ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

22 December 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,

November 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 November 2017 monitoring round was undertaken on 22 November 2017. During the November 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 (BH1c to BH4, BH13 to BH16, BH19, BH20 and BH20s). At BH9 and BH10 only the standing water level (SWL) was measured and no samples were taken. Surface water was collected from the leachate pond (LP1), four on site retention ponds (SWP1, SWP2, SWP4 and SWP5) and Rocklow Creek at four points (SWC2, SWC_Up, SWC_Down and SWC_Down_2). BH20s and SWC_Down_2 were the two new locations added to the monitoring plan. The purpose of these two additions was to eliminate two of the data gaps detected in the scope of the data review conducted on August 2017 (Environmental Earth Sciences NSW 2017). 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 was undertaken 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 November 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, SWC_Down and SWC_Down_2) – 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). One sample collected from the leachate tanks was sent to the National Measurement Institute (NMI) for organic chemical analysis. All three 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 November 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 August 2017 (24.8 mm), September 2017 (0 mm), October 2017 (24 mm) and November 2017[1] (115 mm) was 163.8 mm *(BOM – Albion Park Wollongong Airport weather station).* Groundwater levels decreased at most monitoring wells (BH1c, 4, 9, 10, 14, 15, 19, and 20s). Groundwater increased at the remaining monitoring wells (BH2, 3, 13 and 16). The average of the measured standing water levels throughout the site has increased by ~0.05 mAHD from 0.92 mAHD in August 2017 to 0.97 mAHD in November 2017. This is thought to be associated with relatively high precipitation rates that occurred in November prior to the monitoring period.

5.2 Groundwater

5.2.1 Groundwater sampling locations impacted by leachate

Field and laboratory results from the November 2017 sampling round, specifically from the bores BH1c, BH2, BH3, BH14, BH15, BH16, BH20 and BH20s displayed chemistry that can be related to leachate impact — BH1c, BH3, BH15 and BH20s showed stronger leachate indicators with high levels of TDS, potassium, ammonium and nitrate. 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 to correspond with a ratio of >20 (Table 4, Attachment 1).

Bore BH1c 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/c, Attachment 3). This continued during the current monitoring event and the groundwater was found to have a light brown colour, and leachate odour noted in combination with elevated TDS (4010 mg/L), K^+ (230 mg/L) [resulting in low Ca/K – 0.69] and NH_4^+-N (320 mg/L) concentrations. The low levels of oxygen (1.5 ppm Table 1) and presence of soluble Fe^{2+} indicate an anaerobic state and 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, May 2017, August 2017 and November 2017 rounds and were 8, 7, 7, 6, 6 and 6 mg/L respectively. Further evidence of microbial activity / respiration is elevated HCO_3^- resulting in a low Cl/HCO_3^- ratio of 0.29 (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. NH_4^+-N concentration at BH2 showed an increasing trend since 2010 and reached its historical maximum in August 2017 (49 mg/L). This level was sustained in the November 2017 sampling round. 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^-) and potassium (K^+) concentrations slightly decreased whilst calcium (Ca^{2+}) slightly increased since the last monitoring round (Table 2, Schoeller plot BH2, Attachment 3). This is representative of the small 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 leachate odour was noted.

[1] Up until the day of sampling (22 November 2017)

Groundwater from bore BH3 reported decreases in concentration of three native ions (Na^+, Cl^- and Mg^{2+}) as well as one non-native ion (NH_4^+-N) since last monitoring round. Comparatively, the concentration of NO_3^- and Ca^{2+} increased whilst K^+ remained stable. The L/N ratio (54.41%) has increased since the August 2017 monitoring round (41.74%). 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 NH_4^+-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.

The L/N ratio at bore BH14 showed an increase in the November 2017 round (19.74%) — in August 2017 monitoring round the L/N ratio was 10.07% at this location. Concentrations of K^+ and NO_3^- were higher in the November 2017 monitoring period compared to August 2017 levels (Schoeller plot BH14, Attachment 3). NH_4^+-N concentration decreased from the peak it reached at this location in August 2017 to levels that are consistent with historical data. 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 109.33% which can be attributed to the elevated K^+ concentrations and the decrease in Na^+ and Mg^{2+} concentrations. The K^+/TDS ratio of 18.51% was high when compared to non-leachate influenced sites generally with K^+/TDS < 3 (Schoeller plot BH15, Attachment 1). Ammonium (NH_4^+-N) is elevated at 110 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 elevated levels of soluble Mn^{2+} (0.40 mg/L) and Fe^{2+} (19 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 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 brown/black colour and a sulfuric odour. The sampled redox potential indicates a reducing environment (-145 mV), which may have an influence in the dominance of NH4+-N over NO3. Groundwater sampling in November 2017 indicated leachate impact at BH16 which was represented by the L/N ratio of 21.58% and relatively high K/TDS ratio (5.89%). These elevated levels can be attributed to the decrease in concentrations of native ions (Na^+ Ca^{2+} and Mg^{2+}) and the increase in concentrations of two non-native ions (K^+ and NH_4^+-N). Stockpiles of organic waste in close proximity to bore BH16 could be influencing the groundwater chemical characteristics. Additionally, bores BH15 and BH16 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 (-86 mV) with a light brown colour of the groundwater. The L/N ratio (18.60 %) in the November 2017 round remained relatively stable compared with the last monitoring round (19.96%). K^+, showed a slight decrease from 31 mg/L (August 2017) to 29 mg/L (November 2017). The TDS remained relatively low (730 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 15 mg/L however other landfill indicators were low or absent.

Bore BH20s is located directly adjacent to BH20 but at a shallower depth – *screened intervals of BH20 and BH20s are 6.0-9.0 mBGL and 1.5-4.5 mBGL respectively*. Similarly, this bore was positioned to compare the chemical characteristics on boundary of the landfill site in order to locate potential transport pathways to Rocklow Creek. Field observations at bore BH20s recorded a positive redox (7.9 mV), light brown colour of the groundwater and no odour was detected. The L/N ratio (56.56 %) indicated potentially high leachate impact at this site. However, TDS is relatively low (730 mg/L) making the L/N susceptible to natural variations or fluctuations in chemistry. Chemical characteristics of the bore show groundwater was high in nitrate (42mg/L), low in Na^+, with a moderate Ca/K and K/TDS ratio (Table 4). Ammonium levels (0.2 mg/L) are lower than those seen at the deeper BH20 bore. The presence of nitrate at high levels in this shallower bore location is indicative of nitrification throughout the soil profile.

5.2.2 Remaining groundwater sampling locations

During the November 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.

In the November 2017 monitoring round, bore BH4 showed minor leachate influence. Field observations (such as clear water and no odour) and chemical results such as relatively low K^+ and a corresponding high Ca/K ratio of 10.6 indicate no or limited leachate influence. Ammonium (NH_4^+-N) levels (7.2 mg/L) remains 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 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 November 2017 monitoring round shows a decrease of L/N ratio (7.56%) compared to the August 2017 round (11.38%). TDS levels also decreased from August 2017 to November 2017 sampling events. The chemical composition of the groundwater has remained consistent since monitoring began in 2002 (Schoeller plot BH13, Attachment 3).

Bore BH19 is located on the south west boundary of the site. Field observations included a negative ORP and grey colouring to the groundwater. The chemical characteristics of the groundwater support no or limited leachate influence with an L/N ratio of 7.25% 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 (6.3 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 all but two of the bores across the site with bores BH1c (320 mg/L), BH2 (49 mg/L), BH3 (11 mg/L), BH4 (7.2 mg/L), BH13 (2.7 mg/L), BH15 (110 mg/L), BH16 (6.9 mg/L), BH19 (6.3 mg/L) and BH20 (12 mg/L) above threshold levels. Nitrate (NO_3^-) was reported above guideline thresholds (ANZECC 2000) at BH3 (36 mg/L) and BH20s (42 mg/L).

5.3 Surface water monitoring

During November 2017 monitoring round samples from Rocklow Creek (SWC2, SWC_Up, SWC_Down and SWC_Down_2) 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 within the historical range. SWC_Down_2 was sampled for the first time in November 2017 and hence does not have a corresponding historical data set. 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 330 mg/L and the nitrogen species were low (NH_4-N at 0.1 mg/L and NO_3^- at 0.1 mg/L), which indicate little to no leachate influence.

Surface water sampled at SWP2 showed minor leachate impact. The surface water pond collects runoff from around the site and potential impacts from site activities are often observed. Ammonium concentration reduced to 0.10 mg/L during this sampling round compared to August 2017 round (2.70 mg/L). Nitrate (NO_3^-) was above the ANZECC 2000 trigger value with a concentration of 11 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.

SWP4 displayed ammonium (NH_4^+-N) levels of 1.1 mg/L which is above the defined trigger value. Nitrate (NO_3^-) levels decreased slightly to 15 mg/L which is still above the trigger value established by the ANZECC 2000 guidelines. These values are indicative of the occurrence of the natural process of nitrification by which NH_4-N naturally attenuates. All chemical parameters at this location are within historical ranges. Both SWP4 and SWP2 had a decrease in NH_4-N although it should continue to be monitored for any fluctuations in chemical composition indicating a more prominent leachate impact.

Surface water sampled at SWP5 displayed an L/N ratio associated with significant leachate impact. However, due to the low levels of TDS at this location the L/N ratio is susceptible to natural variations or fluctuations in chemistry. Ammonium concentration was relatively low (0.5 mg/L) with comparatively high nitrate concentration (60 mg/L). Similarly to SWP4, these values are indicative of the process of nitrification by which NH_4-N naturally attenuates.

The four surface water creek sites SWC2, SWC_Up, SWC_Down and SWC_Down_2 were also sampled during the November 2017 sampling event. SWC_Up, SWC_Down and SWC_Down_2 are up-and-down-gradient of SWC2 and help assess leachate impacts within Rocklow Creek. SWC_Down_2 is a new sampling location which was established in order to detect potential leachate impacts to Rocklow Creek originated from the eastern portion of the site (Environmental Earth Sciences NSW 2017). SWC_Up, SWC_Down and SWC_Down_2 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. All surface water creek sampling sites (SWC2, SWC_Up, SWC_Down and SWC_Down_2) had low concentrations of NH_4^+-N (<0.6 mg/L) and NO_3^- (<0.9 mg/L). All four sites will continue to be monitored to ensure leachate is not impacting upon the Rocklow Creek.

5.4 Monitoring of Leachate Tanks

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, NH_4^+-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 18000 and 18000 CFU/100 ml respectively which is a significant increase on the previous monitoring round (Table 3). 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 0.76% to 4.86%. 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 0.00% and 5.74% (RPD < 10%). The relationship between the field determined EC and laboratory measured TDS relationship ranged between 0.54 and 0.82. 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 (except for LP1 which yielded aTDS/EC ratio of 1.77).

RPDs between the intra-laboratory duplicate and the primary sample taken at bore BH3 were all within the acceptable RPD criteria. Thus, the data is considered reliable (Table 6).

5.6 Gas monitoring

Landfill gas was measured in the field using a Flame Ionization Detector (FID) 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 November 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 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. 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 1.2 g/m^2/month total solids, which is below the accepted level of 4 g/m^2/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 bores BH20 and BH20s has detected the presence of leachate indicators despite the nearby surface water sampling locations SWC-Up, SWC-Down and SWC_Down_2 (Rocklow Creek), which displayed results indicating background characteristics. This indicates the occurrence of nitrogen uptake by trees and mangroves in the area between BH20 and Rocklow Creek, protecting the creek from a potential nitrogen impact by eliminating the pathway. Adsorption process is also thought to have a role for stabilising the nitrogen plume at this location. 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 impacted 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. Natural attenuation and lower hydraulic gradients in the downstream of BH15 and BH16 are expected to inhibit its rate of migration and should continue to limit its extent of impact on Rocklow Creek. In order to monitor any potential migration from this area, a new surface water sampling location (SWC_Down_2) was established further downstream in Rocklow Creek during this round of sampling.

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 (SWC2, SWC-Up, SWC-Down and SWC_Down_2) reported no concentrations of NH_4-N and NO_3^- above 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 were also within the guidelines. It is recommended monitoring with an Inspectra Laser Unit and GA5000 continue in proximity to the buildings with special attention to the landfill cap due to exceedances in May 2017.

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

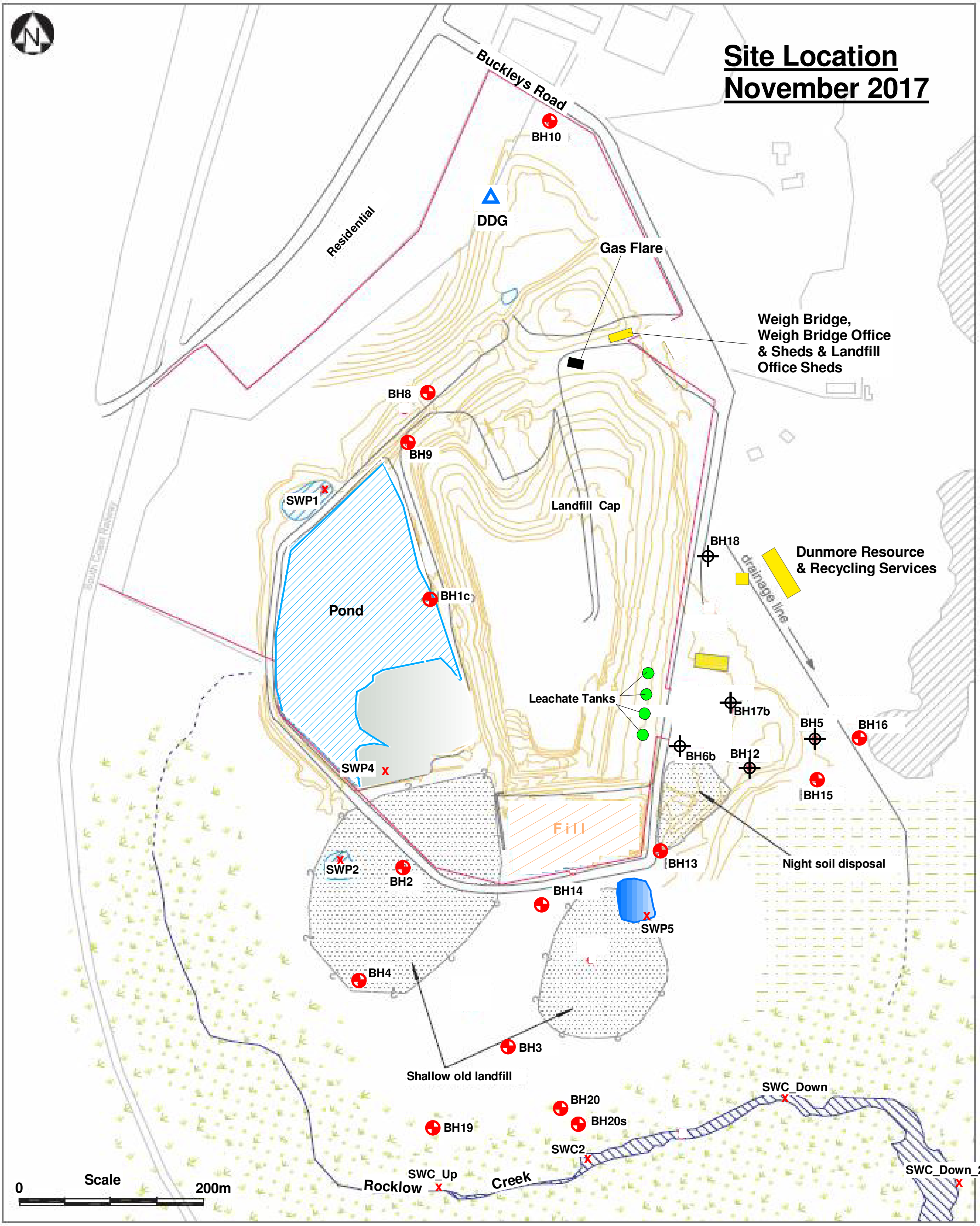
The investigation and remediation of contaminated sites is a field in which legislation and interpretation of legislation is changing rapidly. Our interpretation of the investigation findings should not be taken to be that of any other party. When approval from a statutory authority is required for a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



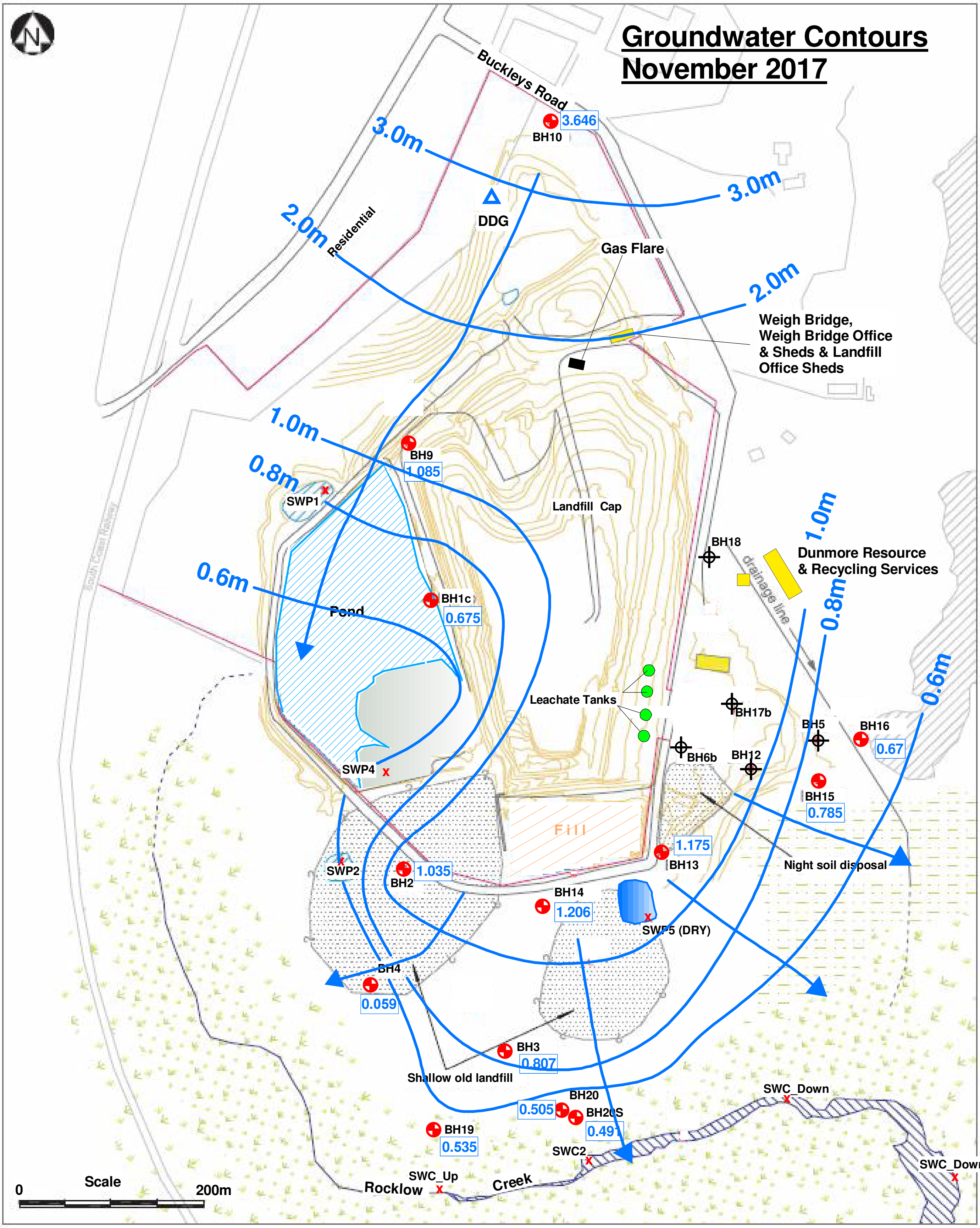
Legend:

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

Note: Based on aerial photo dated 1 Sept. 2010

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title: Site Locations		
Location: Buckleys Road, Dunmore, NSW		
Client: Shellharbour City Council		**Job number:** 112096u
Drawn by: TRJ	**Scale:** As shown	**Figure** 1
Proj Man: MN	**Date:** November 2017	



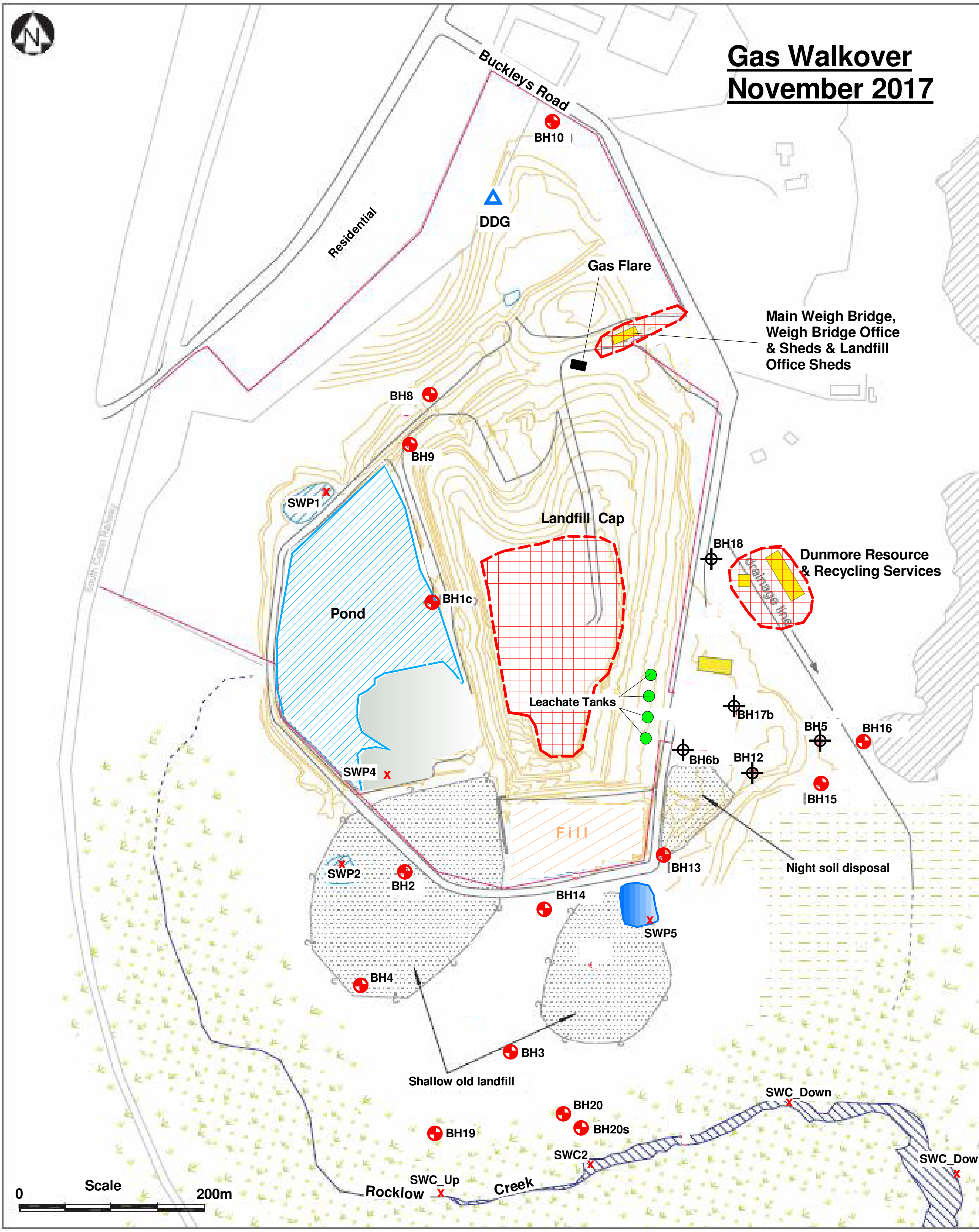
Legend:

Bore locations		Water	
Surface water locations		Buildings	
DDG	Dust gauge location		Decommissioned bores
Inferred groundwater contour (m AHD)		0.67	Standing water levels
			Flow direction

Note: Based on aerial photo dated 1 Sept. 2010

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

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



Legend:

	Bore locations		Water
x	Surface water locations		Buildings
DDG	Dust gauge location		Decommissioned bores
	Gas walkover		

Note: Based on aerial photo dated 1 Sept. 2010

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title: Gas Walkover		
Location: Buckleys Road, Dunmore, NSW		
Client: Shellharbour City Council		Job number: 112096u
Drawn by: TRJ	Scale: As shown	Figure 3
Proj Man: MN	Date: November 2017	

ATTACHMENT 2 TABLES

TABLE 1 FIELD MEASUREMENTS – NOVEMBER 2017

Sample	SWL	SWL	pH	EC	ORP	Temp.	DO	Colour	Odour
Units	mAHD	Dip (m)	-	mS/cm	mV	ºC	ppm	-	-
BH1c	0.675	3.279	7.09	6.73	-43.6	26.5	1.5	light brown	Leachate
BH2	1.035	3.757	6.99	3.246	-105	22.6	1.11	slight brown	Leachate
BH3	0.807	2.957	7.45	1.132	47.3	18.9	6.27	black	no odour
BH4	0.059	4.96	7.31	1.343	-106	19.1	3.81	clear	no odour
BH9	1.085	3.3							
BH10	3.646	1.145							
BH13	1.175	4.12	6.64	1.597	-56	21		clear	no odour
BH14	1.206	4.509	7.01	1.969	5	21.2	2.14		
BH15	0.785	0.625	6.95	5.78	-114.4	17.1	3.18	brown	leachate
BH16	0.67	0.71	7.22	2.224	-145	18.2	0.44	brown/black	H2S
BH19	0.535	4.655	7.6	1.74	-73	18.8	3.72	grey	no odour
BH20	0.505	2.265	6.28	1.34	-86	18.8	6.02	light brown	reducing
BH20s	0.491	2.279	7.08	1.09	7.9	18.7	1.52	light brown	no odour
LP1	-		6.8	4.898	-99.7	24	1.91	black	Leachate
SWC2	-		6.99	9.27	52.2	20	3.9	light brown	no odour
SWC-Up	-		7.3	20.4	70.7	20.2	4.9	light brown	no odour
SWC-Down	-		7.14	10.994	62	20.1	4.5	light brown	no odour
SWC_DOWN_2	-		6.99	23.73	76.2	20.4	5.43	light brown	no odour
SWP1	-		8.15	0.401	-46	18.6	2.08	brown	no odour
SWP2	-		7.76	1.771	35	21.5	7.12	slight brown	no odour
SWP4	-		8.11	2.199	-74	26	8.24	light brown	no odour
SWP5	-		7.51	0.583	35	21.1	6.69	brown	no odour

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 – NOVEMBER 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
BH1c	7.3	4010	650	160	230	120	**320**	895	0.2	0.1		12	3050	0.31	200	6	0.12	**2.5**	18
BH2	7.2	1910	310	240	46	74	**49**	480	0.17	0.1		93	1310	0.1	71	2	0.49	**2.8**	14
BH3	7.3	700	35	150	34	19	**11**	99	0.1	**66**		72	410	0.1	12	7	0.03	0.07	1.1
BH4	7.4	885	94	170	16	30	**7.2**	125	0.1	0.1	0.1	94	655	0.1	16	2	0.16	**0.47**	4.3
BH13	7.4	1080	120	205	21	44	**2.7**	170	0.22	4.2		120	745	0.1	27	2	0.23	0.26	3.4
BH14	7	1070	200	135	44	43	0.6	245	0.52	**30**	0.1	190	565	0.34	48	2	0.26	0.2	1.8
BH15	7	3970	525	170	735	78	**110**	1500	0.18	0.13	0.1	190	1150	1.5	205	2	0.4	**19**	21
BH16	7	1410	235	120	83	62	**6.9**	455	0.17	0.1		380	235	0.15	59	2	0.11	**0.35**	17
BH19	7.4	1000	86	200	17	37	**6.3**	175	0.1	0.13		140	610	0.1	19	2	0.07	0.26	32
BH20	7.7	730	49	135	29	37	**12**	125	0.12	0.1		170	385	0.18	21	2	0.06	0.09	3
BH20s	7.5	770	32	145	76	32	0.2	31	0.12	**42**		130	540	0.1	35	2	0.02	0.12	31
LP1	6.8	8650	1160	810	345	230	**590**	1380	0.17	0.1		1290	5590	6.8	470	1590	7.8	**57**	60
SWC2							0.6			0.84	0.13		125					**0.34**	1.4
SWP1	7	330	44	45	16	15	0.1	50	0.12	0.1		57	205	0.31				0.25	4.4
SWP2	**8.1**	1070	215	83	29	48	0.1	280	0.17	**11**		210	405	0.1				0.07	0.82
SWP4	**8.3**	1210	265	67	28	50	1.1	325	0.33	**15**		205	410	0.1	31	2		0.03	0.17
SWP5	7.6	320	47	36	18	12	0.5	66	0.13	**60**		80	42	0.12	10	2		0.13	3.8
SWC-UP	7.2	12000	3580	190	205	440	0.6	6770	0.33	0.58		880	150	0.1				0.11	1.1
SWC-DOWN	7.2	6380	1710	135	130	240	0.6	3400	0.26	0.75		495	125	0.12				0.13	1.4
SWC_DOWN_2	7.4	19600	5490	280	370	820	0.3	10800	0.38	0.58		1350	215	0.1				0.04	0.65
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 NH_4-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 – NOVEMBER 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	**590**	5590	**57**	60	18000	18000
SWC2	0.6	125	**0.34**	1.4	-	-
SWC-UP	0.6	150	0.11	1.1	-	-
SWC-Down	0.6	125	0.13	1.4	-	-
SWC_DOWN_2	0.3	215	0.04	0.65	-	-
SWP1	0.1	205	0.25	4.4	-	-
SWP2	0.1	405	0.07	0.82	-	-
SWP4	1.1	410	0.03	0.17	-	-
SWP5	0.5	42	0.13	3.8	-	-
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 NH_4-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 – NOVEMBER 2017

Bore	Na/Cl	Na/Ca	Mg/Ca	Ca/K	Cl/SO_4	Cl/HCO_3	K/TDS (%)	L/N (%)
BH1c	0.73	4.06	0.75	0.70	74.58	0.29	5.74	59.15
BH2	0.65	1.29	0.31	5.22	5.16	0.37	2.41	15.24
BH3	0.35	0.23	0.13	4.41	1.38	0.24	4.86	54.41
BH4	0.75	0.55	0.18	10.63	1.33	0.19	1.81	7.96
BH13	0.71	0.59	0.21	9.76	1.42	0.23	1.94	7.56
BH14	0.82	1.48	0.32	3.07	1.29	0.43	4.11	19.76
BH15	0.35	3.09	0.46	0.23	7.89	1.30	18.51	109.34
BH16	0.52	1.96	0.52	1.45	1.20	1.94	5.89	21.58
BH19	0.49	0.43	0.19	11.76	1.25	0.29	1.70	7.25
BH20	0.39	0.36	0.27	4.66	0.74	0.32	3.97	18.60
BH20s	1.03	0.22	0.22	1.91	0.24	0.06	9.87	56.56
LP1	0.84	1.43	0.28	2.35	1.07	0.25	3.99	42.50
SWP1	0.88	0.98	0.33	2.81	0.88	0.24	4.85	15.58
SWP2	0.77	2.59	0.58	2.86	1.33	0.69	2.71	11.59
SWP4	0.82	3.96	0.75	2.39	1.59	0.79	2.31	11.54
SWP5	0.71	1.31	0.33	2.00	0.83	1.57	5.63	82.63
SWC-UP	0.53	18.84	2.32	0.93	7.69	45.13	1.71	4.90
SWC-DOWN	0.50	12.67	1.78	1.04	6.87	27.20	2.04	6.30
SWC_DOWN_2	0.51	19.61	2.93	0.76	8.00	50.23	1.89	5.63

Notes:
1. % indicates ratios are presented in percentage in that column; and
2. L/N = leachate/non-leachate ratio ; [(K + NH4 + NO3 + NO2)/(Ca + Mg + Na)] x 100.

TABLE 5 SUMMARY OF GAS ANALYSIS – NOVEMBER 2017

Location	GA 5000 V/V%	ILU V/V%
Landfill cap	0	0.00019
Main weigh bridge, weigh bridge office and landfill office sheds	0	0.0002
Dunmore Resource & Recycling Services	0	0.0002
GUIDELINES	1.25 % v/v / 0.05 % v/v	1.25 % v/v / 0.05 % v/v

Notes:

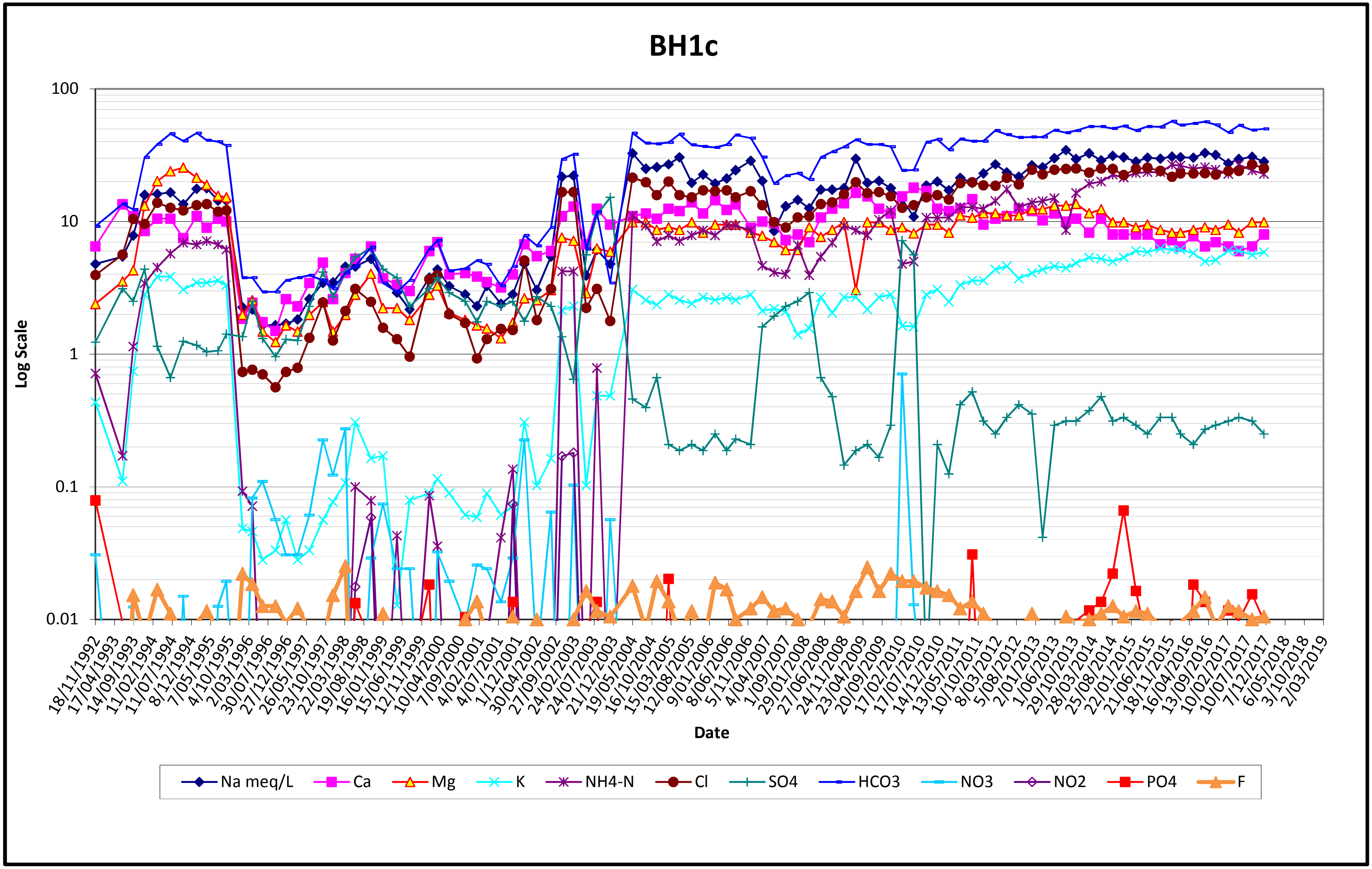
1. results and guidelines are expressed in V/V %;
2. Guidelines are as per the NSW EPA (1996) reporting accumulation value of 1.25 % v/v CH_4; and surface emission trigger value (500 ppm or 0.05 % v/v); and
3. values above the guidelines are **bolded**.

TABLE 6 QA/QC – NOVEMBER 2017

Analytes	BH3	SD1	RPD(%)
pH	7.30	7.30	0.00
TDS	700	710	1.42
Na+	35	38	8.22
Ca++	150	150	0.00
Mg++	19	20	5.13
K+	34	35	2.90
NH4-N	11	11	0.00
Cl-	99	100	1.01
SO4--	72	72	0.00
HCO3-	410	450	9.30
NO3-	0.05	0.05	0.00
PO4---	0.1	0.1	0.00
F-	0.1	0.1	0.00
BOD	1	1	0.00
Fe.D	0.07	0.05	33.33
Fe.T	1.1	1.3	16.67
Mn.D	0.03	0.02	40.00
TOC	12	12	0.00

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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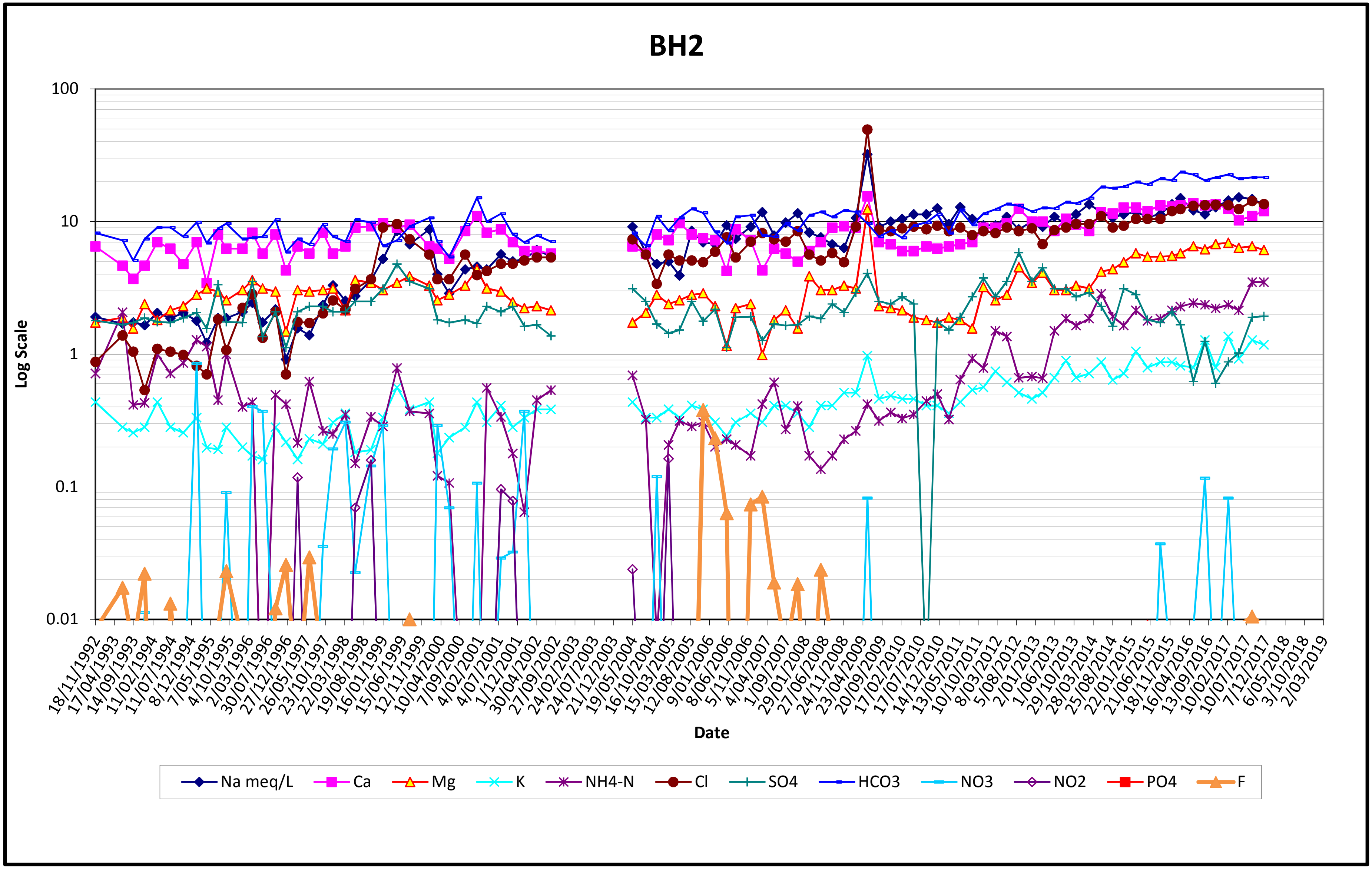
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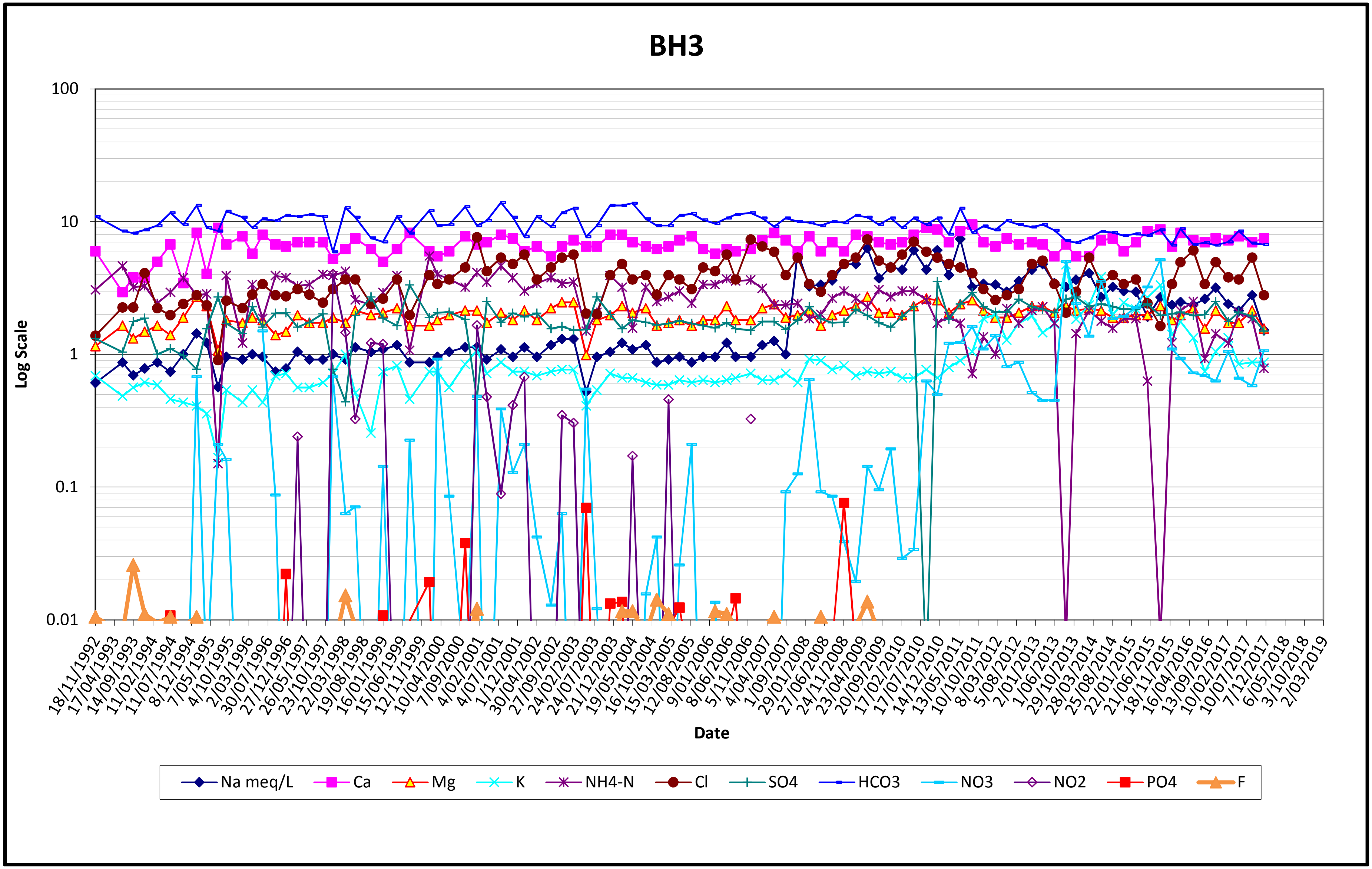

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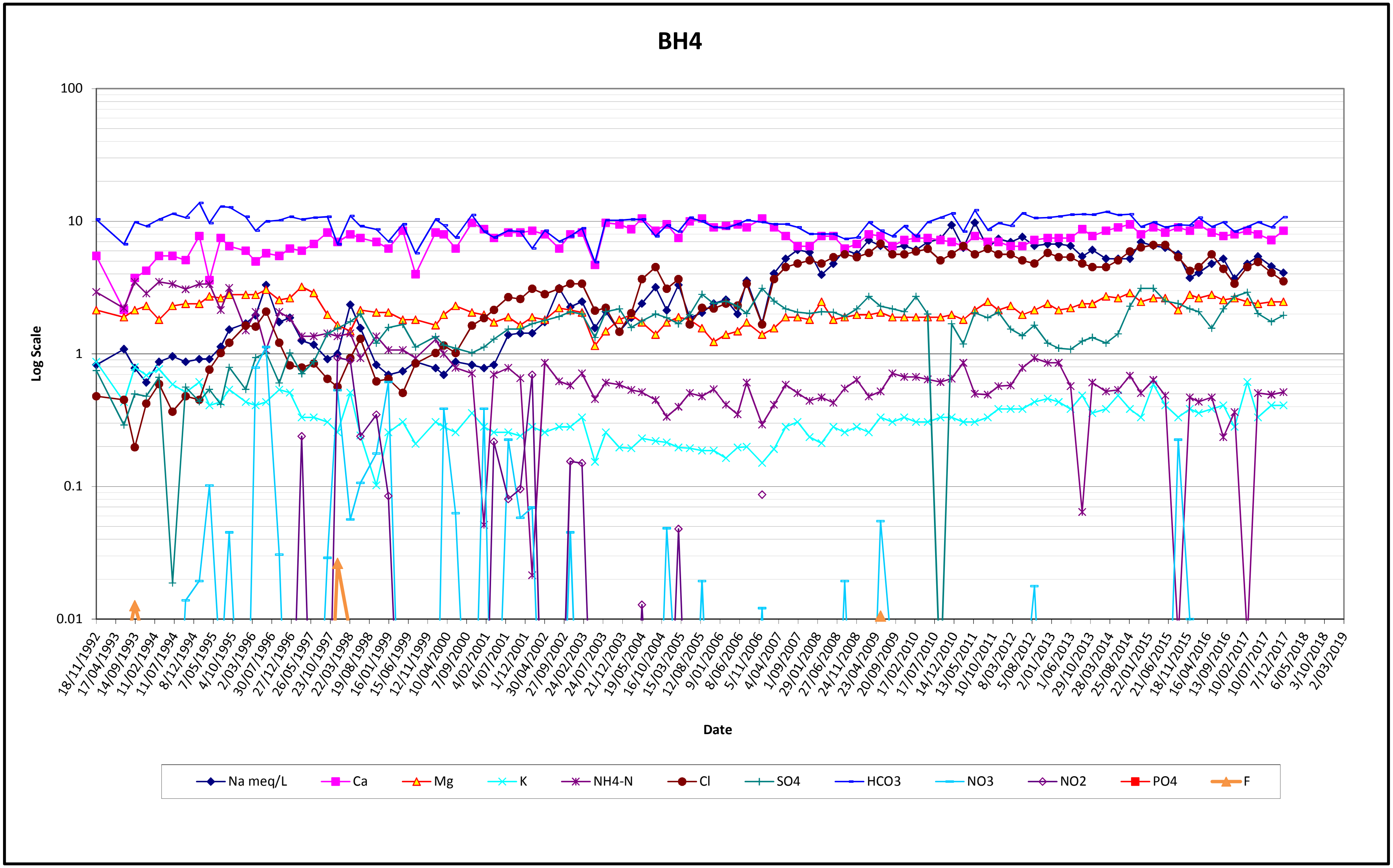
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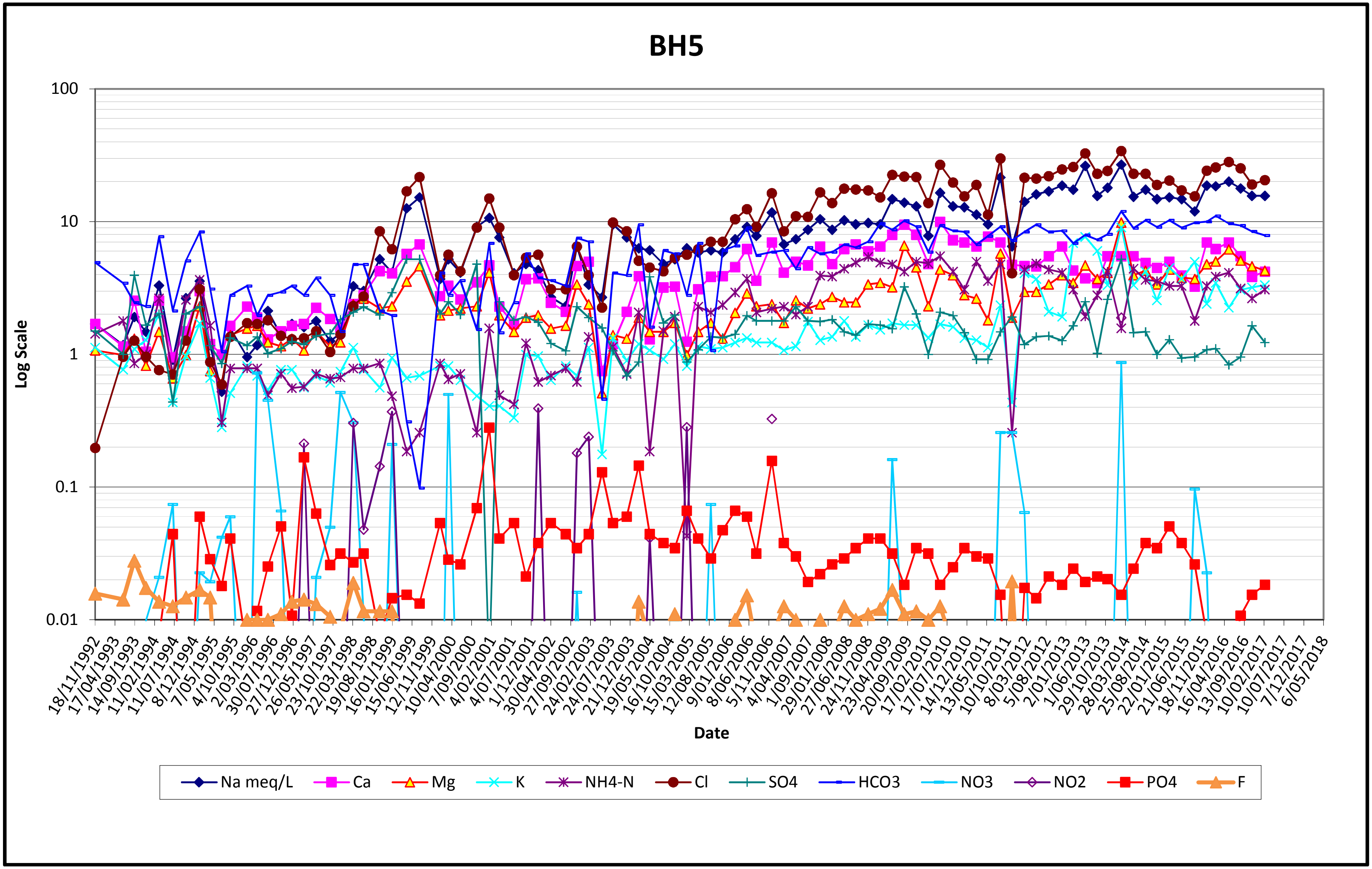
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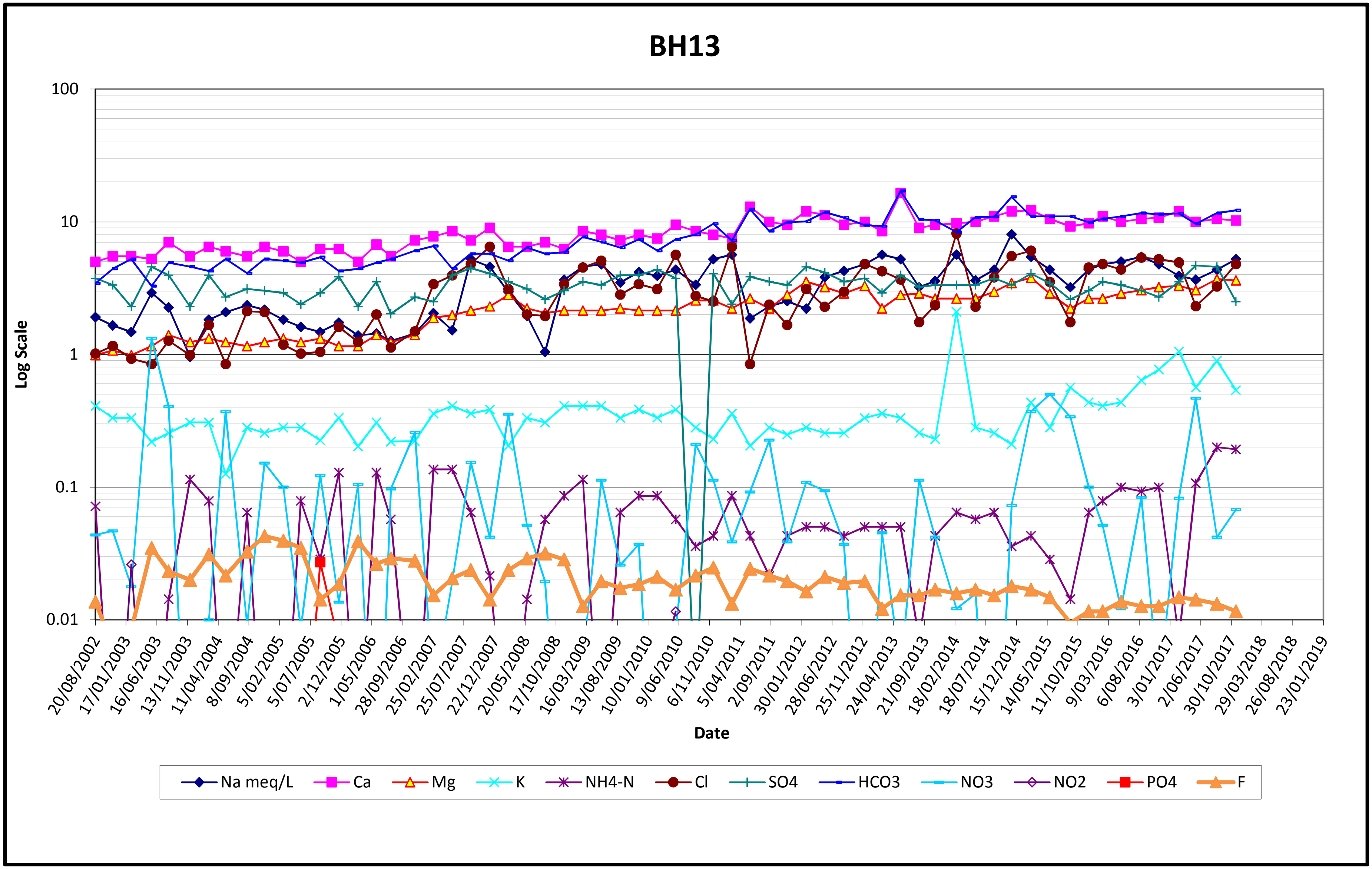
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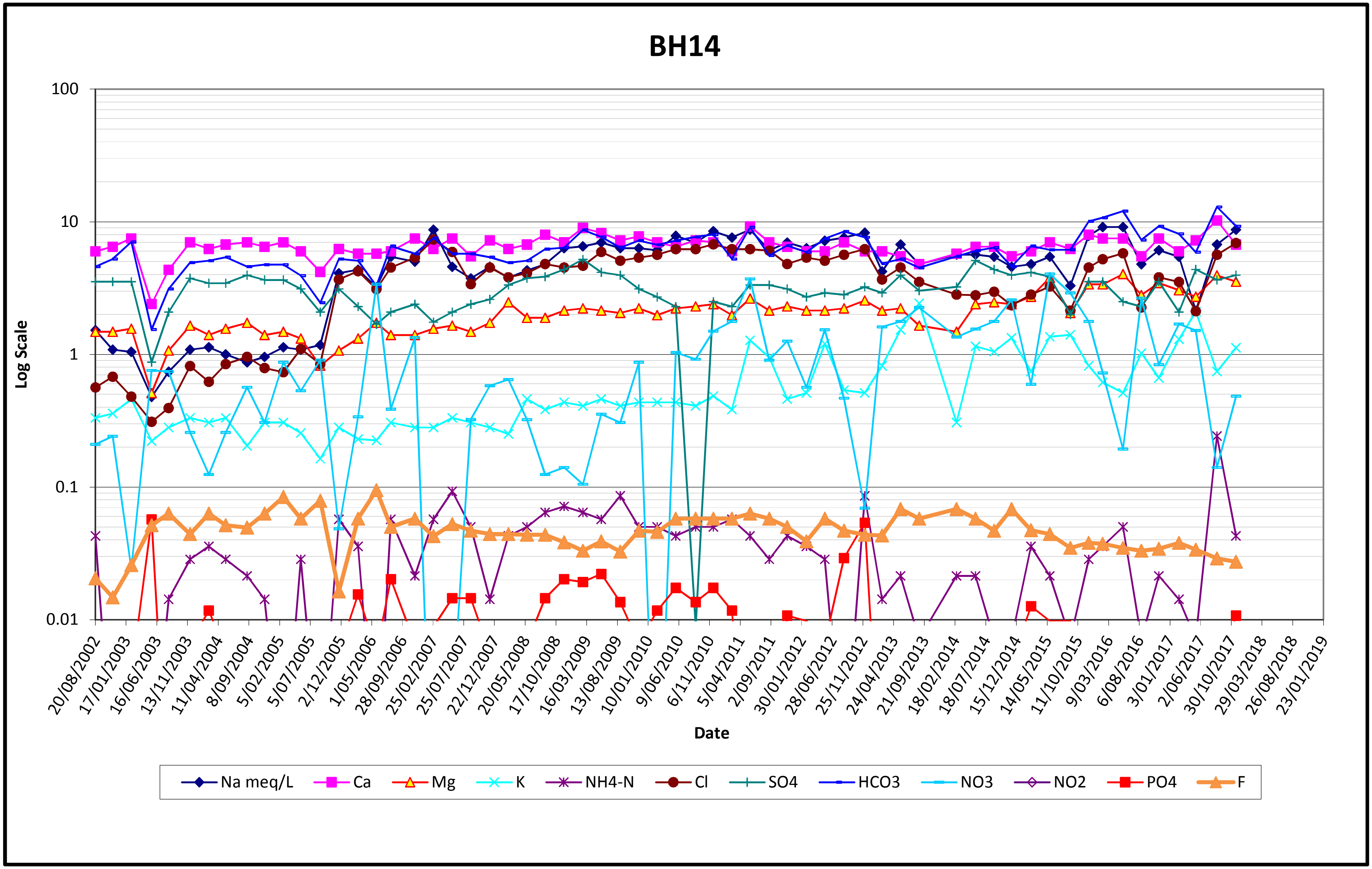
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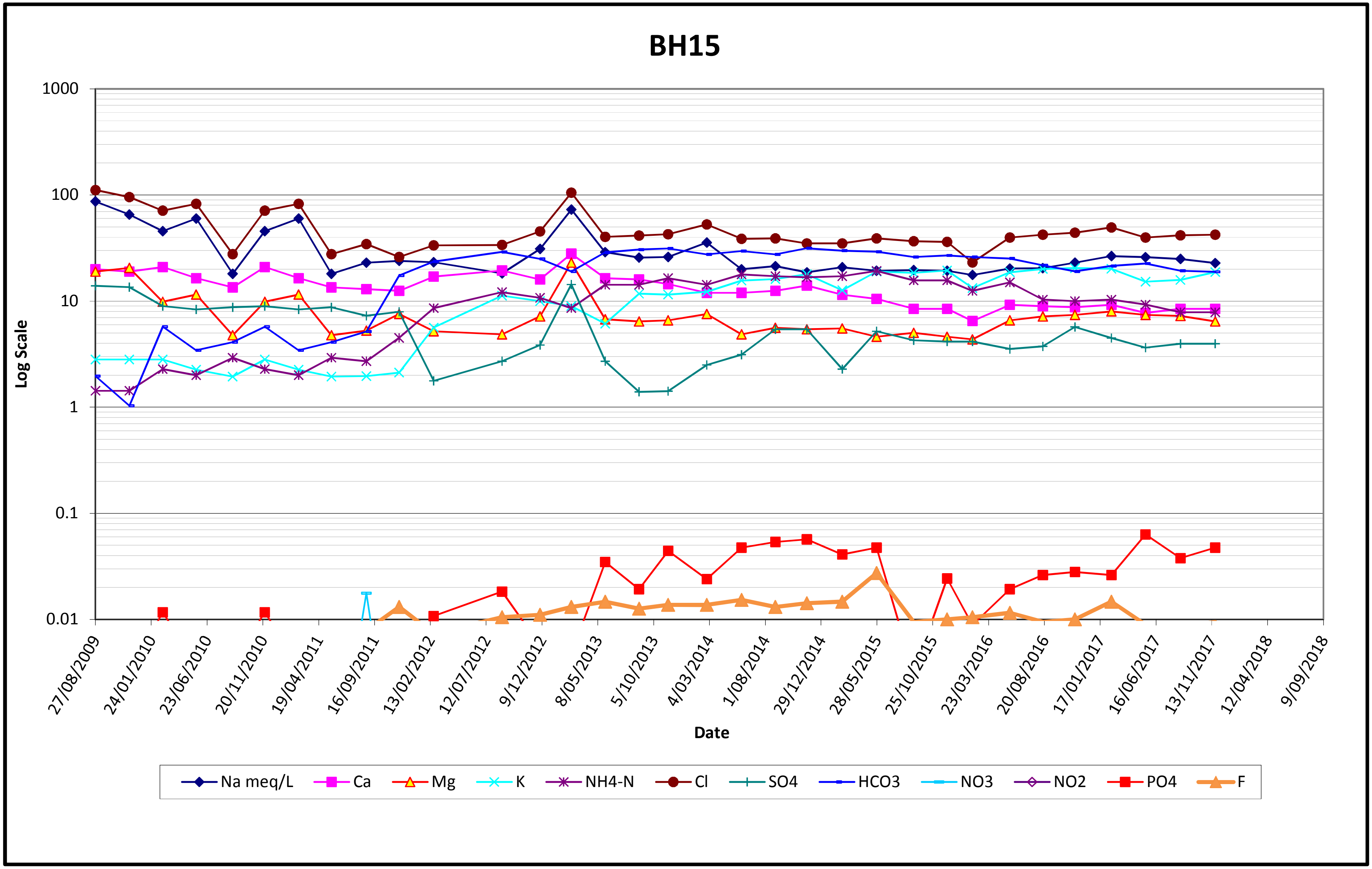

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NO3
NO2
PO4
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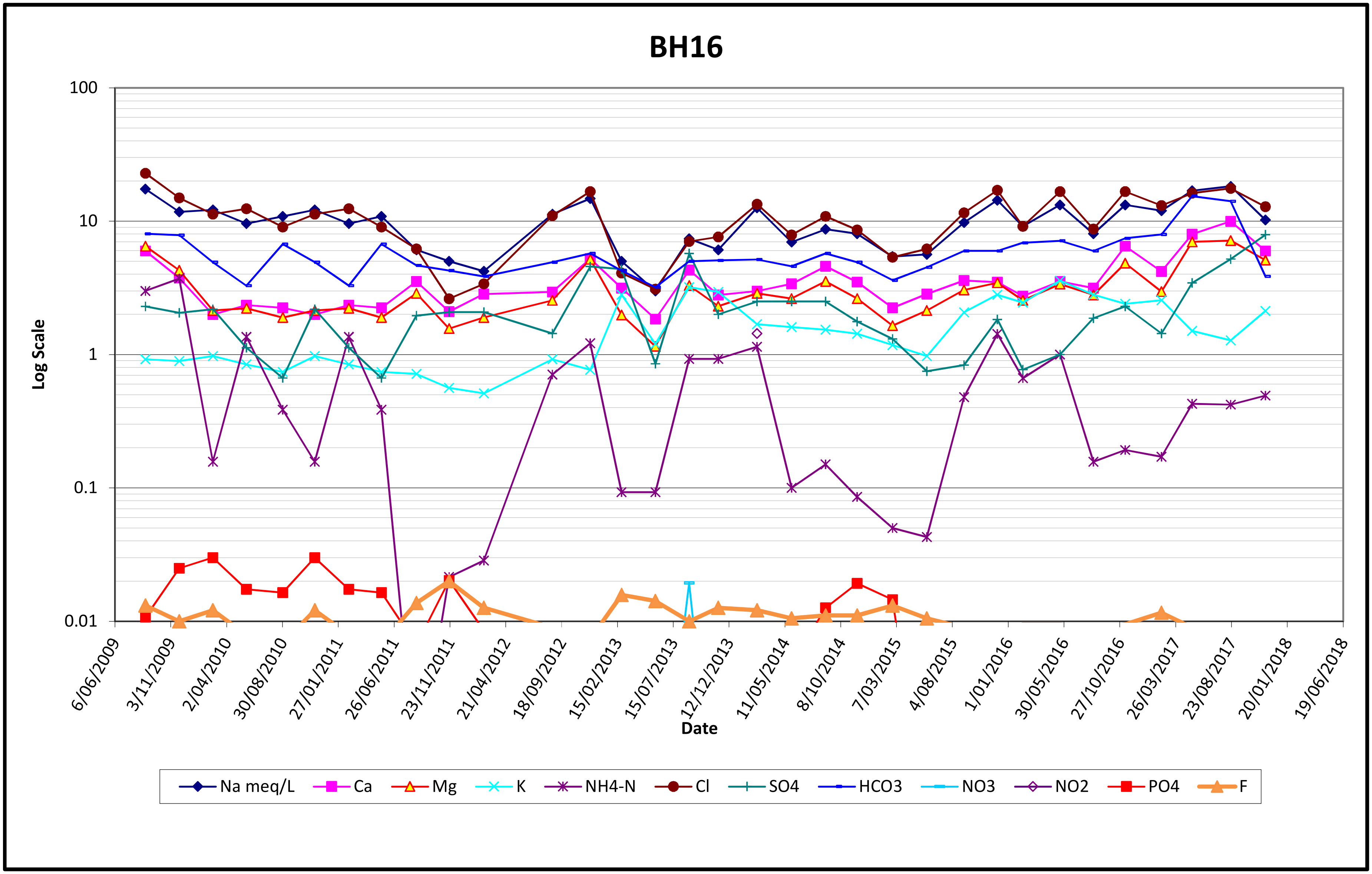
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8/10/2014
7/03/2015
4/08/2015
1/01/2016
30/05/2016
27/10/2016
26/03/2017
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Mg
K
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Cl
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HCO3
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NO2
PO4
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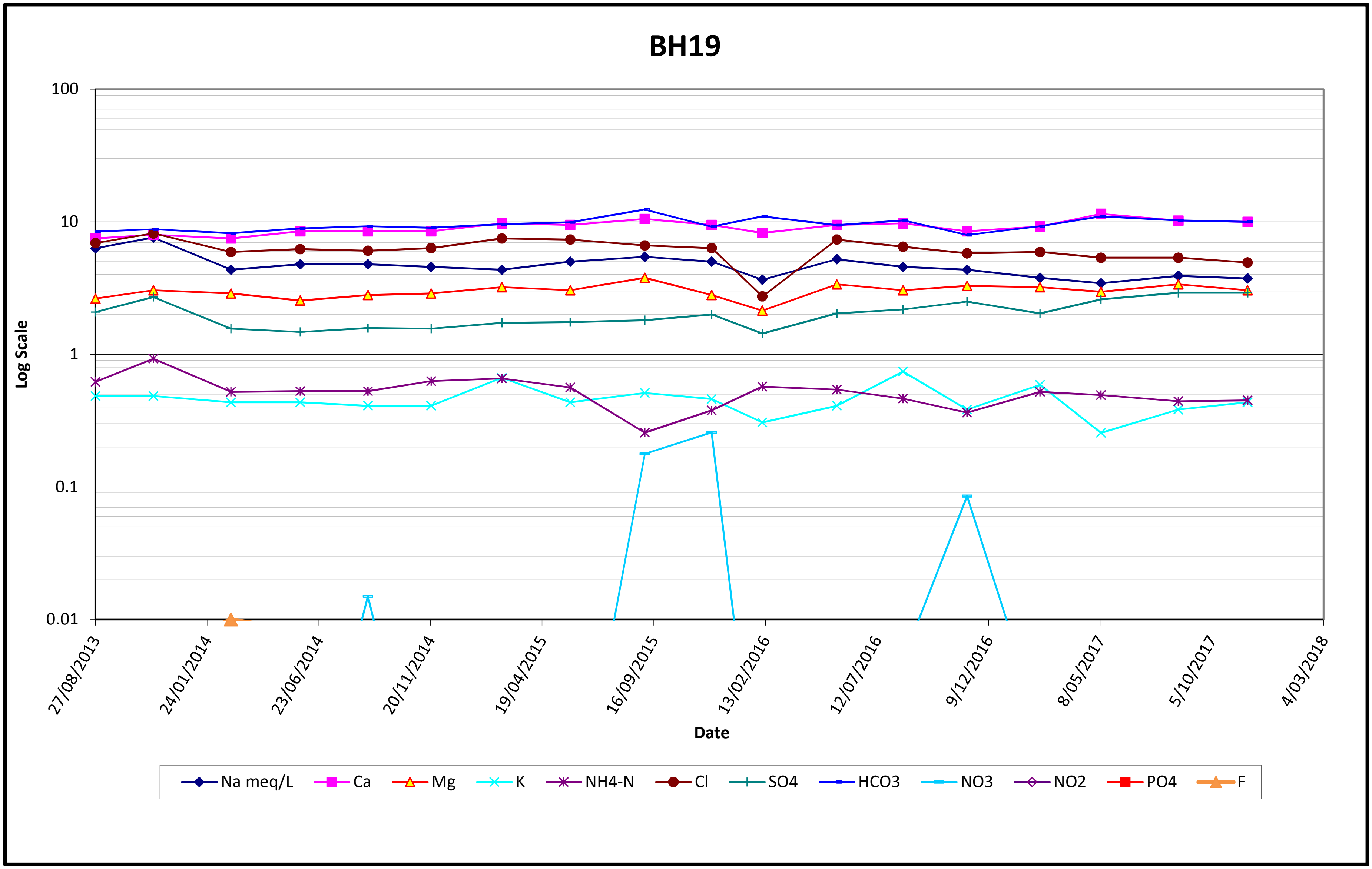
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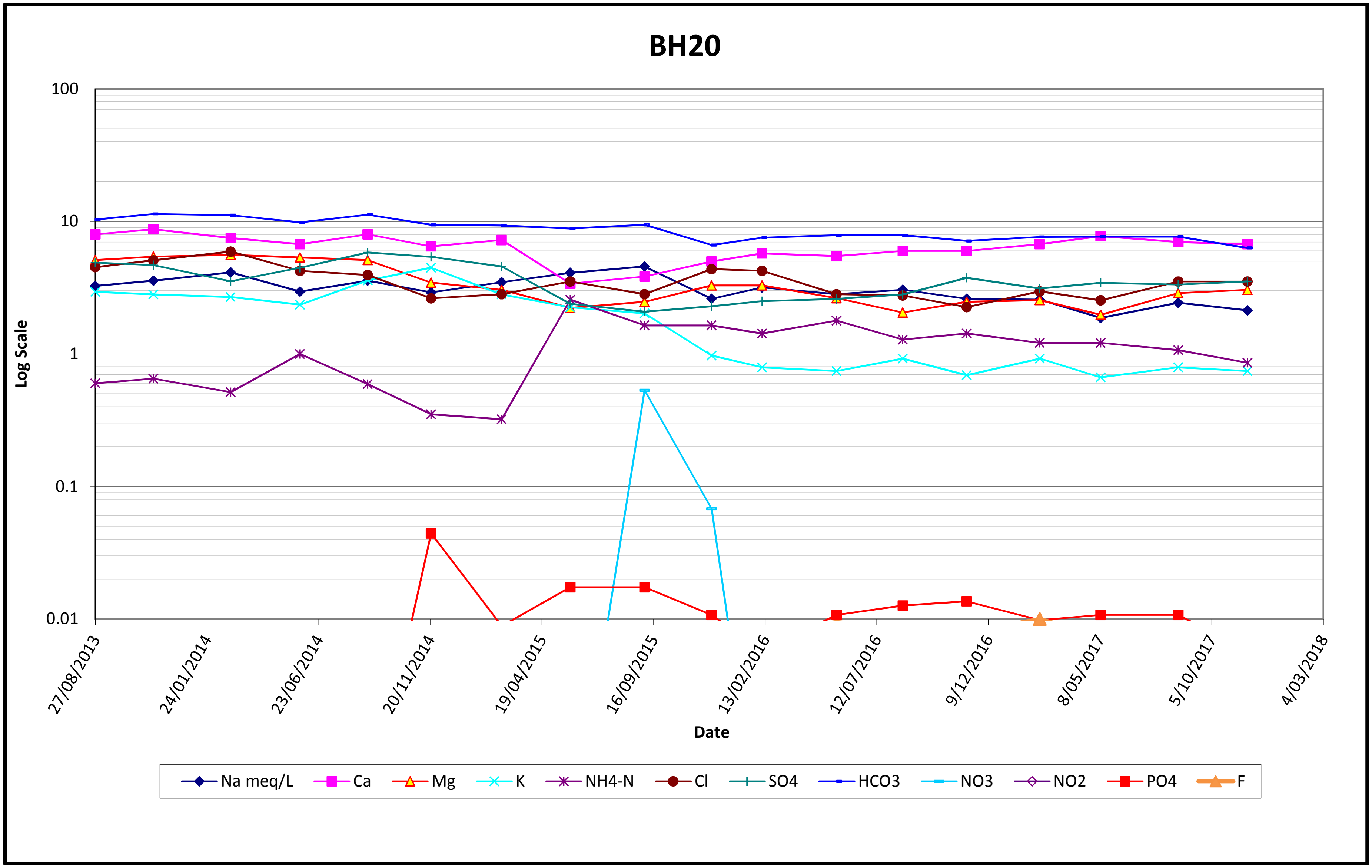
5/10/2017
4/03/2018
Date
Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
NO3
NO2
PO4
F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Date
Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
NO3
NO2
PO4
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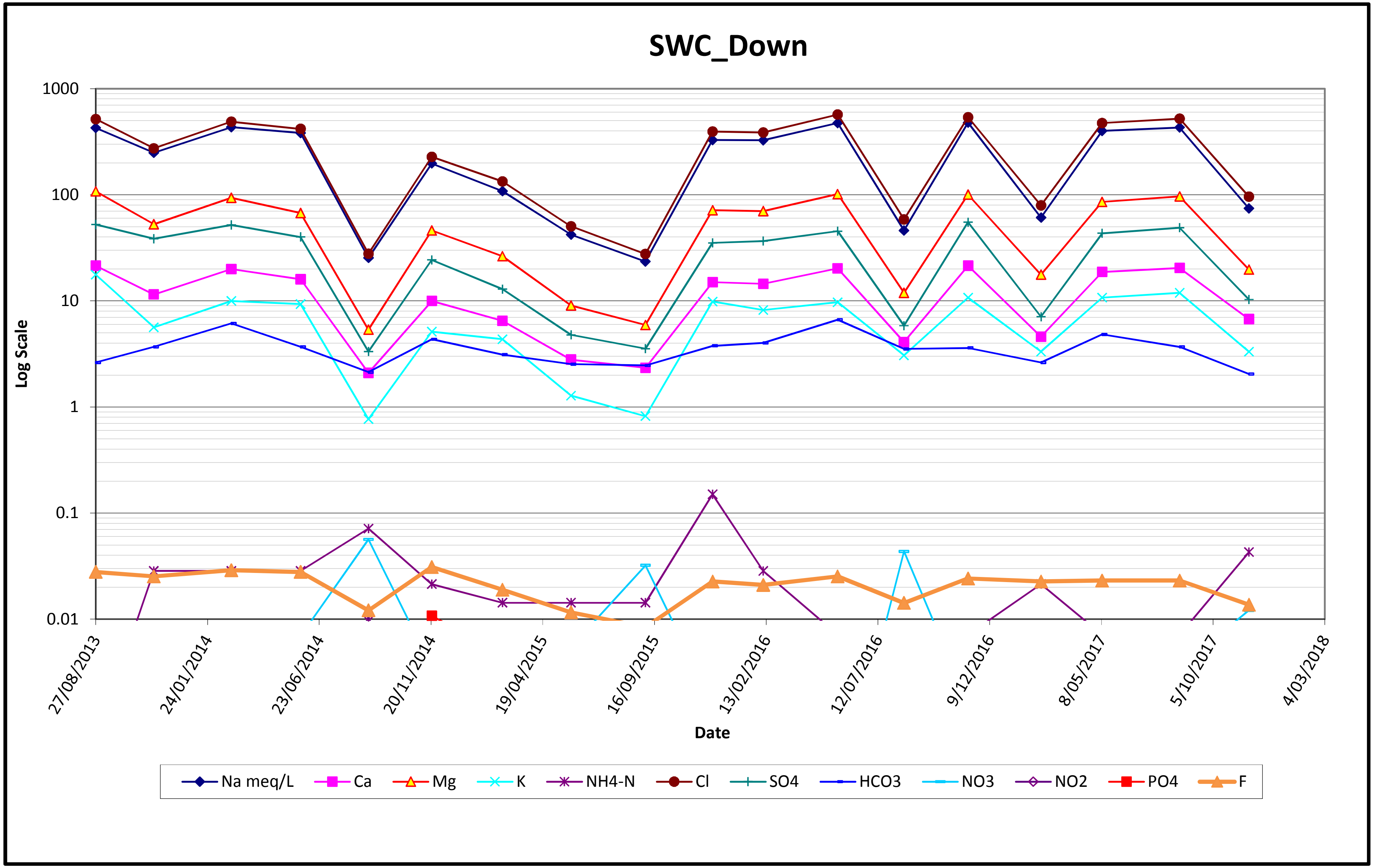

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5/10/2017
4/03/2018
Date
Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
NO3
NO2
PO4
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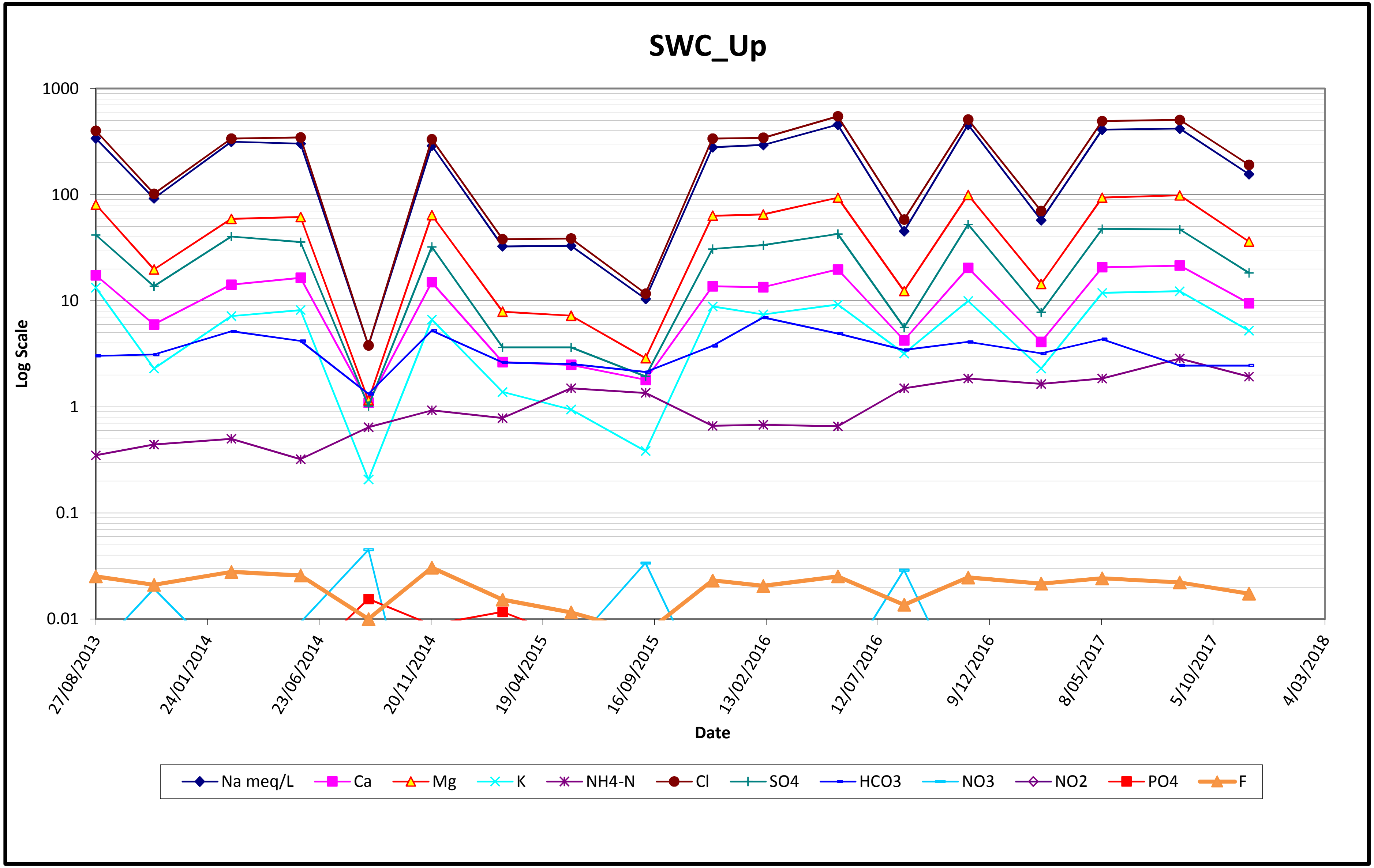

SWC_Up
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5/10/2017
4/03/2018
Date
Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
NO3
NO2
PO4
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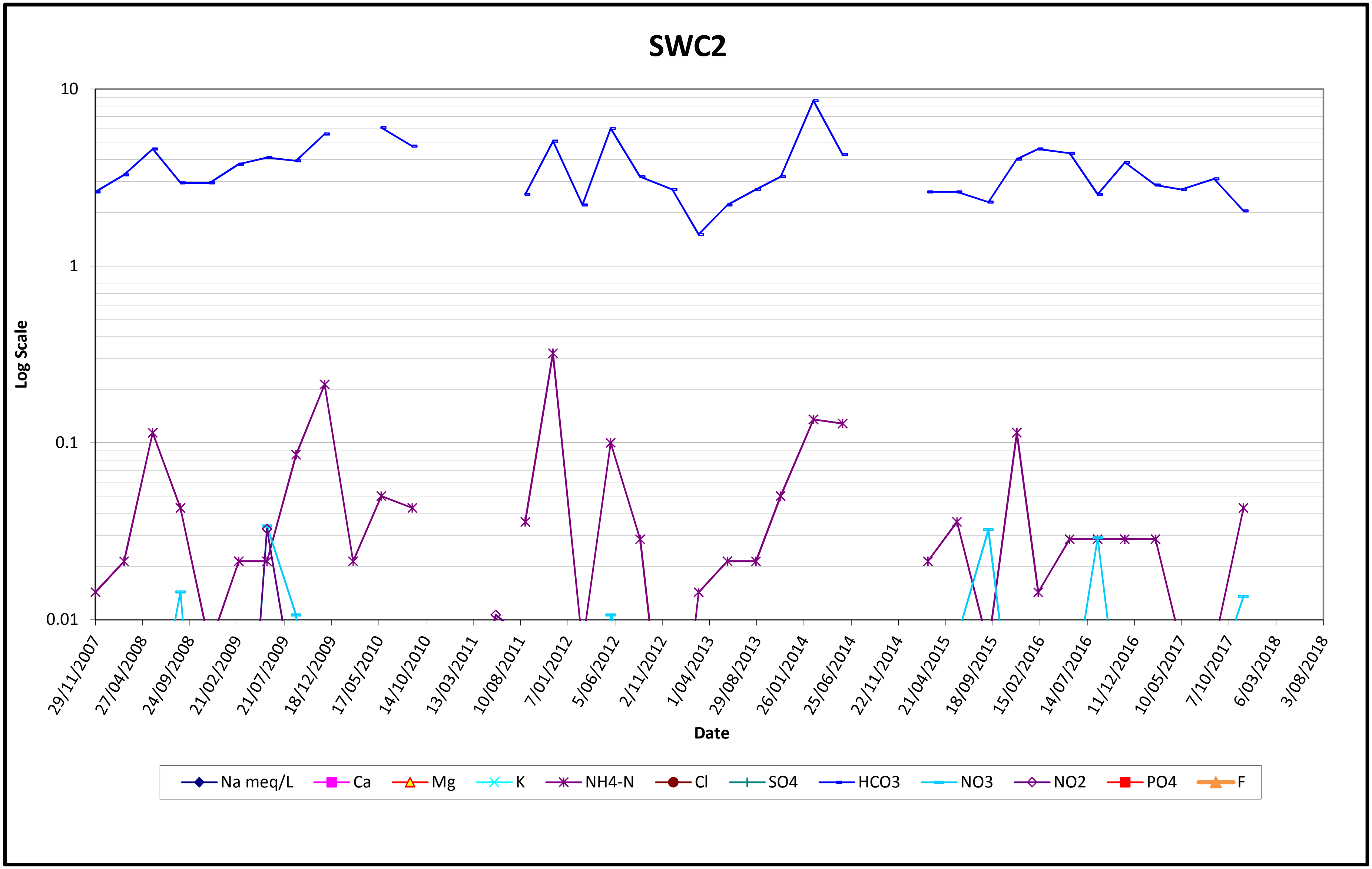

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6/03/2018
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Date
Na meq/L
Ca
Mg
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Cl
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NO3
NO2
PO4
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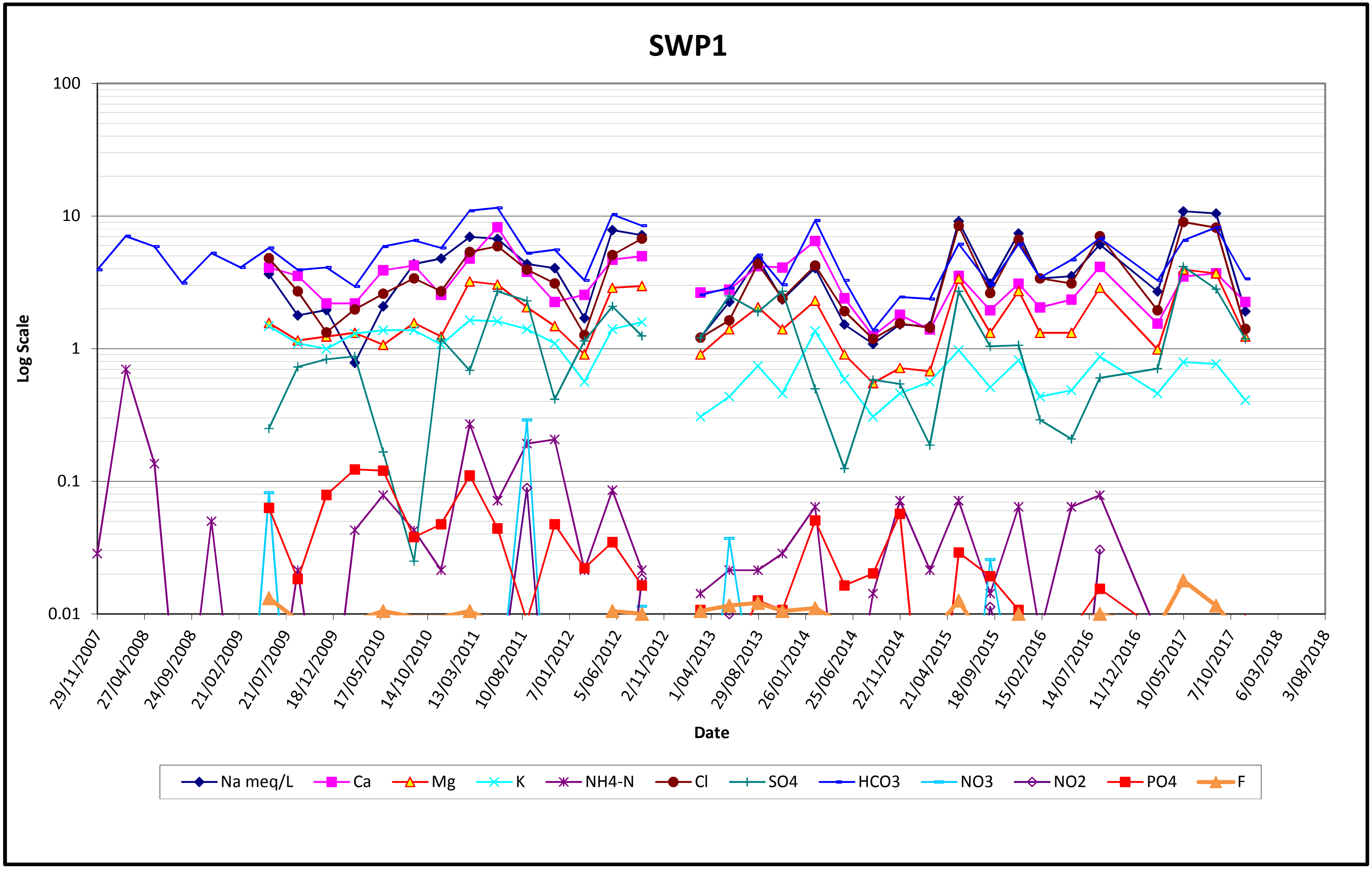

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14/07/2016
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7/10/2017
6/03/2018
3/08/2018
Date
Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
NO3
NO2
PO4
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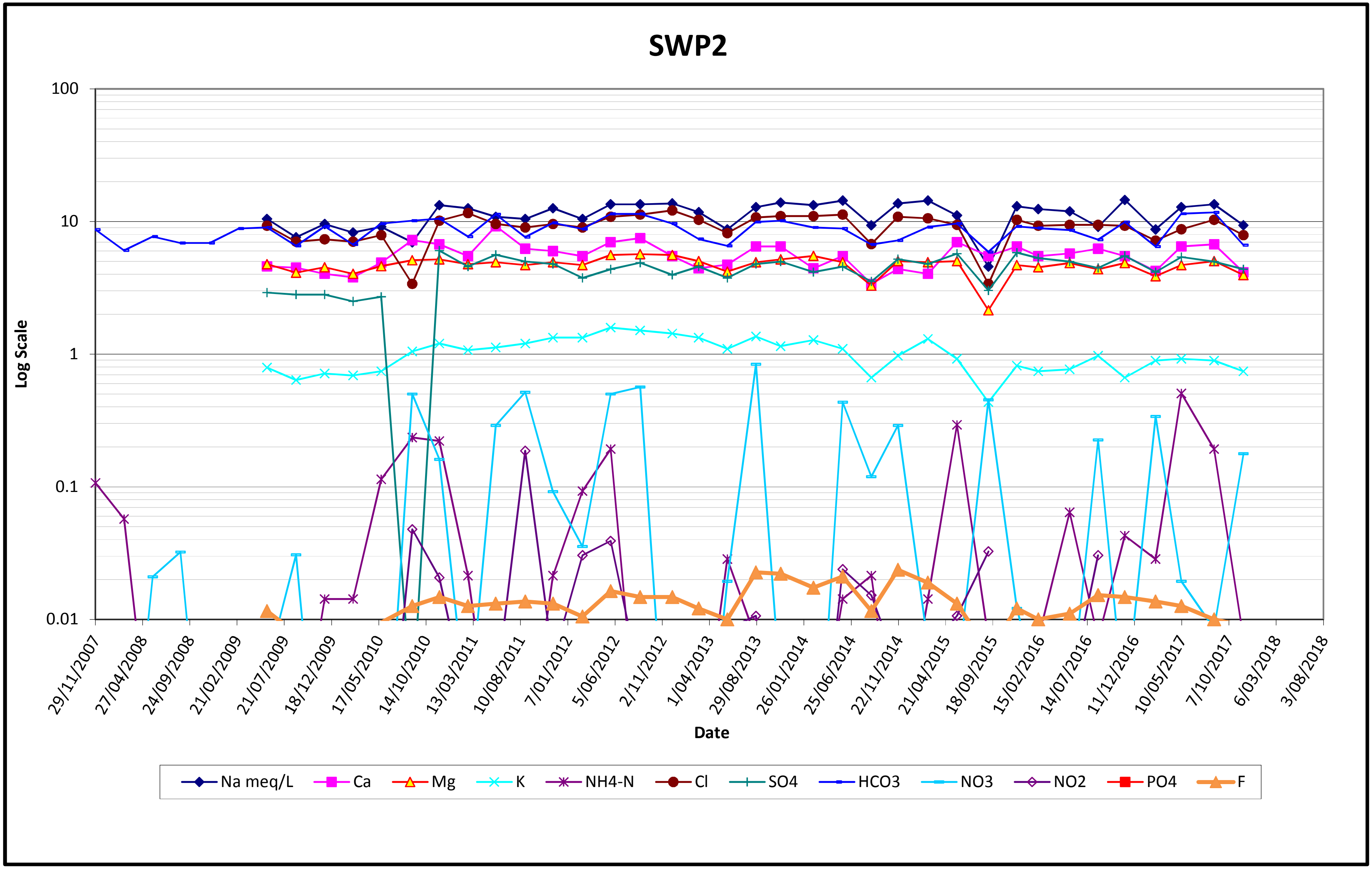
SWP2
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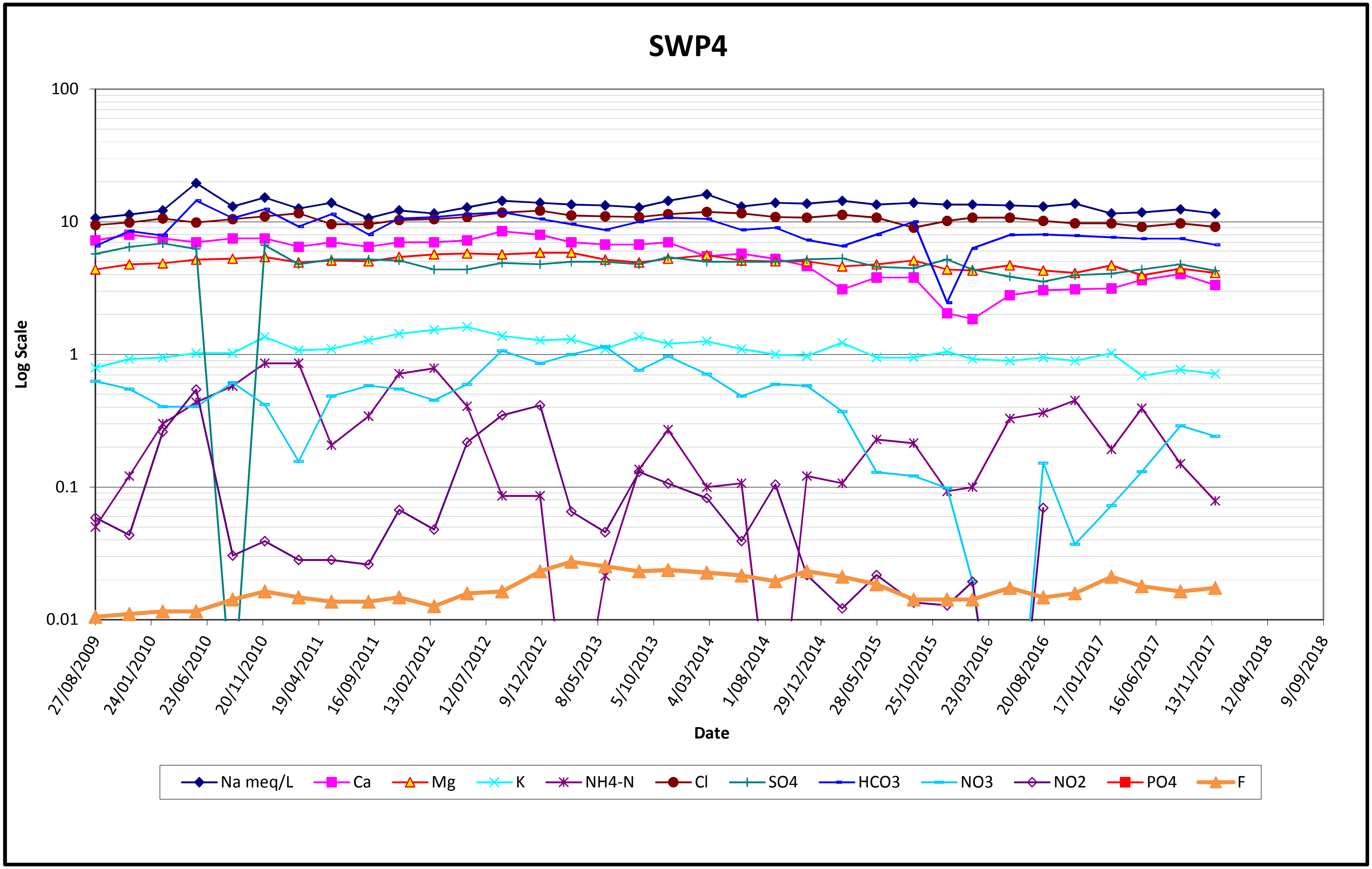
6/03/2018
3/08/2018
Date
Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
NO3
NO2
PO4
F



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13/11/2017
12/04/2018
9/09/2018
Date
Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
NO3
NO2
PO4
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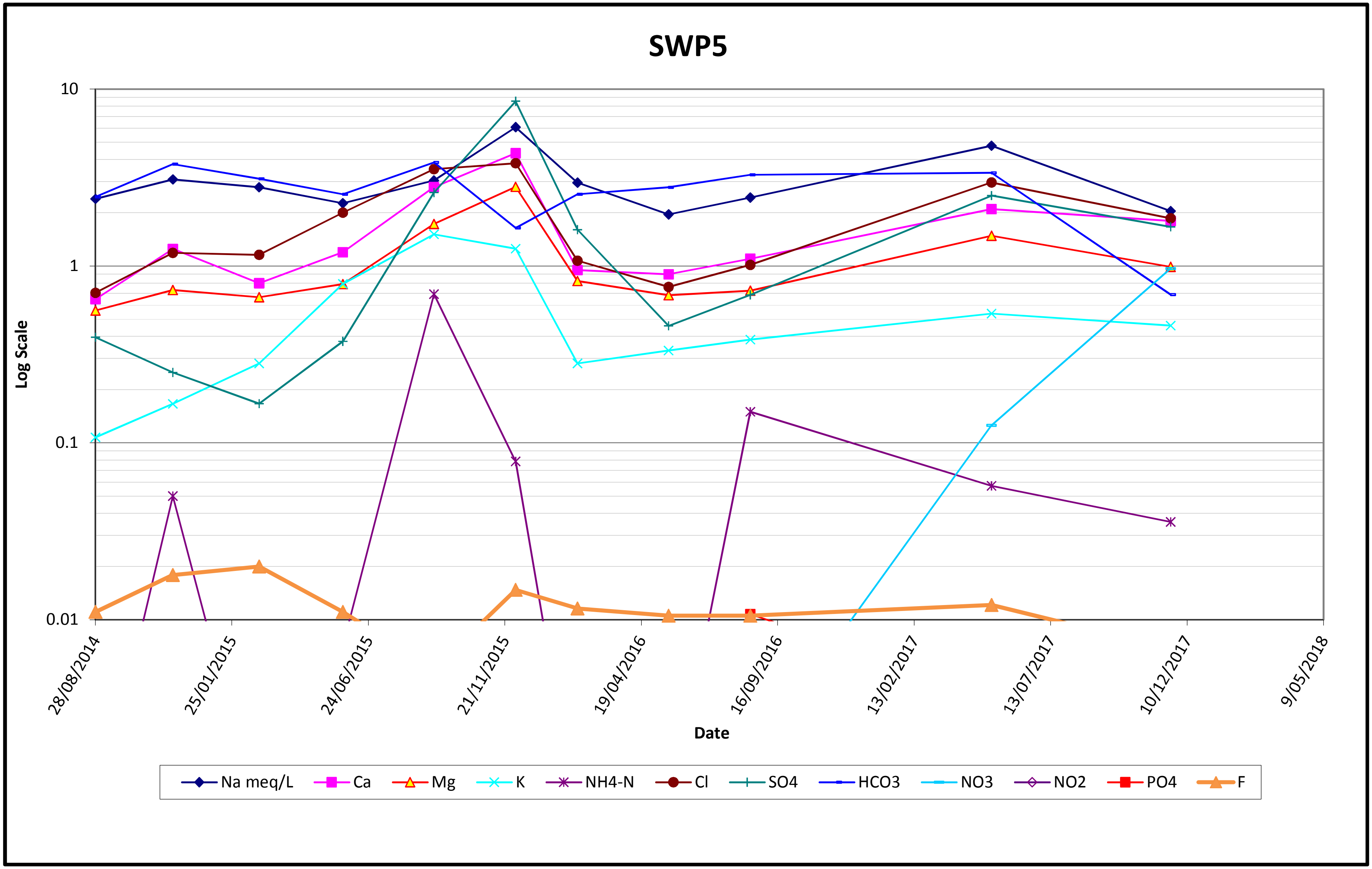
SWP5
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10/12/2017
9/05/2018
Date
Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
NO3
NO2
PO4
F