



7 June 2017

Shellharbour City Council

PO Box 155
Shellharbour Square
Shellharbour City Centre NSW 2529

Attention: **Courtney Williams**
Waste Manager

Dianne Tierney
Waste Manager

Dear Courtney and Dianne,

May 2017 Quarterly Environmental Monitoring – Dunmore Recycling and Waste Disposal Depot, Dunmore, New South Wales.

1.0 Introduction

Environmental monitoring is undertaken on a quarterly basis at the Dunmore Recycling Waste Disposal Depot, Dunmore, NSW (the site), in accordance with Environment Protection Licence (EPL) No. 5984. The monitoring includes sampling groundwater bores, a leachate pond, surface water bodies, a dust gauge and landfill gas at the landfill surface to detect any potential impacts of land filling activities on the environment.

2.0 Scope of works

The quarterly May 2017 monitoring round was undertaken on 8-9 May 2017, whilst BH15 was sampled on 18 May 2017. During the May 2017 monitoring round groundwater, surface water, leachate, gas and dust samples were collected in and around the site.

Groundwater samples were collected from 11 monitoring bores (BH1b to BH4, BH10, BH13 to BH16, BH19, and BH20). No sample was taken and only standing water level (SWL) was measured at BH9. Surface water was collected from the leachate pond (LP1), four on site retention ponds (SWP1, SWP2, SWP4 and SWP5) and Rocklow Creek (SWC2, SWC_Up and SWC_Down). Sampling locations are shown on Figure 1 (Attachment 1).

A dust gauge bottle was collected to the north of the site (DDG) and a gas walkover of all site buildings and the landfill cap was also undertaken. Landfill gas was measured in the field using an Inspectra Laser Unit (ILU) and a GA5000 Landfill Gas Analyser (GA5000).



3.0 Field measurements

Prior to purging, monitoring bores were measured for SWL. During sampling, field measurements were taken including pH, electrolytic conductivity (EC), oxidation/reduction potential (ORP), dissolved oxygen and temperature. Colour and odour of water samples were also noted. Field measurements recorded for each location are presented in Table 1 (Attachment 2).

All sampling undertaken was in accordance with Environmental Earth Sciences NSW (2011) *Soil, Gas and Groundwater sampling manual*.

4.0 Laboratory analysis

The following analyses were undertaken for site groundwater and surface water during the May 2017 monitoring event:

- groundwater – ionic balance (pH, total dissolved salts (TDS), sodium, calcium, potassium, magnesium, fluoride, chloride, ammonium, sulfate, bicarbonate, phosphate and nitrate), total organic carbon (TOC), biological oxygen demand (BOD), total and soluble iron, and soluble manganese;
- surface water (SWC_Up and SWC_Down) – ionic balance, total and soluble iron, turbidity, nitrate, ammonium and bicarbonate;
- surface water (SWC2) – ammonium, nitrate, bicarbonate and total and soluble iron;
- surface water SWP1, SWP2, SWP4 and SWP5 – ionic balance, total and soluble iron and turbidity;
- additional analyses for SWP4 and SWP5 – TOC and BOD; and
- leachate pond – ionic balance, TOC, BOD, total and soluble iron, soluble manganese, turbidity, faecal coliforms and *E. Coli*.

Water samples and the dust sample were sent to Sydney Analytical Laboratories (SAL) for inorganic chemical analyses and to Sonic Healthcare for faecal coliforms and *Escherichia coli* (*E. Coli* counts). Both laboratories are NATA accredited for the methods used.

The inorganic laboratory results for groundwater and surface water are shown in Table 2 and Table 3 (Attachment 2). Calculated ratios of principal ions are presented in Table 4 (Attachment 2).

5.0 Results and discussion

5.1 Groundwater flow

Inferred groundwater contours from the May 2017 standing water level (SWL) measurements are illustrated in Figure 2 (Attachment 1). These were calculated using SWLs from surveyed bores. Groundwater flow direction was towards Rocklow Creek in a southerly direction similar to previous monitoring events (Environmental Earth Sciences NSW, 2010, 2011b, 2012b, 2013, 2014, 2015, 2016 and 2017).



Accumulative rainfall for February 2017 (248.0 mm), March 2017 (376.6 mm) and April 2017 (37.4 mm) was 662 mm (*BOM – Albion Park Wollongong Airport weather station*). Rainfall for February and March were respectively almost double and triple the monthly average according to the Bureau of Meteorology. Groundwater levels increased in 11 out of 12 monitoring wells (BH1b, 2, 3, 4, 10, 13, 14, 16 and BH19), while BH20 showed a reduction in groundwater level. The average of the measured standing water levels throughout the site has increased by ~0.46 mAHD from 0.77 mAHD in February 2017 to 1.23 m AHD in May 2017. This may be related to a tidal influence and may also be potentially impacted by the high total rainfall in February and March 2017.

5.2 Groundwater

5.2.1 Groundwater sampling locations impacted by leachate

Field and laboratory results from the May 2017 sampling round, specifically from bores BH1b, BH2, BH3, BH14, BH15, BH16 and BH20 displayed chemistry that can be related to leachate impact — BH1b and BH15 showed stronger leachate indicators with high TDS, potassium and ammonium levels. Leachate interaction is demonstrated by elevated concentrations of non-native potassium (K^+), ammonium (NH_4^+-N) and nitrate (NO_3^-) relative to native sodium (Na^+), calcium (Ca^{2+}) and magnesium (Mg^{2+}). This comparison is known as the leachate to non-leachate (L/N) ratio.

An L/N ratio >10 may be indicative of leachate impact depending on the combination with other indicators such as odour, colour, BOD and bicarbonate whereas a significant impact is likely at a ratio of >20 (Table 4, Attachment 1).

Bore BH1b is located near the old unlined landfill cell and intercepts leachate within the cell. As such the chemical signature of this bore has historically contained elevated leachate indicators in comparison to other monitoring bores (Schoeller plot BH1 a/b, Attachment 3). This continued during the current monitoring event and the groundwater was found to have a light yellowish brown colour noted in combination with elevated TDS (4,100 mg/L), K^+ (235 mg/L) [resulting in low Ca/K – 0.51] and NH_4^+-N (375 mg/L) concentrations. The absence of oxygen (0.46 ppm Table 1) and presence of soluble Fe^{2+} indicate an anaerobic state and strong biochemical demand in response to microbial respiration. BOD has fluctuated since the bore was installed, ranging from 830 mg/L to 6 mg/L. BODs have remained at similar levels during August 2016, November 2016, February 2017 and May 2017 rounds and were 8, 7, 7 and 6 mg/L respectively. Further evidence of microbial activity / respiration is elevated HCO_3^- resulting in a low Cl/ HCO_3^- ratio of 0.26 (Table 4). This suggests some degradation of the leachate plume has occurred in this monitoring bore.

Bore BH2 is located down gradient from the old unlined landfill cell. Historically elevated levels of NH_4^+-N indicate some leachate impact at this location. In May 2017, NH_4^+-N concentrations (30 mg/L) exceeded the ANZECC (2000) trigger levels. Bicarbonate (HCO_3^-), Na^+ and Mg^{2+} concentrations in groundwater have shown an increasing trend since January 2008 (Table 2, Schoeller plot BH2, Attachment 3). Chlorine (Cl^-), Ca^{2+} , K^+ and NH_4^+-N concentrations decreased since the last monitoring round (Table 2, Schoeller plot BH2, Attachment 3) potentially due to a decrease in TDS. Low oxygen and negative redox (Table 2) continue to suggest microbial respiration and therefore degradation of the leachate is occurring at this location. Additionally, a slightly sulphuric odour was noted.

Groundwater from bore BH3 reported slight decreases in three native ions (Na^+ , Cl^- and Mg^{2+}) as well as two non-native ions (K^+ and NO_3^-). In comparison, NH_4^+-N reported a slight increase in concentration. The L/N ratio (45.78%) has decreased since the February 2017 monitoring round (60.6%), however due to the low TDS (<1000 mg/L) the L/N ratio must be used with some caution. Long term trends (since 1992) show that K^+ concentrations



generally had an increasing trend from February 2011 until November 2015, the levels have then returned to historical levels by August 2016. Nitrogen species (NO_3 , NO_2 and $\text{NH}_4^+\text{-N}$) have remained within historical levels. It was reported and verified during the drilling of BH3 that old unconfined waste dumps were in the vicinity of bore BH3 (outside the designated cells near bore BH2). This waste is likely to have an impact on the results.

Groundwater monitoring bore BH5 had been decommissioned prior to the May 2017 monitoring round, with the NSW Environmental Protection Agency (EPA) notified of this event on 15 May 2017. Bore BH5 historically reported evidence of a reducing environment and leachate impact demonstrated by elevated K/TDS ratios. It was proposed that a leachate plume originating from several possible sources, including a previous overspill of the leachate ponds, a former unlined landfill cell and organic waste stockpiling activities had contributed to these impacts at BH5.

The L/N ratios at bore BH14 have been increasing over the 2016-2017 monitoring period. In November 2016 the L/N ratio was 23.5%, in February 2017 this increased to 55.39% and during the May 2017 monitoring round an L/N ratio of 77.58% was reported. Concentrations of K^+ were higher in the May 2017 monitoring period compared to recent levels however they were still within the historical ranges (Schoeller plot BH14, Attachment 3). An increase in the L/N ratio may potentially be due to the increased concentrations of K^+ and it is suspected that this may indicate southward movement of the leachate plume. The concentration of $\text{NH}_4^+\text{-N}$ remained below the ANZECC 2000 trigger value for 95% protection of aquatic ecosystems. Nitrate (NO_3^-) concentrations were above the trigger value, however decreased to 94 mg/L compared to February 2017 (105 mg/L). Bore BH14 is strategically placed down gradient of landfilling activities and should be continually monitored to determine the water quality in this area.

Bore BH15 displayed an elevated L/N ratio of 86.32% which can be attributed with an elevated K^+ concentration. The K^+ /TDS ratio of 15.22% is high when compared to non leachate influenced sites generally with K^+ /TDS < 3 (Schoeller plot BH15, Attachment 1). Although elevated the L/N ratio has decreased from the February 2017 monitoring round where the L/N ratio was calculated at 104.84% with a K^+ /TDS ratio of 17.91%. Ammonium ($\text{NH}_4^+\text{-N}$) is elevated at 130 mg/L, compared to other non-impacted locations at the site, which is consistent with previous monitoring rounds. Field observations of a negative redox (negative ORP) and low dissolved oxygen are indicative of a reducing environment. This reducing environment promotes the dominance of $\text{NH}_4^+\text{-N}$ and the elevated levels of soluble Mn^{2+} (0.5 mg/L) and Fe^{2+} (14 mg/L). Additionally, bore BH15 is located within a swampy environment where microbiological activity drives reducing reactions that can result in naturally high levels of leachate indicators such as organic carbon, $\text{NH}_4^+\text{-N}$ and HCO_3^- . Furthermore, bore BH15 is located near a drainage line with the groundwater bearing zone <0.5 m below the ground surface. Groundwater therefore has the potential to be influenced from local onsite and offsite works and surface water.

Bore BH16 is located in a swampy area with groundwater field observations recording a yellowish/green colour and a sulfuric odour. Recorded ORP indicates a reducing environment (-174 mV), which may have an influence in the dominance of $\text{NH}_4^+\text{-N}$ over NO_3^- . Slightly elevated $\text{NH}_4^+\text{-N}$ concentrations (6 mg/L) exceeded the ANZECC (2000) criteria and the L/N ratio was 10.25%, a decrease from February 2017 (25.95%). The combination of elevated L/N ratio and an elevated K/TDS ratio (3.01%) indicate that groundwater at bore BH16 may be leachate impacted, although current monitoring results suggest that this impact is decreasing. Bores BH16 and BH15 are located close to a drainage channel where offsite impacts can readily influence the chemical characteristics of the shallow groundwater.



Bore BH20 is located down gradient of the landfill, leachate ponds and shallow old landfill. This bore was positioned to assess the chemical characteristics on the boundary of the landfill site. Field observations at bore BH20 recorded a negative redox, and clear colour of the groundwater. The L/N ratio decreased from the last monitoring round (19.41%) with K^+ also decreasing from 36 mg/L (February 2017) to 26 mg/L (May 2017). The TDS remained low (780 mg/L) making the L/N susceptible to natural variations or fluctuations in chemistry. Chemical characteristics of the bore show groundwater is low in Na^+ , with a moderate Ca/K and K/TDS ratio (Table 4). Ammonium levels remain elevated at 17 mg/L however other landfill indicators were low or absent.

5.2.2 Remaining groundwater sampling locations

During the February 2017 monitoring round, ionic chemistry indicated that bores BH4, BH13 and BH19 only displayed slight to no leachate influence. Chemical composition of each of these bores has been depicted in Schoeller plots in Attachment 3. Bore BH12, has been decommissioned in early February 2017 to create the working area of the windrow pad.

In the February 2017 monitoring round bore BH4 showed minor leachate influence. Field observations (such as clear water and no odour) and chemical results such as NO_3^- levels below the laboratory limit of detection, relatively low K^+ and a high Ca/K ratio of 12.31% indicate no or limited leachate influence. Ammonium (NH_4^+-N) levels increased to 7.1 mg/L which is above the ANZECC (2000) trigger value for 95% protection of aquatic ecosystems however within the historical range for this bore. The historical chemical composition of the groundwater has remained relatively stable since monitoring began in 1992 (Schoeller plot BH4, Attachment 3). This site is located down gradient of the unlined old landfill cell and will continue to be monitored to assess any potential leachate migration towards Rocklow Creek.

Bore BH10 is located up gradient of the site. Groundwater at BH10 was subjected to chemical analysis during the May 2017 monitoring round to provide data on groundwater up-gradient of the landfill. Of all the groundwater monitoring bores that are considered to display little to no leachate impact at the site, BH10 reported the highest TDS concentration (1200 mg/L). This is likely due to the elevated Na^+ (365 mg/L) and Cl^- (420 mg/L) reported. Non-native ions were generally low; K^+ reporting 2.1 mg/L and NO_3^- concentrations not detected above the laboratory limit of reporting. Concentrations of NH_4^+-N were above the ANZECC (2000) trigger levels at 3.2 mg/L and agricultural or residential activities are considered the likely source. The low L/N ratio of 1.26% indicates no leachate impact.

Bore BH13 is located in close proximity to a former night soil area (Figure 1). A slight residual leachate influence has been apparent at this location in the past. Analysis of chemical data from the May 2017 monitoring round shows an increasing leachate influence with an L/N ratio of 16.36% and a TDS level of 1000 mg/L. The chemical composition of the groundwater has remained consistent since monitoring began in 2002 (Schoeller plot BH13, Attachment 3), with fluctuations of NH_4^+-N (1.5 mg/L) and NO_3^- (29 mg/L) a feature.

Bore BH19 is a relatively new monitoring bore located on the south west boundary of the site. Field observations included a negative ORP and cloudy white colour. Groundwater chemical characteristics support no/ limited leachate influence with an L/N ratio of 4.93% and a high Ca/K ratio. Bore BH19 is down gradient of current sand dredging activities and unlined landfill cells. Ammonium (NH_4^+-N) at this location (6.9 mg/L) exceeds the ANZECC (2000) trigger levels. Bore BH19 is positioned to detect any potential leachate migration to the south west of site and will continue to be monitored.

Elevated NH_4^+-N levels were reported in groundwater across the entire site with bores BH1b (375 mg/L), BH2 (30 mg/L), BH3 (29 mg/L), BH4 (7.1 mg/L), BH10 (3.2 mg/L), BH15 (130



mg/L), BH16 (6 mg/L), BH19 (6.9 mg/L) and BH20 (17 mg/L) above threshold levels. Nitrate (NO_3^-) was also reported above guidelines (ANZECC 2000) in samples from bores BH3 (41 mg/L), BH13 (28 mg/L) and BH14 (94 mg/L).

5.3 Surface water monitoring

During May 2017 monitoring round samples from Rocklow Creek (SWC2, SWC_Up and SWC_Down) and four surface water ponds (SWP1, SWP2, SWP4 and SWP5) were collected. Results of surface water analysis (Table 2 and Table 3) indicate that concentrations of ions were in the high range, likely caused by the high rainfall events throughout February and March 2017. This has been depicted in the Schoeller plots provided in Attachment 3.

As these ponds are intended to retain any surface water migrating towards Rocklow Creek, the detection of chemical constituents that may be associated with landfill leachate are expected.

The TDS level detected at SWP1 was 1160 mg/L and the nitrogen species were low ($\text{NH}_4\text{-N}$ at 0.1 mg/L and NO_3^- at 0.31 mg/L), which indicate little to no leachate influence.

Surface water sample SWP2 showed slight indicators of potential leachate impact: The surface water pond collects runoff from around the site and potential impacts from site activities are often observed. Ammonium was 7.1 mg/L during this sampling round which is the most elevated ammonium concentration at this location to date. Nitrate (NO_3^-) was below the ANZECC 2000 trigger value with a concentration of 1.2 mg/L. Fluctuating nitrate is common at this location with previous monitoring events fluctuating between 0.01 and 30 mg/L. All chemical parameters at this location are within historical ranges, with the exception of ammonium.

SWP4 displayed ammonium levels of 5.5 mg/L which is above the defined trigger value and may indicate minor leachate influence. All chemical parameters at this location are within historical ranges. Both this location and SWP2 should continue to be monitored for any fluctuations in chemical composition indicating a more prominent leachate impact.

As previously discussed (Environmental Earth Sciences NSW, 2012a) SWP3 has been filled with large rocks and boulders (0.3 – 1.0 m in diameter), lined with plastic and is now being used as a new landfill cell.

SWP5 reported nitrogen species below the trigger values established in ANZECC (2000) and comparatively low levels of both native and non-native ions.

The two surface water creek sites SWC_Up and SWC_Down were also sampled during the May 2017 sampling event. These two sites are up- and down-gradient of the established SWC2 site and help assess leachate impacts within Rocklow Creek. SWC_Up and SWC_Down had high concentrations of TDS, notably Na^+ and Cl^- (Table 2), this is due to the tidal nature of these waters and differentiates them from landfill groundwater / surface water.

The low nutrient and L/N ratios within Rocklow Creek indicated that there was no leachate impact within Rocklow Creek. Both SWC_Up and SWC_Down had low concentrations of $\text{NH}_4^+\text{-N}$ and NO_3^- (>0.1 mg/L and >0.5 mg/L respectively) which did not exceed the ANZECC (2000) trigger value for 95% protection of freshwater ecosystems. Levels detected at all Rocklow Creek locations, are within historical levels established since monitoring was commenced.



5.4 Leachate Pond monitoring

The chemistry of leachate water at the Dunmore Recycling and Waste Disposal Depot is significantly different when compared to the surface and groundwater chemistry of non leachate influenced bores. This is demonstrated through comparison of chemical data for groundwater from the various bores and the leachate pond presented in Table 2. In particular TDS, TOC, $\text{NH}_4^+\text{-N}$, K^+ , and PO_4 concentrations are generally elevated in leachate pond water compared to other monitoring bores (Schoeller plot Leachate, Attachment 3). Ionic ratios (Table 4) such as low Ca/K (0.40) and high Na/Ca and L/N ratios represent landfill leachate chemical characteristics. These chemical characteristics have been relatively stable over the past 10 years of monitoring.

Laboratory analysis detected *faecal coliforms* and *E.Coli* during this round with concentrations of 330 and 330 CFU/100 ml respectively which is a significant decrease on the previous monitoring round (Table 3). Nevertheless, dermal contact with these waters should be avoided due to health concerns relating to microbial counts.

5.5 Quality assurance/quality control

For quality assurance and quality control the following precision and reliability measures were calculated. The charge balance difference between the summed total of anions against cations (milli-equivalent units) was in the range of 0.06% to 3.51%. The results are a good indication that all major cations and anions present in the groundwater have been analysed and accounted for, providing confidence in the laboratory results obtained.

Field and laboratory practices were further evaluated by comparing the difference between field and laboratory pH and field measured electrical conductivity (EC) against laboratory total dissolved salts (TDS). The range of most relative percent difference (RPD) of field to laboratory pH measurements was between 0.29% and 10.29% (majority of the data is around 0.5% level, with only one sample yielding an RPD > 10%). The relationship between the field determined EC and laboratory measured TDS relationship ranged between 0.6 and 0.94. The majority of data is within the TDS/EC typical range of 0.5 to 0.9 and is consistent with historical levels on site.

The analysis of the intra-laboratory duplicate taken at bore BH16 showed a maximum RPD of 13.3%, which was dissolved iron. This is within acceptable RPD criteria. As a result, the data is considered reliable (Table 6).

5.6 Gas monitoring

Landfill gas was measured in the field using an Inspectra Laser Unit (ILU) and a GA5000 Landfill Gas Monitor (GA5000). Measurements were taken within and around all buildings in a 250 m radius from the current landfill cell as well as across the landfill cap (gas walkover grids of May 2017 round are presented in Figure 3).

All readings were below the site specific criteria outlined in the EPL as the NSW EPA (1996) reporting threshold of 1.25 % v/v CH_4 within onsite buildings and therefore pose no direct risk. Readings were generally below the threshold concentration for closer investigation and potential action (500 ppm or 0.05 % v/v, NSW EPA [1996], Table 5). No landfill gas was detected with the GA5000, however the ILU reported a concentration of 0.098% on the landfill cap. The relevant Council authorities were notified of this event and an email detailing the precise locations on the landfill cap that exceeded guidelines with recommendations for landfill cap reinforcement was sent (Potential Landfill Cap Deficiencies and Their Locations:



05/06/2017). Continued monitoring with both the GA5000 and ILU will be undertaken at quarterly monitoring events.

5.7 Dust

Dust deposition levels to the north of the site were $2.2 \text{ g/m}^2/\text{month}$ total solids, which is below the accepted level of $4 \text{ g/m}^2/\text{month}$ (Australian Standards AS3580.10.1 and AS2724.1). Dust deposition levels to the north of site are within historical ranges and will continue to be monitored to assess the closest sensitive receptor, houses located to the north-west of site.



6.0 Conclusion and recommendations

Groundwater behaviour across the site since the commencement of quarterly monitoring in 1992 has been generally consistent. As the plume beneath the site is generally stable, changes in leachate behaviour into the future are not expected to be significant. Changes to site conditions such as stockpile locations, new landfill cells, new retention ponds and other earth works could potentially impact leachate behaviour on site.

Assessment of monitoring bore BH20 has detected the presence of leachate indicators despite the nearby sampling locations BH19, SWC-UP and SWC-DOWN (Rocklow Creek), which displayed results indicating background characteristics. Although the historical data set of these new locations are relatively limited, it can be said it is likely that on site activities are not significantly impacting Rocklow Creek.

Leachate influenced groundwater may potentially be influencing water quality at bores BH15 and BH16. It is important to note that bore BH15 and BH16 are located in/or near swampy environments or near heavily vegetated areas. Heavily wooded areas to the south can also have a natural attenuation effect on leachate impacted water. This would further inhibit its rate of migration and should continue to limit its extent of impact on Rocklow Creek.

Surface water monitoring indicated that on site activities have had limited impact on water quality at locations SWP1, SWP2, SWP4 and SWP5.

Assessment of Rocklow Creek sampling locations (SWC-Up and SWC-Down) reported no concentrations of $\text{NH}_4\text{-N}$ above the laboratory limit of reporting. These values did not exceed the ANZECC (2000) trigger value for 95% protection of freshwater ecosystems.

Gas concentrations detected at all buildings assessed on site were below guidelines and no action was required to be taken. Gas concentrations on the landfill cap exceeded the site specific criteria outlined in the EPL, requiring action. It is recommended that the landfill cap be reinforced as per emailed recommendation (Potential Landfill Cap Deficiencies and Their Locations: 05/06/2017) and monitoring with an ILU and GA5000 continue with special attention to the buildings.

Depositional dust monitoring results continued to be below guidelines (Australian Standards AS3580.10.1 and AS2724.1) and will continue to be monitored to assess the impact if any dust poses on nearby residential areas.



7.0 Limitations

This letter report has been prepared by Environmental Earth Sciences NSW ABN 109 404 006 in response to and subject to the following limitations:

1. The specific instructions received from Shellharbour City Council;
2. The specific scope of works set out in PO109055 issued by Environmental Earth Sciences NSW for and on behalf of Shellharbour City Council;
3. May not be relied upon by any third party not named in this report for any purpose except with the prior written consent of Environmental Earth Sciences NSW (which consent may or may not be given at the discretion of Environmental Earth Sciences NSW);
4. This report comprises the formal report, documentation sections, tables, figures and appendices as referred to in the index to this report and must not be released to any third party or copied in part without all the material included in this report for any reason;
5. The report only relates to the site referred to in the scope of works being located at Dunmore Recycling and Waste Disposal Depot located at Buckleys Rd Dunmore, NSW ("the site");
6. The report relates to the site as at the date of the report as conditions may change thereafter due to natural processes and/or site activities;
7. No warranty or guarantee is made in regard to any other use than as specified in the scope of works and only applies to the depth tested and reported in this report,
8. Fill, soil, groundwater and rock to the depth tested on the site may be fit for the use specified in this report. Unless it is expressly stated in this report, the fill, soil and/or rock may not be suitable for classification as clean fill if deposited off site;
9. This report is not a geotechnical or planning report suitable for planning or zoning purposes; and
10. Our General Limitations set out at the back of the body of this report.

Should you have any further queries, please contact us on (02) 9922 1777.

On behalf of
Environmental Earth Sciences NSW

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8.0 References

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ENVIRONMENTAL EARTH SCIENCES GENERAL LIMITATIONS

Scope of services

The work presented in this report is Environmental Earth Sciences response to the specific scope of works requested by, planned with and approved by the client. It cannot be relied on by any other third party for any purpose except with our prior written consent. Client may distribute this report to other parties and in doing so warrants that the report is suitable for the purpose it was intended for. However, any party wishing to rely on this report should contact us to determine the suitability of this report for their specific purpose.

Data should not be separated from the report

A report is provided inclusive of all documentation sections, limitations, tables, figures and appendices and should not be provided or copied in part without all supporting documentation for any reason, because misinterpretation may occur.

Subsurface conditions change

Understanding an environmental study will reduce exposure to the risk of the presence of contaminated soil and or groundwater. However, contaminants may be present in areas that were not investigated, or may migrate to other areas. Analysis cannot cover every type of contaminant that could possibly be present. When combined with field observations, field measurements and professional judgement, this approach increases the probability of identifying contaminated soil and or groundwater. Under no circumstances can it be considered that these findings represent the actual condition of the site at all points.

Environmental studies identify actual sub-surface conditions only at those points where samples are taken, when they are taken. Actual conditions between sampling locations differ from those inferred because no professional, no matter how qualified, and no sub-surface exploration program, no matter how comprehensive, can reveal what is hidden below the ground surface. The actual interface between materials may be far more gradual or abrupt than an assessment indicates. Actual conditions in areas not sampled may differ from that predicted. Nothing can be done to prevent the unanticipated. However, steps can be taken to help minimize the impact. For this reason, site owners should retain our services.

Problems with interpretation by others

Advice and interpretation is provided on the basis that subsequent work will be undertaken by Environmental Earth Sciences NSW. This will identify variances, maintain consistency in how data is interpreted, conduct additional tests that may be necessary and recommend solutions to problems encountered on site. Other parties may misinterpret our work and we cannot be responsible for how the information in this report is used. If further data is collected or comes to light we reserve the right to alter their conclusions.

Obtain regulatory approval

The investigation and remediation of contaminated sites is a field in which legislation and interpretation of legislation is changing rapidly. Our interpretation of the investigation findings should not be taken to be that of any other party. When approval from a statutory authority is required for a project, that approval should be directly sought by the client.

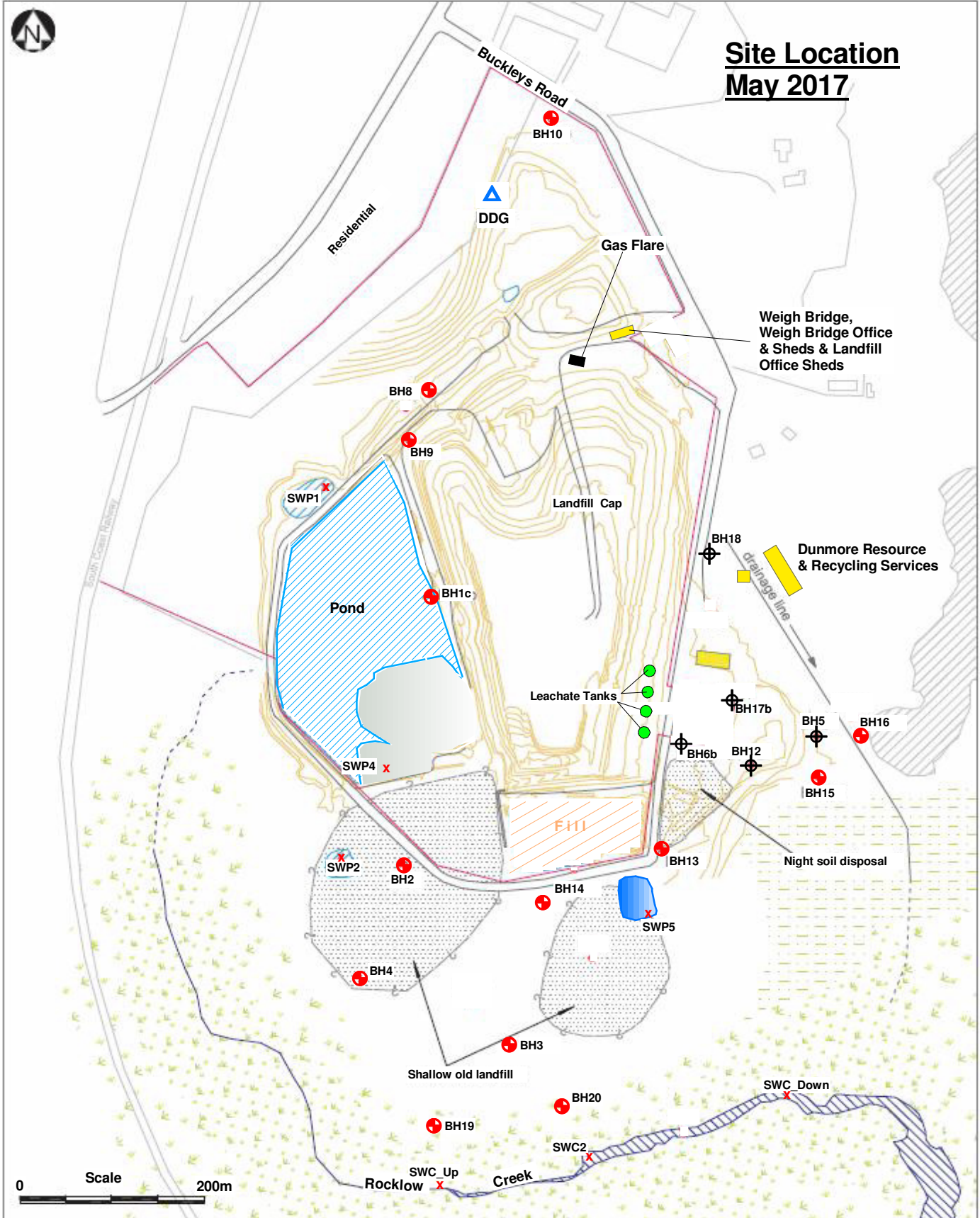
Limit of liability

This study has been carried out to a particular scope of works at a specified site and should not be used for any other purpose. This report is provided on the condition that Environmental Earth Sciences NSW disclaims all liability to any person or entity other than the client in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by any such person in reliance, whether in whole or in part, on the contents of this report. Furthermore, Environmental Earth Sciences NSW disclaims all liability in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by the client, or any such person in reliance, whether in whole or any part of the contents of this report of all matters not stated in the brief outlined in Environmental Earth Sciences NSW's proposal number and according to Environmental Earth Sciences general terms and conditions and special terms and conditions for contaminated sites.

To the maximum extent permitted by law, we exclude all liability of whatever nature, whether in contract, tort or otherwise, for the acts, omissions or default, whether negligent or otherwise for any loss or damage whatsoever that may arise in any way in connection with the supply of services. Under circumstances where liability cannot be excluded, such liability is limited to the value of the purchased service.

ATTACHMENT 1 FIGURES

Site Location May 2017



Legend:

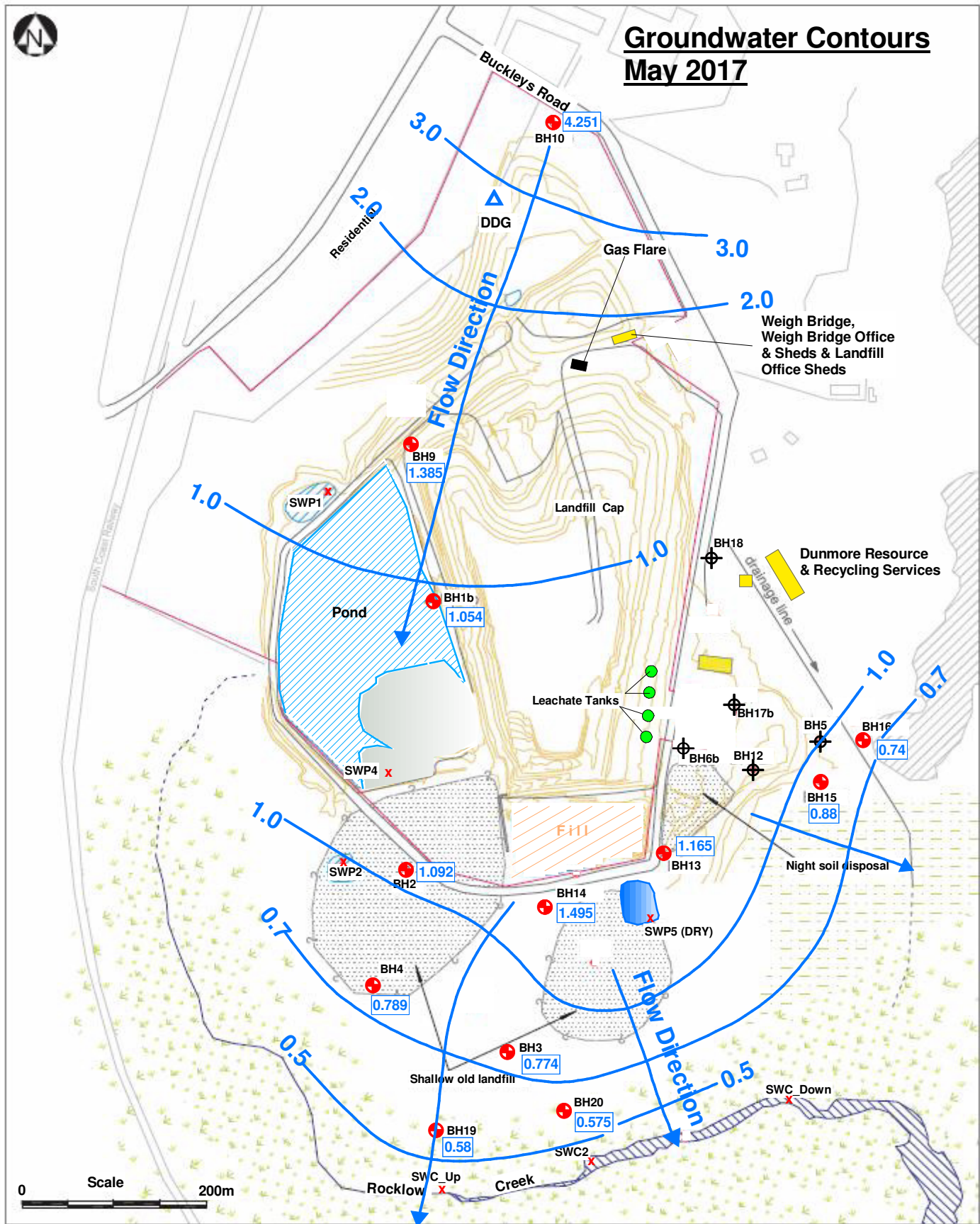
- Bore locations
- x Surface water locations
- ▲ DDG Dust gauge location
- Water
- Buildings
- Decommissioned bores

 ENVIRONMENTAL EARTH SCIENCES <small>THE KNOW AND THE HOW</small>	Title: Site Locations	
	Location: Buckleys Road, Dunmore, NSW	
Client: Shellharbour City Council	Job number: 112096	
Drawn by: TRJ	Scale: As shown	Figure 1
Proj Man: MB	Date: May 2017	

Note: Based on aerial photo dated 1 Sept. 2010



Groundwater Contours May 2017



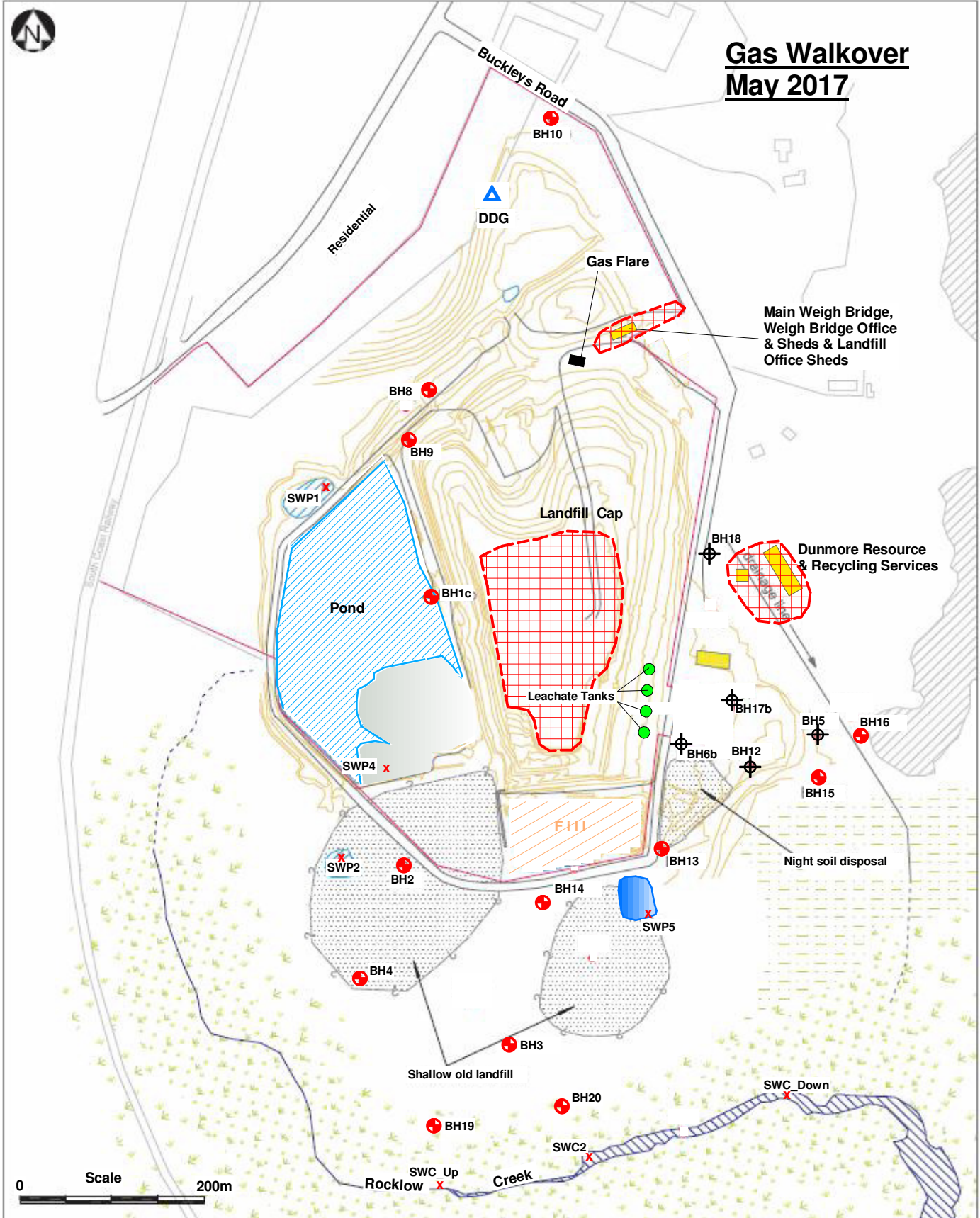
Legend:

- Bore locations
- x Surface water locations
- DDG Dust gauge location
- Inferred groundwater contour (m AHD)
- Standing water levels
- Flow direction
- Water
- Buildings
- Decommissioned bores

Note: Based on aerial photo dated 1 Sept. 2010

	Title: Groundwater Contours May 2017	
	Location: Buckleys Road, Dunmore, NSW	
Client: Shellharbour City Council	Job number: 112096	
Drawn by: TRJ	Scale: As shown	Figure 2
Proj Man: MB	Date: May 2017	

Gas Walkover May 2017



Legend:

- + Bore locations
- X Surface water locations
- ▲ DDG Dust gauge location
- Gas walkover
- Water
- Buildings
- Decommissioned bores

Note: Based on aerial photo dated 1 Sept. 2010

 <small>THE KNOW AND THE HOW</small>	Title: Gas Walkover	
	Location: Buckleys Road, Dunmore, NSW	
Client: Shellharbour City Council		Job number: 112096
Drawn by: TRJ	Scale: As shown	Figure 3
Proj Man: MB	Date: May 2017	

ATTACHMENT 2 TABLES

TABLE 1 FIELD MEASUREMENTS – MAY 2017

Sample	SWL	SWL	pH	EC	ORP	Temp.	DO	Colour	Odour
Units	mAHD	Dip (m)	-	mS/cm	mV	°C	ppm	-	-
BH1b	1.054	2.9	6.78	6.8	-122	24.4	0.46	Brown / light brown / yellow brown	Leachate odour
BH2	1.092	3.7	6.64	2.98	-99	20.1	1.59	Slightly brown	Slightly sulphuric odour
BH3	0.774	2.99	7.11	1.104	-104	18.6	1.75	Clear	None
BH4	0.789	4.23	7.02	1.5	-104	18.2	-0.24	Clear	None
BH10	4.251	0.54	7.04	2.08	-125	17.8	2.36	Clear	None
BH13	1.165	4.13	6.69	1.521	-10	20.9	-0.14	Clear	None
BH14	1.495	4.22	6.34	1.333	133	20.4	-0.18	-	-
BH15	0.88	0.53	6.91	4.582	-99.6	17	0.4	Amber / brown	Slightly sulfuric odour
BH16	0.74	0.64	6.41	3.27	-175	17.2	0.16	Yellow / green	Slightly sulfuric odour
BH19	0.58	4.61	6.99	1.562	-87	18.2	-0.1	Cloudy /white	None
BH20	0.575	2.195	7.47	1.177	-154	18	-0.26	Clear	None
LP1	-	N/A	7.72	12.65	-141	-	3.31	Dark Brown	Leachate odour
SWC2	-	N/A	7.63	41.7	-15	14.4	4.7	Clear	None
SWC-Up	-	N/A	6.97	40.8	-12	14.2	2.6	Clear	None
SWC-Down	-	N/A	7.23	40.4	66	14.8	7.3	Clear	None
SWP1	-	N/A	7.42	1.882	-15	16.4	1.6	Clear/Light Brown	None
SWP2	-	N/A	7.62	2.29	114	14.7	2.79	Clear/Light Brown	None
SWP4	-	N/A	7.58	1.314	-26	17.5	3.47	Clear/Light Brown	None
SWP5	-	N/A	9.09	0.889	40	12.3	12.51	Brown	None

- Notes:**
1. SWL Standing Water Level, measured to the top of the monument or casing; RL – reference level;
 2. - not measured;
 3. N/A = Not applicable
 4. DO = dissolved oxygen;
 5. ORP = electron activity; and
 6. EC= electrolytic conductivity

TABLE 2 WATER LABORATORY RESULTS – MAY 2017

Sample	pH	TDS mg/L	Na mg/L	Ca mg/L	K mg/L	Mg mg/L	NH ₄ -N mg/L	Cl mg/L	F mg/L	NO ₃ mg/L	NO ₂ mg/L	SO ₄ mg/L	HCO ₃ mg/L	PO ₄ mg/L	TOC mg/L	BOD mg/L	Sol. Mn mg/L	Sol. Fe mg/L	Tot. Fe mg/L
BH1b	6.9	4100	680	120	235	100	375	855	0.22	<0.1	-	16	3240	0.31	165	6	0.1	1.1	4.4
BH2	6.8	1860	350	205	36	77	30	440	0.17	<0.1	-	49	1280	<0.1	38	5	0.45	0.28	3.9
BH3	7.2	815	49	155	33	21	29	130	0.13	41	-	100	520	<0.1	14	<2	0.14	0.05	1
BH4	7	930	125	160	13	29	7.1	175	<0.1	<0.1	-	97	600	<0.1	15	<2	0.18	0.19	1.8
BH10	7.1	1200	365	28	2.1	35	3.2	420	0.41	<0.1	-	70	470	3.2	7	14	0.12	0.26	2.4
BH13	6.8	1000	84	200	22	37	1.5	82	0.27	29	-	225	590	<0.1	19	5	0.22	0.12	1.5
BH14	6.6	890	49	145	82	33	<0.1	75	0.64	94	-	210	360	0.3	32	<2	0.12	0.1	0.12
BH15	6.8	3910	595	155	595	90	130	1410	0.17	<0.1	-	175	1380	2	210	3	0.5	14	16
BH16	6.7	1960	390	160	59	85	6	575	0.17	<0.1	-	165	940	0.24	56	<2	0.08	0.37	0.95
BH19	7.1	1050	79	230	10	36	6.9	190	<0.1	<0.1	-	125	670	<0.1	14	<2	0.09	0.25	2
BH20	7.5	780	43	155	26	24	17	90	0.14	<0.1	-	165	470	0.34	18	<2	0.06	0.09	0.72
LP1	7.5	8240	1260	180	445	99	1030	1460	0.5	<0.1	-	135	7000	22	575	97	0.41	2.3	2.4
SWC2	-	-	-	-	-	-	0.1	-	-	0.31	-	-	165	-	-	-	-	0.07	0.84
SWP1	7.5	1160	250	70	31	48	0.1	320	0.34	0.31	-	200	400	<0.1	-	-	-	0.05	0.12
SWP2	7.7	1480	295	130	36	57	7.1	310	0.24	1.2	-	260	700	0.11	-	-	-	0.14	0.16
SWP4	7.7	1230	270	73	27	48	5.5	325	0.34	8.1	-	210	455	<0.1	29	<2	-	0.02	0.09
SWP5	8.2	540	110	42	21	18	0.8	105	0.23	7.8	-	120	205	0.12	30	33	-	0.24	3.3
SWC-UP	7.3	32100	9450	415	465	1140	<0.1	17500	0.46	0.18	-	2280	265	<0.1	-	-	-	0.22	1.2
SWC-DOWN	7.4	30600	9220	375	420	1040	<0.1	16800	0.44	0.27	-	2080	295	<0.1	-	-	-	0.16	-
ANZECC 2000	6.5-8.0	-	-	-	-	-	1.88*	-	-	10.6 [#]	-	-	-	-	-	-	-	0.3	-

Notes:

1. results and guidelines are expressed in mg/L
2. SWC_Do – SWC_Down;
3. - not analysed;
4. guidelines levels from ANZECC (2000) – *Australian and New Zealand guidelines for fresh and marine water quality for the protection of aquatic ecosystems*;
5. * - guideline from freshwater trigger values as total NH₄-N at different pH values - Table 8.3.7 of ANZECC (2000) - based on average laboratory pH of 7.3 from pH values presented above;
6. # - # - based on the recalculated trigger value for freshwater, Hickey 2013; and
7. values above the guidelines are **bolded**.

TABLE 3 SURFACE WATER RESULTS – MAY 2017

Sample	NH ₄ -N	HCO ₃	Sol. Fe	Tot Fe	FCs	E. Coli
Units	mg/L	mg/L	mg/L	mg/L	CFU/100ml	CFU/100ml
LP1	1030	7000	2.3	2.4	1700	1300
SWC2	0.1	165	0.07	0.84	-	-
SWC-UP	<0.1	265	0.22	1.2	-	-
SWC-Down	<0.1	295	0.16	1.1	-	-
SWP1	0.1	400	0.05	0.12	-	-
SWP2	7.1	700	0.14	0.16	-	-
SWP4	5.5	455	0.02	0.09	-	-
SWP5	0.8	205	0.24	3.3	-	-
ANZECC 2000	1.88*	-	0.3 [#]	-	-	-

Notes:

1. - = not analysed;
2. FCs = faecal coliforms;
3. E. Coli = Escherichia coli;
4. guidelines levels from ANZECC (2000) – Australian and New Zealand guidelines for fresh and marine water quality for the protection of aquatic ecosystems;
5. * = guideline from marine trigger values as total NH₄-N at different pH values - Table 8.3.7 of ANZECC (2000) - Table 8.3.7 of ANZECC (2000) - based on average laboratory pH of 7.3 from pH values presented in Table 1;
6. # = interim indicative working level presented in section 8.3.7 of ANZECC 2000 (based on Canadian derived guidelines); and
7. values above the guidelines are **bolded**.

TABLE 4 RATIOS OF PRINCIPAL IONS – MAY 2017

Bore	Na/Cl	Na/Ca	Mg/Ca	Ca/K	Cl/SO ₄	Cl/HCO ₃	K/TDS (%)	L/N (%)
BH1b	0.80	5.67	0.83	0.51	53.44	0.26	5.73	67.79
BH2	0.80	1.71	0.38	5.69	8.98	0.34	1.94	10.46
BH3	0.38	0.32	0.14	4.70	1.30	0.25	4.05	45.78
BH4	0.71	0.78	0.18	12.31	1.80	0.29	1.40	6.43
BH10	0.87	13.04	1.25	13.33	6.00	0.89	0.18	1.26
BH13	1.02	0.42	0.19	9.09	0.36	0.14	2.20	16.36
BH14	0.65	0.34	0.23	1.77	0.36	0.21	9.21	77.58
BH15	0.42	3.84	0.58	0.26	8.06	1.02	15.22	86.32
BH16	0.68	2.44	0.53	2.71	3.48	0.61	3.01	10.25
BH19	0.42	0.34	0.16	23.00	1.52	0.28	0.95	4.93
BH20	0.48	0.28	0.15	5.96	0.55	0.19	3.33	19.41
LP1	0.86	7.00	0.55	0.40	10.81	0.21	5.40	95.85
SWC2	-	-	-	-	-	-	-	-
SWP1	0.78	3.57	0.69	2.26	1.60	0.80	0.03	8.54
SWP2	0.95	2.27	0.44	3.61	1.19	0.44	0.02	9.19
SWP4	0.83	3.70	0.66	2.70	1.55	0.71	0.02	10.38
SWP5	1.05	2.62	0.43	2.00	0.88	0.51	0.04	17.41
SWC-UP	0.54	22.77	2.75	0.89	7.68	66.04	0.01	4.23
SWC-DOWN	0.55	24.59	2.77	0.89	8.08	56.95	0.01	3.95

Notes:

1. SWC_Do – SWC_Down;
2. % indicates ratios are presented in percentage in that column; and
3. L/N = leachate/non-leachate ratio ; $[(K + NH_4 + NO_3 + NO_2)/(Ca + Mg + Na)] \times 100$.

TABLE 5 SUMMARY OF GAS ANALYSIS – MAY 2017

Location	GA 5000 V/V%	ILU V/V%
Landfill cap	0	0.098
Main weigh bridge, weigh bridge office and landfill office sheds	0	0.00123
Dunmore Resource & Recycling Services	0	0.00035
GUIDELINES	1.25 % v/v / 0.05 % v/v	1.25 % v/v / 0.05 % v/v

Notes:

1. results and guidelines are expressed in V/V %;
 2. Guidelines are as per the NSW EPA (1996) reporting accumulation value of 1.25 % v/v CH₄; and surface emission trigger value (500 ppm or 0.05 % v/v); and
 3. values above the guidelines are **bolded**.
-

TABLE 6 QA/QC – MAY 2017

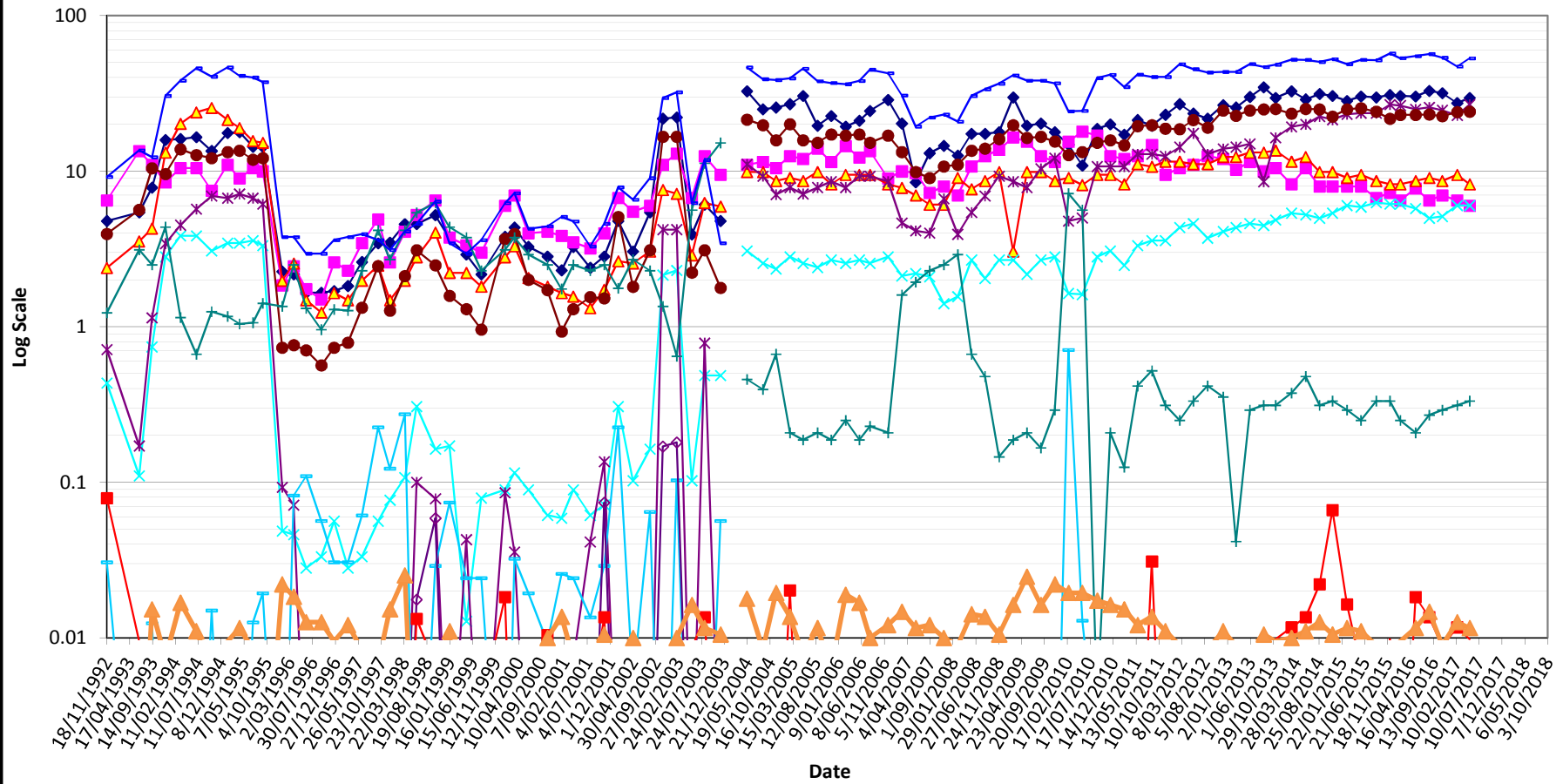
Analytes	BH16	FD1	RPD (%)
pH	6.70	6.70	0.00
TDS	1960	1930	1.54
Na+	390	400	2.53
Ca++	160	165	3.08
Mg++	85	82	3.59
K+	59	57	3.45
NH4-N	6	6.1	1.65
Cl-	575	565	1.75
SO4--	165	160	3.08
HCO3-	940	945	0.53
NO3-	0.05	0.05	0.00
PO4---	0.24	0.23	4.26
F-	0.17	0.18	5.71
BOD	1	1	0.00
Fe.D	0.37	0.4	7.79
Fe.T	0.95	0.92	3.21
Mn.D	0.08	0.07	13.33
TOC	56	58	3.51

Notes:

1. results are expressed in mg/L;
2. RPD – Relative Percentage Difference
3. NA - not analysed;
4. values requiring further investigation are **bolded**.

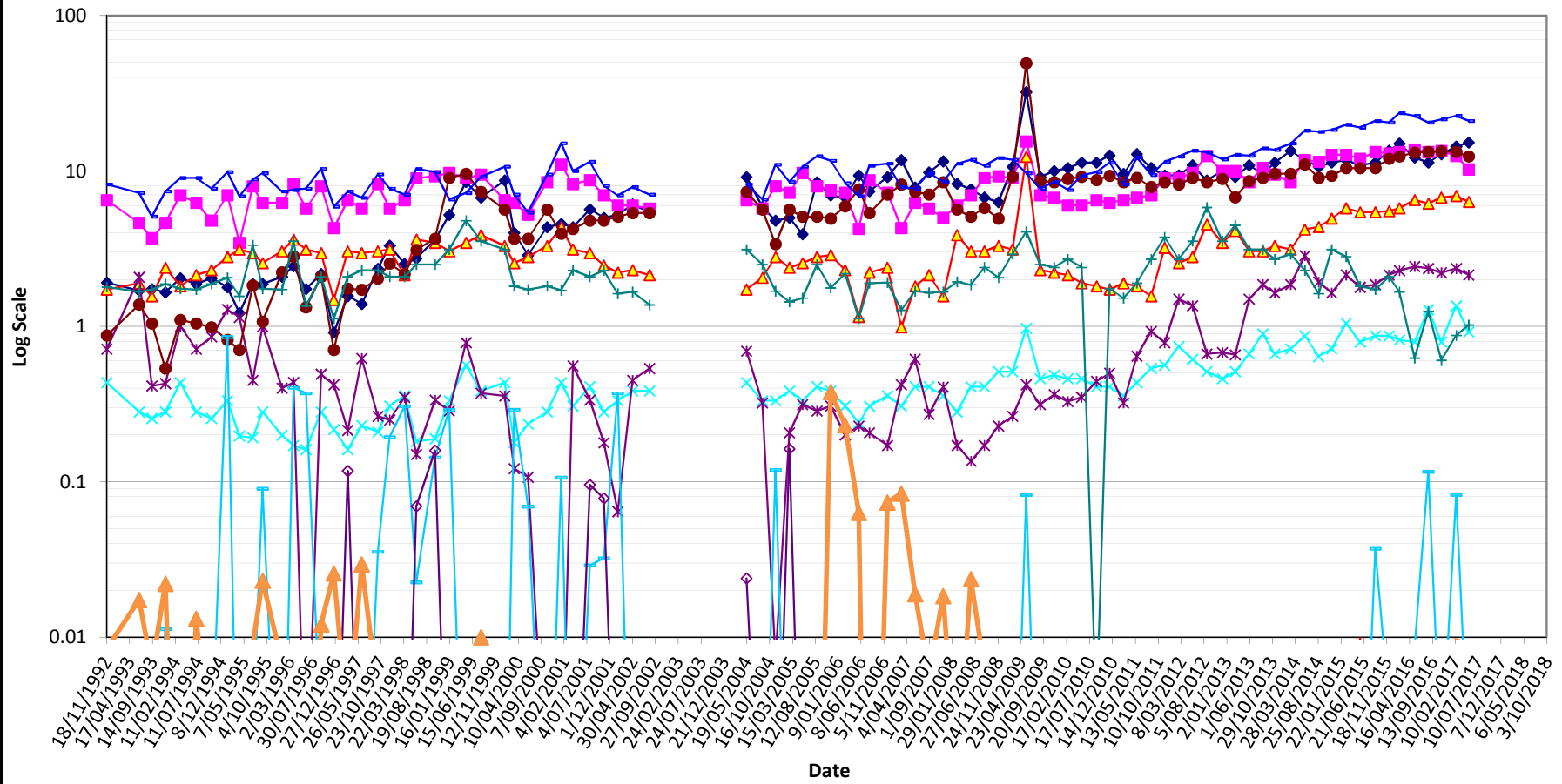
ATTACHMENT 3 SCHOELLER PLOTS

BH1 a/b

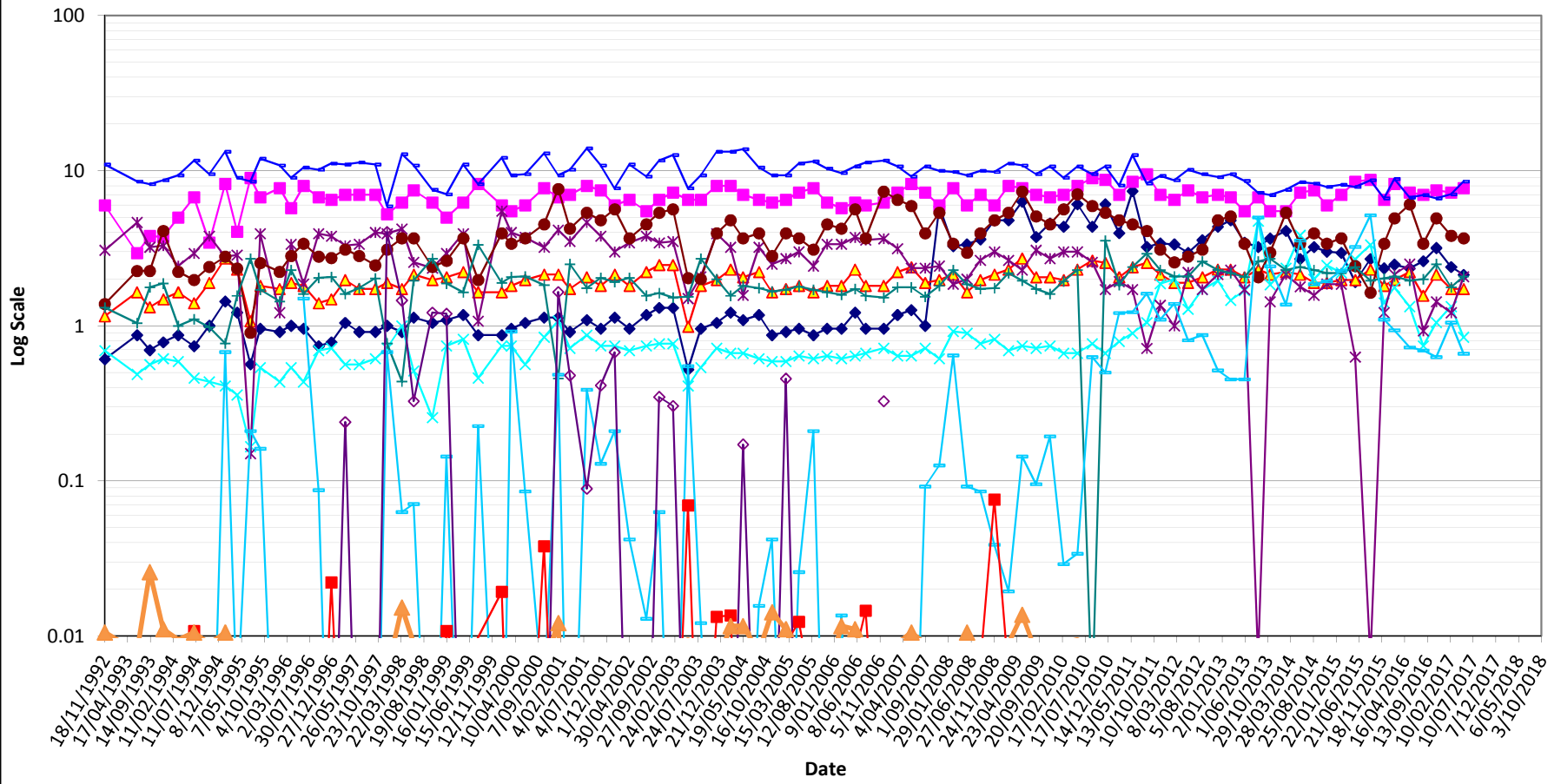


- Na meq/L
- Ca
- Mg
- K
- NH4-N
- Cl
- SO4
- HCO3
- NO3
- NO2
- PO4
- F

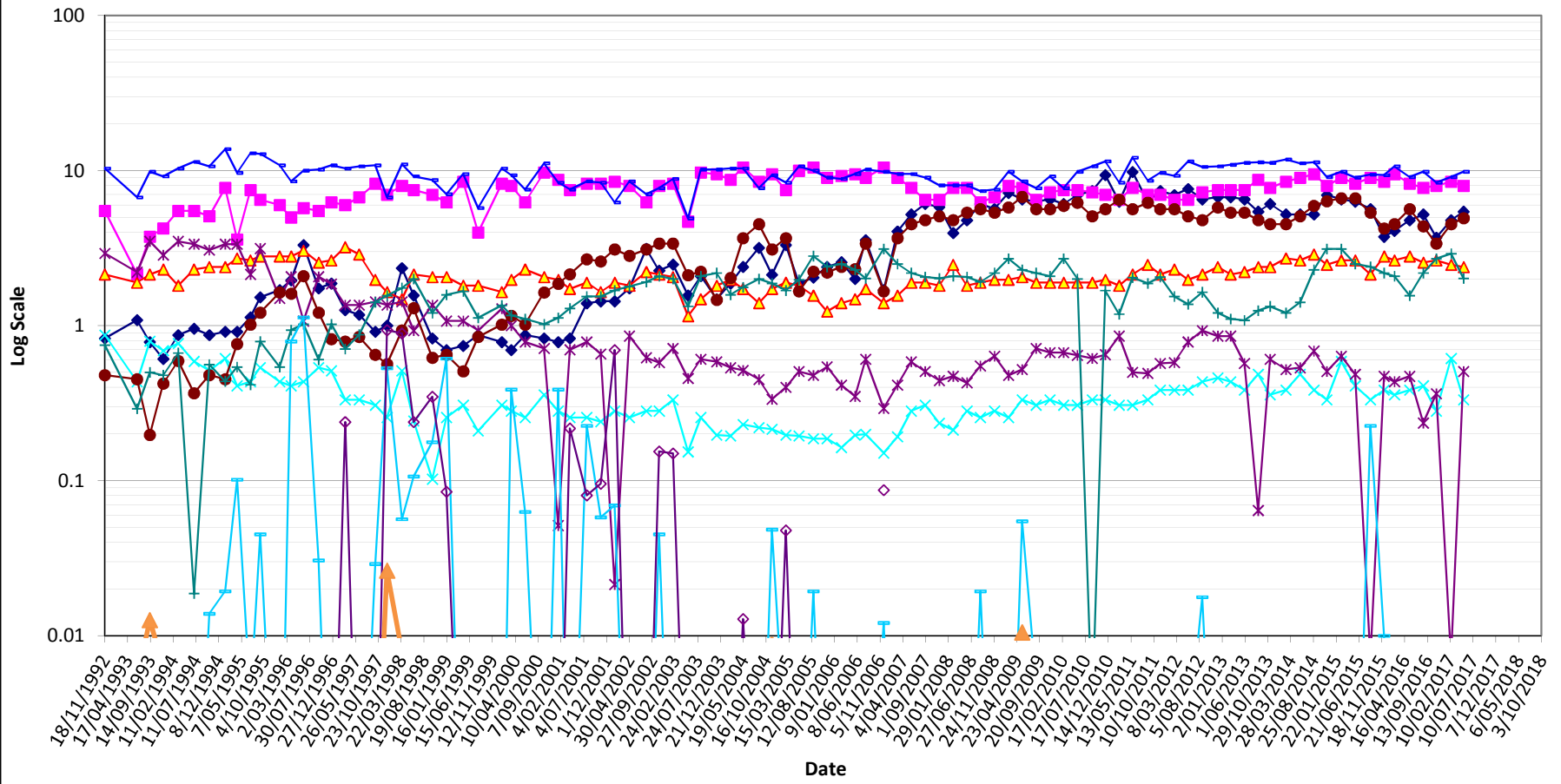
BH2



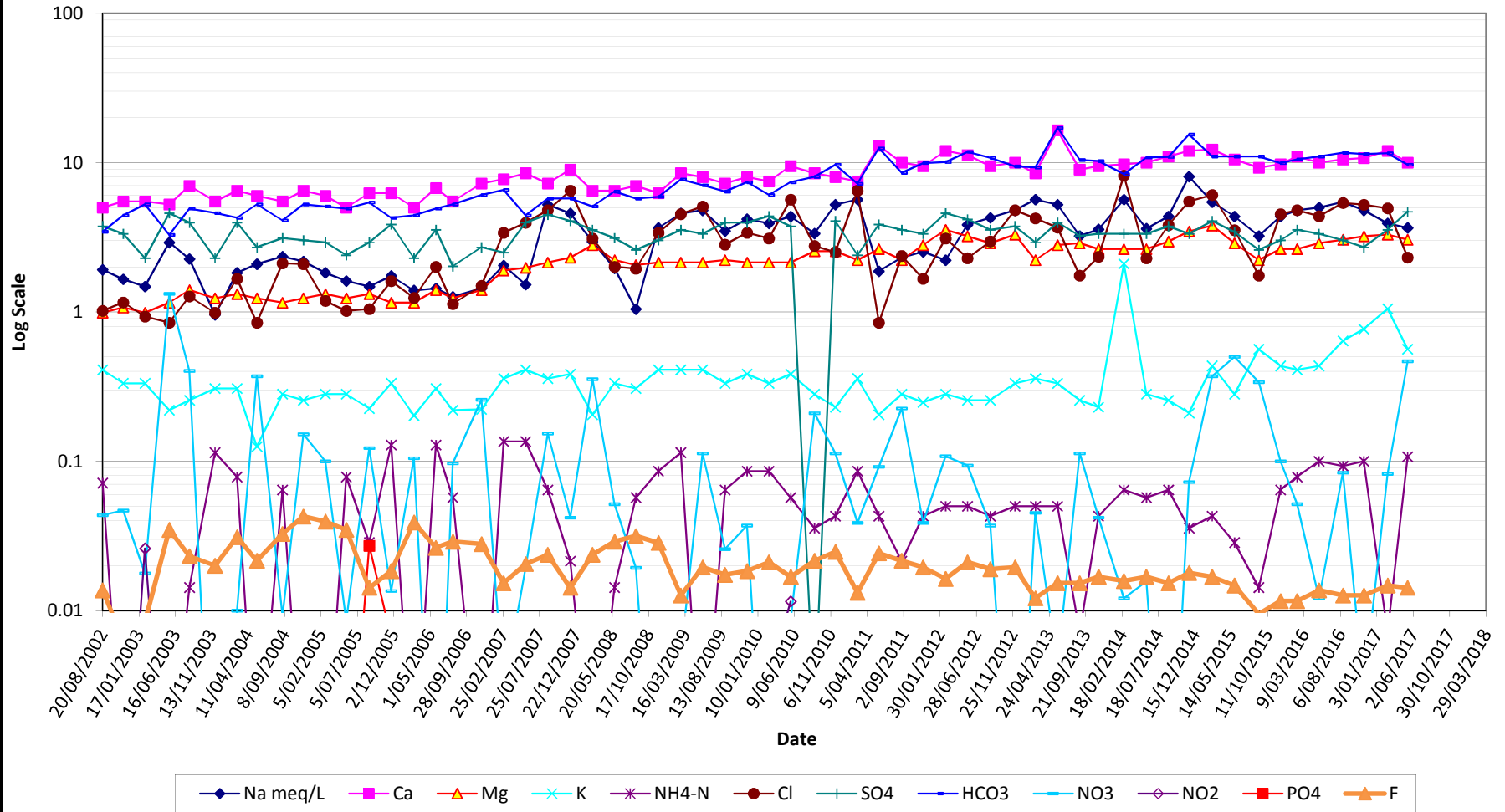
BH3



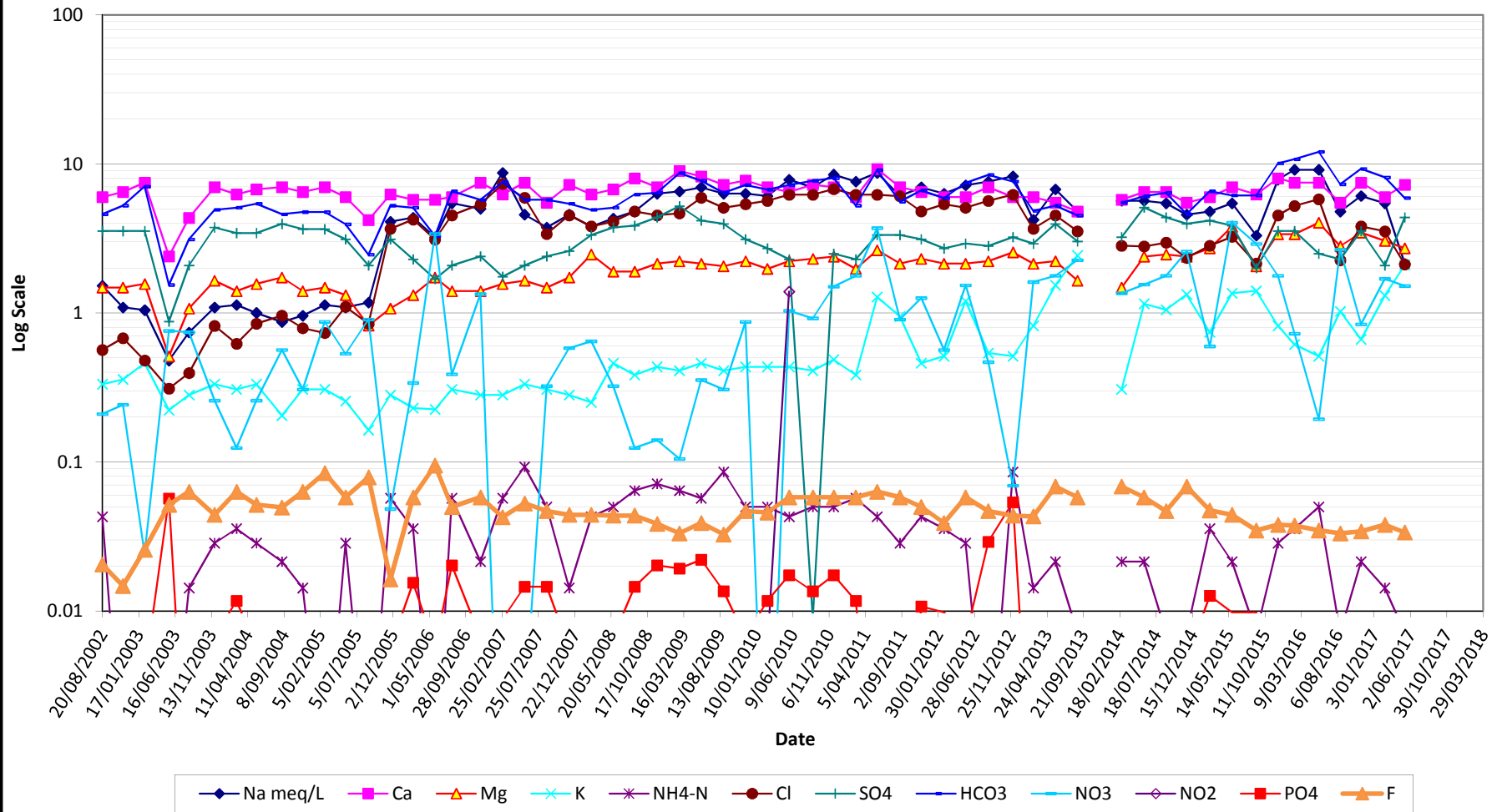
BH4



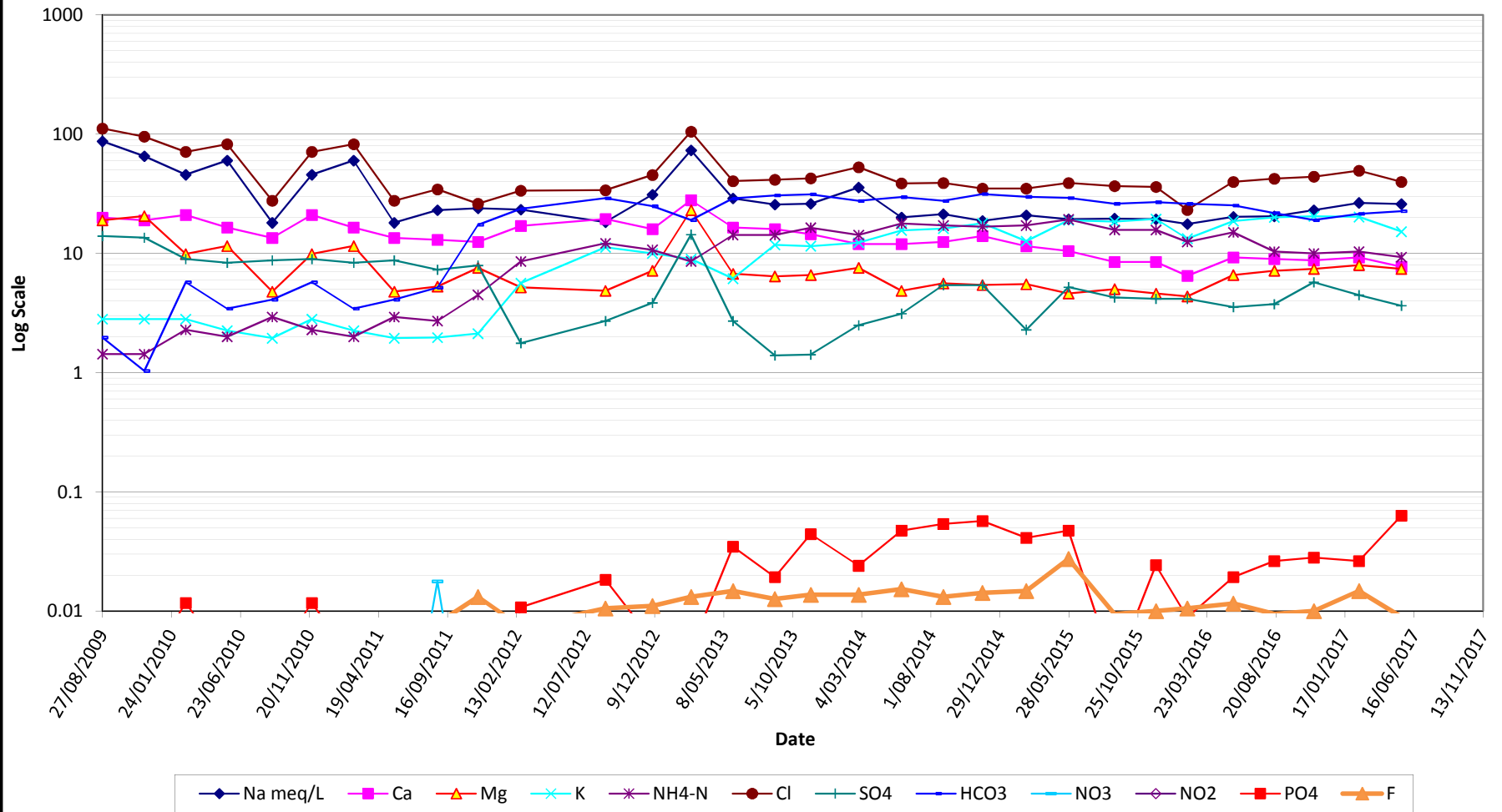
BH13



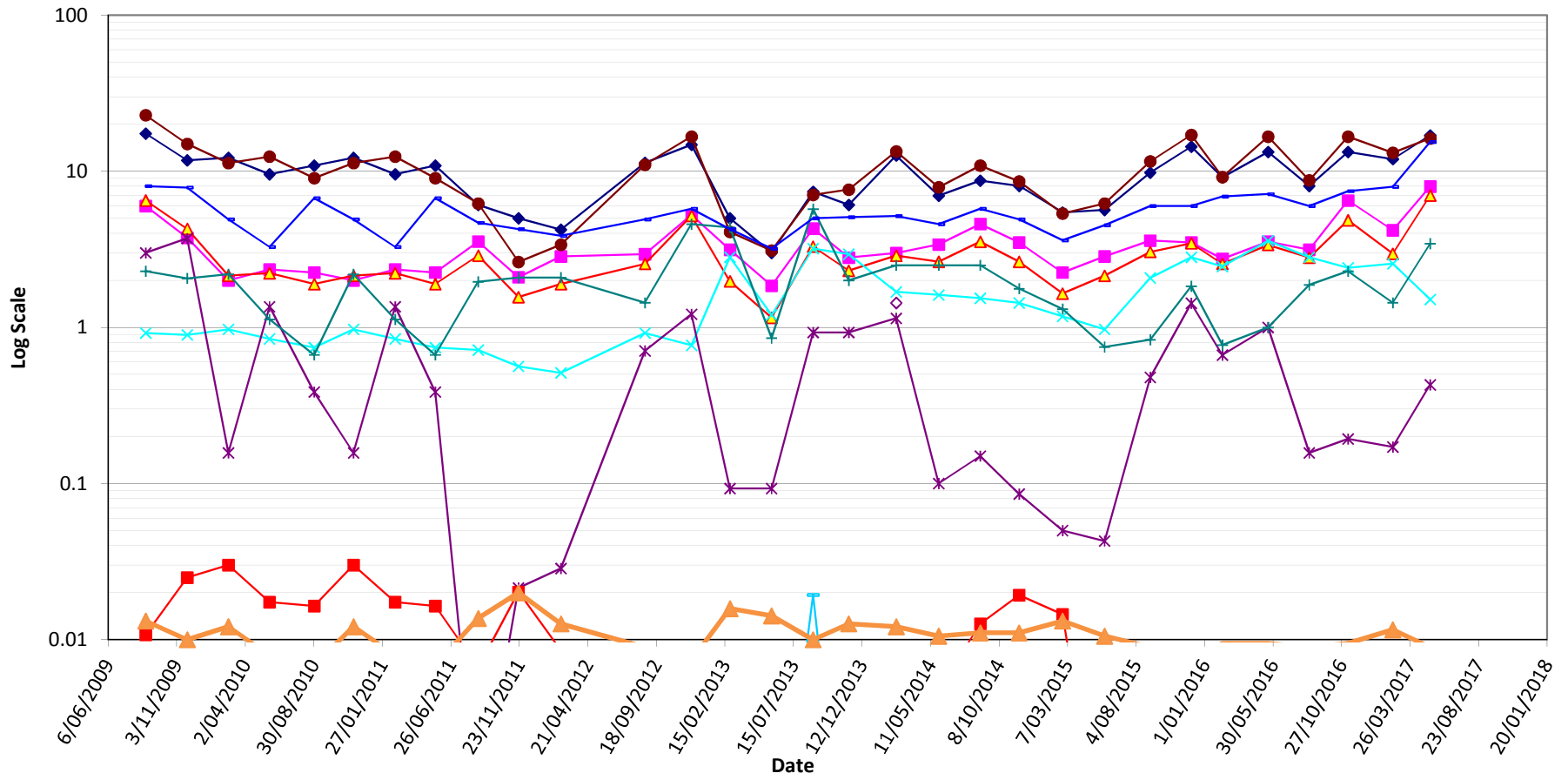
BH14



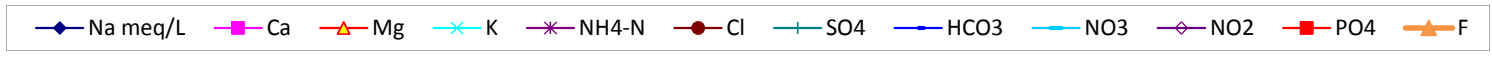
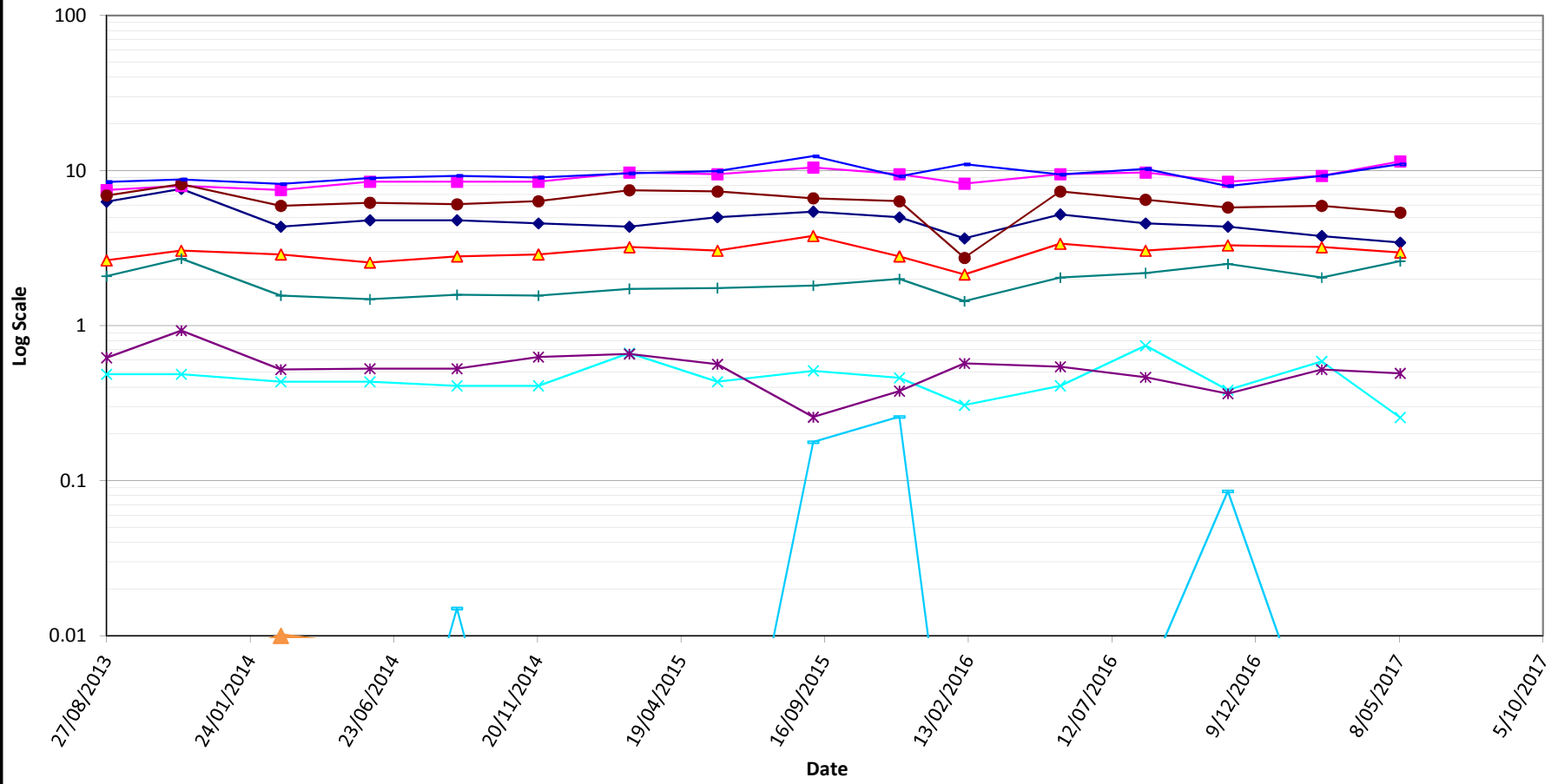
BH15



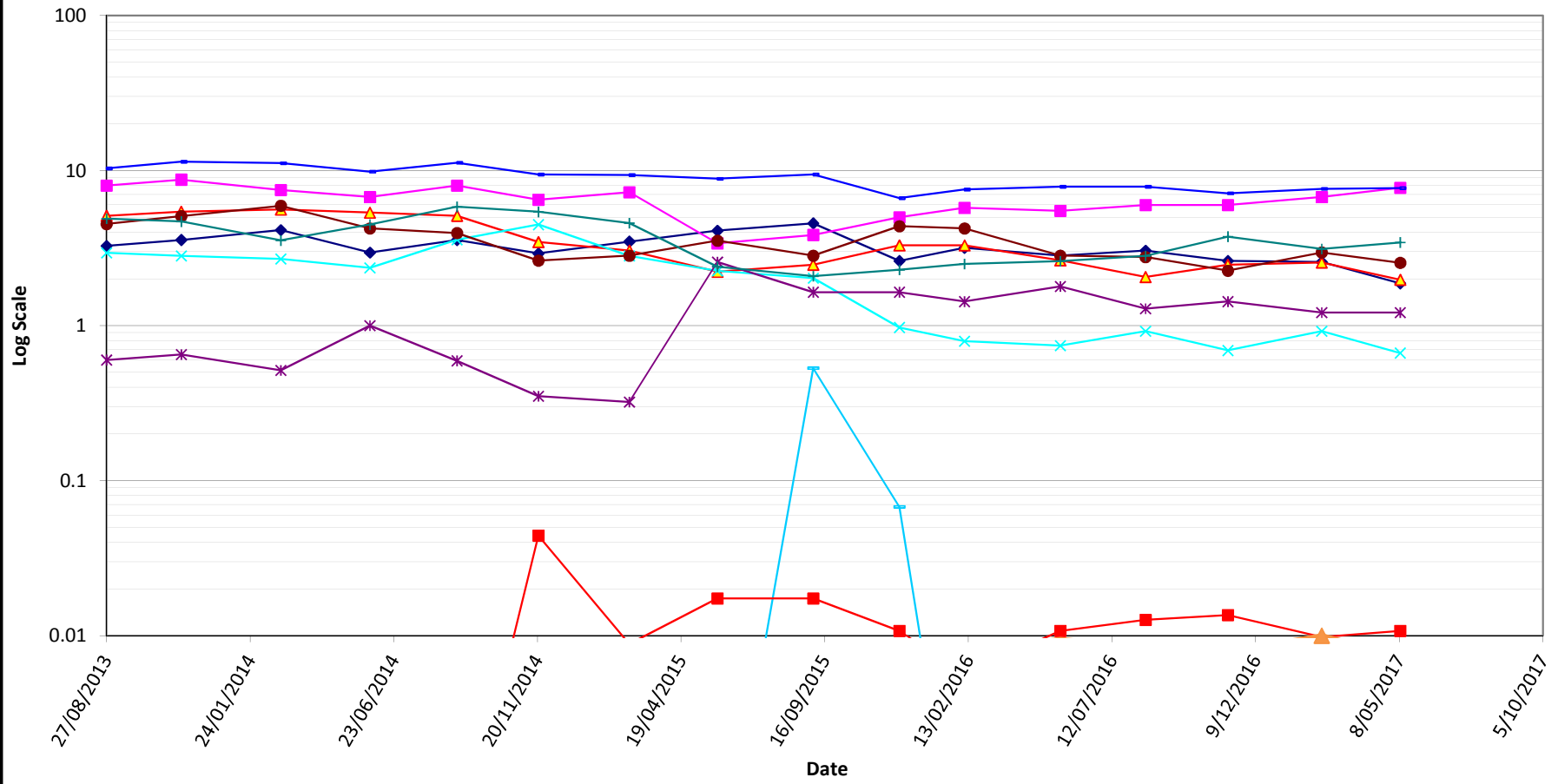
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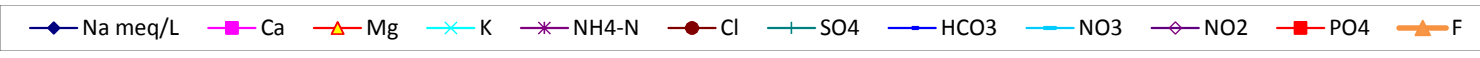
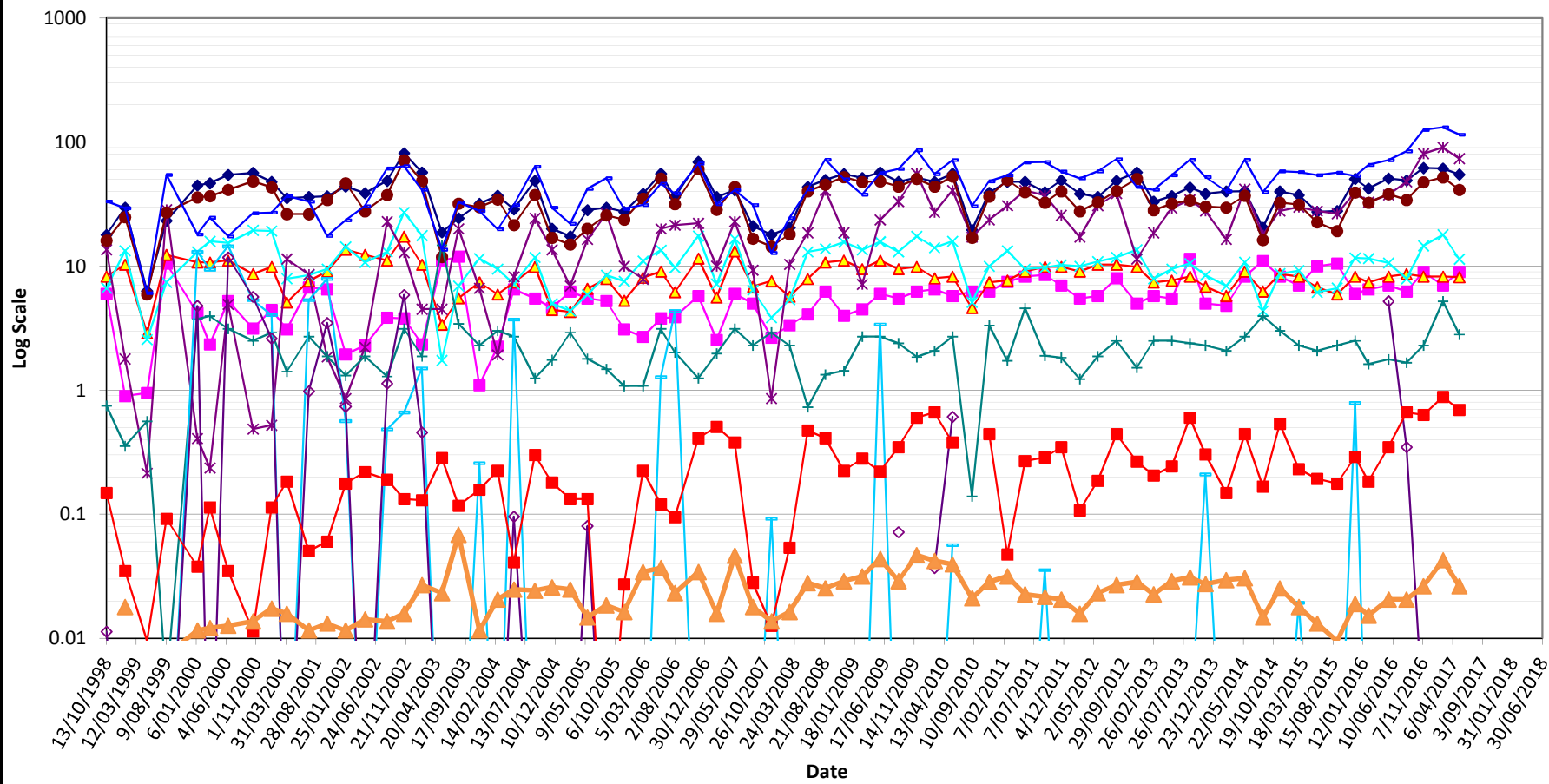
BH19



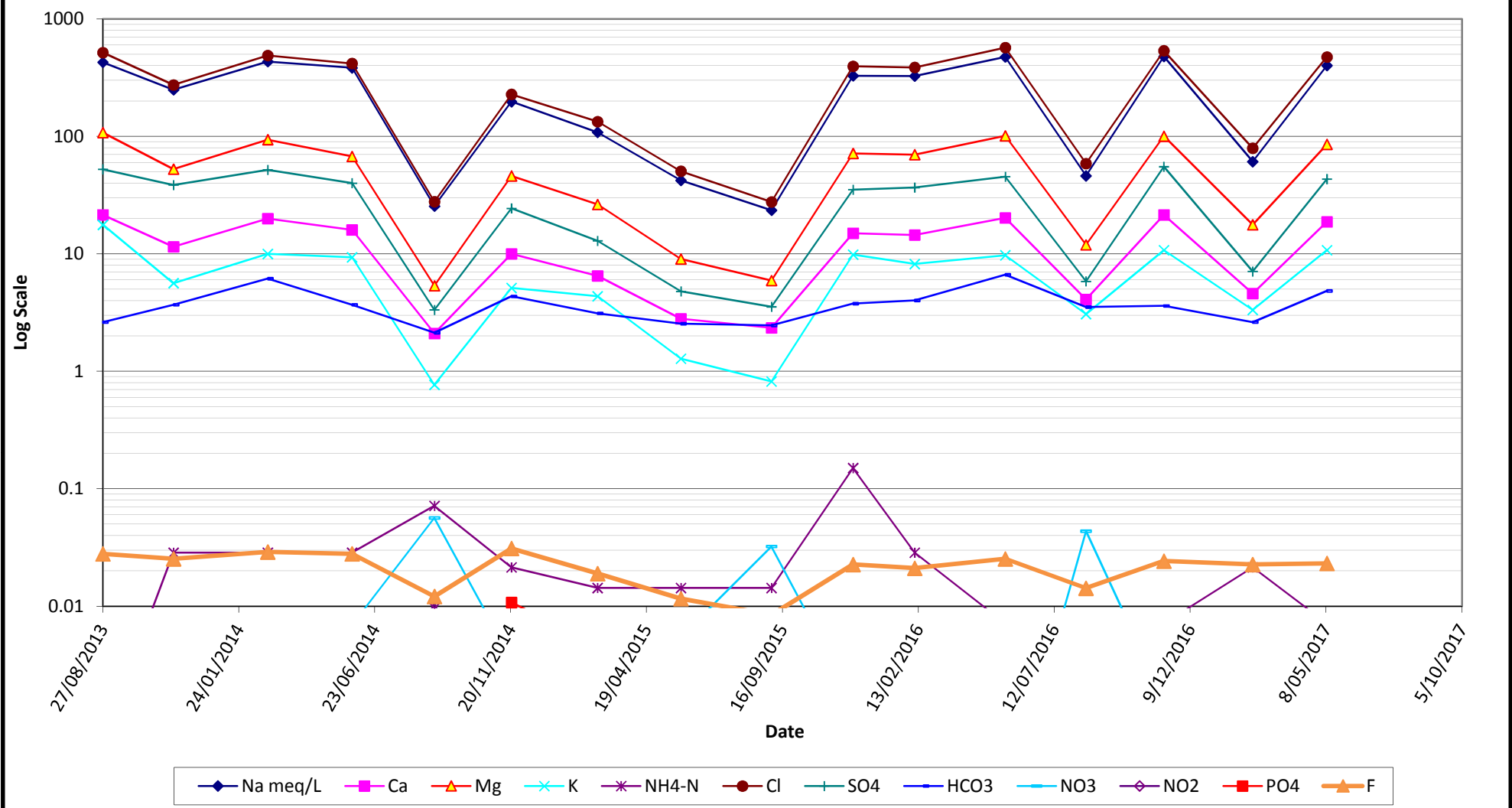
BH20



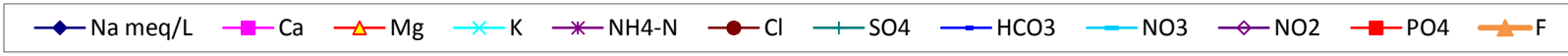
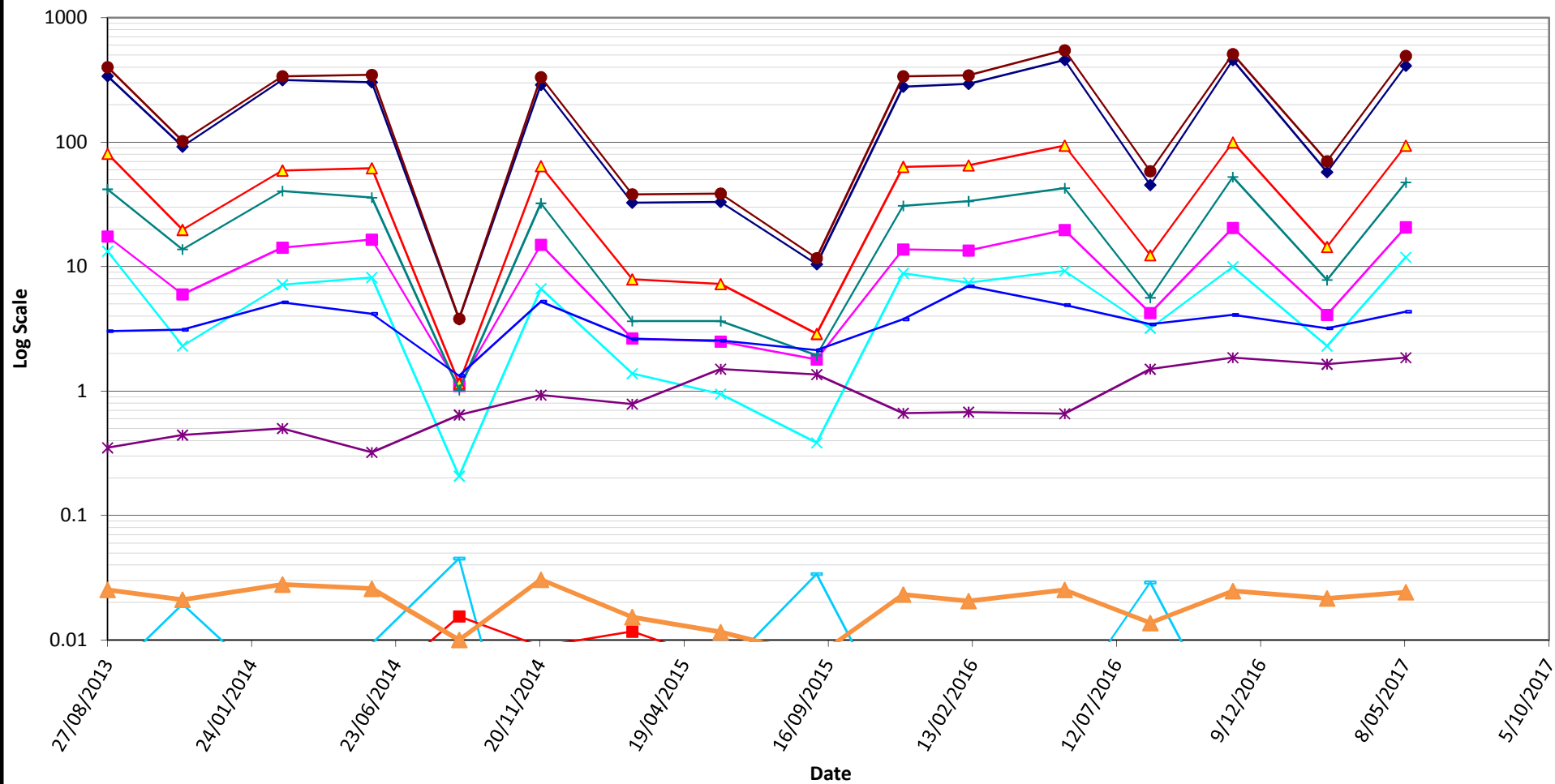
LP



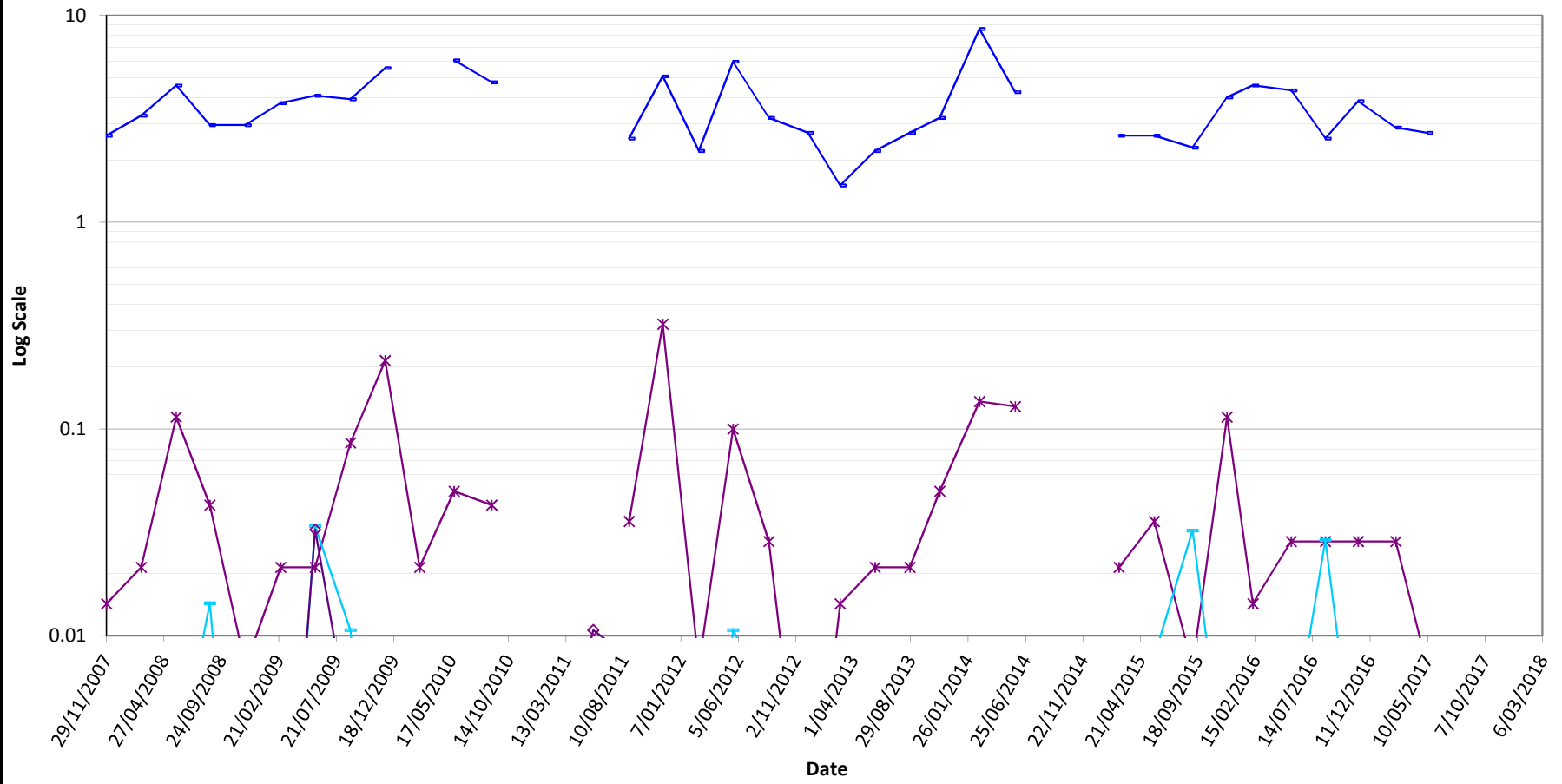
SWC_Down



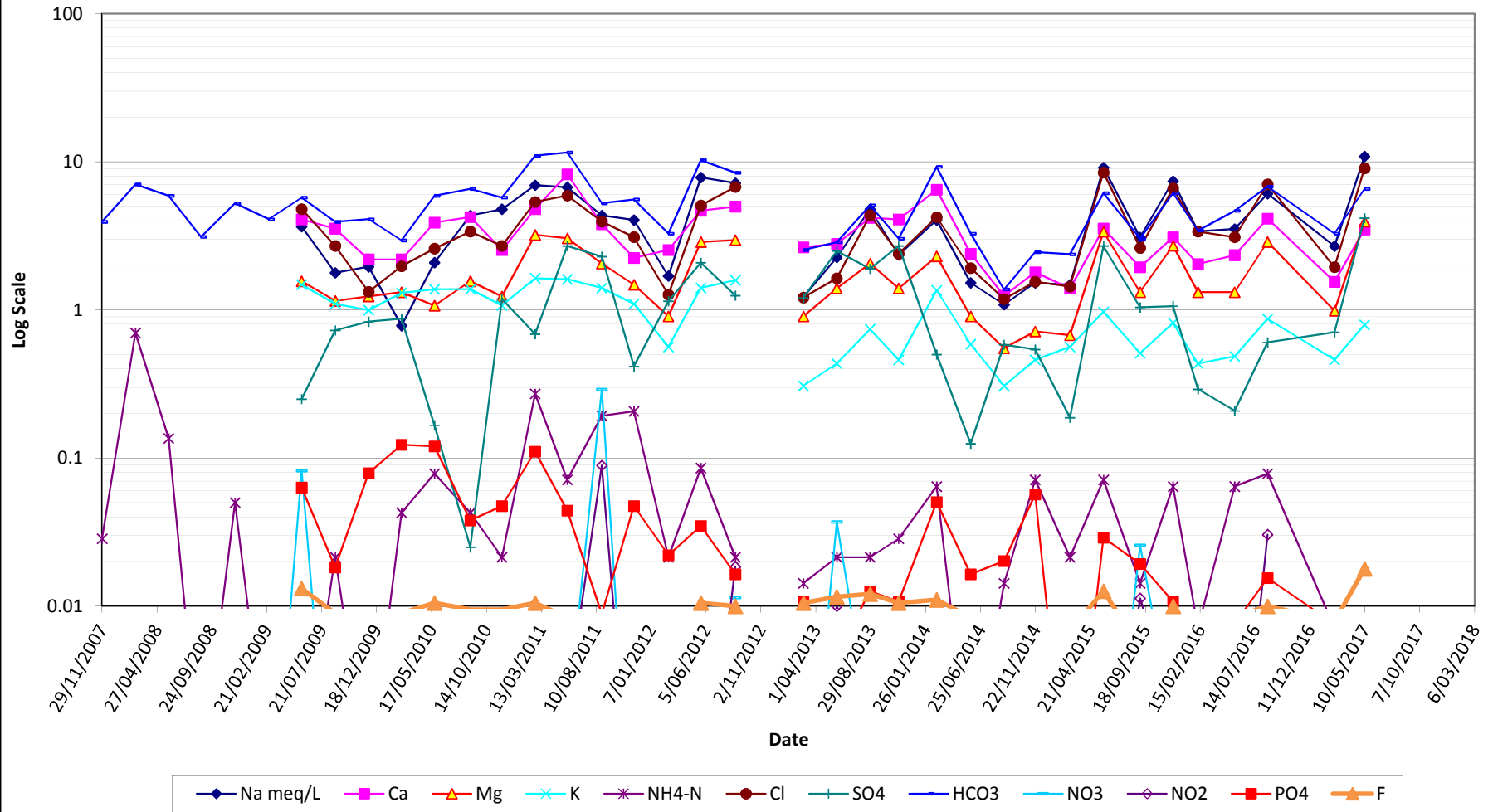
SWC_Up



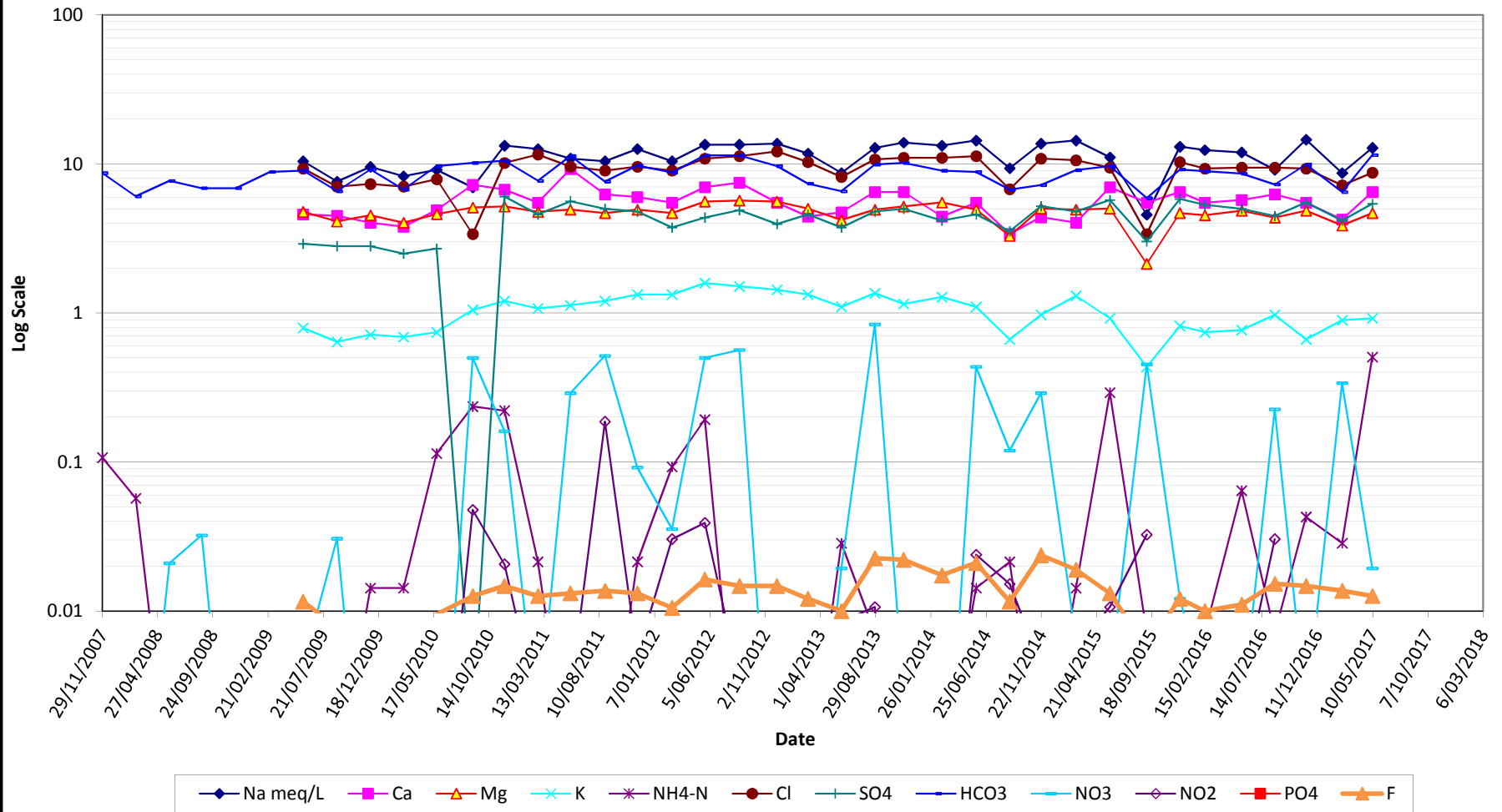
SWC2



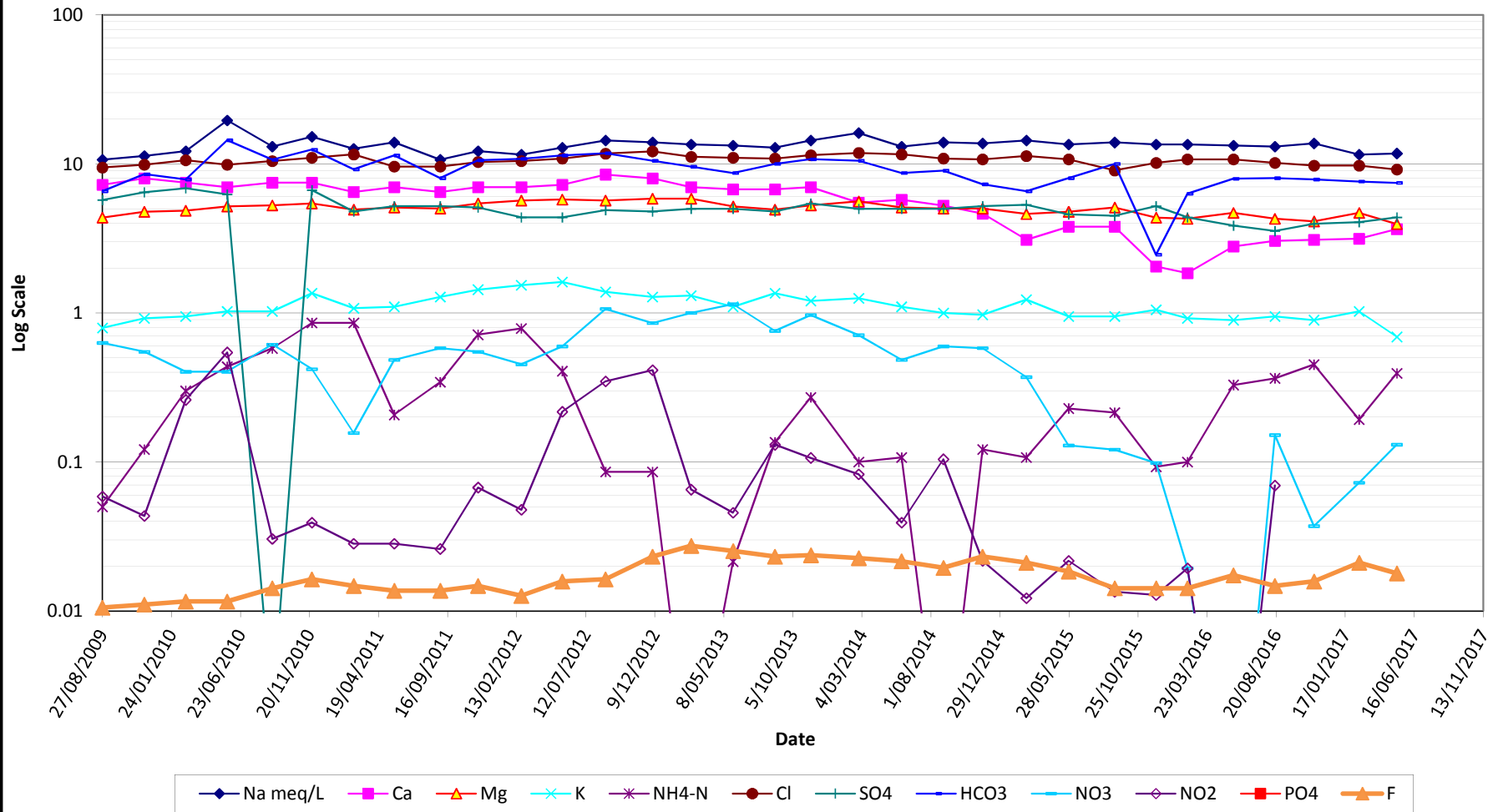
SWP1



SWP2



SWP4



SWP5

