18 April 2018

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,

February 2018 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 February 2018 quarterly monitoring round was undertaken on 13 February 2018. An additional groundwater sample was taken from BH14 on 29 March 2018. During the February 2018 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 (BH1, BH2, BH3, BH4, BH13, BH14 BH15, 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), three on site retention ponds (SWP1, SWP2, and SWP4) and Rocklow Creek at four points (SWC2, SWC_Up, SWC_Down and SWC_Down_2). Sampling was unable to be taken at BH14 on 13 February as there was a root blocking the borehole access at 4.995mBGL. This was revisited and sampled on 29 March 2018. SWP5 retention pond was dry. 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 February 2018 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 and SWP4 – ionic balance, total and soluble iron and turbidity;
- additional analyses for SWP4 – 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). 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 February 2018 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).

Cumulative rainfall for November 2017 (116.4 mm) December 2017 (49.8 mm), January 2018 (56.0 mm) and February 2018[1] (6.2 mm) was 228.4 mm *(BOM – Albion Park Wollongong Airport weather station).* Groundwater levels decreased at all monitoring wells. The average of the measured standing water levels throughout the site has decreased by ~0.13 mAHD from 0.97 mAHD in November 2017 to 0.84 mAHD in February 2018.

5.2 Groundwater

5.2.1 Groundwater sampling locations impacted by leachate

Field and laboratory results from the February 2018 sampling round, specifically from bores BH1c, BH2, BH3, BH4, BH15, BH20 and BH20s displayed chemistry that can be related to leachate impact — BH1c, BH3, BH15, BH20 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 (3910 mg/L), K^+ (210 mg/L) [resulting in low Ca/K – 1.21] and NH_4^+-N (380 mg/L) concentrations. The low levels of oxygen (1.44 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, November 2017 and February 2018 rounds and were 8, 7, 7, 6, 6, 6 and 8 mg/L respectively. Further evidence of microbial activity / respiration is elevated HCO_3^- resulting in a low Cl/HCO_3^- ratio of 0.44 (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 and November 2017 (49 mg/L in both months). NH_4^+-N concentration decreased in the February 2018 monitoring round to a level of 35 mg/L. Bicarbonate (HCO_3^-), Na^+ and Mg^{2+}concentrations in groundwater have shown an increasing trend since January 2008 despite slight decreased concentrations in the February 2018 sampling event (Table 2, Schoeller plot BH2, Attachment 3). Chlorine (Cl^-) and calcium (Ca^{2+}) concentrations slightly decreased whilst potassium (K^+) 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 13 February 2018 (date of sample event)

Groundwater from bore BH3 reported decreases in concentration of one native ion (Ca^{2+}) as well as one non-native ion (NO_3^-) since last monitoring round. Comparatively, the concentration of Na^+, Mg^{2+}, K^+, NH_4^+-N, Cl^-, SO_4^{2-} and HCO_3^- increased. The L/N ratio (40.30%) has decreased since the November 2017 monitoring round (54.41%). 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 BH4 showed an increase in the February 2018 round (12.54%) — in November 2017 monitoring round the L/N ratio was 7.93% at this location. The L/N ratio at this location has not exceeded 10% since February 2003 and this trend should be examined in following monitoring rounds. Increased concentrations of non-native ions NH_4^+-N and K^+ and relatively stable concentrations of native ions Na^+, Ca^{2+} and Mg^{2+} can be attributed to the increase in L/N ratio however this value should be used carefully due to low TDS <1000 mg/L. Bore BH4 is placed on the border of an historic shallow landfill site and down gradient of landfilling activities and should be continually monitored to determine water quality in this area.

Bore BH15 displayed a decrease in L/N ratio however the value remains high at 81.45%. The decrease can be attributed to the decreased levels of K^+ and NO_3^- concentrations and the increase in Na^+, $Ca^{2+}$and Mg^{2+} concentrations. The K^+/TDS ratio of 15.82% 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 135 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+} (0.52 mg/L) and Fe^{2+} (18 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 within 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 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 (-140 mV) with a clear colour of the groundwater and H_2S odour. The L/N ratio (22.51%) in the February 2018 round increased compared with the last monitoring round (16.60%). K^+ showed a slight increase from 29 mg/L (November 2017) to 31 mg/L (February 2018). The TDS remained relatively low (785 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 remained elevated at 16 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 the boundary of the landfill site in order to locate potential transport pathways to Rocklow Creek. In February 2018, field observations at bore BH20s recorded a negative redox (-24 mV), clear colour of the groundwater and an odour was detected. The L/N ratio (60.85 %) continued to indicate potentially high leachate impact at this site. However, TDS is relatively low (790 mg/L) making the L/N susceptible to natural variations or fluctuations in chemistry. Chemical characteristics of the bore show groundwater was low in Na^+, with a moderate Ca/K and K/TDS ratio (Table 4). Ammonium levels (1.3 mg/L) have increased since November 2017 but remain lower than those seen at the deeper BH20 bore. Nitrate levels have decreased significantly in February 2018 to 3.1 mg/L from 42 mg/L in November 2017. It was previously thought that high nitrate levels in this shallower bore location was indicative of nitrification throughout the soil profile. Continued monitoring at this location will be necessary to determine potential transport pathways to Rocklow Creek.

5.2.2 Remaining groundwater sampling locations

During the February 2018 monitoring round, ionic chemistry indicated that bores BH13, BH16 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 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 February 2018 monitoring round shows a slight increase of L/N ratio (7.65%) compared to the November 2017 round (7.56%). TDS levels decreased slightly from November 2017 to February 2018 sampling events. The chemical composition of the groundwater has remained consistent since monitoring began in 2002 (Schoeller plot BH13, Attachment 3).

The L/N ratio at bore BH14 showed a decrease in the February 2018 round (5.61%) — in November 2017 monitoring round the L/N ratio was 19.74% at this location. Concentrations of K^+ were lower in the February 2018 monitoring period compared to November 2017 levels (Schoeller plot BH14, Attachment 3). NH_4^+-N concentration increased slightly to 0.70 mg/L from 0.60 mg/L in November 2017. This increase in the non-native ions was offset by a steep reduction in NO_3^- which dropped by two orders of magnitude – from 30.00 mg/L in November 2017 to 0.13 mg/L in February 2018 monitoring period. Bore BH14 is strategically placed down gradient of landfilling activities and should be continually monitored to determine the water quality in this area given its history of leachate impact.

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 NO_3^-. Groundwater sampling in February 2018 indicated limited to no leachate impact at BH16 which was represented by the L/N ratio of 8.56% and a decrease in K/TDS ratio 5.89% in November 2017 to 2.84% in February 2018. The lower L/N ratio can be attributed to the significant increase in concentrations of the native ion Na^+ and the decrease in concentrations of two non-native ions (K^+ and NH_4^+-N). Bores BH15 and BH16 are located close to a drainage channel where offsite impacts can readily influence the chemical characteristics of the shallow groundwater and should continue to be monitored for fluctuations.

Bore BH19 is located on the south west boundary of the site. Field observations included a negative ORP and a milky colouring to the groundwater. The chemical characteristics of the groundwater support no or limited leachate influence with an L/N ratio of 6.85 % 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 (6.6 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.

NH_4-N concentrations above threshold levels were reported in groundwater across all but two of the sampled bores across the site with bores BH1c (380 mg/L), BH2 (35 mg/L), BH3 (44 mg/L), BH4 (8.9 mg/L), BH13 (2.6 mg/L), BH15 (135 mg/L), BH19 (6.6 mg/L) and BH20 (16 mg/L). Nitrate (NO_3^-) was reported above guideline thresholds (ANZECC 2000) at BH3 (23 mg/L).

5.3 Surface water monitoring

During the February 2018 monitoring round, samples from Rocklow Creek (SWC2, SWC_Up, SWC_Down and SWC_Down_2) and three surface water ponds (SWP1, SWP2, and SWP4) were collected. Results of surface water analysis (Table 2 and Table 3) indicate that concentrations of ions were towards the upper limit of the historical range at sampling locations in Rocklow Creek and within the historical range at the three surface water ponds. SWC_Down_2 was sampled for the second time in February 2018 and hence does not have sufficient historical data to provide an informed comparison. 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.

Ammonium levels detected at SWP1 were 2.50 mg/L, higher than levels recorded in previous monitoring rounds since November 2011 and above ANZECC 2000 trigger values. This may suggest minor leachate impact. Elevated concentrations of soluble iron and a negative redox potential in the February 2018 sampling event were indicative of a reducing environment which may have contributed to low levels of dissolved oxygen and the production of ammonium.

Surface water sampled at SWP2 showed little to no leachate impact. The surface water pond collects runoff from around the site and potential impacts from site activities are often observed. Ammonium concentration increased slightly to 0.20 mg/L during this sampling round compared to November 2017 round (0.10 mg/L). Nitrate (NO_3^-) levels (0.18 mg/L) decreased to below the ANZECC 2000 trigger value that was exceeded in the November 2017 monitoring round. 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 1.5 mg/L which is below the defined trigger value. Nitrate (NO_3^-) levels decreased slightly to 12 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 should continue to be monitored for any fluctuations in chemical composition indicating a more prominent leachate impact.

The four surface water creek sites SWC2, SWC_Up, SWC_Down and SWC_Down_2 were also sampled during the February 2018 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 still a relatively 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^- (<0.1 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, BOD, TOC, Na^+, NH_4^+-N, K^+, HCO_3^-,PO_4 and total iron 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 (1.00) 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 <20 CFU/100 ml for both, which is a significant decrease from the previous monitoring round (Table 3). Fluctuation in these concentrations in leachate tanks are common and thus dermal contact with these waters should continue to be avoided due to historic levels of elevated concentrations and the corresponding health concerns relating to high 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 0.19% to 1.99%. 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 0.13% and 7.40% (RPD < 10%). The relationship between the field determined EC and laboratory measured TDS relationship ranged between 0.50 and 1.06. 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 BH19 which yielded a TDS/EC ratio of 1.06).

RPDs between the intra-laboratory duplicate and the primary sample taken at bore BH13 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 February 2018 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 0.2 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. The process of adsorption is also thought to have a role in stabilising the nitrogen plume at this location. Although the historical data sets 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 bore BH15. It is important to note that bores BH15 and the adjacent 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. SWC_Down_2 should continue to be sampled to monitor any potential migration from this area to 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 (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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112096_Feb_2018_V1

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.

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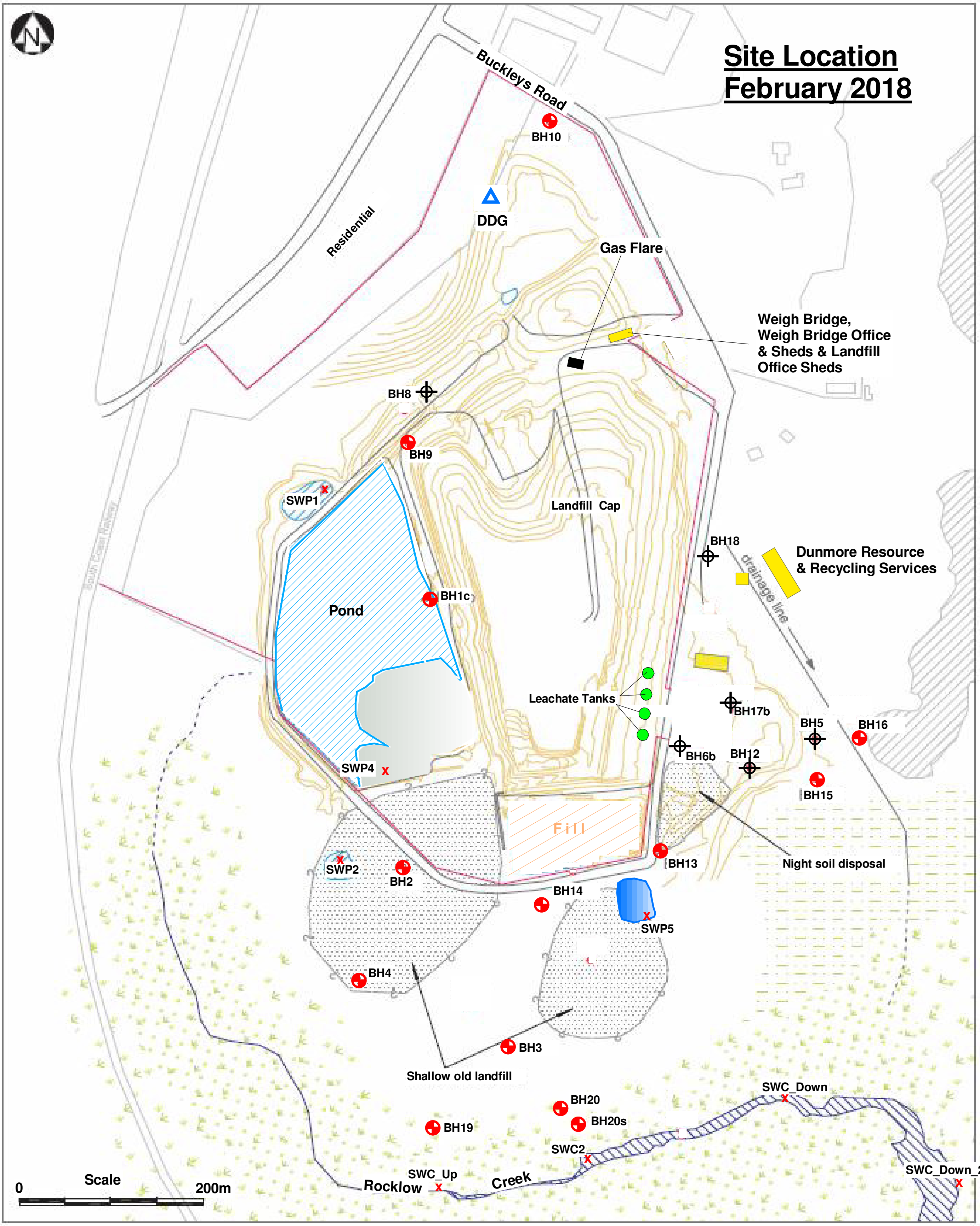
ATTACHMENT 1 FIGURES



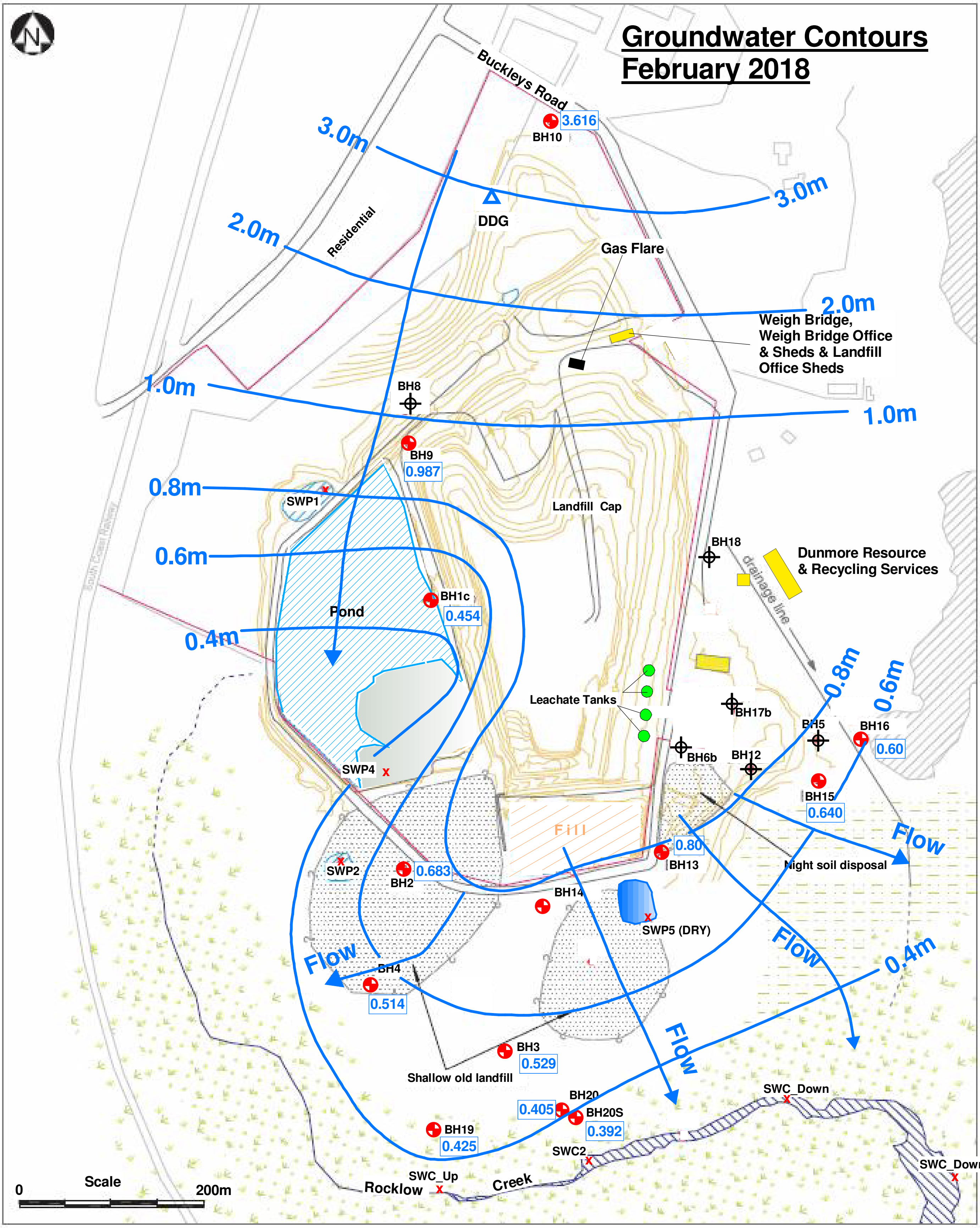
Legend:

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
CONTAMINATION RESOLVED

Title:	Site Locations	
Location:	Buckleys Road, Dunmore, NSW	
Client: Shellharbour City Council		Job number: 112096v
Drawn by: TRJ	Scale: As shown	Figure 1
Proj Man: MN	Date: February 2018	



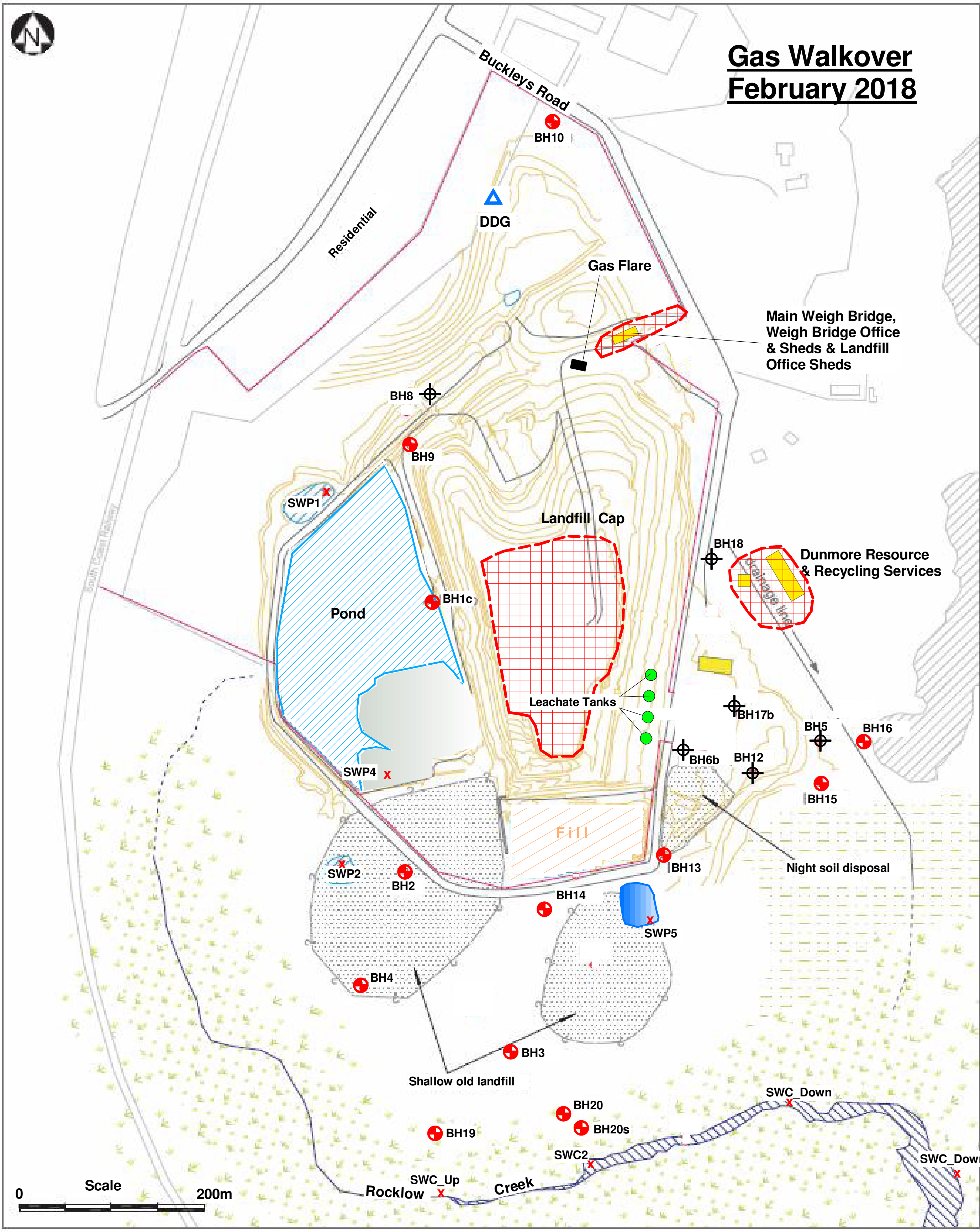
Legend:

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
CONTAMINATION RESOLVED

Location: Buckleys Road, Dunmore, NSW		Title: Groundwater Contours February 2018	
Client: Shellharbour City Council			Job number: 112096v
Drawn by: TRJ	Scale: As shown		Figure 2
Proj Man: LV	Date: February 2018		

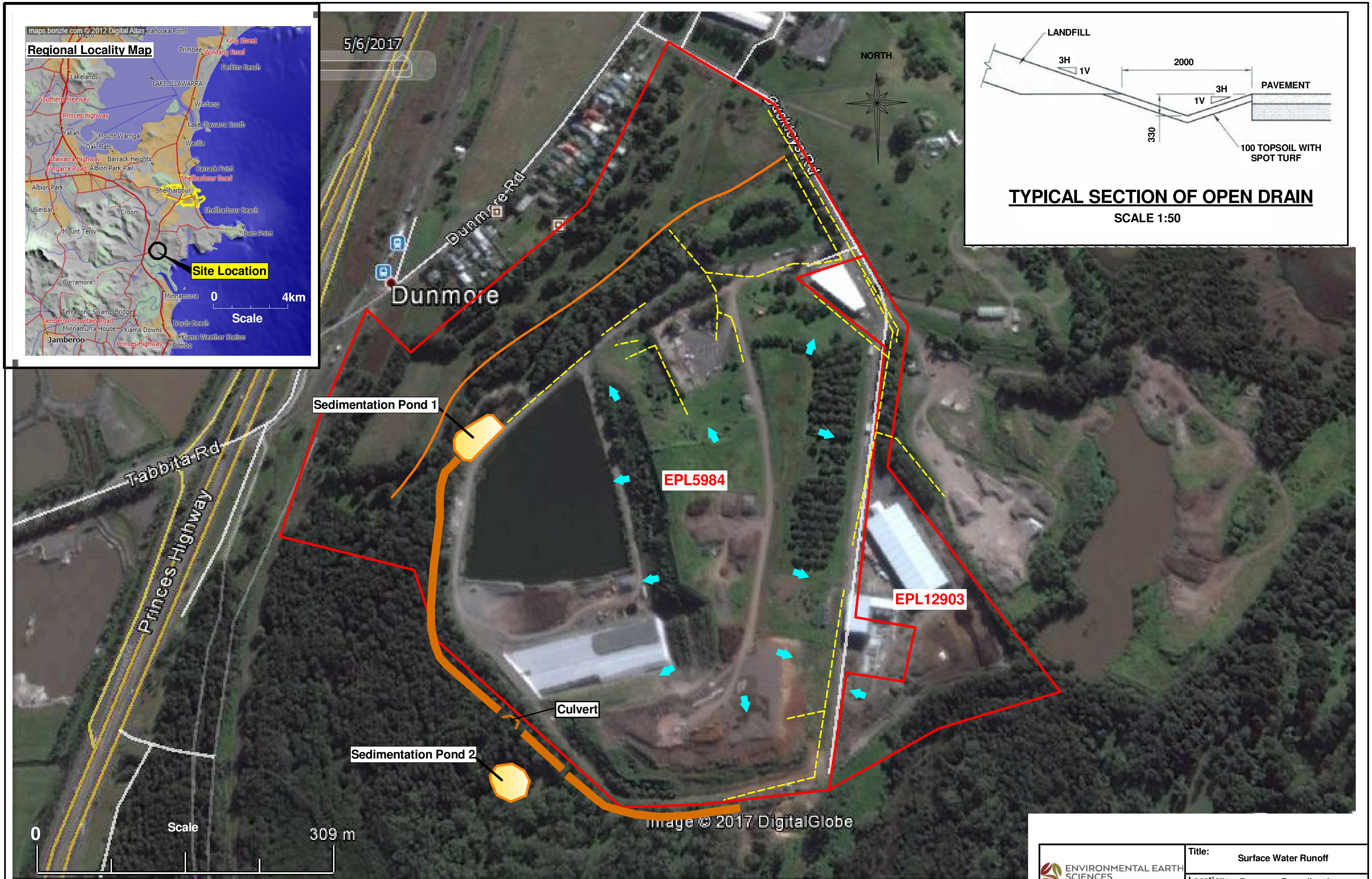


Legend:

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

Note: Based on aerial photo dated 1 Sept. 2010

ENVIRONMENTAL EARTH SCIENCES CONTAMINATION RESOLVED	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: February 2018	



Legend:

- licence boundary
- levee bank
- drainage layout
- approx. stormwater diversion drain
- approx. stormwater flow direction

Reference: Google Earth Pro digital image 5/6/2017.

ENVIRONMENTAL EARTH SCIENCES (CONTAMINATION RESOLVED)	Title: Surface Water Runoff	
	Location: Dunmore Recycling & Waste Disposal Depot, Shellharbour	
Client: Shellharbour City Council		Job number: 112096v
Drawn by: TRJ	Scale: As shown	Source: See Ref.
Proj Man: LV	Date: February 2018	Figure 4

ATTACHMENT 2 TABLES

TABLE 1 FIELD MEASUREMENTS – FEBRUARY 2018

Sample	SWL	SWL	pH	EC	ORP	Temp.	DO	Colour	Odour
Units	mAHD	Dip (m)	-	mS/cm	mV	ºC	ppm	-	-
BH1c	0.454	3.5	7.05	6.34	-99	28.1	1.44	Light brown	Leachate
BH2	0.683	4.109	7.14	2.746	-111	23.3	1.22	Clear	Leachate
BH3	0.529	3.235	7.5	1.883	-111	20.4	2.9	Clear with black floaties	None
BH4	0.514	4.505	7.11	1.513	-98	21	0.23	Clear	None
BH9	0.987	3.398	-	-	-	-	-	-	-
BH10	3.616	1.175	-	-	-	-	-	-	-
BH13	0.8	4.495	7.13	1.715	-64	22.6	0.63	Clear	None
BH14	0.765	4.95	6.57	2.124	7	21.9	0.47	Clear	None
BH15	0.64	0.77	6.72	7.79	-79	23.1	0.97	Light brown	Yes
BH16	0.6	0.78	6.69	3.71	-151	21	1.84	Light brown	Yes
BH19	0.425	4.765	7.14	0.917	-66	20.7	0.22	Milky	None
BH20	0.405	2.365	7.55	1.455	-140	20.7	0.05	Clear	H2S
BH20s	0.392	2.378	7.49	1.158	-24	21.5	0.07	Clear	Yes
LP1	-	-	7.63	11.84	146	26.4	1.23	Black	Leachate
SWC2	-	-	7.17	52.4	-16	24.5	2.89	Clear	None
SWC-Up	-	-	7.34	52.3	-16	24.7	2.94	Murky	Yes
SWC-Down	-	-	7.66	52.8	34	24.4	3.81	Clear	None
SWC_DOWN_2	-	-	7.64	53.1	40	24.2	3.78	Clear	None
SWP1	-	-	7.43	0.911	-85	23.5	0.84	Dark brown	Decomposing
SWP2	-	-	7.6	2.212	-240	25.1	0.3	Clear/Light brown	None
SWP4	-	-	8.53	2.192	-45	28.2	7.66	Light brown/Clear	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 – FEBRUARY 2018

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	7.2	3910	665	130	210	100	**380**	805	0.1	0.1	-	14	3170	0.92	195	8	0.09	**3.2**	15
BH2	7.2	1730	300	195	49	69	**35**	430	0.1	0.62	-	160	985	0.1	60	2	0.44	**4.1**	13
BH3	7.3	950	110	125	39	28	**44**	230	0.1	**23**	-	83	530	0.1	19	4	0.22	0.08	7.4
BH4	7.2	810	95	145	25	32	**8.9**	155	0.1	0.1	0.1	110	510	0.1	19	2	0.17	**0.75**	4.6
BH13	7.2	1060	110	215	25	42	**2.6**	135	0.1	0.49	-	170	730	0.1	23	2	0.27	0.26	2
BH14	6.9	1390	100	320	26	58	0.7	250	0.14	0.13		120	975	0.28	38	2	0.25	0.06	1.8
BH15	6.8	4520	740	215	715	89	**135**	1920	0.1	0.1	0.26	245	1110	1.1	200	2	0.52	**18**	25
BH16	6.8	2150	580	105	61	50	1.8	1070	0.1	0.1	-	145	160	0.18	28	2	0.08	**0.37**	5.1
BH19	7.3	970	88	190	15	39	**6.6**	180	0.1	0.1	-	170	520	0.1	16	2	0.08	0.13	68
BH20	7.5	785	66	125	35	36	**16**	155	0.1	0.1	-	210	320	0.28	24	2	0.08	0.03	1.8
BH20s	7.5	790	50	100	110	38	1.3	55	0.1	3.1	-	190	460	0.1	20	2	0.07	0.12	7.1
LP1	7.8	7080	1190	200	390	110	**810**	1530	0.19	1.2	-	120	5600	19	800	240	0.43	**1.5**	100
SWP1	6.9	595	115	60	18	24	**2.5**	100	0.1	0.1	-	15	480	0.1	-	-	-	**4.5**	110
SWP2	7.8	1290	275	100	32	56	0.2	325	0.1	0.18	-	195	545	0.1	-	-	-	0.12	0.18
SWP4	**8.3**	1340	340	61	27	57	1.5	360	0.13	**12**	-	280	380	0.1	34	2	-	0.02	0.12
SWC-UP	7.2	36600	10900	440	460	1170	0.2	20200	0.19	0.1	-	2530	380	0.1	-	-	-	0.04	0.25
SWC-DOWN	7.3	36200	11100	425	455	1170	0.1	20000	0.2	0.1	-	2450	185	0.1	-	-	-	0.07	0.18
SWC_DOWN_2	7.2	35900	10800	440	470	1220	0.1	19200	0.18	0.1	-	2560	245	0.1	-	-	-	0.1	0.17
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 – FEBRUARY 2018

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	**810**	5600	**1.5**	100	<20	<20
SWC2	0.3	255	0.06	0.21	-	-
SWC-UP	0.2	380	0.04	0.25	-	-
SWC-Down	0.1	185	0.07	0.18	-	-
SWC_DOWN_2	0.1	245	0.1	0.17	-	-
SWP1	**2.5**	480	**4.5**	110	-	-
SWP2	0.2	545	0.12	0.18	-	-
SWP4	1.5	380	0.02	0.12	-	-
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 – FEBRUARY 2018

Bore	Na/Cl	Na/Ca	Mg/Ca	Ca/K	Cl/SO_4	Cl/HCO_3	K/TDS (%)	L/N (%)
BH1c	1.27	4.46	1.27	1.21	77.91	0.44	5.37	65.93
BH2	1.08	1.34	0.58	7.76	3.64	0.75	2.83	15.00
BH3	0.74	0.77	0.37	6.25	3.75	0.75	4.11	40.30
BH4	0.95	0.57	0.36	11.31	1.91	0.52	3.09	12.54
BH13	1.26	0.45	0.32	16.78	1.08	0.32	2.36	7.65
BH14	0.62	0.27	0.30	24.01	2.82	0.44	1.87	5.61
BH15	0.59	3.00	0.68	0.59	10.62	2.98	15.82	81.45
BH16	0.84	4.82	0.79	3.36	10.00	11.51	2.84	8.56
BH19	0.75	0.40	0.34	24.71	1.43	0.60	1.55	6.85
BH20	0.66	0.46	0.47	6.97	1.00	0.83	4.46	22.51
BH20s	1.40	0.44	0.63	1.77	0.39	0.21	13.92	60.85
LP1	1.20	5.19	0.91	1.00	17.28	0.47	5.51	80.08
SWP1	1.77	1.67	0.66	6.50	9.03	0.36	3.03	10.35
SWP2	1.30	2.40	0.92	6.10	2.26	1.03	2.48	7.51
SWP4	1.46	4.86	1.54	4.41	1.74	1.63	2.01	8.84
SWC-UP	0.83	21.60	4.39	1.87	10.82	91.49	1.26	3.68
SWC-DOWN	0.86	22.77	4.54	1.82	11.06	186.07	1.26	3.59
SWC_DOWN_2	0.87	21.40	4.57	1.83	10.16	134.88	1.31	3.77

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 – FEBRUARY 2018

Location	GA 5000 V/V%	ILU V/V%
Landfill cap	0	0.00001
Main weigh bridge, weigh bridge office and landfill office sheds	0	0.0001
Dunmore Resource & Recycling Services	0	0.00036
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**.

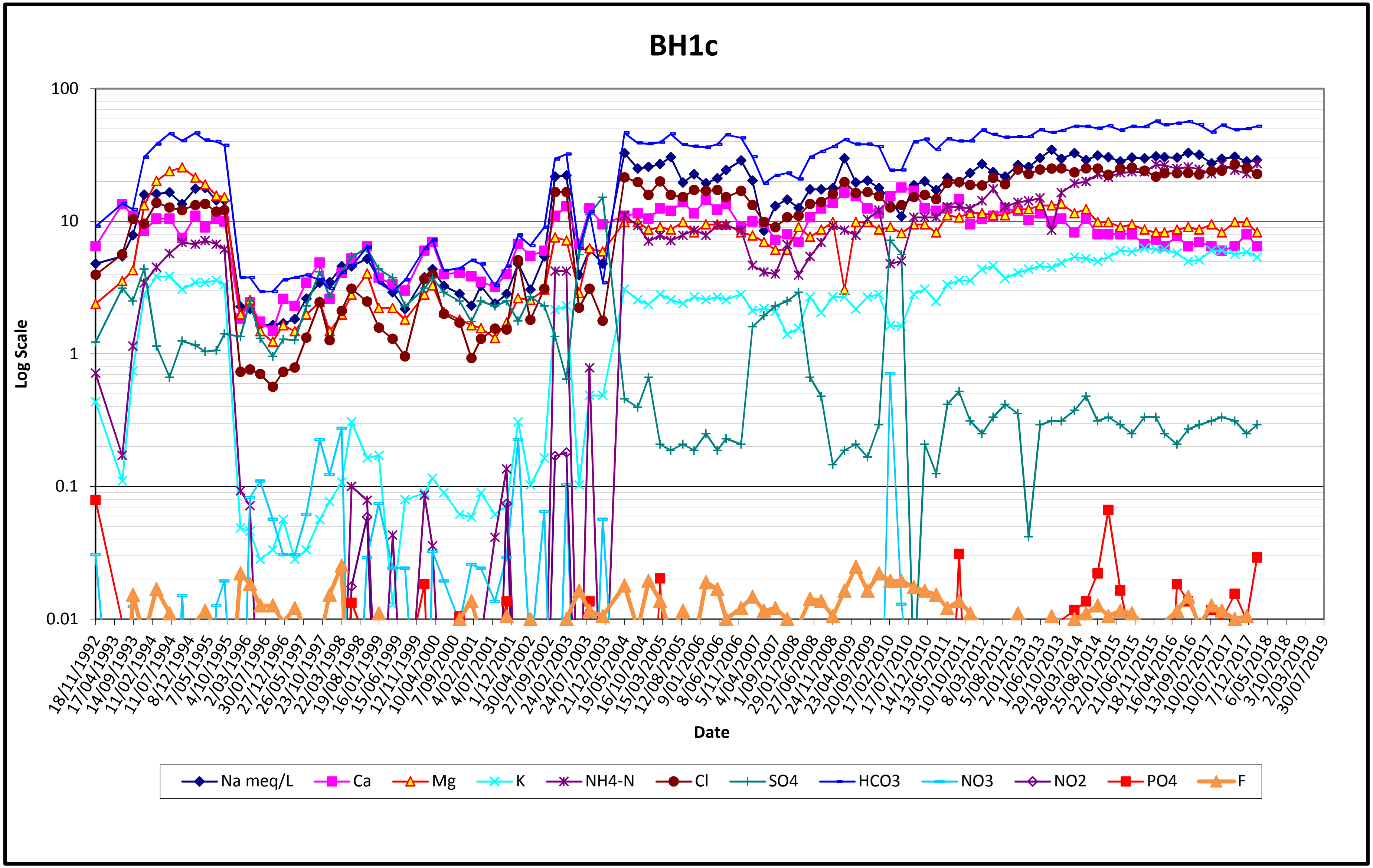
TABLE 6 QA/QC – FEBRUARY 2018

Analytes	BH13	FD1	RPD(%)
pH	7.20	7.20	0.00
TDS	1060	1070	0.94
Na+	110	100	9.52
Ca++	215	210	2.35
Mg++	42	40	4.88
K+	25	23	8.33
NH4-N	2.6	2.7	3.77
Cl-	135	145	7.14
SO4--	170	160	6.06
HCO3-	730	715	2.08
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	0.26	0.22	16.67
Fe.T	2	2.2	9.52
Mn.D	0.27	0.28	3.64
TOC	23	23	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**.

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

ATTACHMENT 3 SCHOELLER PLOTS



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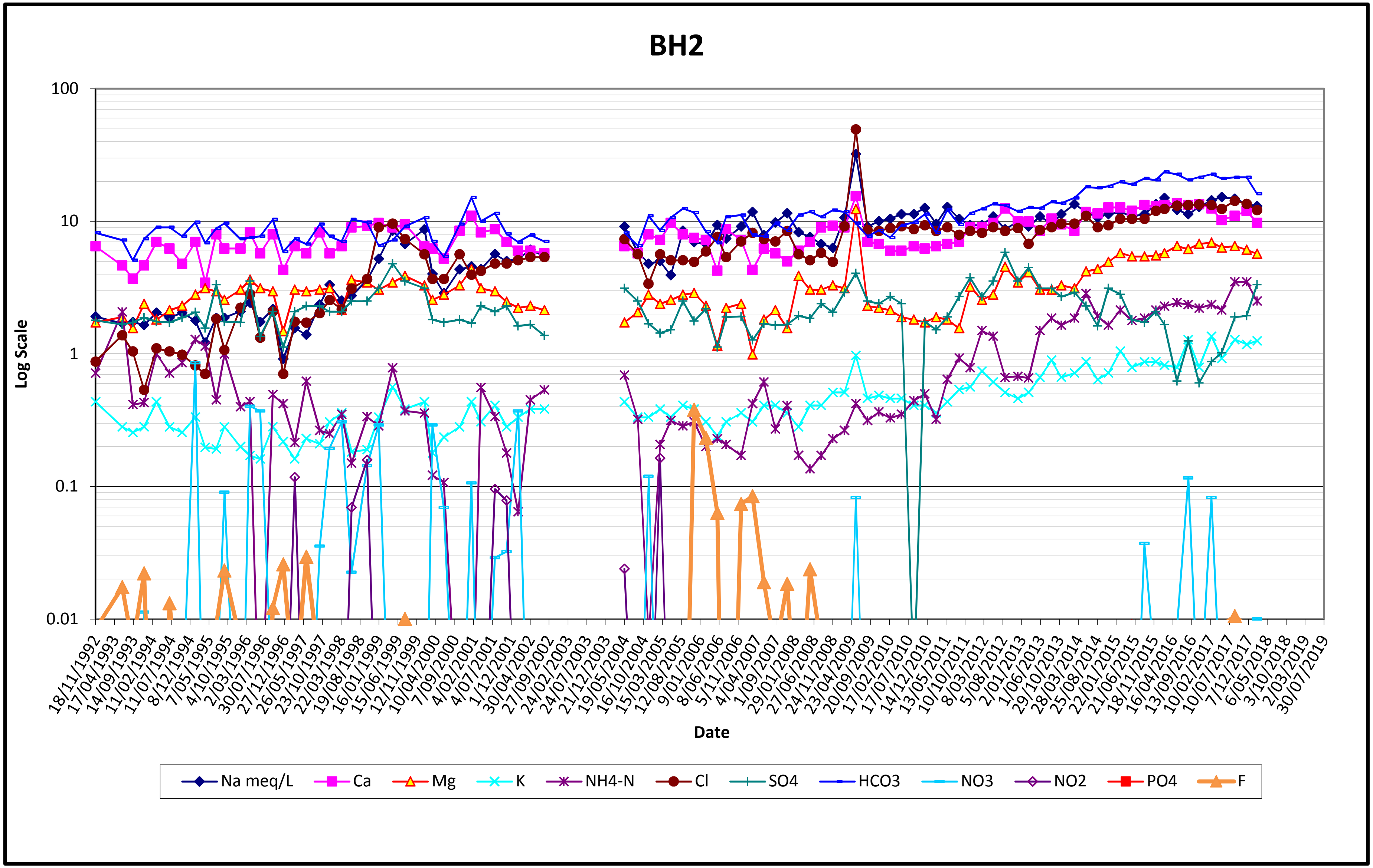
F



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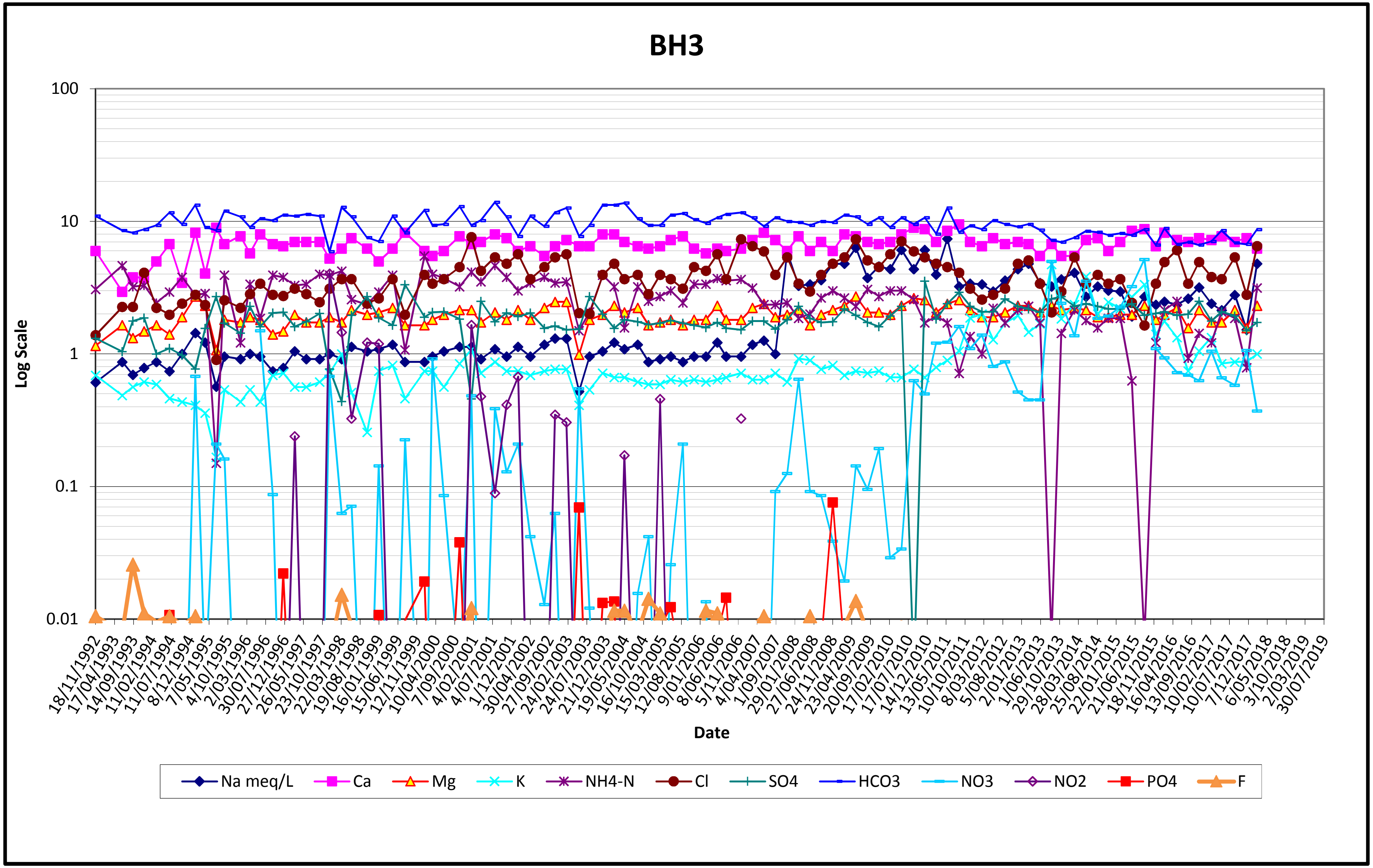

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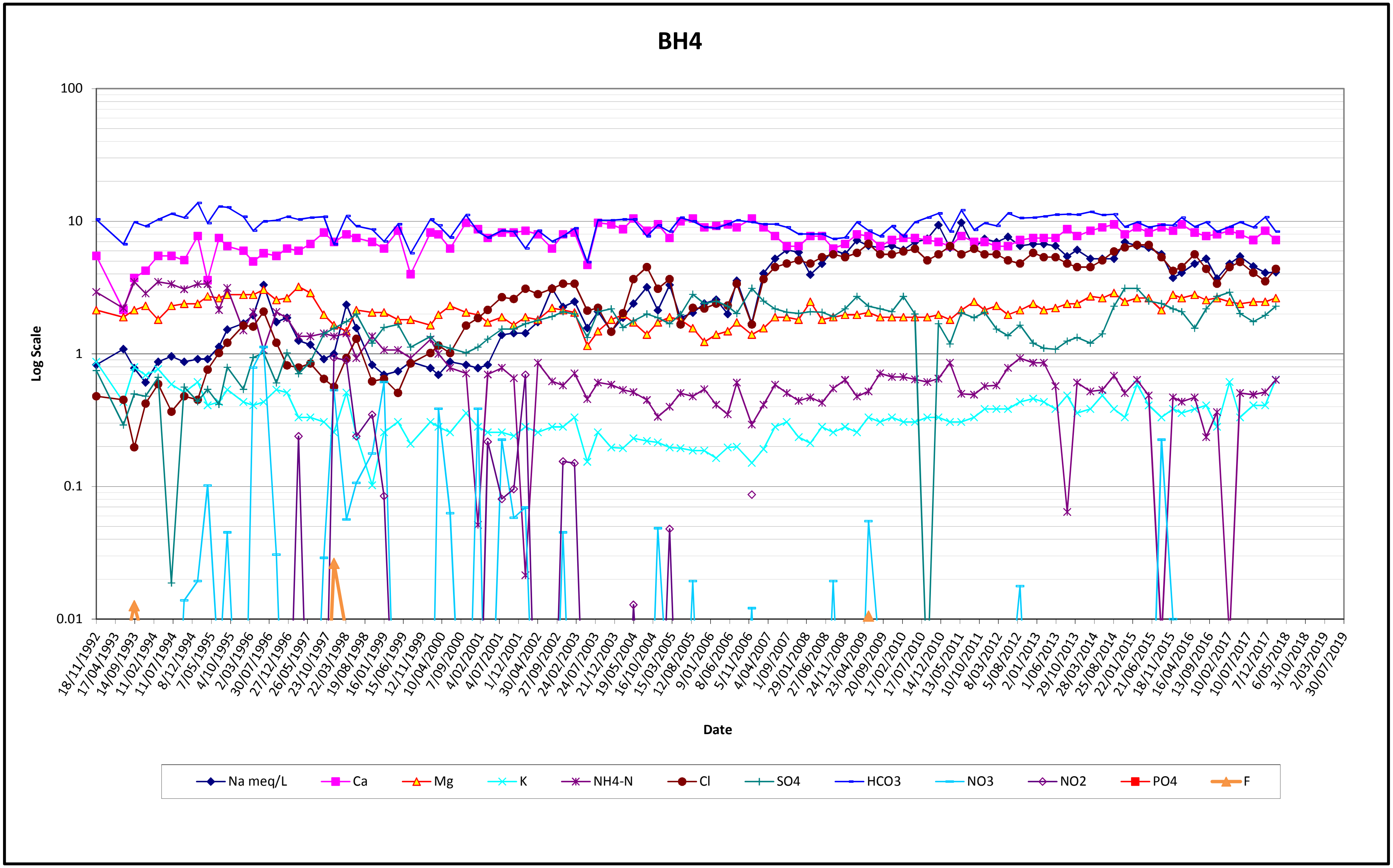

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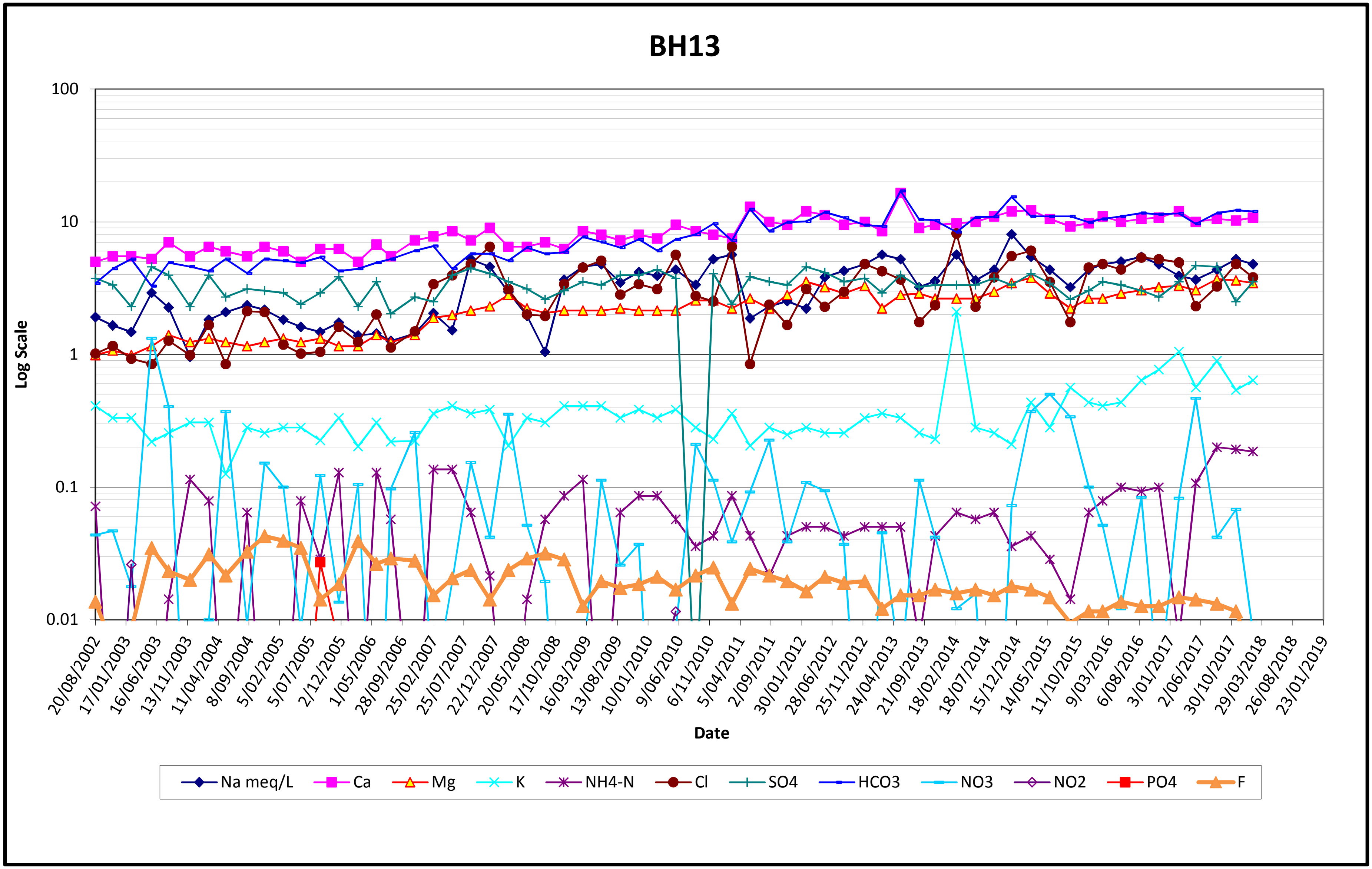

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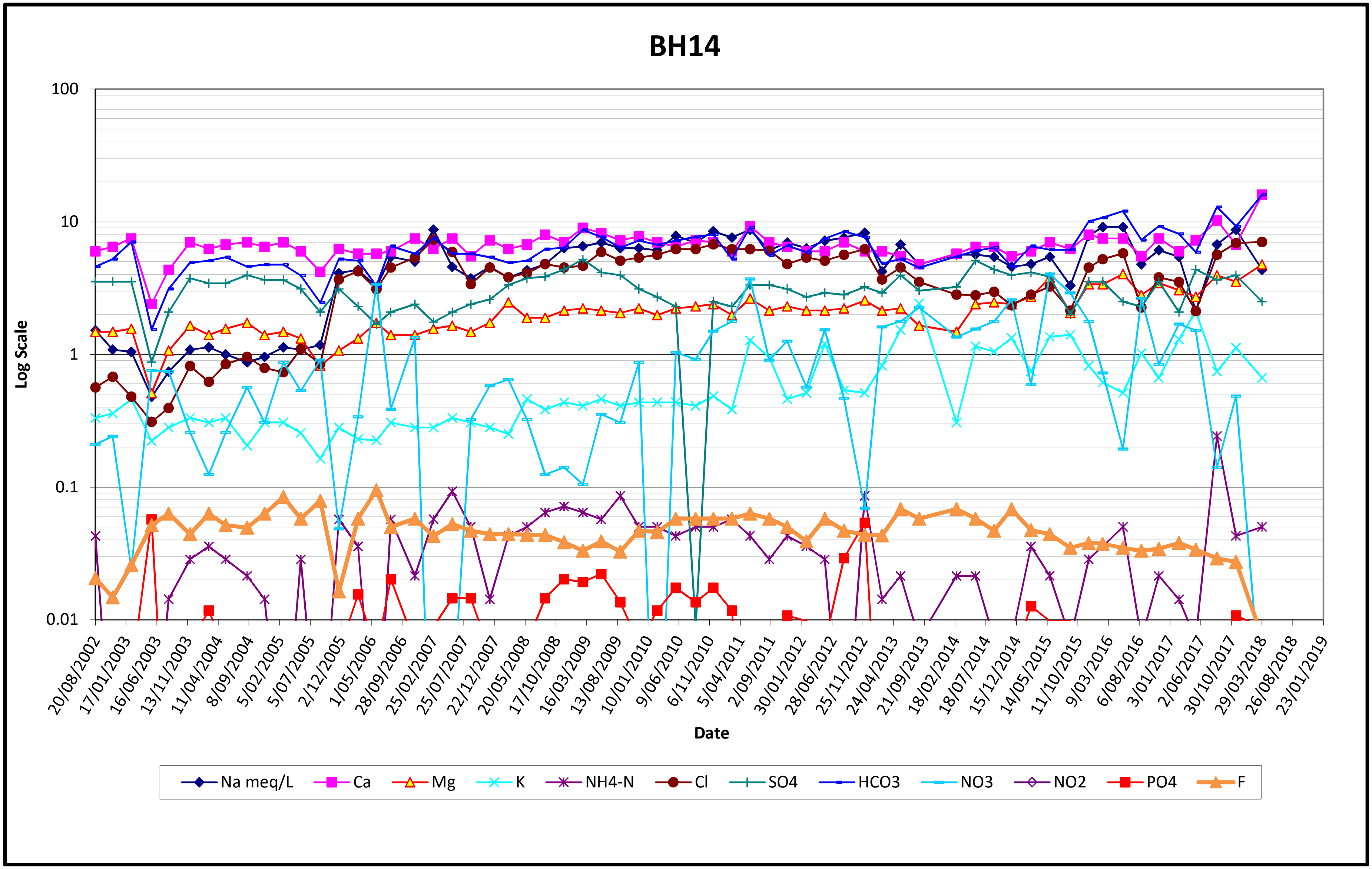
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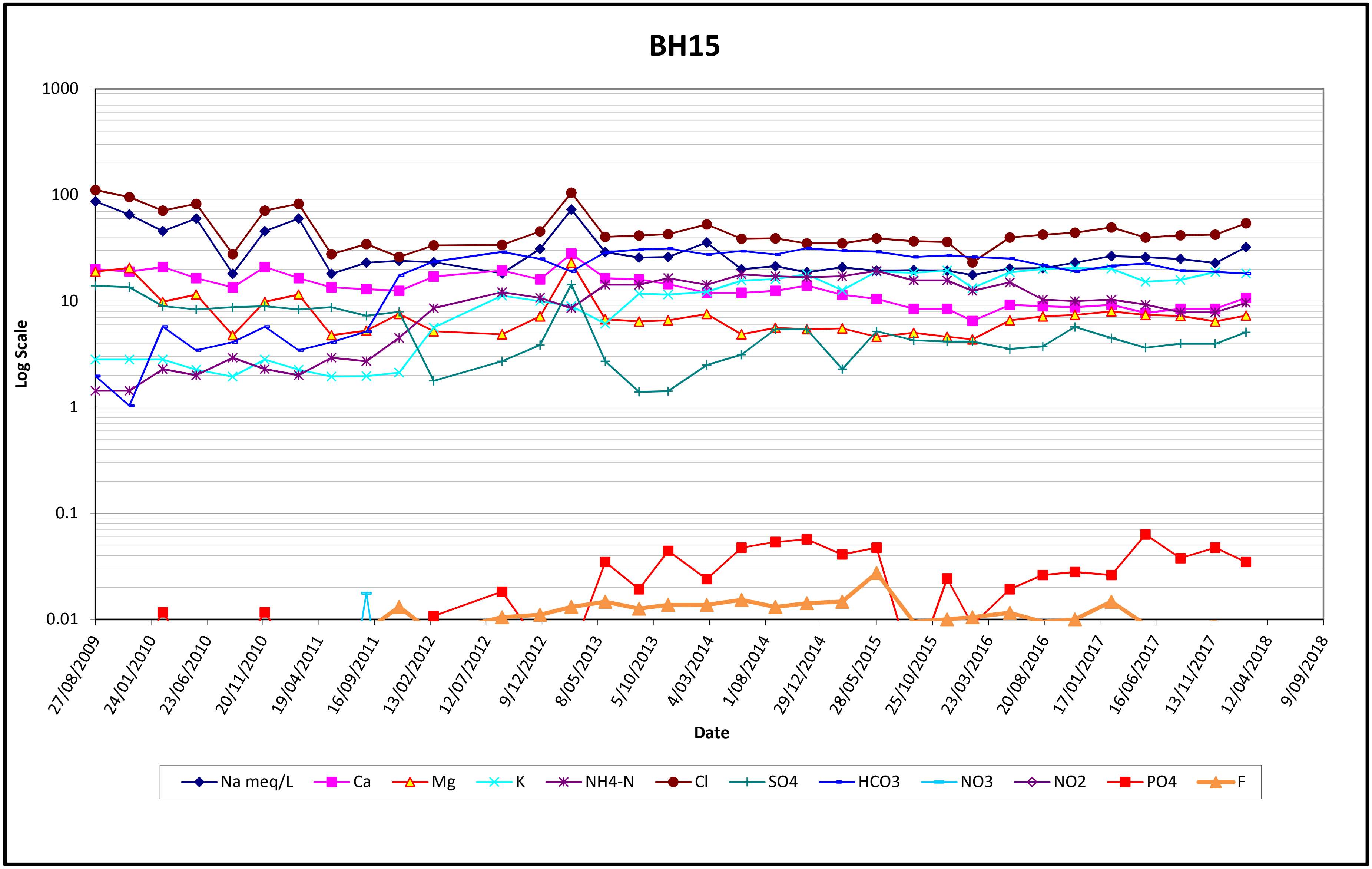
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Mg
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HCO3
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NO2
PO4
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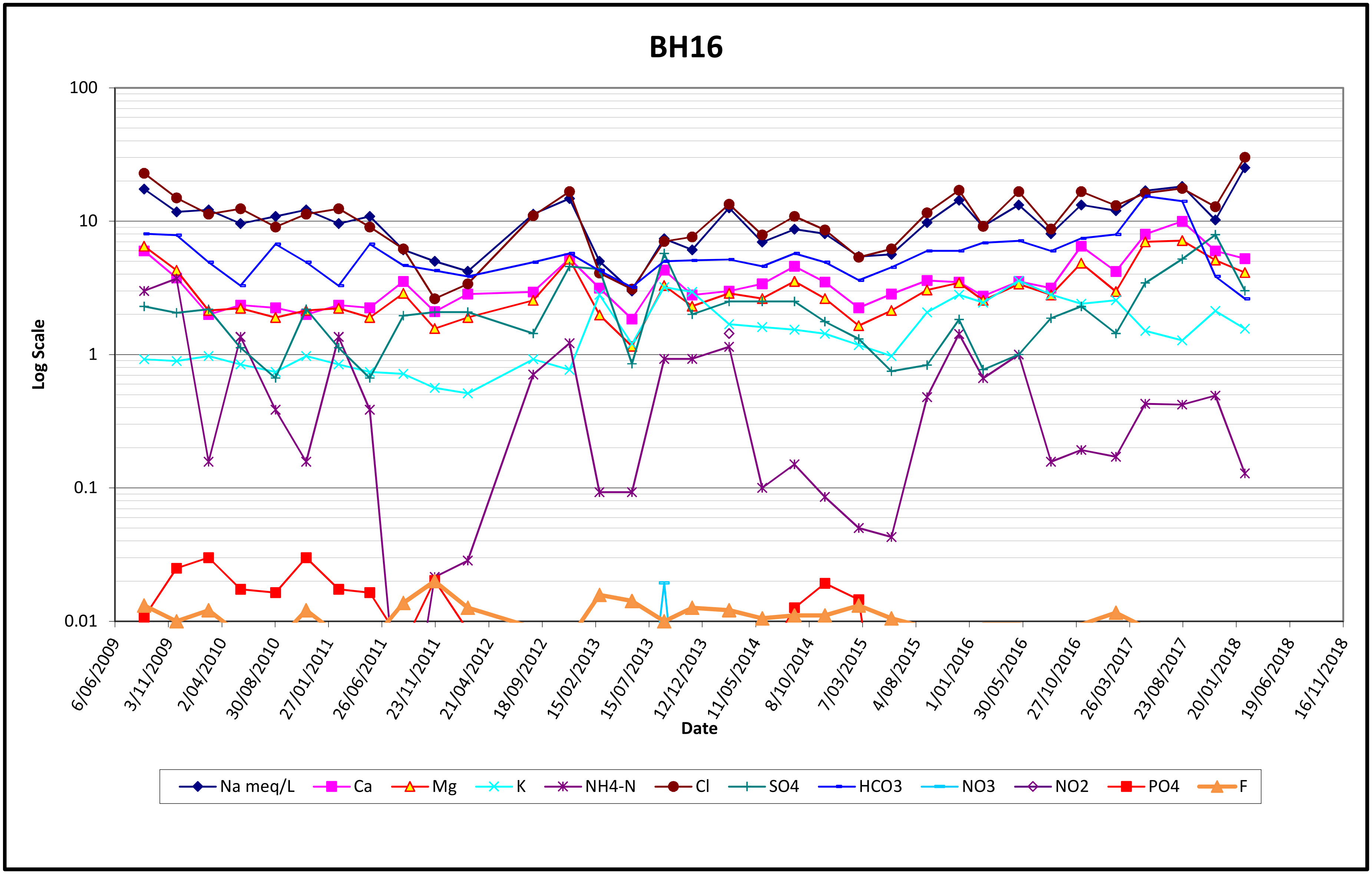

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Cl
SO4
HCO3
NO3
NO2
PO4
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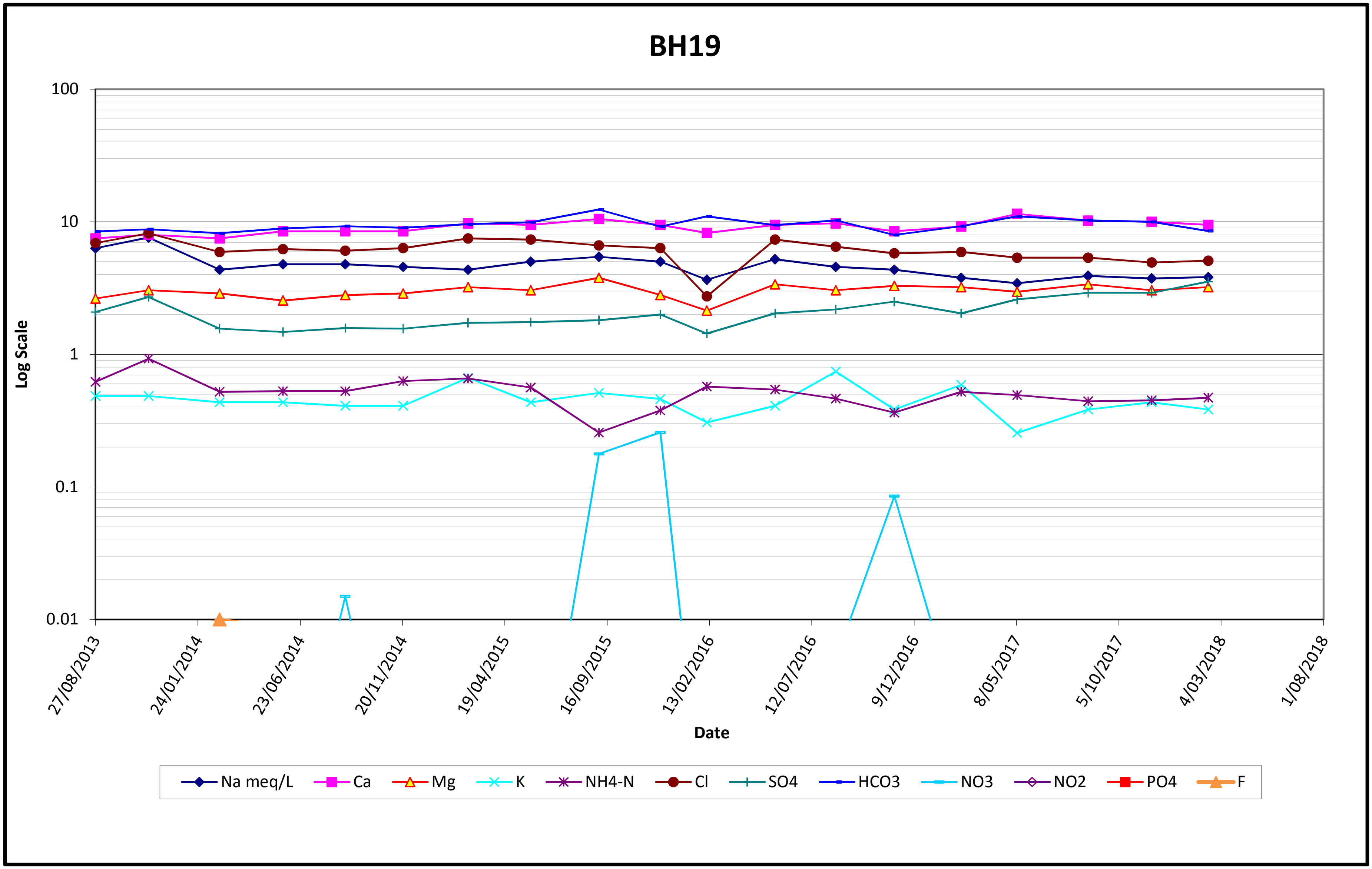
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Na meq/L
Ca
Mg
K
NH4-N
Cl
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HCO3
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PO4
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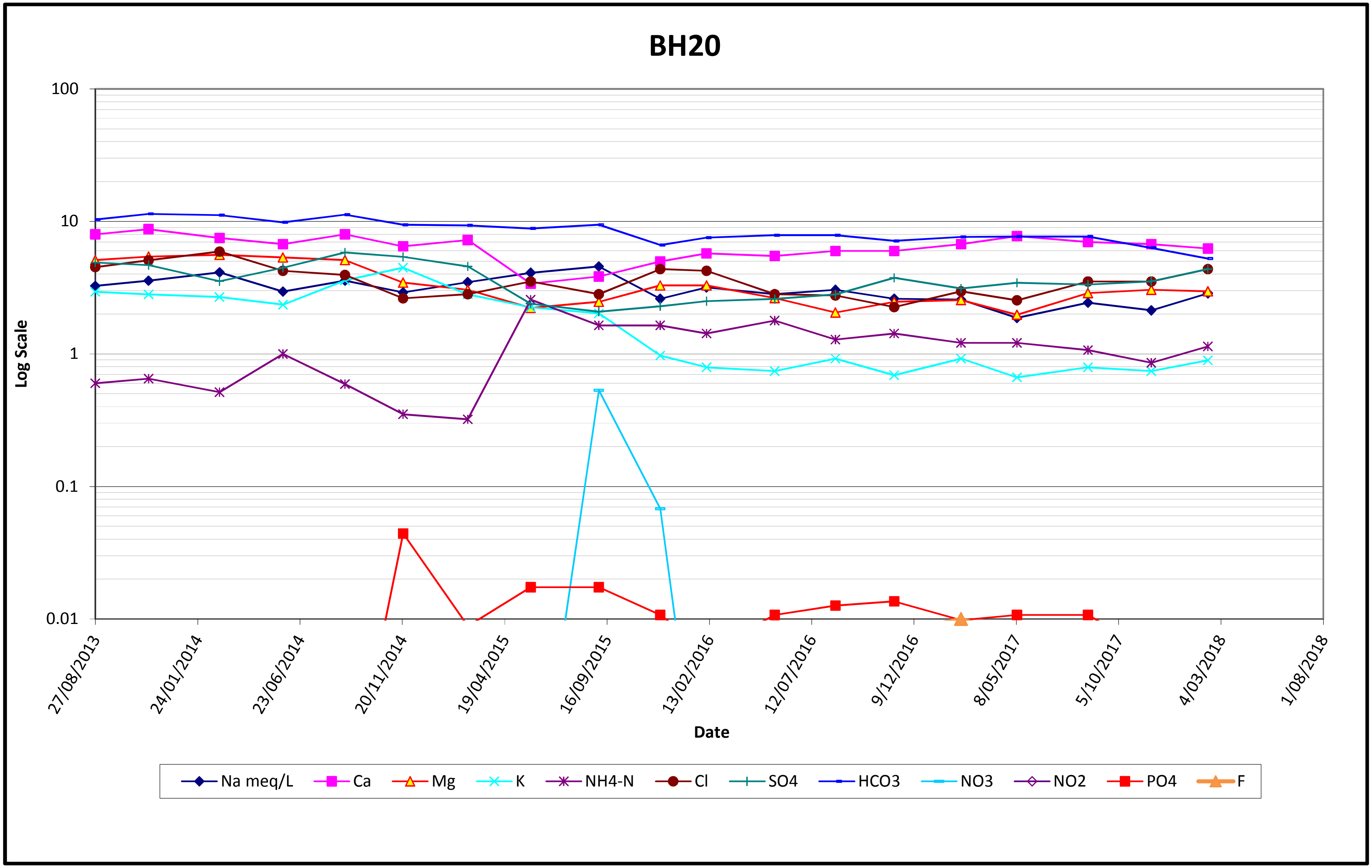

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NO2
PO4
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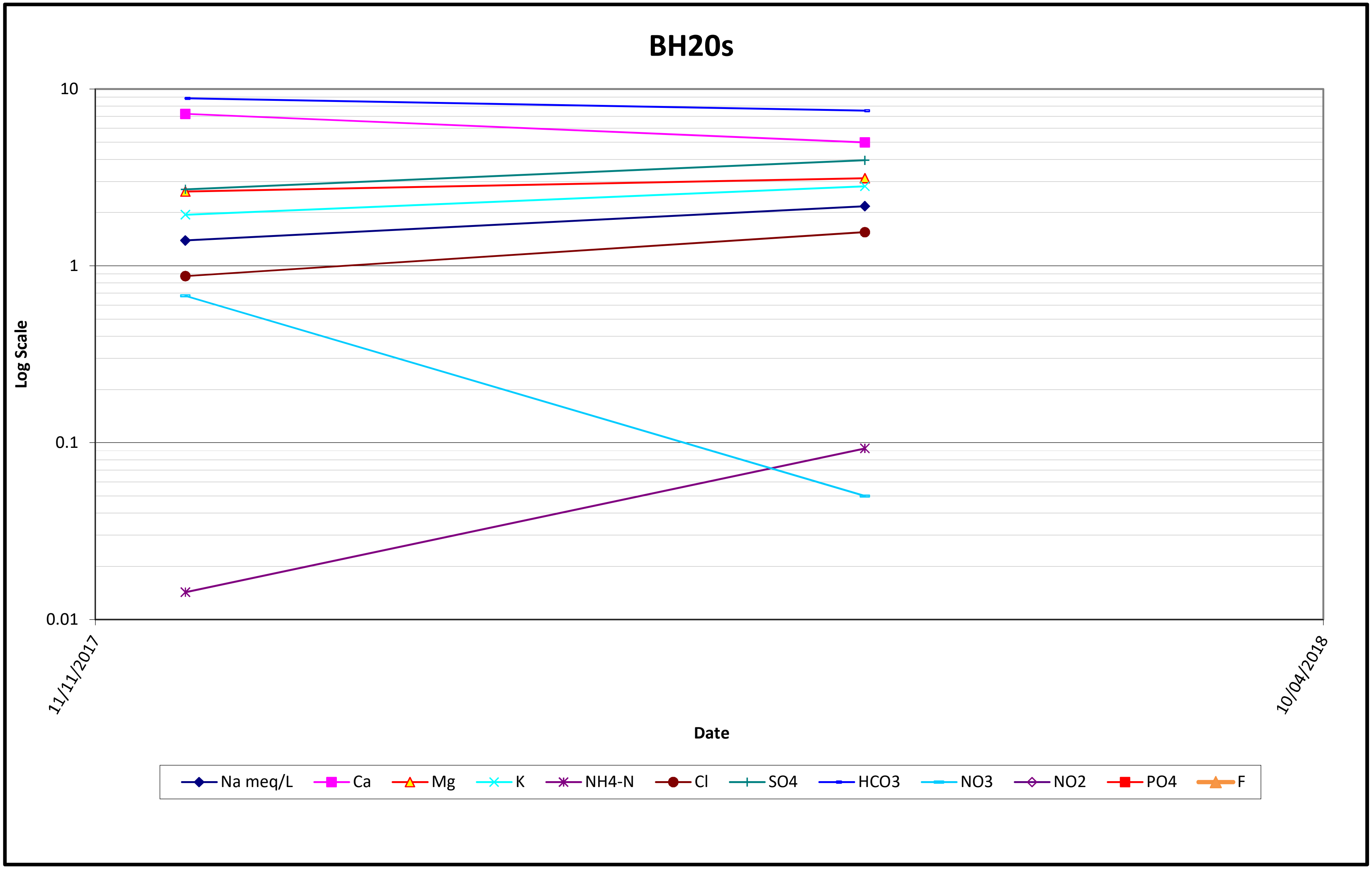
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Mg
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NO2
PO4
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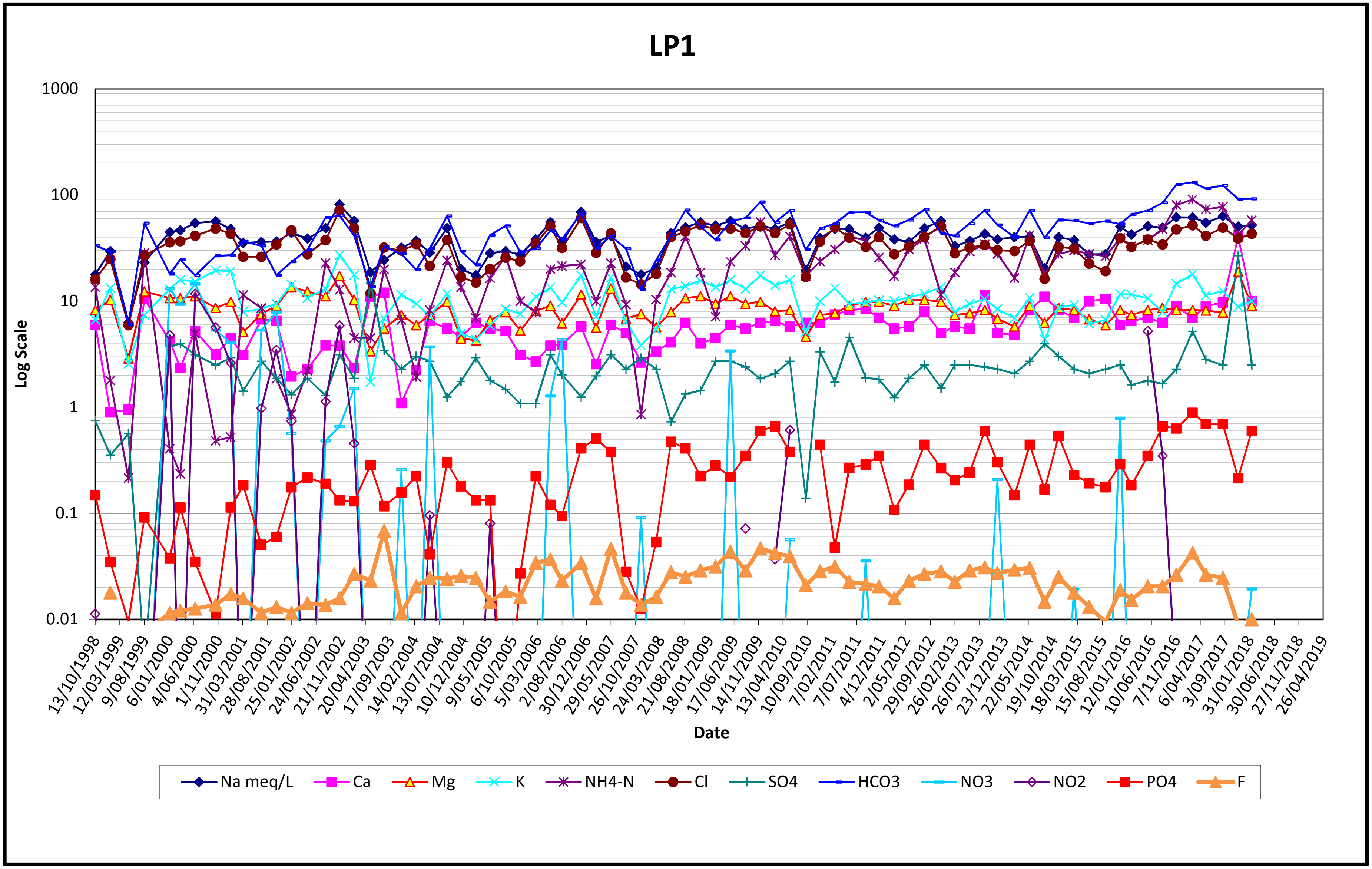
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Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
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PO4
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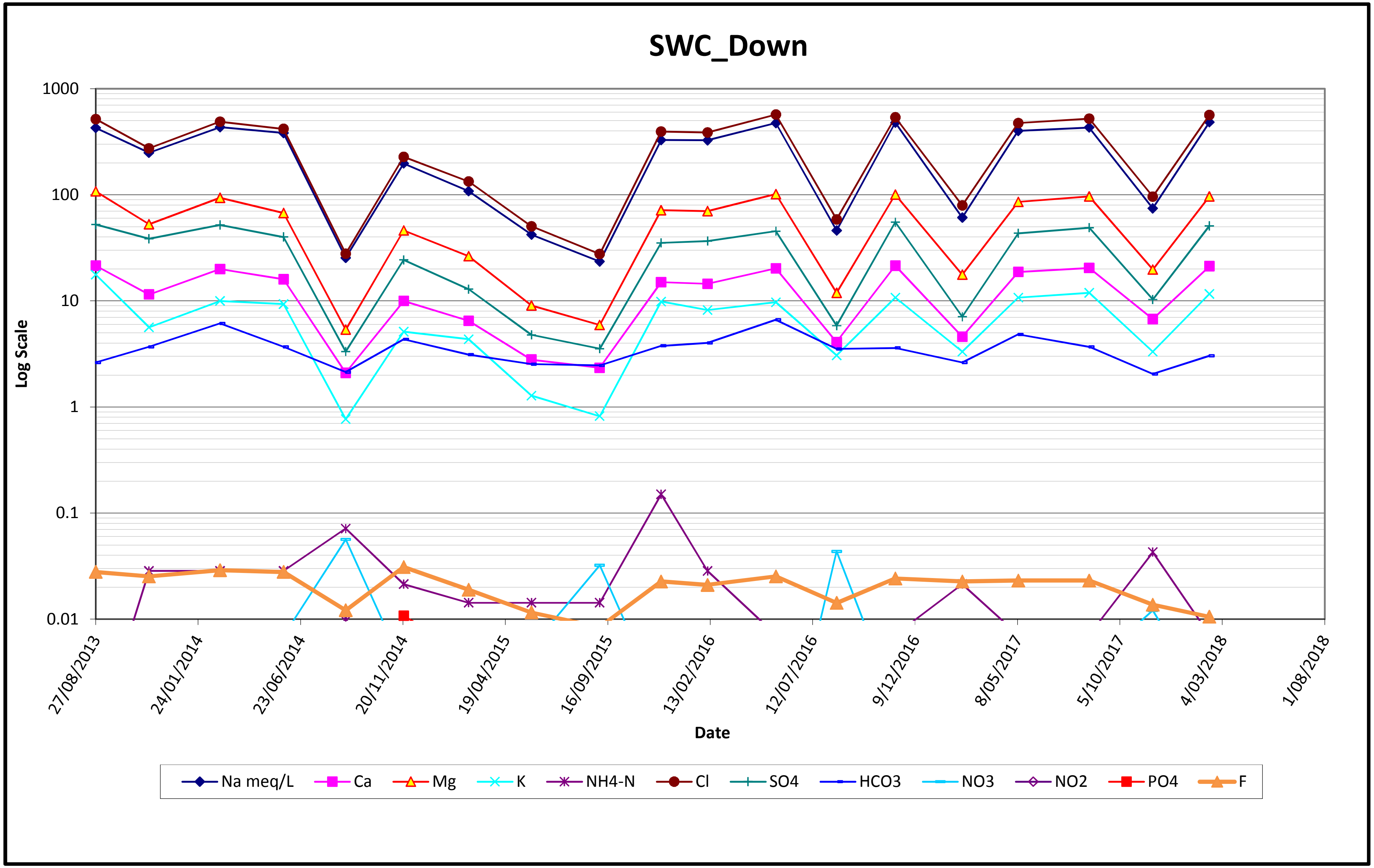
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4/03/2018
1/08/2018
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Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
NO3
NO2
PO4
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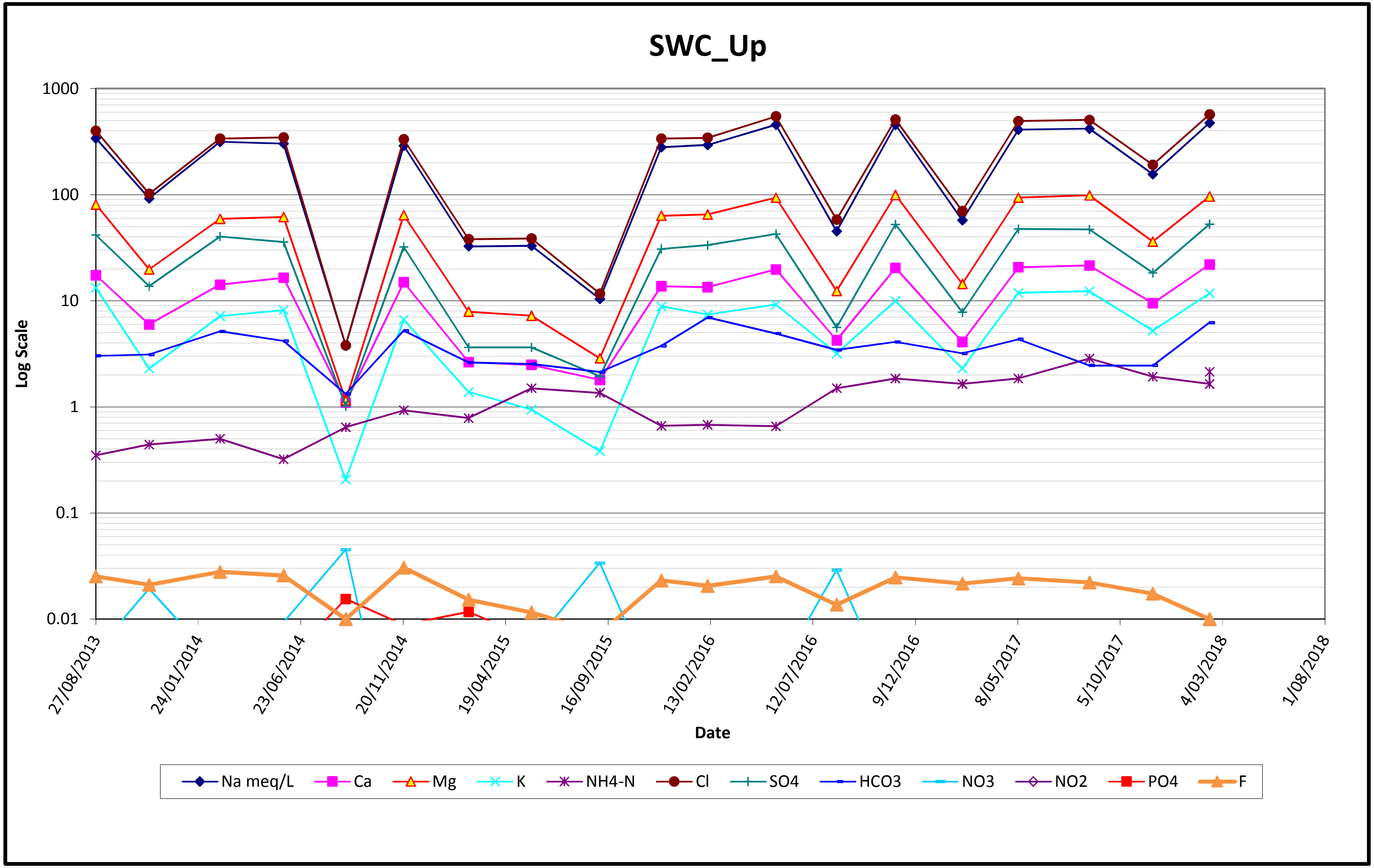

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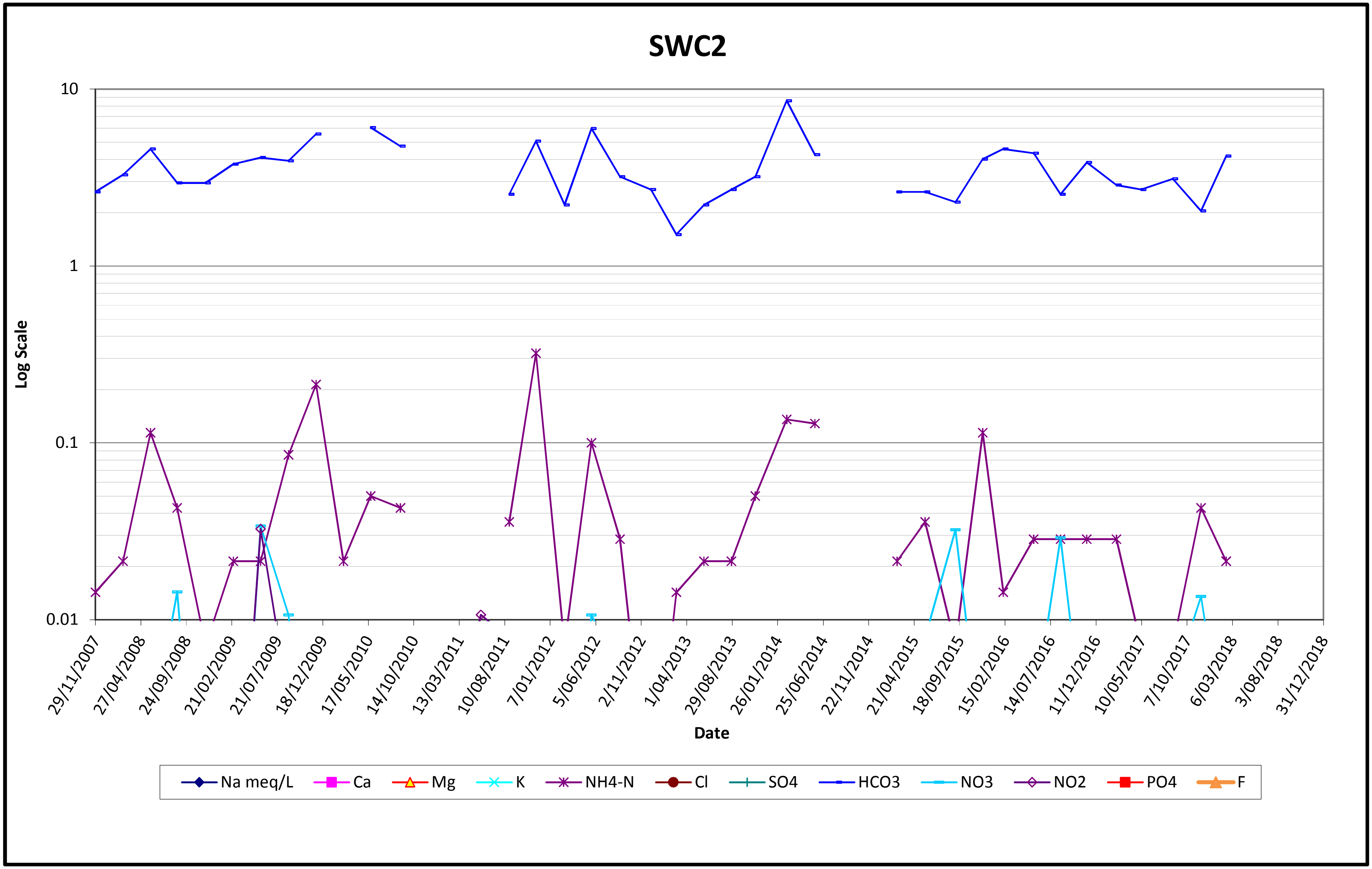
4/03/2018
1/08/2018
Date
Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
NO3
NO2
PO4
F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31/12/2018
Date
Na meq/L
Ca
Mg
K
NH4-N
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NO3
NO2
PO4
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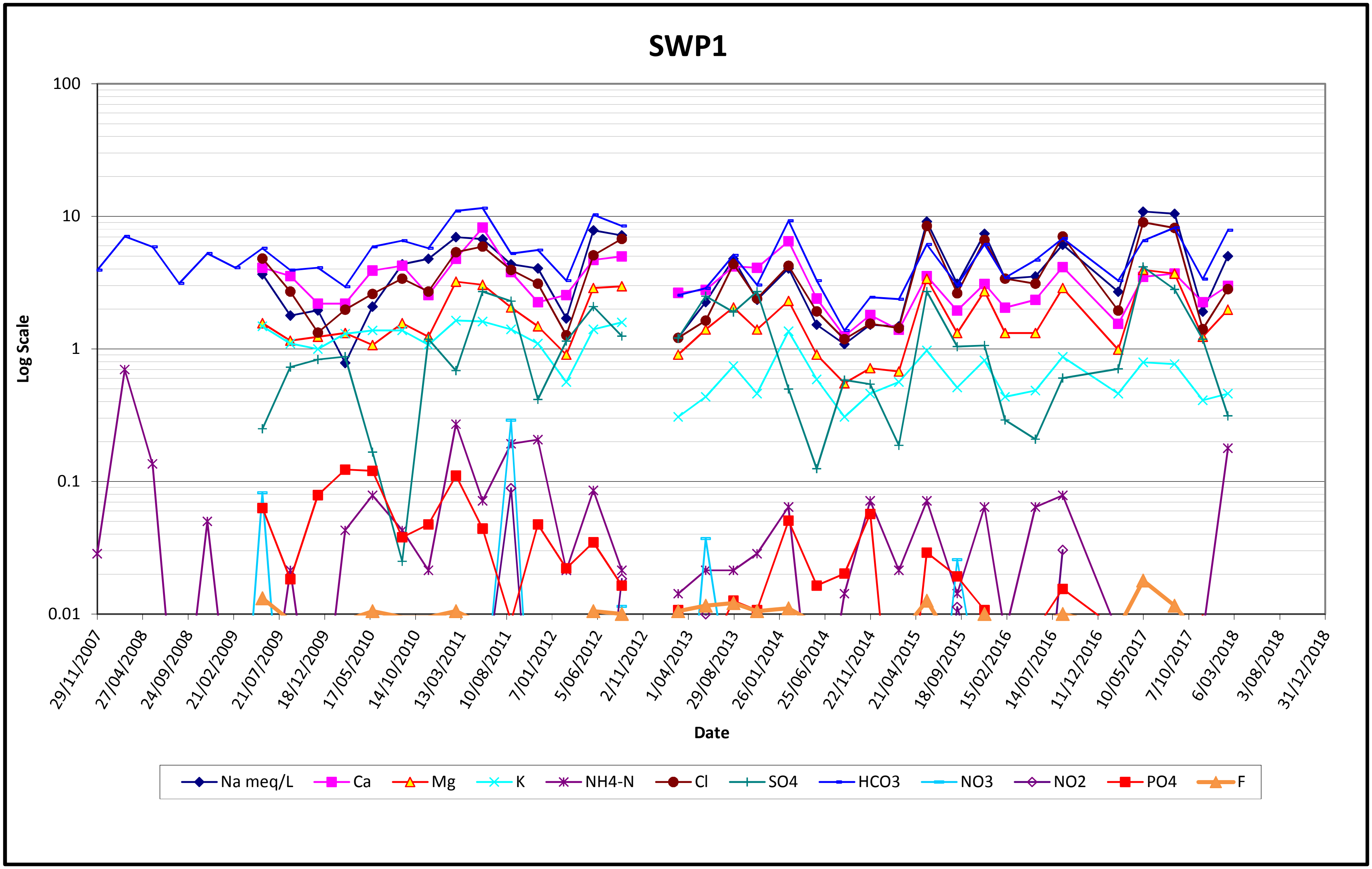
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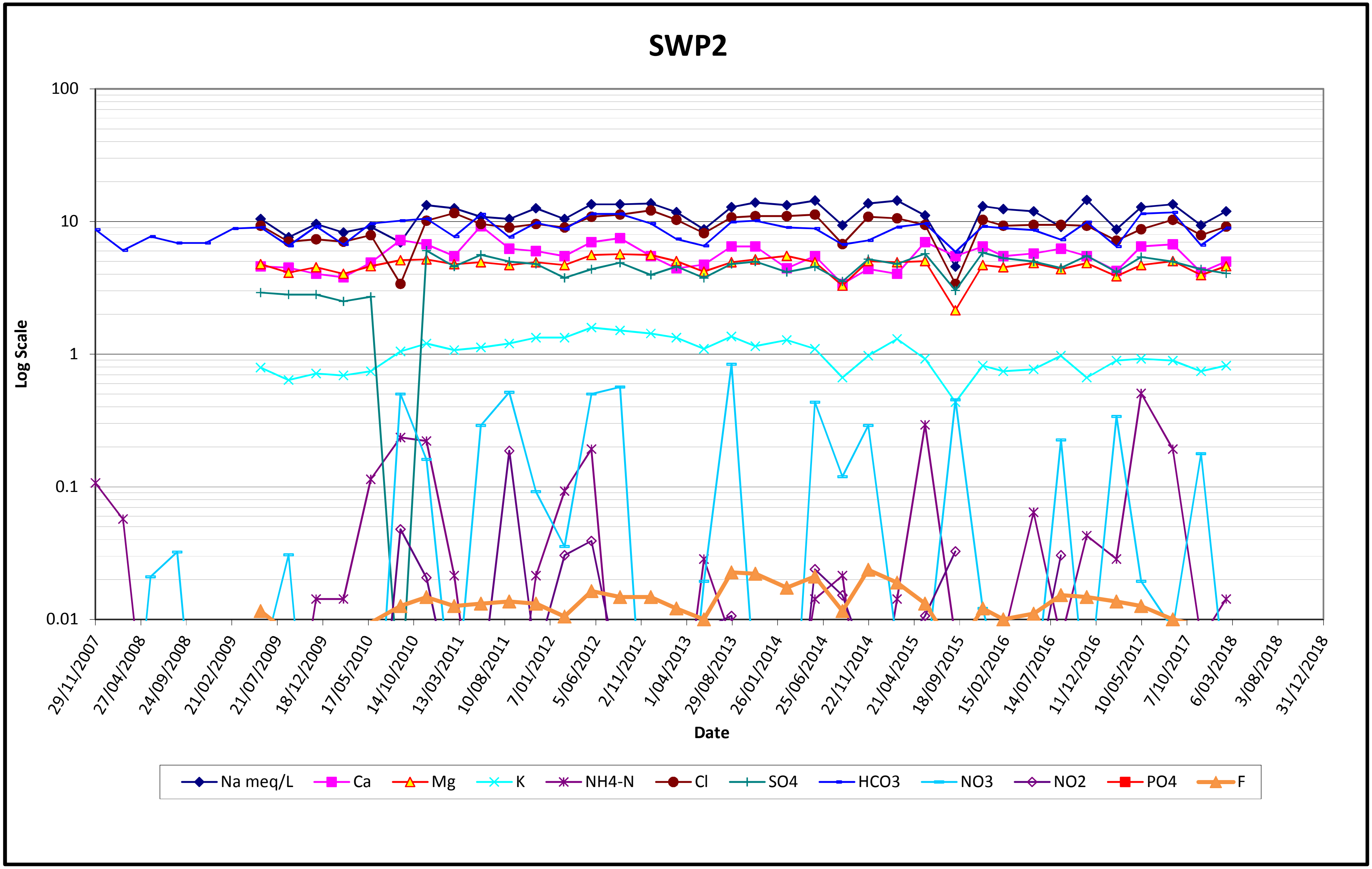
31/12/2018
Date
Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
NO3
NO2
PO4
F



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3/08/2018
31/12/2018
Date
Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
NO3
NO2
PO4
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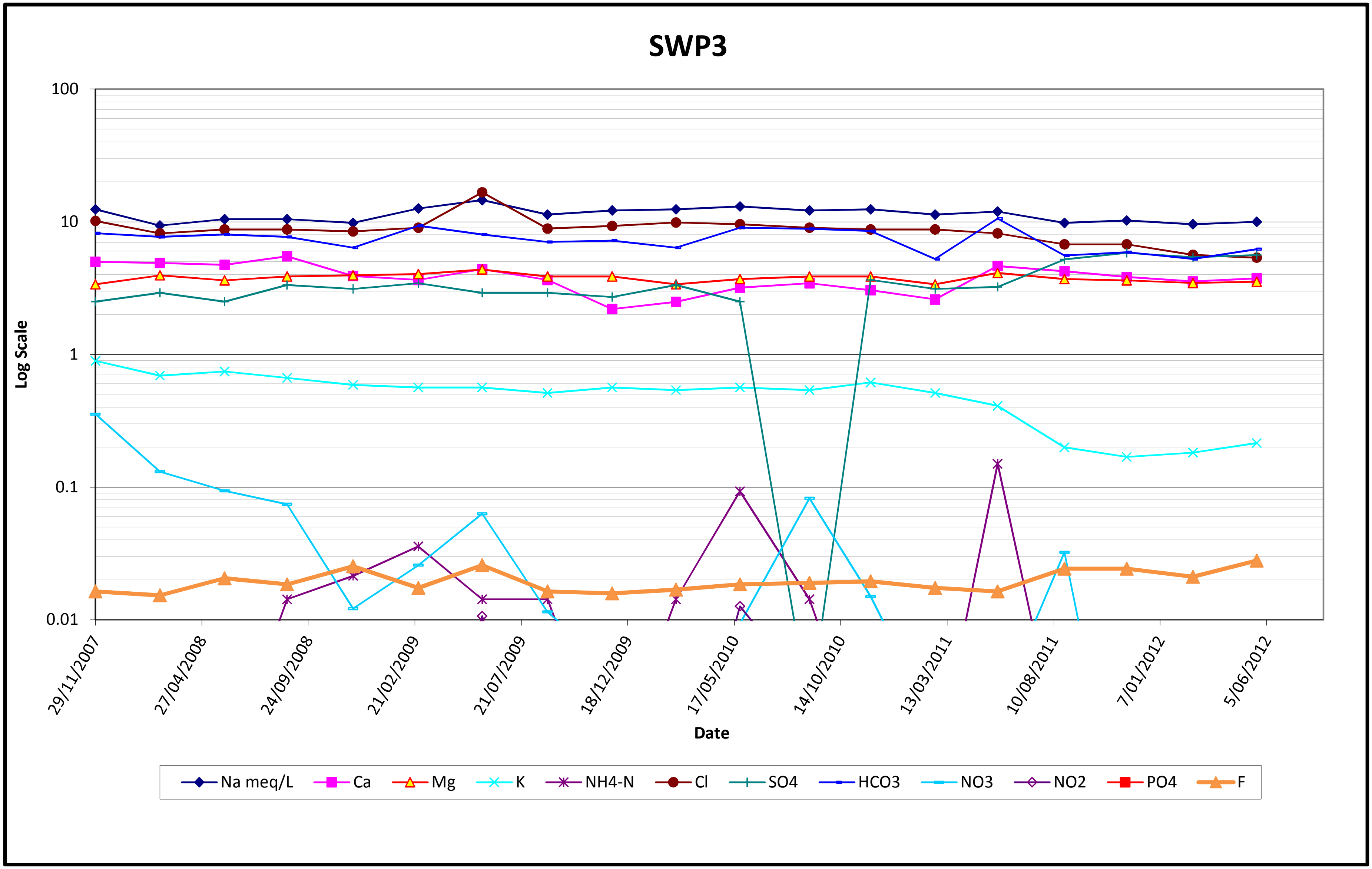
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Date
Na meq/L
Ca
Mg
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NH4-N
Cl
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NO2
PO4
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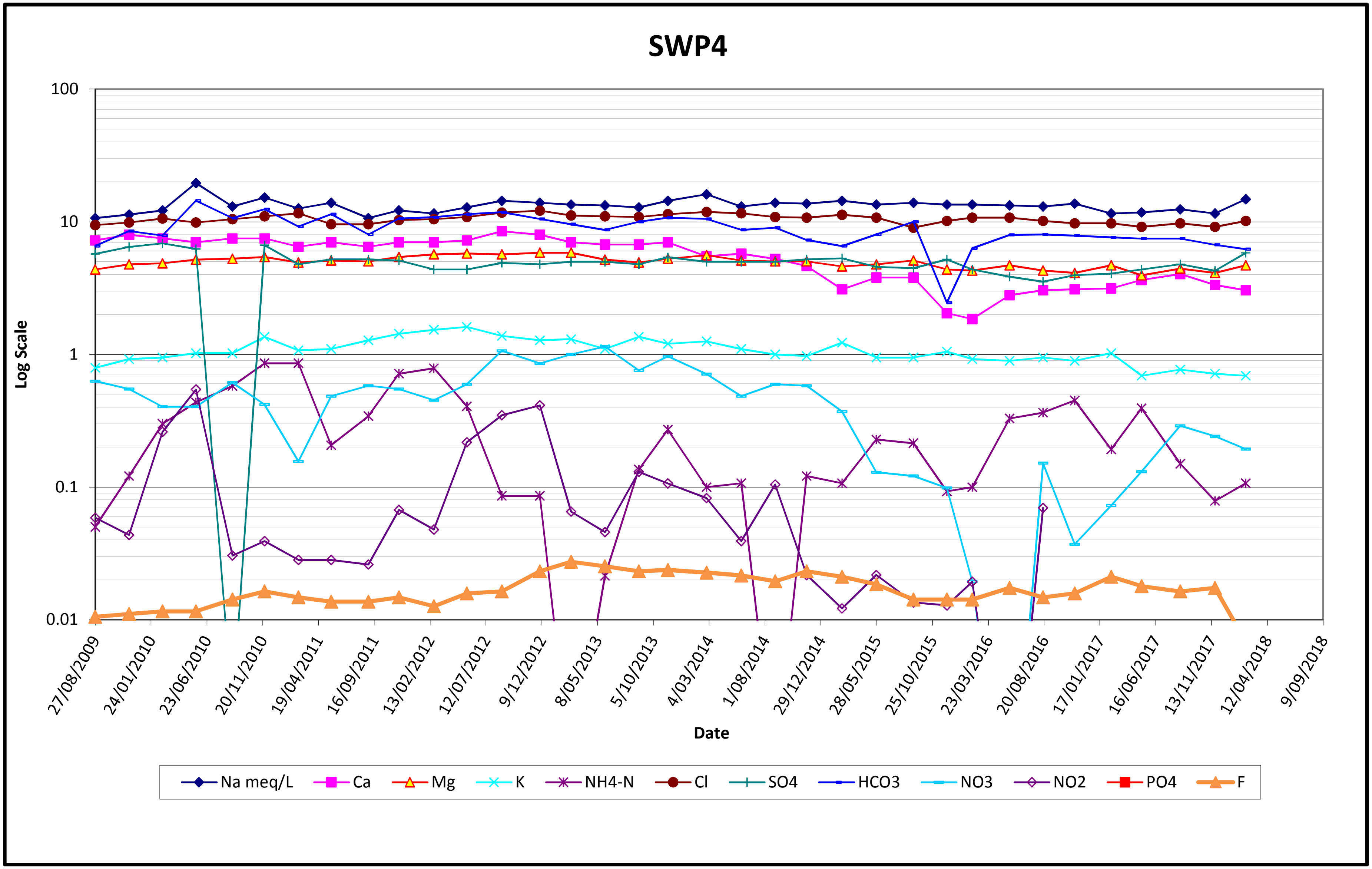

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PO4
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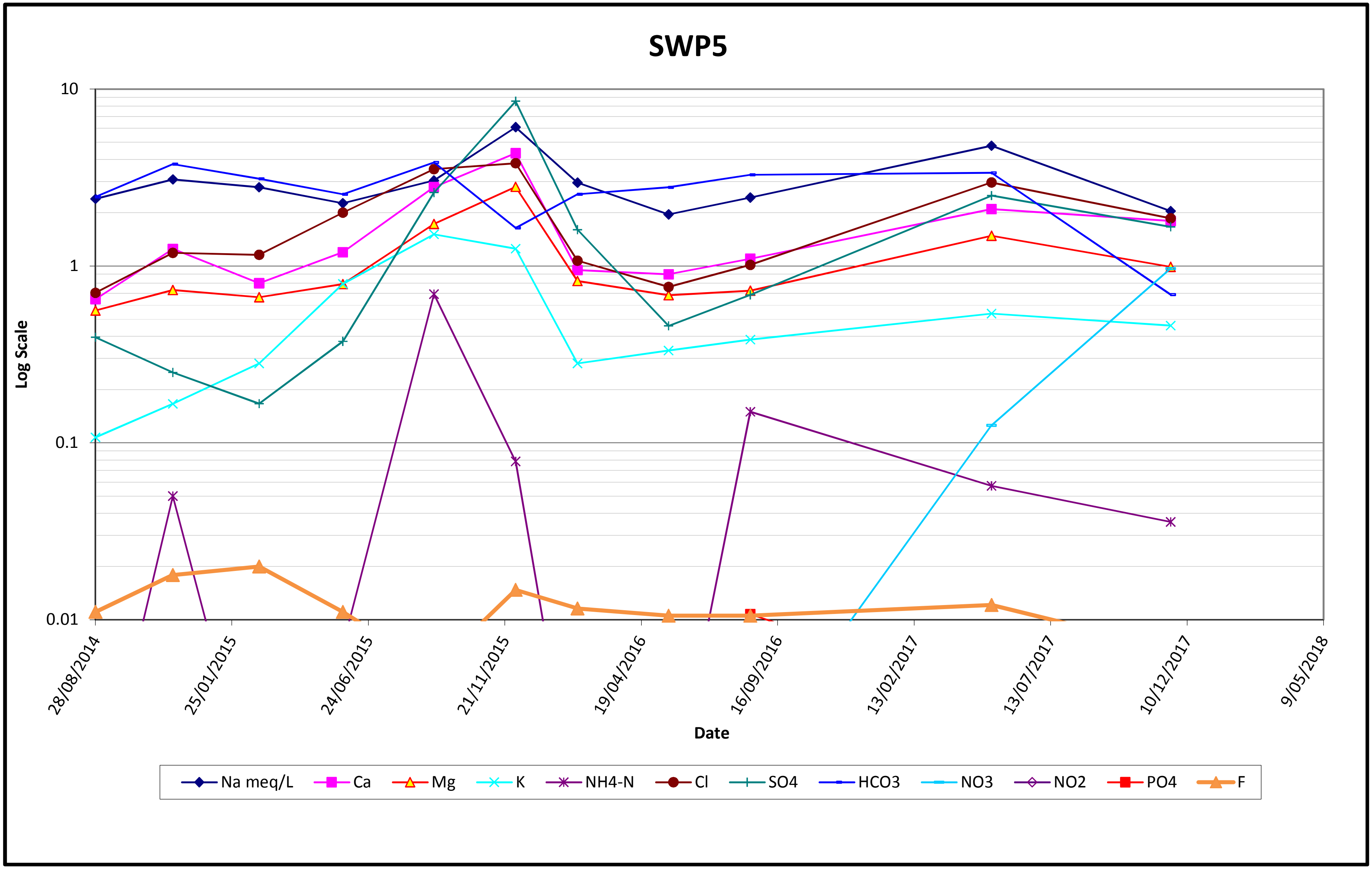

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Date
Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
NO3
NO2
PO4
F