EAST WASTE MANAGEMENT SITE, LLANWERN STEELWORKS

PERMIT EAWML/30003

2022 Annual Review of Environmental Monitoring

Report Number 2215r1v1d0123

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January 2023

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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 previously and as this poses a direct risk to surface water quality Tata has previously informed NRW and is understood to be continuing to monitor and manage mitigation measures. The available data suggests that these measures are effective at protecting the reen in closest proximity. There is no evidence of significant sustained change or deterioration in water quality in the reen as it passes the site.

Restoration capping works have been on stop for several years as some of the soils imported to the site have been found to contain Japanese Knotweed. Tata is evaluating options and until a decision has been made, the site is not accessible to Geotechnology. This means that gas monitoring points, one ground water well (BH3) and one leachate sample point (EL1) have not been accessed since 2017.

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. To date, approximately one third of the site has been covered with a combination of geomembranes and capping soils. The capping has been on hold for approximately two years due to the presence of Japanese Knotweed in soils to be used for restoration.

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 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^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 was planned to be completed over several campaigns spanning three years. All works are currently on hold pending an investigation of soil quality and development of a plan for accommodating soils found to contain Japanese Knotweed.

The capping works will ultimately 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.

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 still not been capped, it is likely that insufficient volumes exist for successful flaring. However, this can only be ascertained once the cap and vents are in place.

The completion of the gas collection system 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.

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, 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 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 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 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, 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 have been found to be elevated in the east. At the time of the previous assessments, this was not problematic for surface water in the adjacent reen 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. As BH3 has not been accessible for some time, the current status of groundwater levels on the eastern side is not known.

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. As the landfill is capped, this drainage will reduce.

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 in 2007 (see Geotechnology report 525.1/0/0207). The LandSim model identified that at no time do List 1 substances (now referred to as hazardous 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. The HRA has not been revisited since 2007.

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.

Since 2016, samples have been collected from the leachate collection ditch at position 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 low risk of surface run-off directly entering the reen system to the east. However, to ensure that the situation is monitored, two sample points are positioned upstream (SW1) and downstream of the landfill (SW2), as shown on Figure 6.

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.

The net rated thermal input for the gases evolved at LEWMS were predicted to peak in 2001. Since this time yields would be expected to drop and by 2020 the model predicted yields to be too low to self-sustain thermal treatment by flaring. The conclusion of the previous assessment, undertaken in 2007, was that a bio-filter was the only potential option for landfill gas treatment. This assessment has not been revisited since this time.

As the site is progressively capped from the south to the north, a gas drainage and collection infrastructure is being placed within the cap. By covering with a gas drainage blanket, surface emissions of gas from the waste will be collected although the flux is not expected to be of significance.

Monitoring of landfill gas was being undertaken at GM1, GM2 and GM3, although these points have not been monitored for several years due to access to the site being prevented due to the presence of Japanese Knotweed.

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 2015 annual report a modified, rationalised monitoring programme was suggested and this is reproduced in Table 4-1. This modified programme was initially implemented by the operator during 2016 as it was more closely aligned to the AMP. The analytical parameters analysed are summarised in Table 4-2. It is understood that this programme has been agreed with Natural Resources Wales (NRW).

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	EL1 and EL2
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 (upstream) and SW2 (downstream)
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
Note Gas monitoring and monitoring at BH3 not undertaken since 2017 due to knotweed occurrence limiting site access				

Table 4-2 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 (gw only)	✓	✓
pH	✓	✓
Electrical Conductivity	✓	✓
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.

4.3 NRW Assessments

Geotechnology is not aware of any NRW feedback or Compliance Assessment Reports (CAR) relating to previously provided annual reports.

Geotechnology is aware that Tata has, in recent years, been in closer communication with NRW and that Tata has confirmed to the NRW closed landfill team that the site is being actively monitored and managed.

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 supervision to sample as involves crossing rail - 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. Access currently prohibited
BH 4	Down gradient Groundwater Monitoring	Shallow and Deep Groundwater	Borehole	On corner of lorry access – walk/ vehicular access Destroyed.
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. Access currently prohibited
GM2	Measure internal gas presence in landfill	Landfill Gas	Gas Well	On landfill cap. Access currently prohibited
GM3	Measure internal gas presence in landfill	Landfill Gas	Gas Well	On landfill cap. Access currently prohibited
Note: Geotechnology suggests that each groundwater well is inspected to ensure monitoring interval is still accessible. BH4 is no longer monitored as it is not accessible.				

Each time samples are collected the monitoring infrastructure is inspected. The wells are generally in a good state of repair and as the site is secure there is little prospect of vandalism as they are not currently locked.

5.1.1 Leachate Monitoring

Leachate monitoring should comprise a walkover survey of the landfill edge, to examine for the presence of any leachate breakout and sampling from the perimeter ditch. Due to the site being inaccessible due to the presence of knotweed, this aspect requires review.

Suspected leachate breakout was observed on the eastern flank of the site in 2016 and reported to NRW by Tata. Tata rapidly implemented the construction of a low permeability bund to trap the breakout and Geotechnology understands that the situation is being actively monitored and managed.

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 (BHs 1 to 7) are shown on Figure 6. All positions are currently inspected quarterly to ensure that they provide suitable monitoring infrastructure. Each headworks are unlocked but the site is secure.

As BH3 is not currently accessible the previously recommended improvements are still to be completed. At BH3, access needs to be improved as the vegetation is very dense, particularly during the summer months. Vegetation also needs to be routinely cleared at BH7 to aid continued safe reliable access.

5.1.3 Surface Water Monitoring Infrastructure

No further improvements are required. All samples are collected with a telescopic sampling rod to avoid personnel coming into close contact with steel sided channels containing deep 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.

No monitoring has been undertaken since 2017 as the site has not been accessible whilst soil quality is being inspected and management options developed. The site is also not yet fully capped.

No assessment of surface emissions is currently undertaken. NRW may require this once the site is capped.

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 TDC Harbourside laboratories 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 TDC Harbourside based at the Engineering Centre for Manufacturing and Materials (ECM) in Margam, adjacent to the Port Talbot steelworks.

All samples are returned to the laboratory for analysis in cooler boxes on the same day as collection.

5.3 Actions required

- Suspected seasonal leachate breakout on eastern flank of site should continue to be monitored and managed to ensure protection of reen
- Access to BH3 should be improved and maintained once site is accessible
- Vegetation should be routinely cleared from around boreholes to avoid damage to headworks and enable continued safe access

6 TOPOGRAPHIC SURVEY AND SETTLEMENT MONITORING PROGRAMME

Once the landfill surface is restored and capped, the final surface topography will be surveyed. NRW will likely require plates to be positioned on the surface of the waste that are then surveyed at regular intervals to assess for waste settlement. This approach could potentially be modified, if required, through discussion with NRW.

7 LEACHATE LEVEL AND QUALITY

7.1 Level

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. There is no direct means of monitoring leachate levels within the waste.

7.2 Leachate Collection Ditches

As the landfill is not formally lined, the only way of indirectly monitoring leachate quality is to sample the unlined leachate collection ditch that runs along the western toe of the landfill. The base of this ditch is in the upper surface of the upper clay to limit infiltration to groundwater. Monitoring of the ditch started 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 alkaline conditions, although some, such as aluminium, is detectable. This may be influenced by the ability of some metals to forms oxyanions.

The ditch water has a pH that is persistently over 12 and EC typically over 3000 microS/cm and dominated by a Ca-HCO_3 hydrochemical signature, as the leachate has passed through steelmaking slags with soluble alkaline phases. During 2021 and 2022, the leachate sample was slightly more dilute than that encountered in previous years, possibly due to the influence of the capping completed to date. Ammonia and phosphate have been impersistently detected at elevated concentrations but most trace metals are at low levels, due to the strongly alkaline conditions.

The ditch is culverted past BH5 as it drains to the on-site works treatment facility. During sampling in late 2022, the ditch was found to be spilling over the concrete containment structure and weir adjacent to BH5. When the levels are this high there is a possibility of the concentrated seepage infiltrating to land and groundwater as the construction of the concrete weir and surrounding structure is unknown.

Appendix 1 contains a time series record of the monitoring results gathered to date. The reader should note that the laboratory is not able to quantify pH levels above 12 and so for the purposes of graphical presentation all values reported as >12 pH units are fixed at pH 12.

8 GROUNDWATER LEVEL AND QUALITY

8.1 Groundwater Flow

Historic groundwater monitoring data (although incomplete) indicated that head loss, and therefore water movement, was predominantly from the east to the west. In recent years, when data has been available from BH3 the scenario has been found to be a little more complicated.

Based on more recent monitoring data (when BH3 was accessible) the data indicates that the hydraulic gradients are shallow and sometimes lowest in the east. An outbreak of leachate was observed on the eastern side of the site in 2016 (just south of BH3) and this would appear to be coincident with the low point in the system at the time. Geotechnology understands that Tata continues to closely monitor this position and has previously informed NRW, who has also visited the site. A temporary bund to protect the adjacent reen has been constructed.

Groundwater levels and flow patterns are likely to change as the site is progressively capped. Time series plots are included in Appendix 1. Plans of the piezometric surface have not been included as the monitoring datatset is incomplete due to lack of data from BH3. The available data suggests groundwater flow is from the east to the west with waterlevels less spikey and more stable in deeper groundwater. In June 2019, some of the highest waterlevels were observed. Since 2020 waterlevels have been comparable to the longer term average for each monitoring location.

8.2 Shallow Groundwater

As expected, sampling of shallow groundwater in the mainly slag made ground in close proximity to the site reveals that it is impacted by infiltration that has passed through the partially capped and 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 ditch at EL2.

As noted previously, groundwater in close proximity to the landfill typically contains low levels of non-hazardous substances which sometimes exceed Environmental Quality Standards. Since 2018, the monitoring reveals declining concentrations of several parameters, such as EC, Ca, Mg, but these trends appear to have stabilised in 2021 and 2022. Although there are some declining trends there are also short-term spikes in concentration of several parameters, particularly in the concentration of trace metals. These variations in concentration do not appear to be persistent. At BH5, the electrical conductivity increased during 2021 but has reduced in 2022, close to levels previously observed. At BH7, EC has been slowly increasing in recent years although the levels reached are similar to those many years ago. Both of these positions are close to the southern tip of the landfill and the leachate collection ditch. Interestingly, the pH at BH5 is pH 8 and at BH7 it is pH 12.

Short-term fluctuations in the concentration of several parameters including ammonia, phosphate, Cr, Cu, Fe, Pb, V and Zn has occurred in recent years. There is no clear long-term upward trend evident and some parameters have reduced in concentration. The highest concentrations tend to be found at BH5 and BH7 and also BH2. This latter borehole is located to the west of the landfill on the opposite side of the works access road and seepage drainage ditch. As a consequence, the groundwater chemistry at BH2 may be influenced by other processes. The precise cause of the short-term variations in concentration is unclear at this stage but the initiation of capping in the south may be influencing groundwater quality in the shallow aquifer. The variations could also be due to variable leaching of the waste mass in response to vegetation being cleared ahead of capping and also subtle changes in groundwater levels causing flushing of secondary precipitates.

Hazardous substances have been intermittently detected in shallow groundwater. During 2022, cadmium and mercury were not found above the analytical detection limit but nickel and lead were detected at several positions, sometimes above Environmental Quality Standards.

The annual scan for volatile organic compounds failed to detect any substances in shallow groundwater.

8.3 Deep Groundwater

In contrast to the shallow groundwater, deep groundwater is less alkaline pH 8 and the water chemistry is slightly more consistent (less spikey) than shallow groundwater. As the pH is lower than that encountered in the shallow groundwater, the data suggests that there is persistent limited hydraulic connection between the two water bodies, as would be expected due to the low permeability sequence of sediments present.

In this context, the data from BH7 appears anomalous as the pH at BH7 is similar to that in the shallow made ground. Geotechnology has checked this installation to ensure that the headworks are in satisfactory condition and there were no obvious visual surface defects although surrounding vegetation is dense. 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.

In general, 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. Several trace metals, including hazardous substances, have been historically impersistently detected in deep groundwater. The concentration levels observed in 2021 and 2022 were comparable to those found in previous years apart from short-term spikes in the concentration of several metals, including copper and iron. Arsenic concentrations have remained at concentrations above the EQS at BH5D, although the concentration detected in 2022 was lower than in 2020 and 2021. Like shallow groundwater, hazardous substances Cd and Hg were not detected in deep groundwater in 2022 but lead and nickel were detected.

9 SURFACE WATER

9.1 Reen Hydrochemistry

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

Although there is a clay bund running along the eastern flank of the waste mass, 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 (and other parameters) are also sometimes 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 9-1). At this stage, there is no clear evidence that the reen quality is being impacted by the landfill.

Plate 9-1 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 on several occasions, as shown in Plate 9-2, suggests that there are upstream sources of suspended solids and other potential pollutants like ammonia. These also influence water chemistry downstream of the landfill.

Plate 9-2 Suspended solids in surface water upstream of site

9.2 Contingency Actions Taken

No specific contingency actions were required but Tata should continue to actively manage and observe the potential leachate breakout along the eastern flank in order to identify if further measures are needed to ensure the adjacent reen remains protected.

10 LANDFILL GAS

Internal landfill gas monitoring started in 2015. Since 2016, monitoring has only been undertaken on two occasions as access to the site has been restricted whilst the quality of imported soils containing Japanese Knotweed is inspected and a management plan developed.

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). 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. The landfill is not predicted to be a significant source of landfill gas that might influence off-site receptors or site users apart from the atmosphere.

11 AMENITY ISSUES

Geotechnology is not aware of any complaints received or specific additional requirements for any dust, noise or odour monitoring.

12 SUMMARY AND RECOMMENDATIONS

12.1 Evaluation and Summary

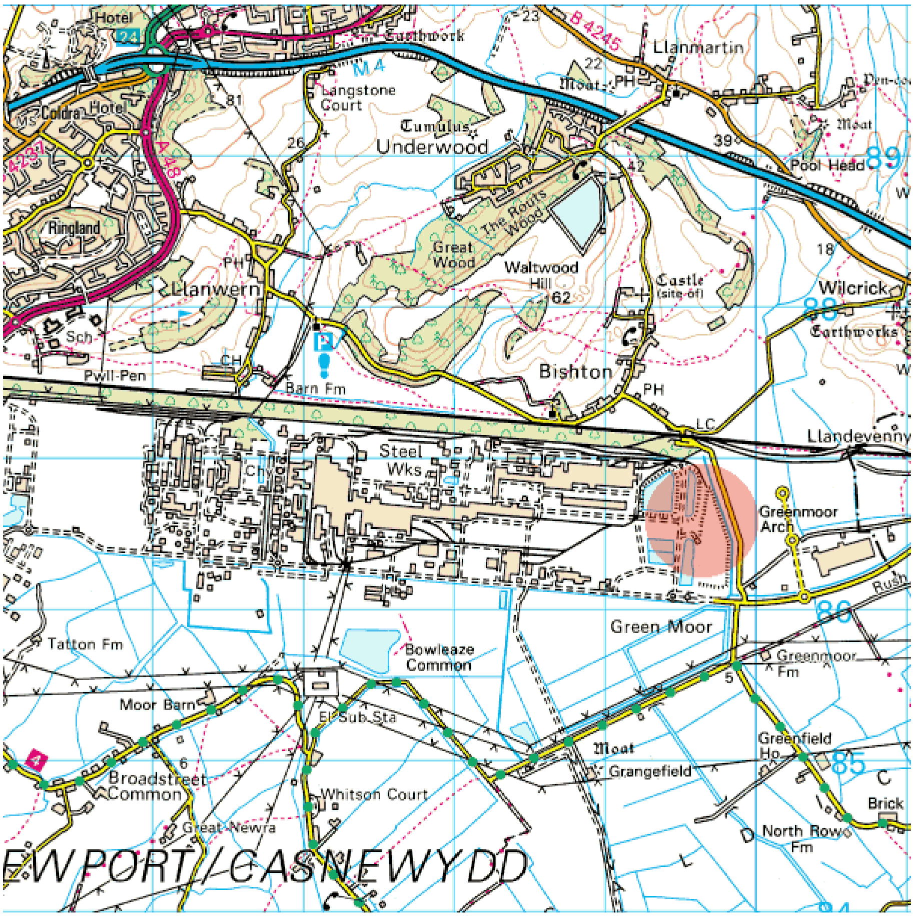
The current monitoring programme has confirmed historical observations that shallow groundwater is impacted by leachate from the unlined waste mass. Due to the network of shallow drainage ditches around the landfill shallow leachate is being intercepted and directed to the works effluent treatment plant. Potential leachate breakout has been observed on the eastern edge of the landfill and as this could potentially impact surface water Tata should continue to monitor and improve 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 once the site is accessible.
- The strongly alkaline running along the western site boundary was observed to be potentially over-spilling the concrete containment structure and weir adjacent to BH5. When the levels are this high there is a possibility of the concentrated seepage infiltrating to land and groundwater as the construction of the concrete weir and surrounding structure is unknown. The channel should be checked for obstructions and routinely maintained.

As capping works are currently on hold, rainwater is infiltrating the waste as the vegetation has been largely stripped.

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

Figure 2 Environmental Setting

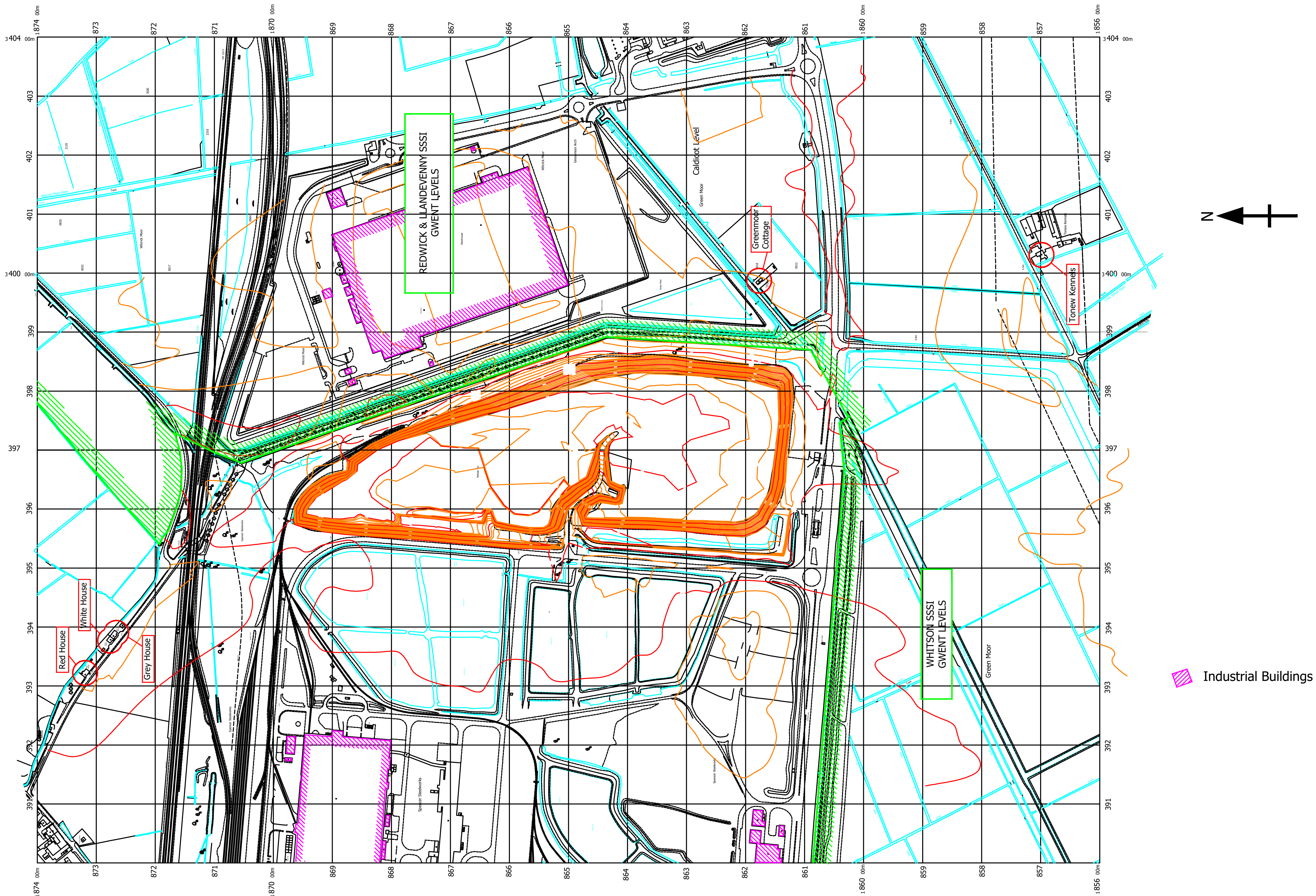


Figure 3 Hydrology

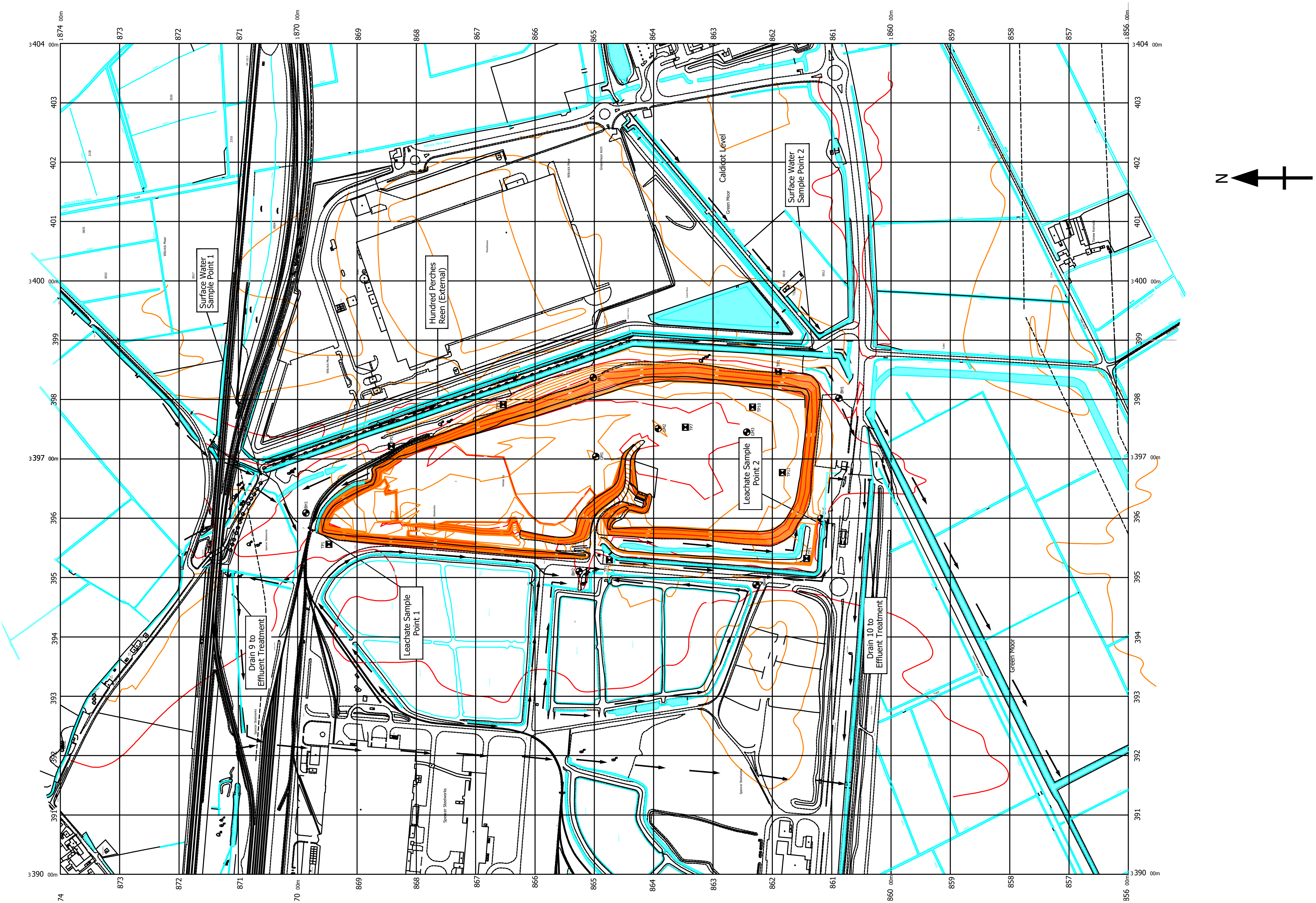
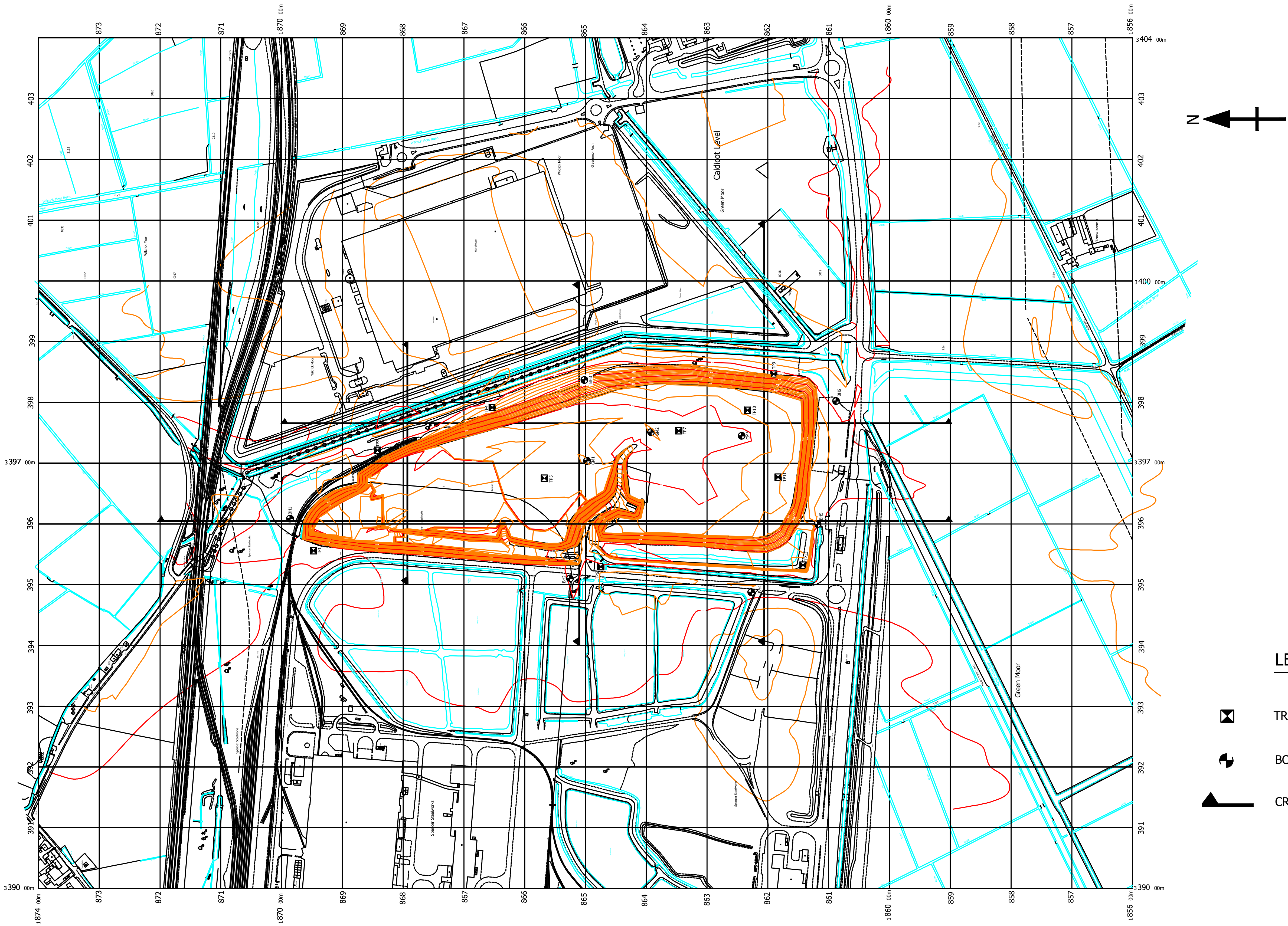


Figure 4 Site Investigation Locations



LEGEND

TRIAL PIT LOCATION

BOREHOLE LOCATION

CROSS SECTION LOCAT

Figure 5 Geological Cross Sections

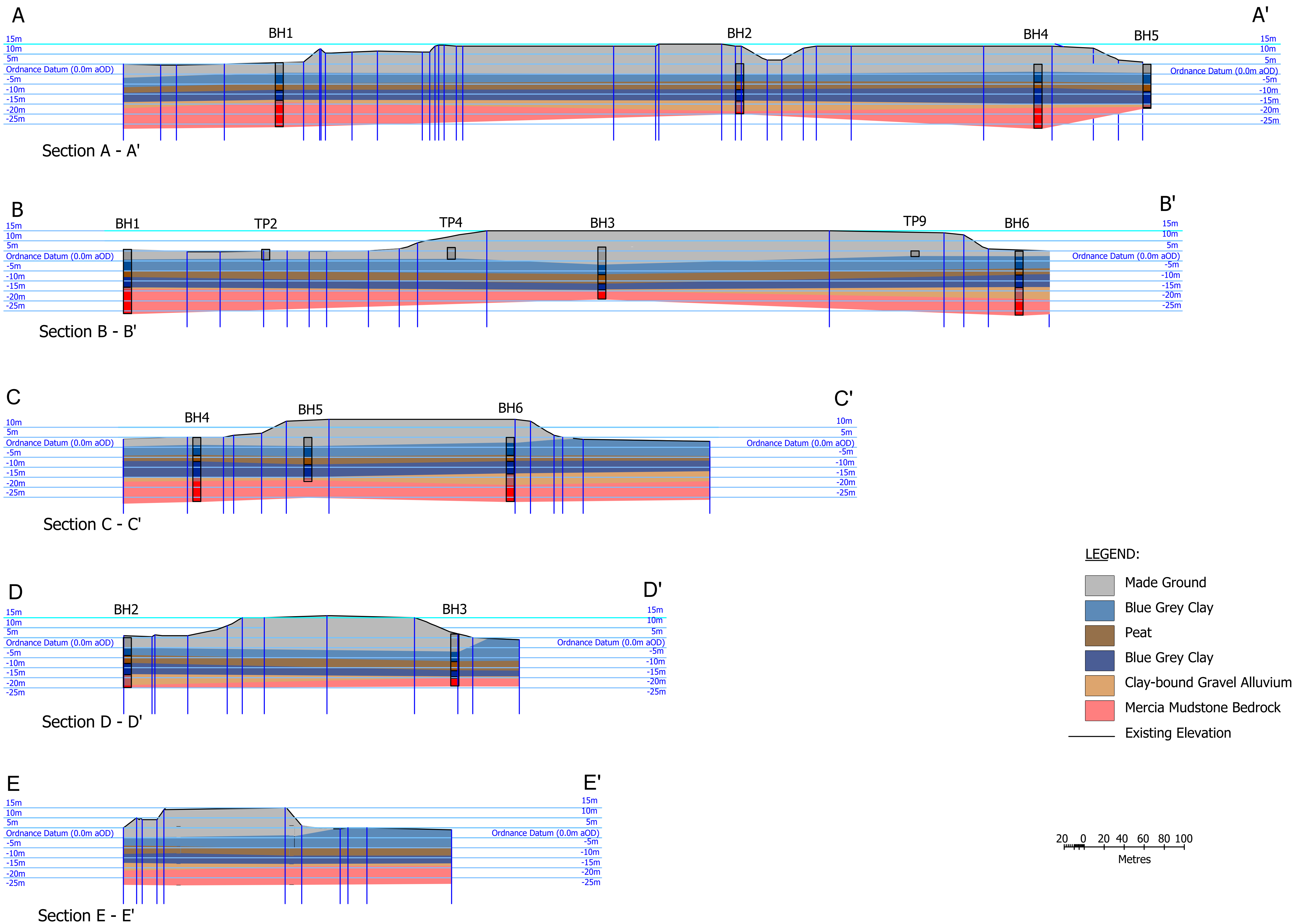


Figure 6 Available Monitoring Newtowk

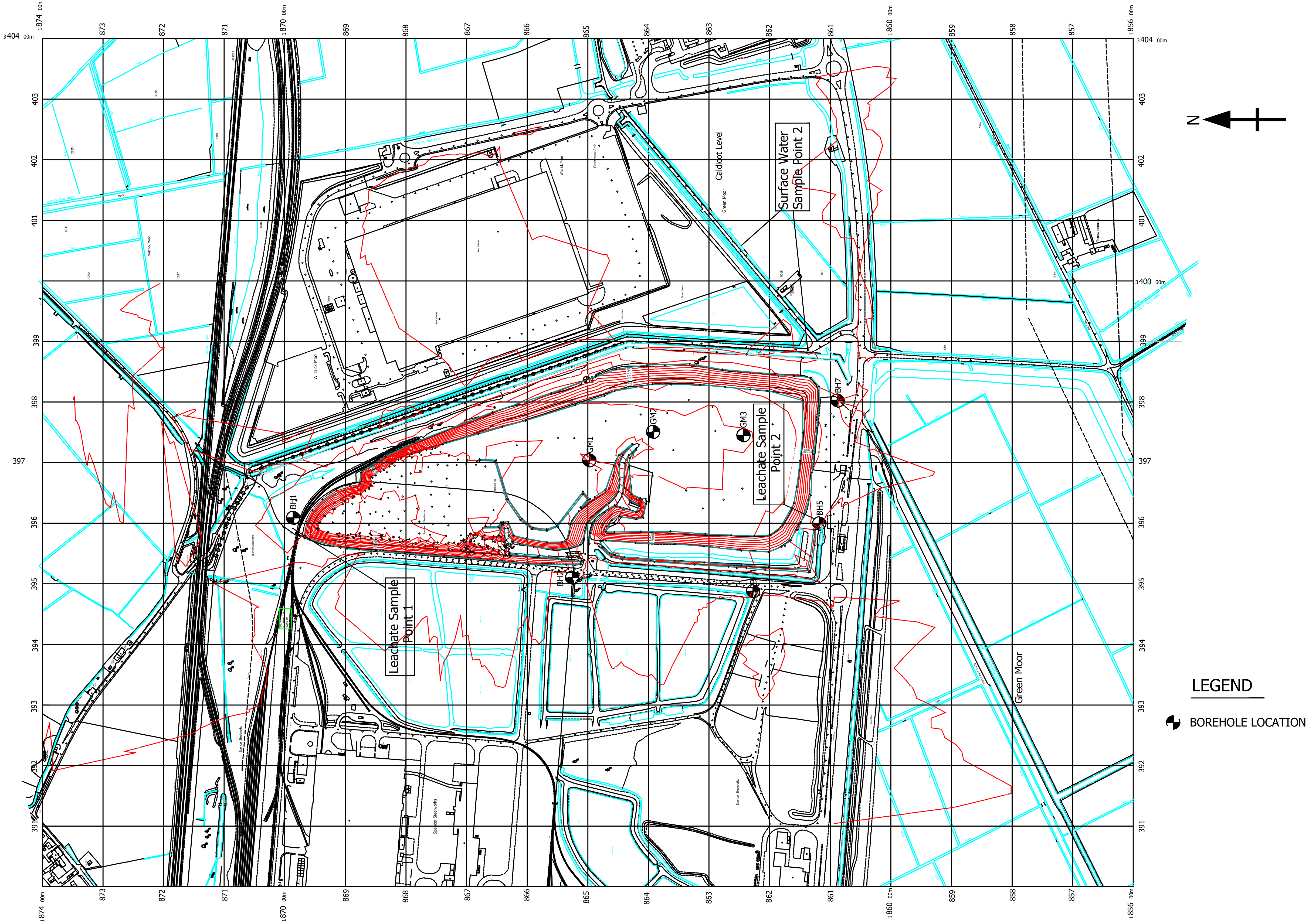


Figure 7 Hydrogeological Conceptual Site Model

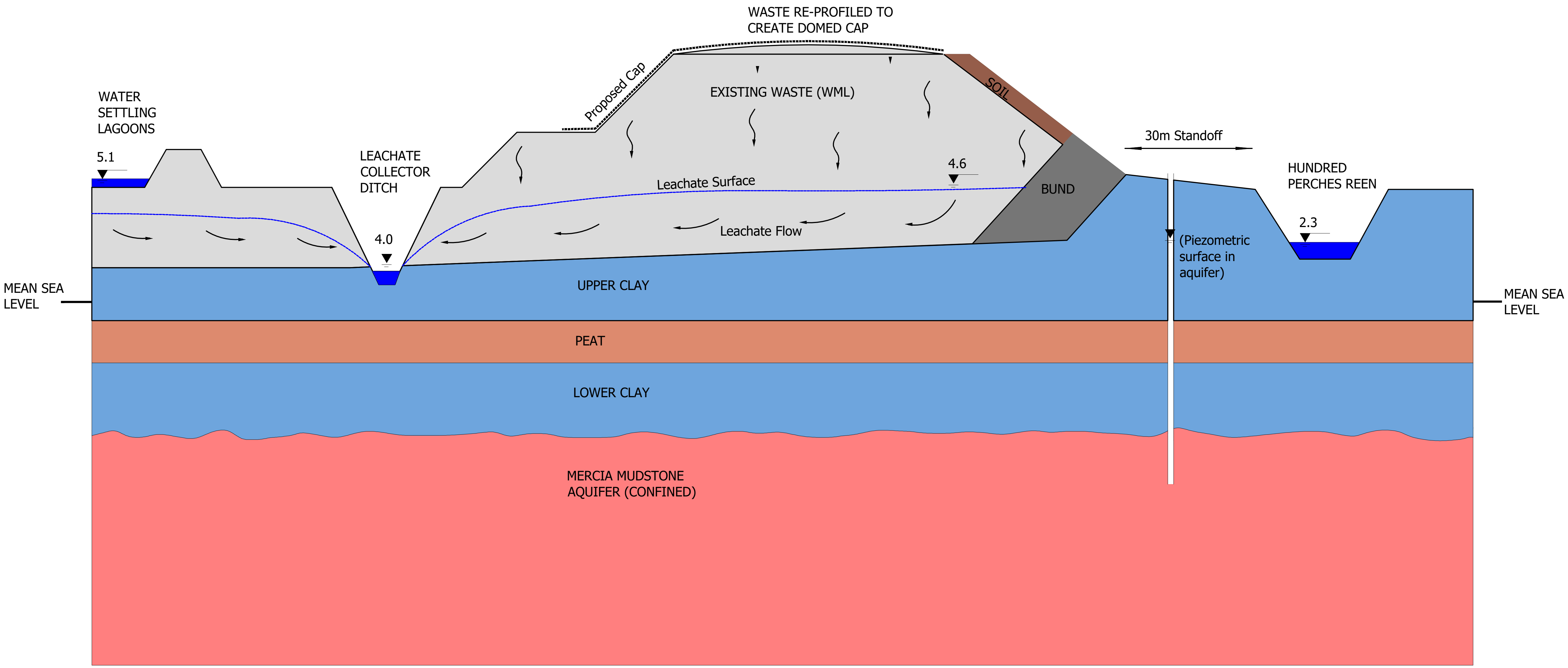
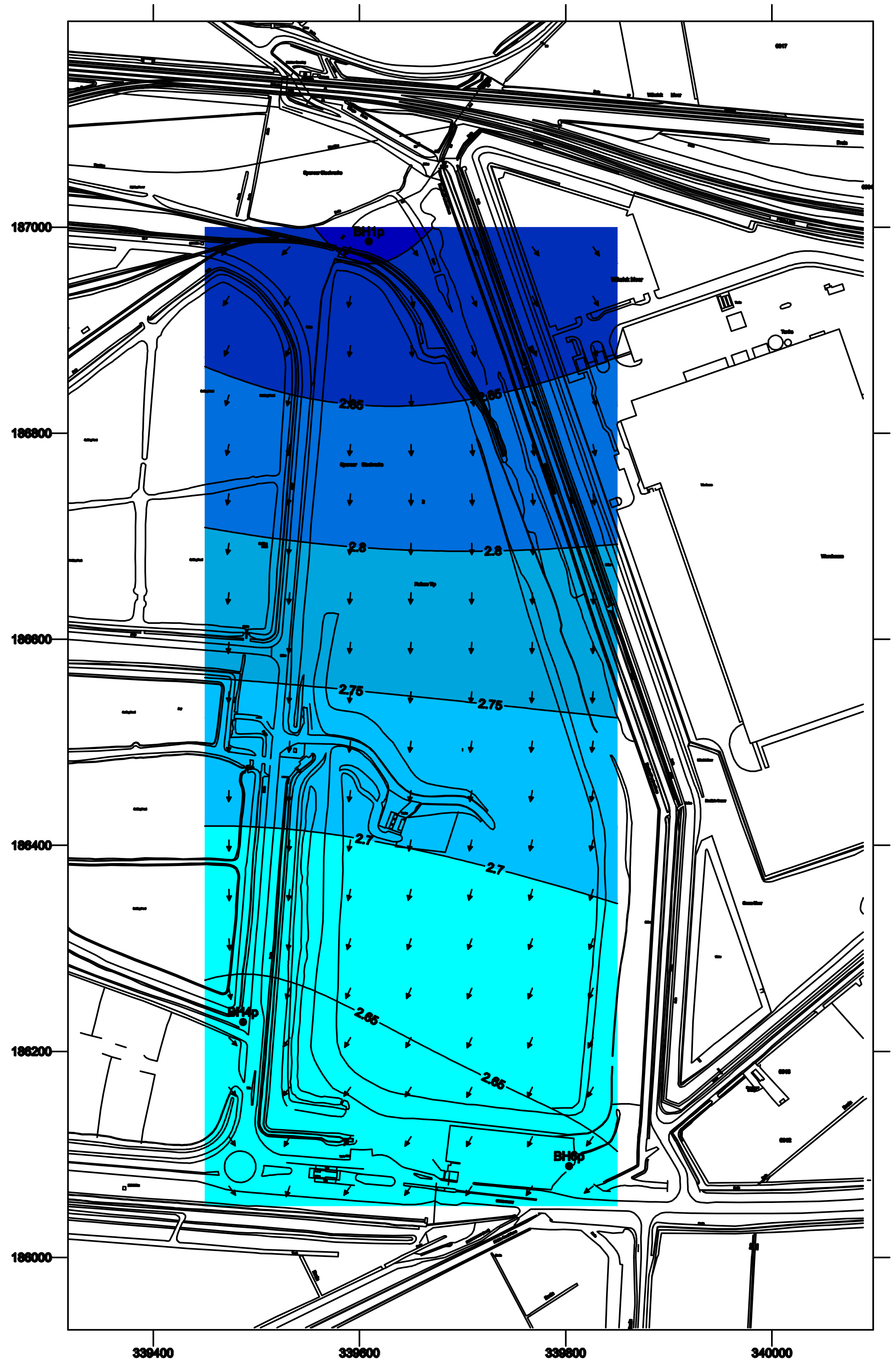
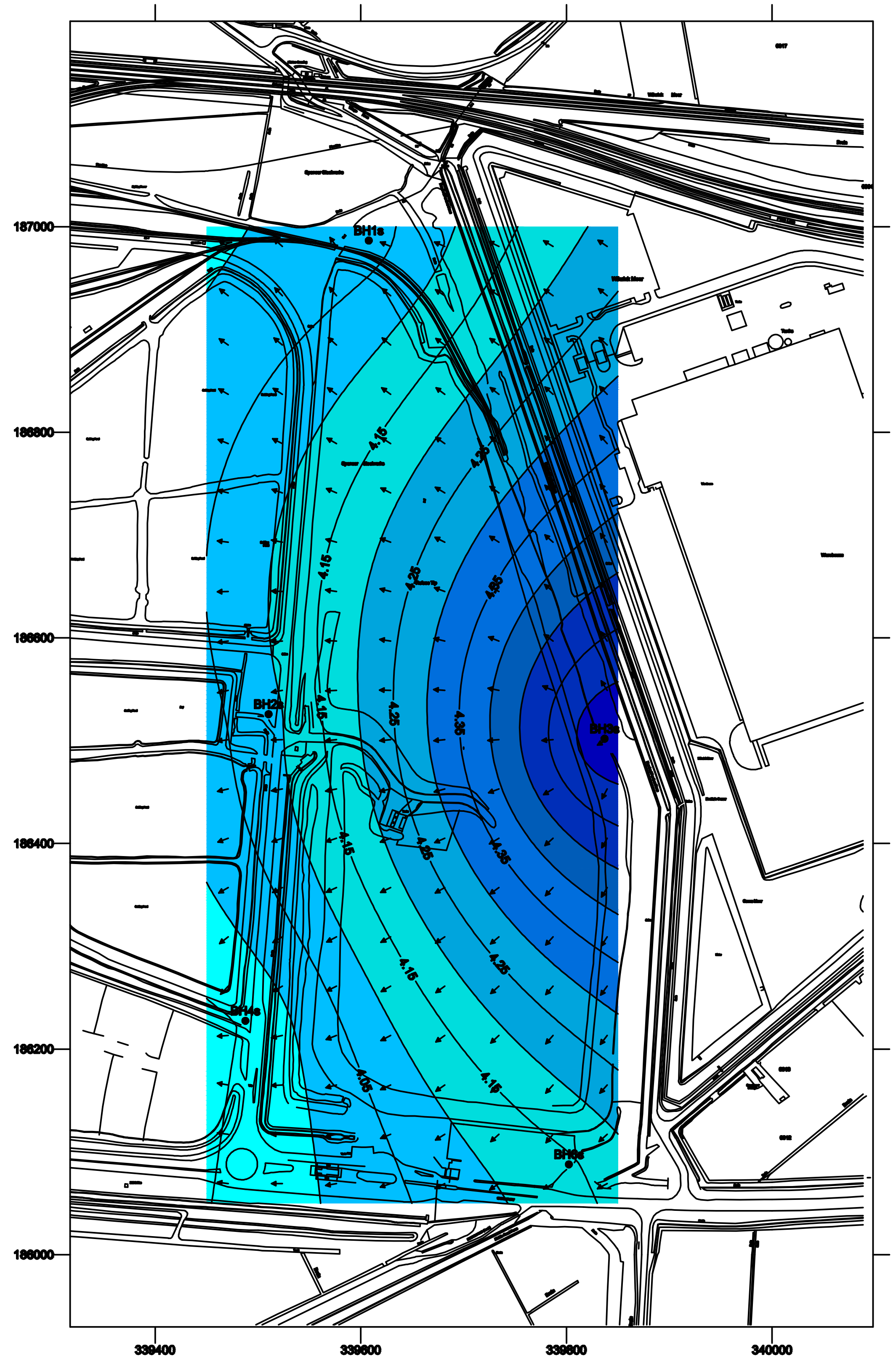


Figure 8 Historical Groundwater Levels



AQUIFER FLOW



LEACHATE FLOW

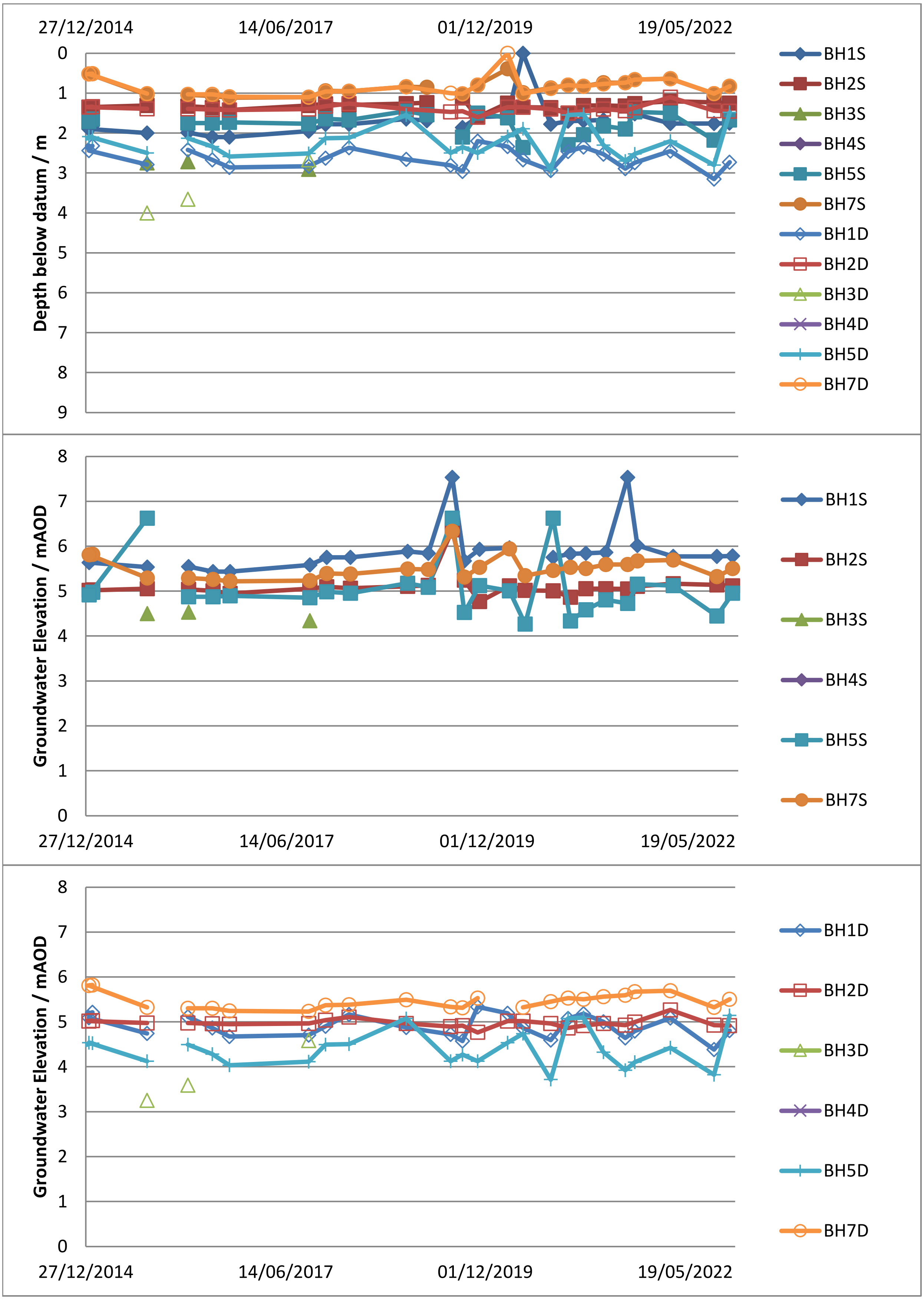
EAST WASTE MANAGEMENT SITE, LLANWERN STEELWORKS

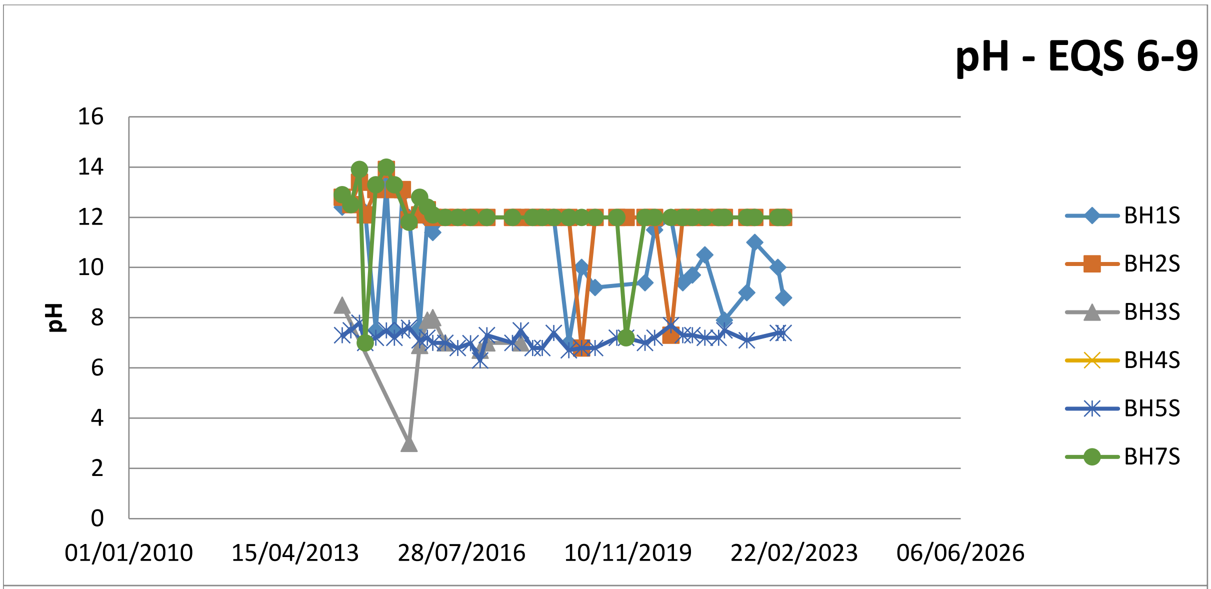
PERMIT EAWML/30003

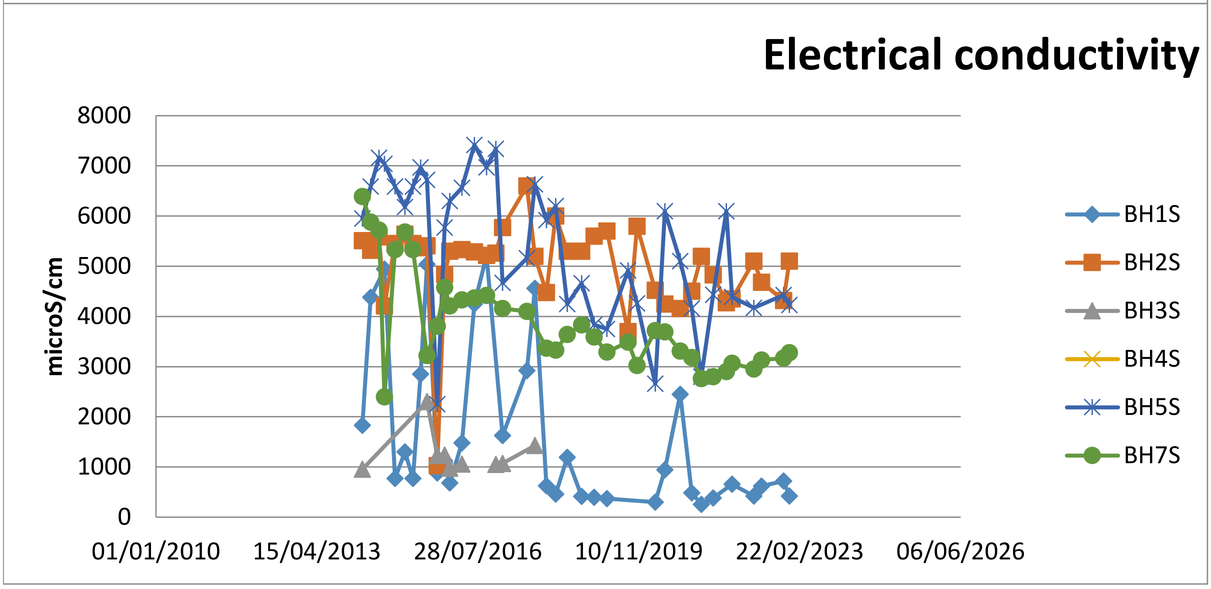
2022 Annual Review of Environmental Monitoring

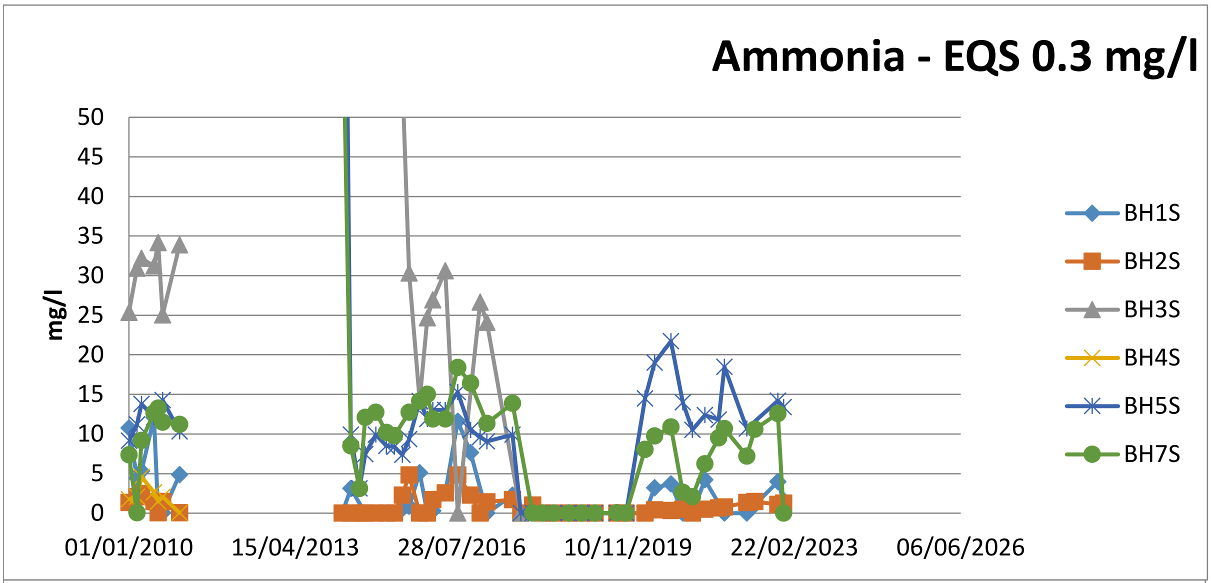
Appendix 1 Groundwater and Leachate Levels and Chemistry

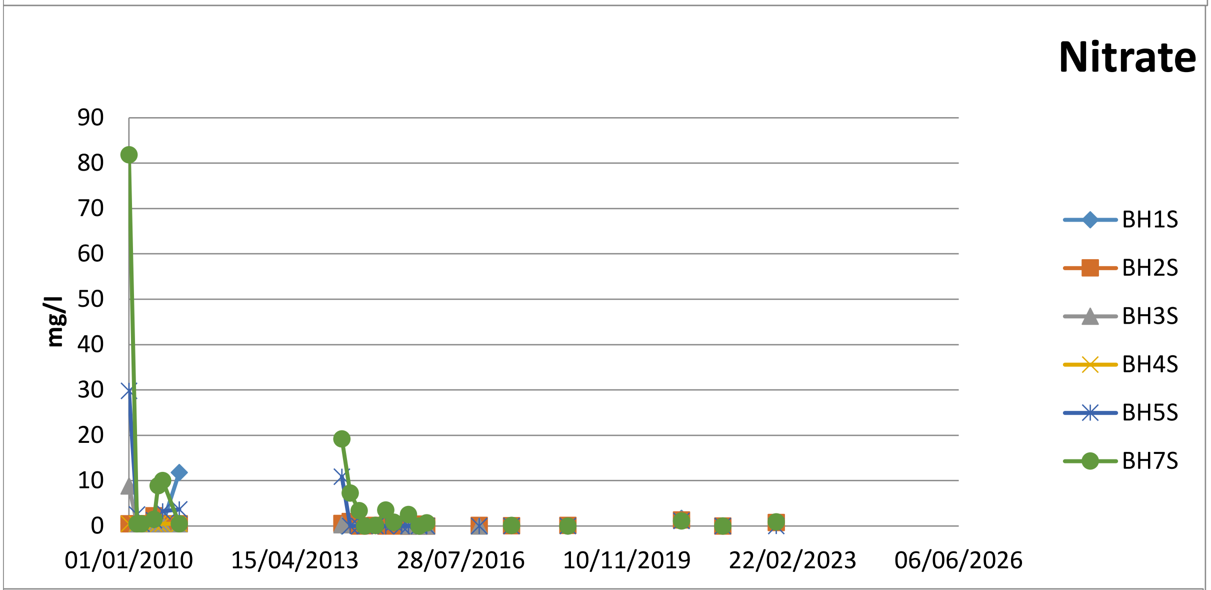
Report Number 2215r1v1d0123

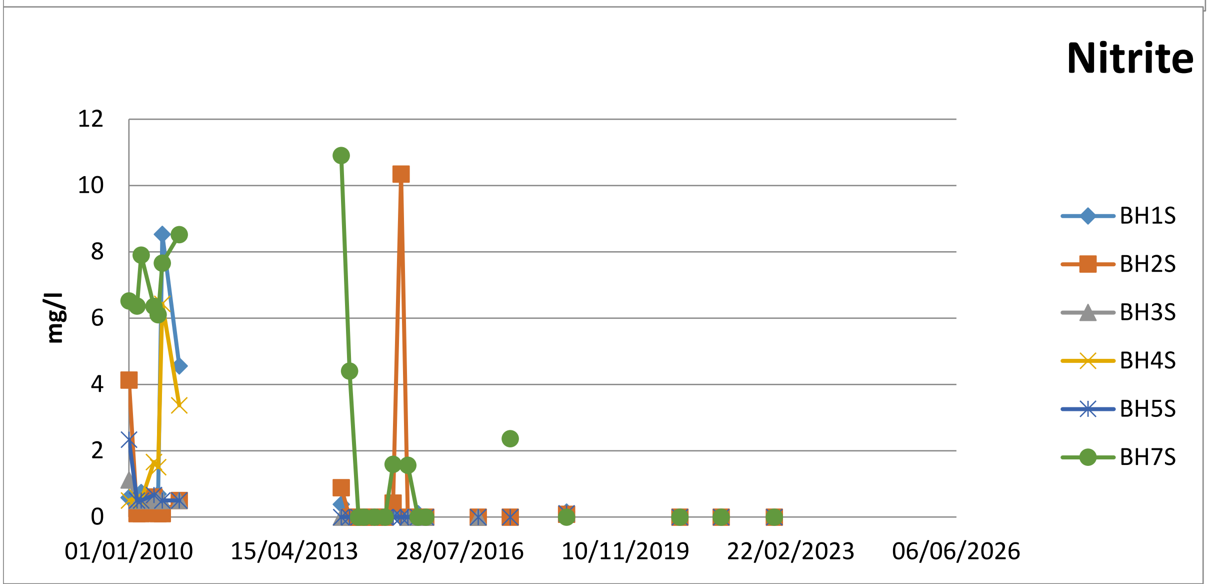

27/12/2014
14/06/2017
01/12/2019
19/05/2022
Depth below datum / m
0
1
2
3
4
5
6
7
8
9
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D
Groundwater Elevation / mAOD
8
7
6
5
4
3
2
1
0
27/12/2014
14/06/2017
01/12/2019
19/05/2022
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S
Groundwater Elevation / mAOD
8
7
6
5
4
3
2
1
0
27/12/2014
14/06/2017
01/12/2019
19/05/2022
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

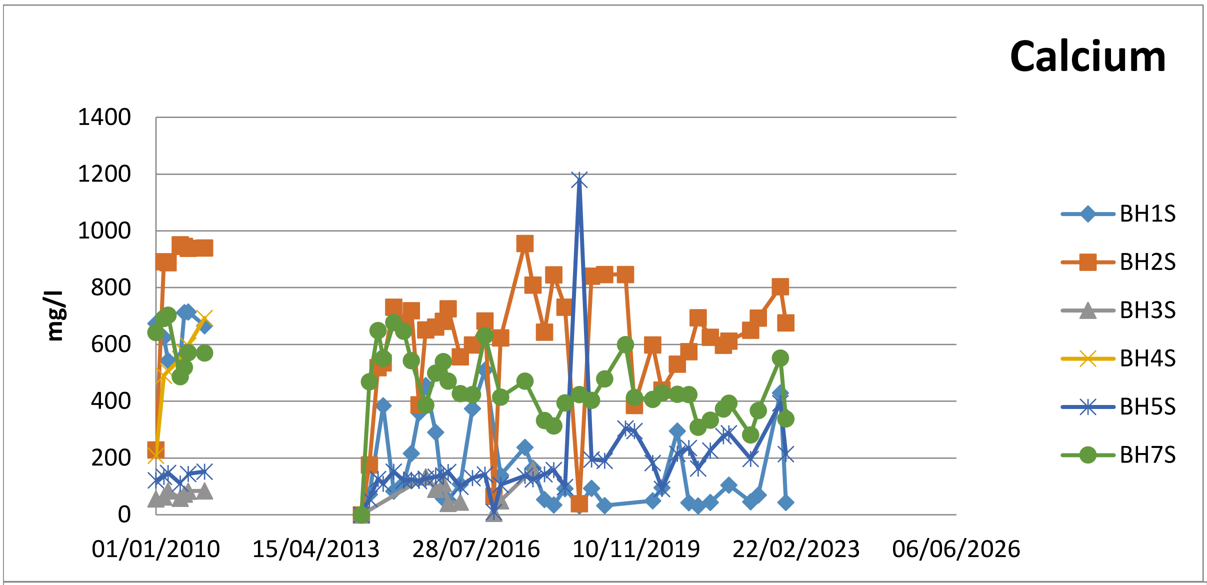

pH - EQS 6-9
16
14
12
10
8
6
4
2
0
pH
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

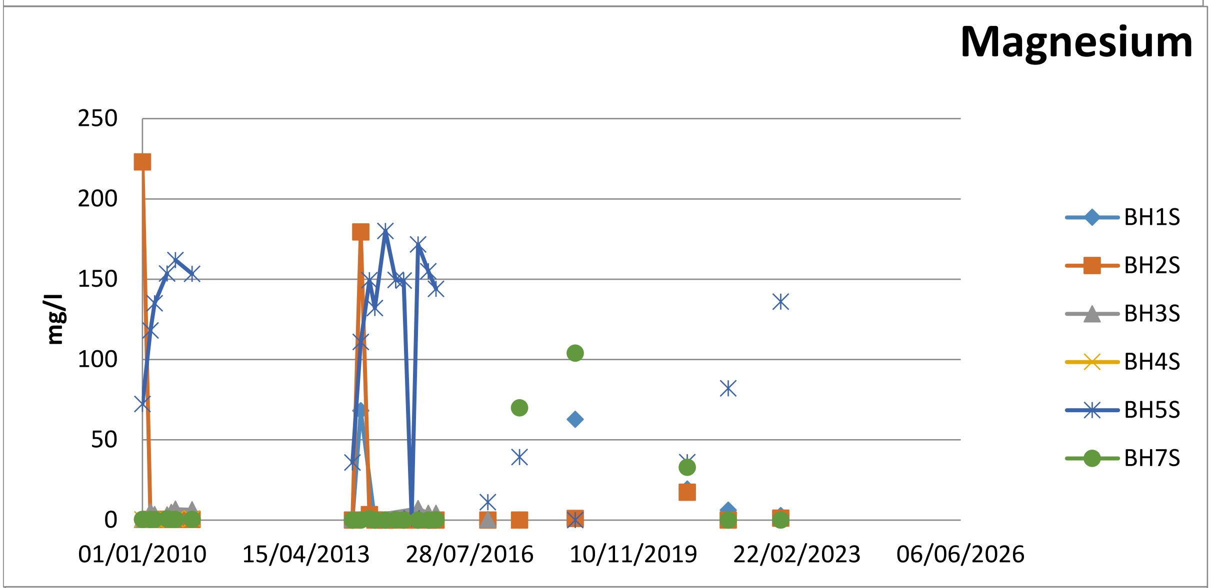

Electrical conductivity
8000
7000
6000
5000
4000
3000
2000
1000
0
microS/cm
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

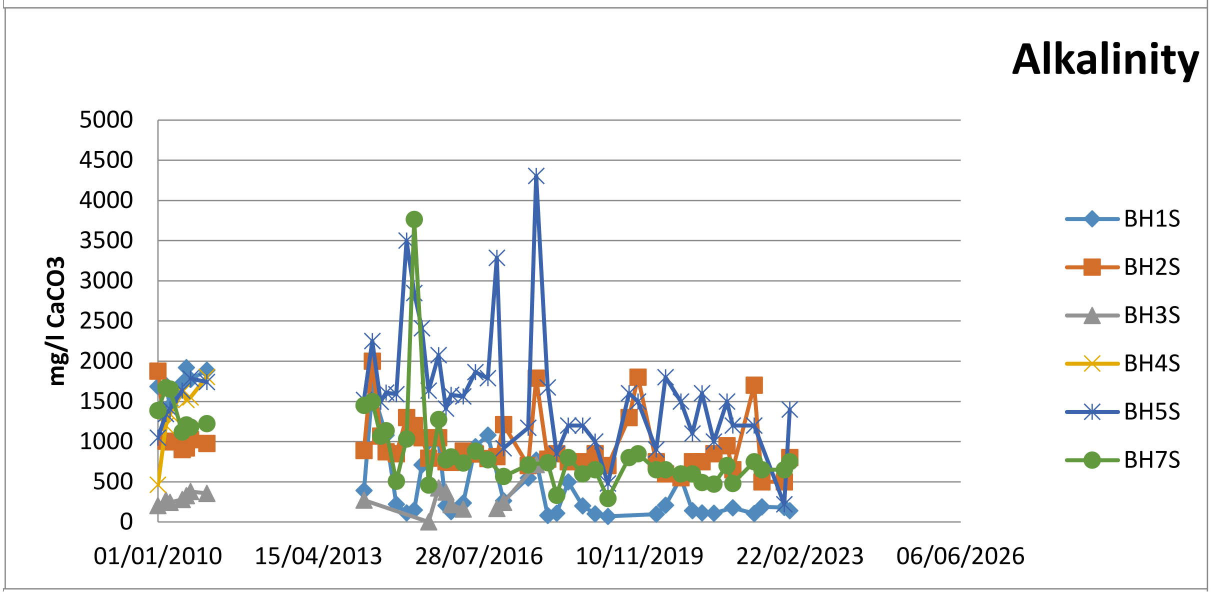

Ammonia - EQS 0.3 mg/l
mg/l
50
45
40
35
30
25
20
15
10
5
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

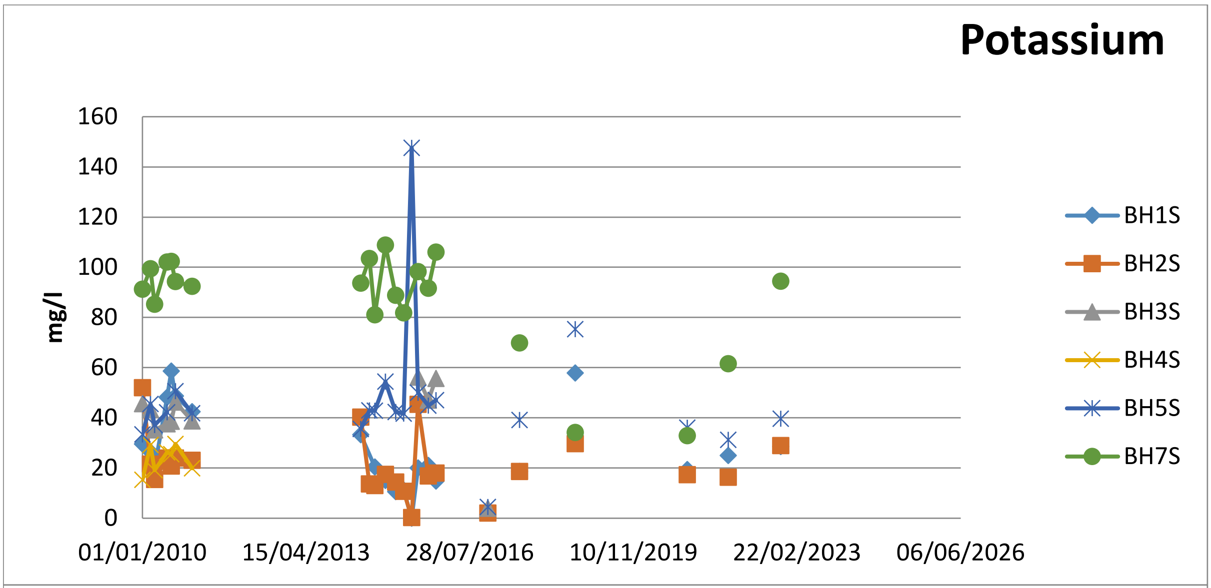

Nitrate
mg/l
90
80
70
60
50
40
30
20
10
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

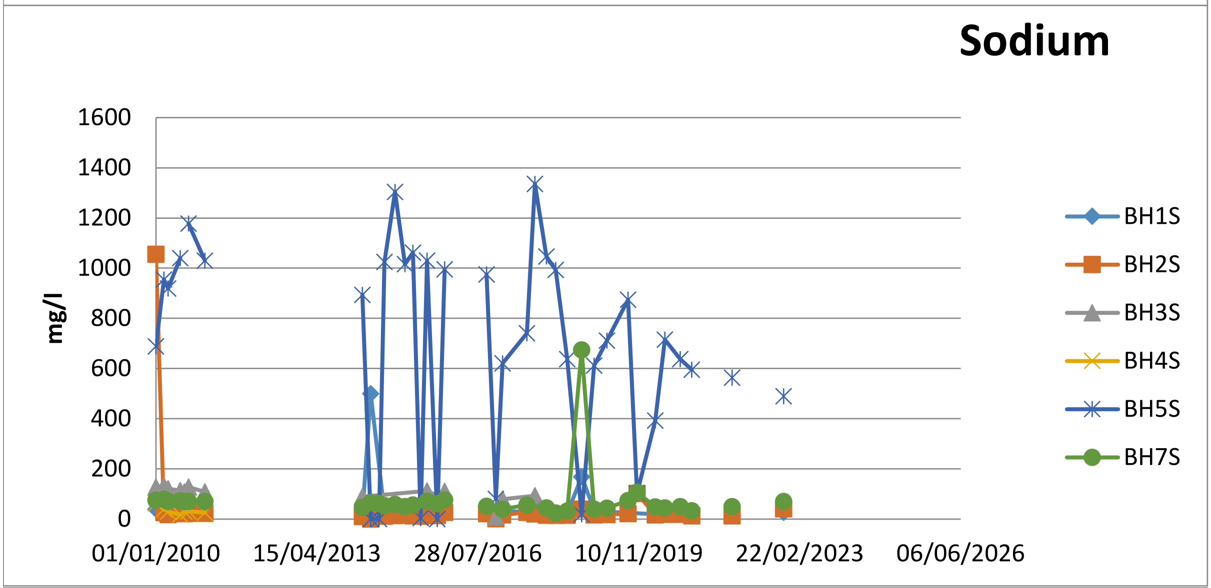

Nitrite
mg/l
12
10
8
6
4
2
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

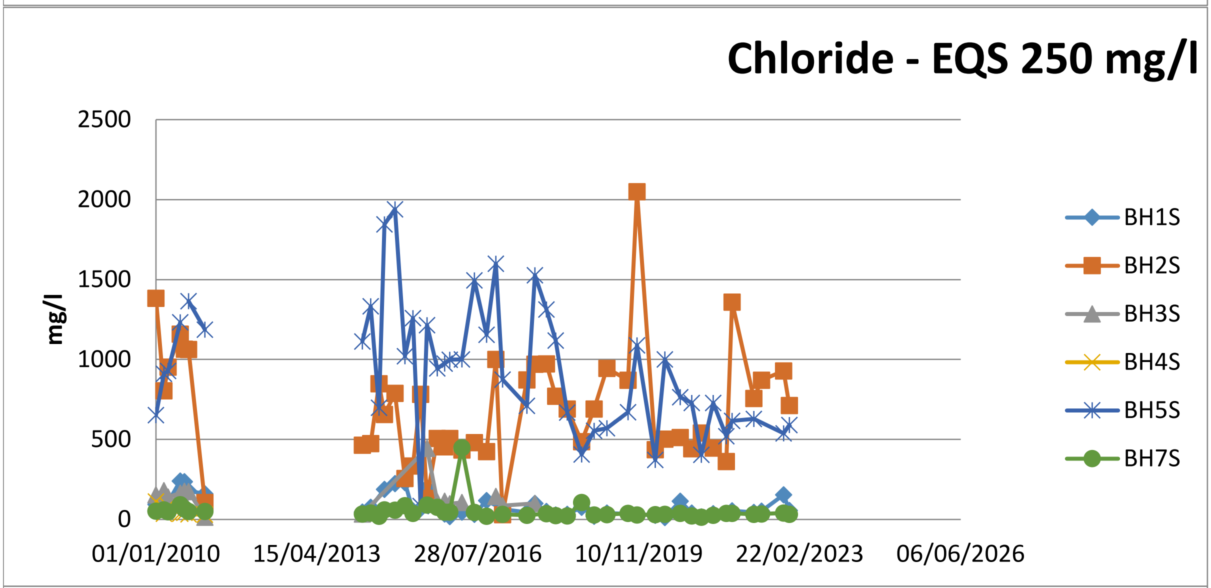

Calcium
1400
1200
1000
800
600
400
200
0
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

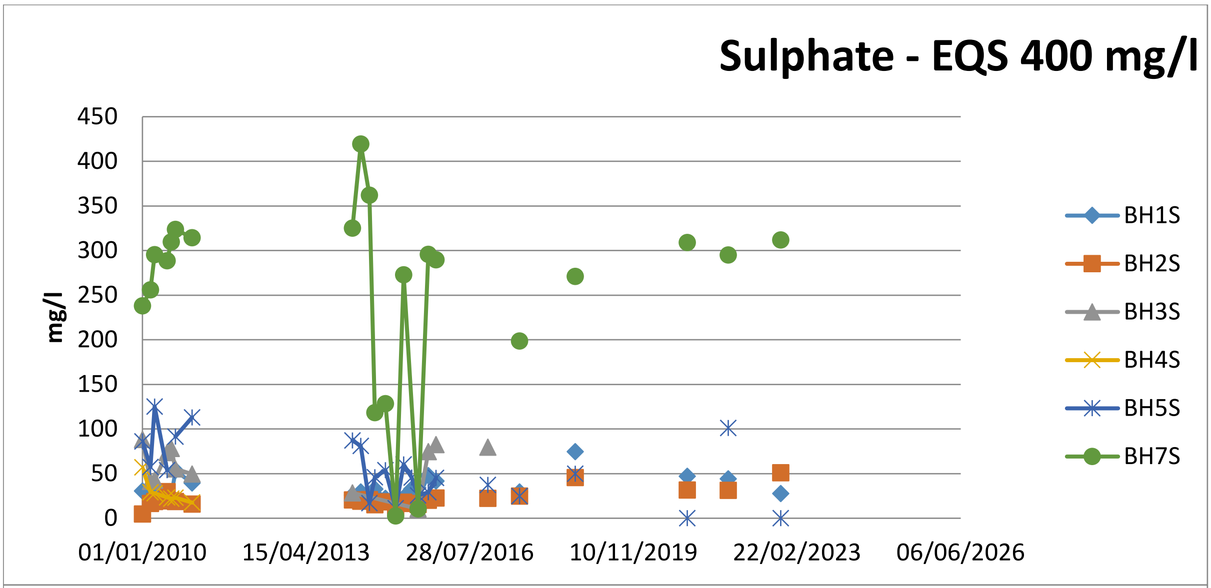

Magnesium
250
200
150
100
50
0
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

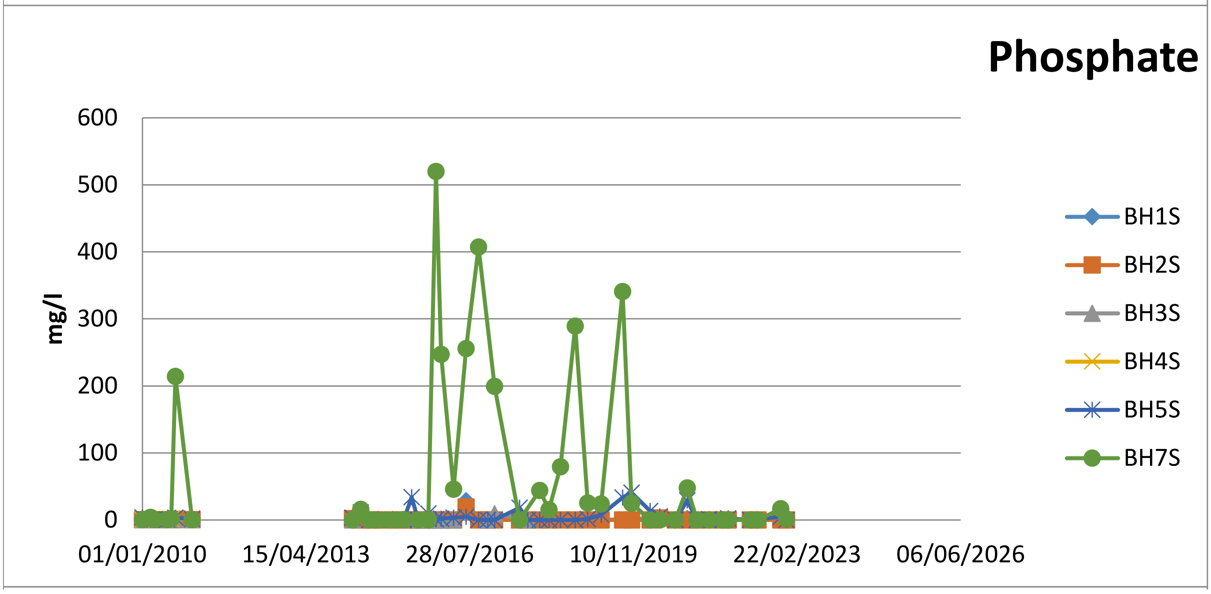

Alkalinity
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
mg/l CaCO3
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

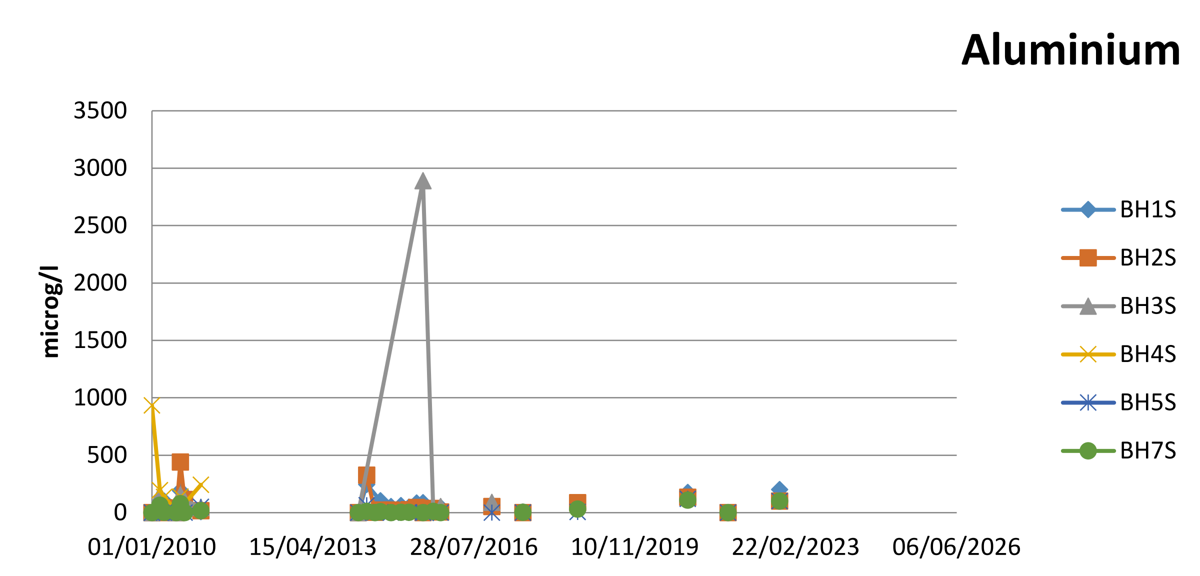

Potassium
160
140
120
100
80
60
40
20
0
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

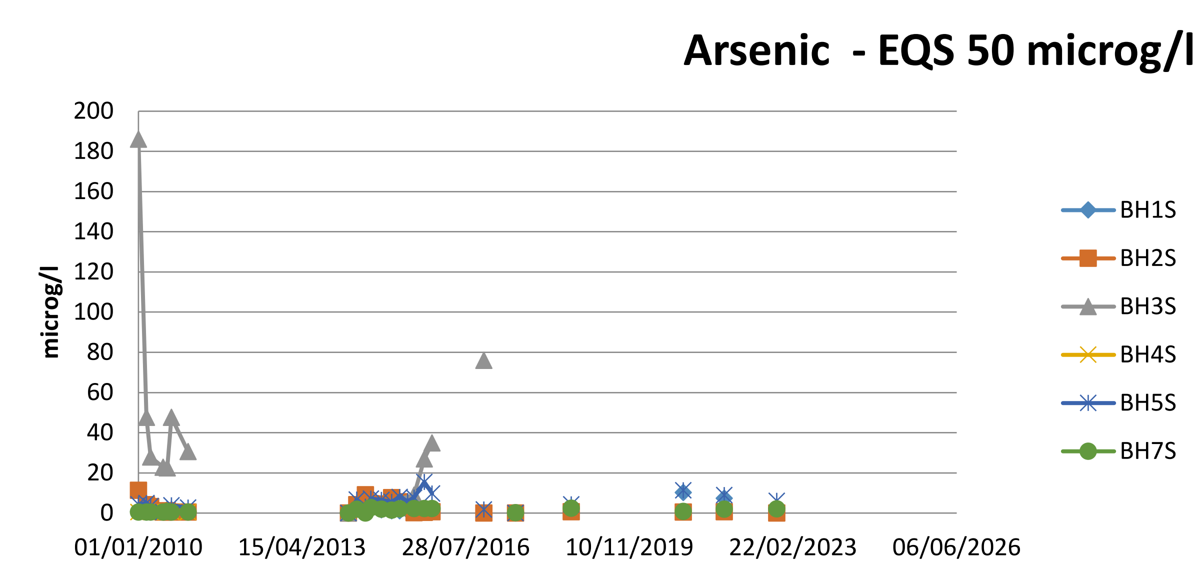

Sodium
1600
1400
1200
1000
800
600
400
200
0
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

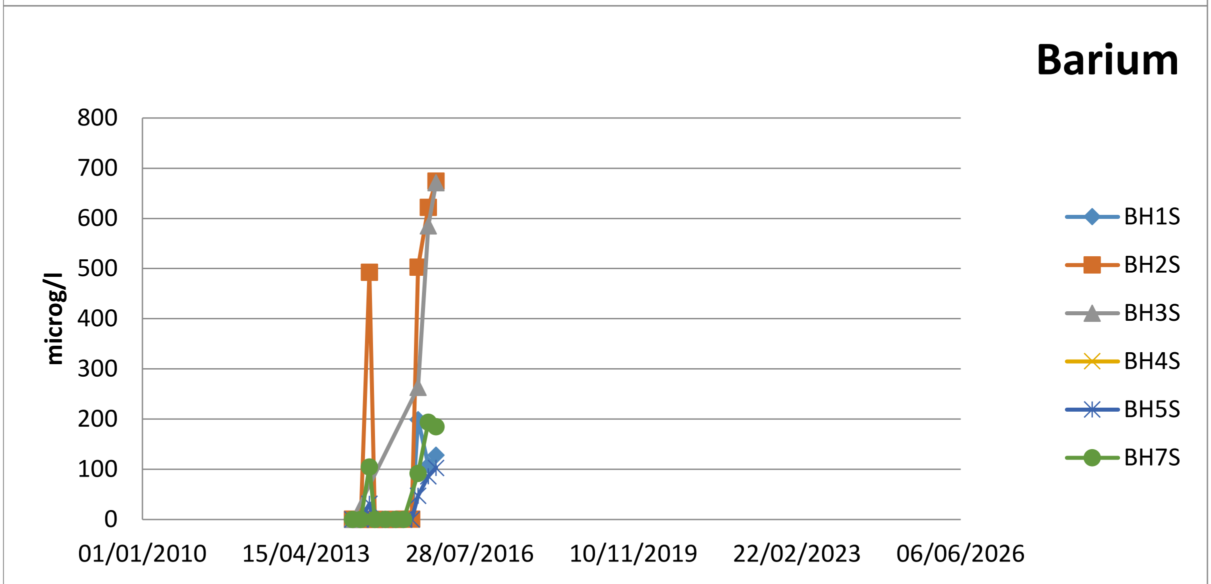

Chloride - EQS 250 mg/l
2500
2000
1500
1000
500
0
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

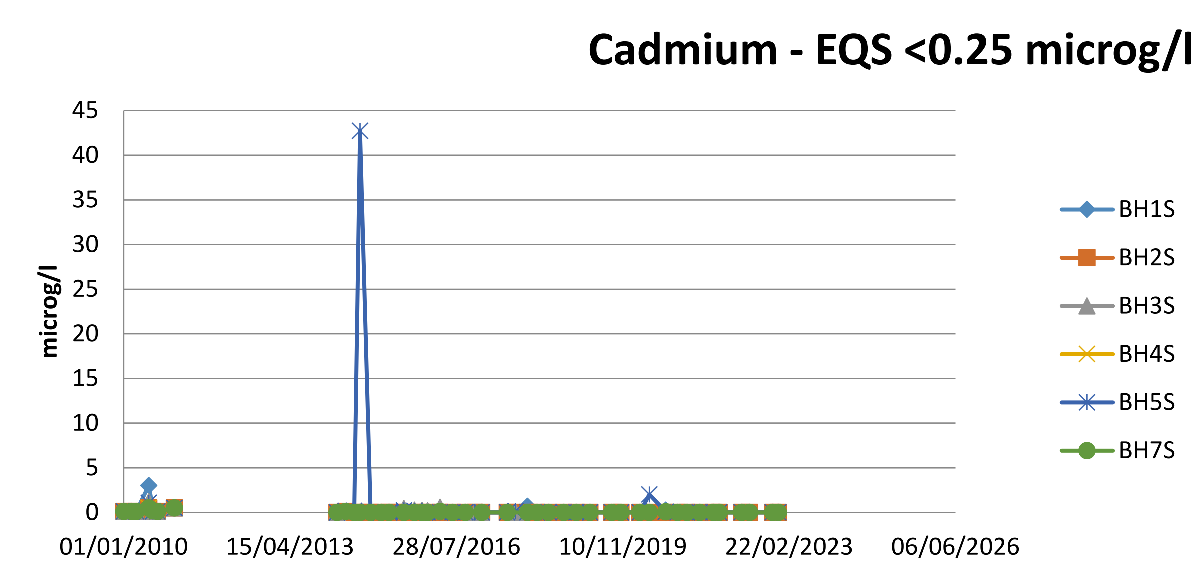

Sulphate - EQS 400 mg/l
mg/l
450
400
350
300
250
200
150
100
50
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

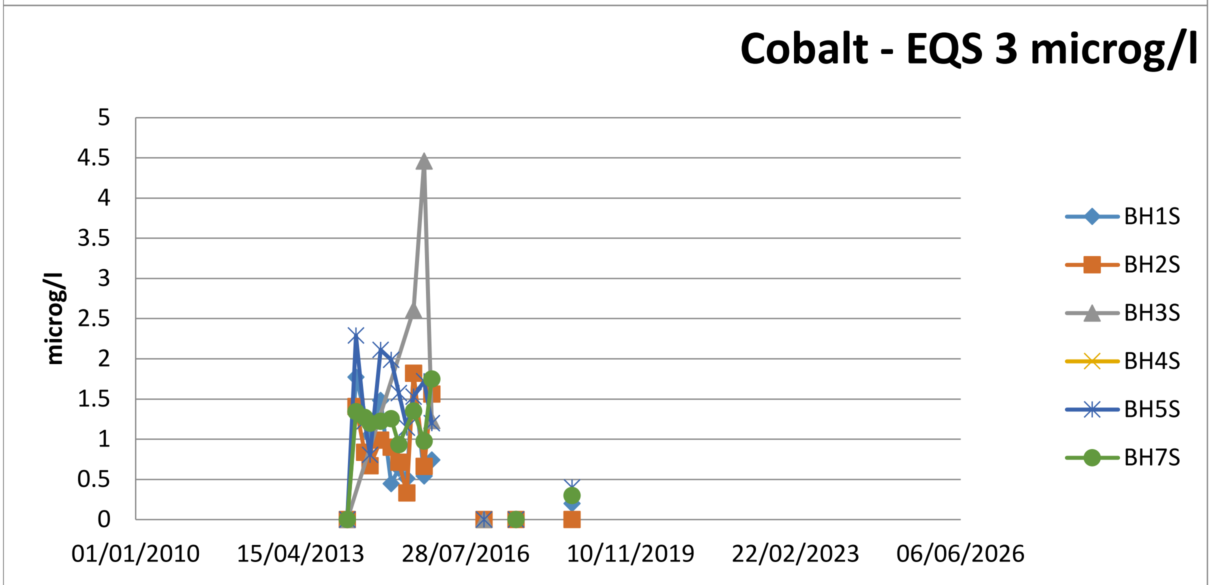

Phosphate
mg/l
600
500
400
300
200
100
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

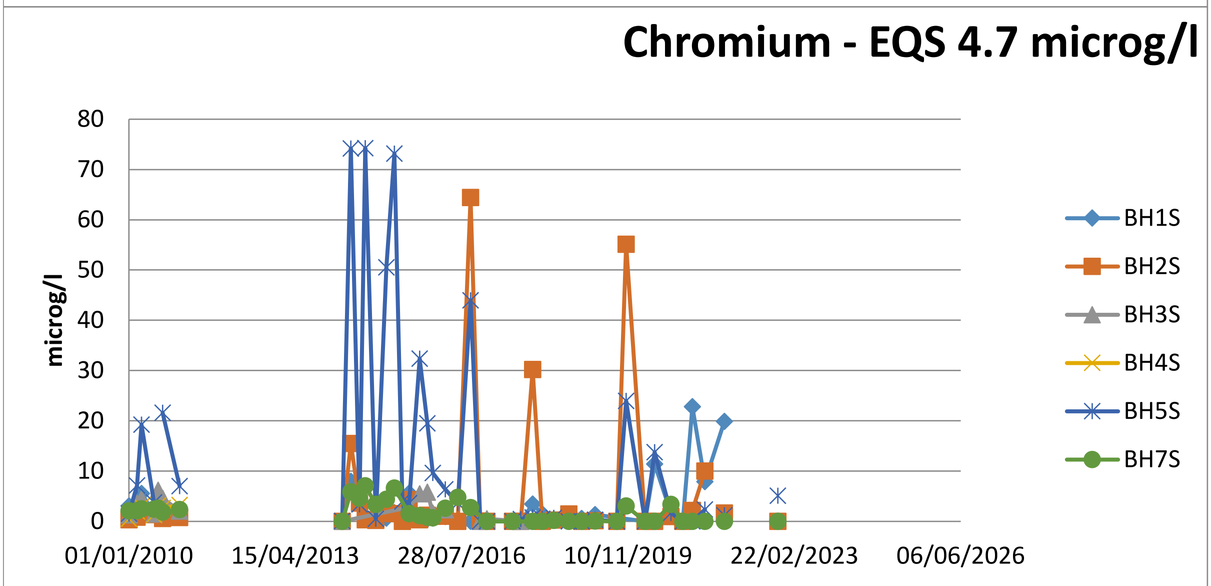

Aluminium
3500
3000
2500
2000
1500
1000
500
0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

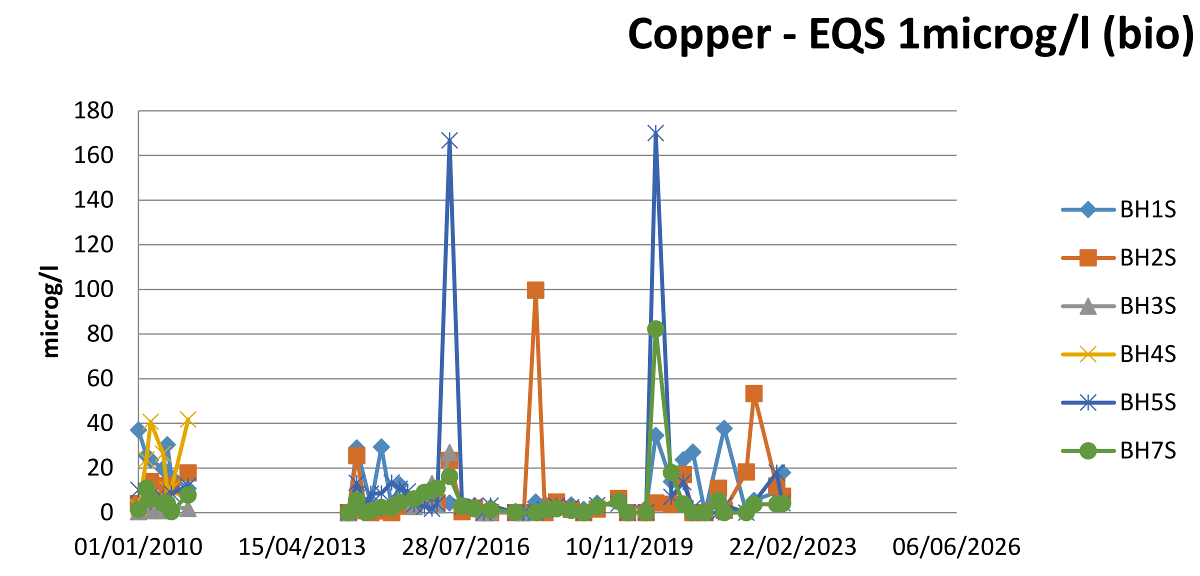

Arsenic - EQS 50 microg/l
200
180
160
140
120
100
80
60
40
20
0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

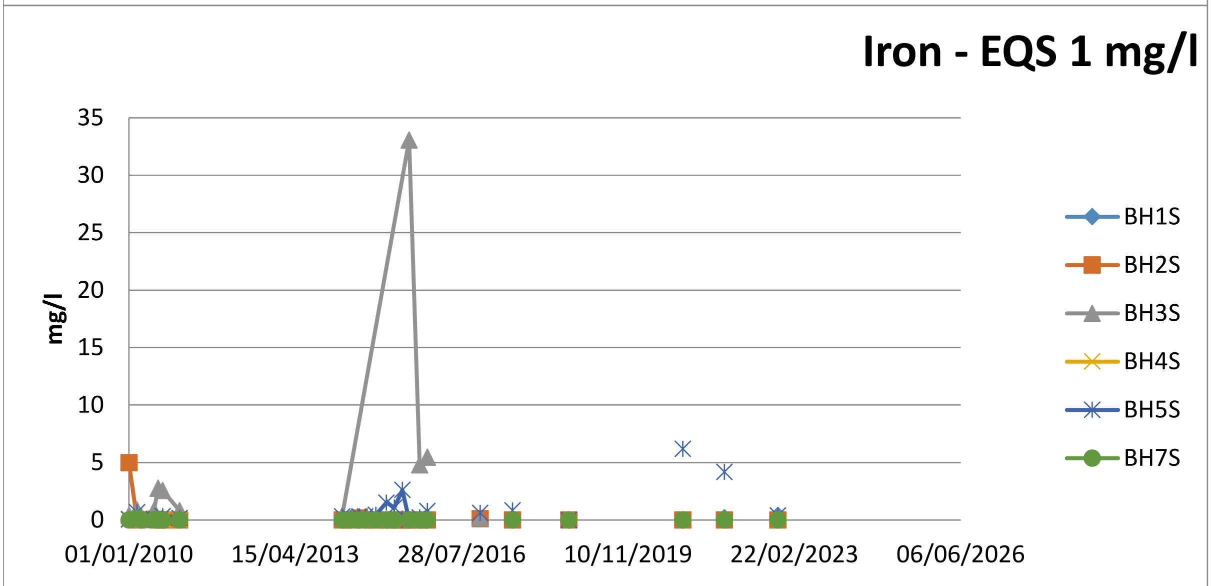

Barium
800
700
600
500
400
300
200
100
0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

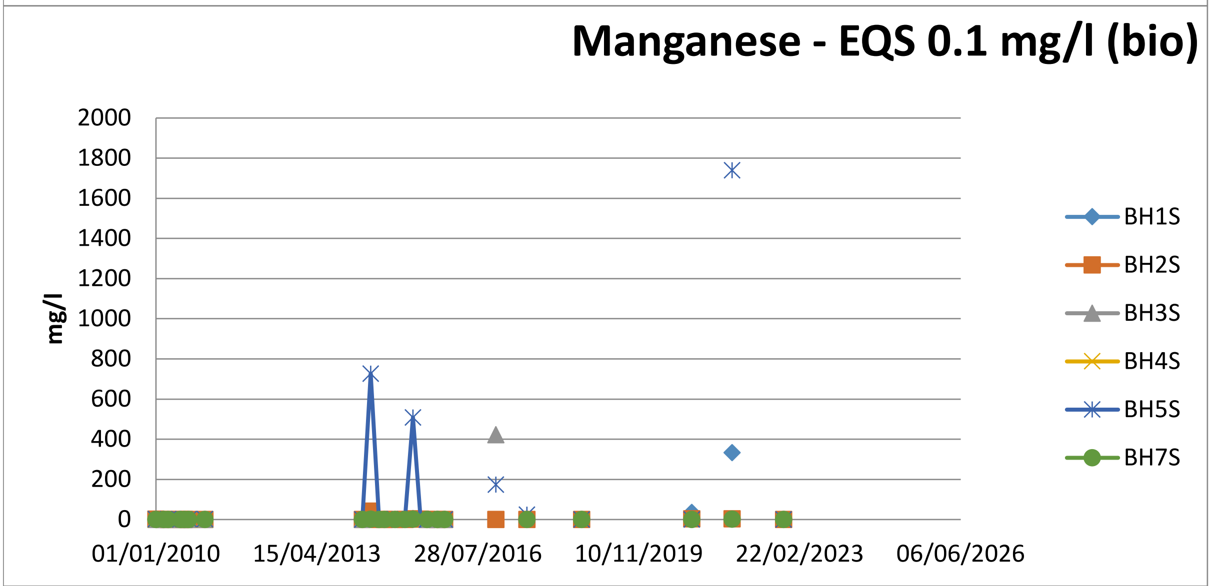

Cadmium - EQS <0.25 microg/l
microg/l
45
40
35
30
25
20
15
10
5
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

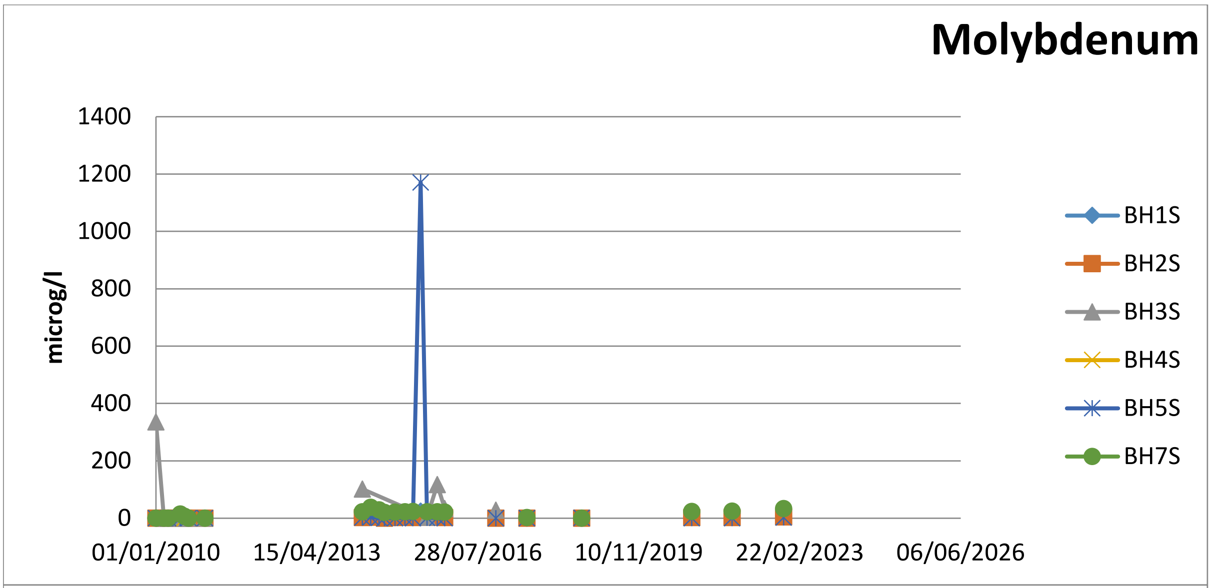

Cobalt - EQS 3 microg/l
microg/l
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

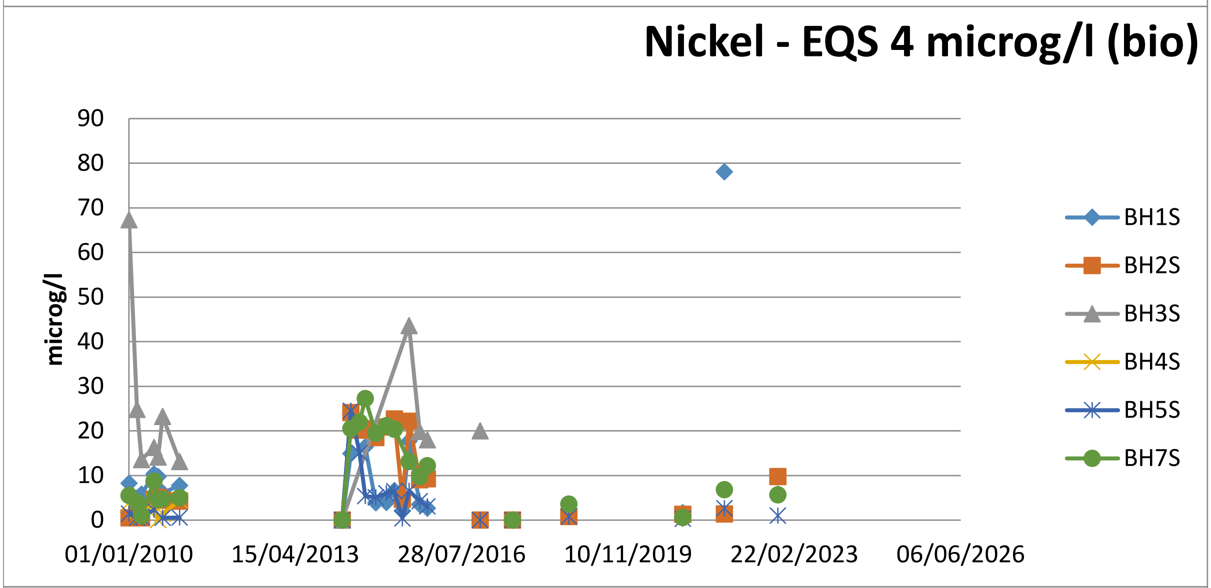

Chromium - EQS 4.7 microg/l
microg/l
80
70
60
50
40
30
20
10
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

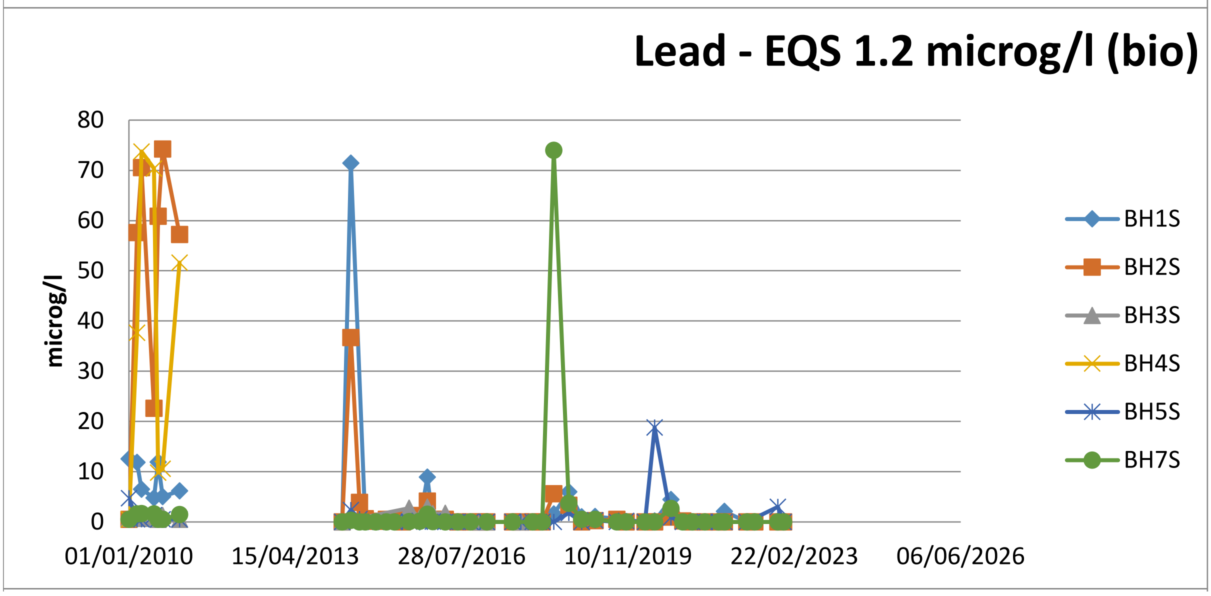

Copper - EQS 1microg/l (bio)
microg/l
180
160
140
120
100
80
60
40
20
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

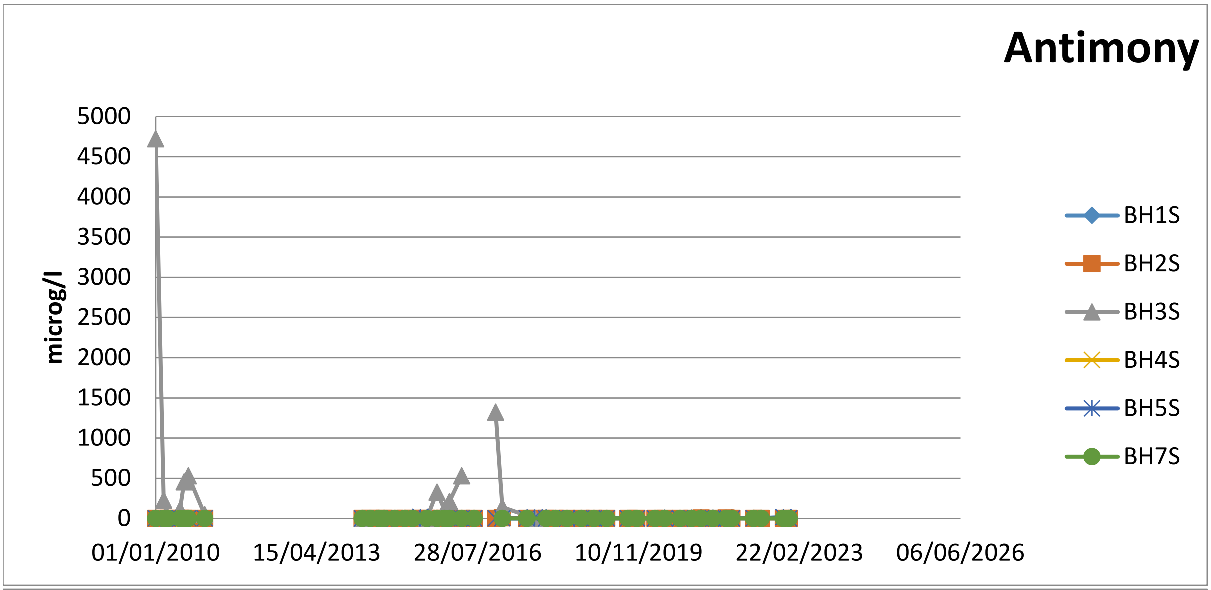

Iron - EQS 1 mg/l
mg/l
35
30
25
20
15
10
5
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

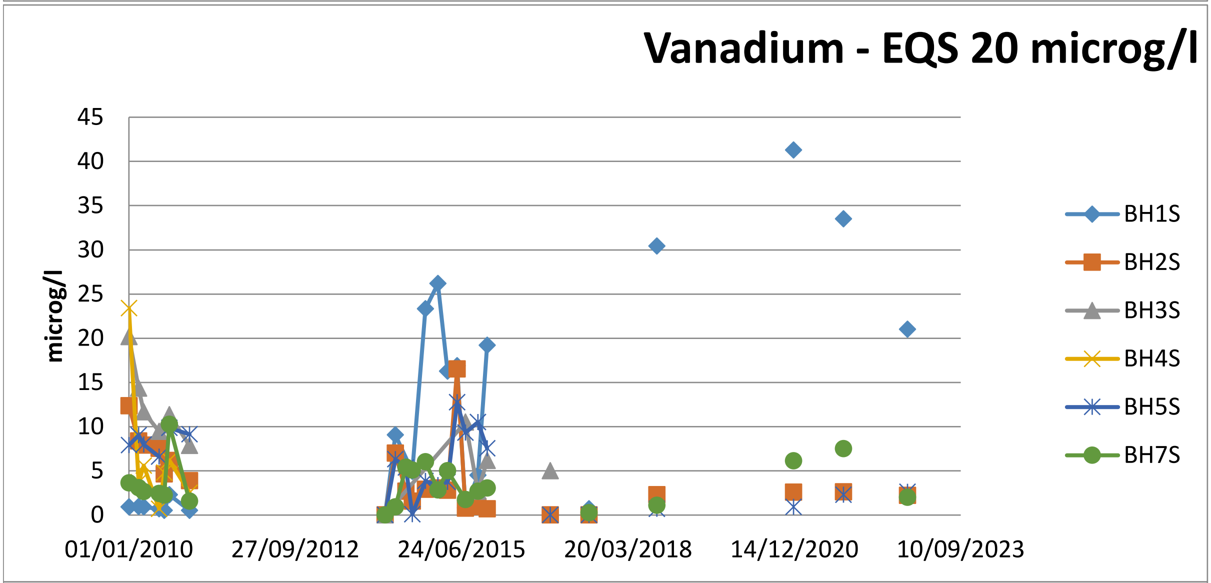

Manganese - EQS 0.1 mg/l (bio)
mg/l
2000
1800
1600
1400
1200
1000
800
600
400
200
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

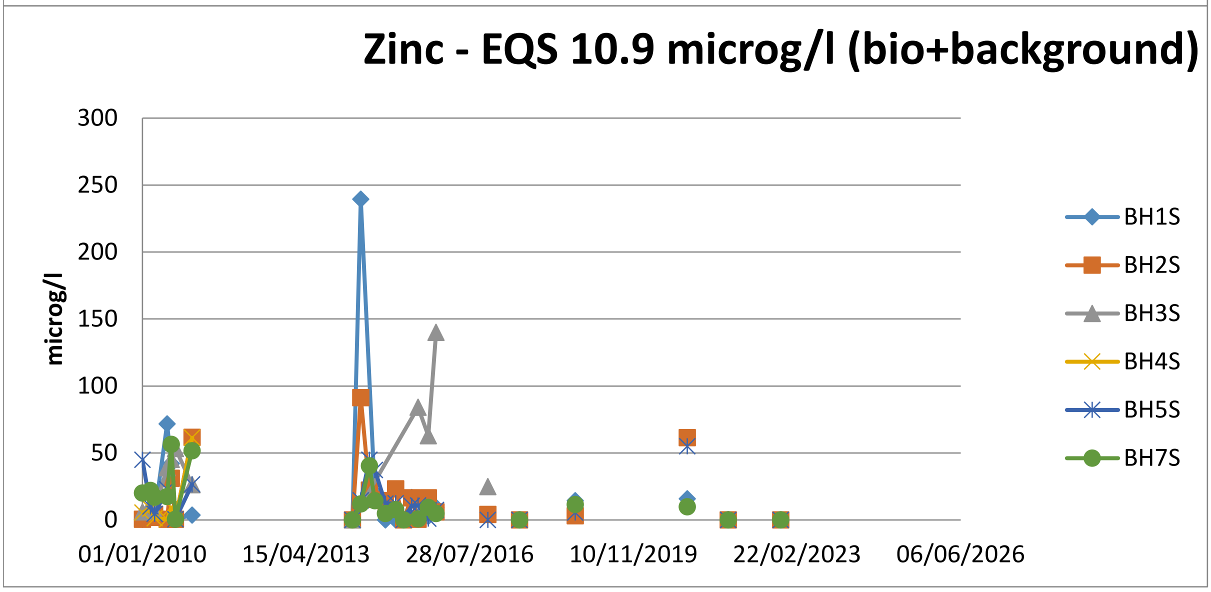

Molybdenum
microg/l
1400
1200
1000
800
600
400
200
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

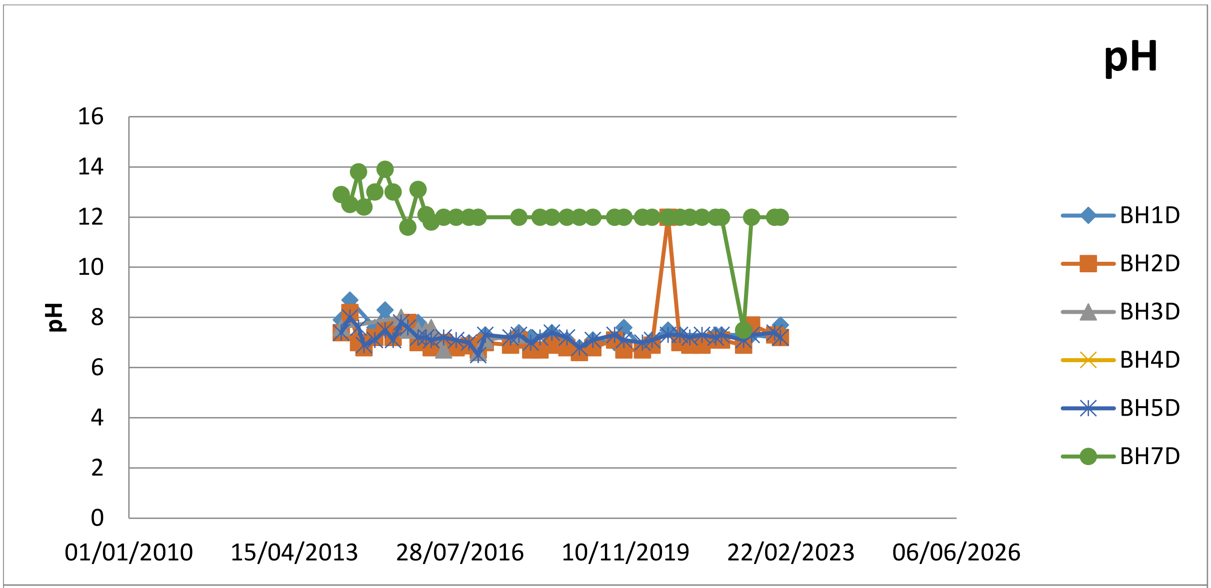

Nickel - EQS 4 microg/l (bio)
microg/l
90
80
70
60
50
40
30
20
10
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

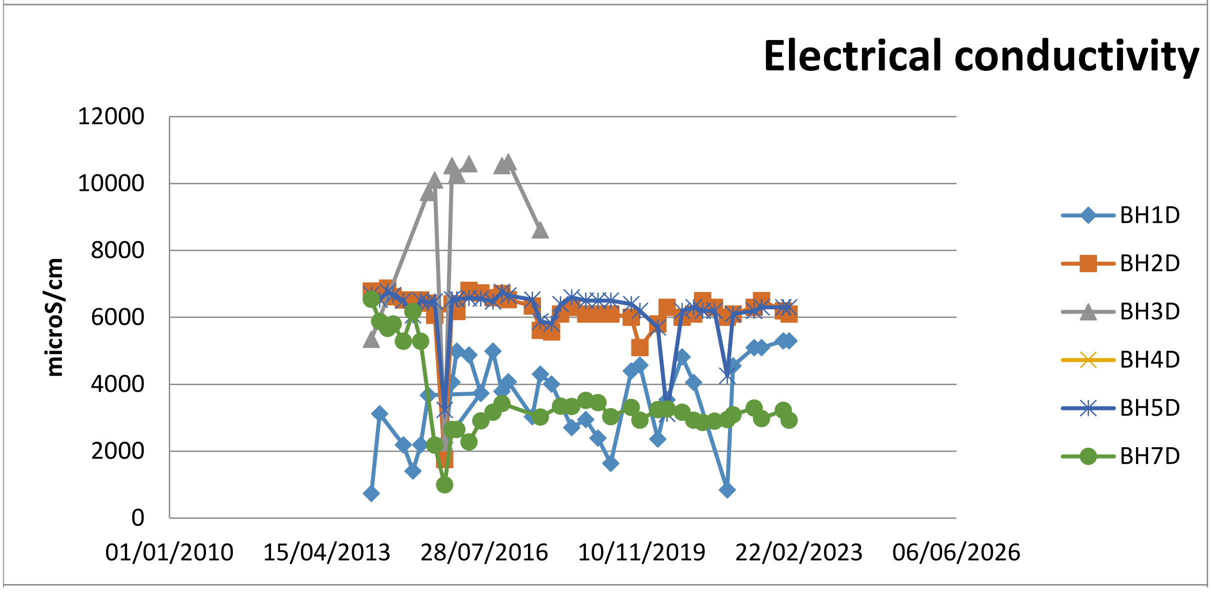

Lead - EQS 1.2 microg/l (bio)
microg/l
80
70
60
50
40
30
20
10
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

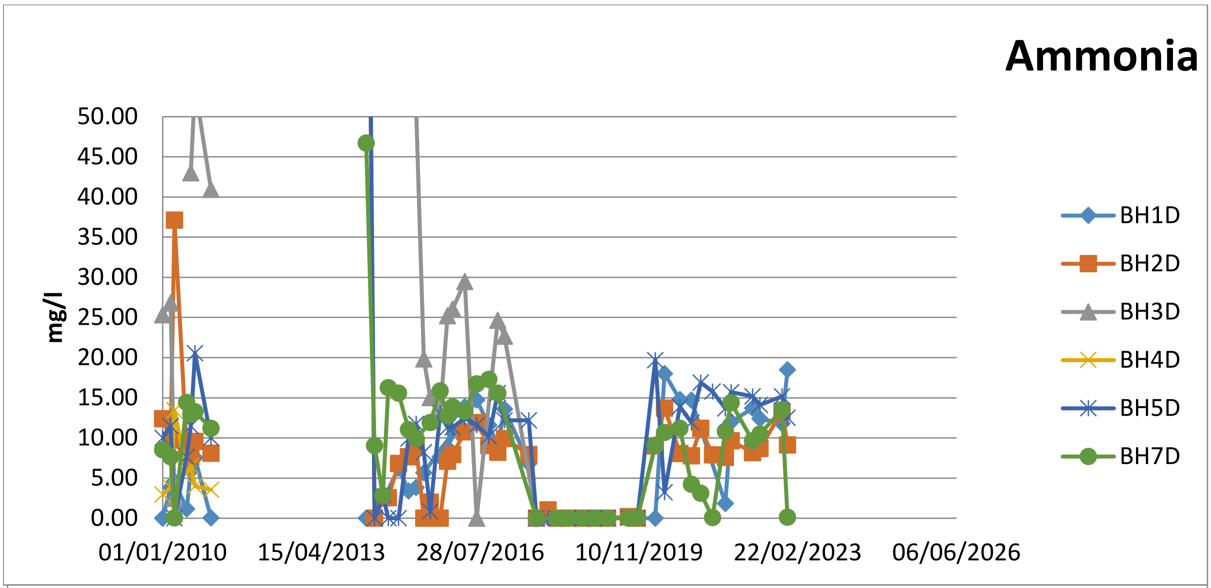

Antimony
microg/l
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

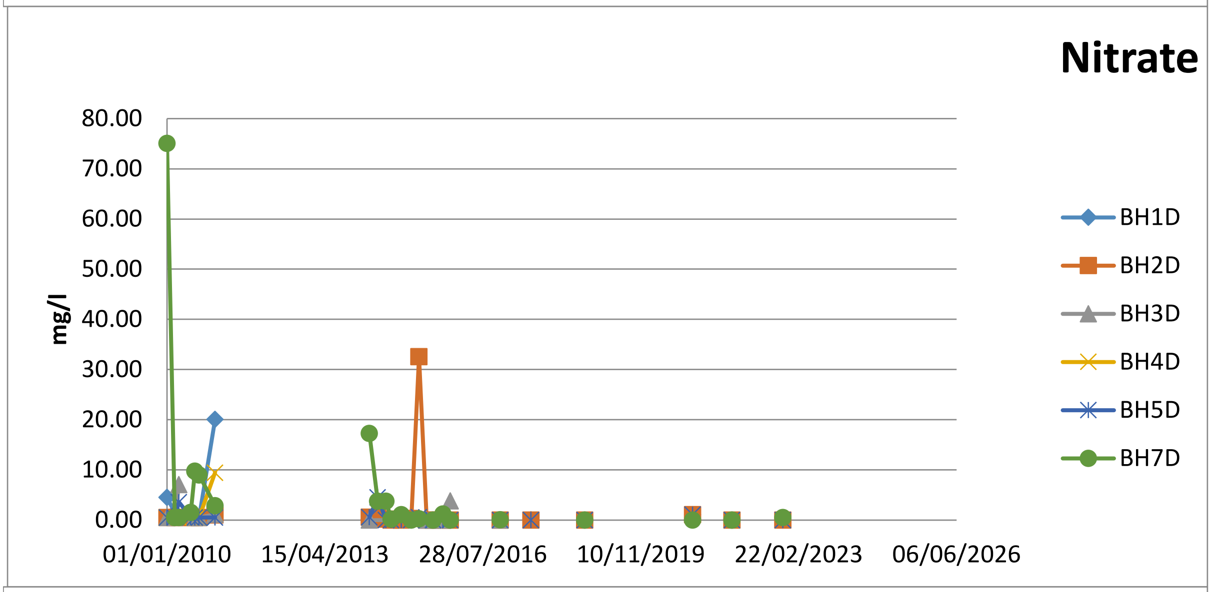

Vanadium - EQS 20 microg/l
microg/l
45
40
35
30
25
20
15
10
5
0
01/01/2010
27/09/2012
24/06/2015
20/03/2018
14/12/2020
10/09/2023
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S

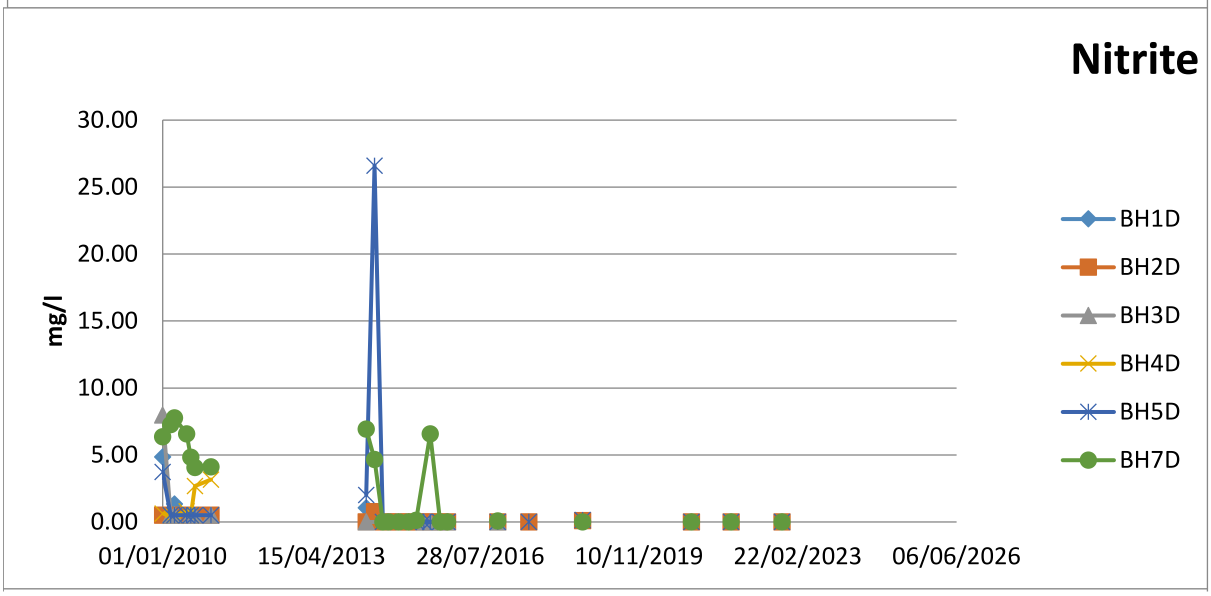

Zinc - EQS 10.9 microg/l (bio+background)
microg/l
300
250
200
150
100
50
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1S
BH2S
BH3S
BH4S
BH5S
BH7S


pH
16
14
12
10
8
6
4
2
0
pH
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

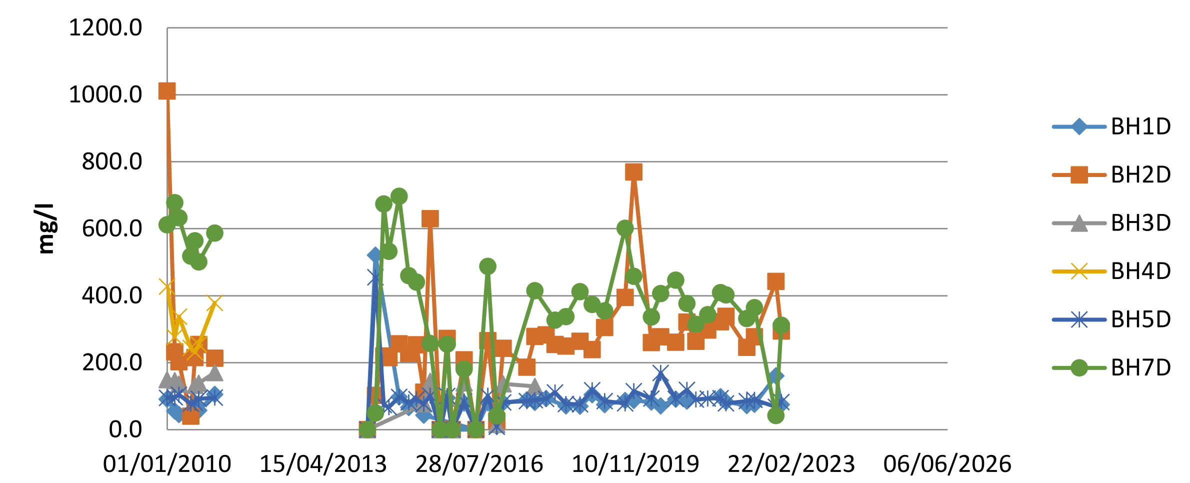

Electrical conductivity
12000
10000
8000
6000
4000
2000
0
microS/cm
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D


Ammonia
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

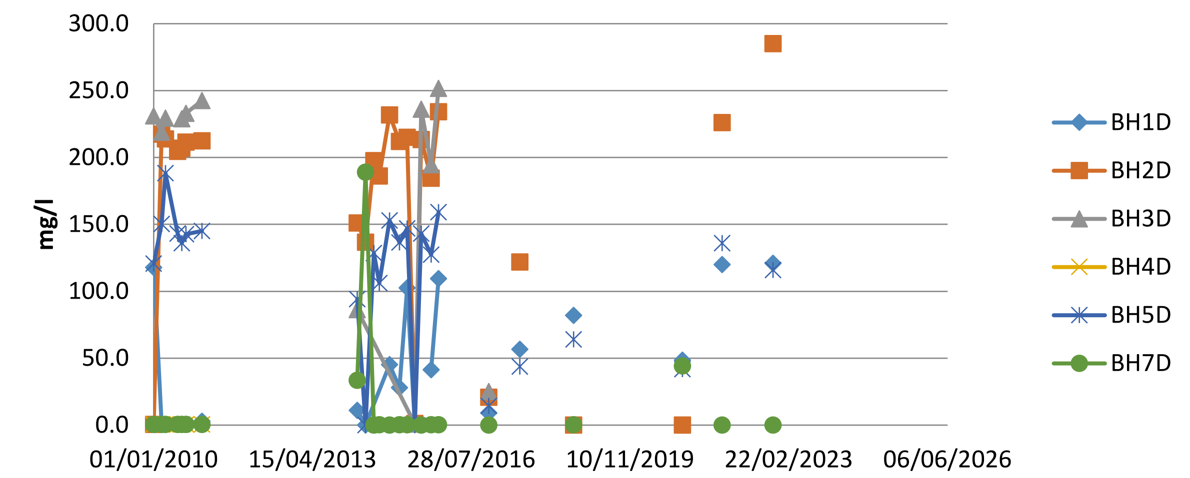

Nitrate
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D


Nitrite
30.00
25.00
20.00
15.00
10.00
5.00
0.00
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

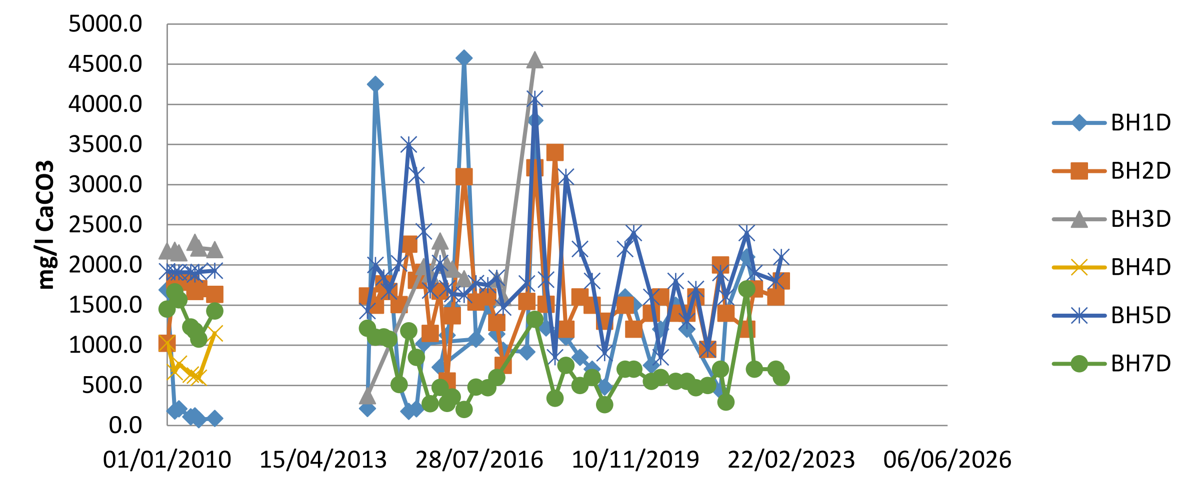
Calcium

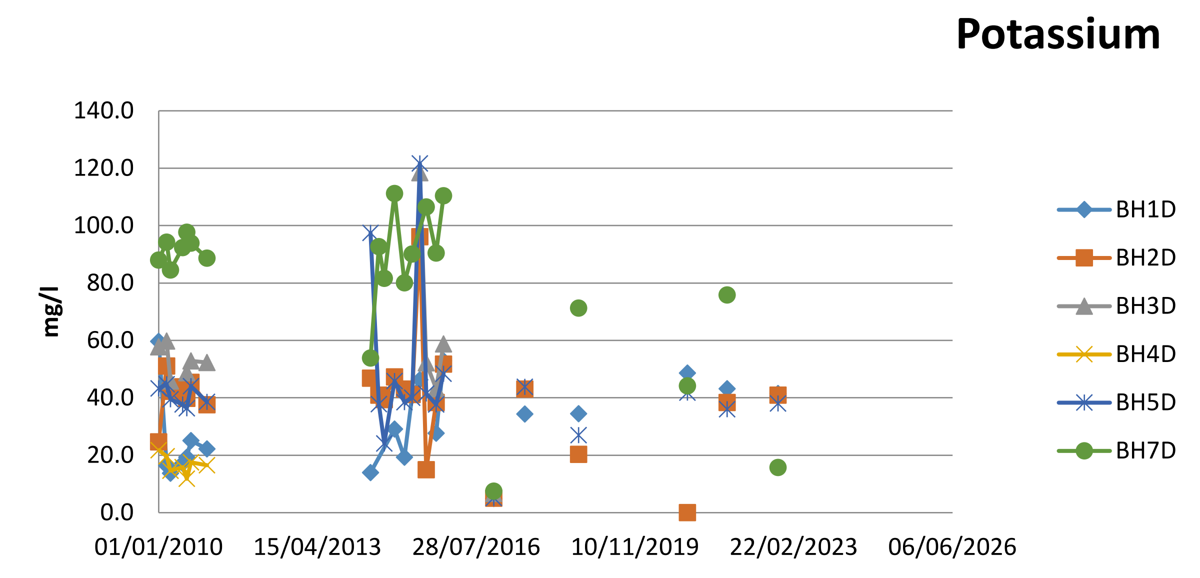


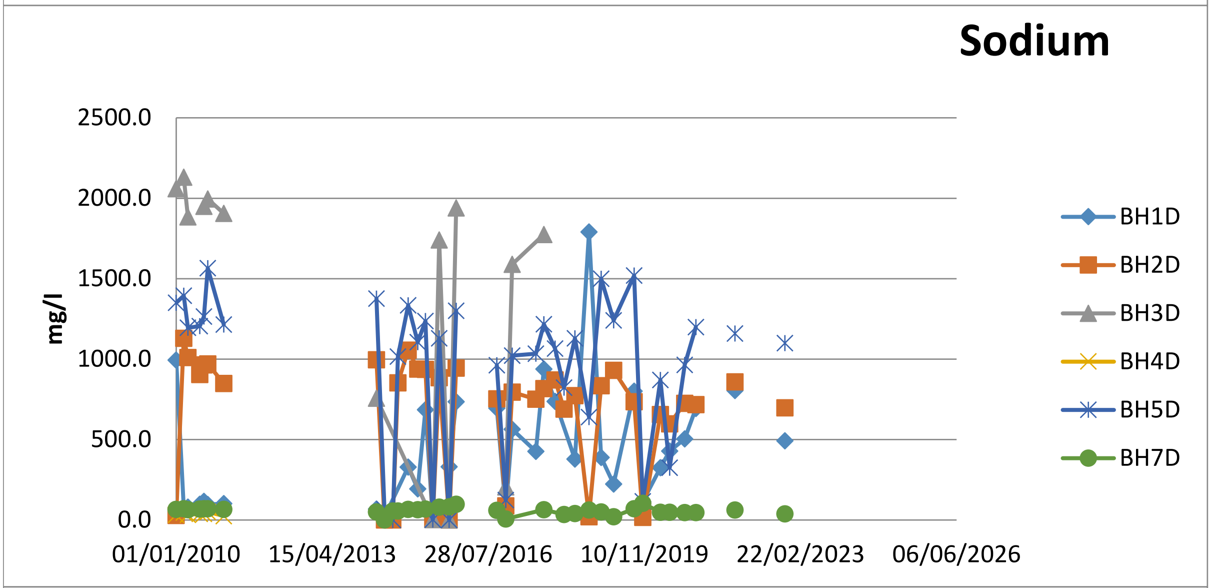
Magnesium

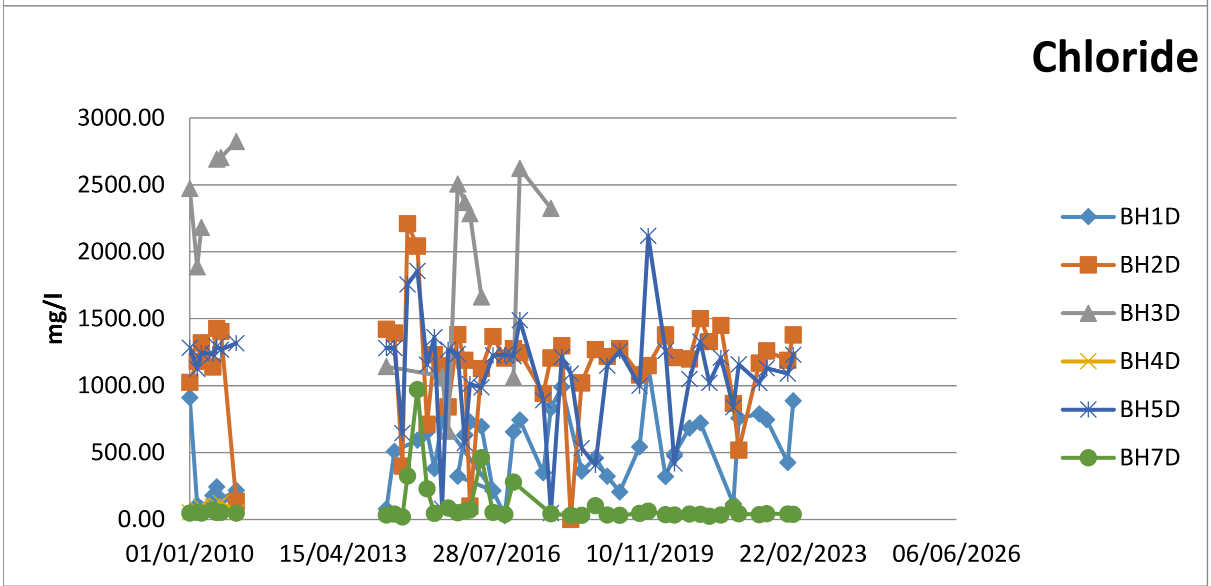


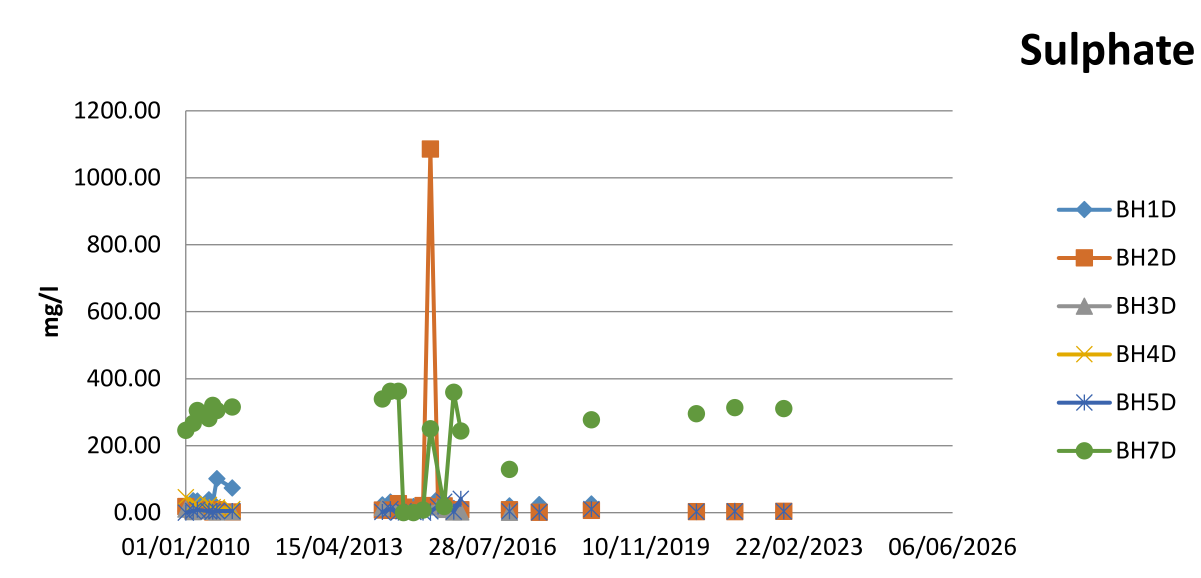
Alkalinity

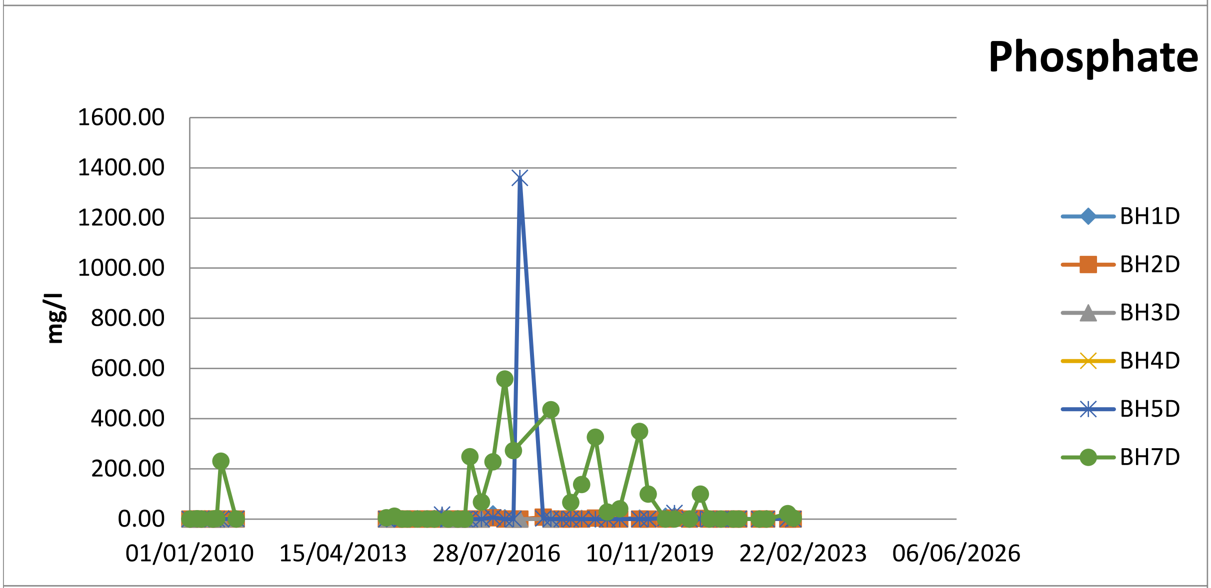


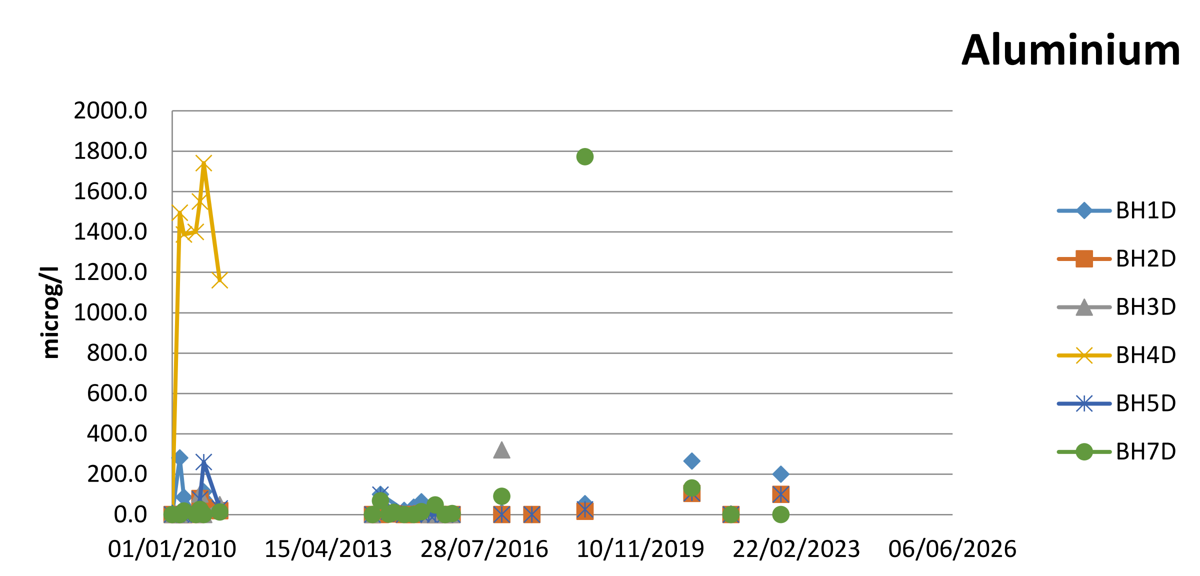

Potassium
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

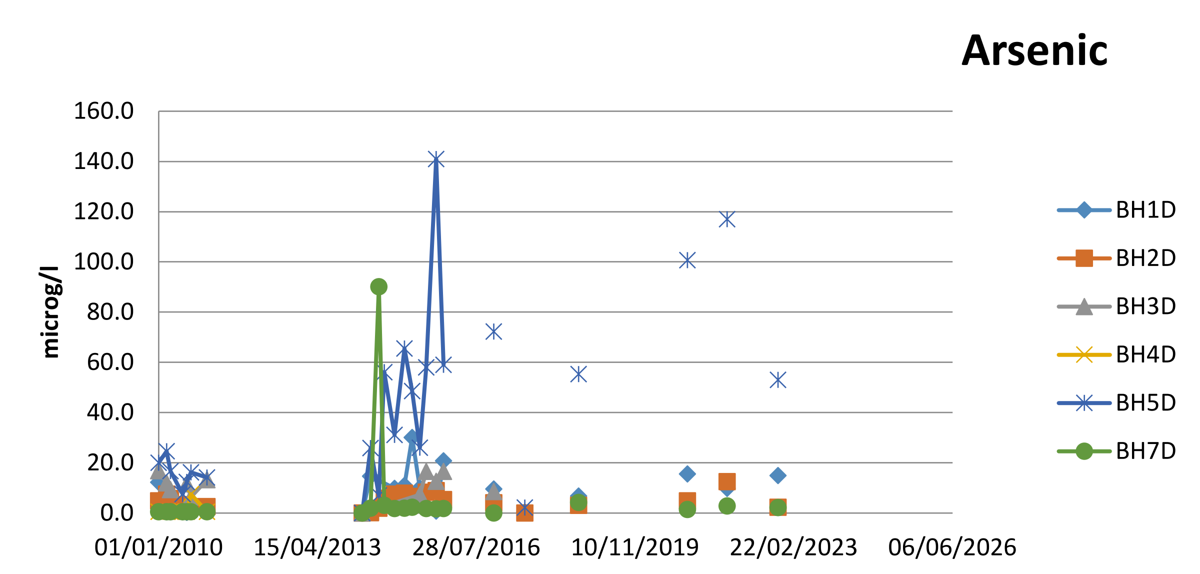

Sodium
2500.0
2000.0
1500.0
1000.0
500.0
0.0
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

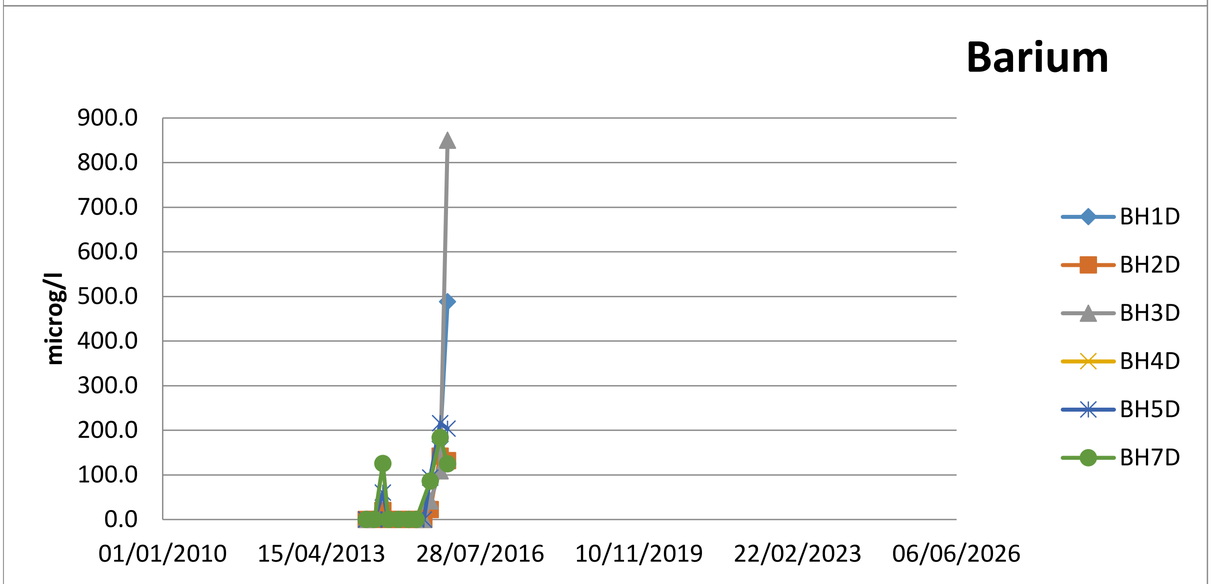

Chloride
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

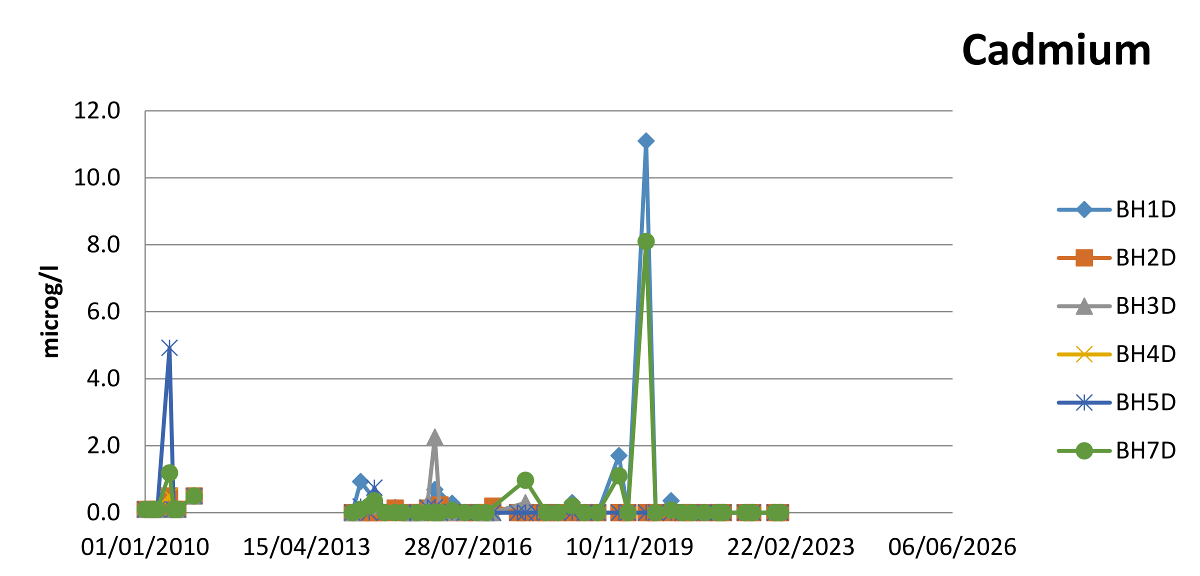

Sulphate
mg/l
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

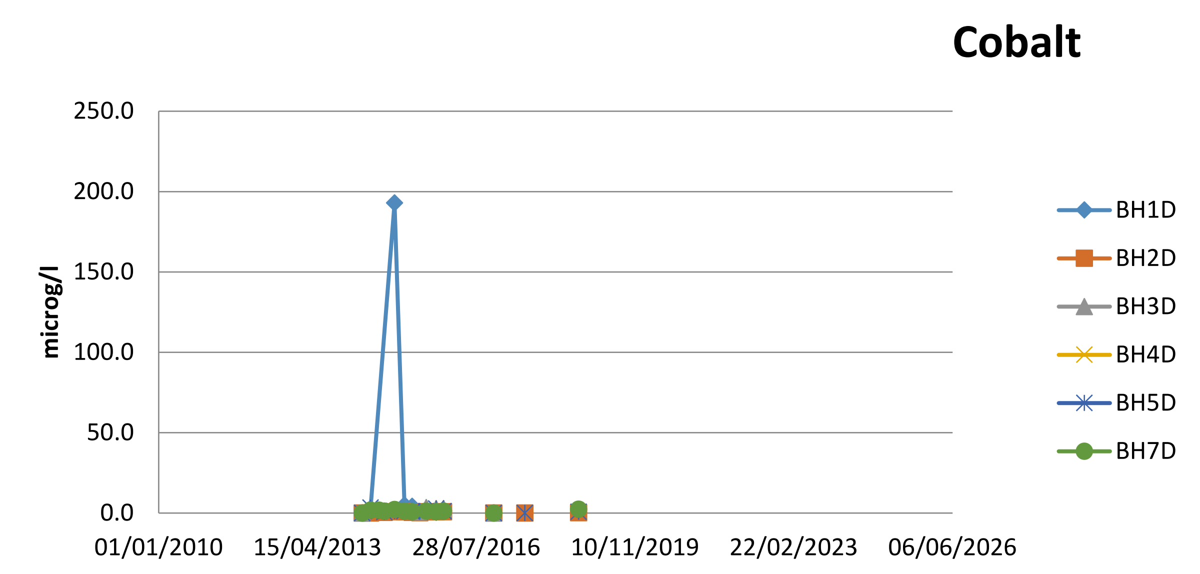

Phosphate
mg/l
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

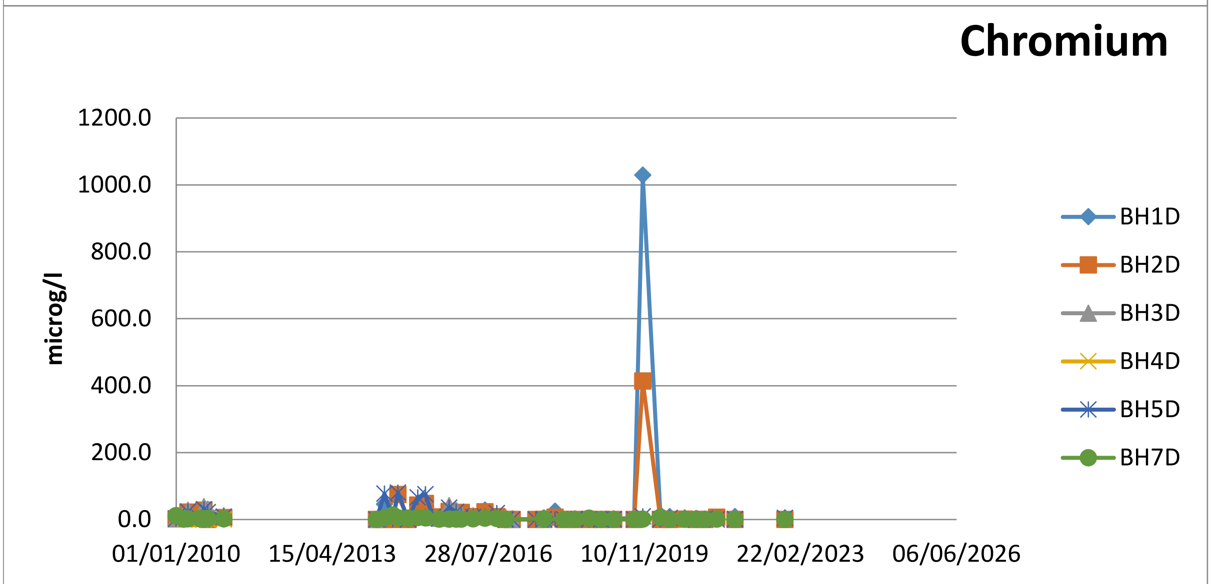

Aluminium
2000.0
1800.0
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

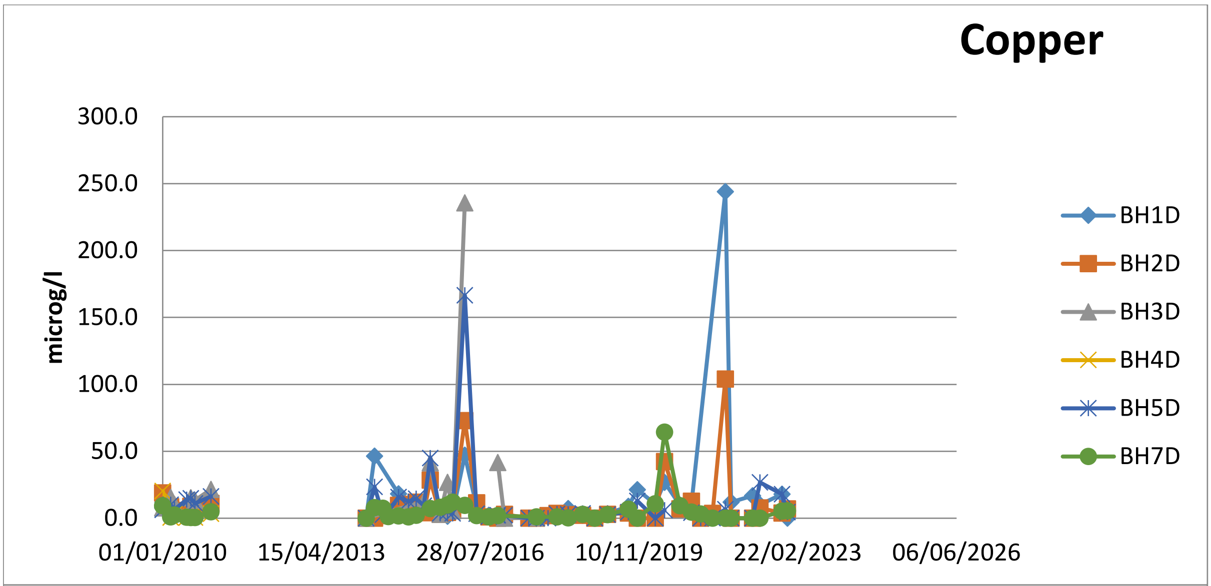

Arsenic
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

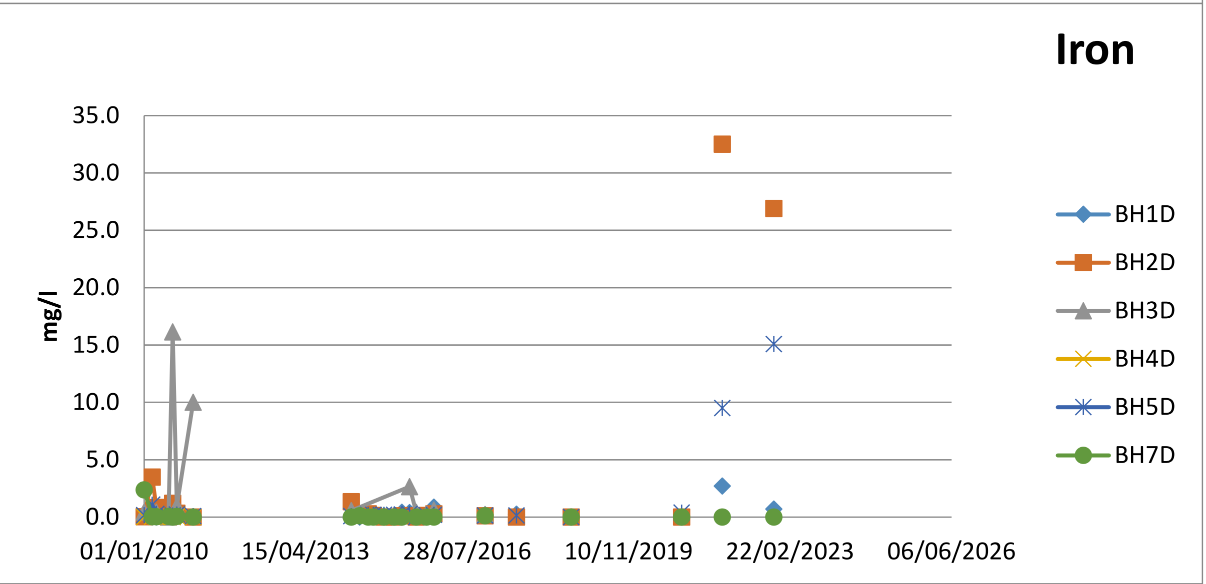

Barium
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

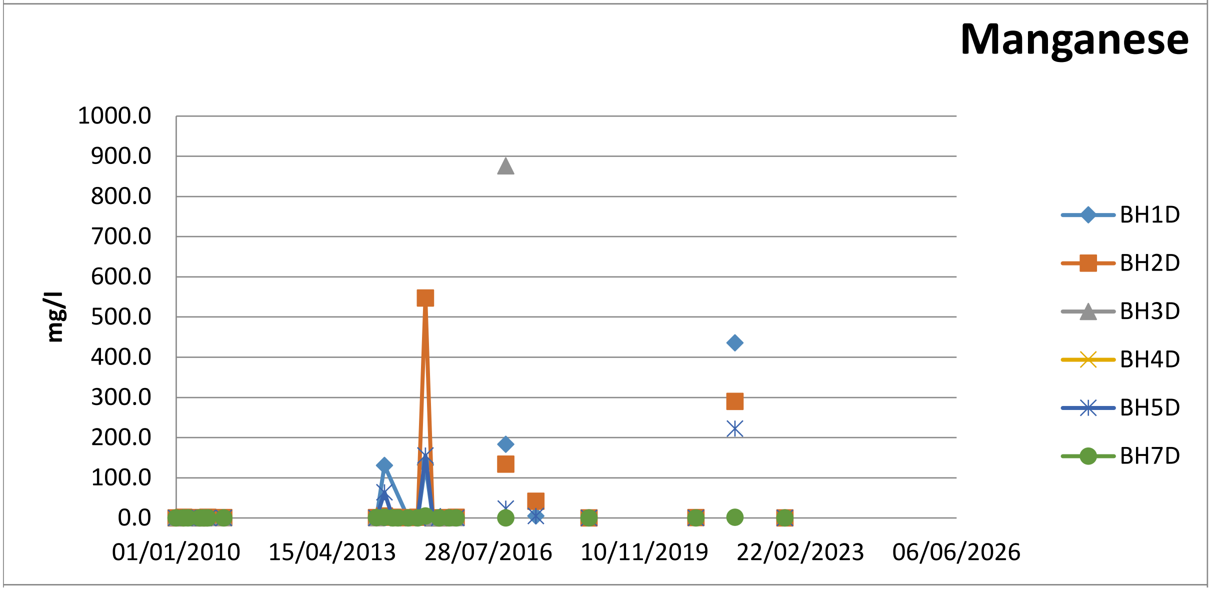

Cadmium
12.0
10.0
8.0
6.0
4.0
2.0
0.0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

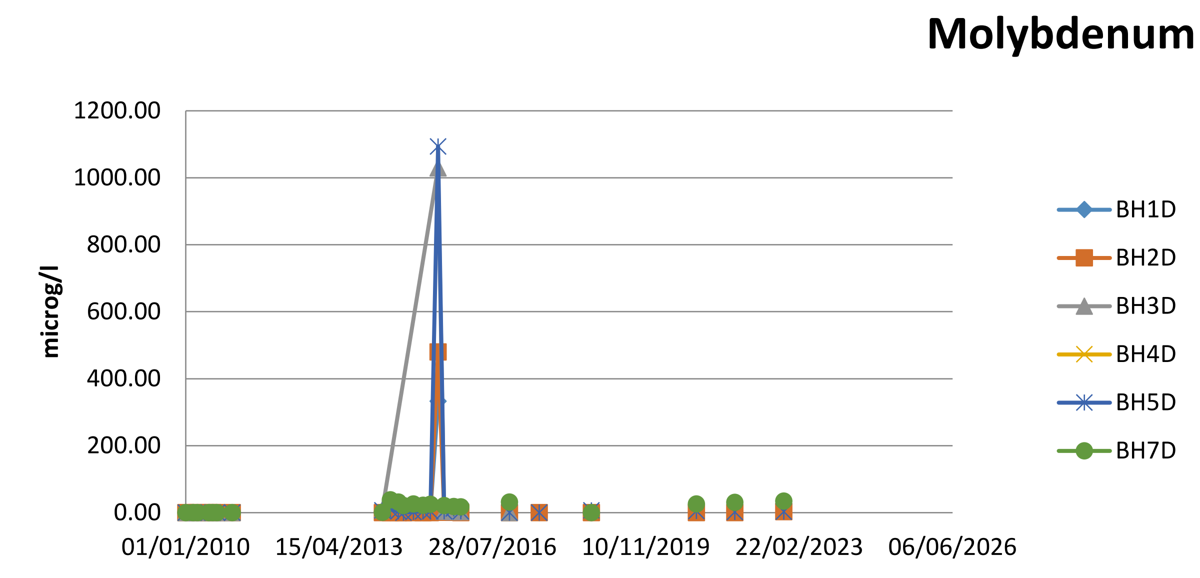

Cobalt
250.0
200.0
150.0
100.0
50.0
0.0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

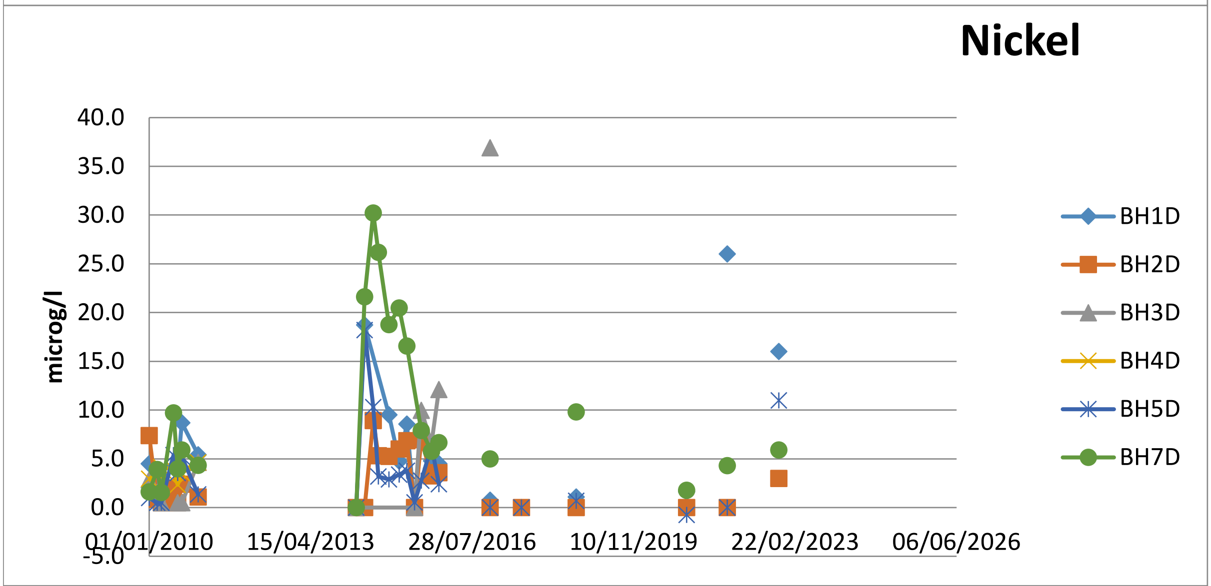

Chromium
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

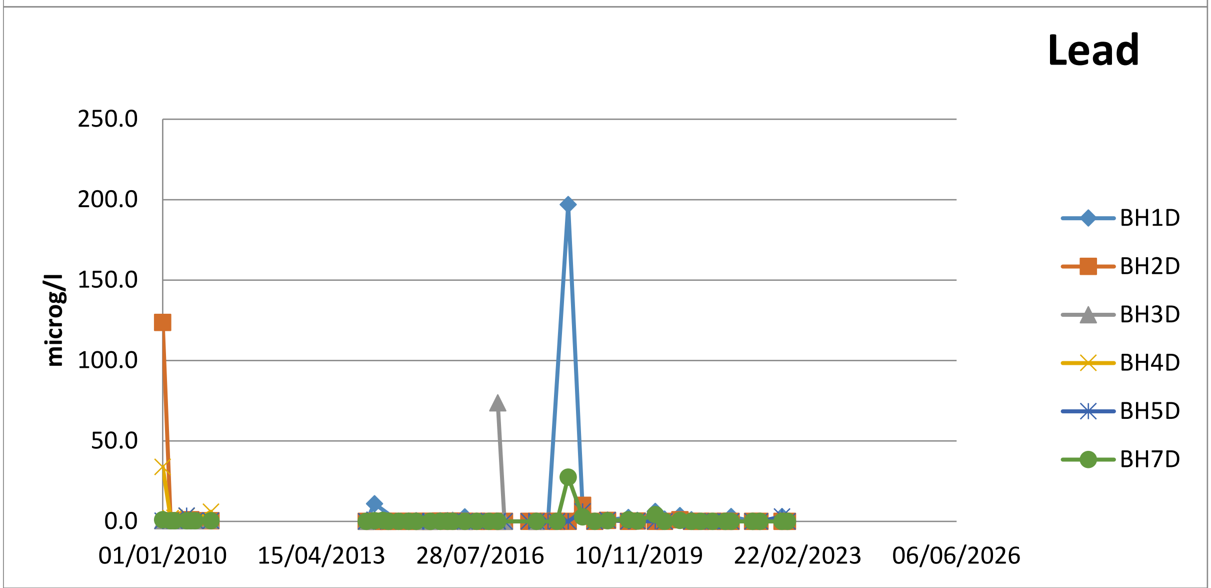

Copper
microg/l
300.0
250.0
200.0
150.0
100.0
50.0
0.0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

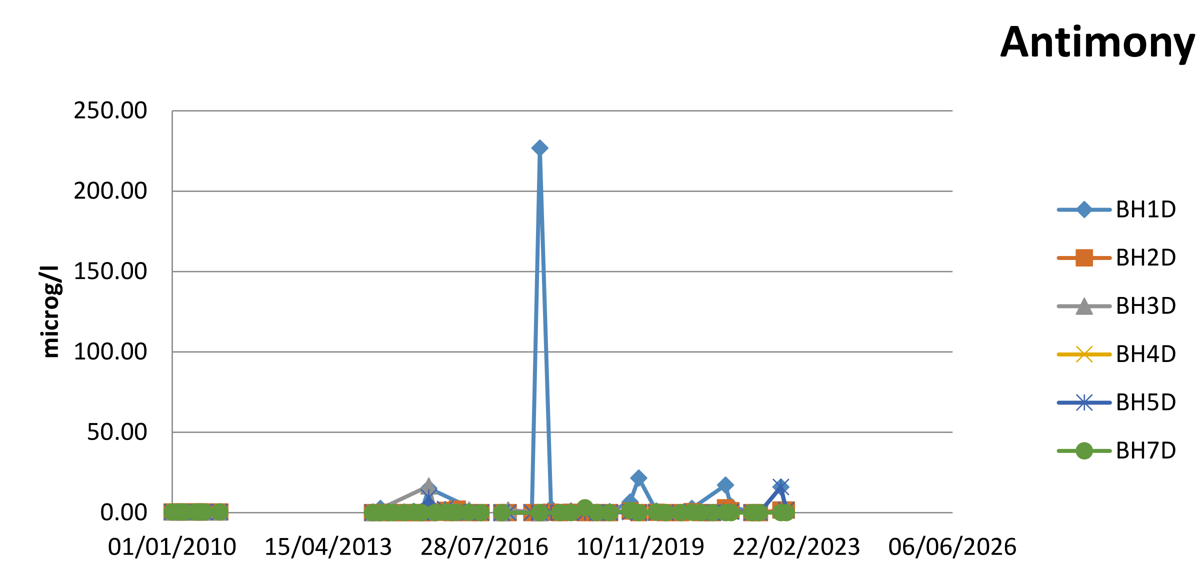

Iron
mg/l
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

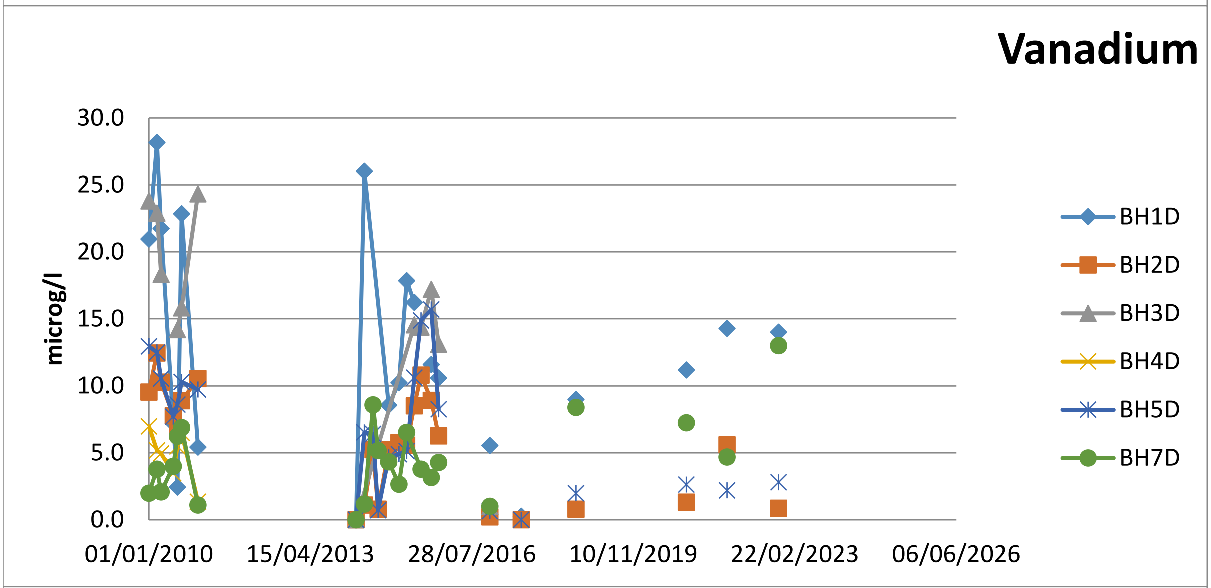

Manganese
mg/l
1000.0
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

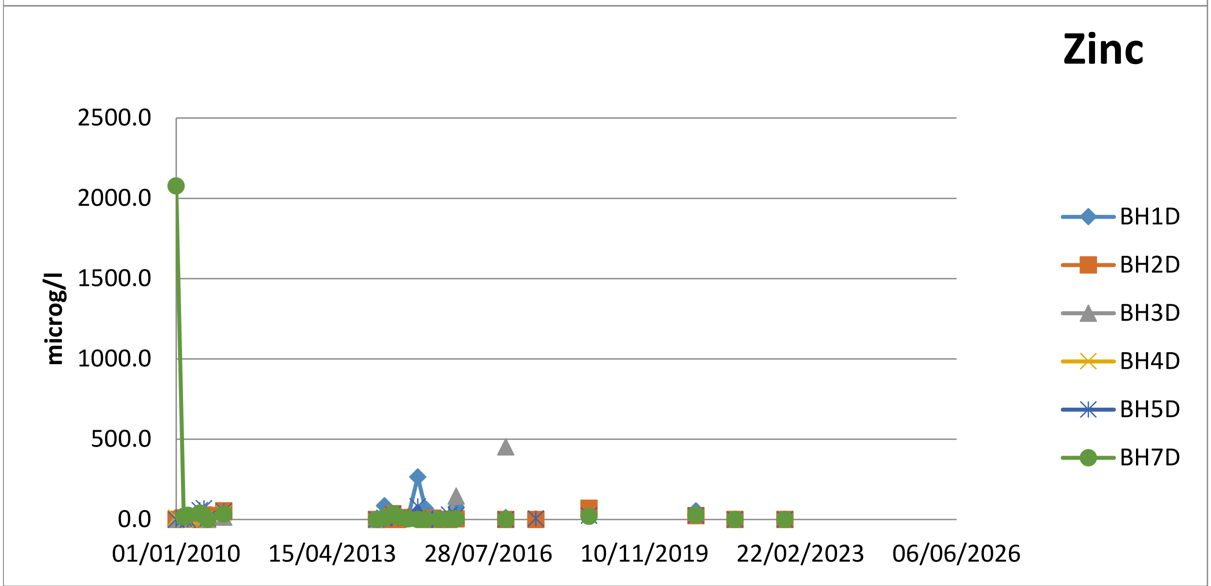

Molybdenum
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D


Nickel
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D


Lead
250.0
200.0
150.0
100.0
50.0
0.0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D


Antimony
250.00
200.00
150.00
100.00
50.00
0.00
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D


Vanadium
30.0
25.0
20.0
15.0
10.0
5.0
0.0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D


Zinc
2500.0
2000.0
1500.0
1000.0
500.0
0.0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
BH1D
BH2D
BH3D
BH4D
BH5D
BH7D

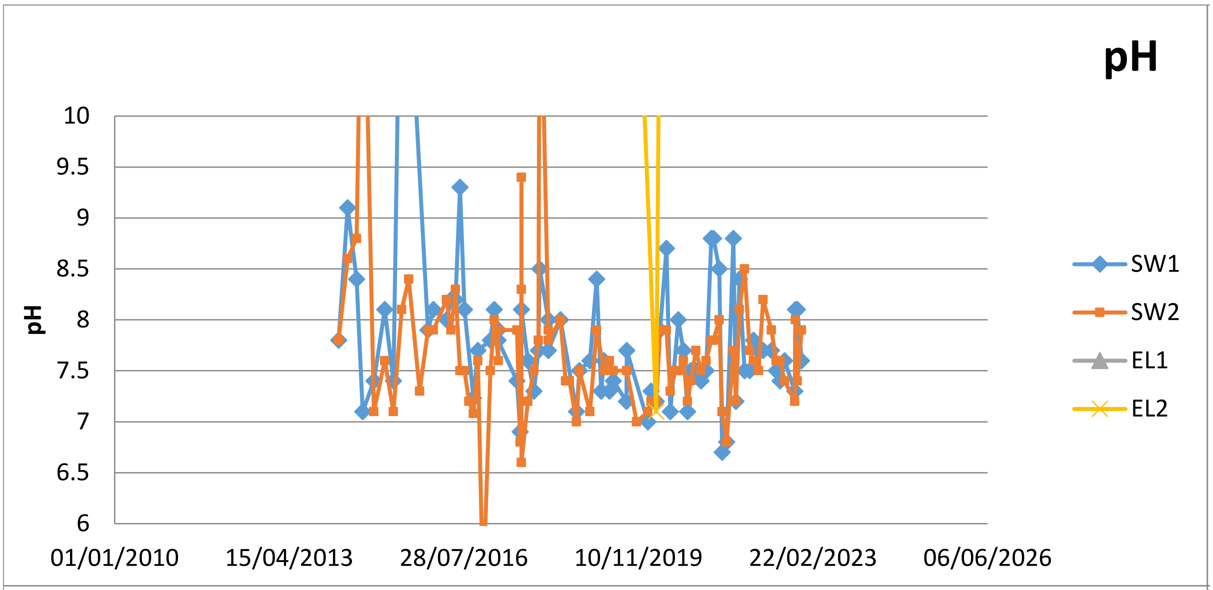
EAST WASTE MANAGEMENT SITE, LLANWERN STEELWORKS

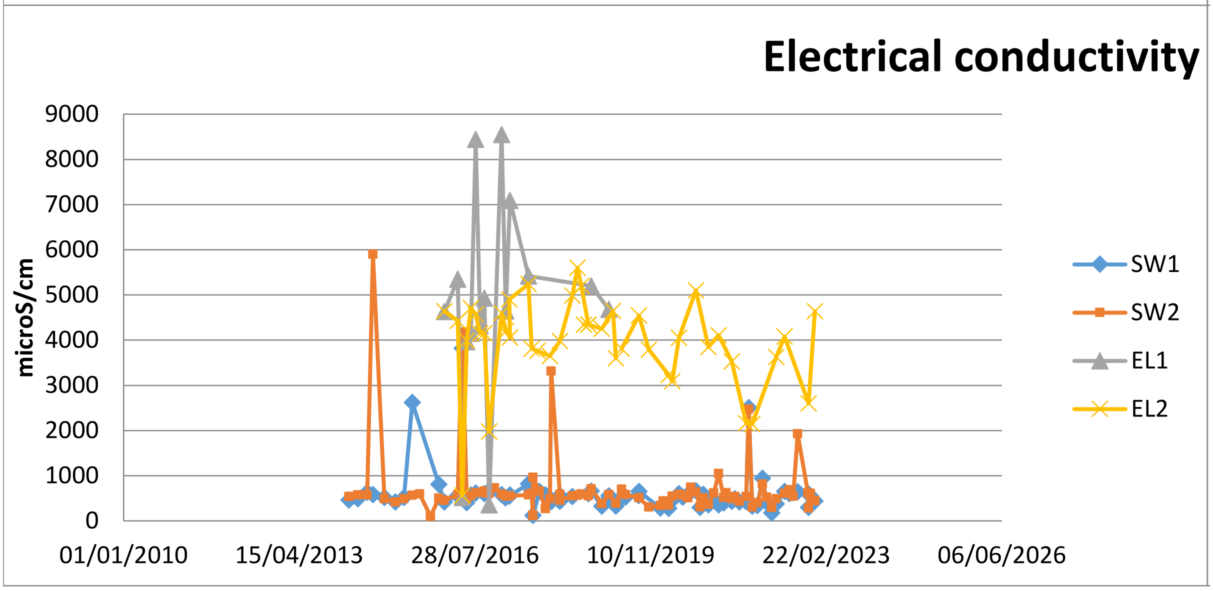
PERMIT EAWML/30003

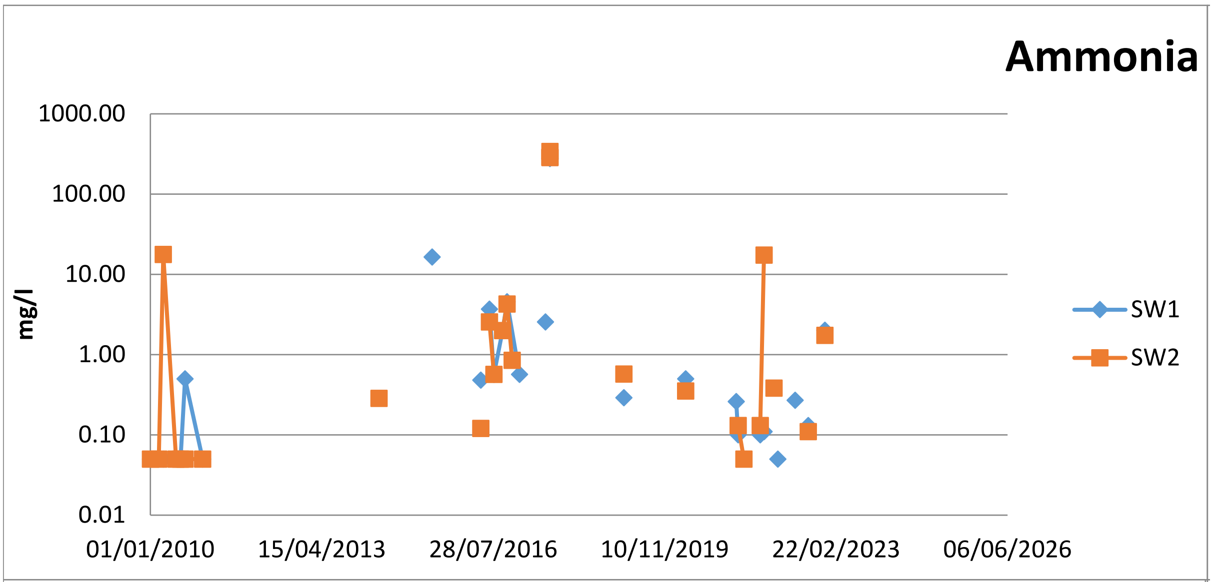
2022 Annual Review of Environmental Monitoring

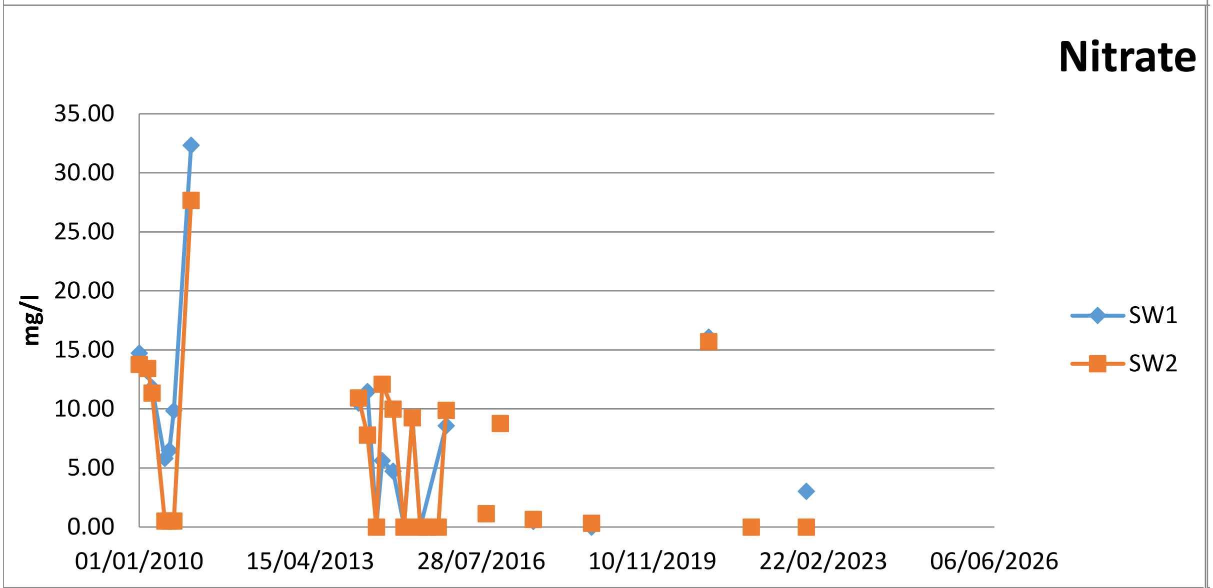
Appendix 2 Surface Water Chemistry

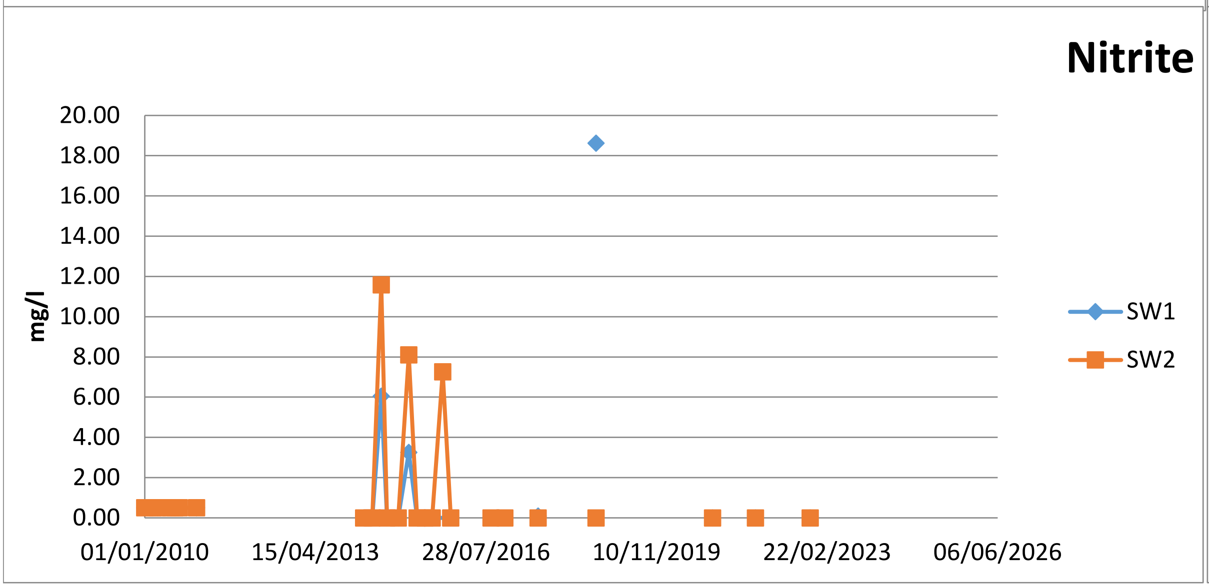
Report Number 2215r1v1d0123

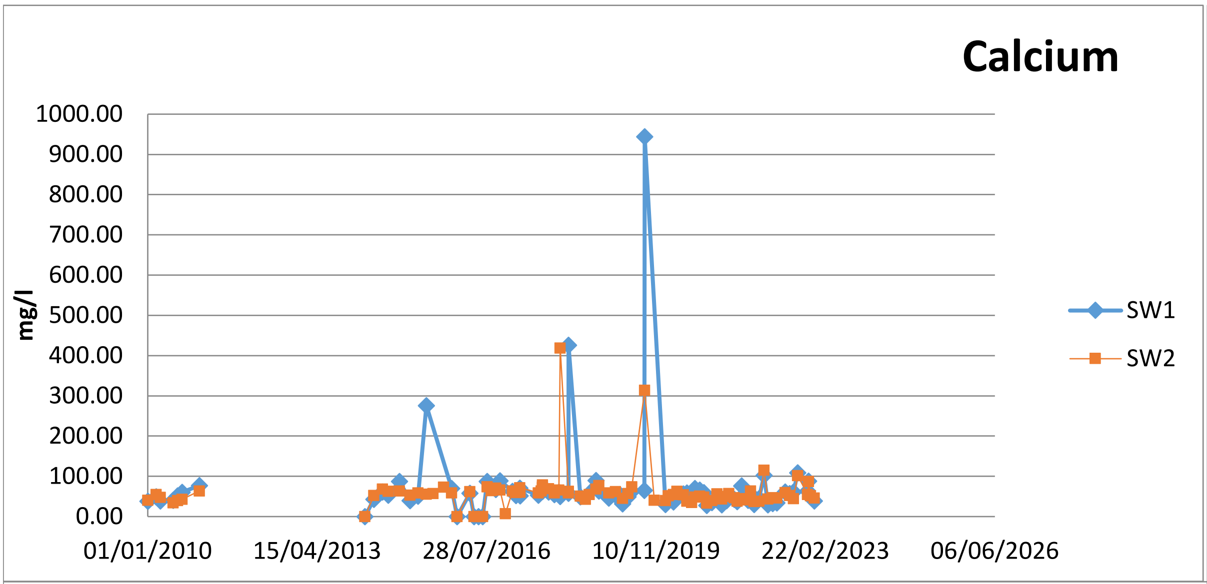

pH
10
9.5
9
8.5
8
7.5
7
6.5
6
pH
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2
EL1
EL2

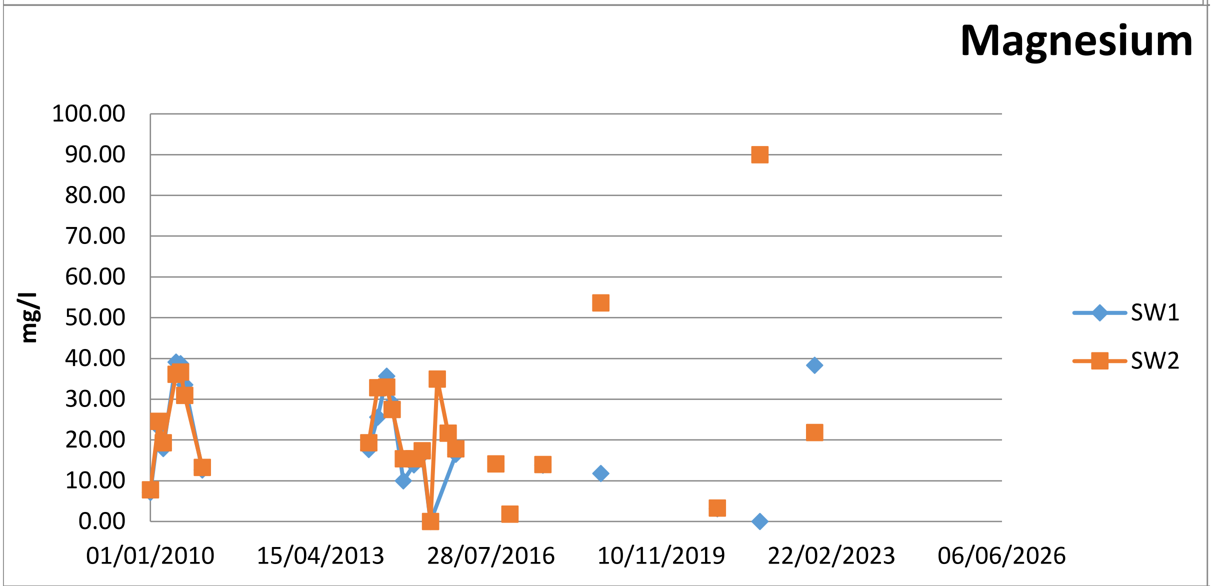

Electrical conductivity
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
microS/cm
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2
EL1
EL2

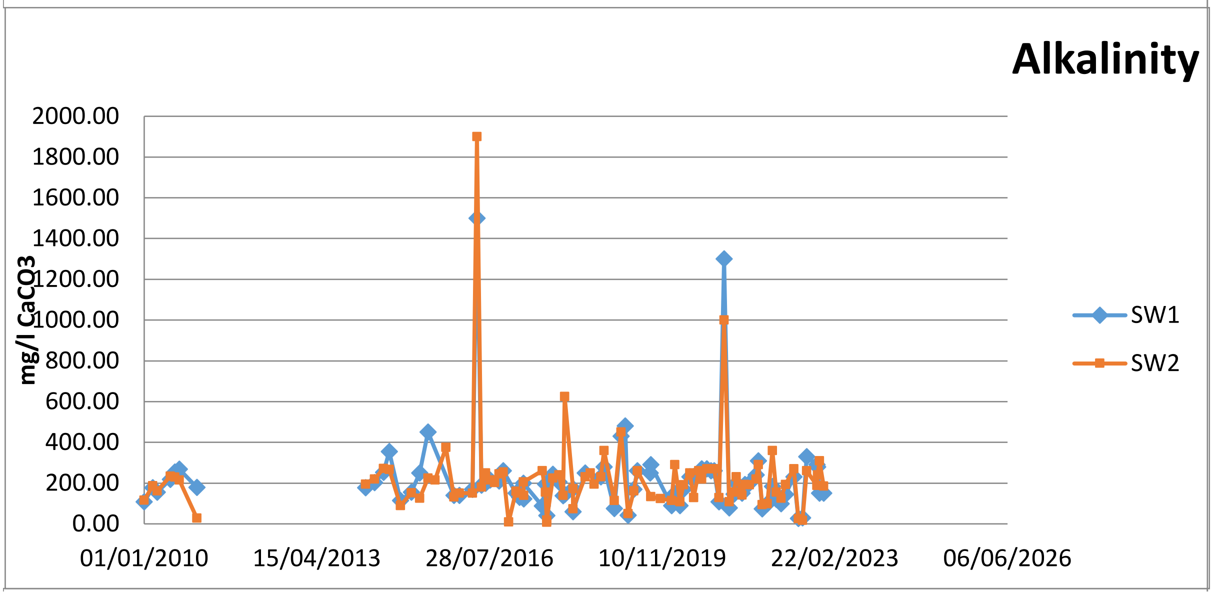

Ammonia
1000.00
100.00
10.00
1.00
0.10
0.01
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

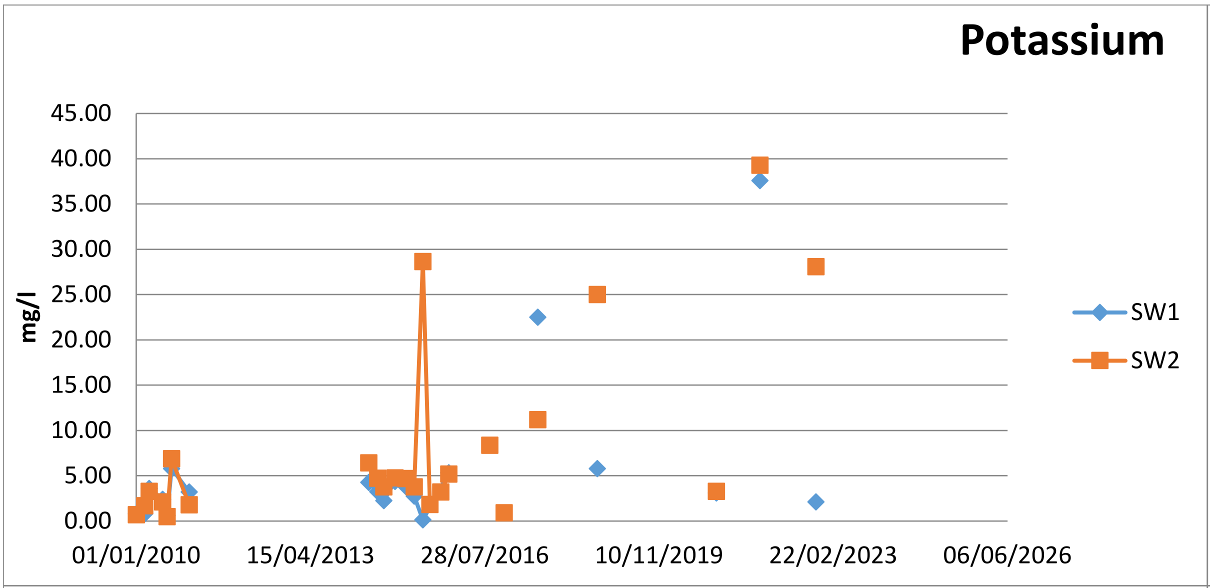

Nitrate
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

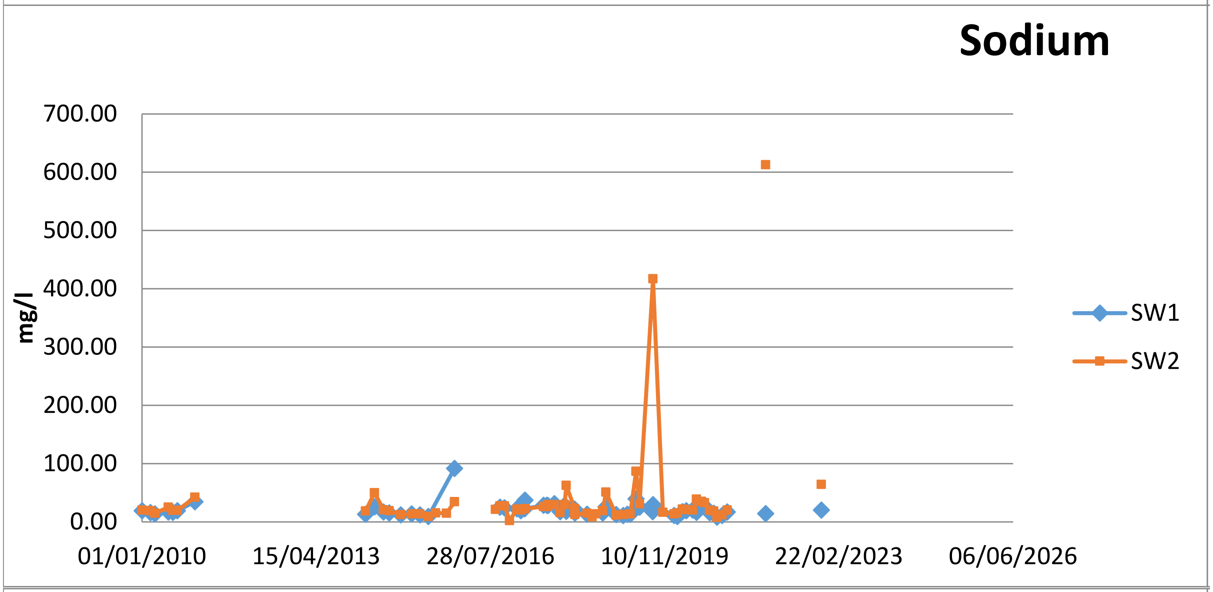

Nitrite
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

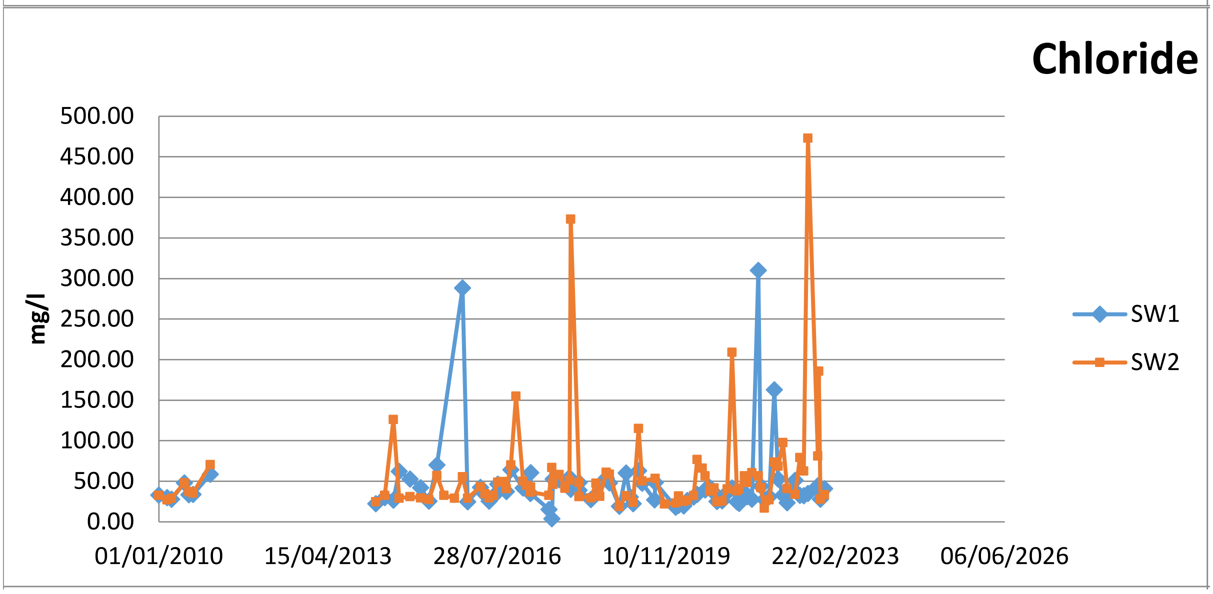

Calcium
mg/l
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

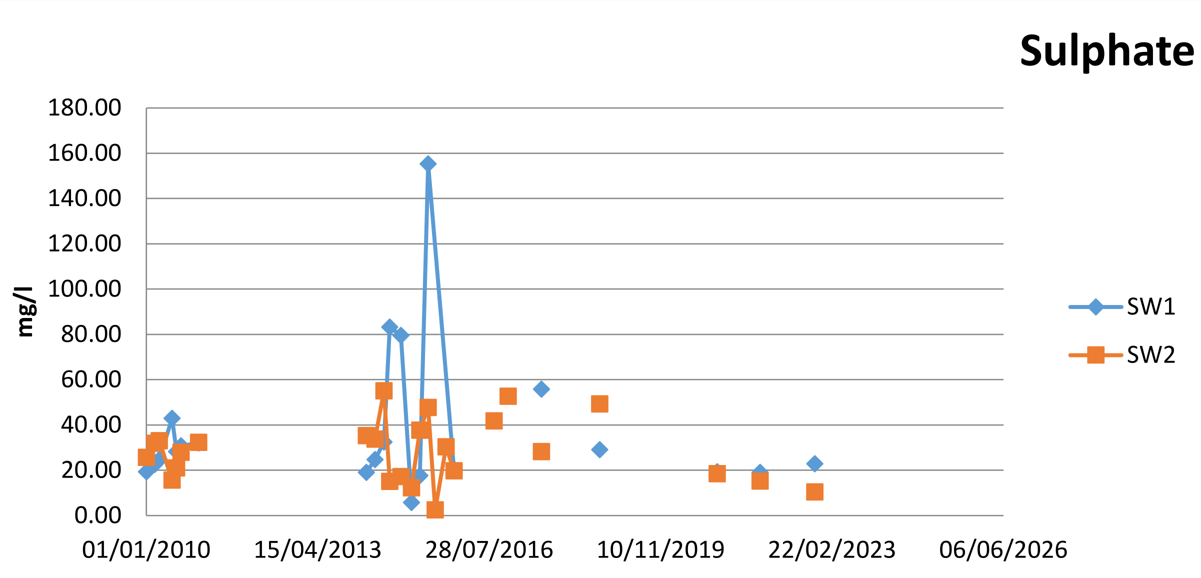

Magnesium
mg/l
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

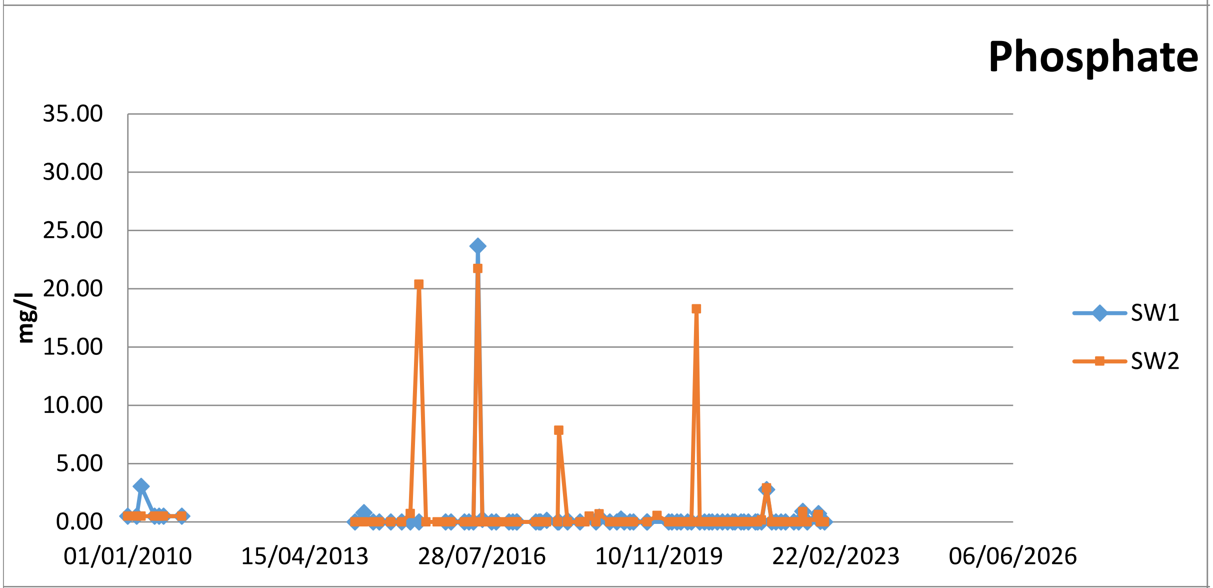

Alkalinity
mg/l CaCO3
2000.00
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

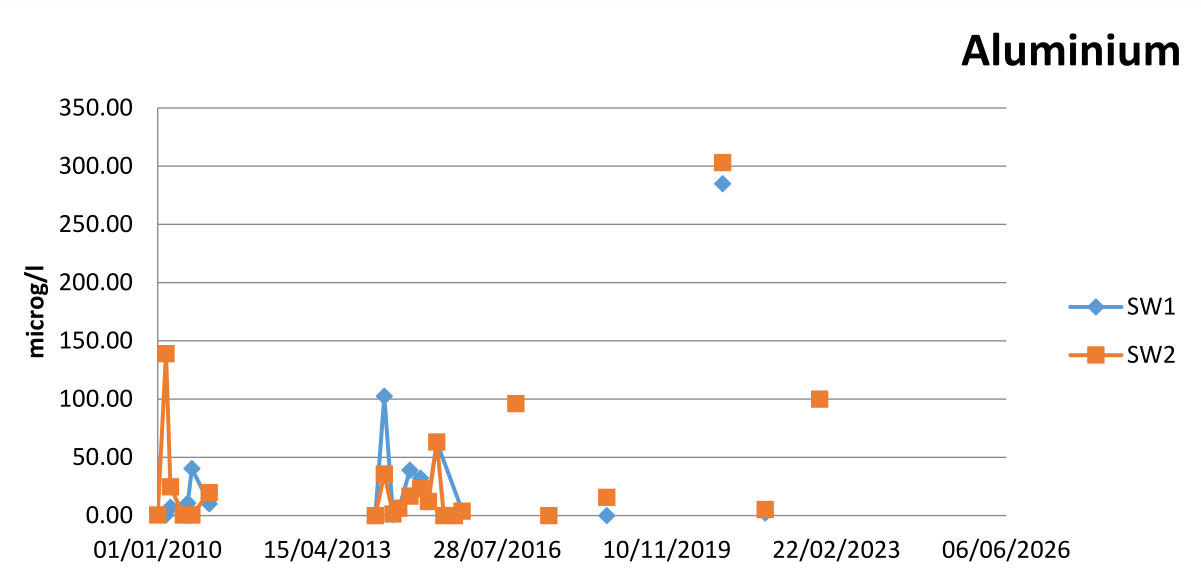

Potassium
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

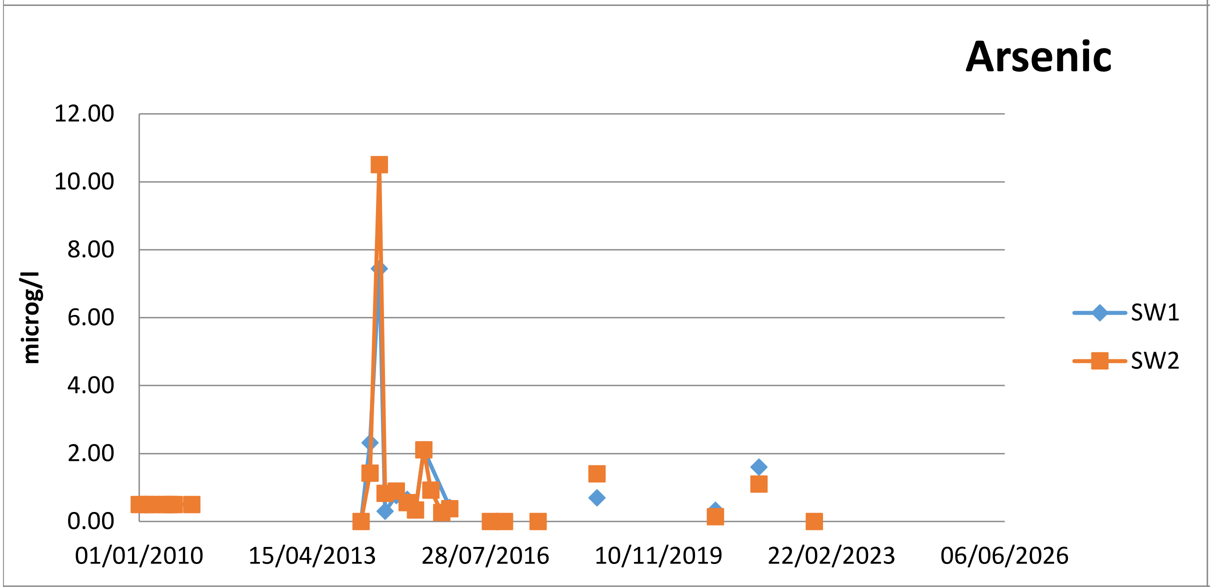

Sodium
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

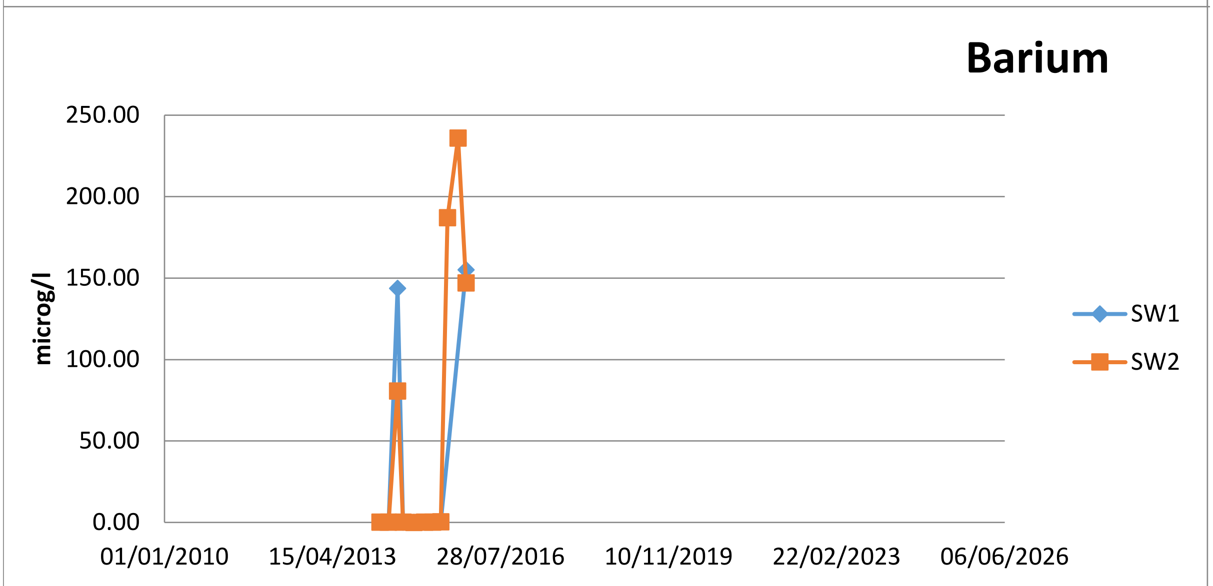

Chloride
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

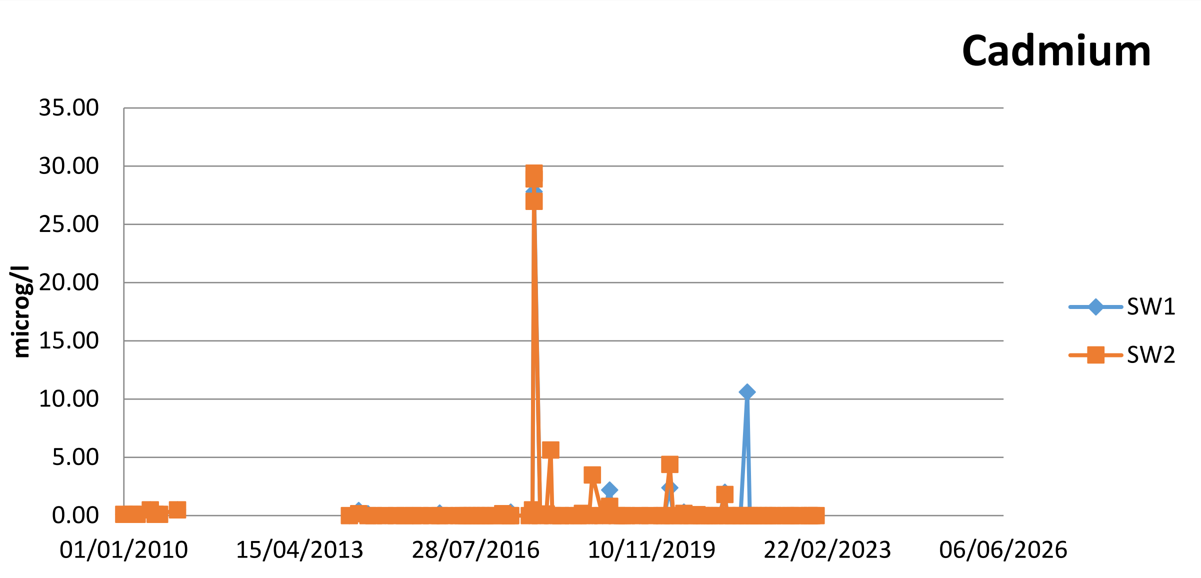

Sulphate
mg/l
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

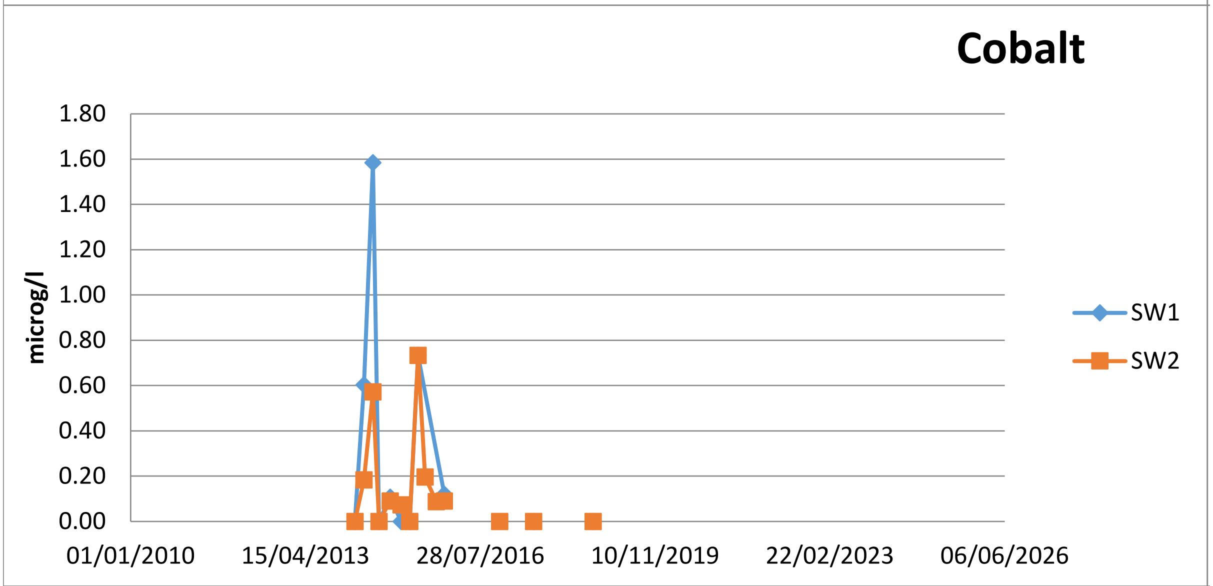

Phosphate
mg/l
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

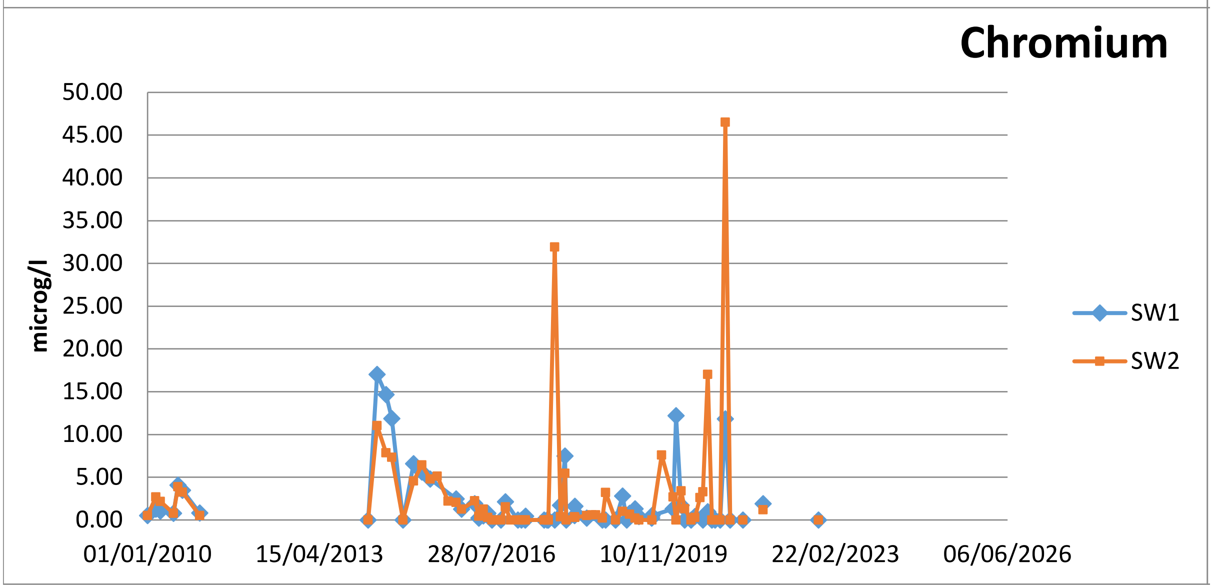

Aluminium
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

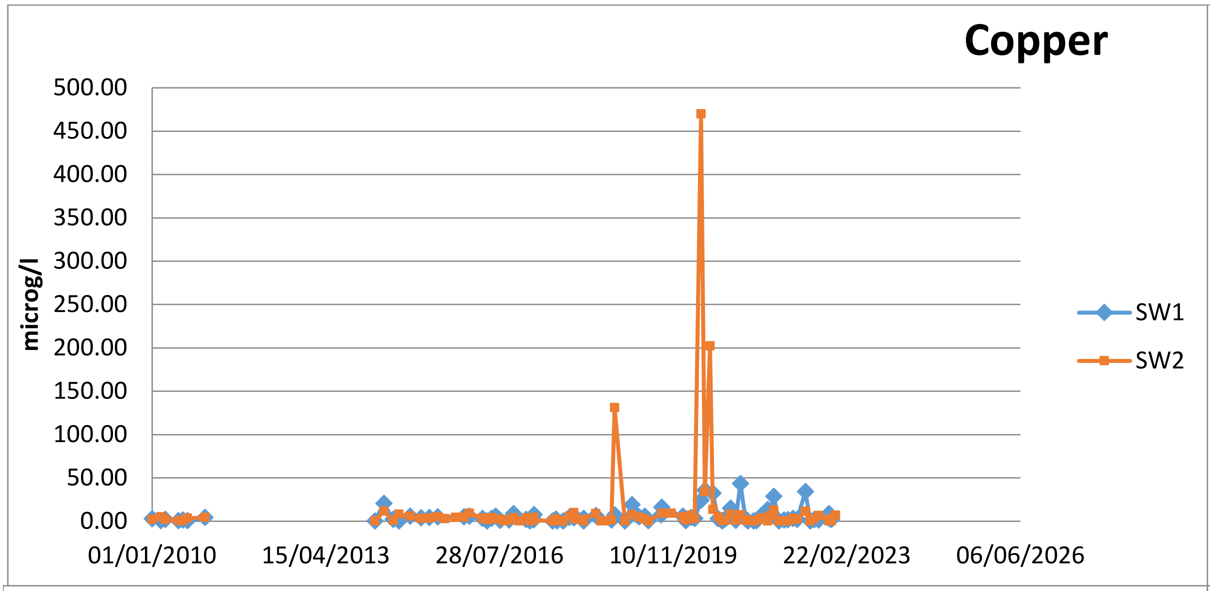

Arsenic
12.00
10.00
8.00
6.00
4.00
2.00
0.00
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

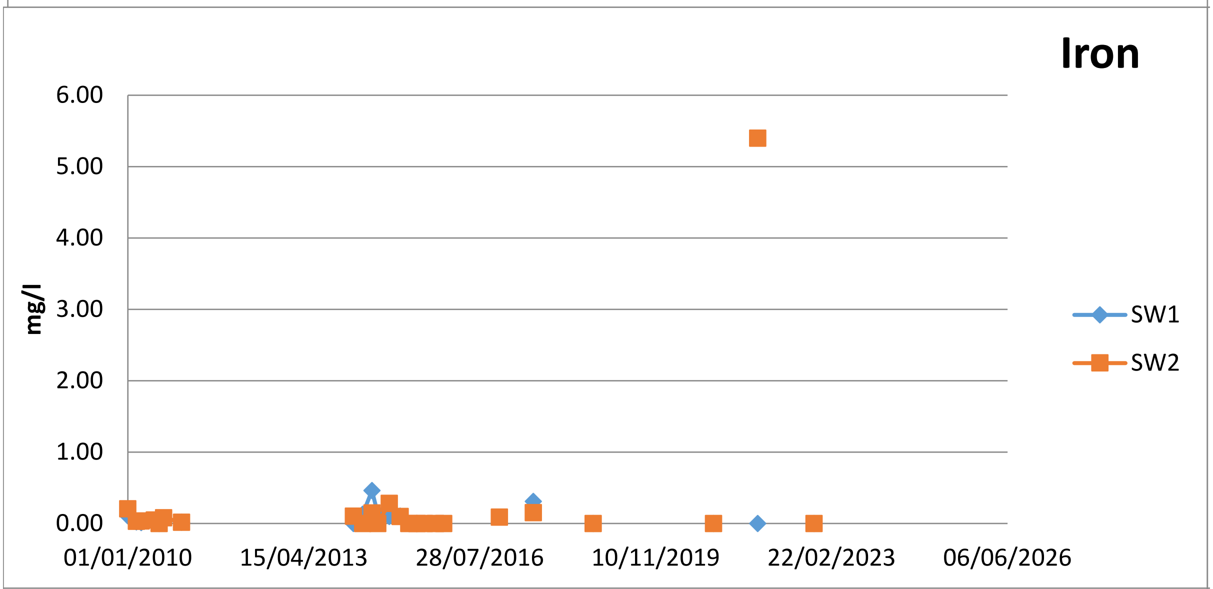

Barium
250.00
200.00
150.00
100.00
50.00
0.00
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

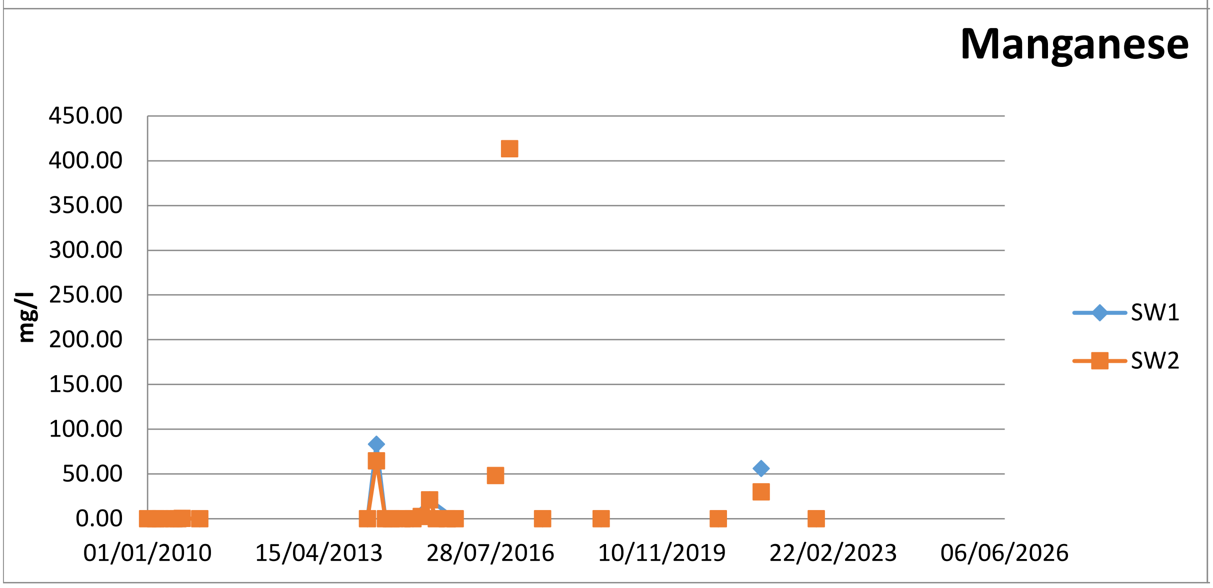

Cadmium
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

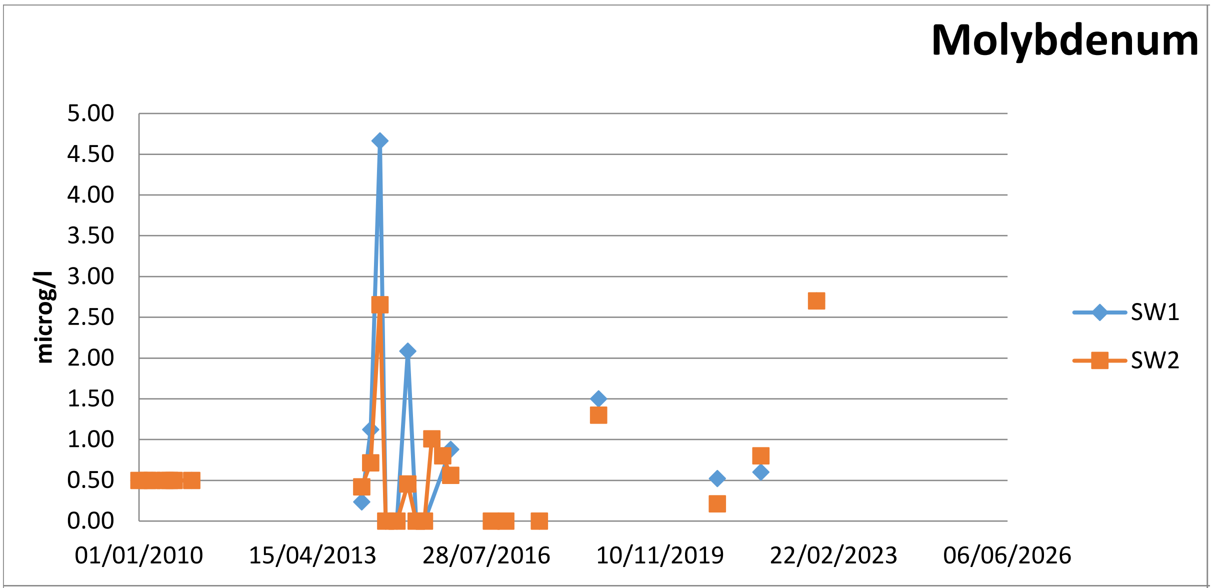

Cobalt
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

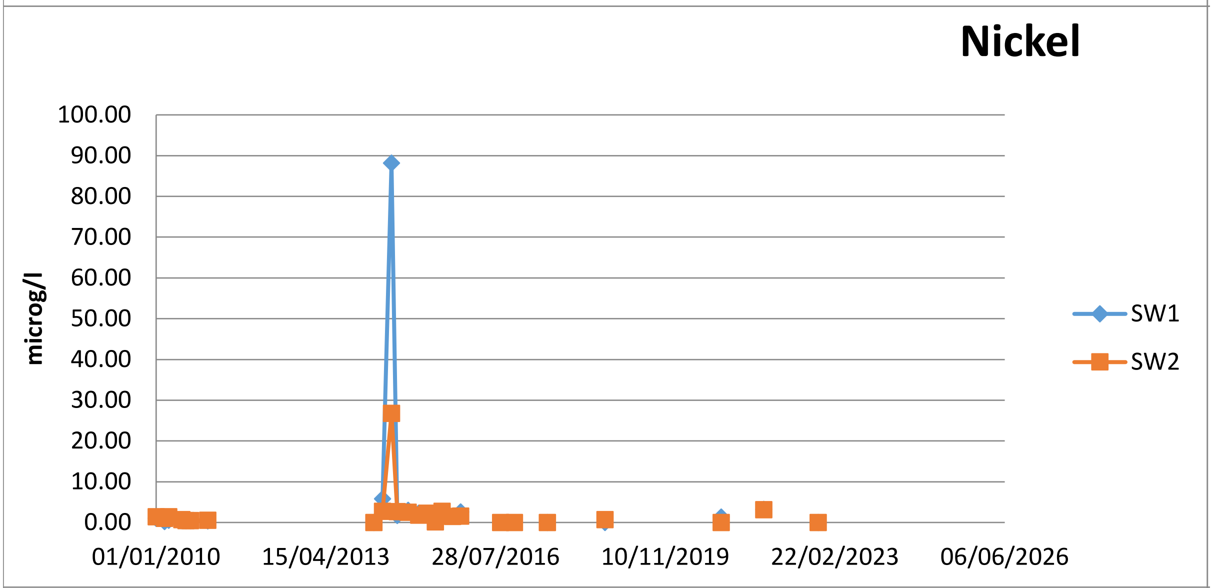

Chromium
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

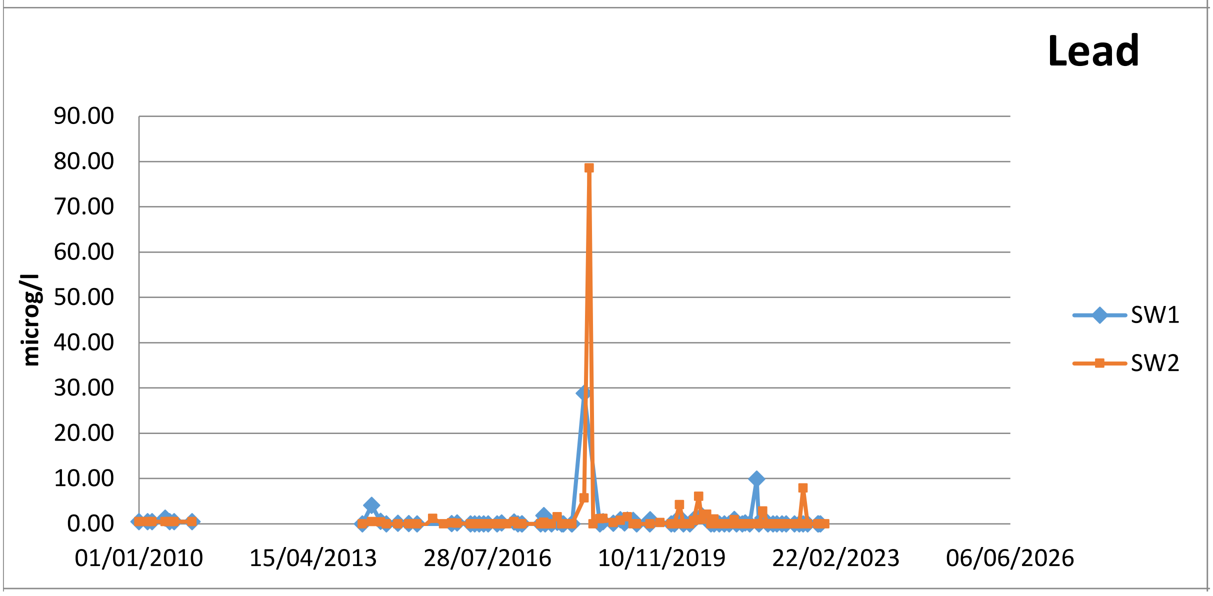

Copper
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

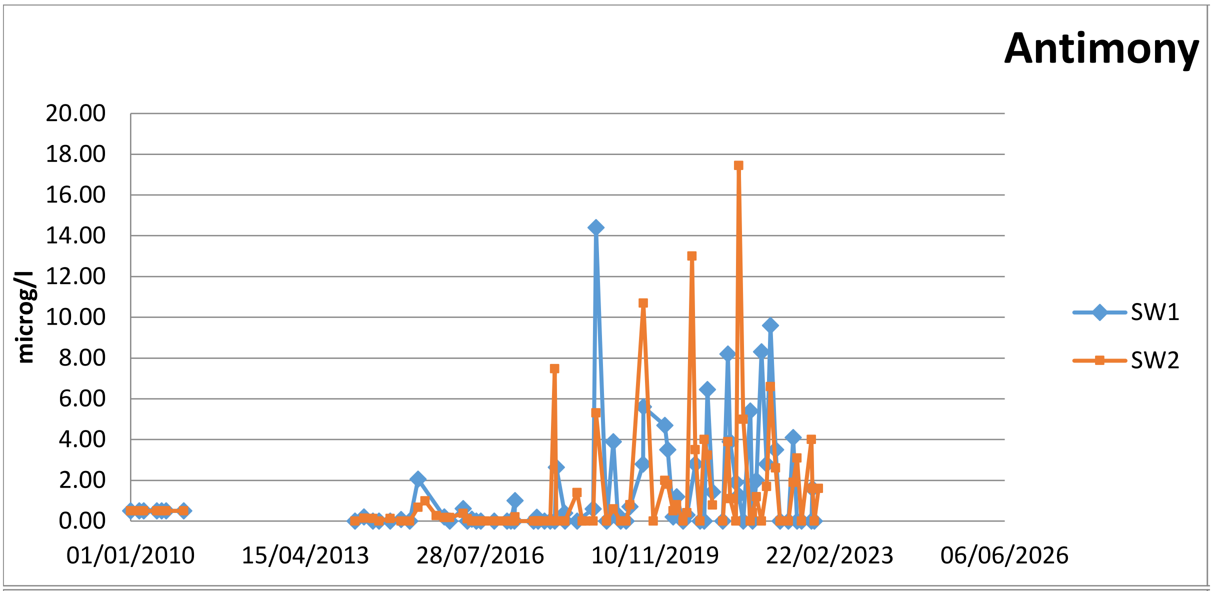

Iron
6.00
5.00
4.00
3.00
2.00
1.00
0.00
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

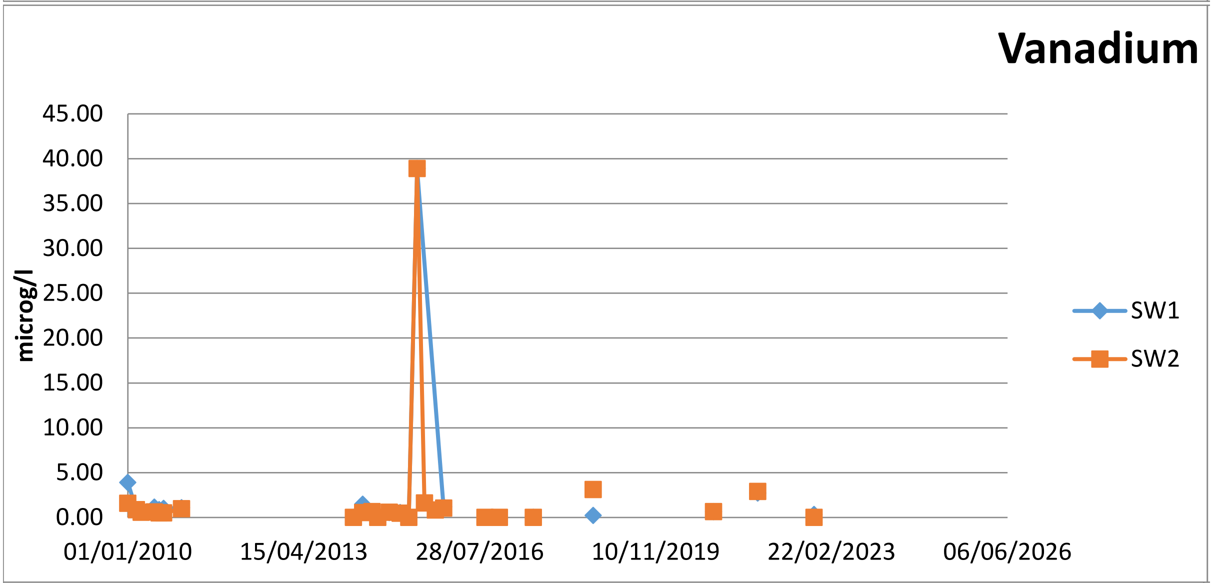

Manganese
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

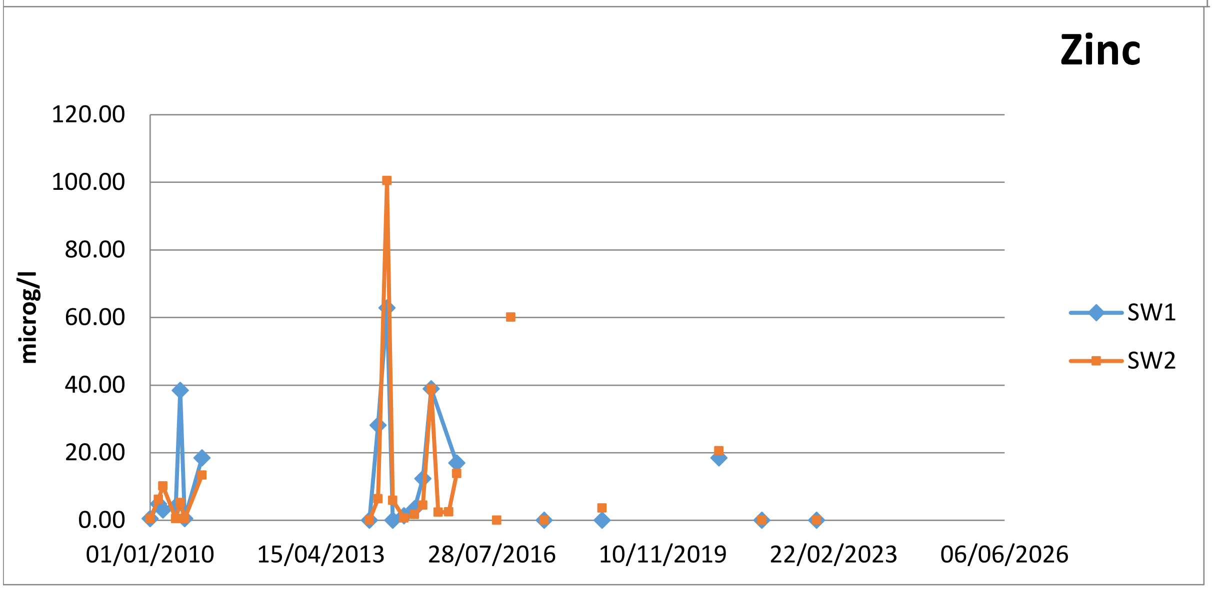

Molybdenum
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

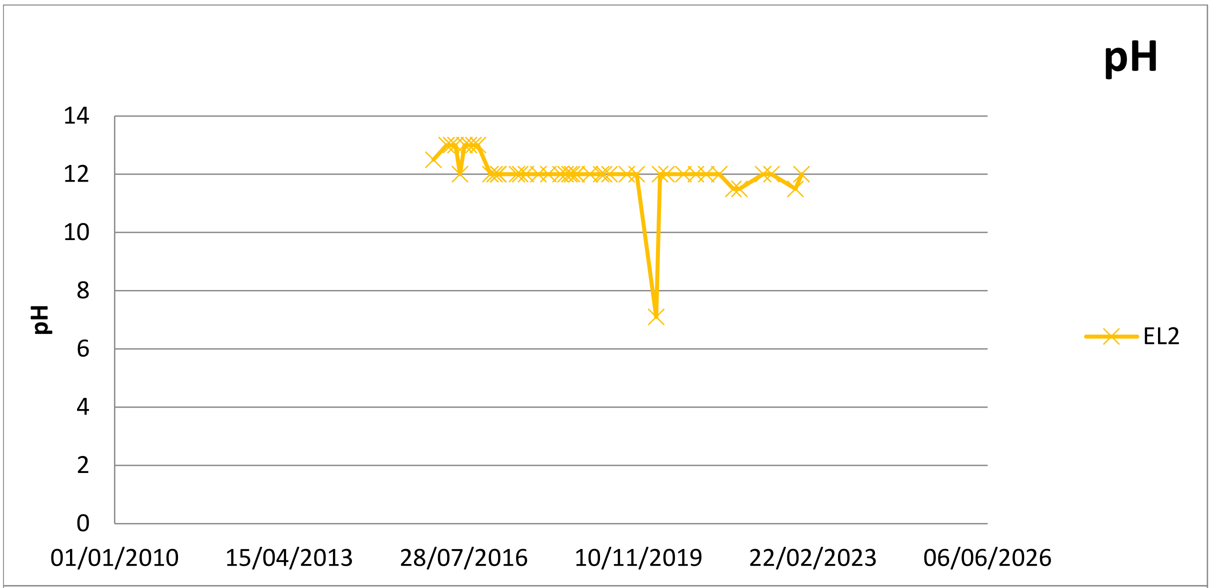

Nickel
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

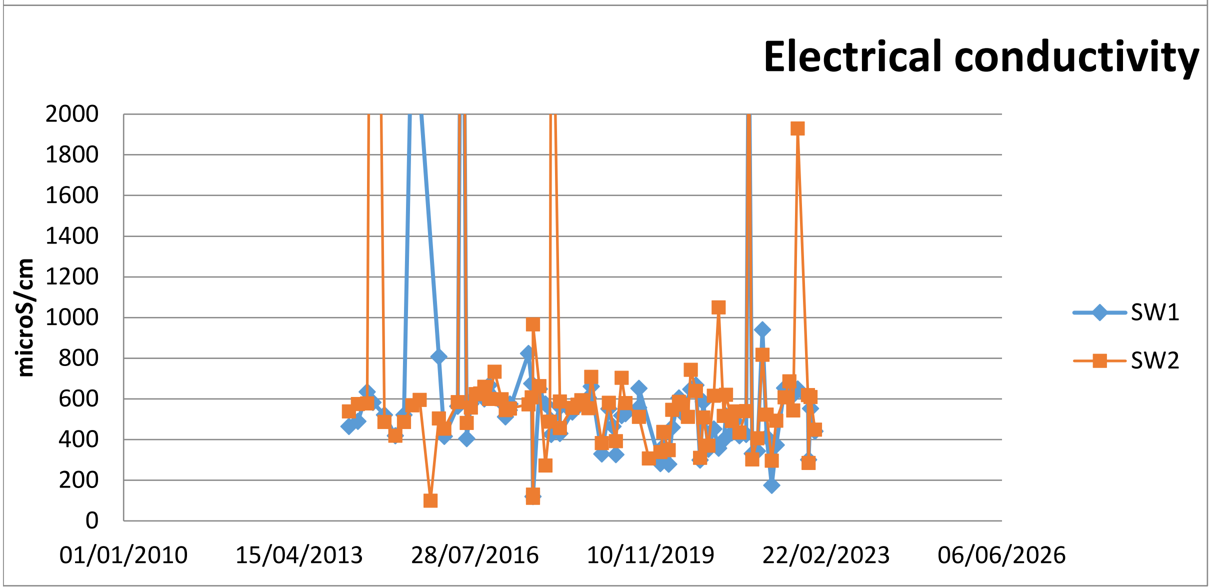

Lead
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

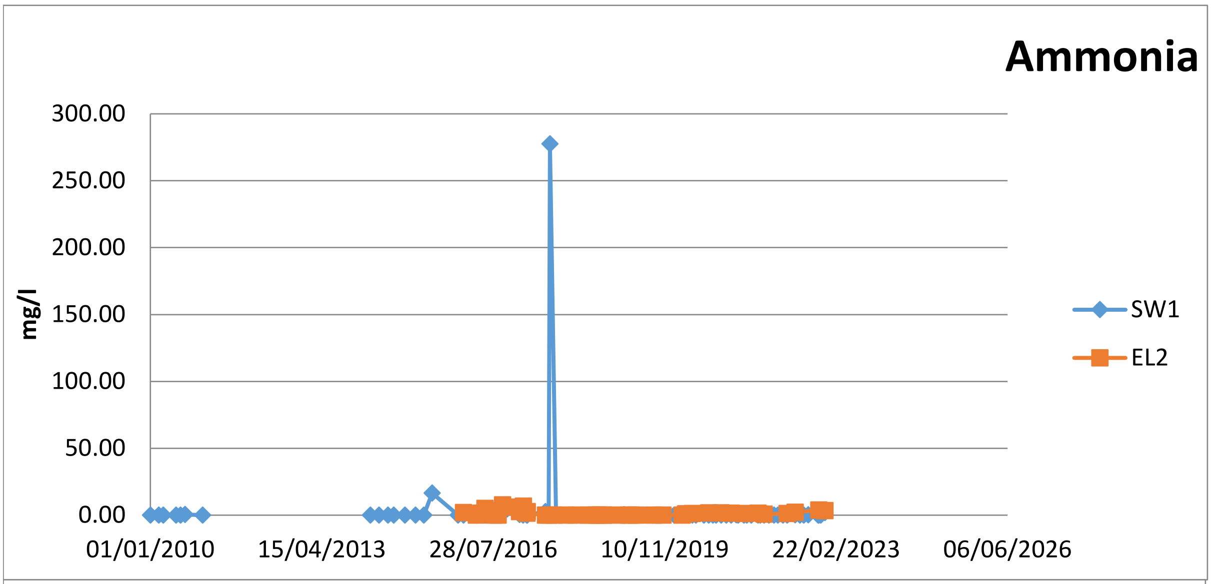

Antimony
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

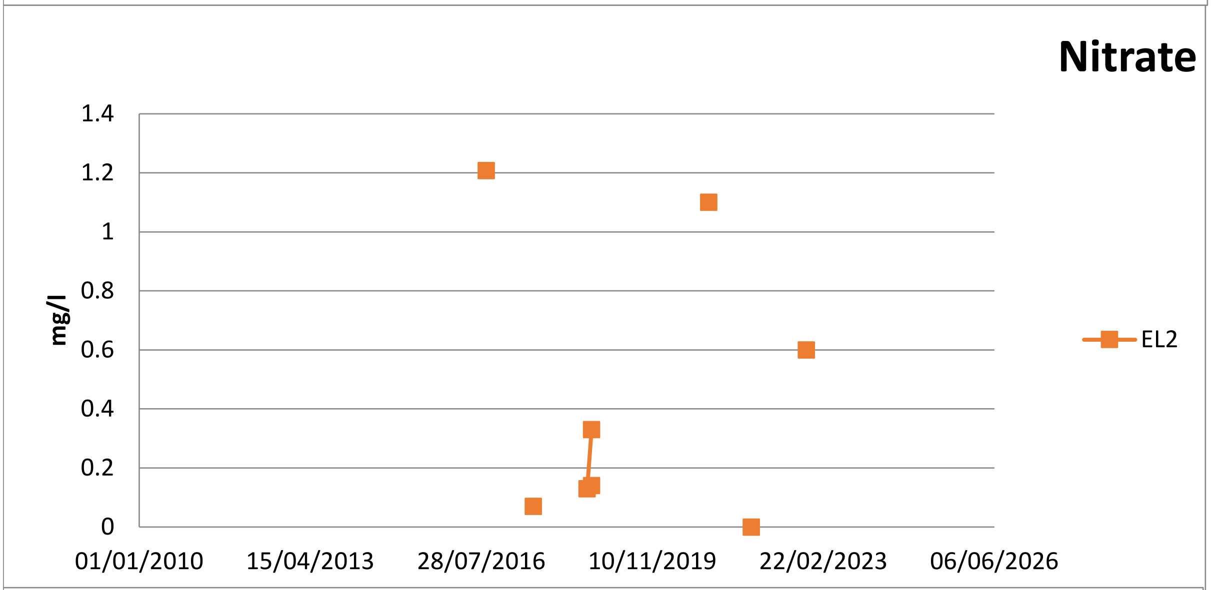

Vanadium
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

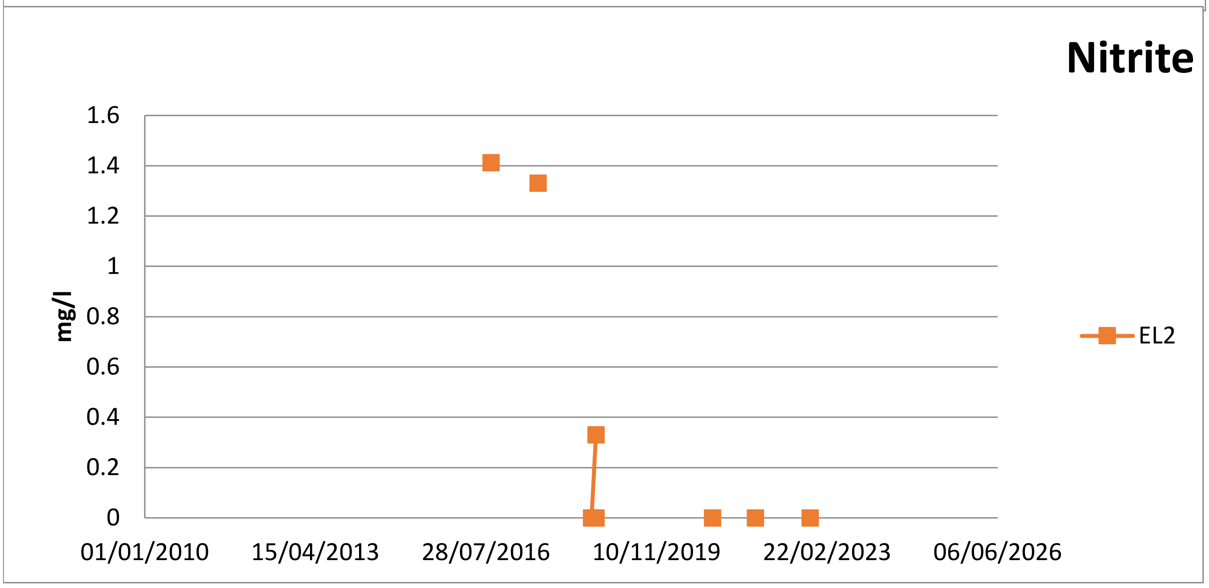

Zinc
120.00
100.00
80.00
60.00
40.00
20.00
0.00
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

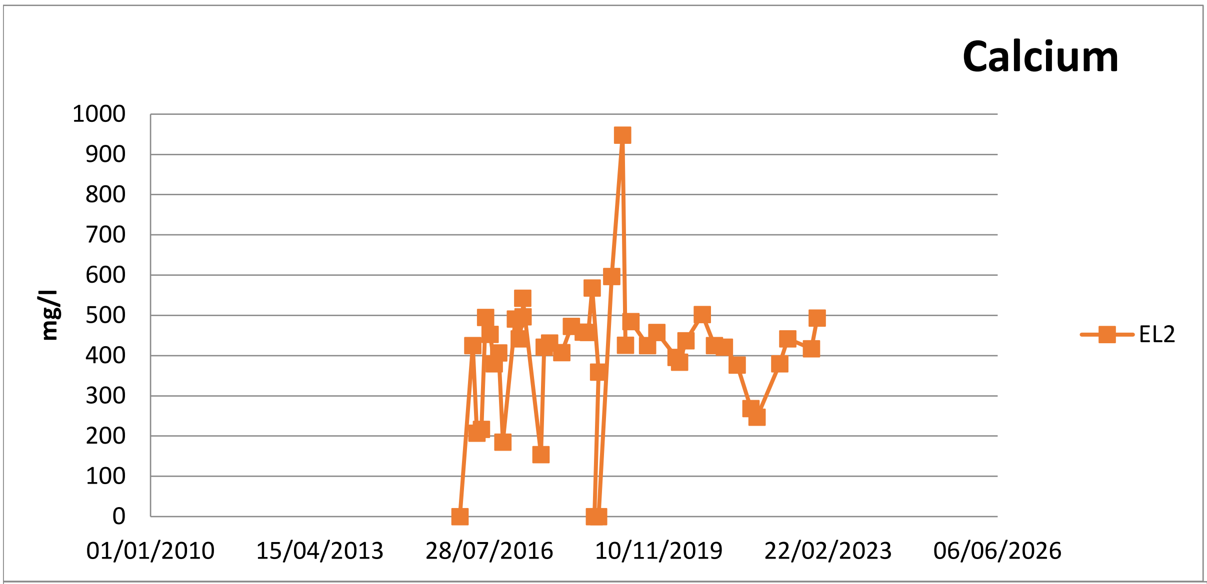

pH
14
12
10
8
6
4
2
0
pH
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
EL2

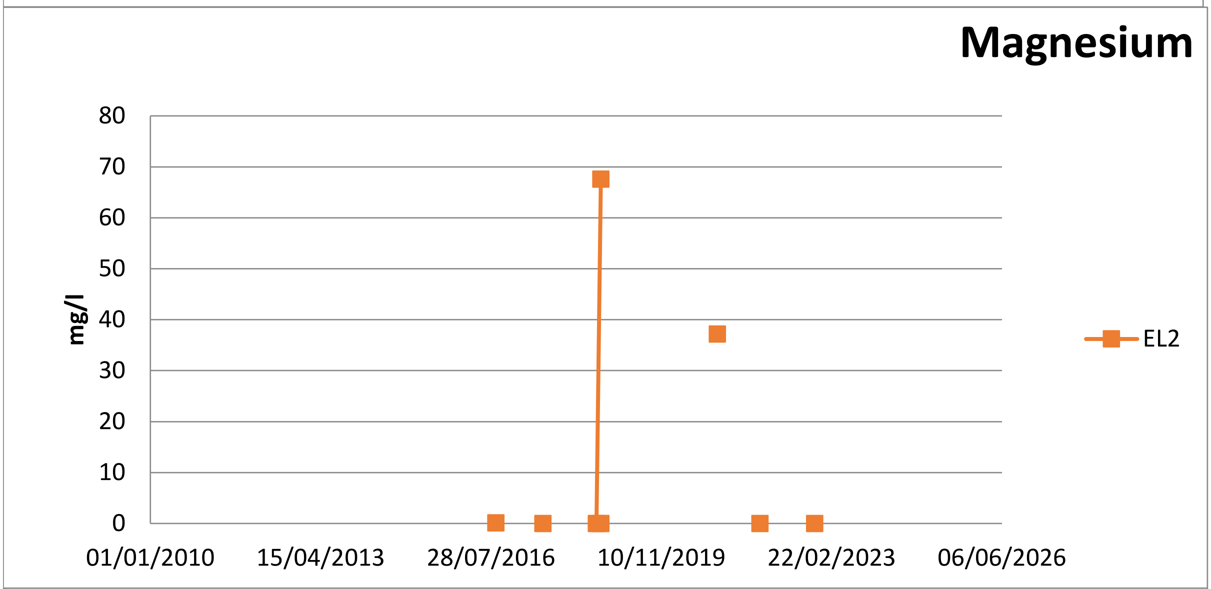

Electrical conductivity
2000
1800
1600
1400
1200
1000
800
600
400
200
0
microS/cm
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
SW2

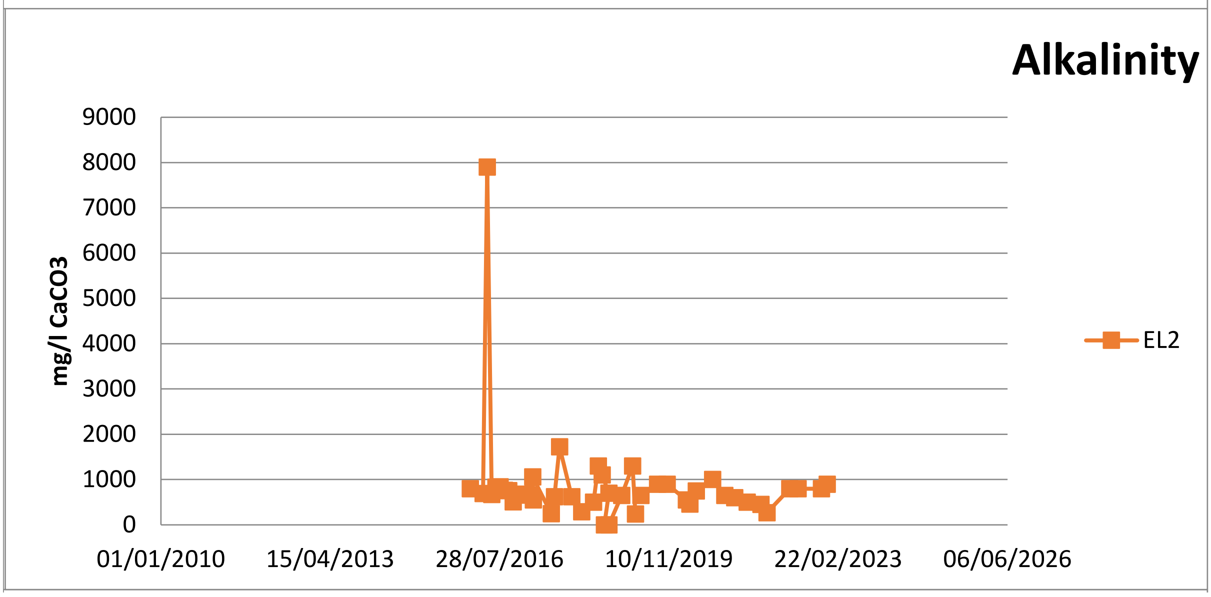

Ammonia
mg/l
300.00
250.00
200.00
150.00
100.00
50.00
0.00
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
SW1
EL2

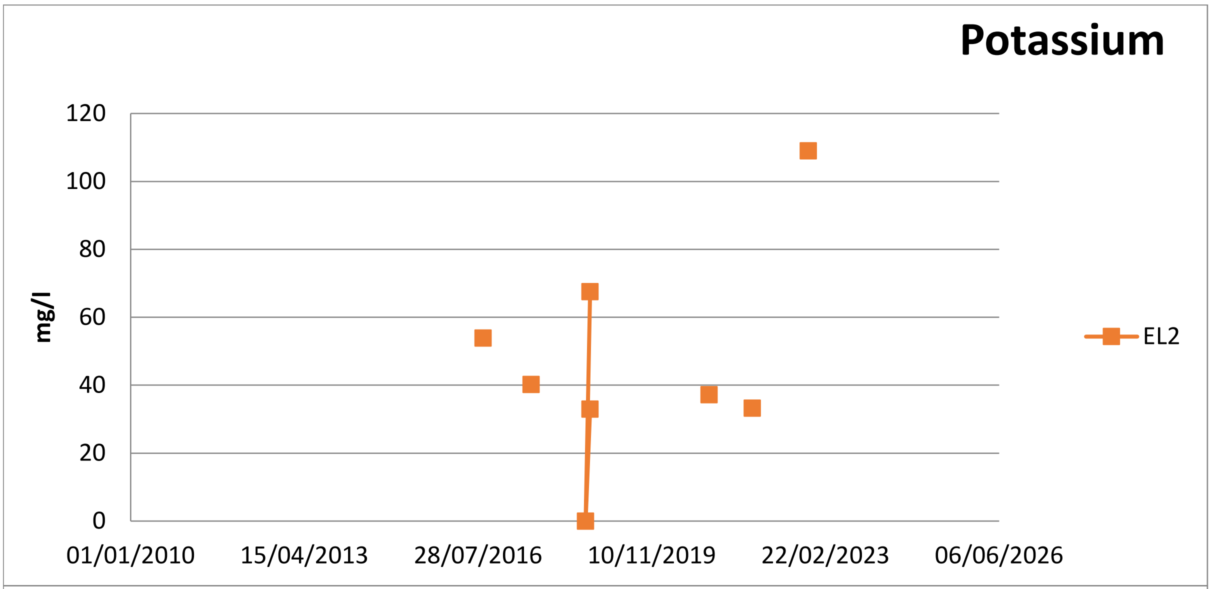

Nitrate
mg/l
1.4
1.2
1
0.8
0.6
0.4
0.2
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
EL2

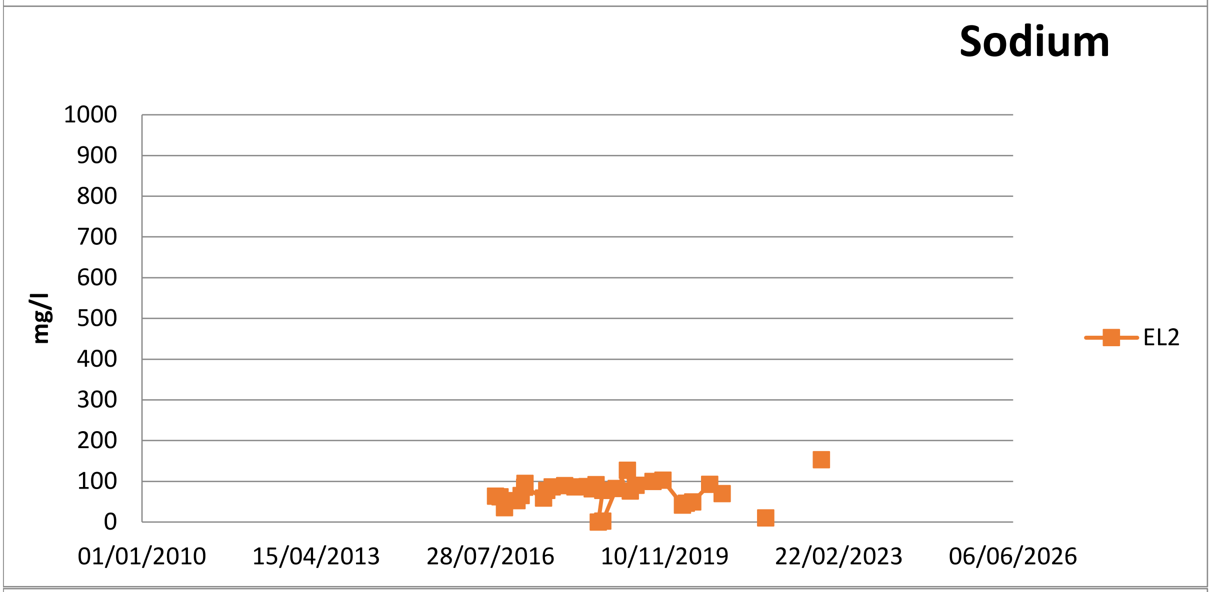

Nitrite
mg/l
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
EL2

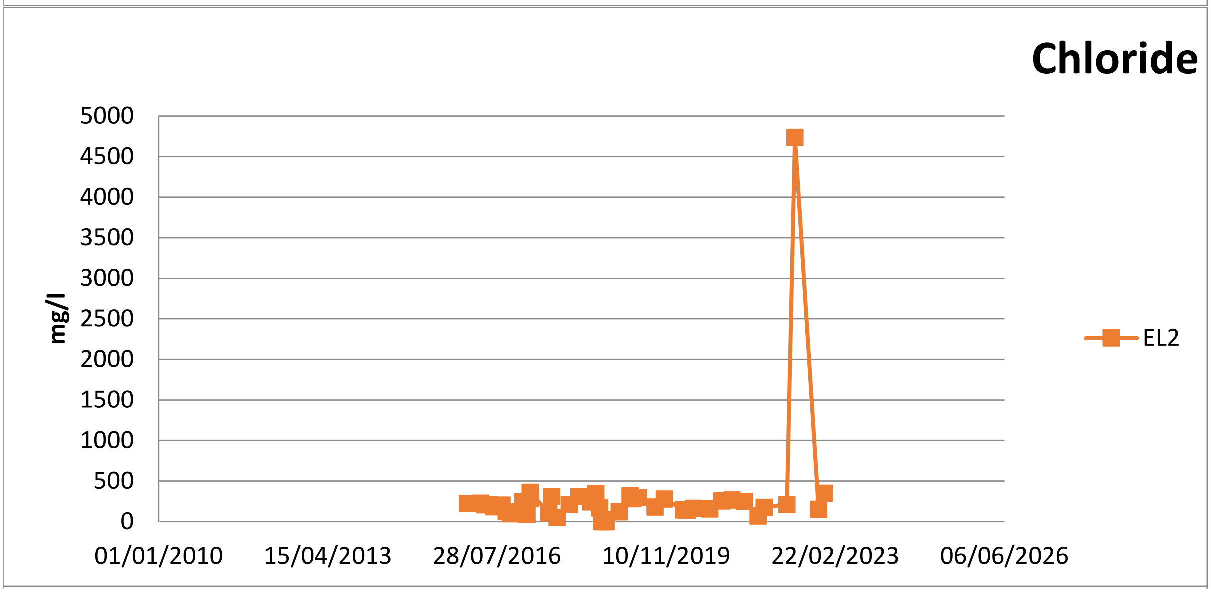

Calcium
mg/l
1000
900
800
700
600
500
400
300
200
100
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
EL2


Magnesium
mg/l
80
70
60
50
40
30
20
10
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
EL2


Alkalinity
mg/l CaCO3
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
EL2


Potassium
120
100
80
60
40
20
0
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
EL2


Sodium
1000
900
800
700
600
500
400
300
200
100
0
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
EL2


Chloride
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
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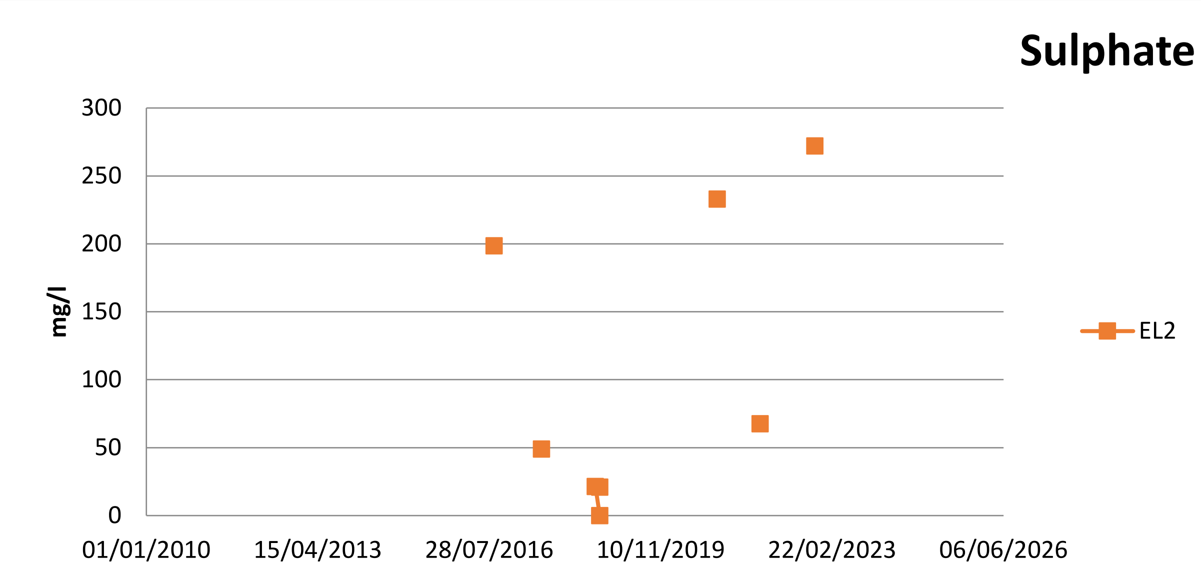
Sulphate
300
250
200
150
100
50
0
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
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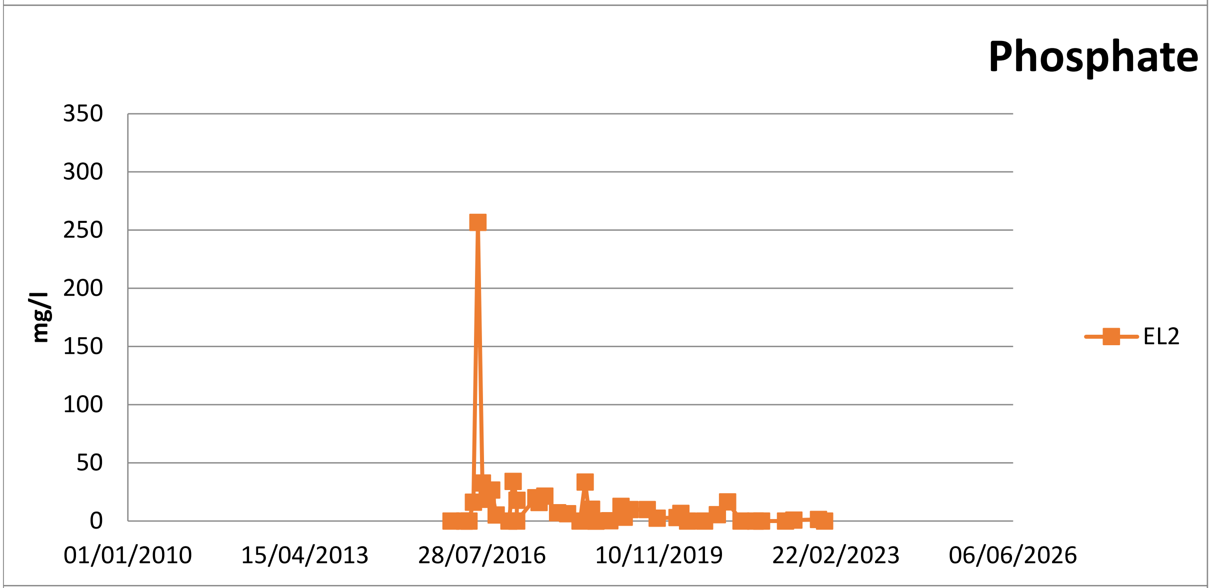
Phosphate
350
300
250
200
150
100
50
0
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
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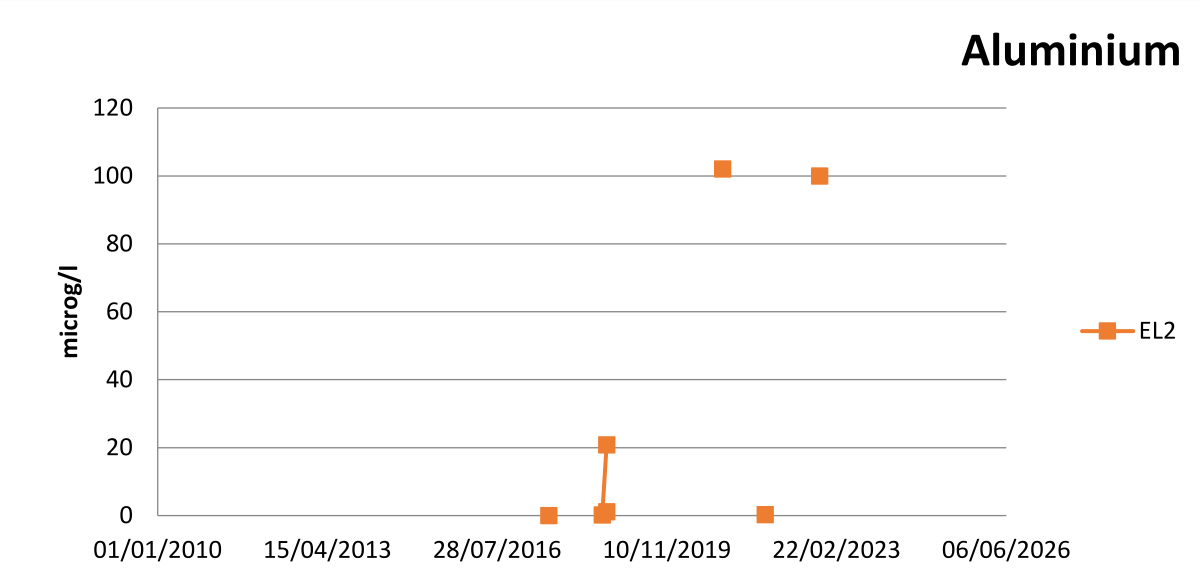
Aluminium
120
100
80
60
40
20
0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
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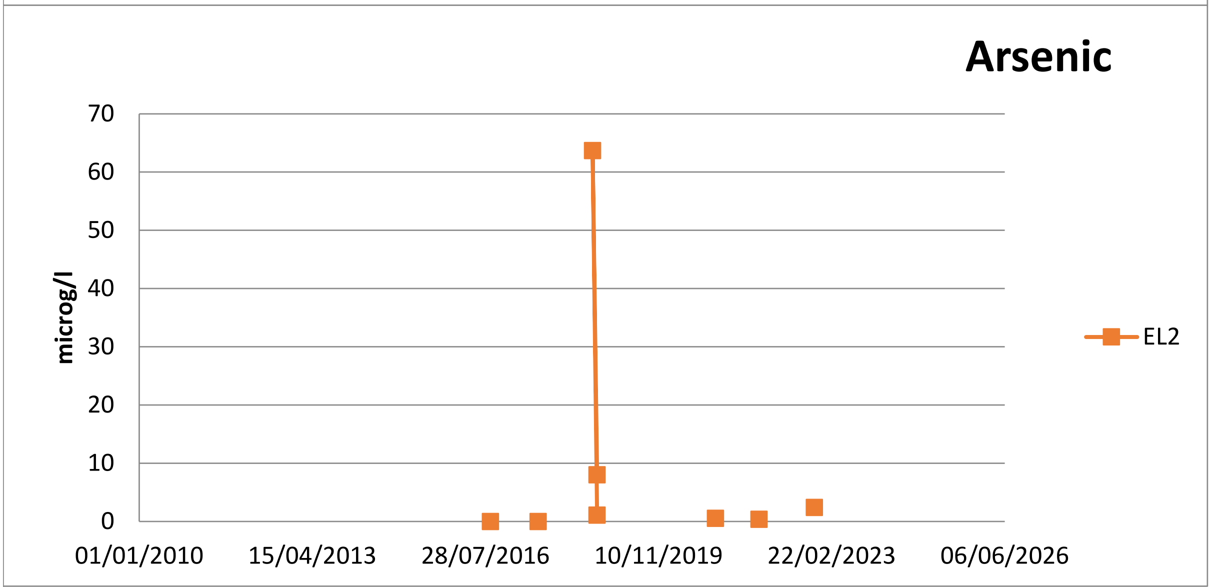
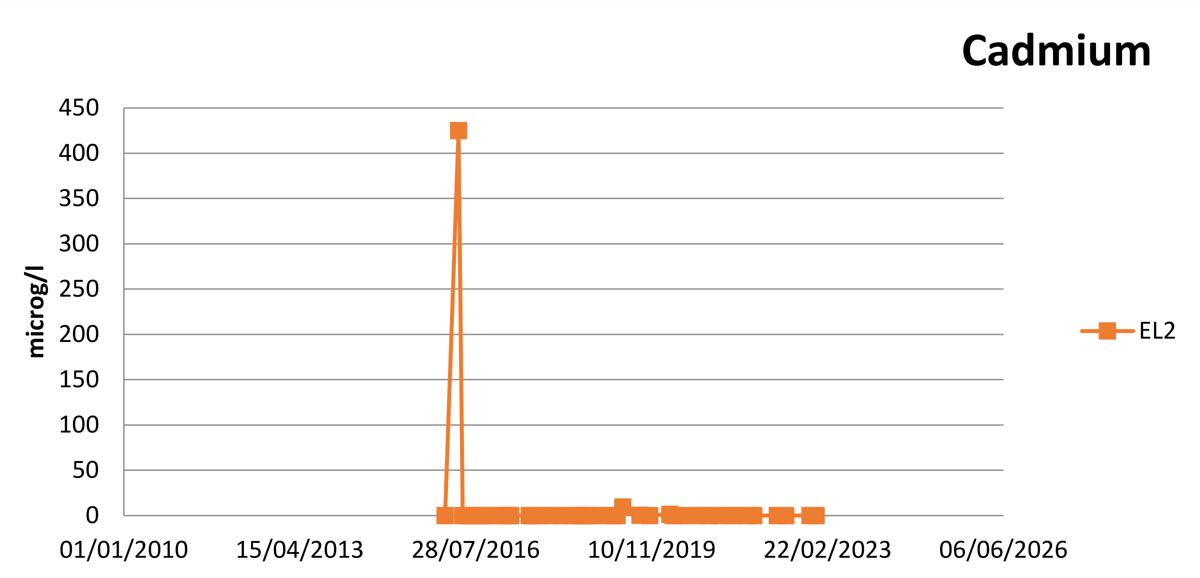
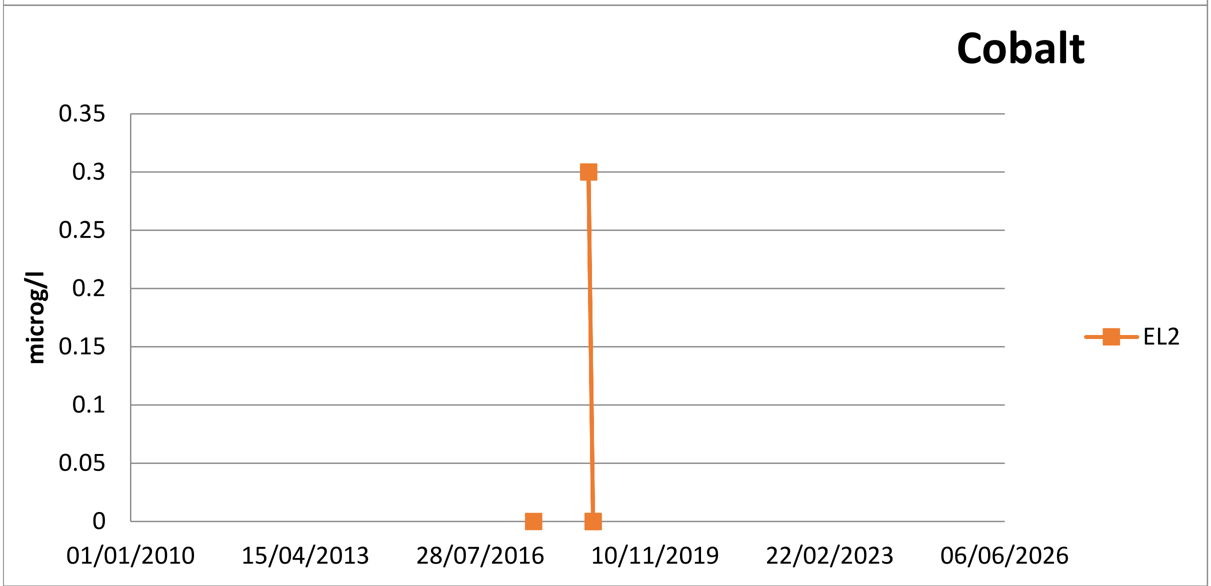
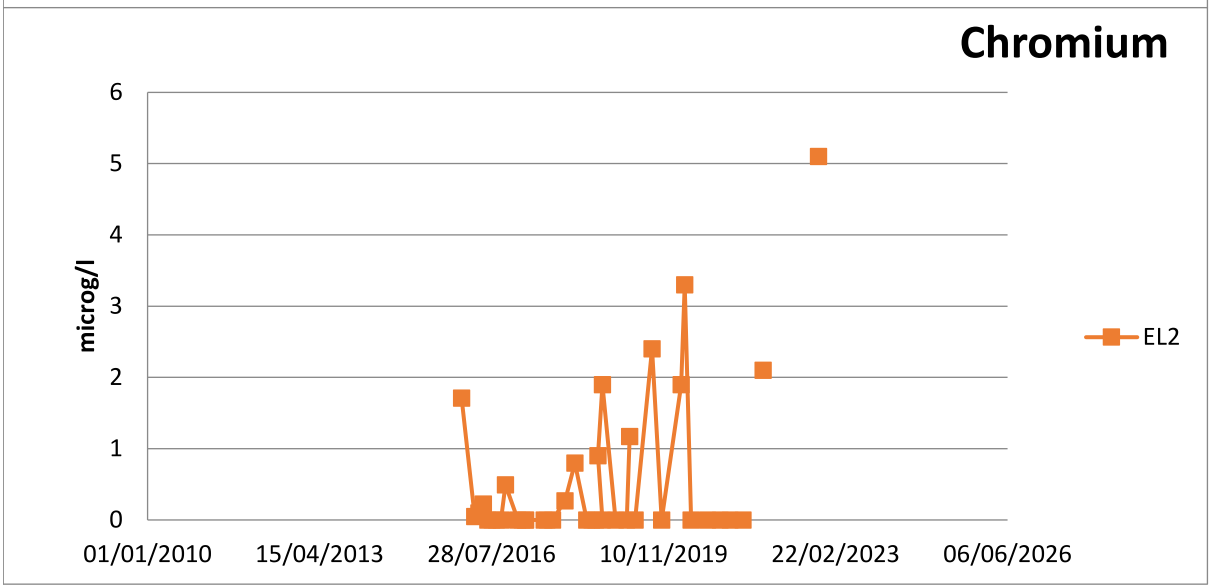
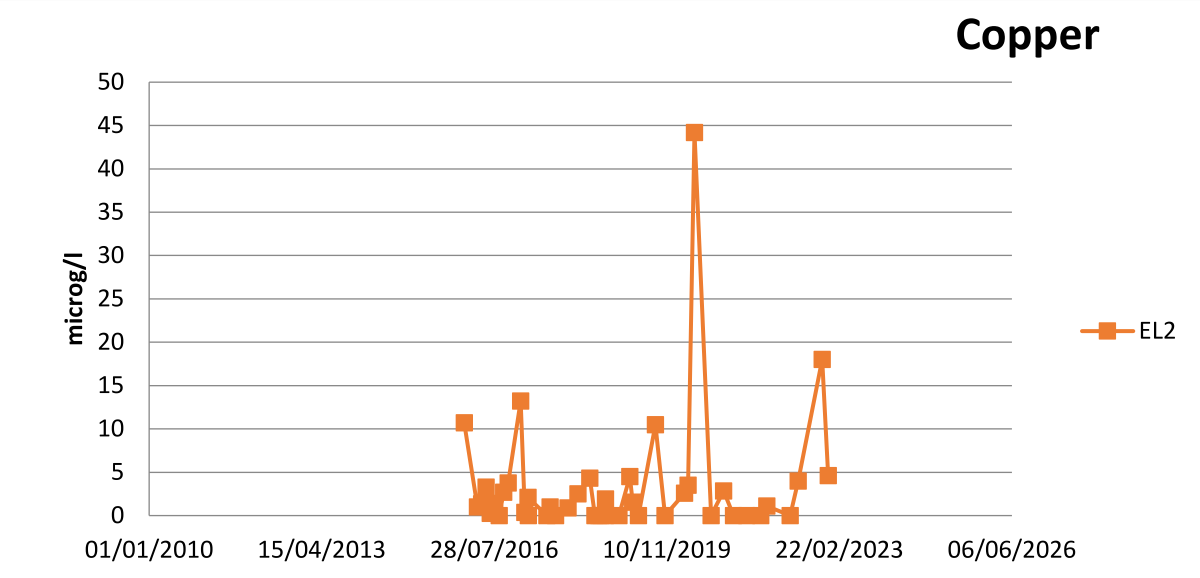

Arsenic
70
60
50
40
30
20
10
0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
EL2


Cadmium
microg/l
450
400
350
300
250
200
150
100
50
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
EL2


Cobalt
microg/l
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
EL2


Chromium
microg/l
6
5
4
3
2
1
0
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
EL2


Copper
50
45
40
35
30
25
20
15
10
5
0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
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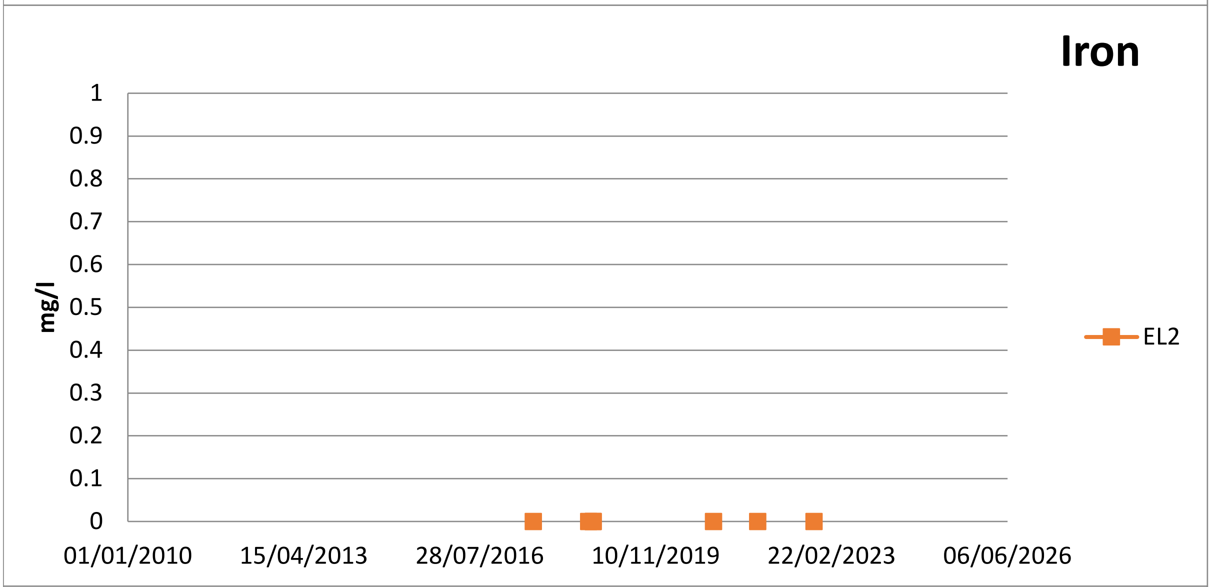
Iron
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
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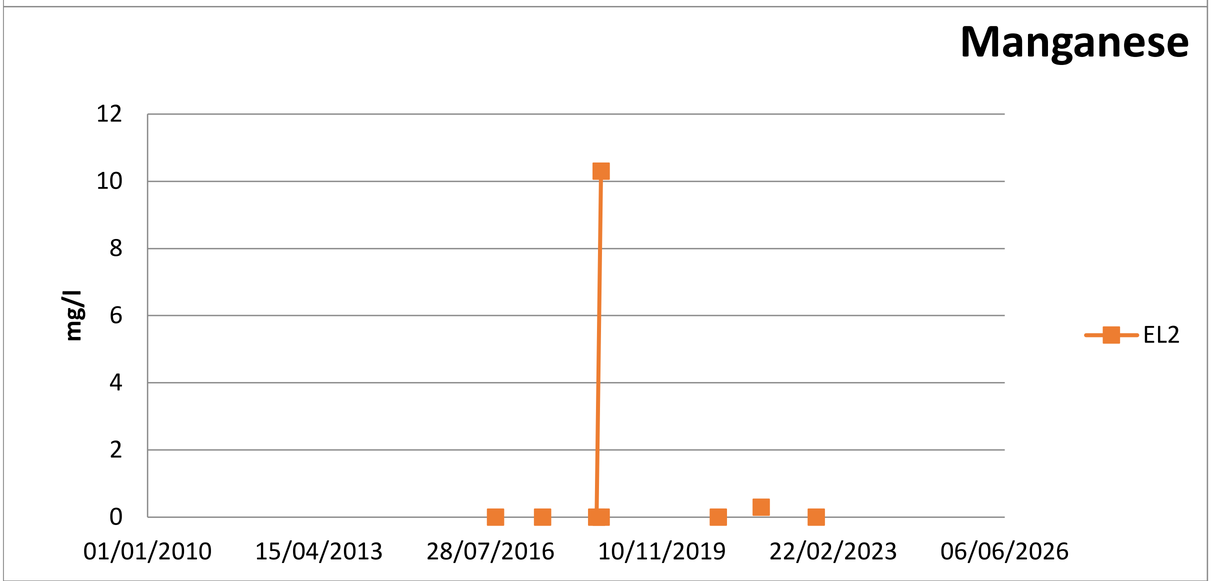
Manganese
12
10
8
6
4
2
0
mg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
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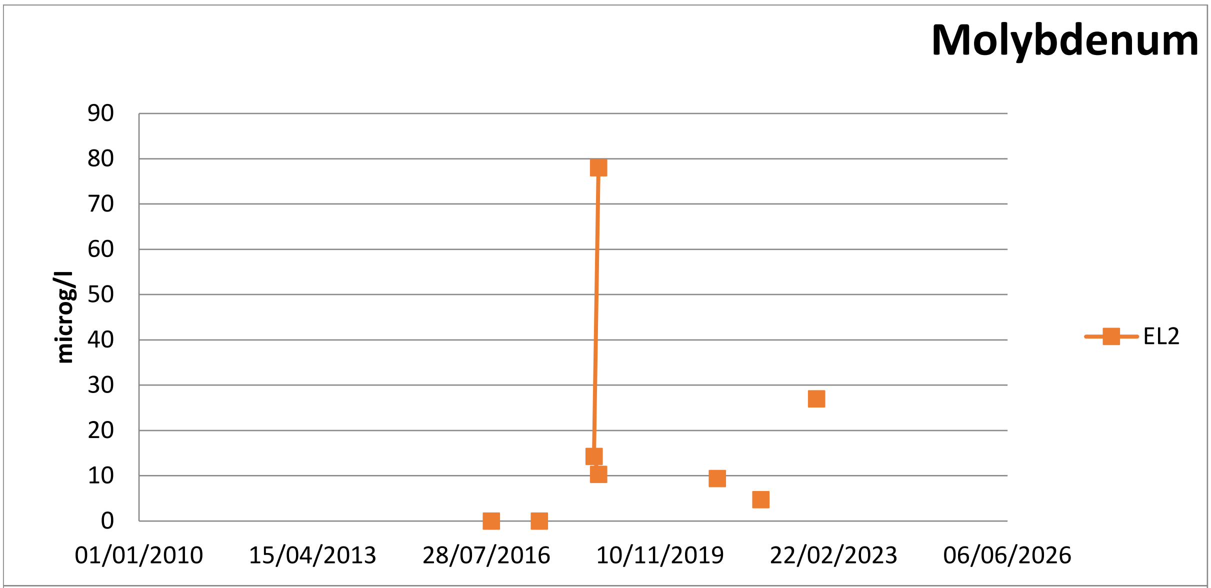
06/06/2026
EL2


Molybdenum
90
80
70
60
50
40
30
20
10
0
microg/l
01/01/2010
15/04/2013
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10/11/2019
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06/06/2026
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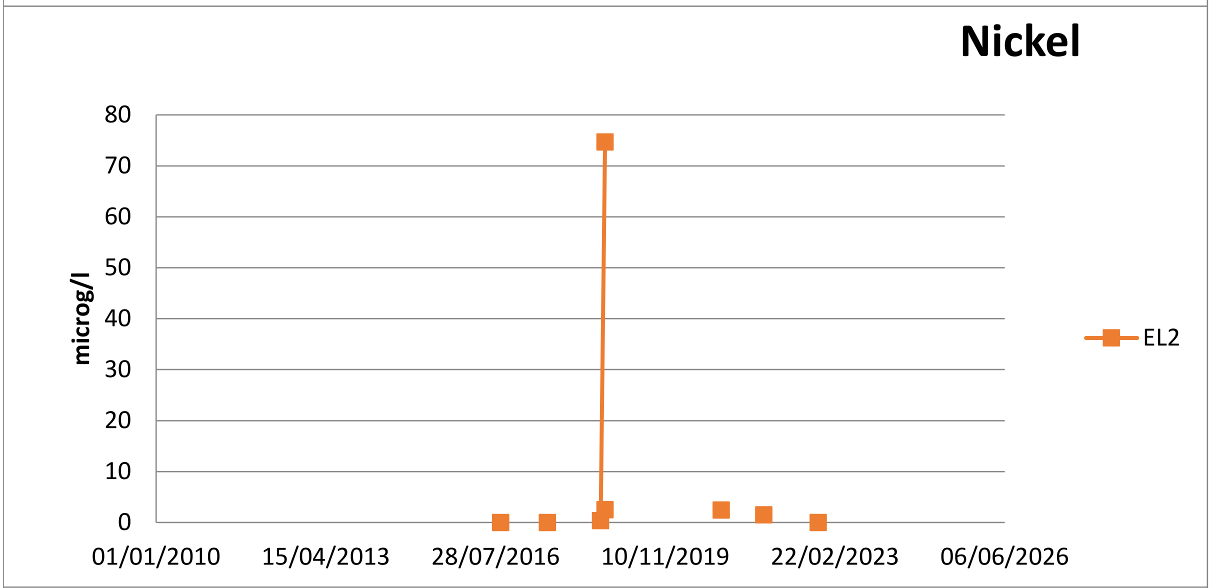
Nickel
80
70
60
50
40
30
20
10
0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
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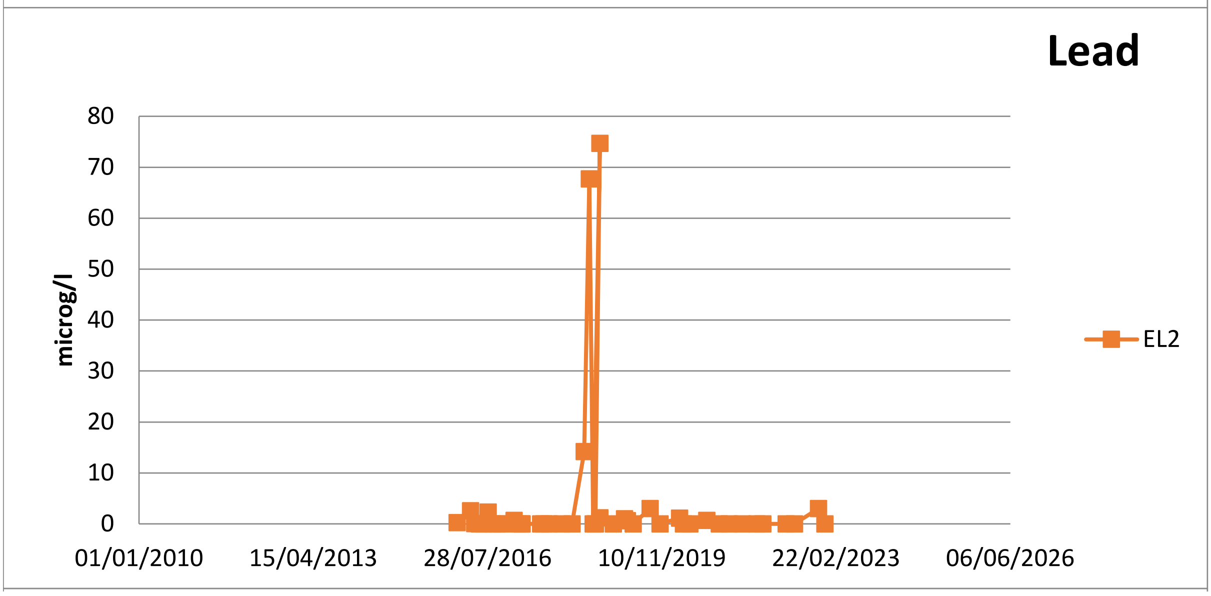
Lead
80
70
60
50
40
30
20
10
0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
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06/06/2026
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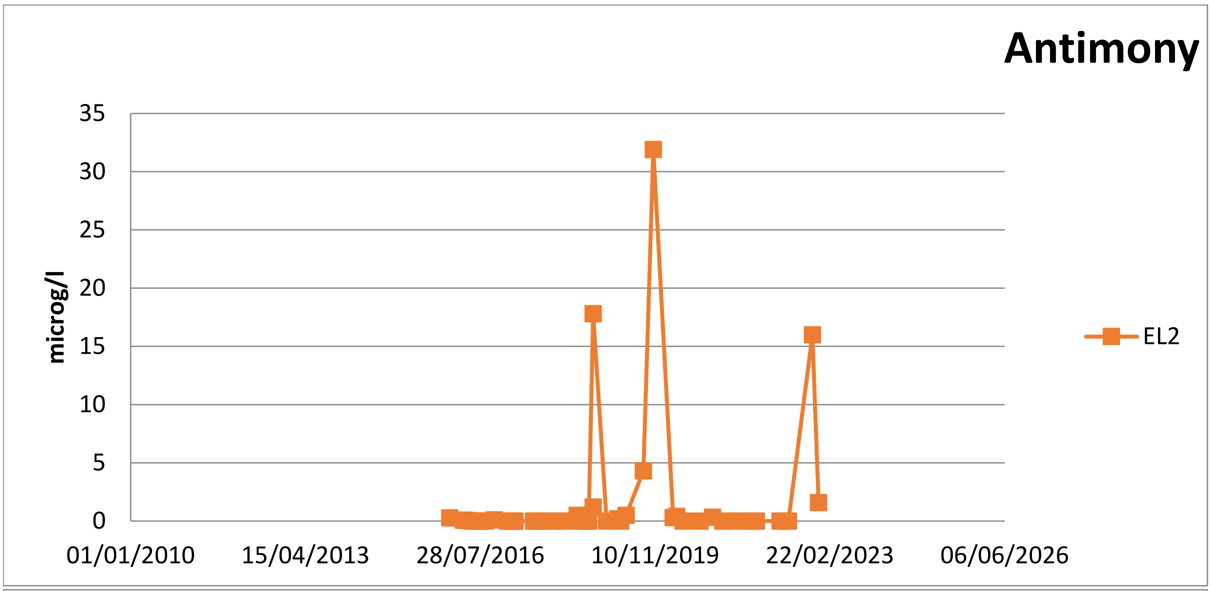
Antimony
35
30
25
20
15
10
5
0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
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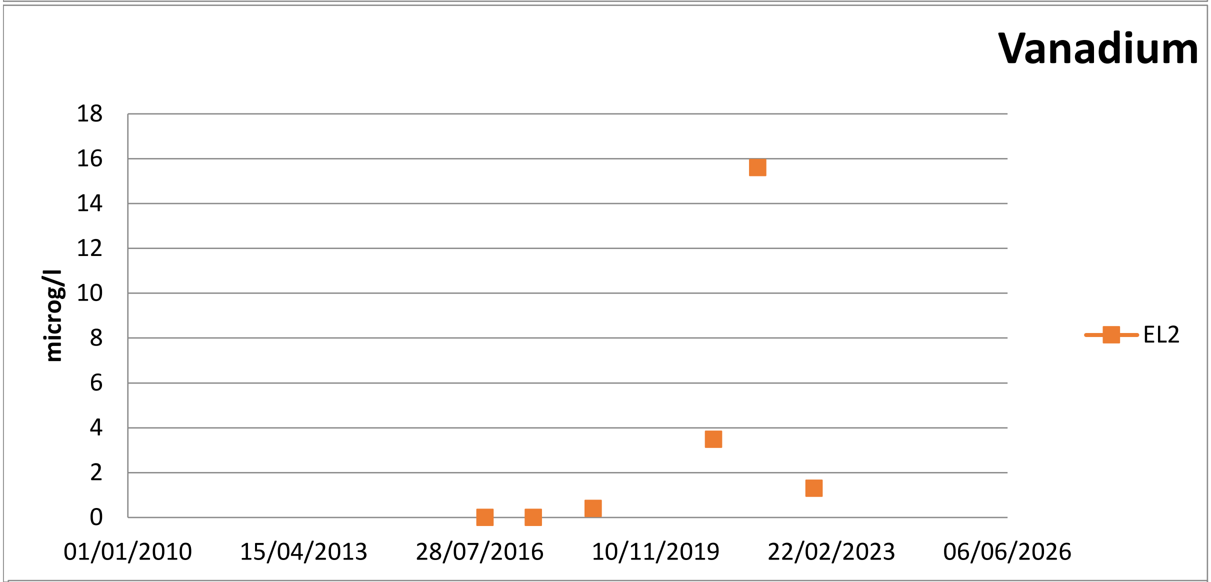
Vanadium
18
16
14
12
10
8
6
4
2
0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
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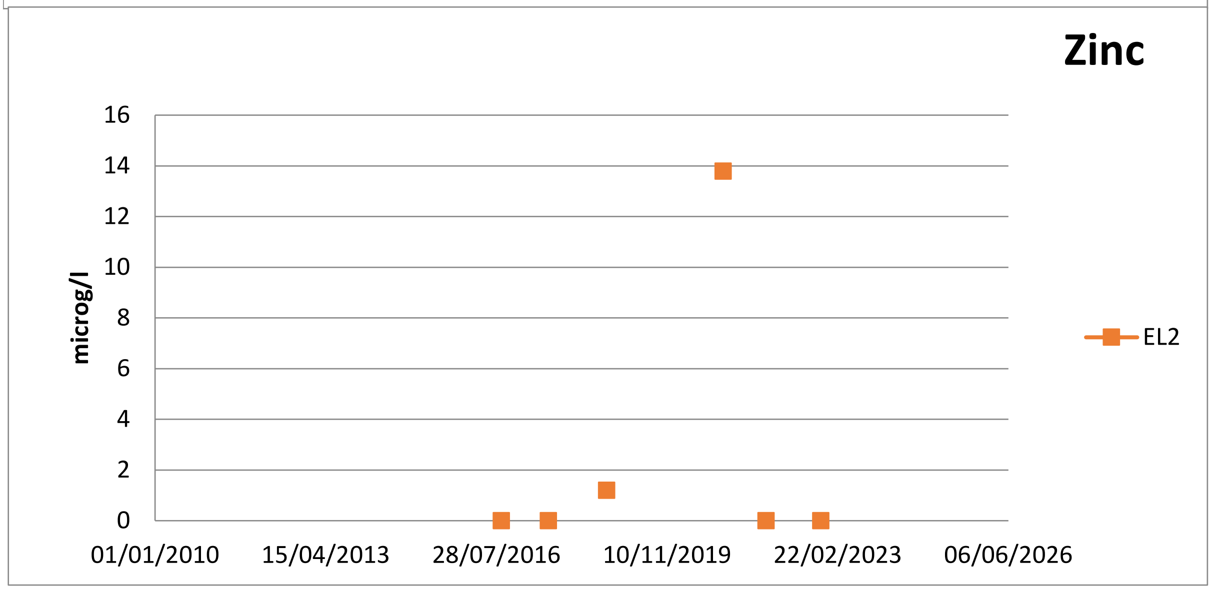
Zinc
16
14
12
10
8
6
4
2
0
microg/l
01/01/2010
15/04/2013
28/07/2016
10/11/2019
22/02/2023
06/06/2026
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