SOUTH SIDE QUEENSWAY WASTE MANAGEMENT SITE, LLANWERN STEELWORKS

2016 Annual Review of Environmental Monitoring

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Executive Summary

The landfill area has been an area of industrial waste disposal for many years having initially been developed in the 1970's to accept wastes from the Llanwern steel works. The landfill was one of two landfill sites operated at the Llanwern site, the other being the East Waste Management Site (EWMS). The landfill accepted industrial wastes from the steel making activity whilst the EWMS accepted general wastes, refuse, biodegradable wastes as well as industrial waste.

The 89 Ha occupied by the site was developed in a series of cells, historically termed lagoons. Lagoon 12 was constructed first on the west by raising four large bunds on top of the stabilising slag layer placed over the majority of the 89 Ha. Fine metallic dust (50% iron, 3% zinc) washed from the flues of the BOS plant was suspended in water and pumped from the steel works into Lagoon 12. There it settled and hardened to form the waste deposit seen today. Infilling in Lagoon 12 was completed by the mid 1980's with Lagoon 25 coming on stream as a replacement. Lagoon 25 was also constructed by developing slag bunds onto the stabilising slag layer, with the metallic fines pumped into the Lagoon. Infilling in Lagoon 25 was completed in 2002 with the demise of the steel making plant. There are no lining systems for either the base or side slopes of either Lagoon 12 or 25.

Throughout the duration of disposal activities, steel and iron slag was deposited to the north and east of Lagoons 12 and 25. Deposits of coarse granular slag of up to 7m thickness covered parts of the areas but today approximately 1m remains as the slag has been commercially worked and recovered. Apart from the lagoons the entire area now occupied by SSQ Non-Hazardous Landfill has largely reduced to a 1m thick slag stabilising layer.

Groundwater and surface water sampling around the perimeter of the site reveals that groundwater within the upper layer of made ground is dominated by an elevated pH and alkalinity due to slaking of lime. The concentration of non-hazardous pollutants and hazardous substances is generally low although hazardous substances are sometimes detected. The elevated pH and alkalinity is likely limiting the mobility of several potential contaminants.

Deeper groundwater, within the alluvial sequence, also has low concentrations of most non-hazardous pollutants and hazardous substances but has a pH of approximately 8. As this pH is very different from the pH in the overlying made ground there would appear to be little hydraulic connectivity between the groundwater bodies encountered. This is not unexpected due to the sequence of low permeability sediments present.

Cadmium was detected in April at monitoring positions in the made ground, peat and bedrock but below analytical detection levels at all other times. The source / cause of this variation is unclear at this stage and will continue to be evaluated. Similarly, the detection of an oil sheen on the sample of groundwater from BH16S will also be monitored.

1 INTRODUCTION

The Environment Agency (now Natural Resources Wales) issued a Closure Notice (No. GR/EM4/01) for Llanwern Landfill, South Side of Queensway (SSQ) which specified that the landfill must cease accepting waste for disposal as of 25 February 2008 and that it must be maintained, monitored and controlled as required by the conditions of the authorisation numbered 024/79. In response, Tata commissioned Geotechnology to prepare a Closure Report and Aftercare Monitoring Plan (see Geotechnology Report 664.1/0/0708).

One of the requirements of the Aftercare monitoring period is the production of annual interpretive reports that evaluate the most recent environmental monitoring results. This report reviews the data collected up to December 2016.

2 SITE SETTING

2.1 Site Location and Extent

The Llanwern Landfill is located in an area referred to as South Side of Queensway (SSQ) which lies immediately to the south of Llanwern Steelworks to the east of Newport. The centre of the landfill site is at Ordnance Survey Grid Reference ST375 858, as shown on the site location plan (Figure 1). Access to the site is only possible through the steelworks off Queensway Road which runs east to west through the plant, north of the landfill.

Until recently, Queensway was a road entirely within the works boundary but the road has become a public road as the steelworks boundary has shrunk following closure of the “heavy end”, where iron and steel was produced. The parcel of land to the south of Queensway (known as South Side Queensway or SSQ for short) is now separated from the secure part of the works. Parts of the site can be accessed by members of the public directly from this road.

In the 1970’s, Newport Borough Council, issued a COPA licence for the disposal of waste materials from the works within SSQ. The licence was never surrendered or rescinded and the licence transferred into the Waste Management regime. Various parts of the SSQ Waste Management site were subsequently taken into the IPPC permit for the steelworks, but this permit ceased with the cessation of steelmaking in 2002. Subsequently, several parts of the SSQ Site were taken into the existing steelworks PPC Permit (Permit BS3905). A Non Hazardous landfill has also been permitted under the PPC regime within SSQ (PPC Permit GP 3331SV). This PPC landfill is referred to as South Side Queensway Non Hazardous Landfill (SSQNHL) and its location is shown on Figure 2. This landfill has yet to be constructed and has not yet entered its pre-operational phase. Photographs of the current site conditions, taken by NRW in September 2016, are provided in Appendix 3.

As a result of the different waste management activities and changes in regulatory regime, the boundary positions of the currently applicable regulatory regime are complex. To assist with understanding the current situation the position of all relevant boundaries are shown in Figure 2 and Figure 3. The position of key surface water collection ditches within the site boundary is also shown on Figure 3. These ditches collect surface run-off from SSQ which is diverted to the main works treatment plant prior to discharge in accordance with the current discharge consent. The regulatory boundaries shown on Figure 2 are:

- Current Waste Management Licence Boundary No. 024/79
- Boundary of SSQNHL PPC Permit GP 3331SV
- Relevant boundaries of Llanwern Steelworks PPC Permit BS3905

In the context of the areas of SSQ which have now been definitively closed and which are of most relevance to this report, these are distinguished from the other site areas as coloured blocks on Figure 3. On Figure 3 the area which has been definitively closed is outlined with a black dashed line with key sub-areas shaded. The closure plan therefore only referred to the areas within the dashed closure boundary and no other areas. The areas bound by the closure plan are:

- Slag Area W
- Slag Area E
- Lagoons 25 and 12 comprising slurry from the BOS and Blast Furnace plants
- Powerline Valley

There are also small areas outside of these distinguished areas although these have not been impacted by waste activities.

2.2 Site Setting

The site lies within an existing industrial area. The northern area of land within SSQ is occupied by Newport Galvanizers Ltd. and Air Products Ltd. North of Queensway road is the steel plant itself. To the west of the site lies an area currently occupied by Multiserv. To the east of the site lies the works effluent treatment reed beds. The steel plant boundary lies some 57m to the south of the site with the land ownership boundary lying further to the south again. Land to the south of Tata's ownership comprises Bowleaze Common which is part of the Wentloog levels, an area of ecological interest benefiting from statutory protection with a SSSI (Site of Special Scientific Interest) designation. This land comprises flat, low lying, sparsely populated and reclaimed grazing land.

The landfill site is partly located within the path of a proposed relief road which is to be constructed between junctions 23 and 29 of the M4. The relief road will run between Magor and Congleton.

2.3 Ground Conditions

The geology of the site has been determined from published information and several phases of site investigations.

The site is located on a Holocene sequence of low permeability sediments that overlie Mercia Mudstone. The mudstones, exposed to the north of the site, show a shallow dip to the SSW.

2.3.1 Holocene sediments

A Holocene sequence of clays and peat overlie bedrock at the site. This sequence of clays and peats are typically 10 to 15 meters thick across the Gwent levels and were formed within the last 10,000 years or so. At the site, these sediments have been found to be locally up to 17 meters thick and to comprise an upper and lower clay layer separated by a peat horizon.

The upper clay layer varies in thickness from 3.1m (borehole 18) and 7m (borehole 21) across the site and has been found in all site investigation boreholes. Laboratory testing of 4 undisturbed samples of the upper clay layer have established permeabilities in the range 1.4 x 10^{-10} and 9.2 x 10^{-10} ms^{-1}.

A peat layer has been encountered, below the upper clay, in all the boreholes at the site and has been found to be between 1 and 2 m thick. Six variable head permeability tests have been undertaken in boreholes completed within the peat which have established a range of permeabilities between 4.8 x 10^{-7} ms^{-1} and 7.2 x 10^{-6} ms^{-1}. The peat, in relative terms, is the "most permeable" unit within the Holocene sediments beneath the site.

The lower clay layer has been found to vary in thickness between 1 metre (borehole 21) and 8.9 metres (borehole 23) and once again has been has been identified in all the site investigation boreholes. Whilst no sampling and testing for permeability has been undertaken from this unit, lithologically it is closely related to the upper clay unit and, as such, it would be expected to have a permeability of 5 x 10^{-10} ms^{-1}.

There is some evidence that limited thin lenses of gravel occur between the lower clay and the weathered Mercia Mudstone.

2.3.2 Bedrock

The bedrock found below the Holocene sediments at the site is Mercia Mudstone (formally known as Keuper Marl). The Mercia Mudstones of the area are documented to consist of red or chocolate fine silty mudstones with conchoidal fractures.

From site investigation boreholes, the Mercia Mudstone has been found to have a weathered surface of approximately 1 to 2 meters in thickness. Falling head tests have been carried out in four piezometers completed within this weathered horizon. Borehole 23 on site, as well as 3 boreholes adjacent to the site, have established permeabilities of around 1×10^{-5} ms^{-1}.

The un-weathered Mercia Mudstone, which has very low matrix permeability and extremely limited secondary fracture permeability, is an important unit in terms of groundwater flow at the site, in that it is considered to provide the impermeable base to the groundwater "flow" system within the overlying Holocene sediments.

Rockhead below the Holocene sediments of the Gwent Levels is between -5m and -7.5 m below OD.

2.3.3 Made Ground

Currently the area is covered with fill materials comprising mainly steelmaking BOS slag (steel slag) which was deposited under the terms of a COPA licence in the 1970's. This layer is currently approximately 1m thick.

2.4 Hydrogeology

2.4.1 Aquifer Characteristics

There are no Source Protection Zones (SPZ) in the vicinity of the site, the nearest SPZ is that for the Great Spring which at its nearest point is more than 5km away from the site and is hydraulically isolated from the site by the intervening geology.

The strata below and in the vicinity of the site is considered by Natural Resources Wales as a non-aquifer (as shown on the Agency's published Vulnerability Maps). Both the Holocene sediments and the underlying Mercia Mudstone are of low to extremely low permeability, which supports the Agency's classification of the area as a Non Aquifer. There is no known licensed or unlicensed groundwater abstraction from strata underlying the Caldicot Levels.

The upper clay, with proven permeabilities in the range of 4×10^{-10} and 9.2×10^{-10} ms^{-1} and with a thickness of between 3.1 meters (borehole 18) and 7 meters (borehole 21) is a natural geological barrier that prevents vertical flow from the ground surface to the water table. Both the smaller drainage ditches around the site and the larger reens such as Hundred Perch Reen are founded within and do not pass through the upper clay layer.

Permeability values for the upper clay were acquired from testing undisturbed samples (U100's) in the laboratory and can, therefore, be relied upon to reflect field conditions. Uncertainty in the quality of the permeability results is reduced when all samples are considered, thus giving a narrow range and the fact that one of results comes from testing during the Site Investigation carried out by Enviros in 2002.

The lower clay, having a thickness across the site of between 1 meter (borehole 21) and 8.9 meters (borehole 23) has the same lithological and sedimentological characteristics as the upper clay. Whilst its permeability has not been directly tested, it is considered to have permeabilities in a narrow range centred around 5×10^{-10} ms^{-1}, similar to that of the upper clay. As such the lower clay, like the upper clay, likely presents a significant barrier to vertical flow.

The peat horizon that has been identified across the site has permeabilities in the range of 4.8×10^{-7} ms^{-1} and 7.2×10^{-6} ms^{-1} and a thickness varying between 1 and 2 meters. It can be considered permeable in a relative sense, when compared to the upper and lower clays. Its position below the site, sandwiched between two layers of low permeability clay results in it becoming a credible route for the horizontal movement of limited volumes of groundwater. This is not because the peat in itself is particularly permeable or that it represents an aquifer, but simply that it represents a “permeability contrast” when considering its location between two very low permeability clays. No significant amount of groundwater can be extracted from the peat.

There are possible localised lenses of gravels between the lower clay and the weathered Mercia Mudstone. The evidence for these gravels comes from samples taken at the depth of the weathered mudstone and there is a potential for some confusion between the two. However, with respect to groundwater flow, were there gravels in such circumstances, they would have a permeability similar to that attributed to the weathered mudstone which is considered contiguous across the site, so in hydrogeological terms their presence or absence is irrelevant.

The weathered layer of Mercia Mudstone, located below the lower clay and above the un-weathered Mercia Mudstone has similar hydrogeological significance as the peat layer, in that its permeability, as established from variable head tests, is of the order of 1×10^{-5} ms^{-1}**.** As with the peat layer, this provides opportunity for horizontal movement of groundwater.

The significance of the underlying un-weathered Mercia Mudstone is that it is the impermeable base above which the limited groundwater movement occurring in this geological setting, takes place.

The absence of any groundwater abstractions from this hydrogeological setting, in an area where mains supply requires significant investment in infrastructure, supports the assertion that groundwater is not a viable resource in this low permeability setting.

2.4.2 Groundwater Flow

Historical hydrographs developed from the collection of groundwater level data show a variation between summer and winter groundwater levels of less than 0.5 meters. The small variation in groundwater levels over a 12 month period demonstrates that the amounts of recharge reaching the groundwater system within the peat and weathered mudstone horizon are very limited, particularly when considering the low specific yield of each formation.

Groundwater below the site has been encountered solely within the made ground, peat and weathered mudstone (bedrock) layers. Rest groundwater levels within the peat and bedrock units are observed as being almost identical suggesting that the peat and weathered mudstone horizons are in hydraulic continuity with one another. There is no lithological evidence for linkage between these two units directly below the site as all boreholes demonstrate the presence of the lower clay layer.

The historical groundwater gradient within the low permeability Holocene sediments has been previously found to be approximately 0.0033 towards the east-southeast, that is Hundred Perch Reen. Groundwater gradients are very shallow, reflecting extremely low rates of recharge to the peat due to the overlying low permeability upper clay layer and the frequency of reens which groundwater within the peat discharges to.

2.5 Hydrology

The site is located close to the boundary of the Caldicot Levels which are part of the larger Gwent Levels. The Gwent Levels are an extensive low lying area of estuarine alluvium located on the north side of the Severn estuary in Southeast Wales between Cardiff and the River Rhymney in the west and Chepstow on the River Wye in the east.

The Levels were created through the enclosing and draining of tidal saltmarshes and their continued existence requires the ongoing management of seawalls which prevent their frequent inundation by the sea. In order to manage runoff from the low permeability sediments that make up the levels and to transport runoff from adjacent areas of higher ground a complex system of channels have been constructed. The channels make up a hierarchical network, smaller ditches discharging into larger water courses known as reens, which in turn discharge into the sea via pumps and tidal gates. This network is the key feature of the Levels, both in terms of their ecological importance and the historic landscape. The minor ditches around the site are completed above the water table whilst the deeper reens around the site are completed within the Upper Clay, just below the water table. The drainage network and flows within it are managed by the Caldicot and Wentloog Drainage Board (an IDB).

Almost all of the annual recharge falling on the site leaves via surface runoff due to the low permeability nature of the sites soils and the underlying low permeability Holocene sediments.

The closest water courses to the site which are not part of the sites own drainage infrastructure, are the Elver Pill Reen and the Hundred Perches Reen, some 359 meters to the ESE of the site. Due to their managed nature, flows within the reens can be variable and flow data is limited. Previous spot gauging of Hundred Perches Reen taken at the point where Queensway crosses the reen to the north of the site, shows flows to be in the order of 78 litres per second.

The Caldicot Levels are a SSSI, primarily as they are representative grazing marsh/reen habitat and due to their invertebrate assemblages, plant species, otters, water voles and breeding birds. The nearest SAC to the site is the River Usk some 4 kilometres to the west of the site. There is no hydraulic connection between the site and the River Usk with all surface water from the levels draining directly into the Severn Estuary.

2.6 Conceptual Site Model

To enable the risks posed to groundwater and surface water to be evaluated, a conceptual hydrogeological model was developed as part of the closure process. The diagrammatic representation of the model is provided in Figure 4.

3 LAND USE AND CLOSURE PLANNING

3.1 Overview

The landfill area has been an area of industrial waste disposal for many years, initially developing in the 1970's to accept wastes from the Llanwern Steel Works. The landfill was one of two landfill sites operated at the Llanwern site, the other being the East Waste Management Site (EWMS). The landfill accepted industrial wastes from the steel making activity whilst the EWMS accepted general wastes, refuse, biodegradable wastes as well as industrial waste.

The 89 Ha occupied by the site was developed in a series of cells, historically termed lagoons. Lagoon 12 was constructed first on the west by raising four large bunds on top of the stabilising slag layer placed over the majority of the 89 Ha. Fine metallic dust (50% iron, 3% zinc) washed from the flues of the BOS plant was suspended in water and pumped from the steel works into Lagoon 12. There it settled and hardened to form the waste deposit seen today. Infilling in Lagoon 12 was completed by the mid 1980's with Lagoon 25 coming on stream as a replacement. Lagoon 25 was also constructed by developing slag bunds onto the stabilising slag layer, with the metallic fines pumped into the Lagoon. Infilling in Lagoon 25 was completed in 2002 with the demise of the steel making plant. There are no lining systems for either the base or side slopes of either Lagoon 12 or 25.

Throughout the duration of disposal activities, steel and iron slag was deposited to the north and east of Lagoons 12 and 25. Deposits of coarse granular slag of up to 7m thickness covered the areas indicated on Figure 3 as Slag Area W, Slag Area E and the SSQ Non-Hazardous Landfill. Since its deposition, both steel slag and blast furnace slag have become commercially viable for a variety of applications and most of the deposit has now been removed. The entire area now occupied by SSQ Non-Hazardous Landfill has therefore been reduced to a 1m thick slag stabilising layer.

Lagoon 27 is divided into four equal quarters and has accepted wastes from the Hot Mill under an IPC and now a PPC Permit. This area lay outside the scope of the closure report for the areas in SSQ. Similarly, the water treatment lagoons in the NE of the site now fall under the works PPC Permit and therefore did not form part of the closure report.

Some of the activities in these areas have been carried out by Tata and its predecessors (Corus and British Steel) whilst some have been carried out by contractors (such as Harsco and Multiserv) and others by third parties (such as Air Products, Newport Galvanisers, and Tarmac).

3.2 Areas Comprising Slag

These areas have been re-worked by Multiserv and Tarmac. Multiserv first recovered the steel from the material to enable excavation of secondary aggregate by Tarmac. This recovery operation went on for several years but is now largely complete. The recovery process worked from east to west, from the area of SSQNHL towards Slag Area W. In order to enable the continued tracking of vehicles, a foundation layer of weathered slag approximately 1m thick is all that remains following removal of the workable slag.

3.3 Lagoons 12 and 25

Lagoons 12 and 25 are very similar in terms of their site position, construction and deposit. Lagoon 12 is, however, approximately 20 years old whilst Lagoon 25 is 10 years old.

Assessments completed as part of the closure report demonstrated that the lagoons did not pose a significant risk to controlled waters due to the chemical stability of the stored material, the lack of sensitivity of the hydrogeological setting and the collection of surface run-off by the sites' surface water drainage system. Further, the stability assessment demonstrated that there were no concerns over their long-term stability.

As the lagoons pose no risk to the aquatic environment and have been shown to be stable, the restoration plan focussed on preventing the release of dust during dry conditions, improving the overall site aesthetics and ensuring that the surface water collection ditches are regularly maintained. As can be seen from Figure 2, both lagoons are partially vegetated, with the vegetation at Lagoon 12 more advanced than Lagoon 25. As a consequence, there have been no recorded issues regarding dust blow events. Therefore, there is no intention to disturb this habitat at this time. Rather, the occurrence of dust release at both lagoons will be monitored and only, if necessary, will additional soil cover be placed. Such an approach will also benefit the appraisal of recovery operations which is ongoing.

3.4 Powerline Valley

No specific restoration plans were planned for this area as no waste activities have occurred within the area.

3.5 Other Areas

No specific restoration plans were planned for these areas at this stage as no waste activities have occurred within these areas.

4 MONITORING PROGRAMME

The current available monitoring network is illustrated in Figure 5.

4.1 Groundwater and Surface Water

The AMP set out the determinants to be examined in groundwater and surface water. During 2014 and 2015, Tata commissioned more frequent monitoring than required by the AMP and implemented most of the characterisation suite. Following the completion of the first 12 months of monitoring, the AMP suggested that the analytical data should be reviewed to identify parameters from the characterisation suite that should be included in the indicator suite. This review was presented in the 2014 Annual Monitoring Report and the new programme, summarised in Tables 4-1 and 4-2 started to be implemented during 2016.

Table 4-1 New Monitoring Schedule

Monitoring Parameter	Monitoring Location	Frequency	Type of Monitoring Point
Groundwater	BH13 to BH19, BH24 (already installed), BH201 - BH205	Quarterly	50mm diameter piezometer wells
Surface water	SW1, SW2 and SW3	Quarterly	Surface water body comprising reens
Leachate	Lagoon 12 and 25 embankments	Six Monthly	Visual observation and physical measurement
Dust and Particulates	As required	As required	Dust gauges as required
Odour	As required	As required	Subjective assessment in particular area
Stability	Lagoon 12 embankment	Annual	Visual observation and physical measurement

Table 4-2 New Analytical Programme

Measurement	Groundwater and Surface Water Suite	
Monitoring Positions	All surface water and groundwater locations	
Frequency	Annually	All other times
Suite Reference	Characterisation Suite	Indicator Suite
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	•	•
Total hydrocarbons	•	
Polyaromatic hydrocarbons	•	
VOC and SVOC compounds	•	

Samples cannot always be collected from the surface water sample monitoring locations due to dense vegetation growth.

4.2 Dust

The AMP details the dust monitoring programme to be implemented.

4.3 Waste Stability

The previous assessment of the stability of the waste mass, its containment bunds and the surrounding ground did not reveal the possibility of slope failure with even the most pessimistic model parameters. Waste settlement is not expected as the site has received biodegradable wastes, simply hydraulically placed industrial wastes that are now becoming cemented by mineral precipitation. Accordingly, waste settlement monitoring and waste/ bund stability monitoring is not required by the AMP.

However, in recognising that there is a possibility that part of the eastern bund of Lagoon 12 is not cemented and could have an inadequate FOS (though failure is not indicated) there should be an annual walk-over each springtime to look for evidence of shallow translational slips. This needs to be implemented.

4.4 Leachate Breakout

The AMP suggested leachate breakout monitoring should comprise six monthly site walkovers, particularly around the embankments of Lagoons 12 and 25.

4.5 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. The laboratory is being audited in Feb 2017 where they hope to get accreditation for pH, TDS anions and metals by ICP-MS. As their current ICP has become redundant a new instrument is being purchased but this is not likely to be accredited until mid-2017.

4.6 Actions required

- Safe access to the surface water sampling points needs to be improved. Given that vegetation growth is inevitable, routine maintenance and signage would be beneficial.
- A large tree has fallen across the path of the access track on the southern side of the site. This prevents vehicular access to the southwestern monitoring points.


Plate 1. Fallen tree blocking access track

- Consideration could be given to preventing public access to the site and wider SSQ area.

5 GROUNDWATER LEVEL AND QUALITY

5.1 Groundwater Flow

Figure 6 presents groundwater levels encountered in the shallow made ground and peat layer during 2015 and 2016. These plans have been developed from measurements of water level at the piezometers summarised in Table 5-1.

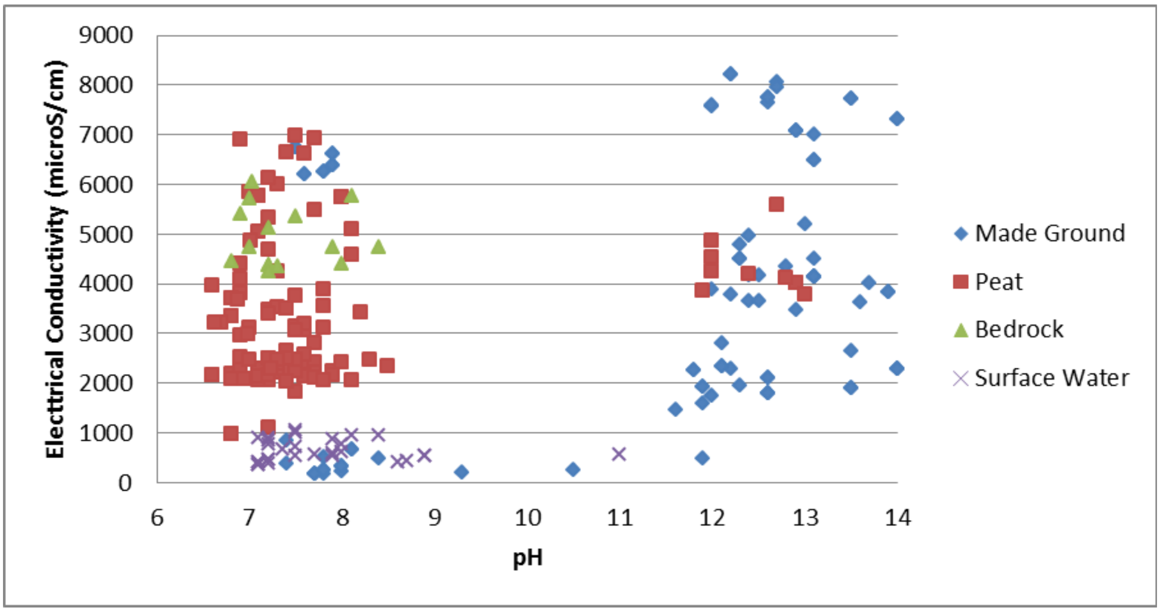
Table 5-1 Groundwater Monitoring Wells

ID	Monitoring Interval
BH13S	Made Ground
BH16S	Made Ground
BH18S	Made Ground
BH201S	Made Ground
BH203S	Made Ground
BH13D	Peat
BH16D	Peat
BH17	Peat
BH18D	Peat
BH19	Peat
BH201D	Peat
BH202D	Peat
BH203D	Peat
BH205D	Peat

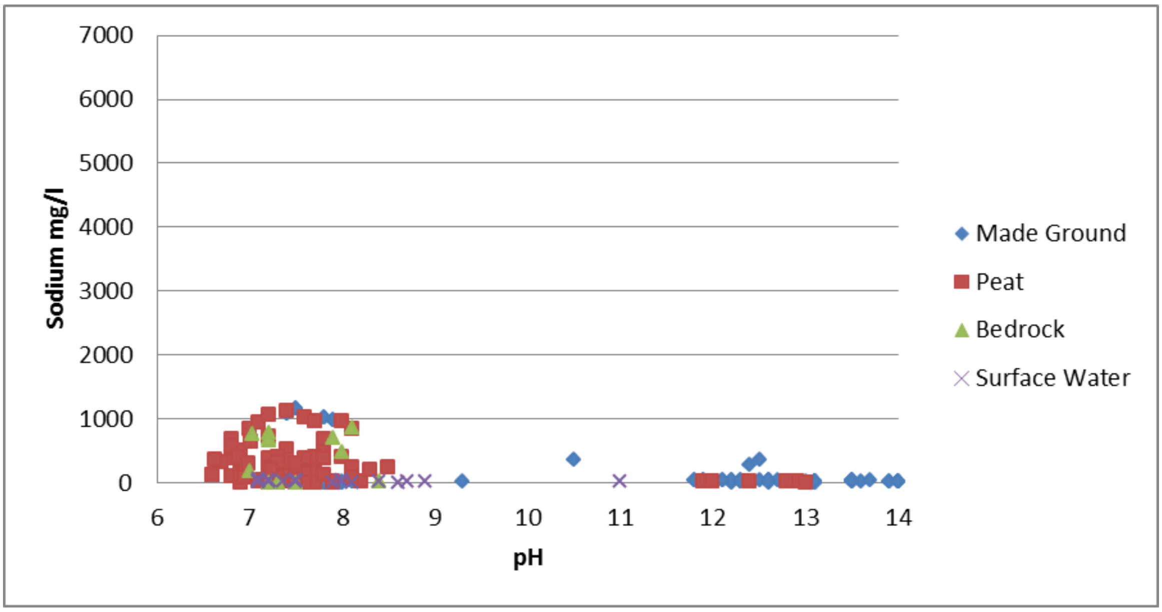
The direction and gradient of groundwater observed in 2015 and 2016 is very similar to that noted previously; shallow gradients fall from the north/northwest towards the south/southeast.

5.2 Groundwater Chemistry

Appendix 1 contains a summary of the groundwater chemistry data gathered to date. The data is presented as a series of hydrochemical contour plan and time series charts. To help understand the differences in groundwater chemistry between the shallow made ground, peat and underlying bedrock a series of scatter plots are also presented in the appendix and presented in the text (see below).



The data indicates that groundwater within the shallow made ground is distinct and characterised by elevated pH (typically > pH 11). This is principally because the made ground comprises steel slag that leaches lime. In comparison, the groundwater in the peat is circumneutral (pH 6 – 8) although there is potential evidence of some interconnection between the made ground and peat at BH202 as the pH is elevated at this point.



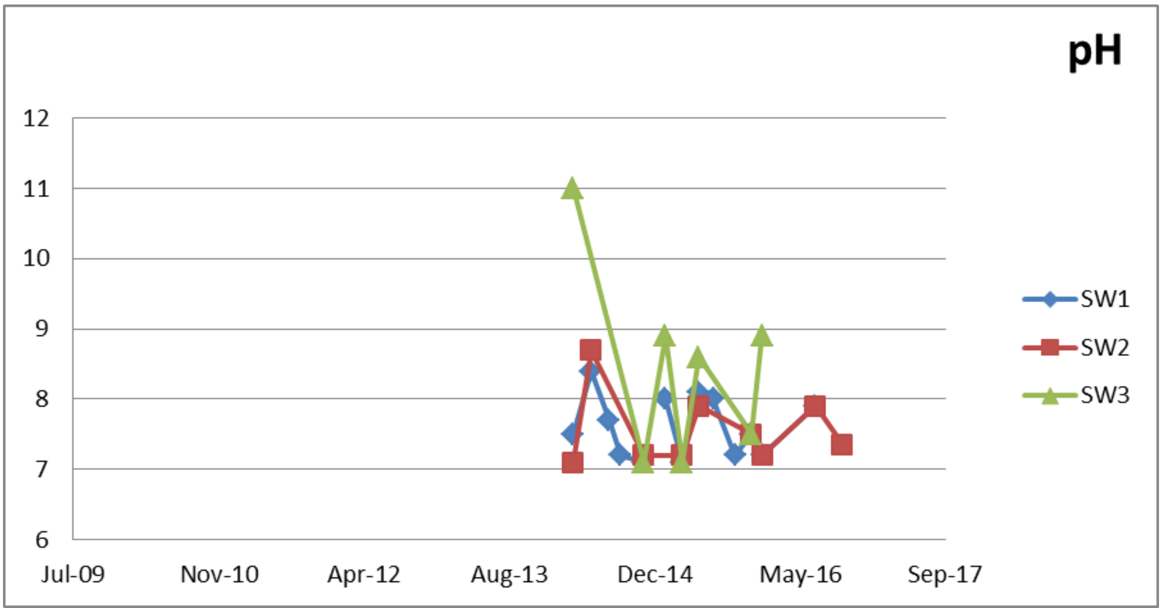
As a consequence of the highly alkaline pH, most non-hazardous and hazardous substances are either below detection limits or at low concentrations in the made ground. However, hazardous substance cadmium has been detected on several occasions and sometimes at elevated concentration (e.g. 324 microg/l at BH18S in 2015). Cadmium was detected in groundwater sampled from the made ground in 2016 (106 microg/l at BH201) and also in samples from the underlying peat (377 microg/l at BH19) and bedrock (72 microg/l at BH24). The only time cadmium was detected at any of these positions located along the southern flank of the site was April 2016; this potentially suggests that sampling / analytical error could be a contributory factor despite dedicated pumps and sampling bottles being used.

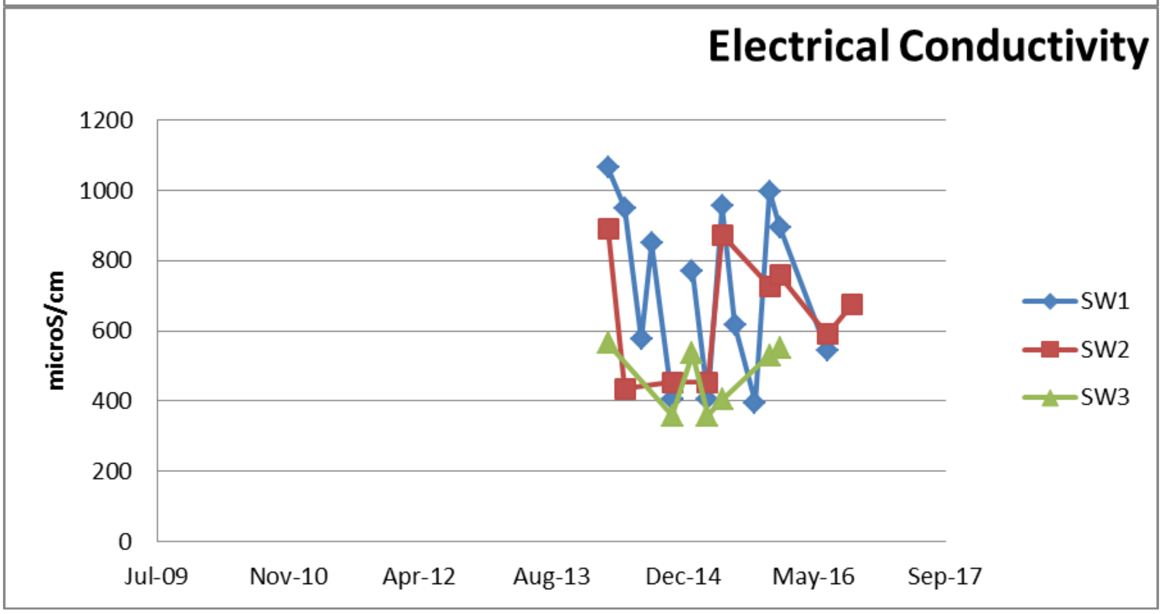
The concentration of several parameters such as chloride, copper and chromium do sometimes exceed Environmental Quality Standards. Interestingly, the groundwater within the peat is as mineralised as the groundwater within the shallow made ground. However, this is not considered to be due to leaching from the overlying waste, as several parameters are at higher concentration and pH is significantly lower, but from processes within and possibly below the peat, including the potential influence of sub-artesian groundwater in the underlying bedrock.

At BH16, an oil sheen was noted on the sample retrieved from the made ground in December 2016. This had not been observed previously.

6 SURFACE WATER

The results of the surface water monitoring are presented in Appendix 2. The data gathered during the past 12 months is similar to that collected several years ago suggesting a large degree of stability in the water chemistry.





Surface water is circumneutral, moderately mineralised with low levels of non-hazardous substances. As surface water progress from east to west the mineralisation decreases from or 800 microS/cm to less than 600 microS/cm. The main reason for this change is decreasing alkalinity although most parameters are lower downgradient of SW1. Apart from a few short term breaches, all data is typically within Environmental Quality Standards.

7 AMENITY ISSUES

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

The site can, however, be readily accessed by members of the public.

8 SUMMARY AND RECOMMENDATIONS

8.1 Evaluation and Summary

Monitoring of groundwater and surface water has revealed conditions similar to those previously observed. Shallow groundwater chemistry is dominated by the leaching of slag based wastes with elevated pH and alkalinity. Such chemistry is not widely evident in the underlying peat as the made ground and peat are separated by low permeability clays. Mineralised groundwater within the peat is not considered to be a consequence of downwards percolation from the overlying made ground. The detection of cadmium in made ground, peat and underlying bedrock will continue to be carefully scrutinised. As will the occurrence of an oil sheen at BH16.

Like the groundwater in the peat, surface water on the southern, downgradient edge of the site is circumneutral. With low levels of non-hazardous substances the quality tends to meet Environmental Quality Standards.

8.2 Actions Required

- The integrity of the site boundary should be checked to ensure members of the public cannot gain access
- Vegetation in the vicinity of several sampling points requires routine clearance to enable continual safe access.
- The AMP suggested leachate breakout monitoring should comprise six monthly site walkovers, particularly around the embankments of Lagoons 12 and 25. This needs to be implemented.
- There should be an annual walk-over each springtime to look for evidence of shallow translational slips along the embankment of Lagoon 12.

Figure 1 Site Location Plan

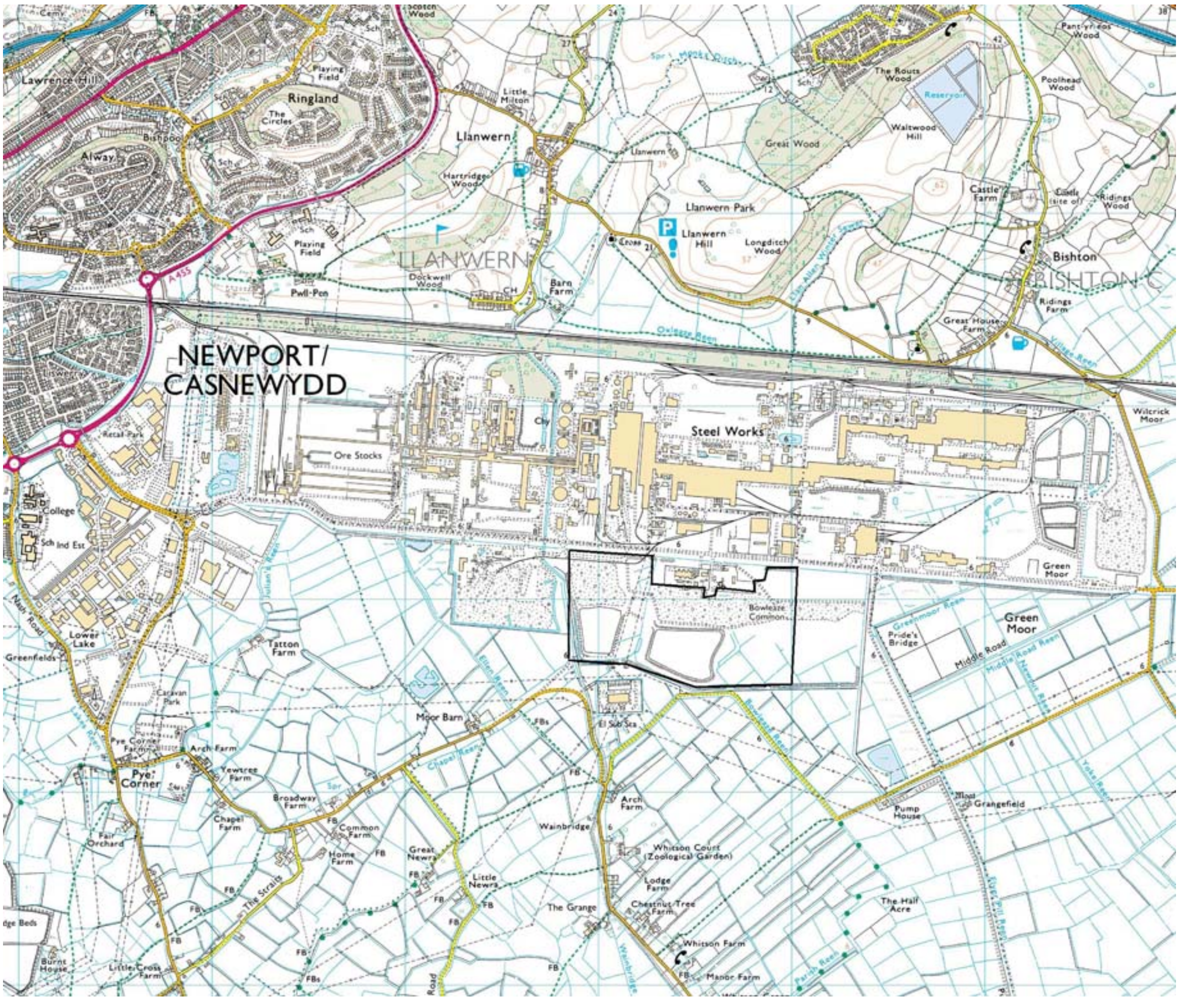


Figure 2 Site Plan Showing Permit Boundaries

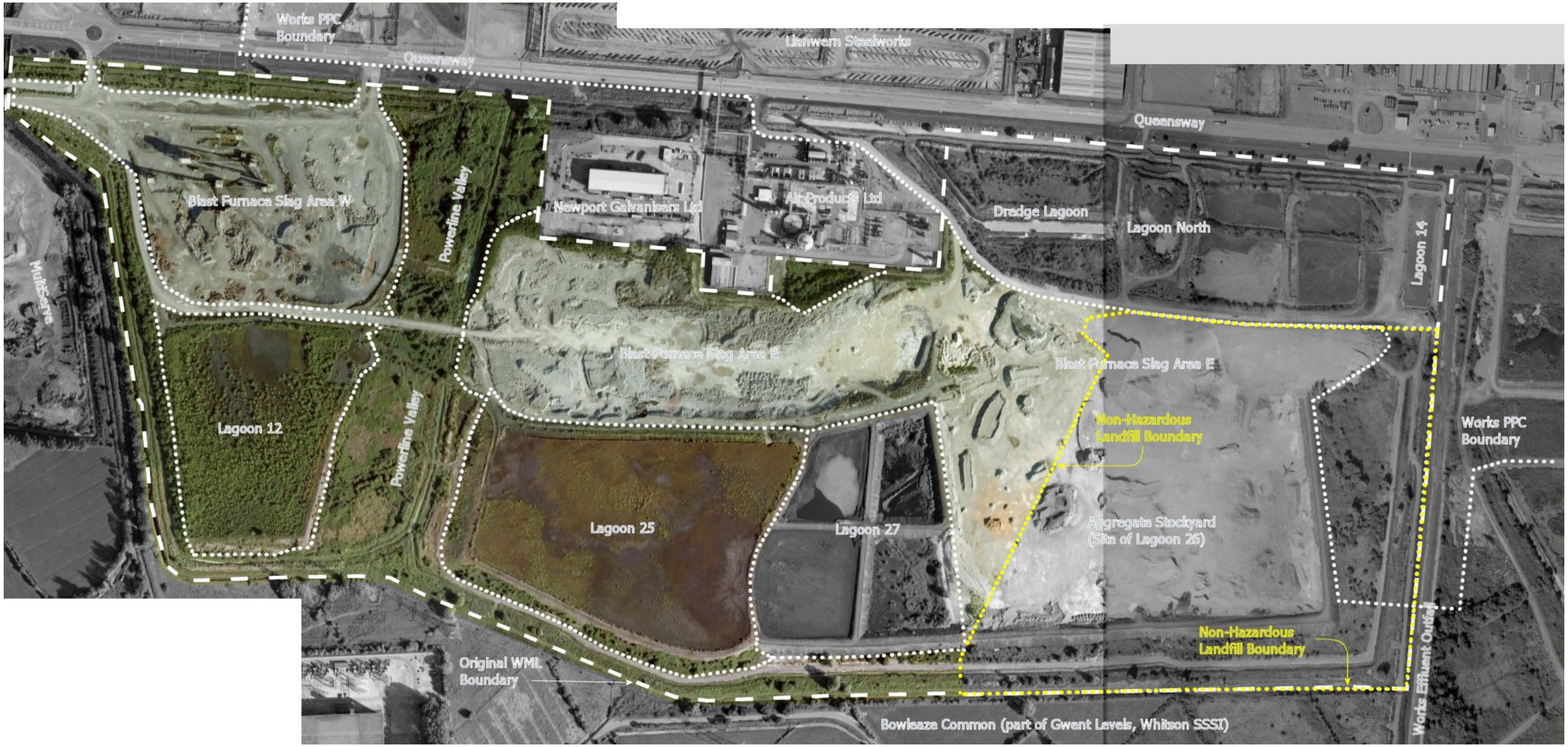
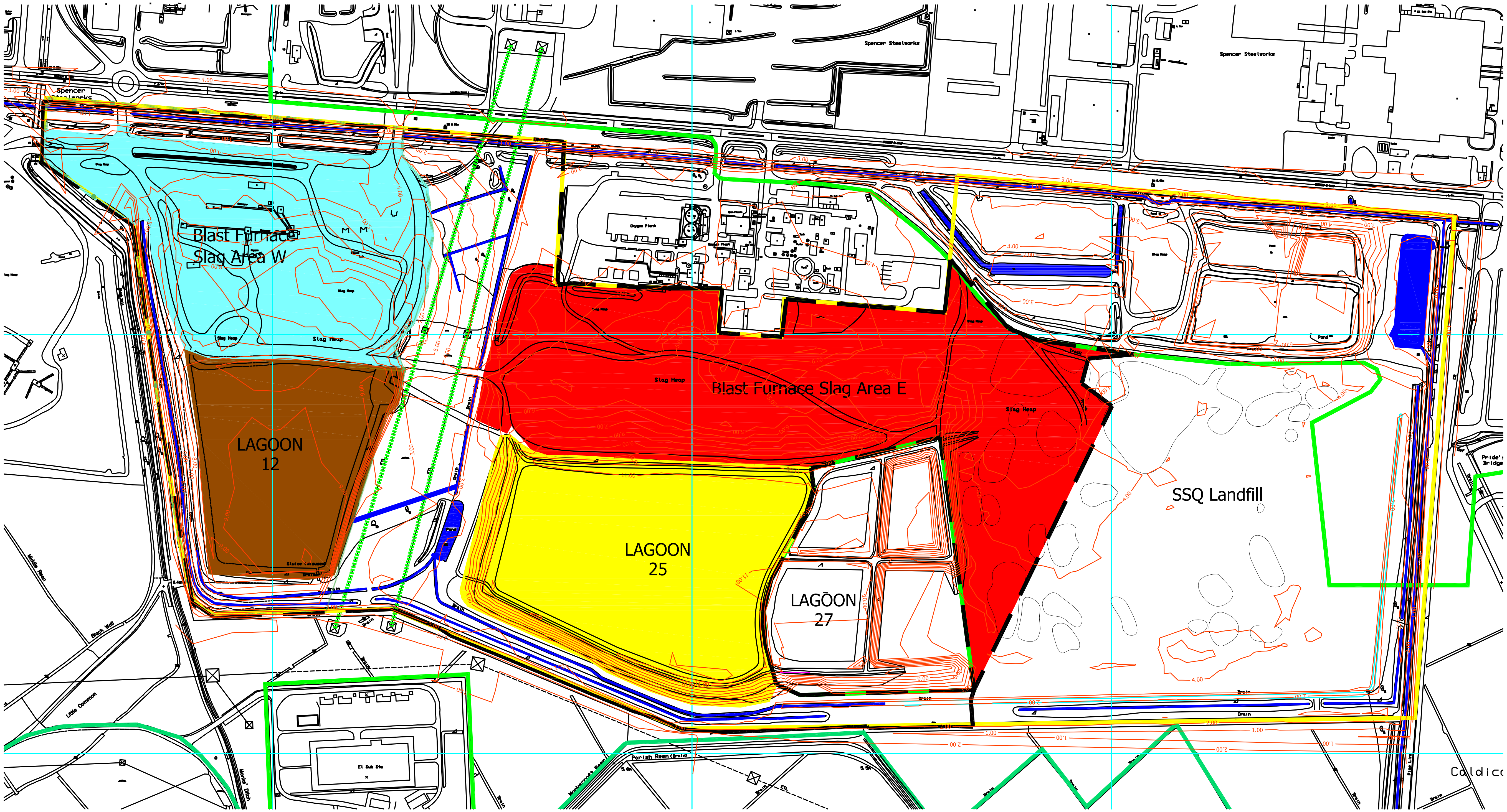


Figure 3 Areas of Site Included in Closure Plan



Blast Furnace Slag Area E
Blast Furnace Slag Area W
Lagoon 25
Lagoon 12
Definitive Closure Boundary

Figure 4 Conceptual Site Model

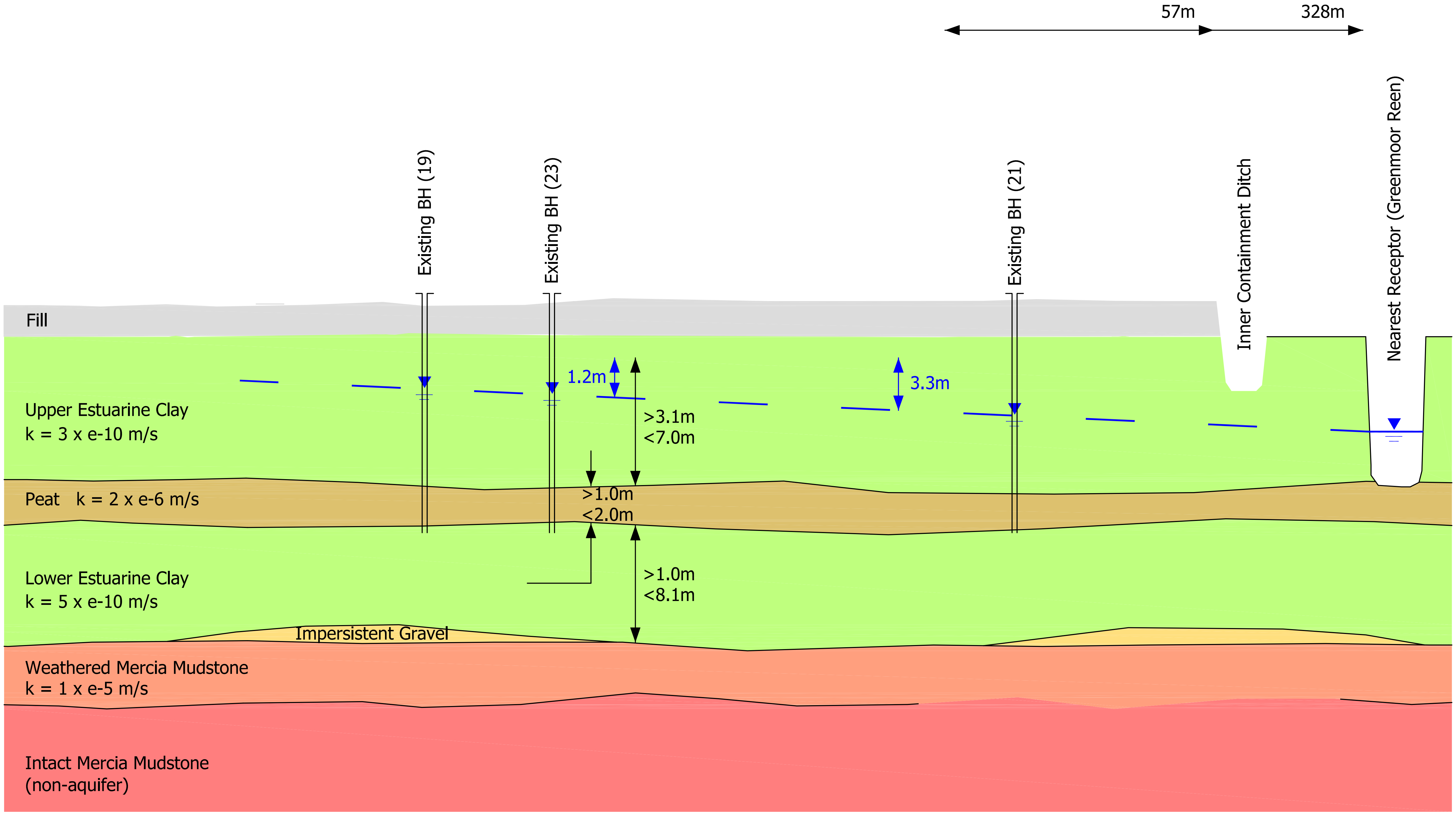
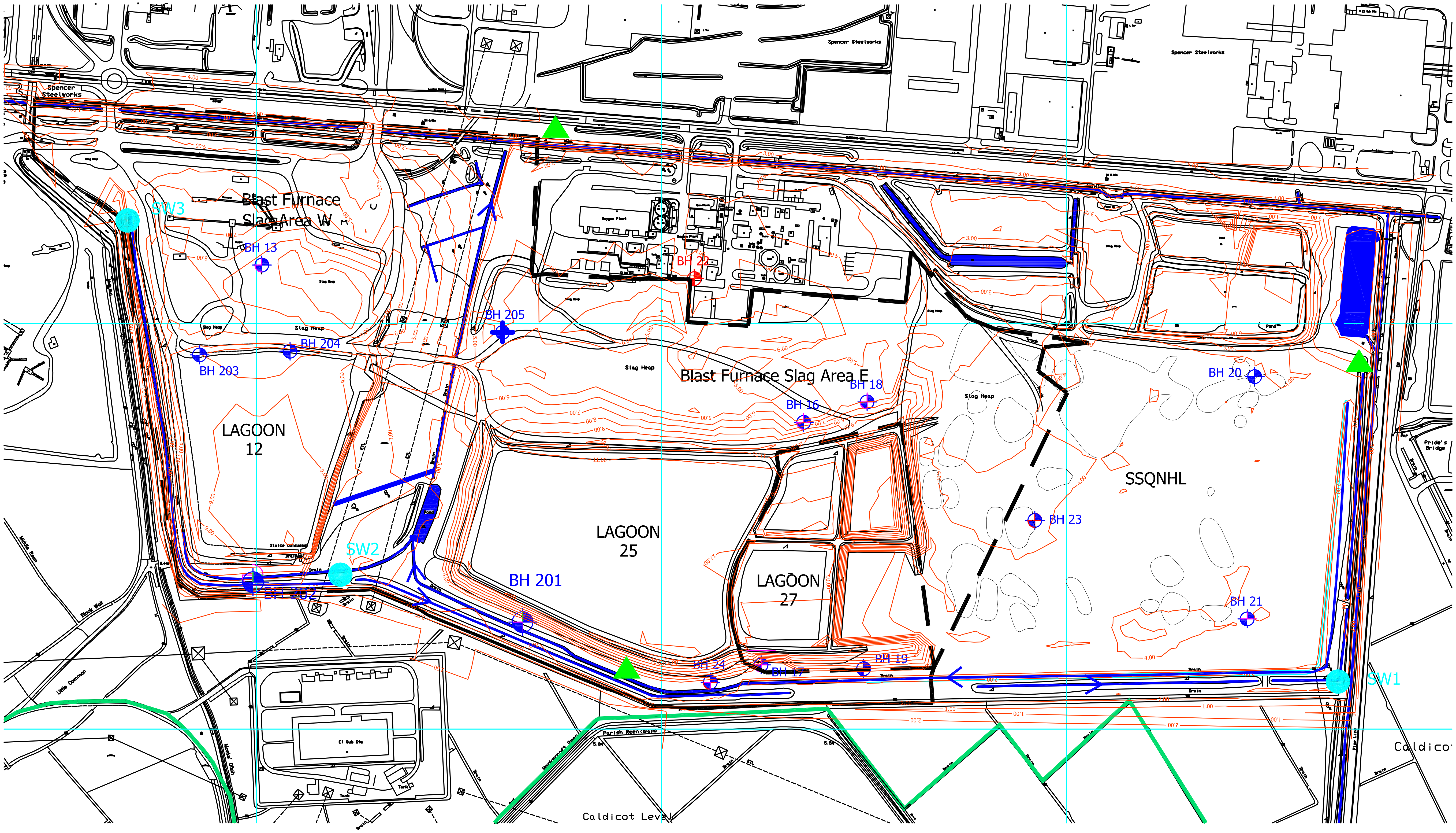
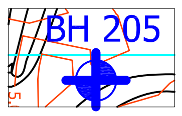
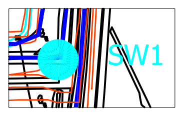


Figure 5 Available Monitoring Network



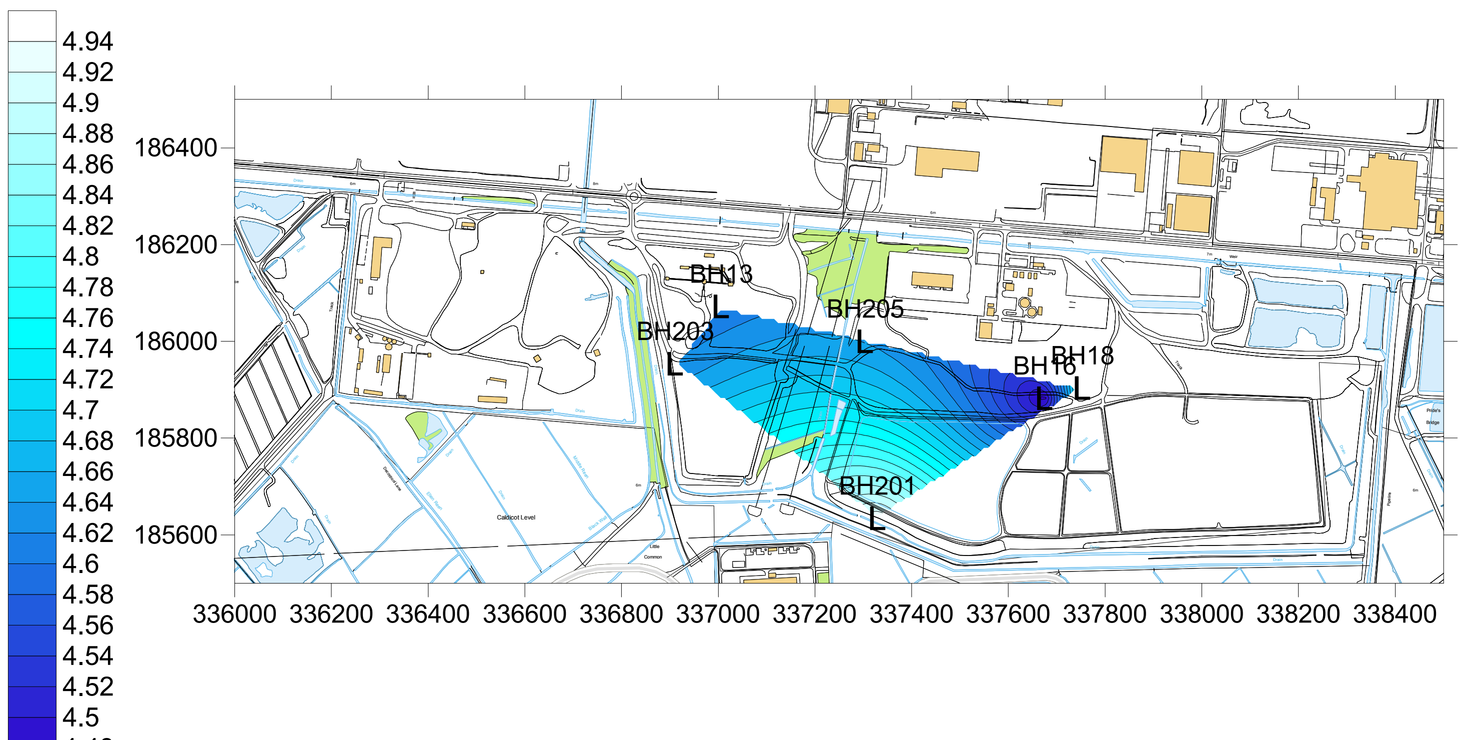


Monitoring Position to be replaced

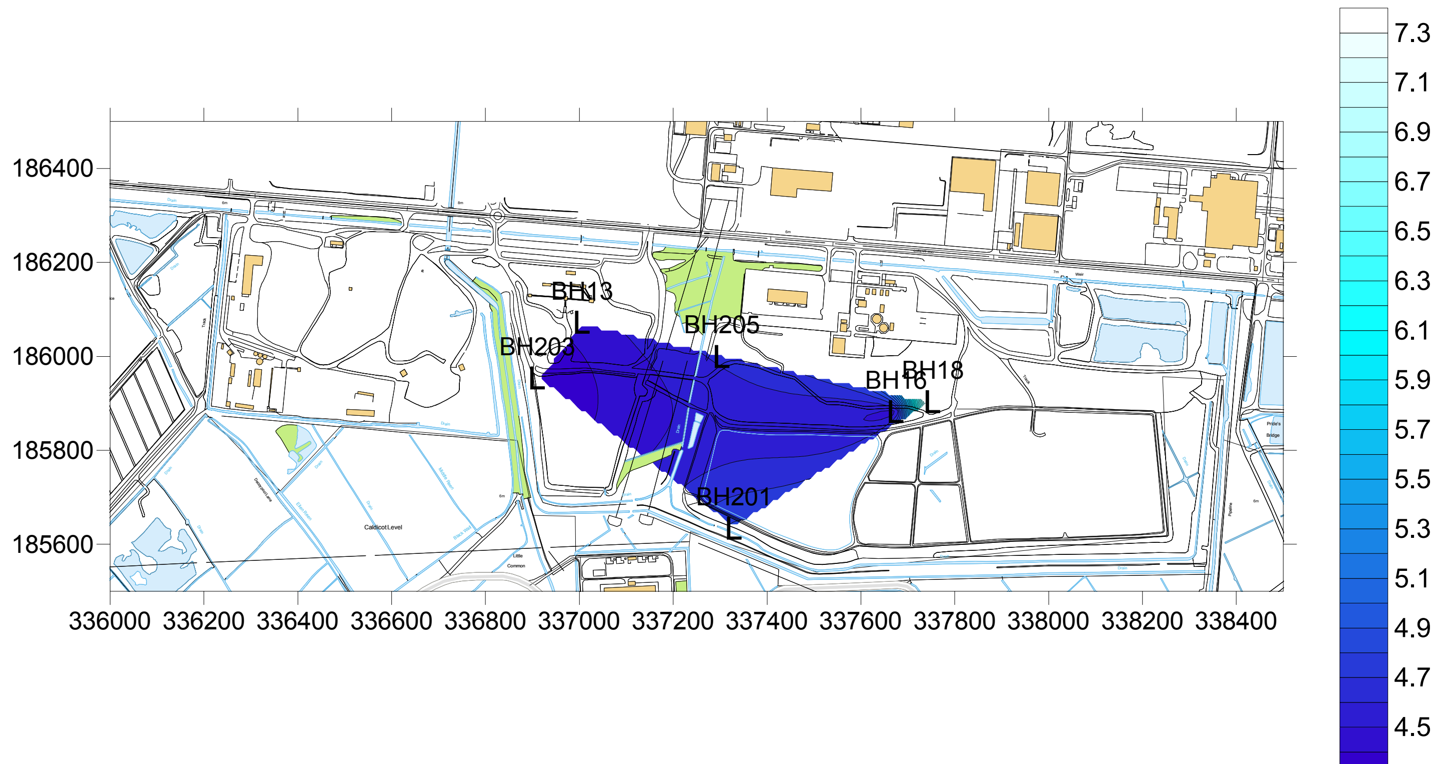


Surface Water and Leachate Monitoring Position

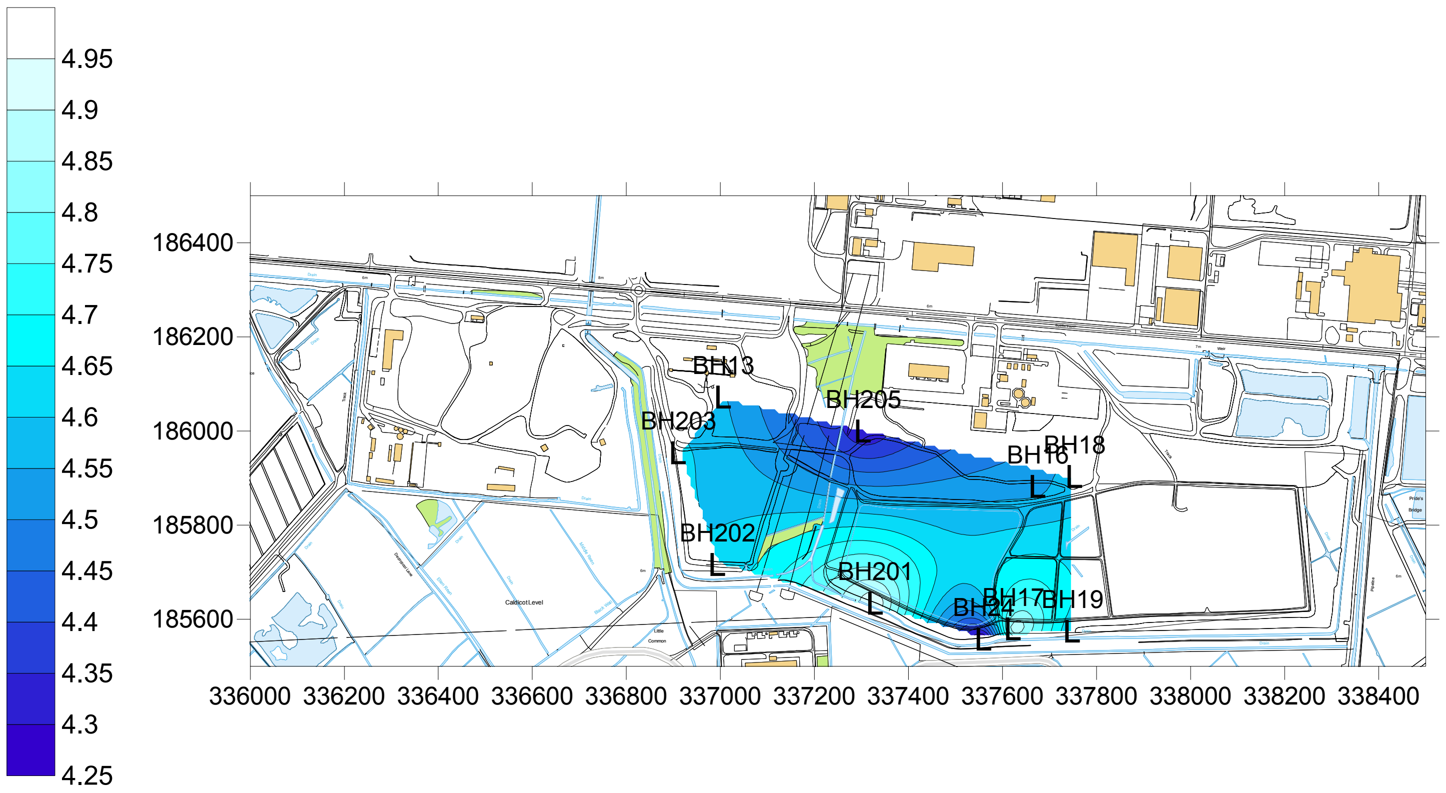
Figure 6 Groundwater Contours



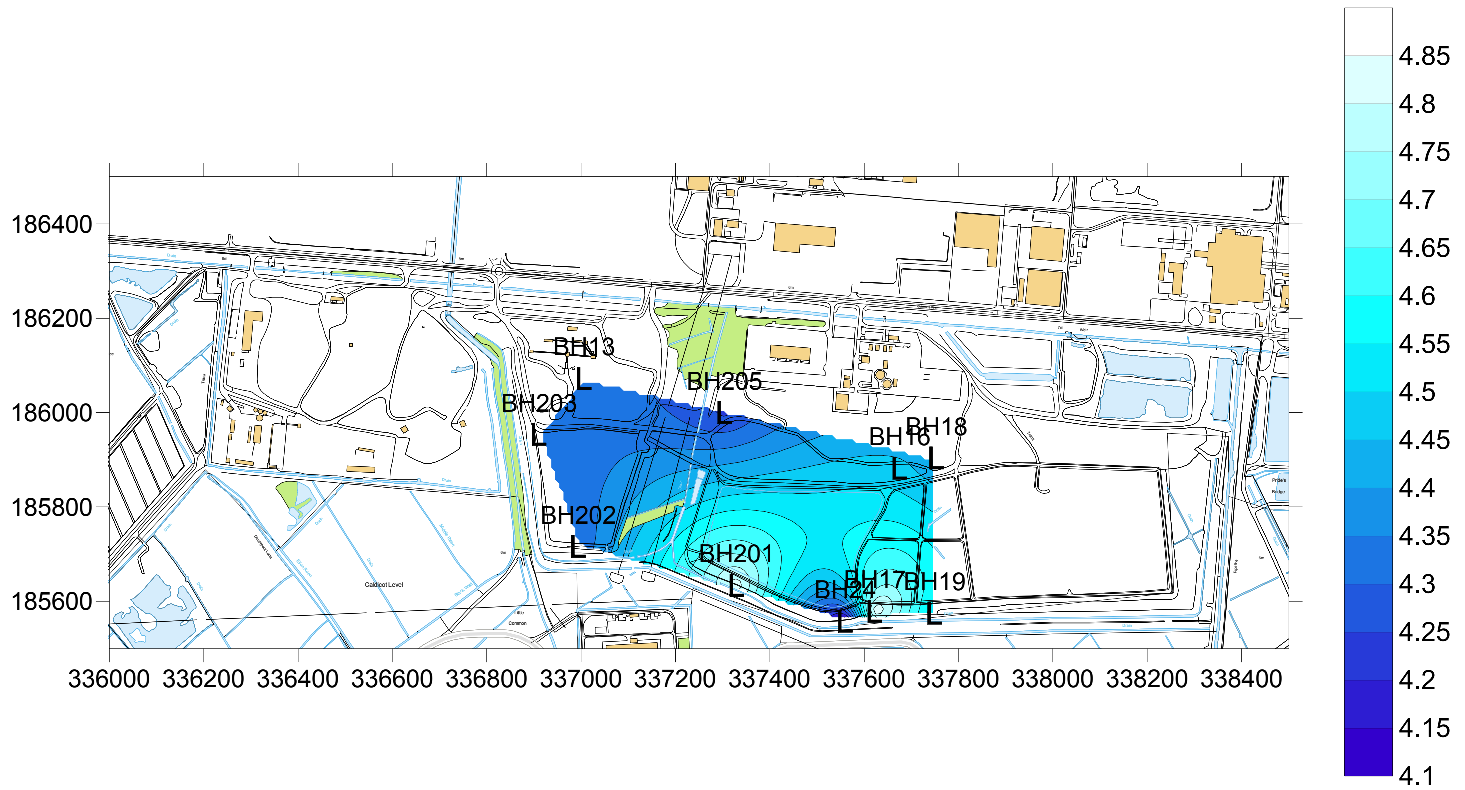
March 2015 Shallow



July 2014 Shallow



March 2015 Deep



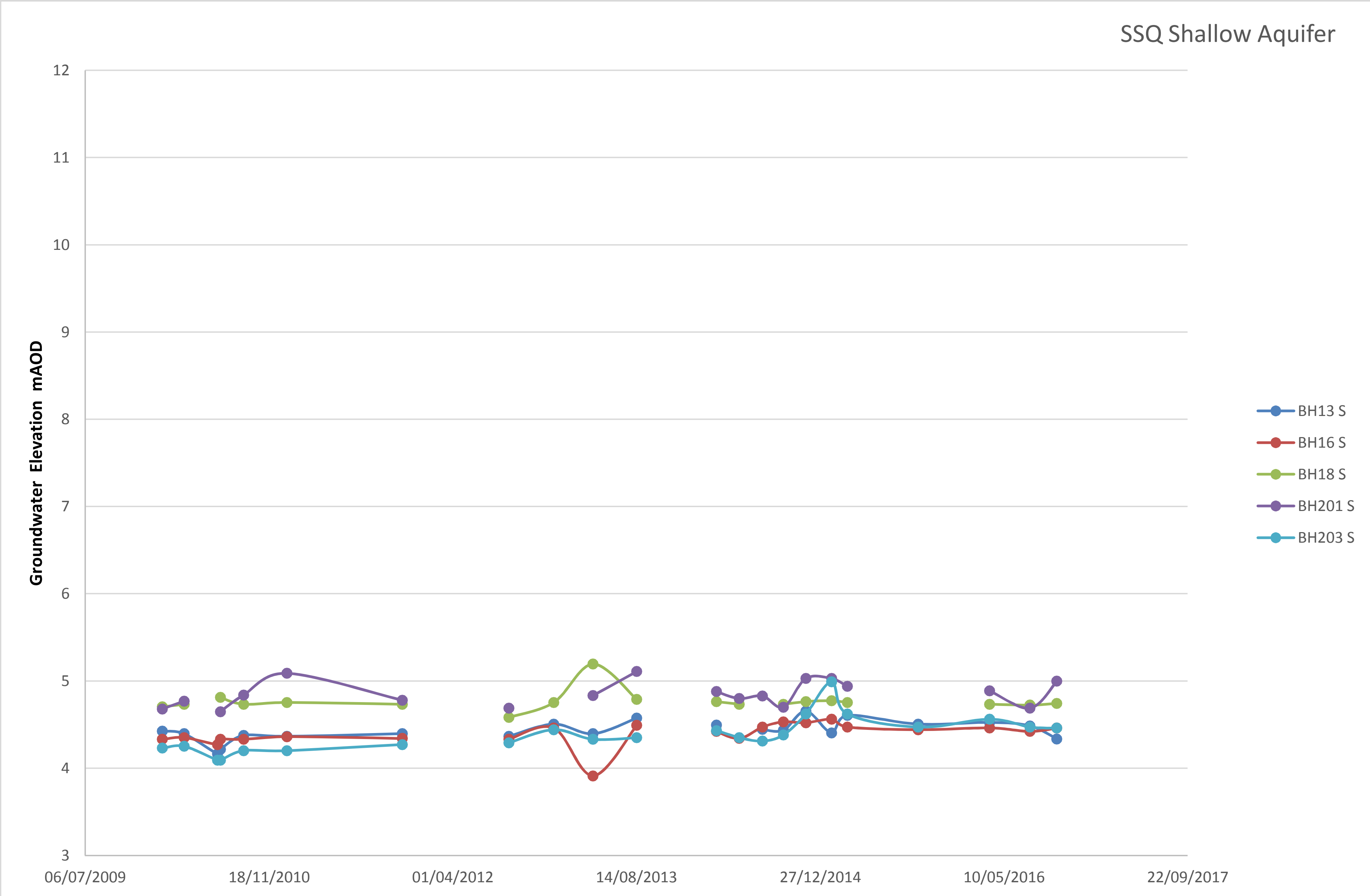
July 2014 Deep

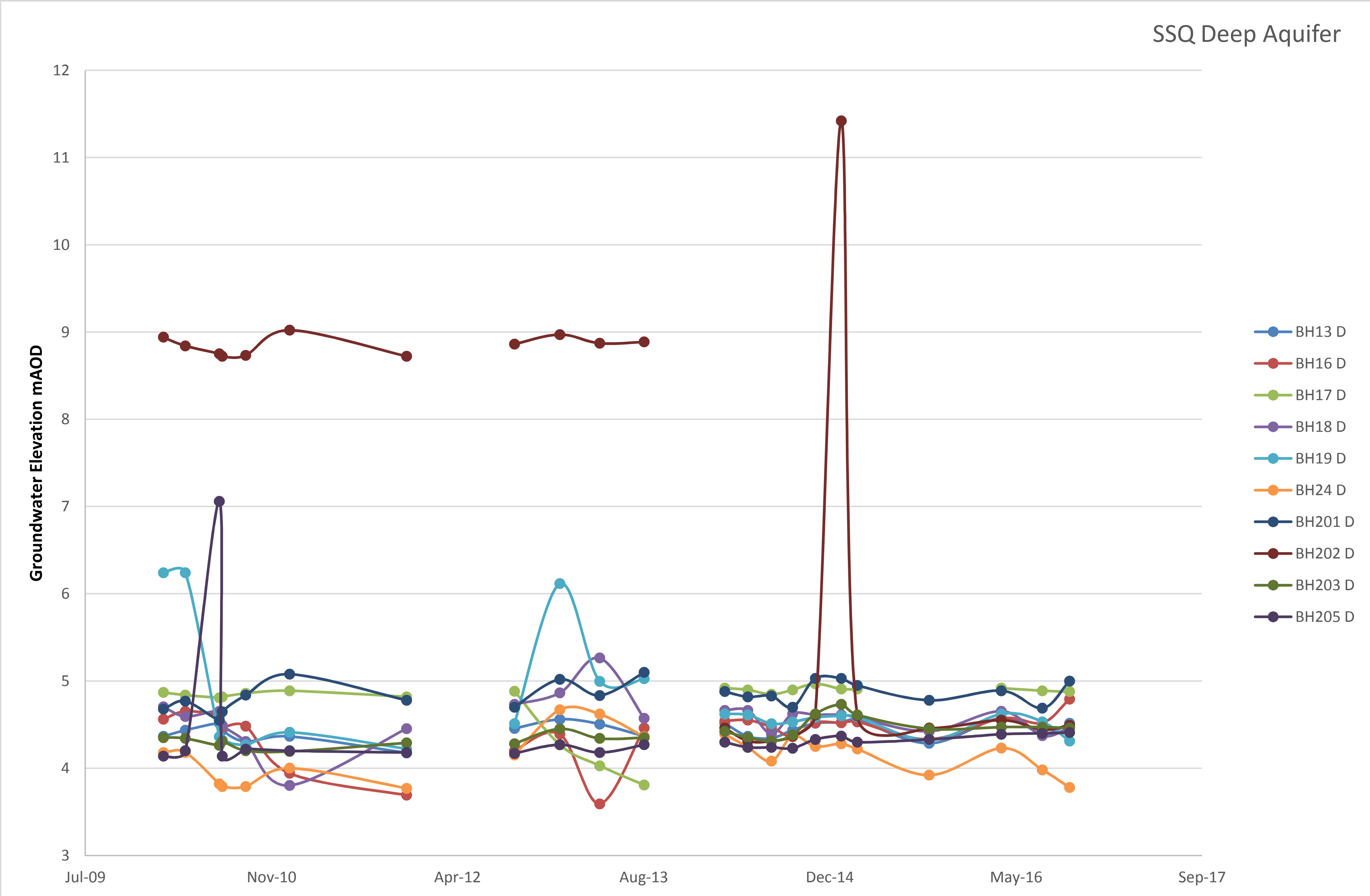
SOUTH SIDE QUEENSWAY WASTE MANAGEMENT SITE, LLANWERN STEELWORKS

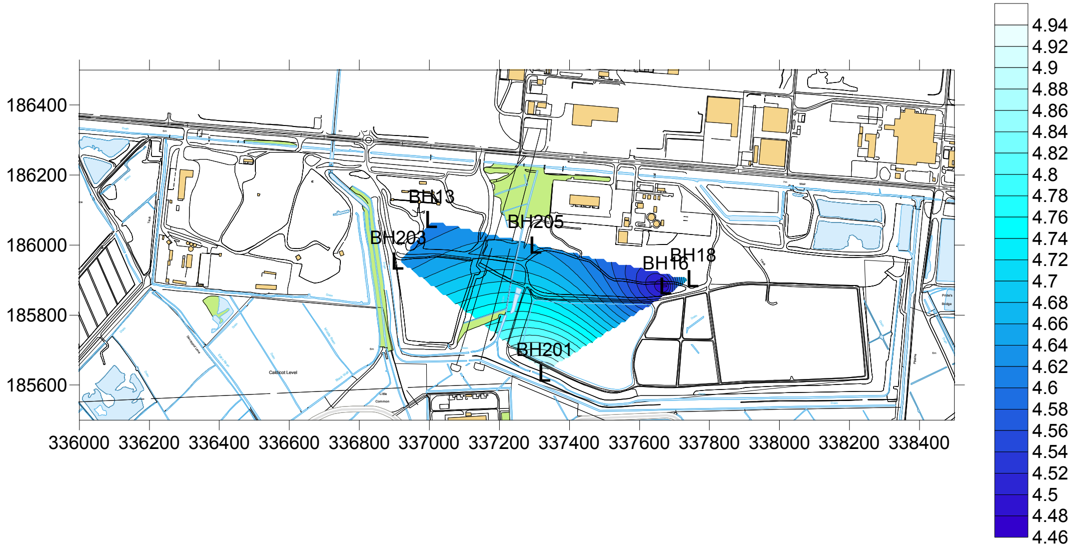
2016 Annual Review of Environmental Monitoring

Appendix 1
Groundwater Level and Chemistry Analysis

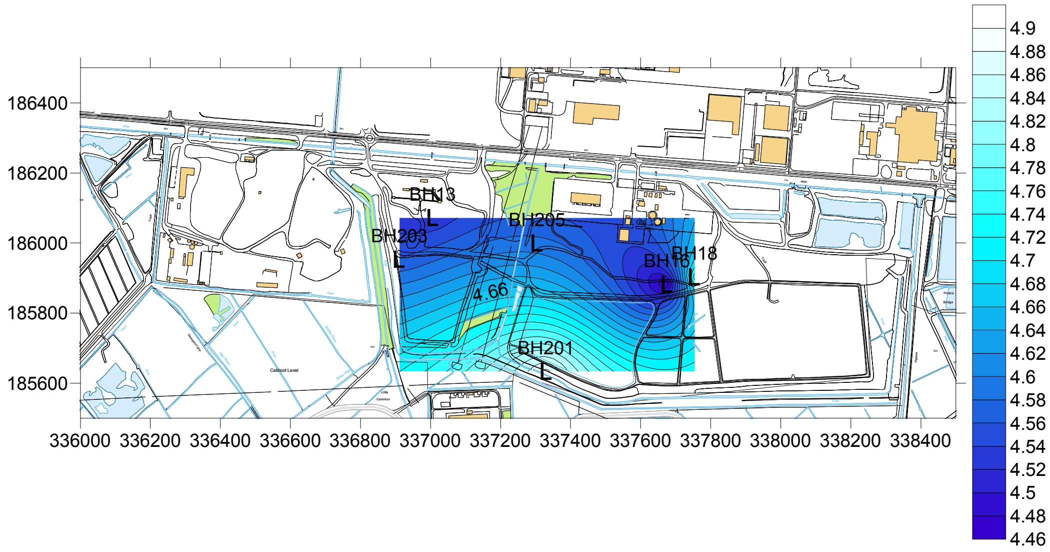
Report Number 1555r2v1d0117


SSQ Shallow Aquifer
12
11
10
9
8
7
6
5
4
3
Groundwater Elevation mAOD
06/07/2009
18/11/2010
01/04/2012
14/08/2013
27/12/2014
10/05/2016
22/09/2017
BH13 S
BH16 S
BH18 S
BH201 S
BH203 S

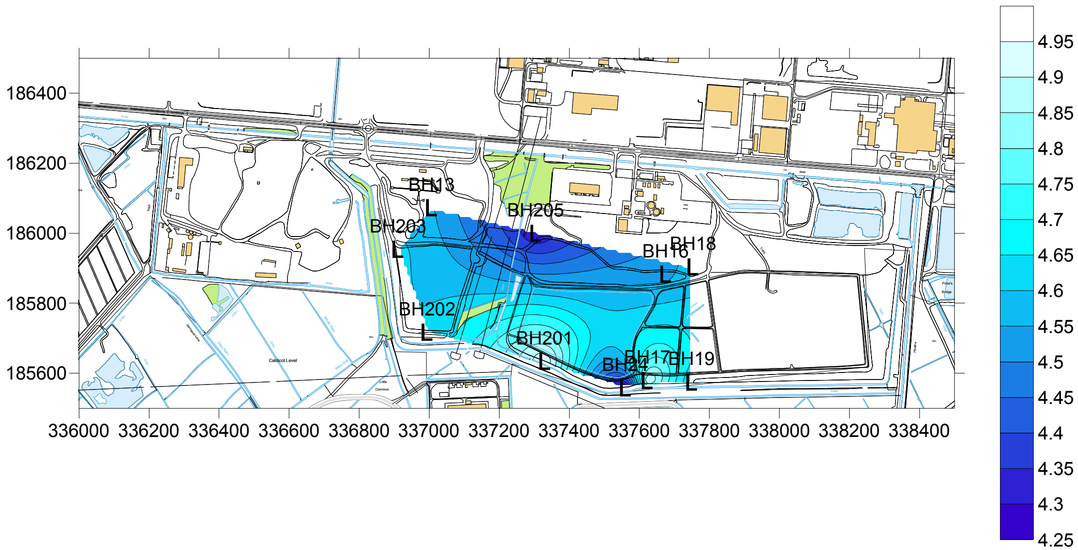

SSQ Deep Aquifer
Groundwater Elevation mAOD
12
11
10
9
8
7
6
5
4
3
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
BH13 D
BH16 D
BH17 D
BH18 D
BH19 D
BH24 D
BH201 D
BH202 D
BH203 D
BH205 D



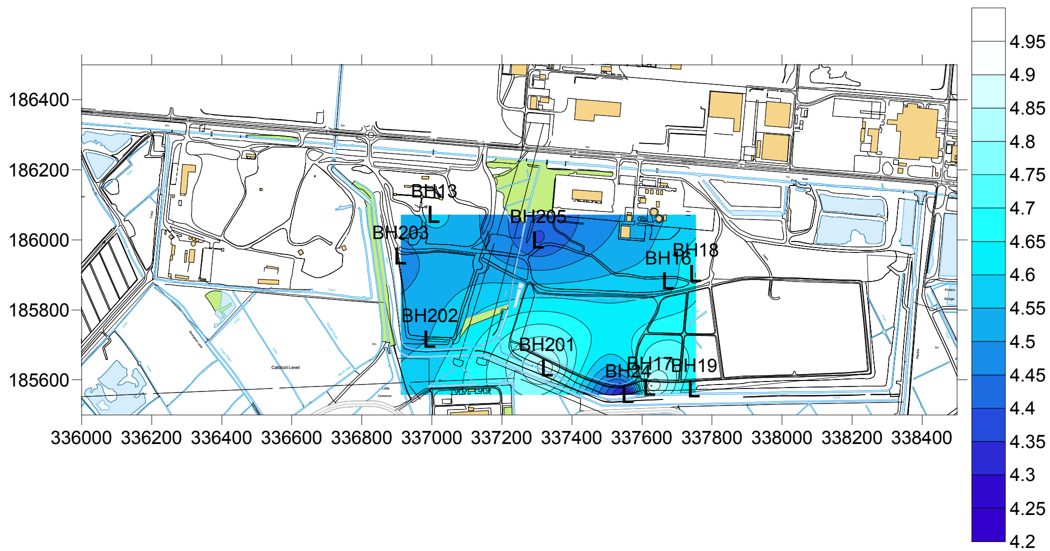
March 2015 Shallow



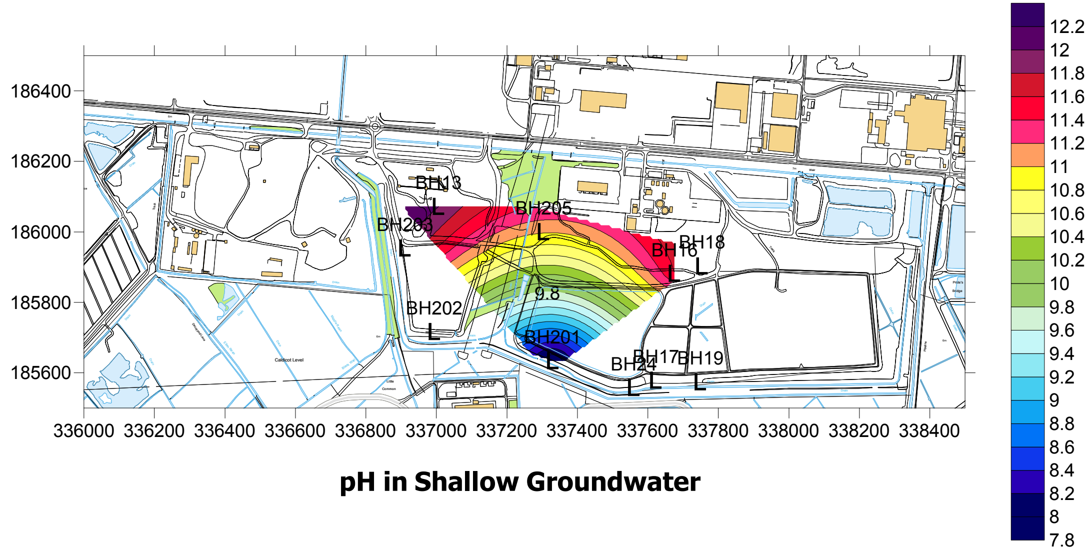
April 2015 Shallow



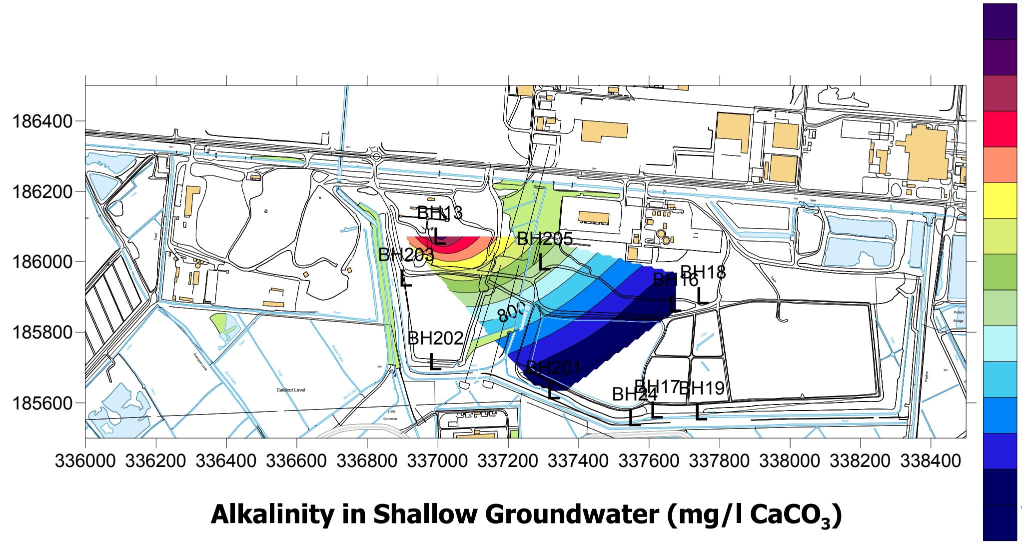
March 2015 Deep



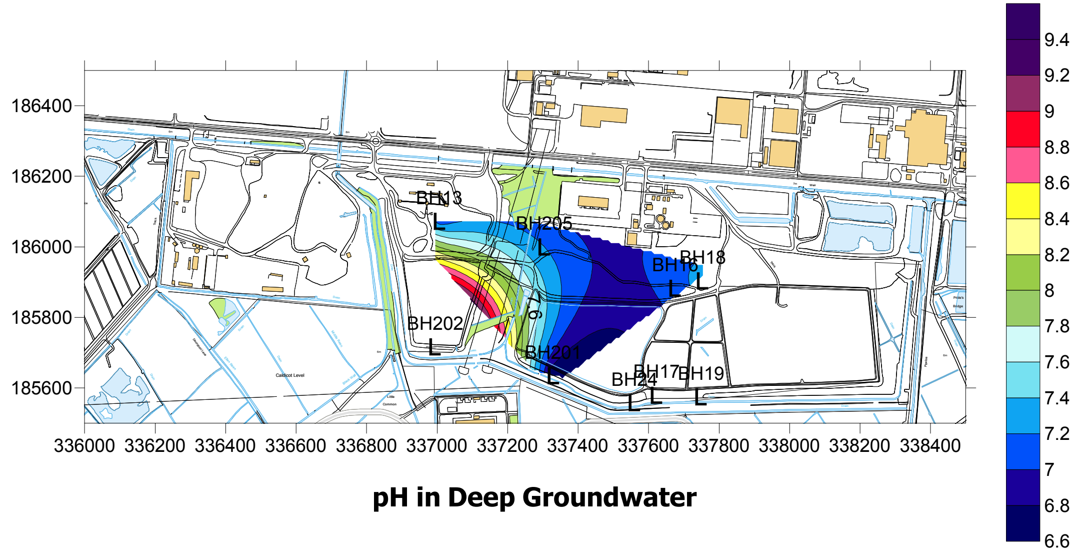
April 2016 Deep



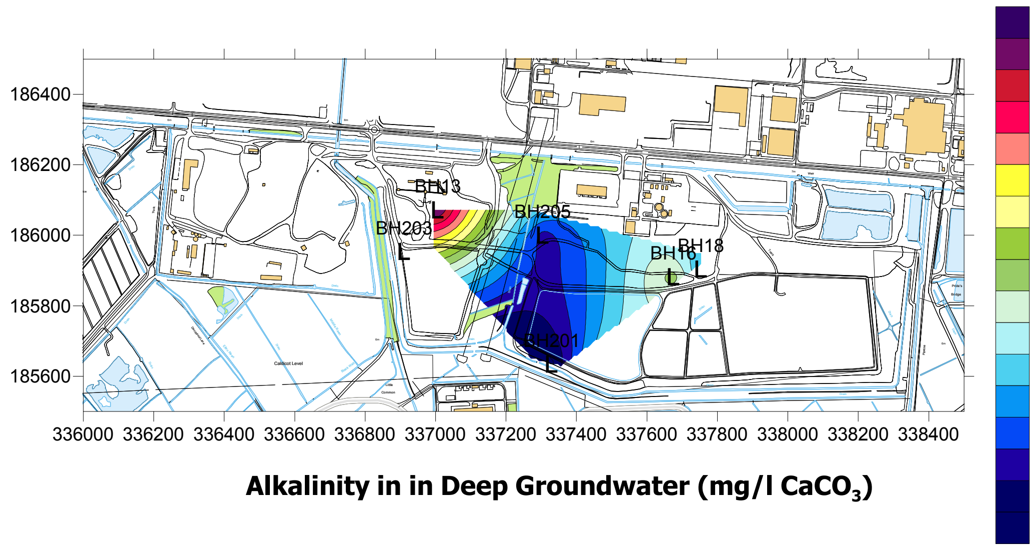
pH in Shallow Groundwater



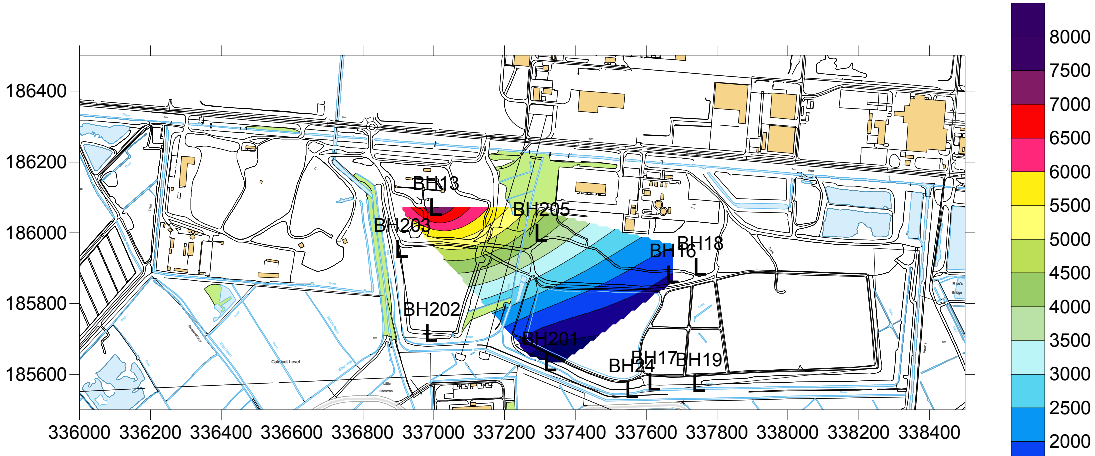
Alkalinity in Shallow Groundwater (mg/l $CaCO_3$)



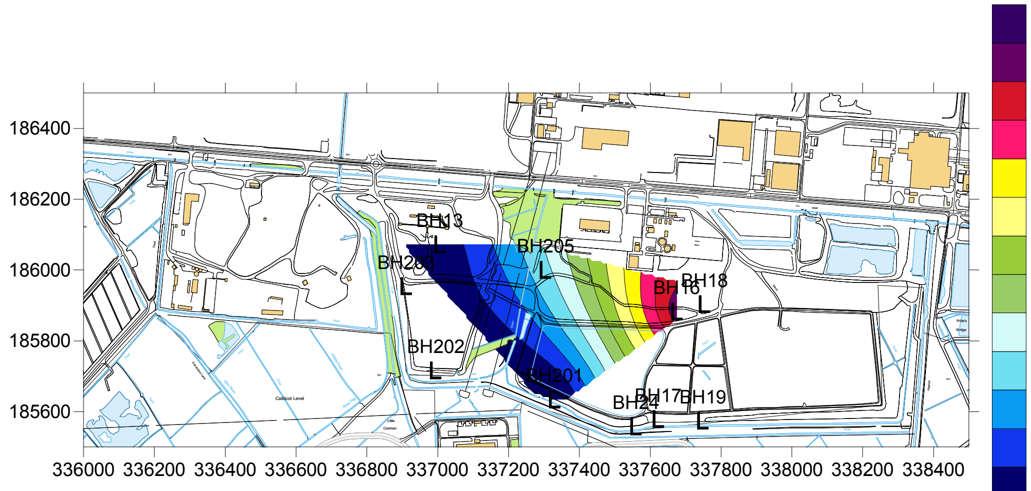
pH in Deep Groundwater



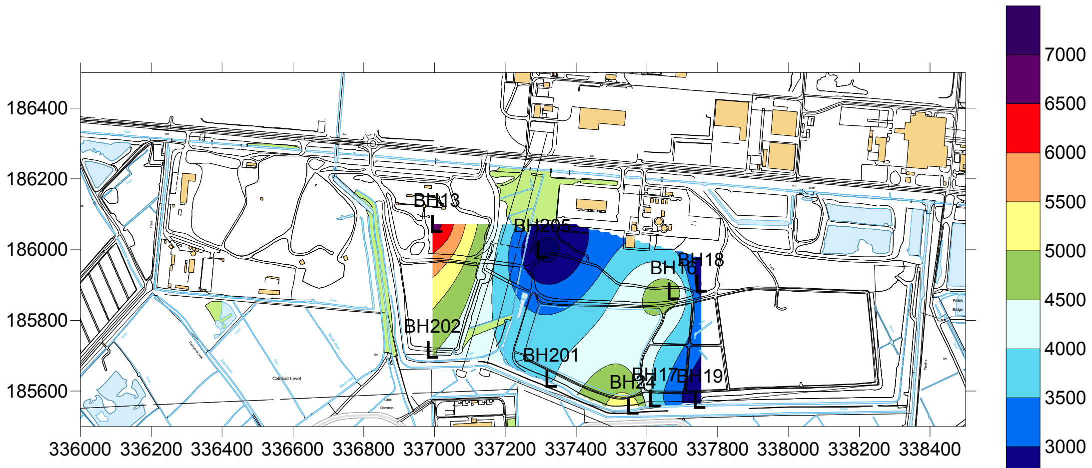
Alkalinity in in Deep Groundwater (mg/l $CaCO_3$)



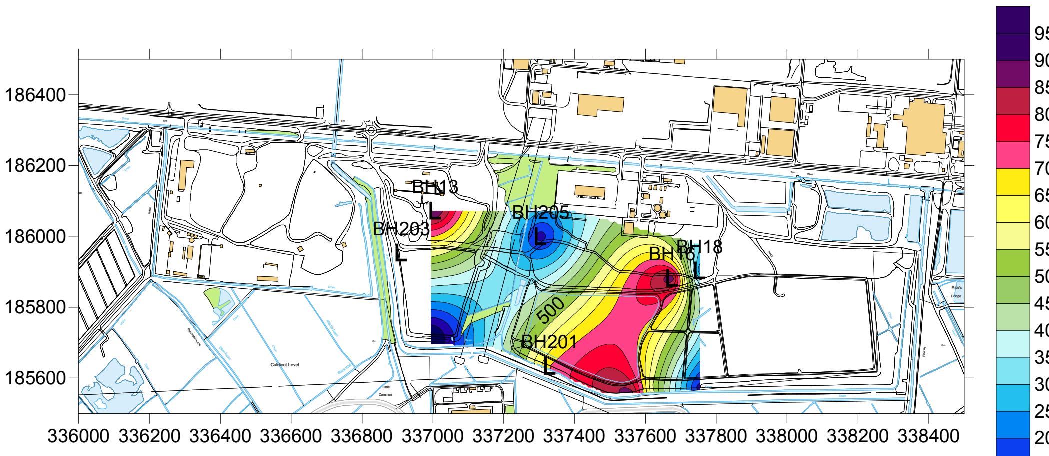
EC in Shallow Groundwater (microS/cm)



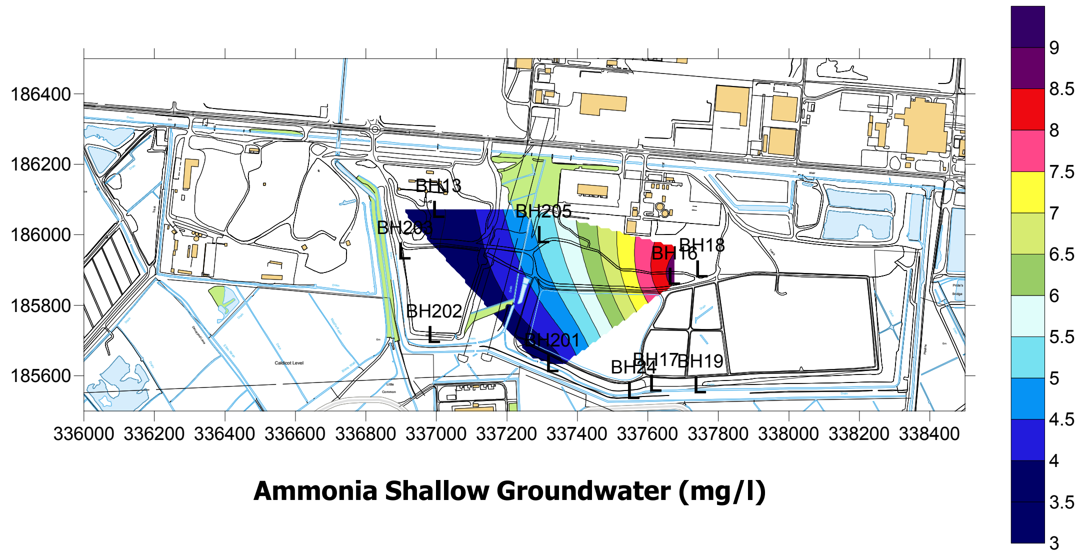
Chloride in Shallow Groundwater (mg/l)



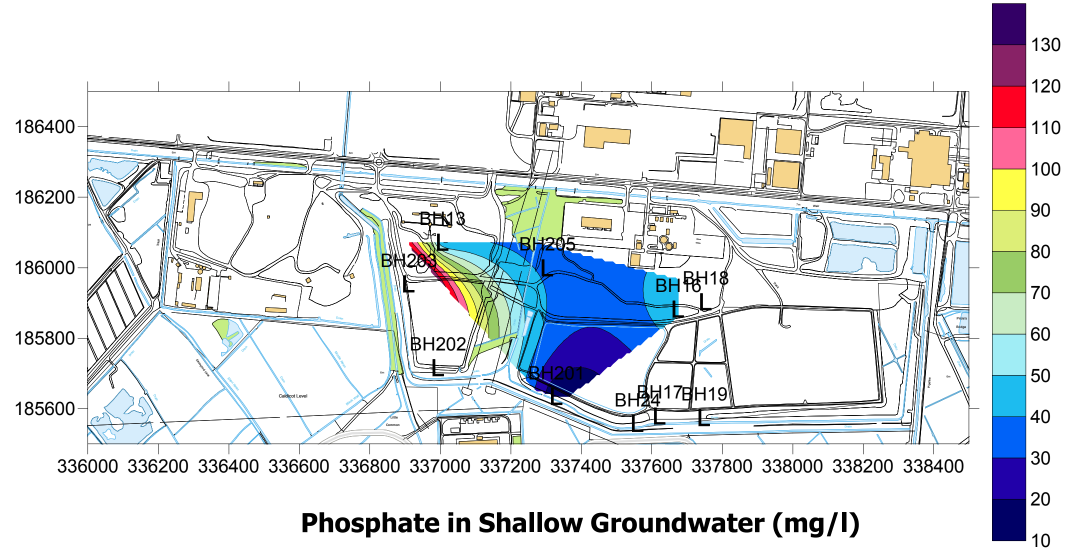
EC in Deep Groundwater (microS/cm)



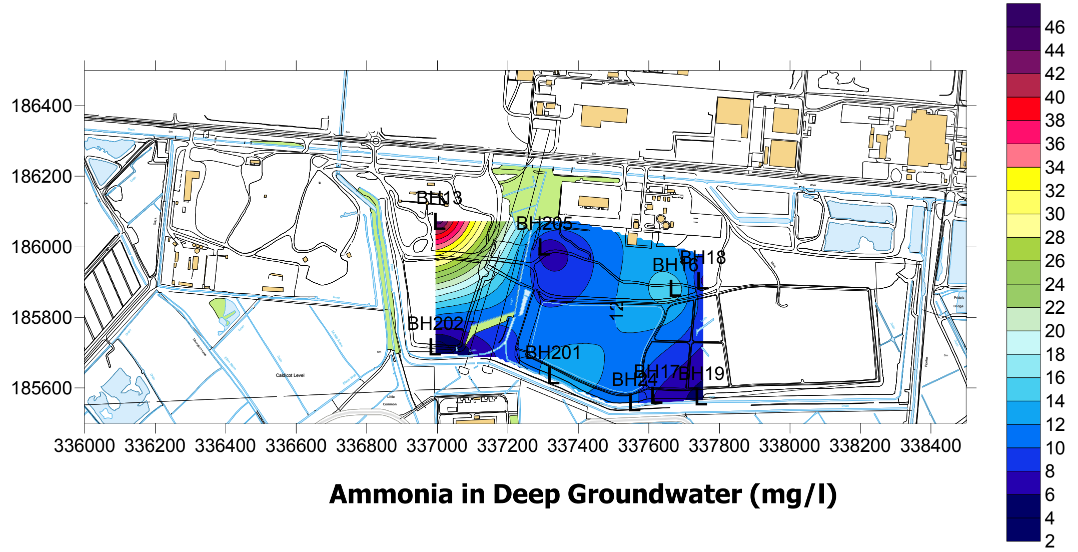
Chloride in Deep Groundwater (mg/l)



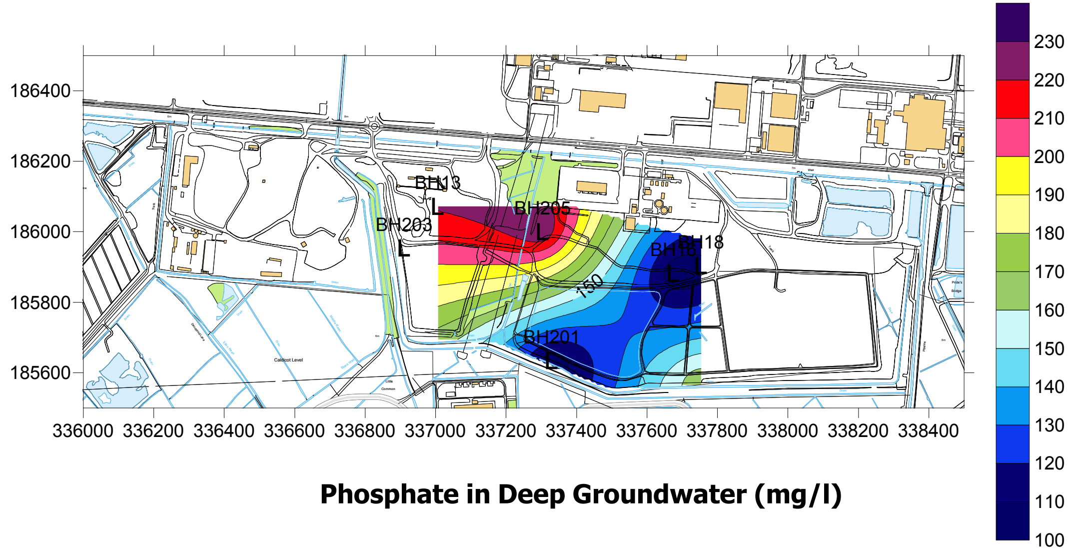
Ammonia Shallow Groundwater (mg/l)



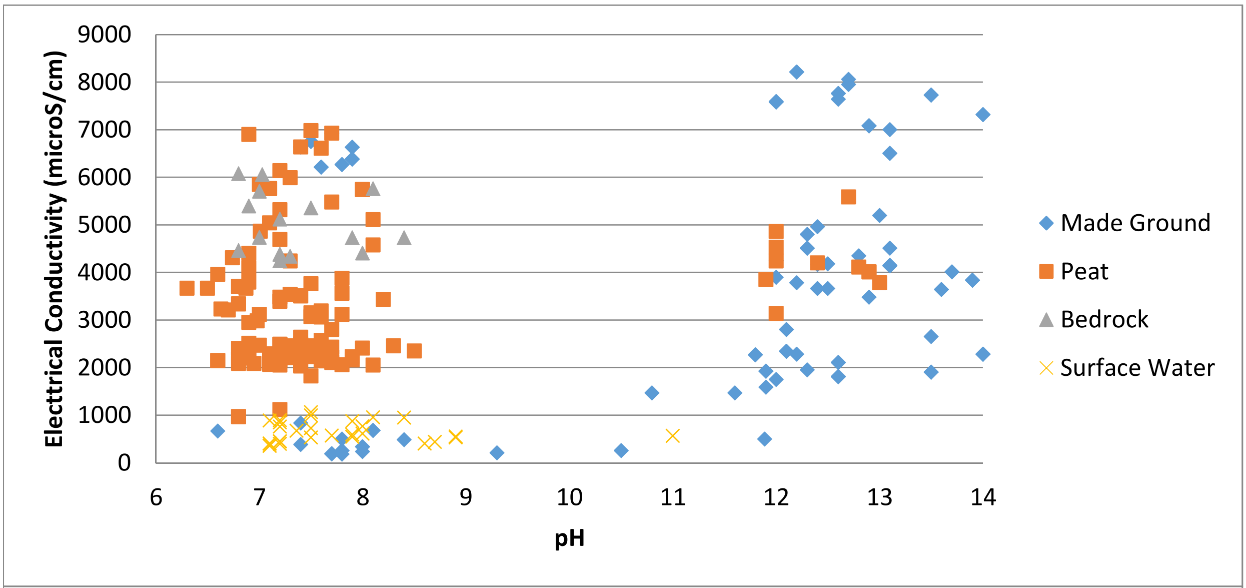
Phosphate in Shallow Groundwater (mg/l)

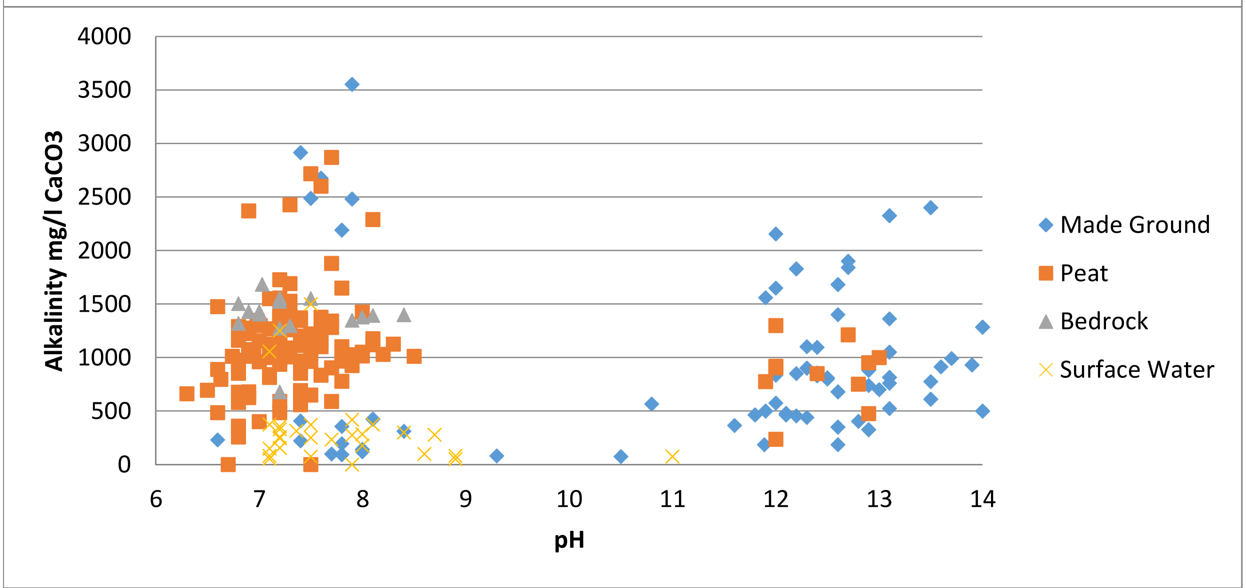


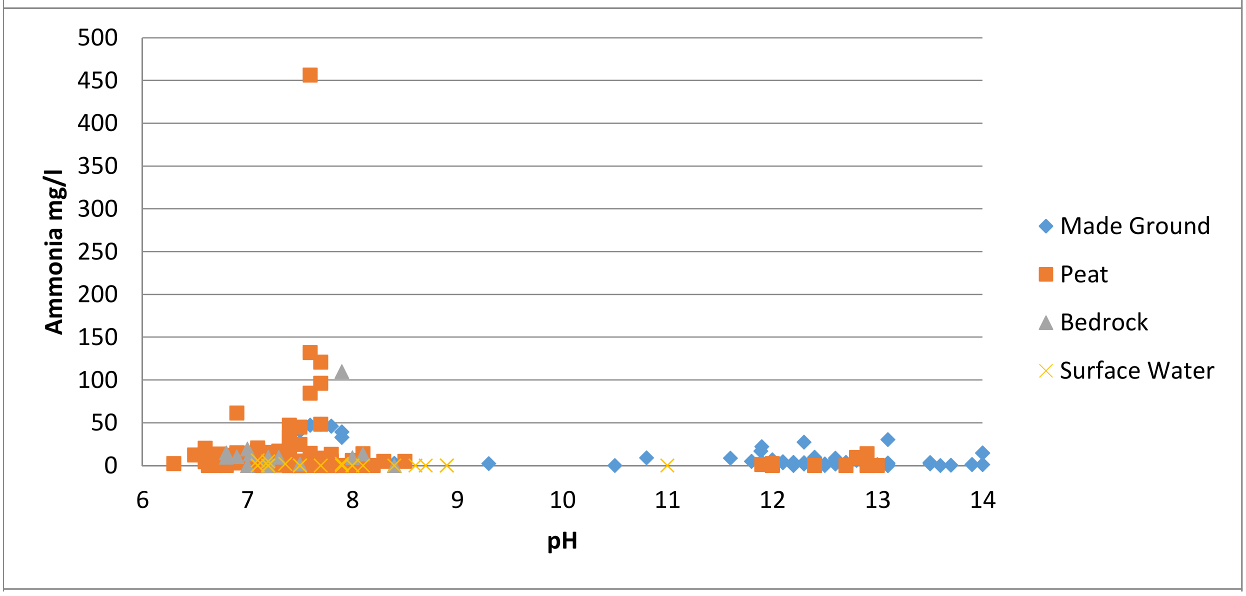
Ammonia in Deep Groundwater (mg/l)

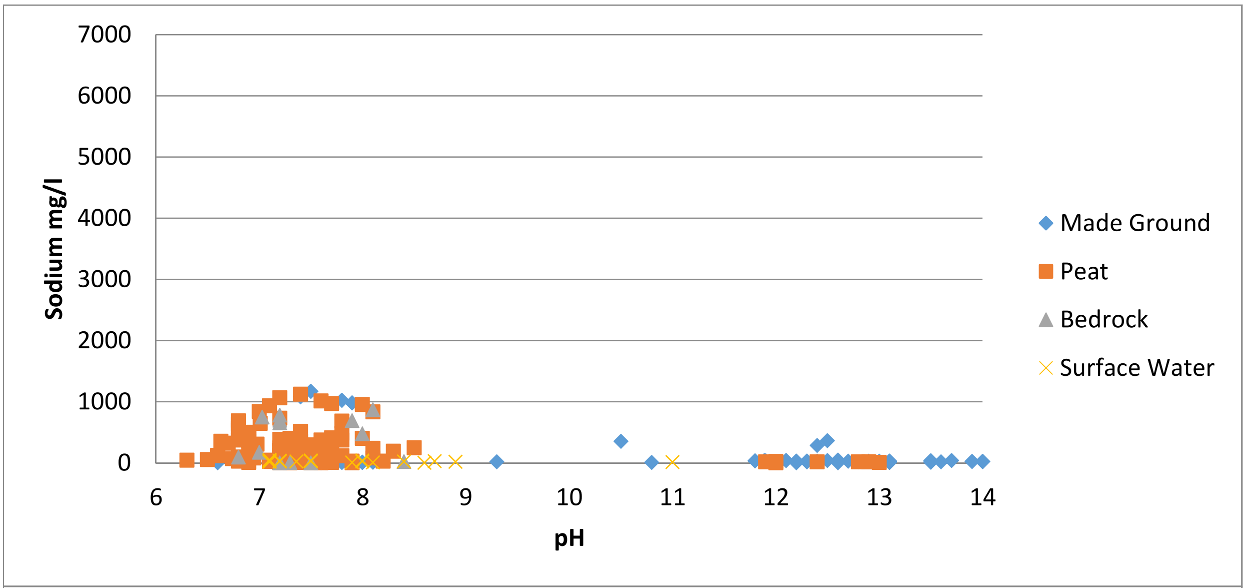


Phosphate in Deep Groundwater (mg/l)

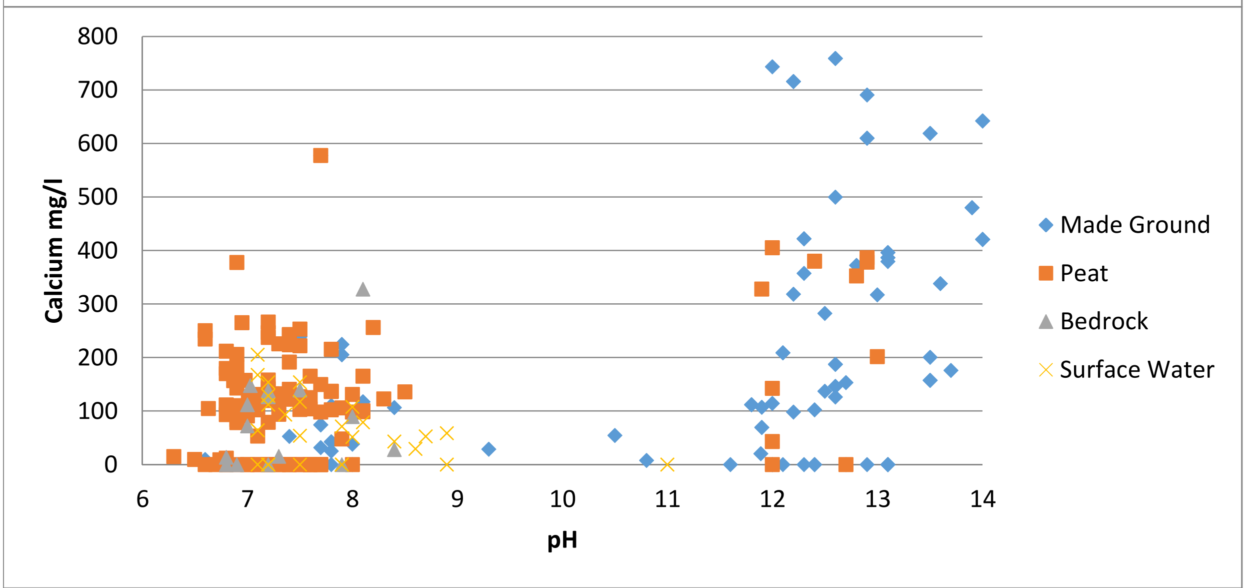

Electtrical Conductivity (microS/cm)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
6
7
8
9
10
11
12
13
14
pH
Made Ground
Peat
Bedrock
Surface Water


Alkalinity mg/l CaCO3
4000
3500
3000
2500
2000
1500
1000
500
0
6
7
8
9
10
11
12
13
14
pH
Made Ground
Peat
Bedrock
Surface Water

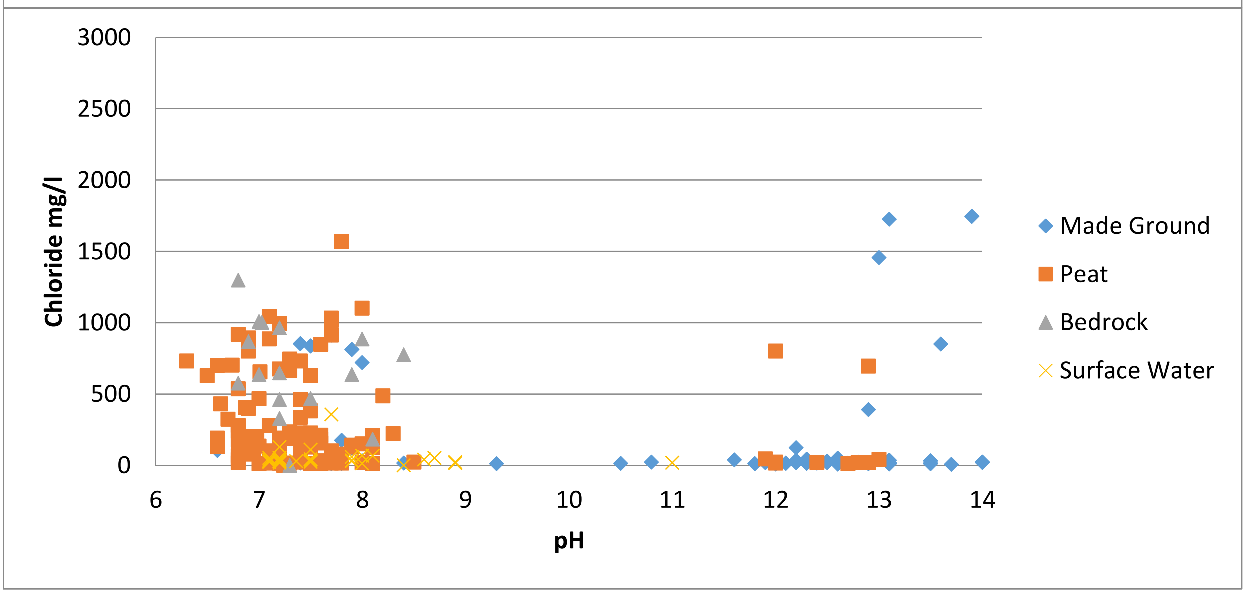

Ammonia mg/l
500
450
400
350
300
250
200
150
100
50
0
6
7
8
9
10
11
12
13
14
pH
Made Ground
Peat
Bedrock
Surface Water



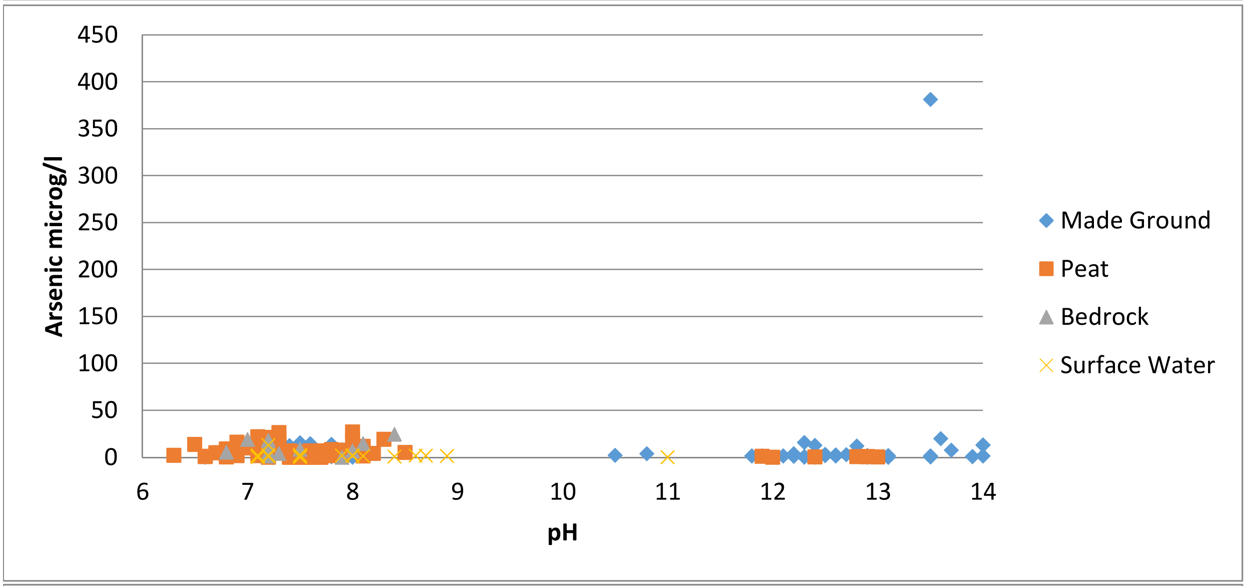
Sodium mg/l
7000
6000
5000
4000
3000
2000
1000
0
6
7
8
9
10
11
12
13
14
pH
Made Ground
Peat
Bedrock
Surface Water



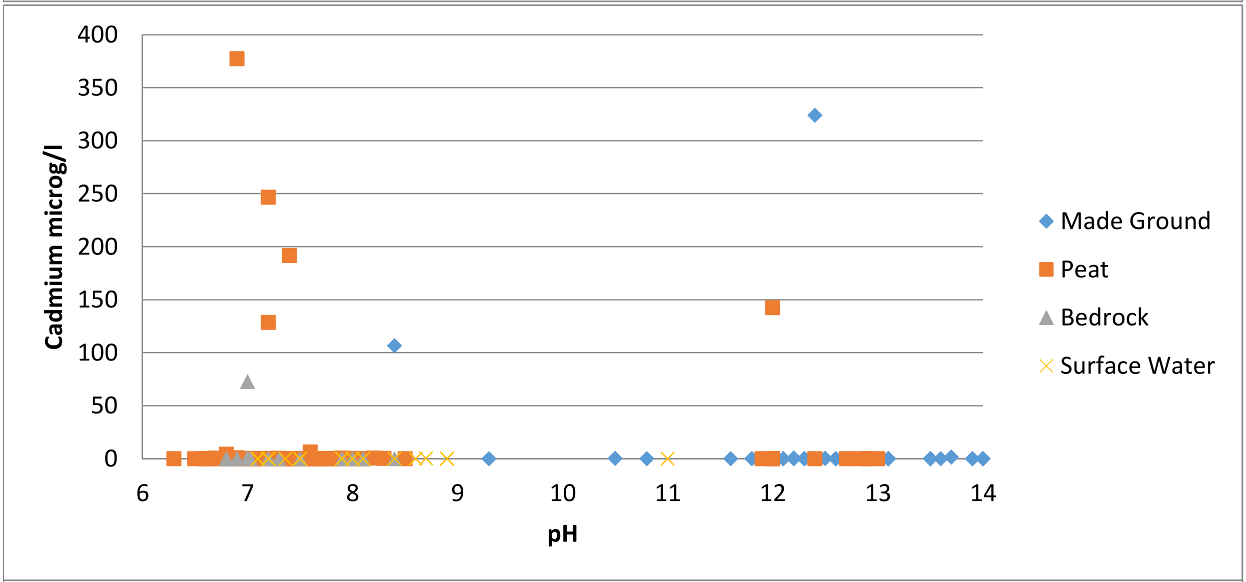
Calcium mg/l
800
700
600
500
400
300
200
100
0
6
7
8
9
10
11
12
13
14
pH
Made Ground
Peat
Bedrock
Surface Water



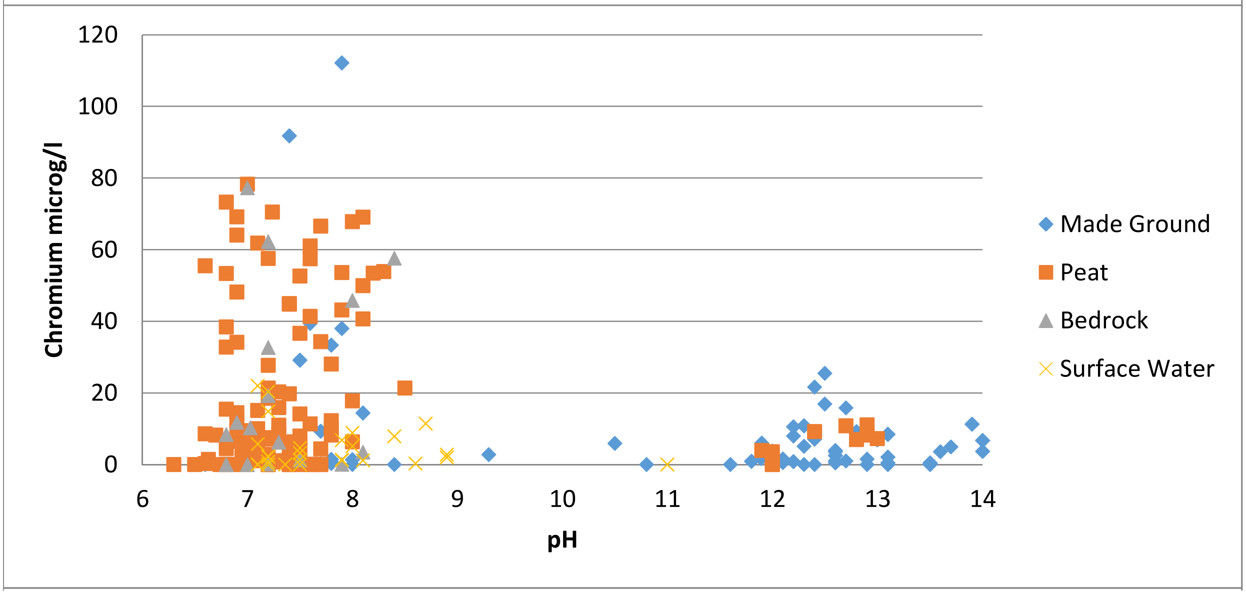
Chloride mg/l
3000
2500
2000
1500
1000
500
0
6
7
8
9
10
11
12
13
14
pH
Made Ground
Peat
Bedrock
Surface Water



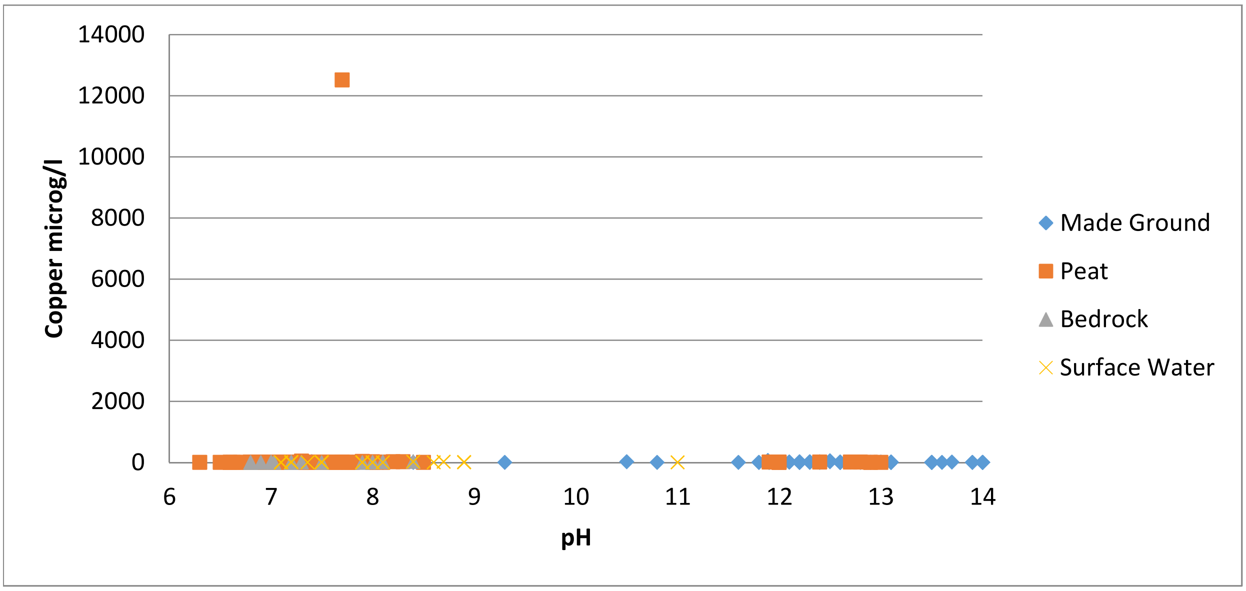
Arsenic microg/l
450
400
350
300
250
200
150
100
50
0
6
7
8
9
10
11
12
13
14
pH
Made Ground
Peat
Bedrock
Surface Water



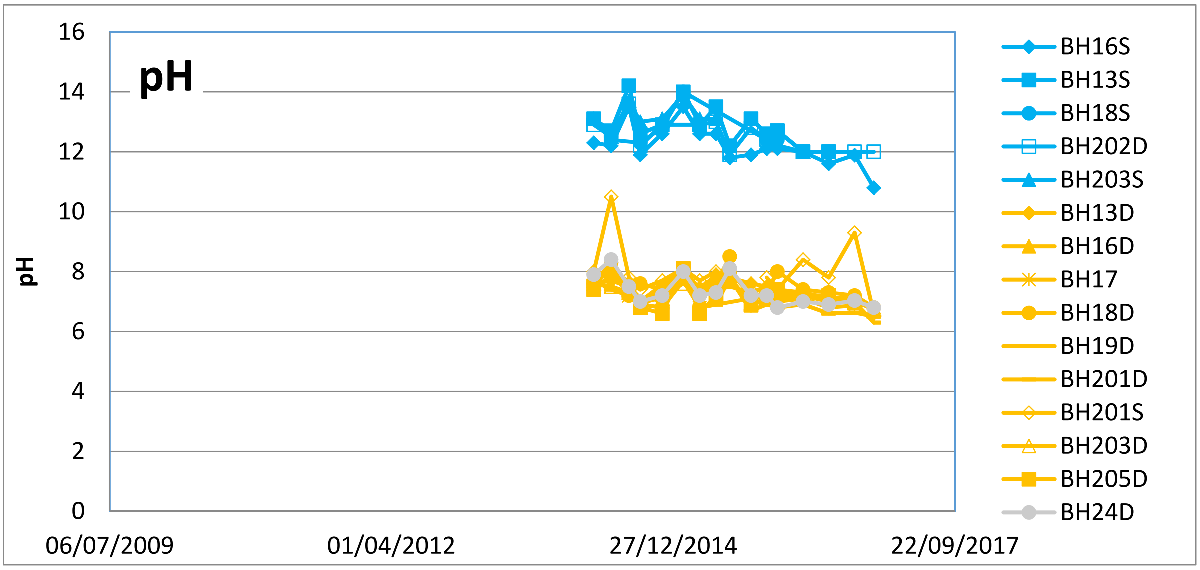
Cadmium microg/l
400
350
300
250
200
150
100
50
0
6
7
8
9
10
11
12
13
14
pH
Made Ground
Peat
Bedrock
Surface Water

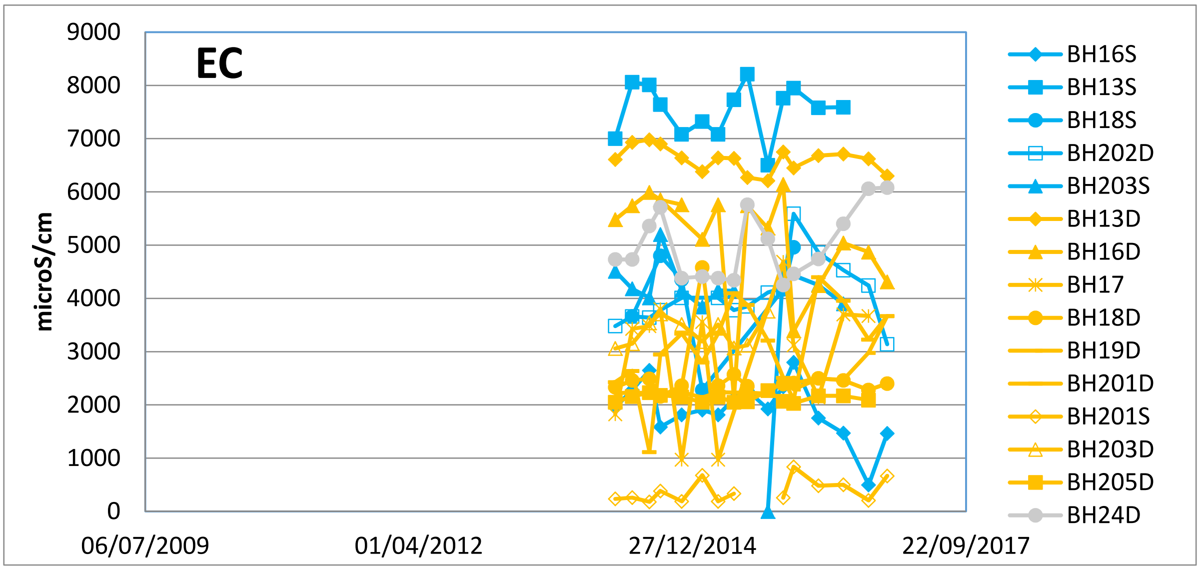


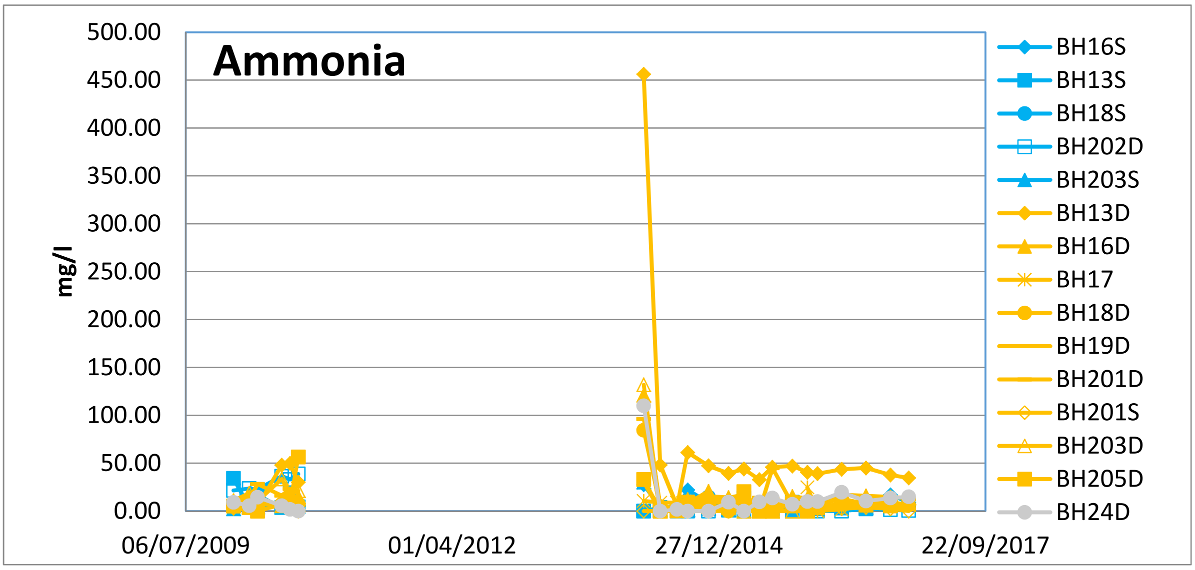
Chromium microg/l
120
100
80
60
40
20
0
6
7
8
9
10
11
12
13
14
pH
Made Ground
Peat
Bedrock
Surface Water

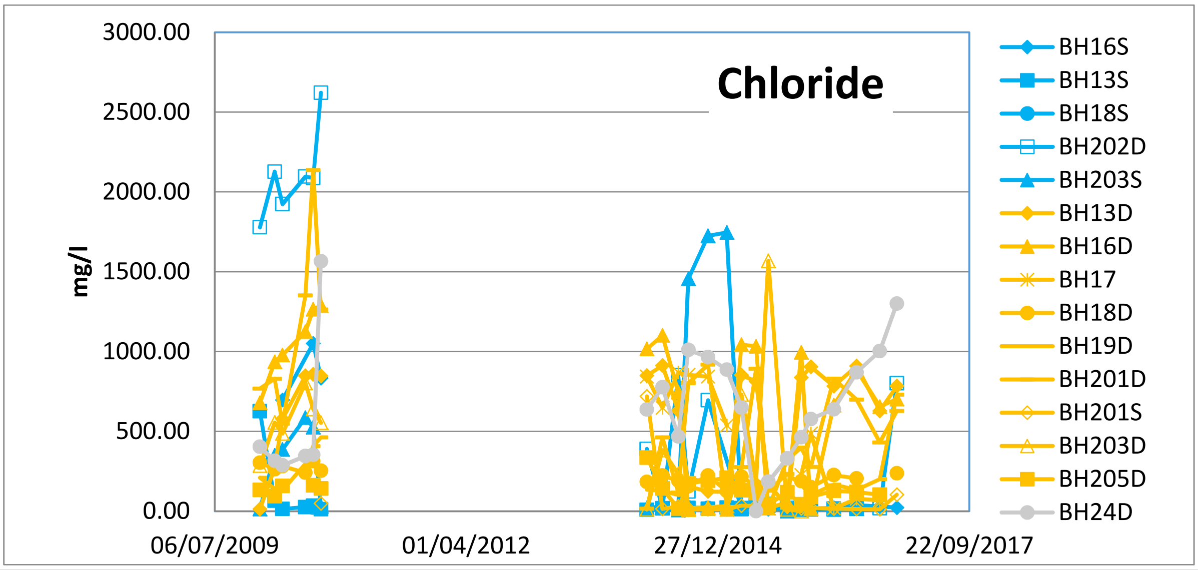


14000
12000
10000
8000
6000
4000
2000
0
Copper microg/l
6
7
8
9
10
11
12
13
14
pH
Made Ground
Peat
Bedrock
Surface Water


pH
16
14
12
10
8
6
4
2
0
pH
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH16S
BH13S
BH18S
BH202D
BH203S
BH13D
BH16D
BH17
BH18D
BH19D
BH201D
BH201S
BH203D
BH205D
BH24D


EC
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
microS/cm
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH16S
BH13S
BH18S
BH202D
BH203S
BH13D
BH16D
BH17
BH18D
BH19D
BH201D
BH201S
BH203D
BH205D
BH24D


Ammonia
mg/l
500.00
450.00
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
BH16S
BH13S
BH18S
BH202D
BH203S
BH13D
BH16D
BH17
BH18D
BH19D
BH201D
BH201S
BH203D
BH205D
BH24D


Chloride
mg/l
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH16S
BH13S
BH18S
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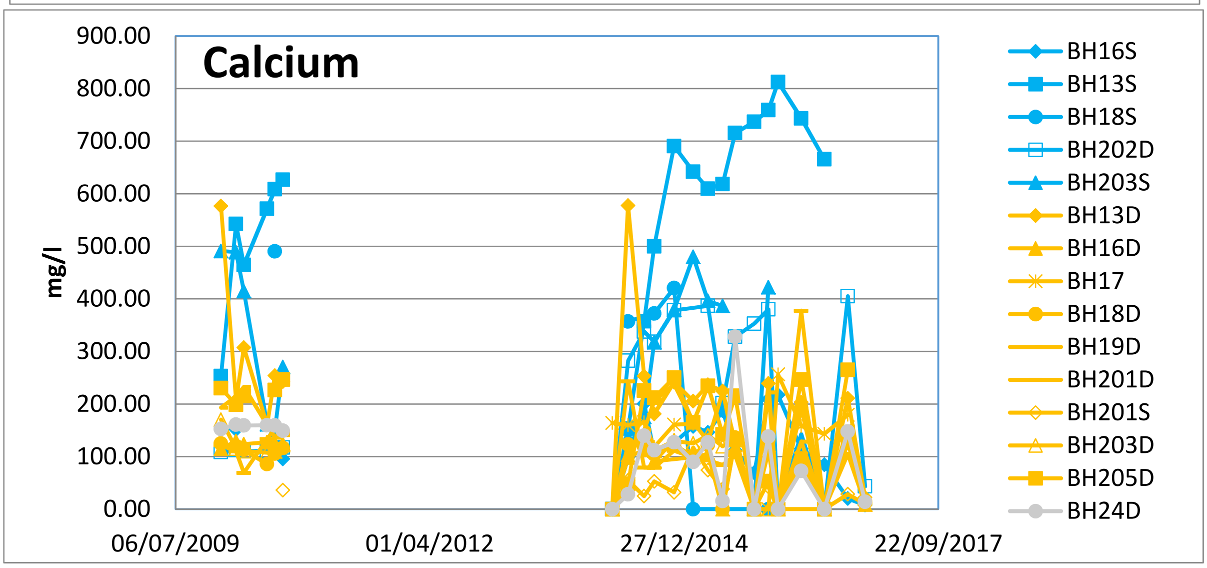
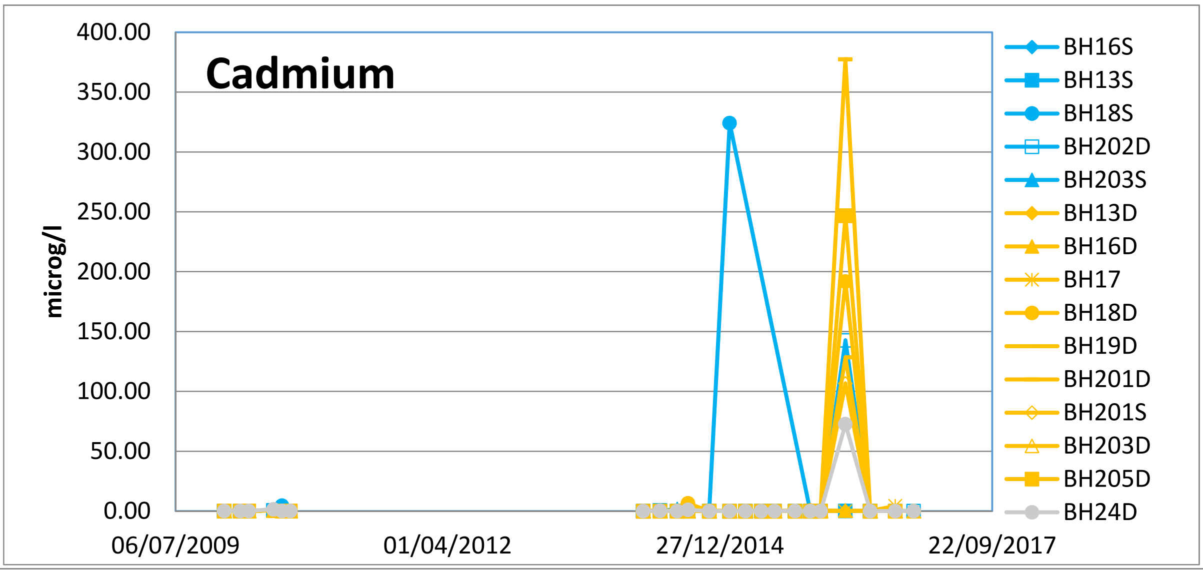
BH203D
BH205D
BH24D


Calcium
mg/l
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH16S
BH13S
BH18S
BH202D
BH203S
BH13D
BH16D
BH17
BH18D
BH19D
BH201D
BH201S
BH203D
BH205D
BH24D


Cadmium
microg/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
BH16S
BH13S
BH18S
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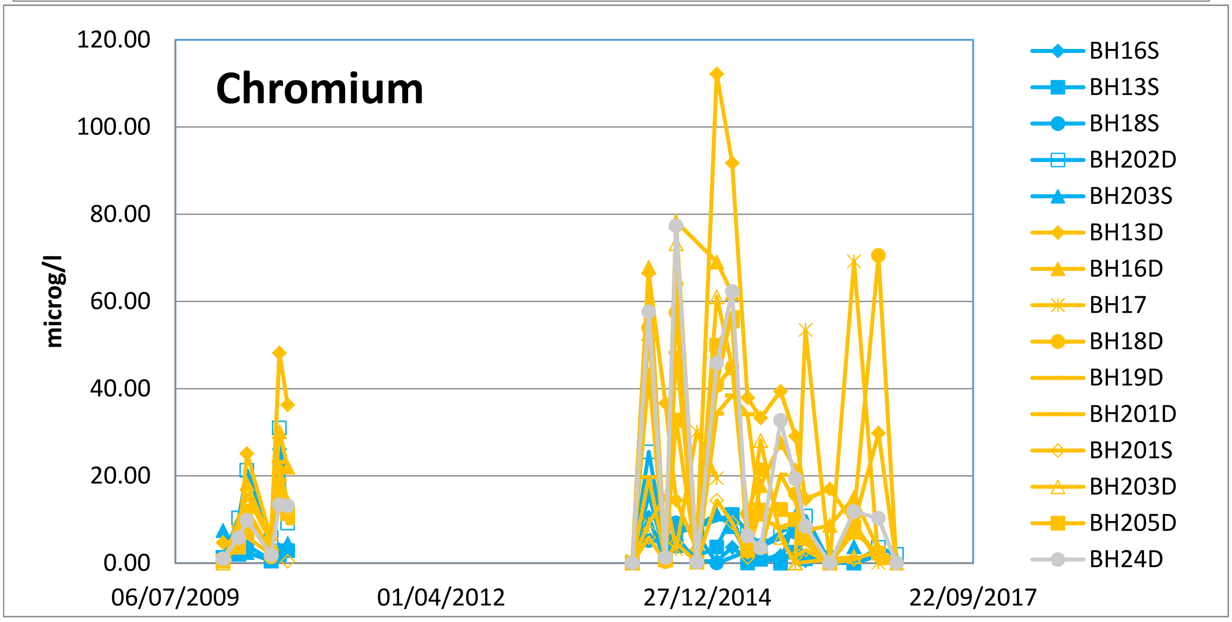
BH203D
BH205D
BH24D


Chromium
microg/l
120.00
100.00
80.00
60.00
40.00
20.00
0.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH16S
BH13S
BH18S
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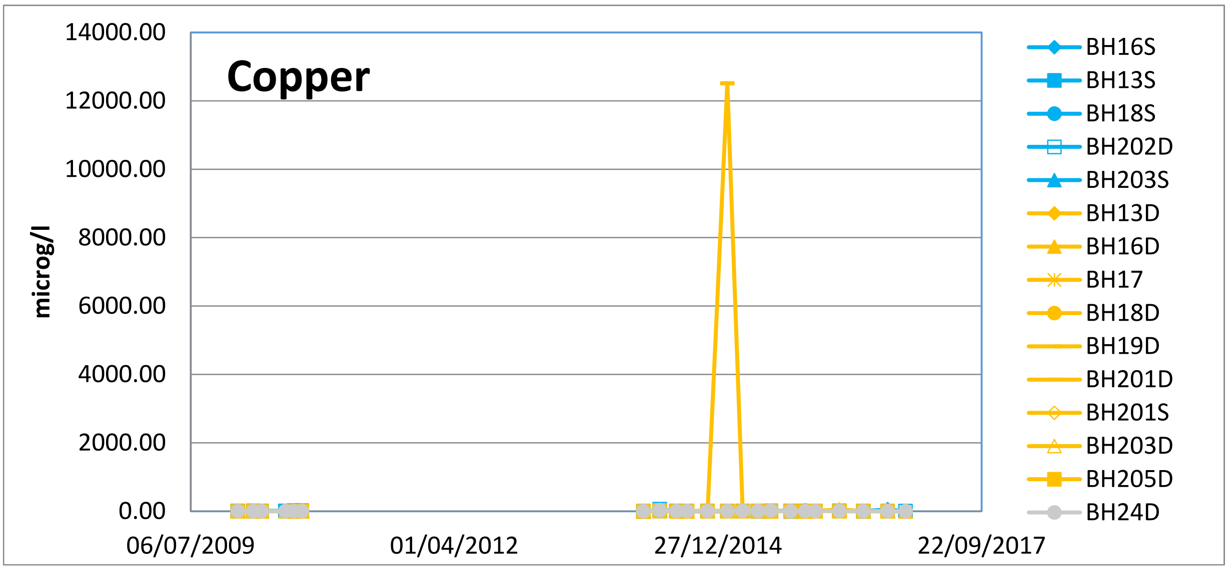
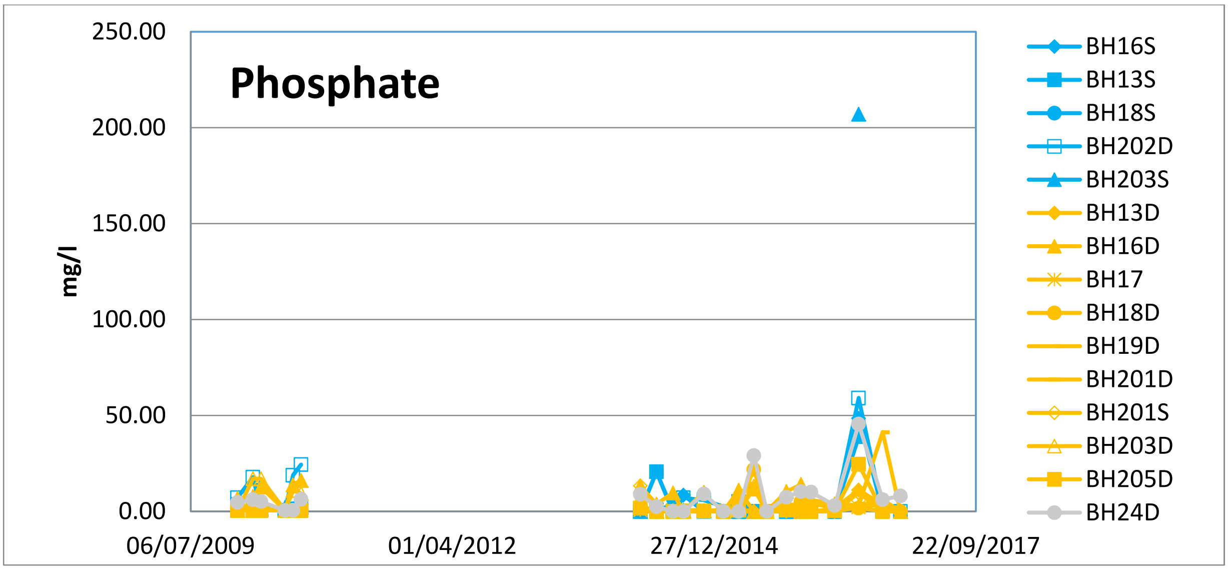
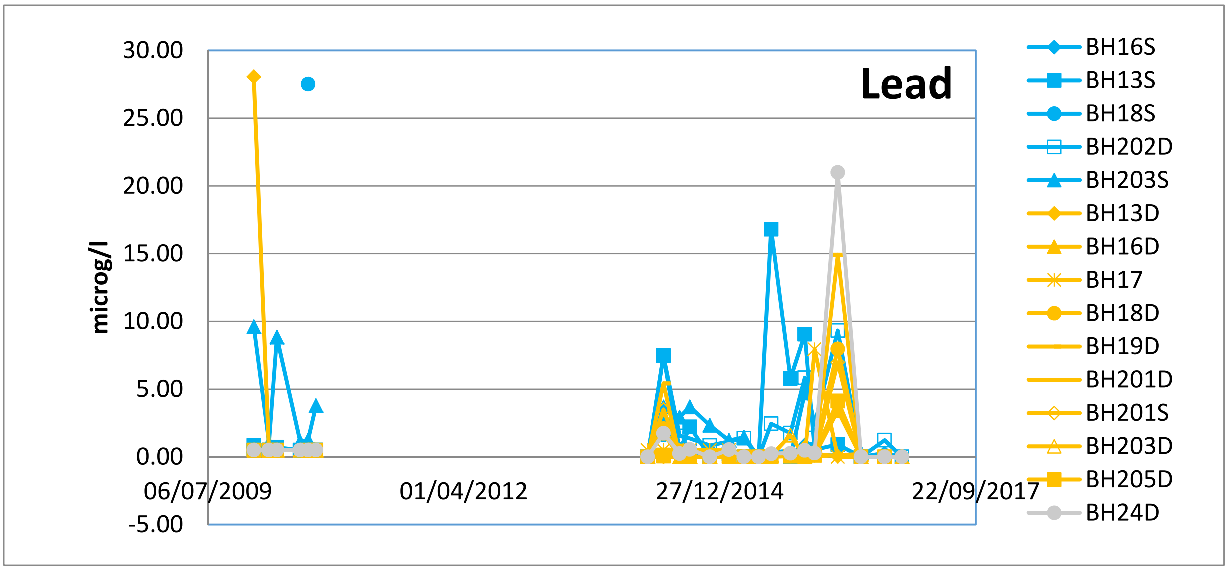
BH203D
BH205D
BH24D


Copper
microg/l
14000.00
12000.00
10000.00
8000.00
6000.00
4000.00
2000.00
0.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH16S
BH13S
BH18S
BH202D
BH203S
BH13D
BH16D
BH17
BH18D
BH19D
BH201D
BH201S
BH203D
BH205D
BH24D


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
BH16S
BH13S
BH18S
BH202D
BH203S
BH13D
BH16D
BH17
BH18D
BH19D
BH201D
BH201S
BH203D
BH205D
BH24D


Lead
microg/l
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
06/07/2009
01/04/2012
27/12/2014
22/09/2017
BH16S
BH13S
BH18S
BH202D
BH203S
BH13D
BH16D
BH17
BH18D
BH19D
BH201D
BH201S
BH203D
BH205D
BH24D

SOUTH SIDE QUEENSWAY WASTE MANAGEMENT SITE, LLANWERN STEELWORKS

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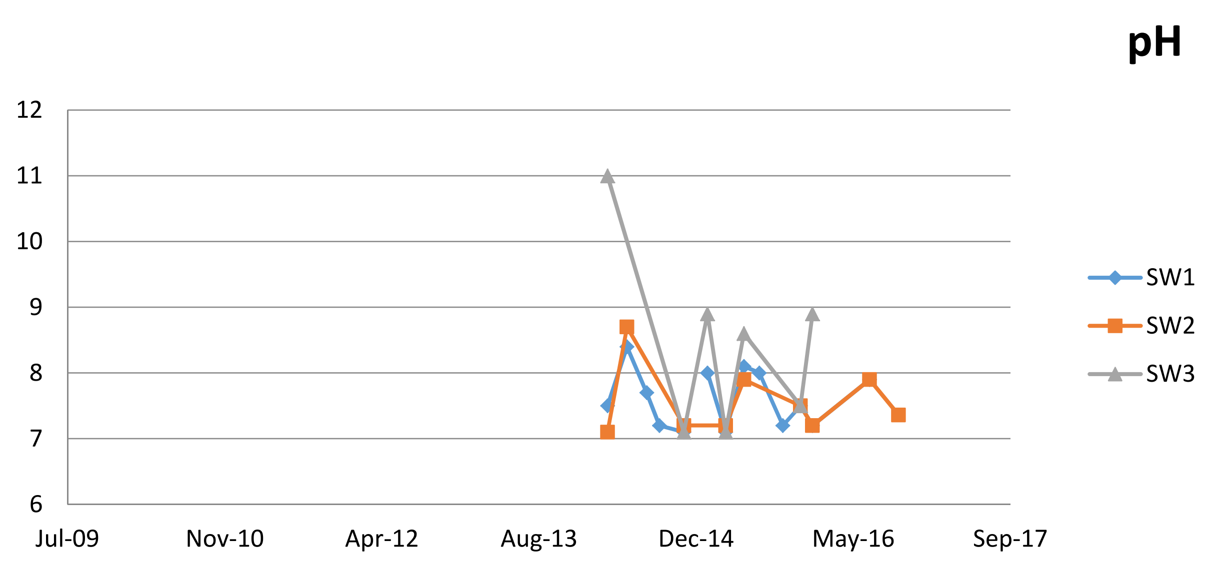
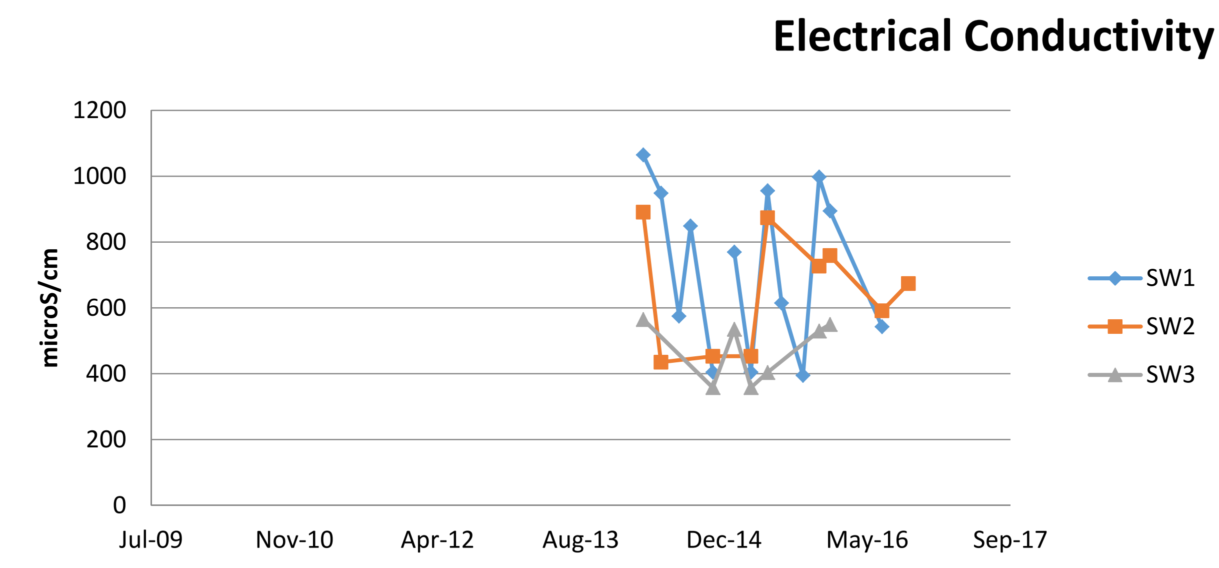
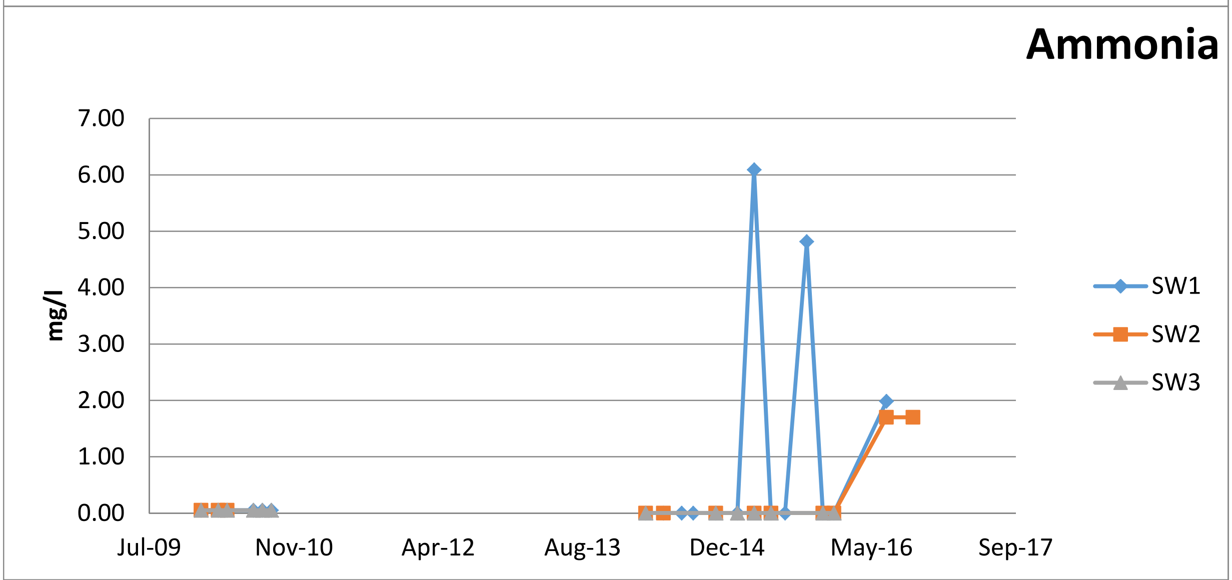
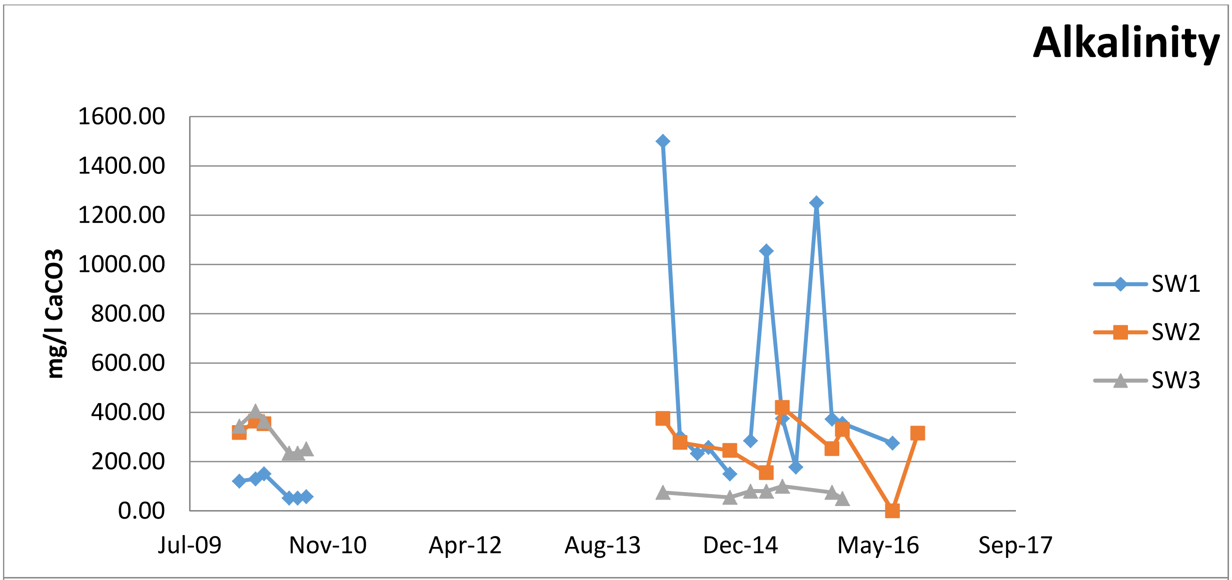
Appendix 2
Surface Water Chemistry Analysis

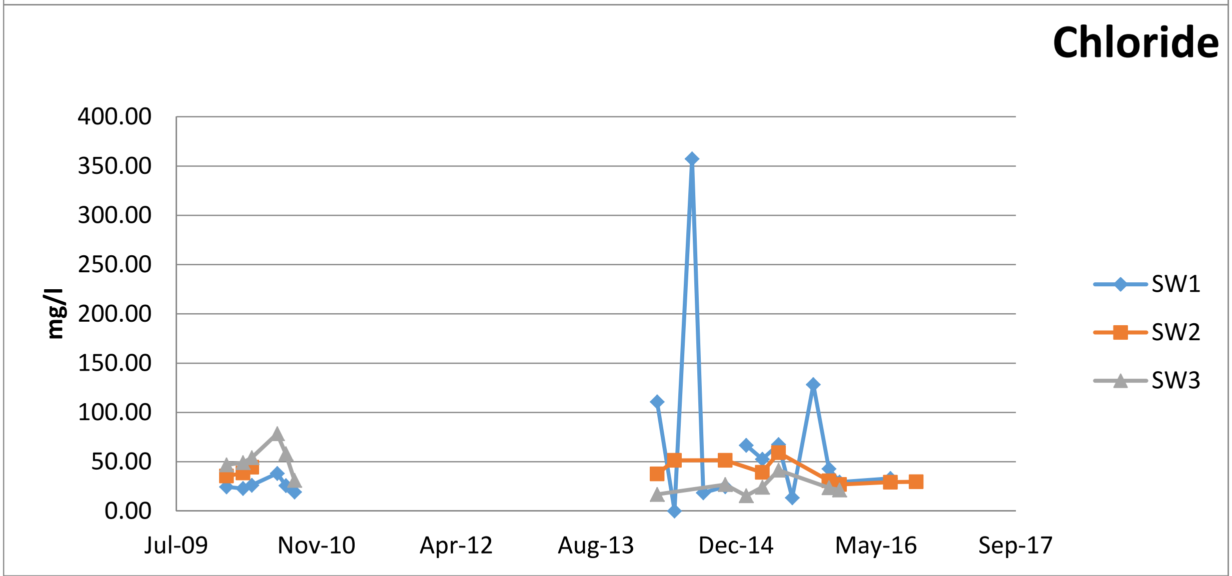
Report Number 1555r2v1d0117

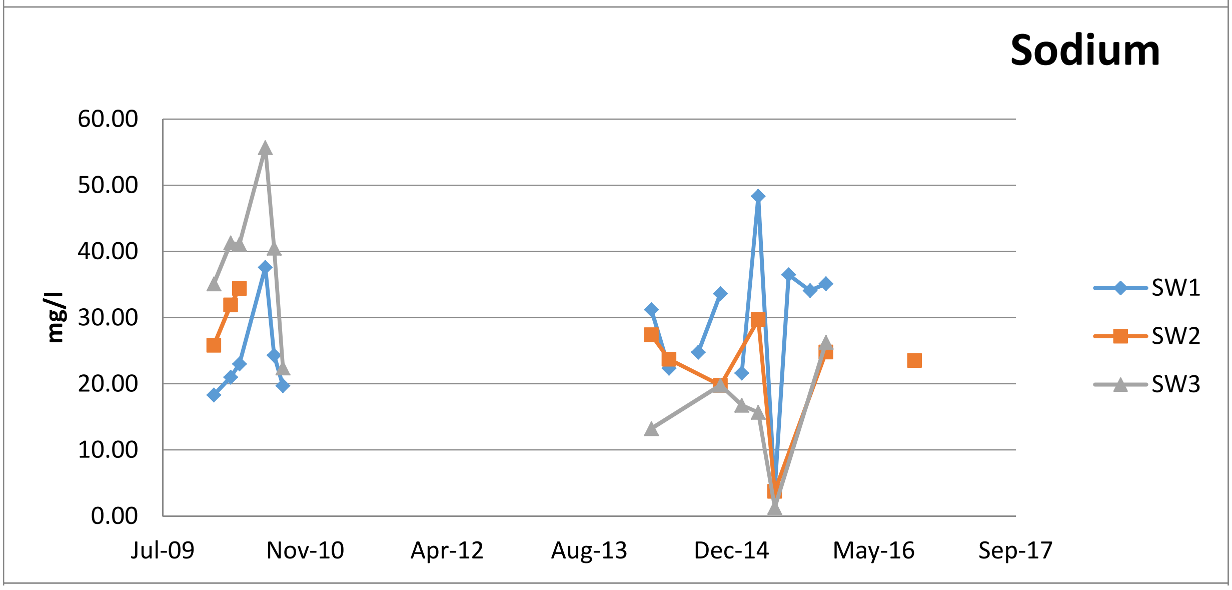

pH
12
11
10
9
8
7
6
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
SW1
SW2
SW3

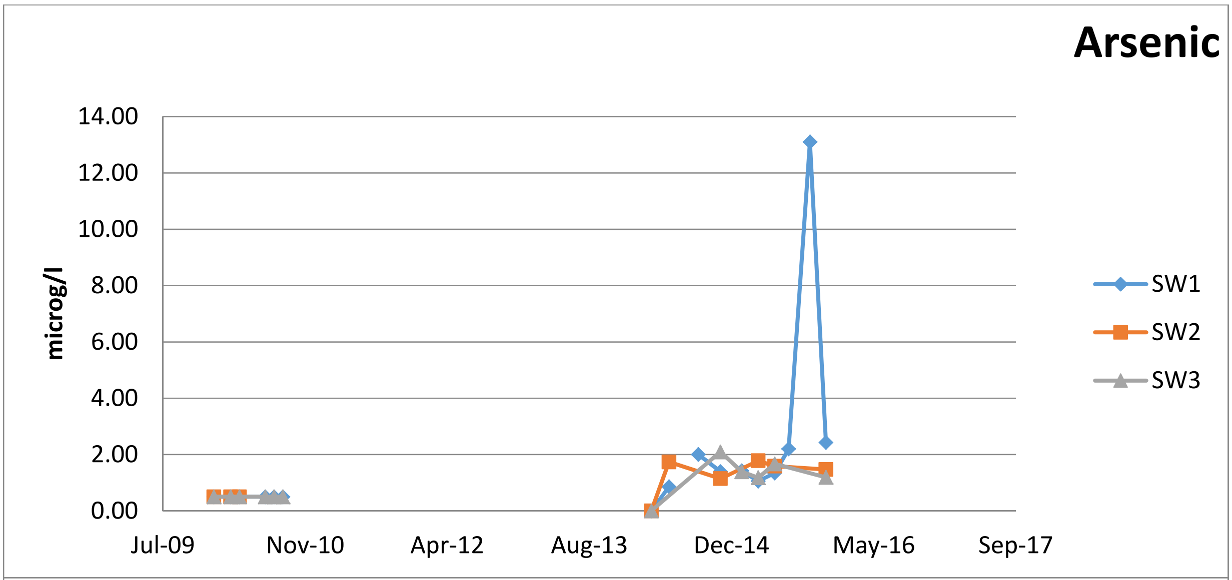

Electrical Conductivity
microS/cm
1200
1000
800
600
400
200
0
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
SW1
SW2
SW3


Ammonia
mg/l
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
SW1
SW2
SW3

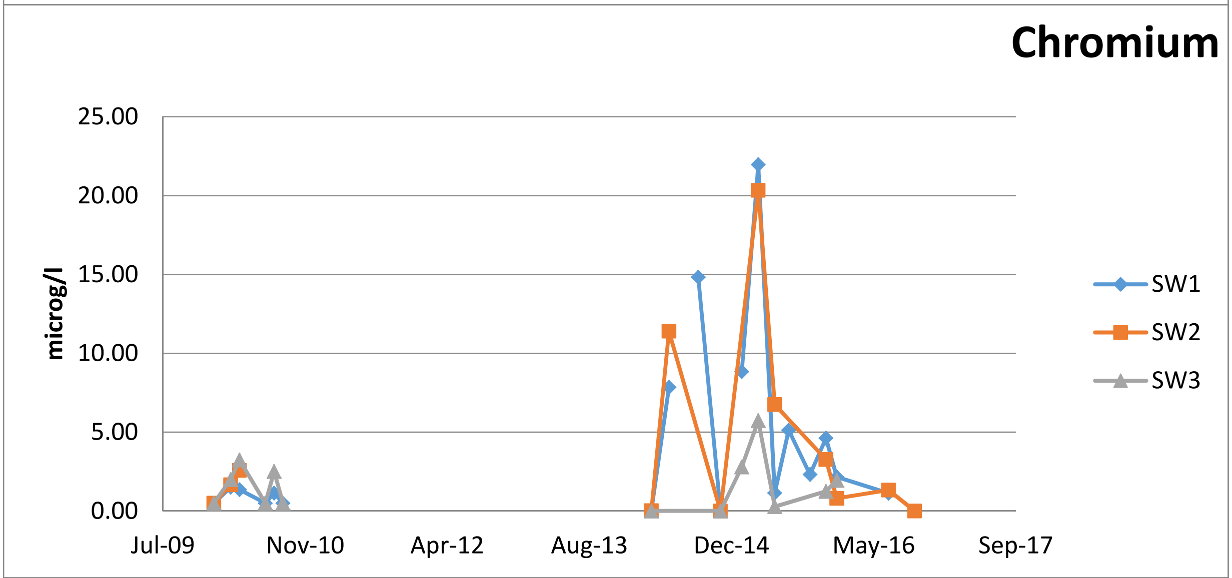

Alkalinity
mg/l CaCO3
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
SW1
SW2
SW3


Chloride
mg/l
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
SW1
SW2
SW3

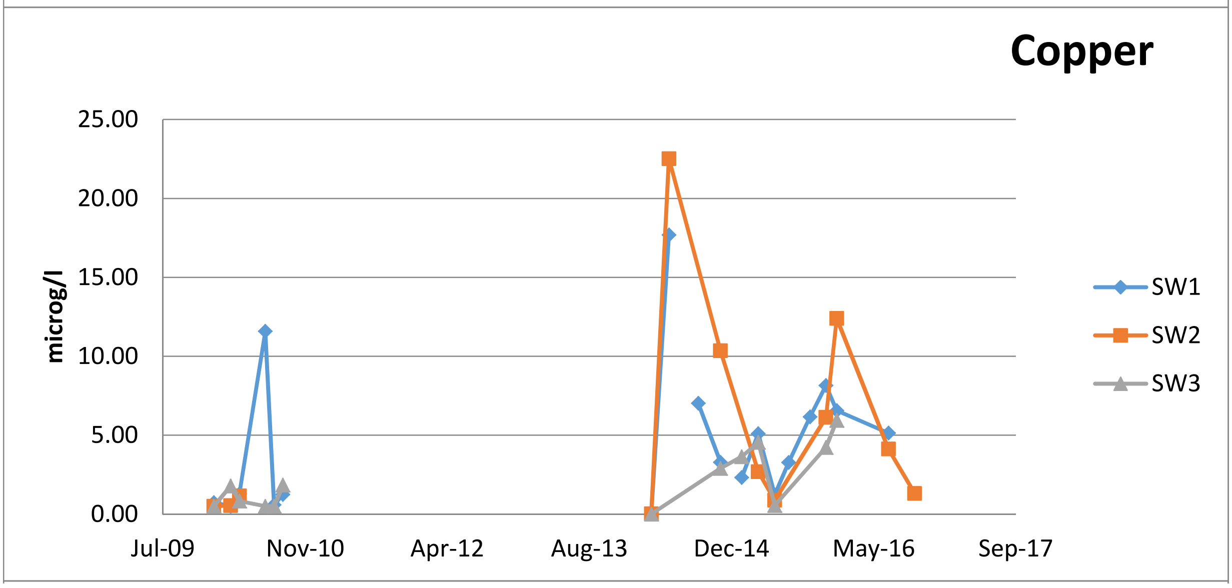

Sodium
mg/l
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
SW1
SW2
SW3



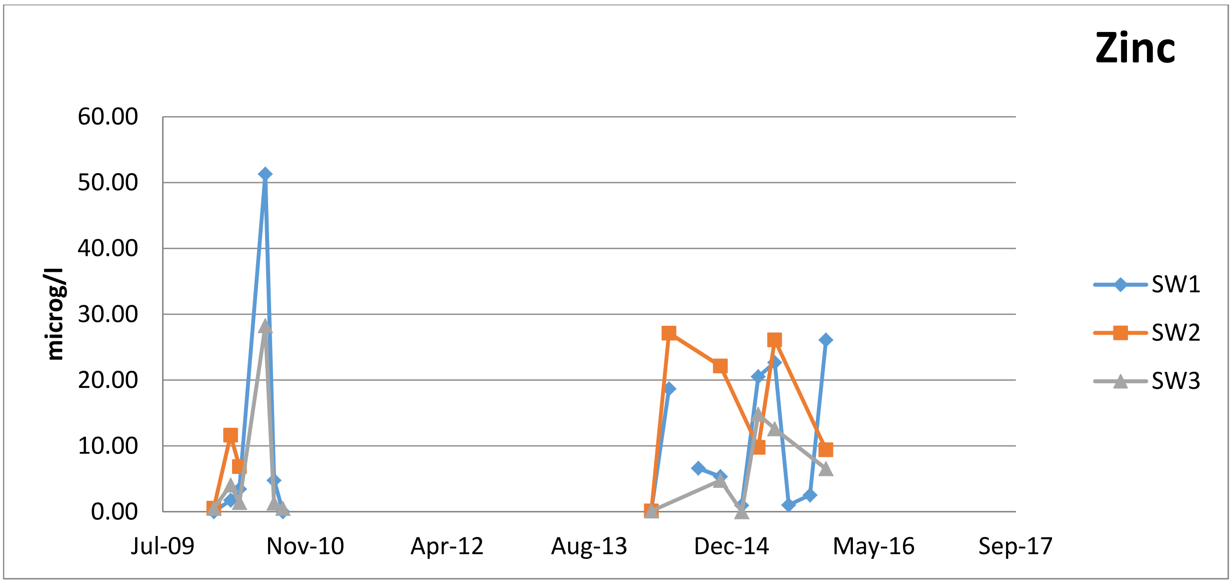
Arsenic
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
microg/l
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
SW1
SW2
SW3



Chromium
25.00
20.00
15.00
10.00
5.00
0.00
microg/l
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
SW1
SW2
SW3



Copper
25.00
20.00
15.00
10.00
5.00
0.00
microg/l
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
SW1
SW2
SW3


Zinc
microg/l
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
SW1
SW2
SW3

SOUTH SIDE QUEENSWAY WASTE MANAGEMENT SITE, LLANWERN STEELWORKS

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Appendix 3
Photographs taken by NRW in September 2016

Report Number 1555r2v1d0117

Photos from site visit on 3rd September 2016

Photo 126 – Blast furnace slag (BFS) area

Photo 127 – Lagoon 12

Photo 128 – Power lane valley looking towards BFS East and Lagoon 25

Photo 129 – Lagoon 25

Photo 130 – Lagoon 27 (A)

Photo 131 – Looking east out towards SSQ PPC permitted area


Photo 132 - Looking North out over SSQ PPC permitted area

Photo 133 – Lagoon 27 (A)

Photo 134 – Lagoon 27 (A)

Photo 135 – Lagoon 27 (A)

Photo 136 – Looking south towards SSQ PPC from Lagoon 27. Trees form boundary to site. Lagoon 27B not enclosed.

Photo 137 – Lagoon 27A

Photo 138 – Lagoon 27C

Photo 139 – Lagoon 27C

Photo 140 – Lagoon 27D

Photo 141 – Lagoon 27D

Photo 142 – Looking West over Lagoon 25

Photo 143 – View over water treatment area


Photo 144 – Looking south over SSQ PPC site

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