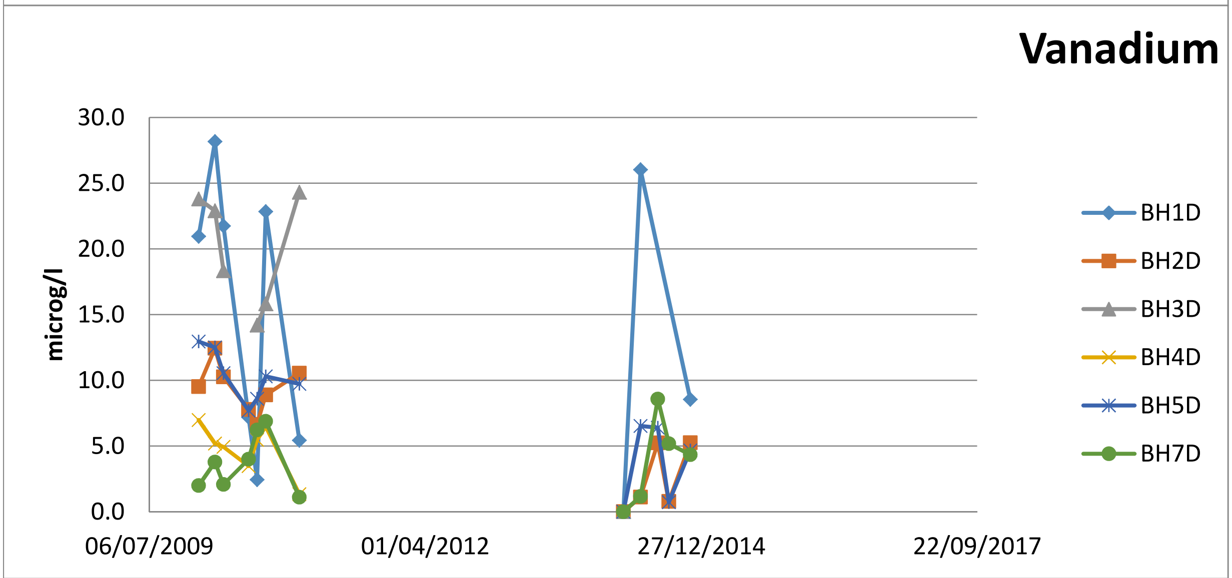

Manganese
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

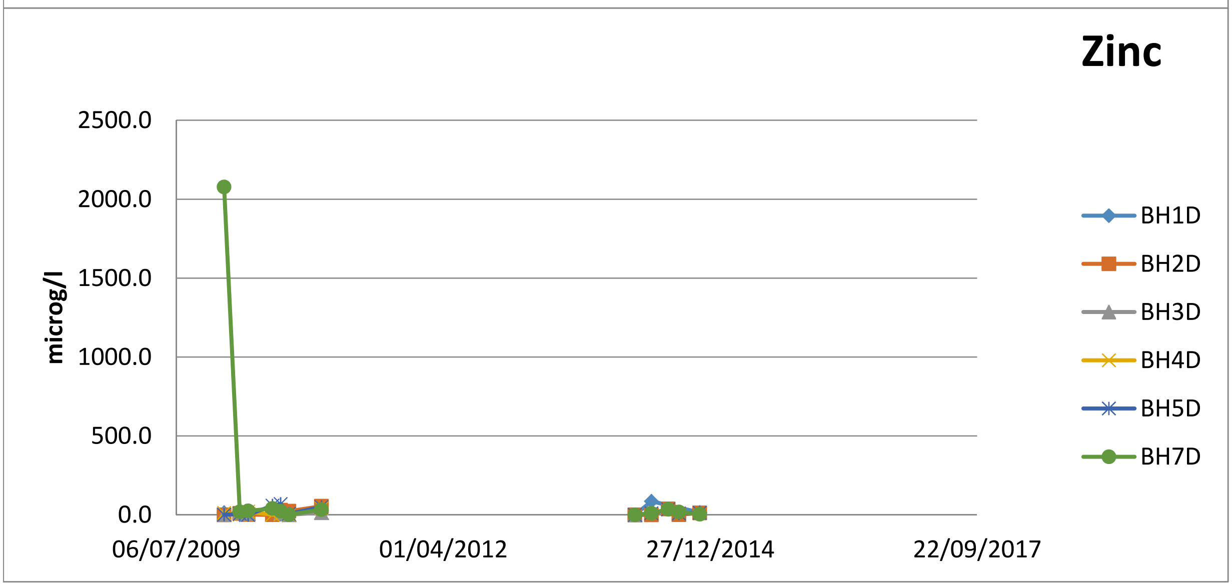

Molybdenum
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D


Nickel
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D


Lead
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D


Antimony
microg/l
3.00
2.50
2.00
1.50
1.00
0.50
0.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D


Vanadium
microg/l
30.0
25.0
20.0
15.0
10.0
5.0
0.0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D


Zinc
microg/l
2500.0
2000.0
1500.0
1000.0
500.0
0.0
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

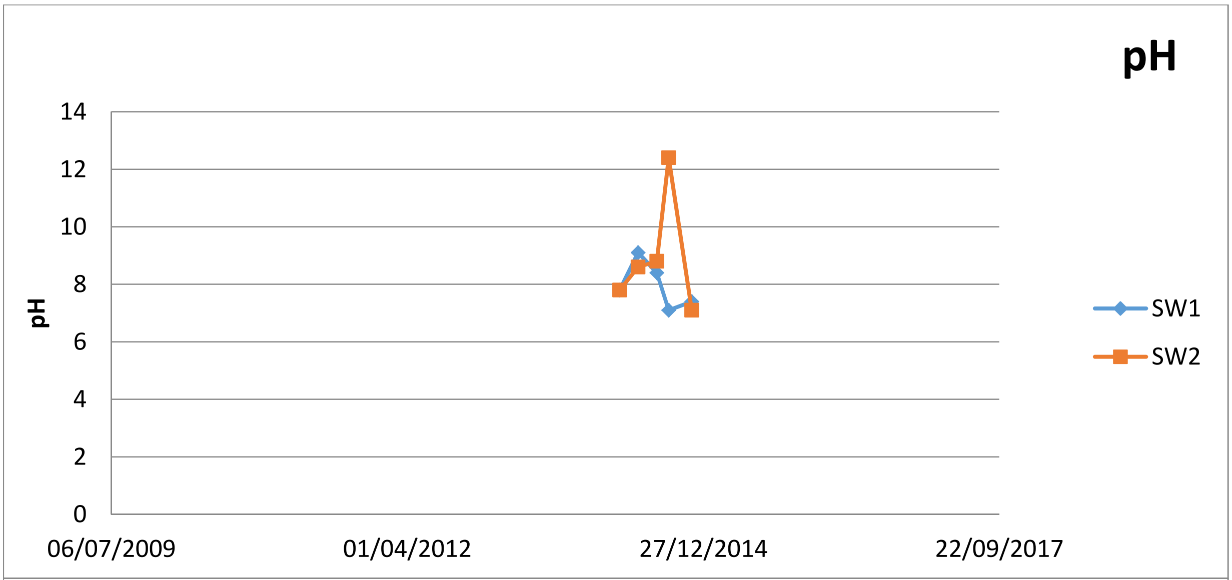
EAST WASTE MANAGEMENT SITE, LLANWERN STEELWORKS

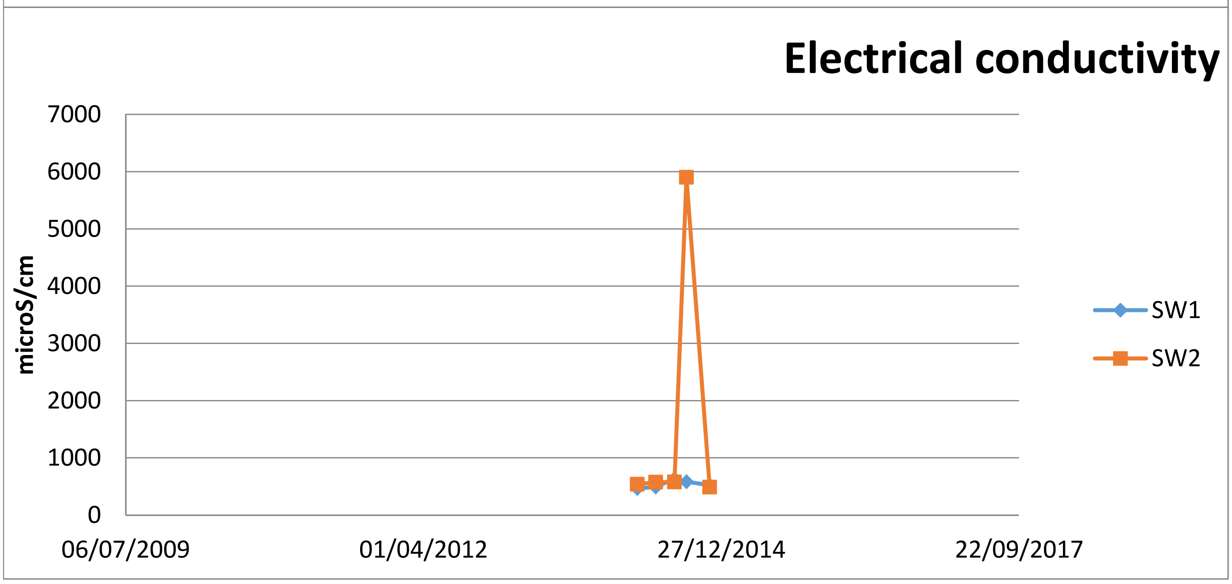
PERMIT EAWML/30003

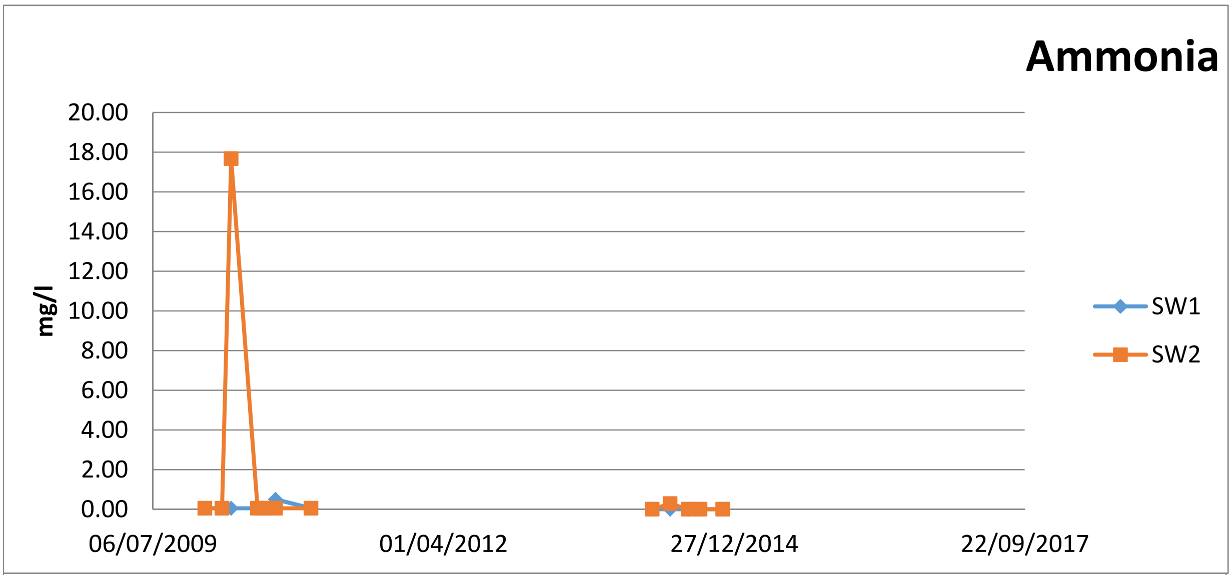
2014 Annual Review of Environmental Monitoring

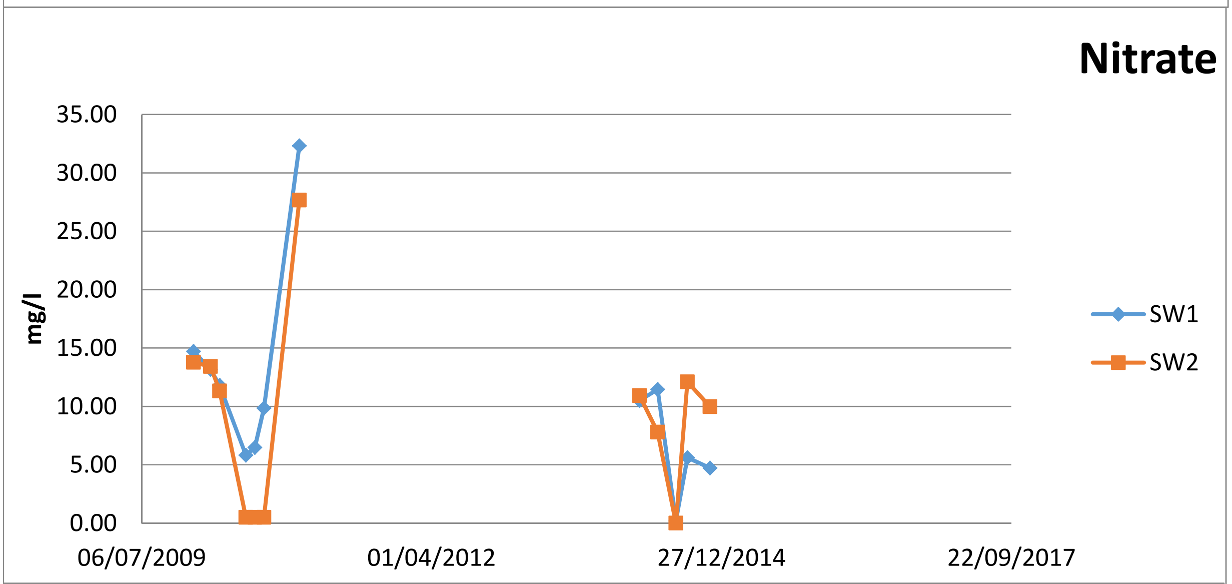
Appendix 2
Temporal Variation of Surface Water Chemistry

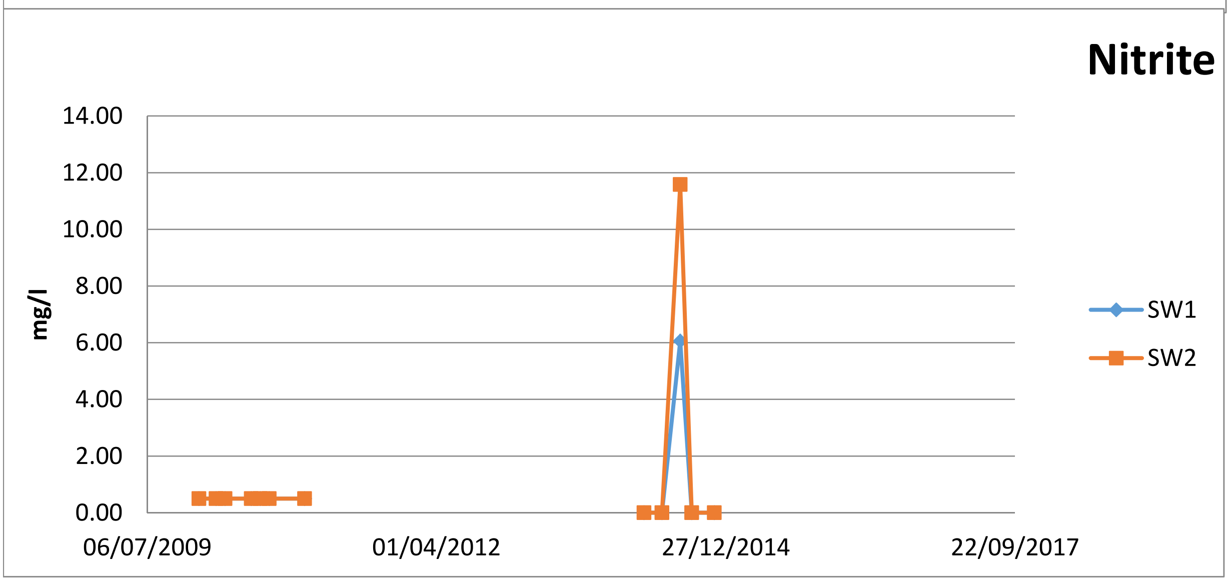
Report Number 1435r1v1d0315

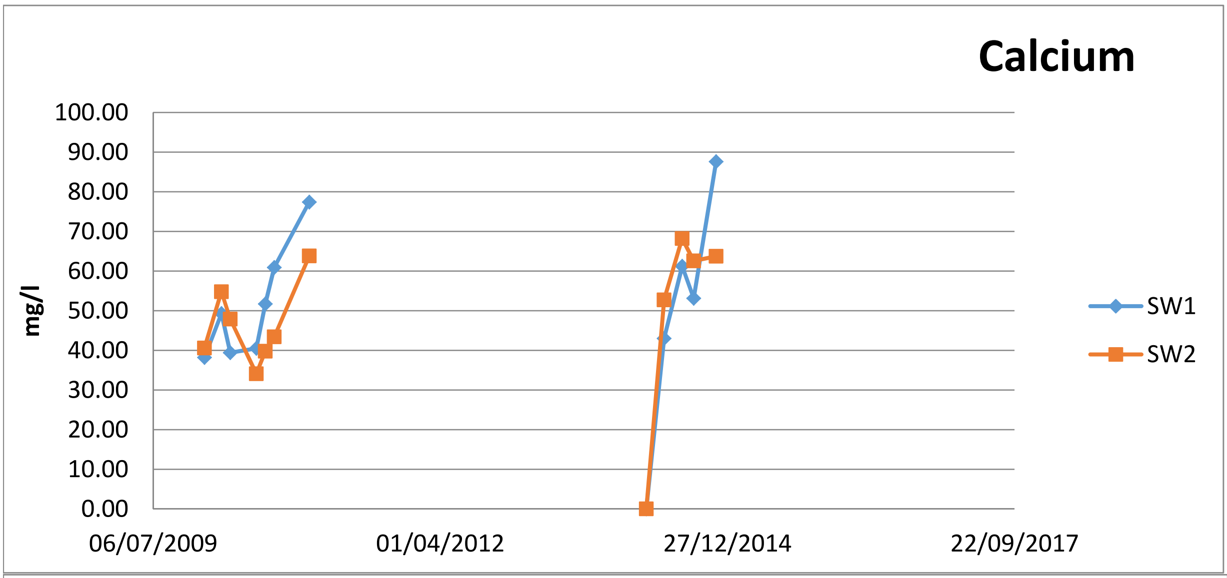

pH
14
12
10
8
6
4
2
0
pH
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

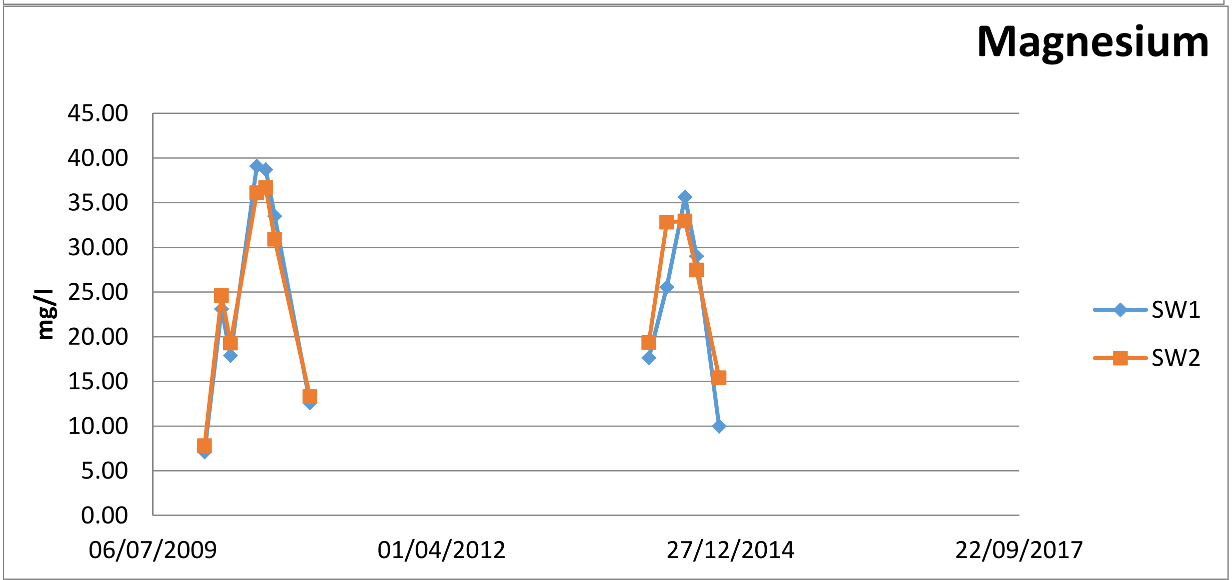

Electrical conductivity
7000
6000
5000
4000
3000
2000
1000
0
microS/cm
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

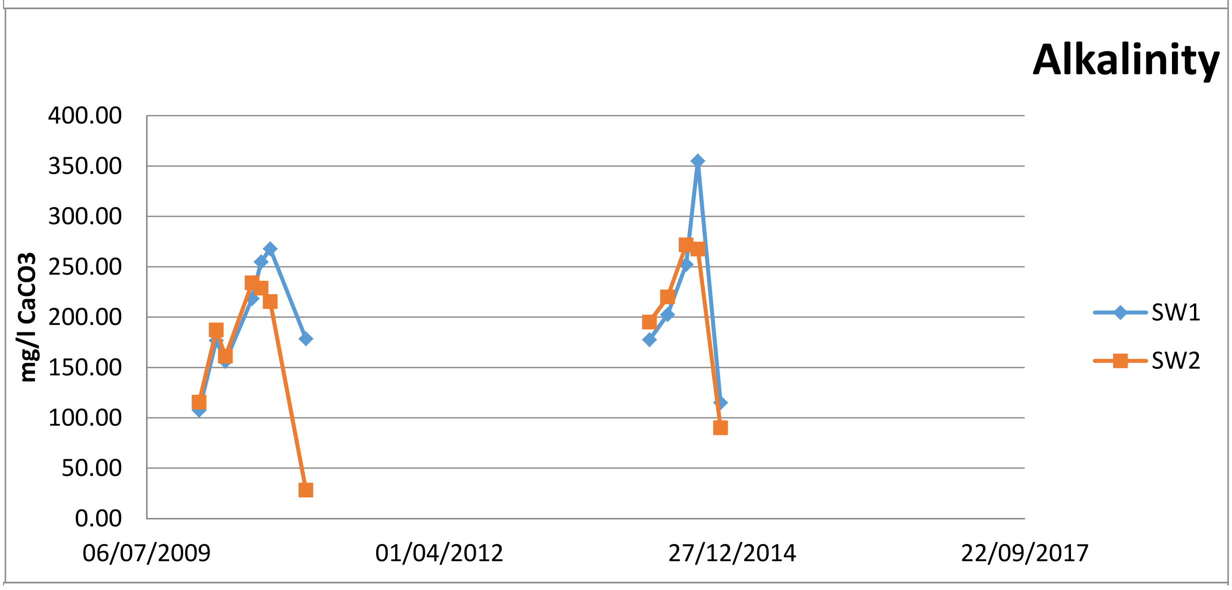

Ammonia
mg/l
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

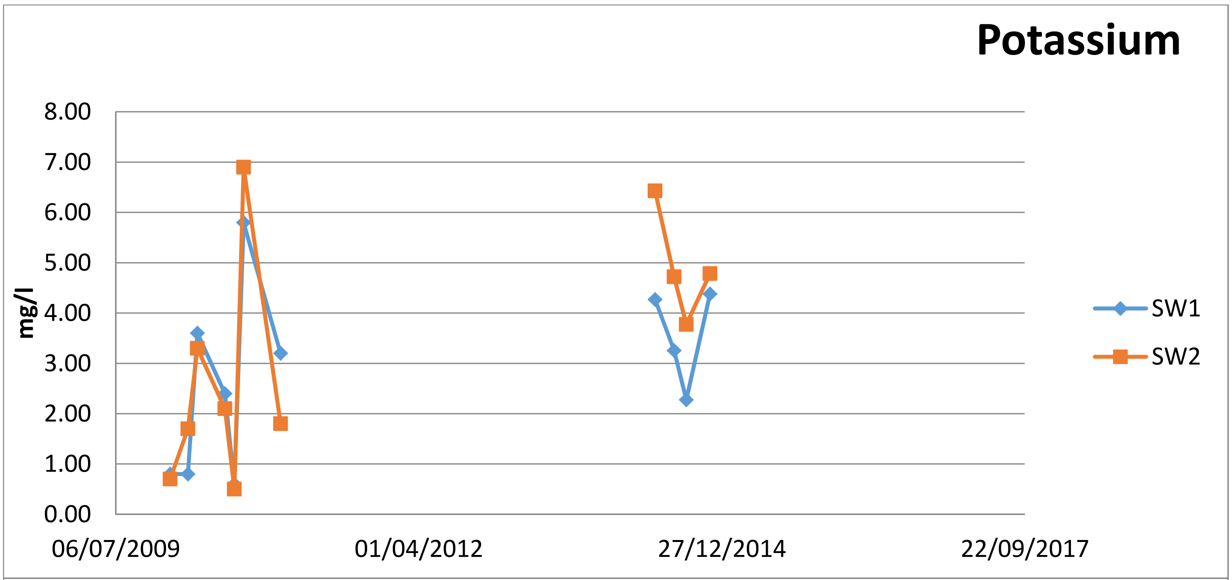

Nitrate
mg/l
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

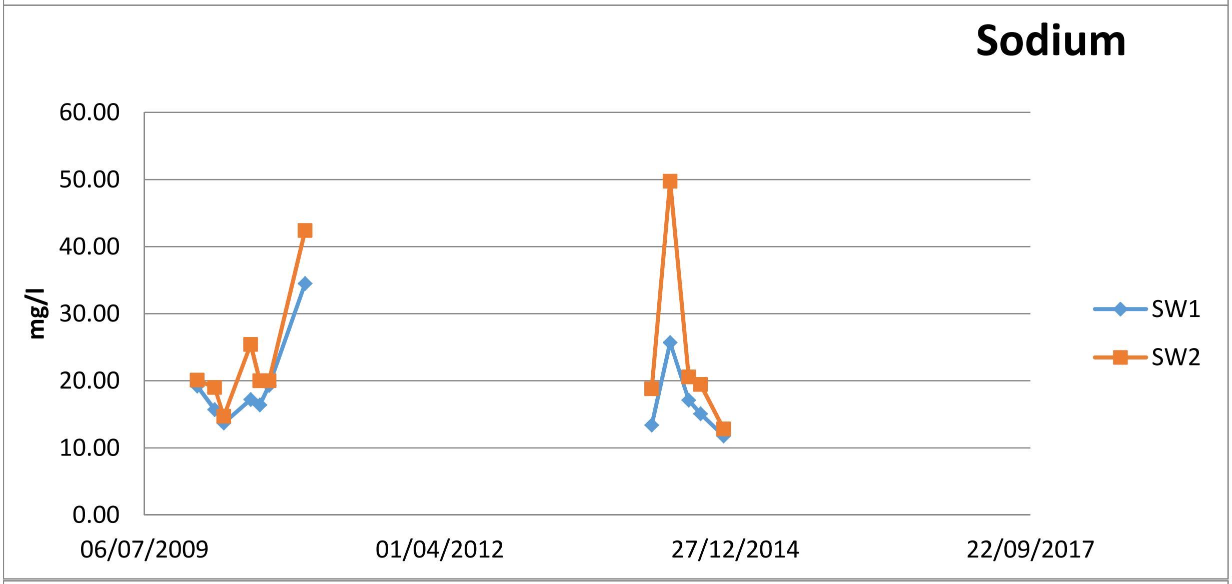

Nitrite
mg/l
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

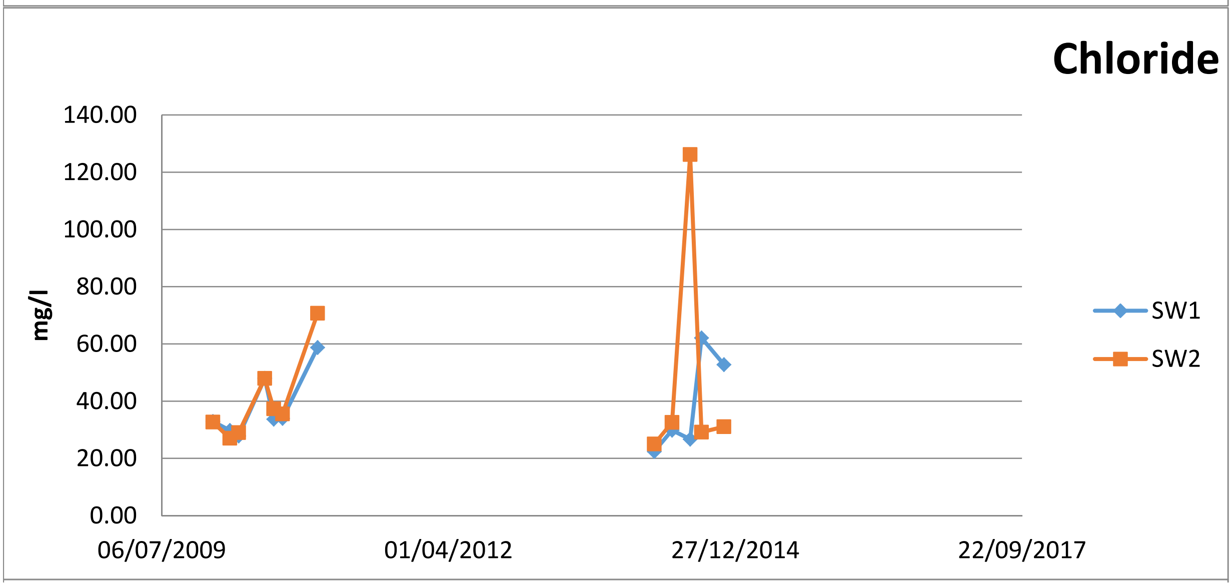

Calcium
mg/l
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

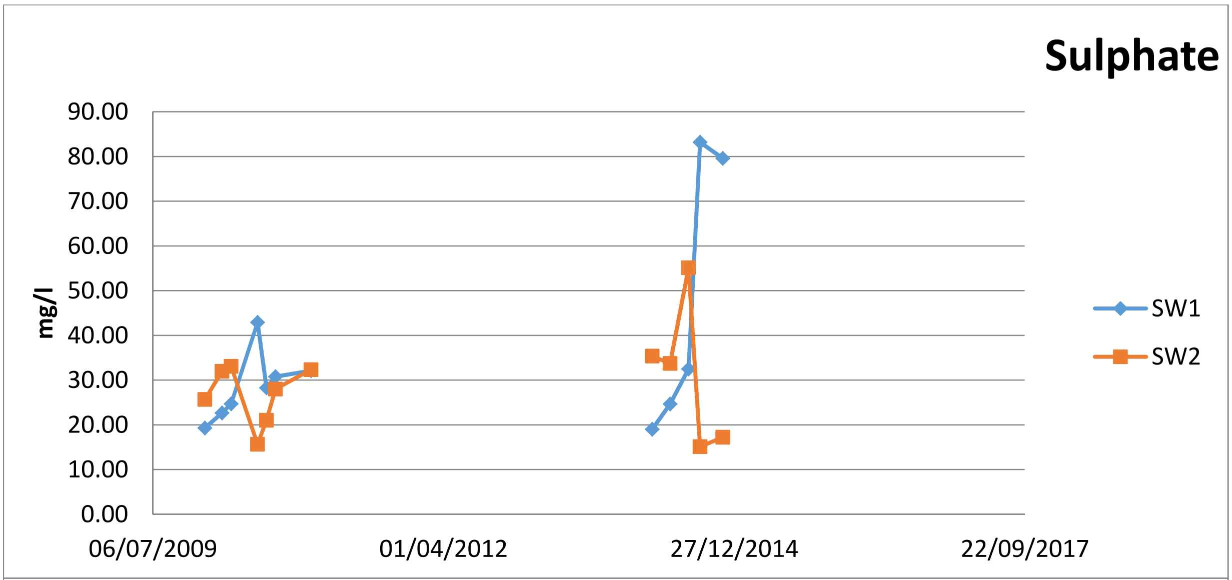

Magnesium
mg/l
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

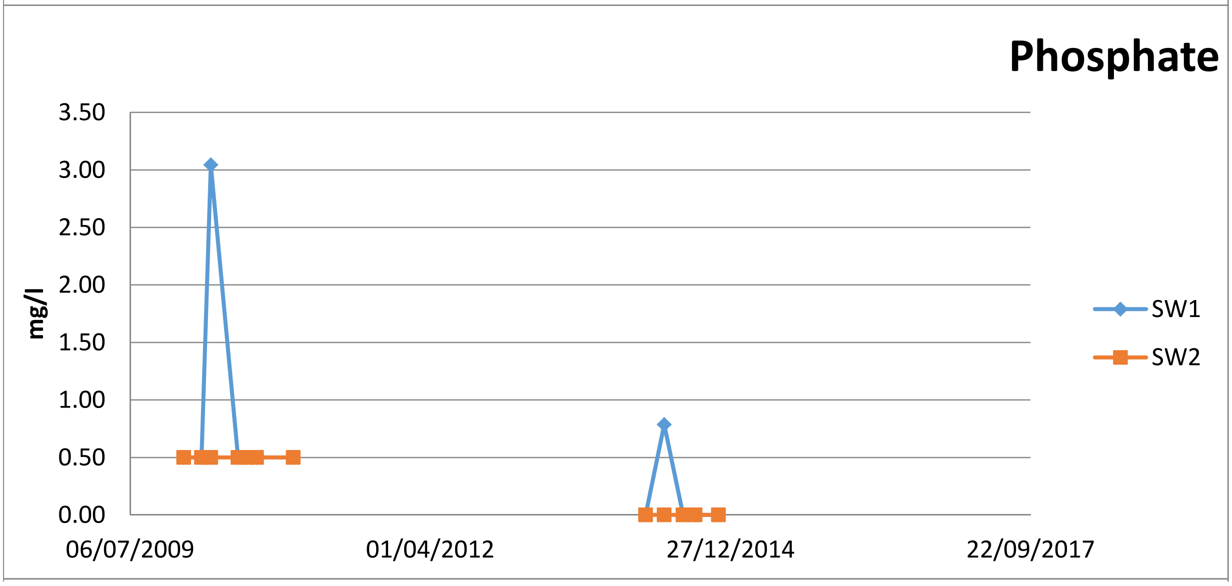

Alkalinity
mg/l CaCO3
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

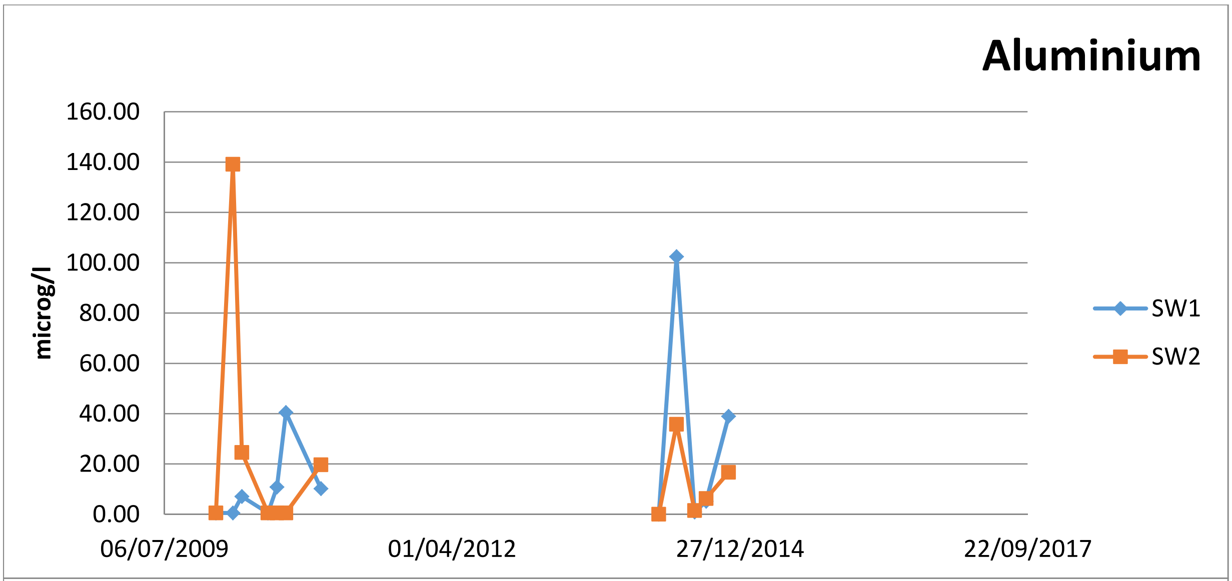

Potassium
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

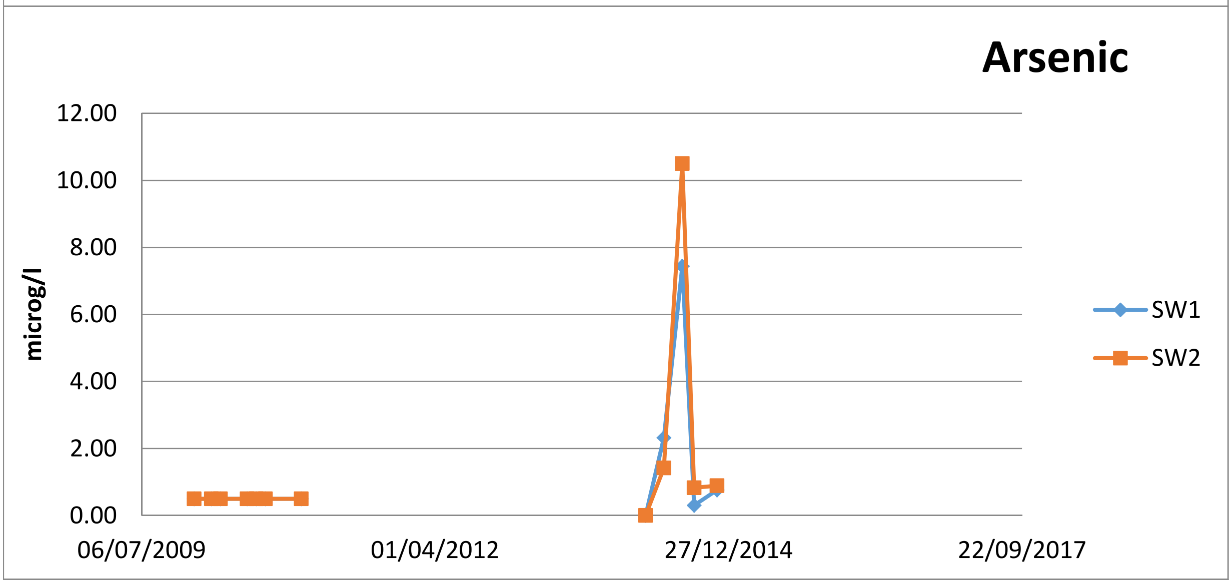

Sodium
60.00
50.00
40.00
30.00
20.00
10.00
0.00
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

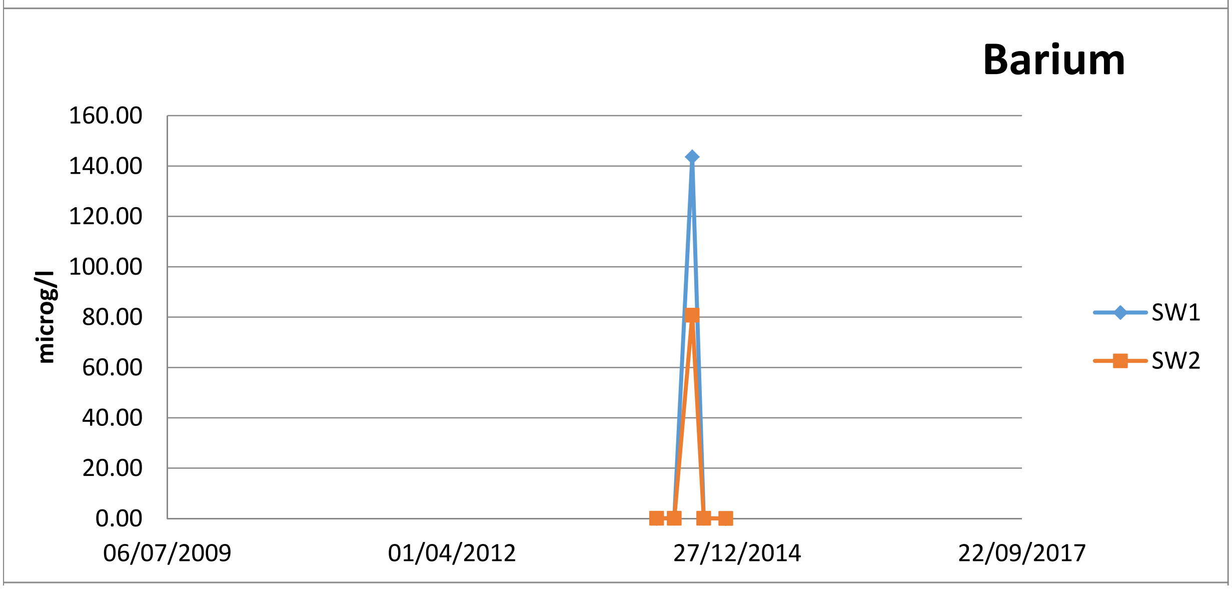

Chloride
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

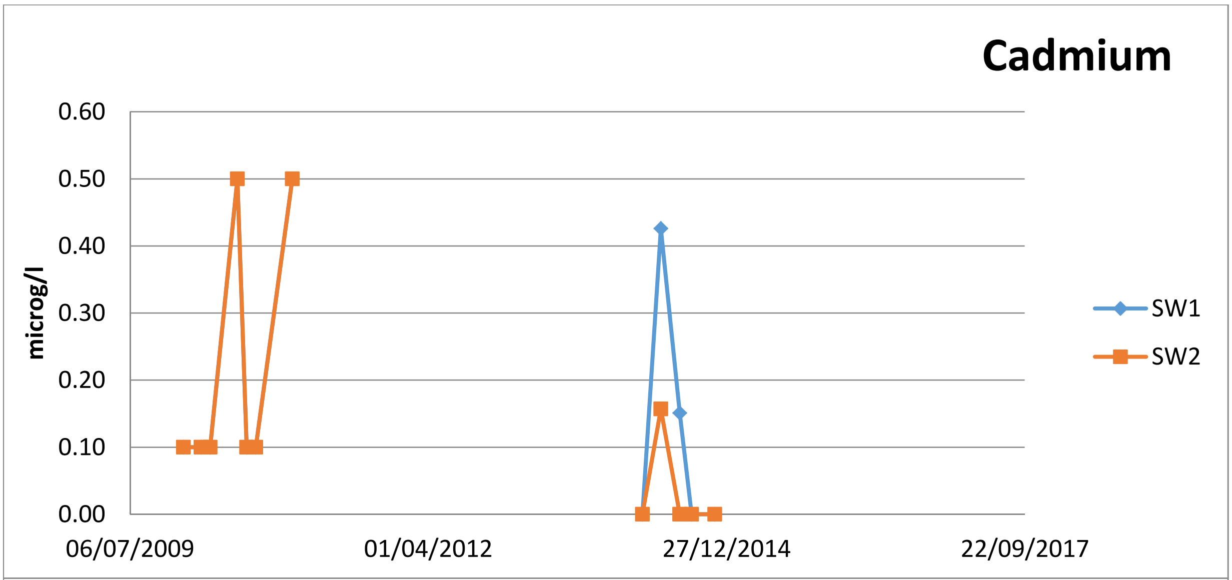

Sulphate
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

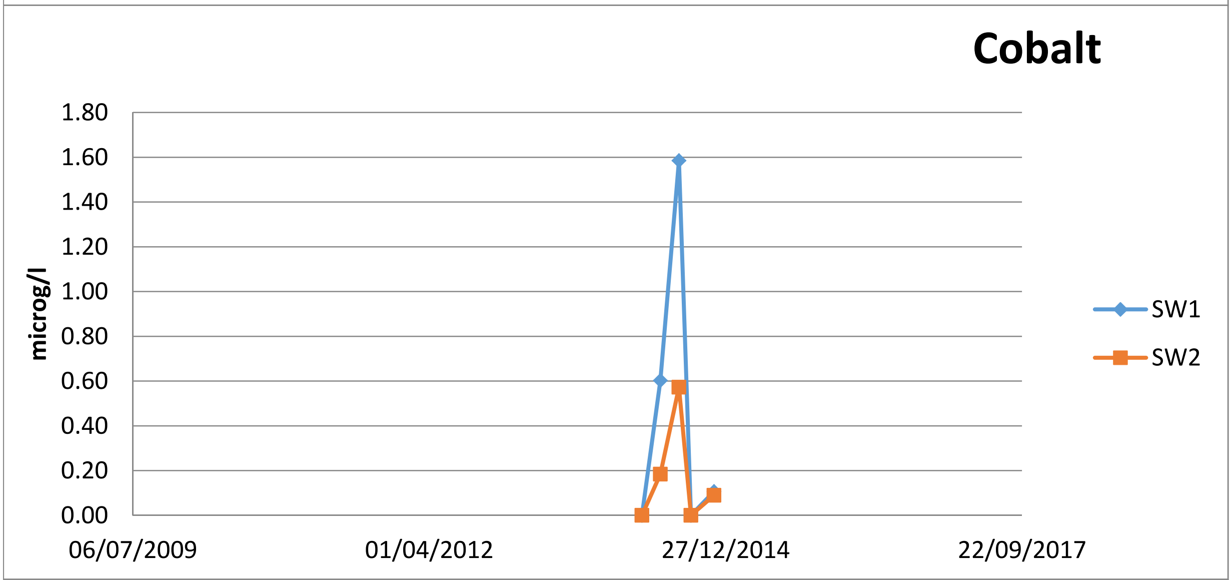

Phosphate
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

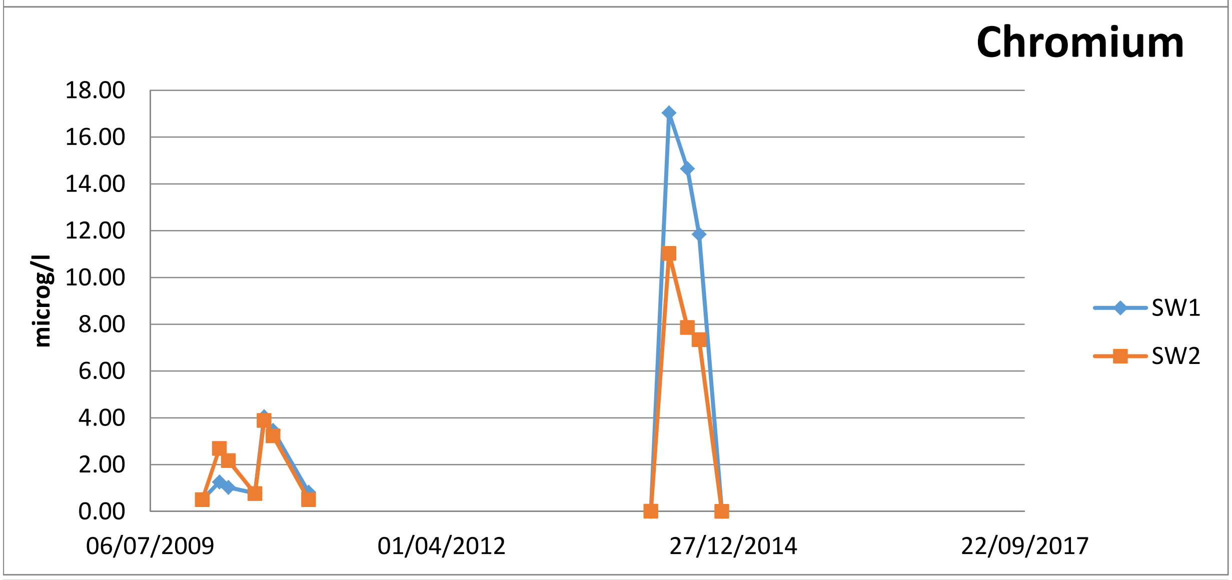

Aluminium
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

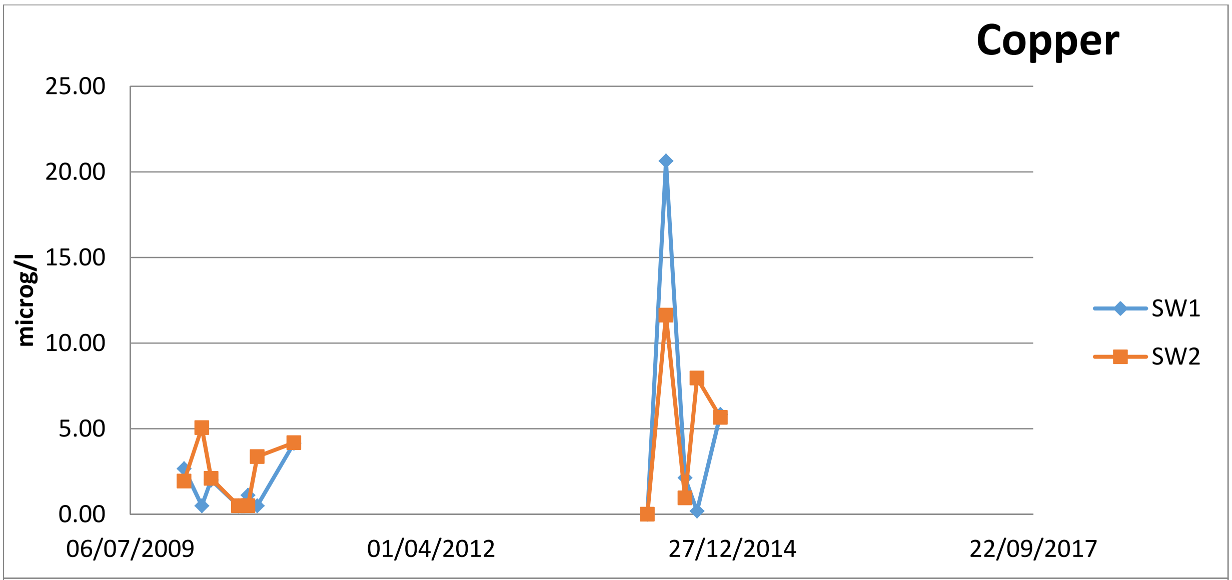

Arsenic
12.00
10.00
8.00
6.00
4.00
2.00
0.00
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

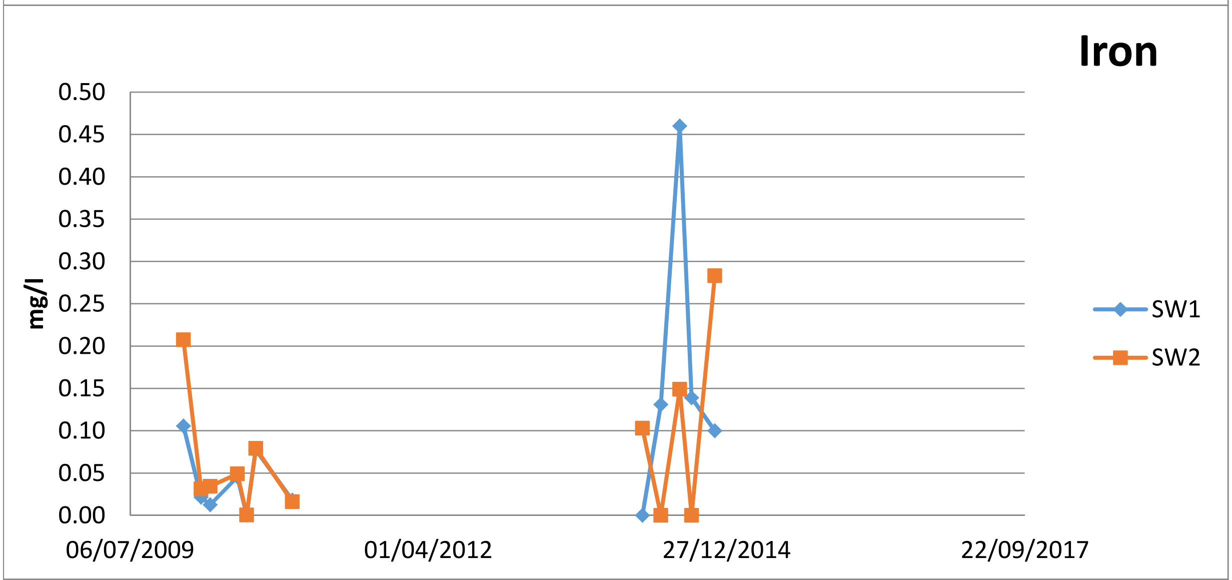

Barium
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

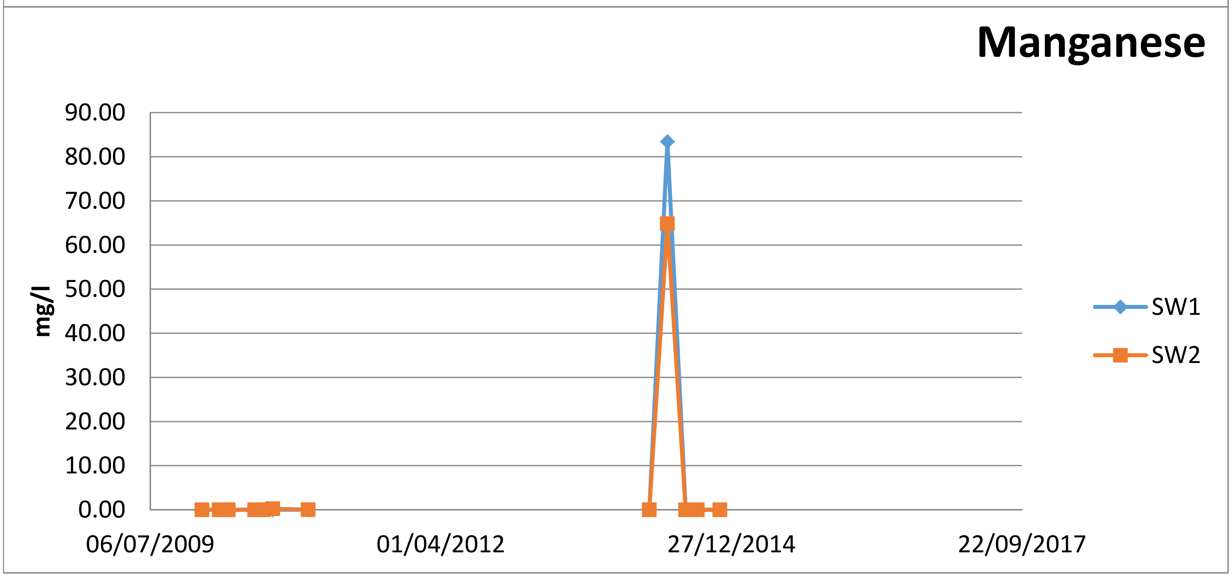

Cadmium
0.60
0.50
0.40
0.30
0.20
0.10
0.00
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

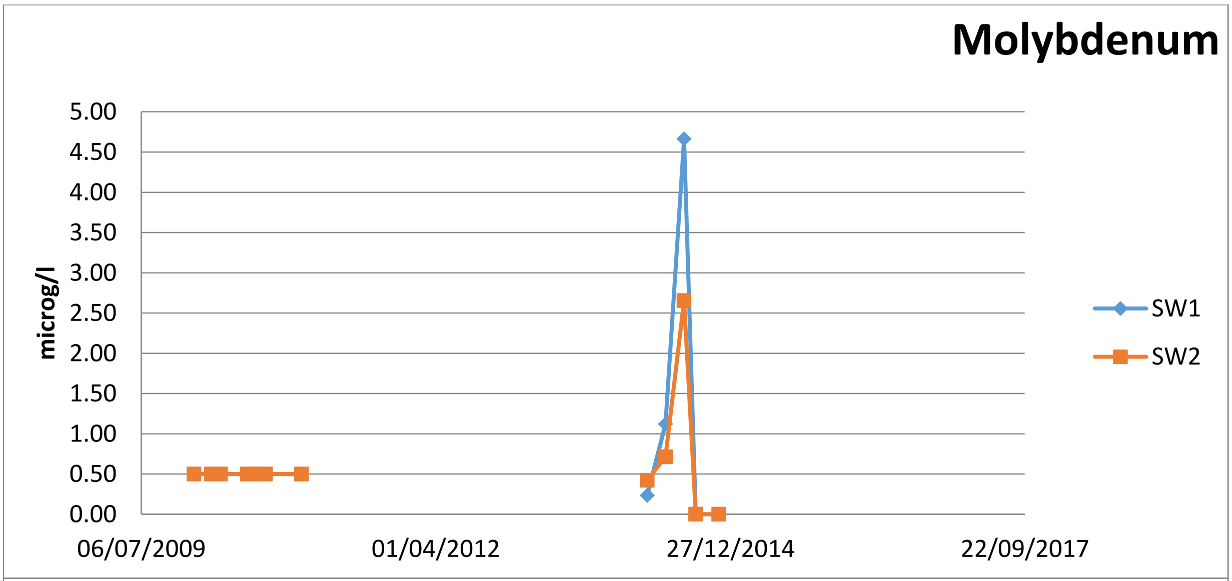

Cobalt
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

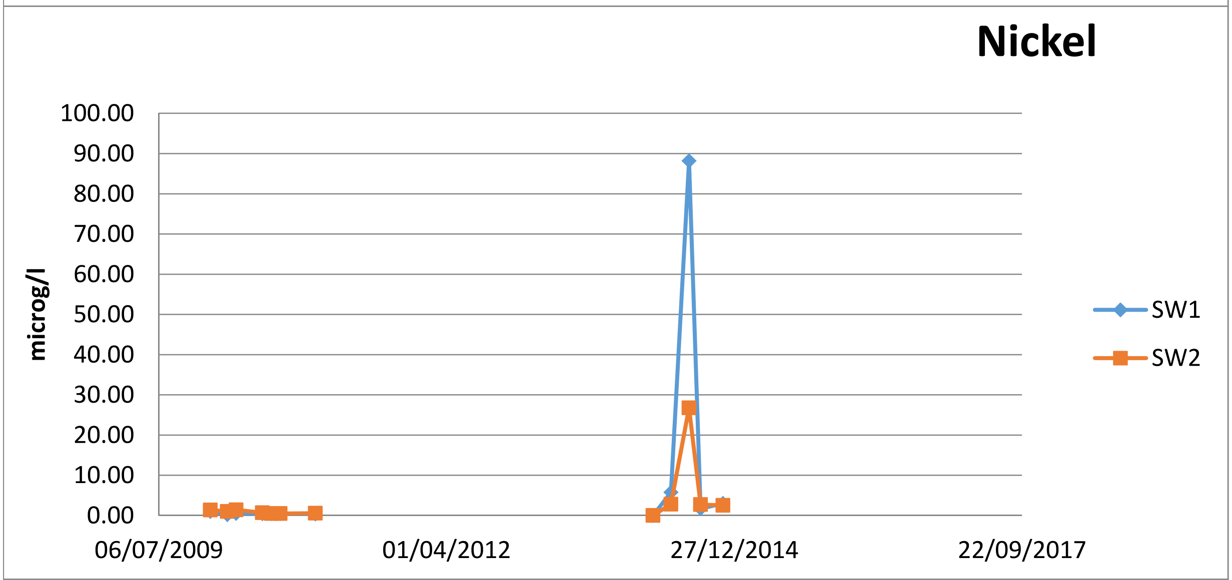

Chromium
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

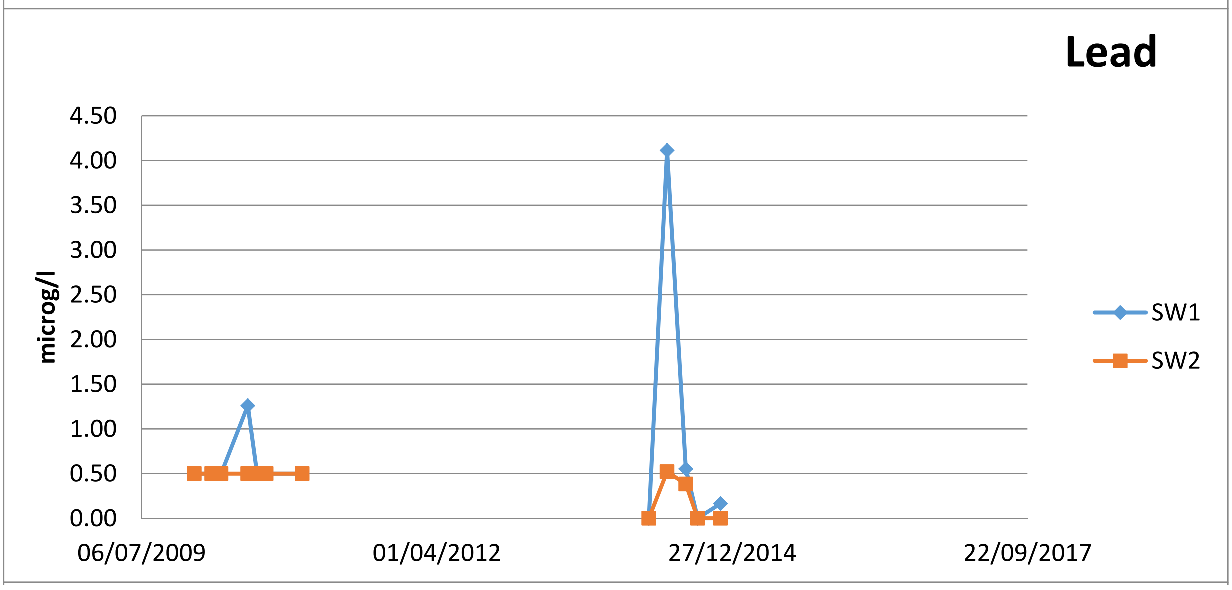

Copper
25.00
20.00
15.00
10.00
5.00
0.00
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

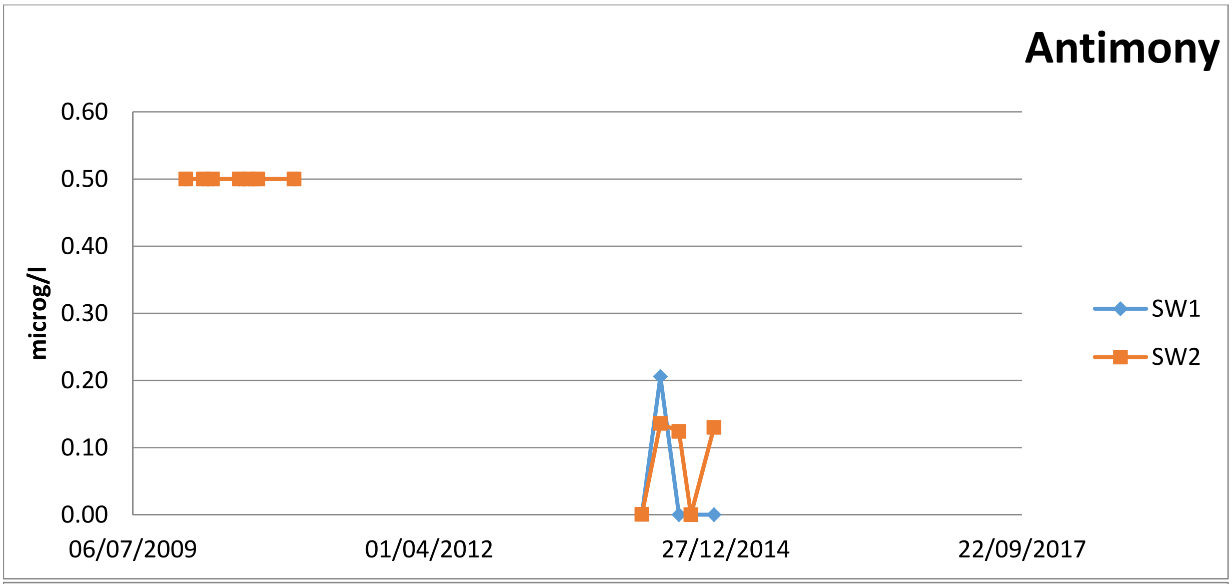

Iron
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

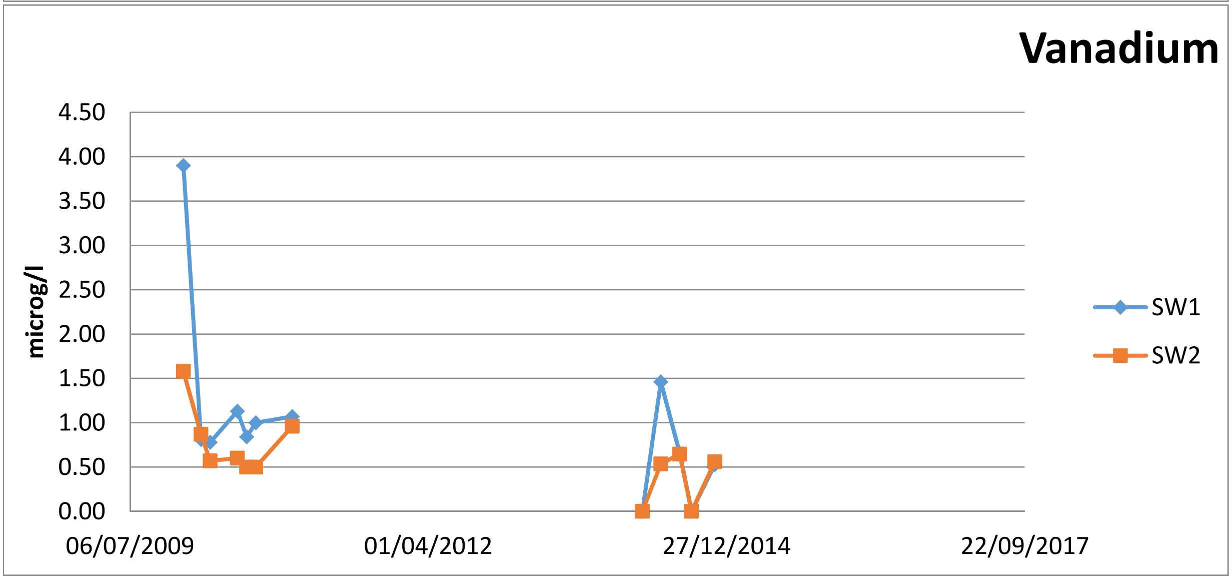

Manganese
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
mg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2

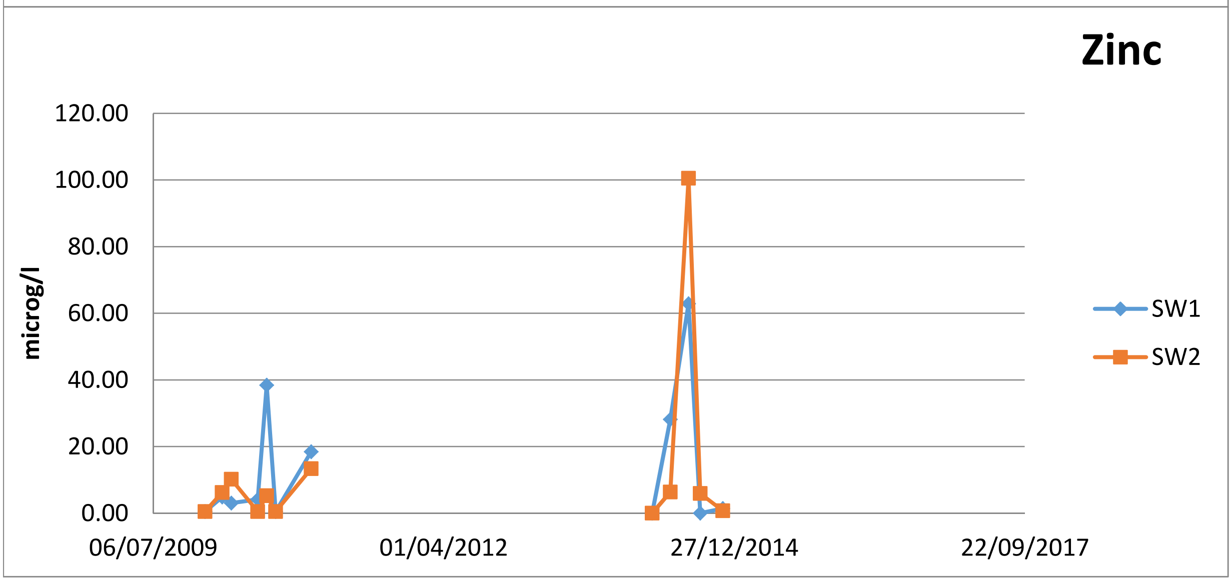

Molybdenum
microg/l
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2


Nickel
microg/l
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2


Lead
microg/l
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2


Antimony
0.60
0.50
0.40
0.30
0.20
0.10
0.00
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2


Vanadium
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2


Zinc
120.00
100.00
80.00
60.00
40.00
20.00
0.00
microg/l
06/07/2009
01/04/2012
27/12/2014
22/09/2017
SW1
SW2