16 November 2016

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 2016 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 landfilling activities on the environment.

2.0 Scope of works

The quarterly November 2016 monitoring round was undertaken on 8 and 9 November 2016. During the November 2016 monitoring round groundwater, surface water, leachate, gas and dust samples were collected in and around the site.

Groundwater samples were collected from 12 monitoring bores (BH1b to BH5, BH12 to BH16, BH19, and BH20), while BH8 to BH10 were only measured for standing water level (SWL). Surface water was collected from the leachate pond (LP1), two on site retention ponds (SWP2 and SWP4) and Rocklow Creek (SWC_UP and SWC_Down). Sampling locations are shown on Figure 1 (Attachment 1).

A dust gauge bottle was collected to the north of the site (DDG) and a gas walkover of all site buildings and the landfill cap was also undertaken (Figure 3). 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 standing water level (SWL). During sampling, field measurements were taken including pH, electrolytic conductivity (EC), oxidation/reduction potential (ORP), dissolved oxygen and temperature. Colour and odour of water samples were also noted. Field measurements recorded for each location are presented in Table 1 (Attachment 2).

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

4.0 Laboratory analysis

The following analyses were undertaken for site groundwater and surface water during the November 2016 monitoring event:

- groundwater – ionic balance (pH, total dissolved salts (TDS), sodium, calcium, potassium, magnesium, fluoride, chloride, ammonium, sulfate, bicarbonate, phosphate and nitrate), total organic carbon (TOC), biological oxygen demand (BOD), total and soluble iron, and soluble manganese;
- surface water (SWC_Up and SWC_Down) – total and soluble iron, turbidity, nitrate, nitrite, ammonium and bicarbonate;
- surface water SWP2, SWP4, SWC_Up and SWC_Down – 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). Both laboratories are NATA accredited for the methods used.

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

5.0 Results and discussion

5.1 Groundwater flow

Inferred groundwater contours from the November 2016 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 and 2016).

Accumulative rainfall for August (57.0 mm), September (54.2 mm) and October (18.8 mm) 2016 was 130.0 mm *(BOM – Albion Park weather station).* In comparison to the last monitoring period in August 2016, standing groundwater levels decreased by 0.04 – 0.4 m across the site in all bores except for BH20, which increased by 0.025 m. Previous and current monitoring results have shown that bores BH19 and BH20 appear to be influenced by rainfall and tidal influence from the adjacent Rocklow Creek Thus, resulting in fluctuating SWLs in comparison to the other bores. All groundwater levels are still within historic levels.

5.2 Groundwater

5.2.1 Groundwater sampling locations impacted by leachate

Field and laboratory results from the November 2016 sampling round, specifically from bores BH1b, BH3, BH5, BH14, BH15, BH16 and BH20 displayed chemistry that can be related to leachate impact — BH1b and BH15 showed stronger leachate indicators with high TDS, L/N, and ammonium levels. This is demonstrated by elevated concentrations of non-native potassium (K^+), ammonium (NH_4^+-N) and nitrate (NO_3^-) relative to native sodium (Na^+), calcium (Ca^{2+}) and magnesium (Mg^{2+}). This comparison is known as the leachate to non-leachate (L/N) ratio.

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

Bore BH1b is located near the old unlined landfill cell and intercepts leachate within the cell. As such the chemical signature of this bore has historically contained elevated leachate indicators in comparison to other monitoring bores (Schoeller plot BH1, Attachment 3). This continued during the current monitoring event and the groundwater was found to have a grey colour noted in combination with elevated TDS (4,020 mg/L), K^+ (200 mg/L) [resulting in low Ca/K – 0.7] and NH_4^+-N (345 mg/L) concentrations. The absence of oxygen (0.9%, Table 1) and presence of soluble Fe^{2+} indicate a high chemical or biological demand in response to microbial respiration. It is noted that BOD has fluctuated since the bore was installed, ranging from 830 mg/L to 7 mg/L. BODs have remained in similar levels during August and November 2016 rounds and were 8 mg/L to 7 mg/L respectively. Further evidence of microbial activity is elevated HCO_3^- resulting in a low Cl/ HCO_3^- ratio of 0.24 indicating microbial respiration (Table 4). This suggests some degradation of the leachate plume has occurred in this monitoring bore.

Groundwater from bore BH3 showed increases in three native ions (Na^+, Cl^- and Mg^{2+}) as well as two non-native (NH_4-N, and K^+) ions. Other ions did not show significant variations from the previous period. The L/N ratio (40.2%) was slightly higher than the August 2016 event, 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 since 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.

Commensurate with previous monitoring events, leachate indicators in the groundwater from BH3 are elevated and above the levels found at the up-gradient bore BH2. These results suggest the presence of waste dumps in the vicinity of bore BH3 outside the designated cells near bore BH2. This was confirmed during installation of bore BH3, as shallow waste was encountered during drilling.

Bore BH5's groundwater was amber in colour, with sulfuric odour and a negative redox (Table 1). A dominance of NH_4^+-N over NO_3^- is further evidence of a highly reducing environment. In comparison to historical data, leachate indicators have remained relatively stable (Schoeller plot BH5, Attachment 3). Leachate impact is also demonstrated by an elevated K/TDS ratio compared to other non impacted sites (Table 4). A K/TDS ratio >4-10 indicates elevated potassium in relation to the other dissolved analytes. It is likely that the ongoing influence at bore BH5 is contributed to a leachate plume originating from several possible sources, including a previous overspill of the leachate ponds, the former unlined landfill cell and organic waste stockpiling activities.

In August 2016 the L/N ratio at bore BH14 was elevated reaching 81% (~10 times more than the May 2016 level), during this monitoring round (November 2016) the L/N ratio has decreased to 23.5%, which is still higher than the May 2016 level. Concentrations of NO_3^- and K^+ were lower in November 2016 monitoring period compared to the August 2016 levels and were within the historical ranges (Schoeller plot BH14, Attachment 3). As previously noted surface water pond SWP3, directly up gradient of bore BH14, has been completely filled and is operating as a new landfill cell (Figure 2). The concentration of NH_4^+-N remained below the ANZECC 2000 trigger value for 95% protection of aquatic ecosystems. Nitrate (NO_3^-) concentrations were above the trigger value and similar to bore BH3, which is directly down hydraulic gradient of bore BH14. This bore 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 which can be largely associated with a high K^+ concentration (800 mg/L) compared to non leachate influenced sites with K^+ < 50 mg/L (Schoeller plot BH15, Attachment 1). NH_4^+-N is also elevated at 140 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 brown coloured water are indicative of a reducing environment. This reducing environment promotes reactions, which in turn results in the dominance of NH_4^+-N and the elevated levels of soluble Mn^{2+} (0.51 mg/L) and Fe^{2+} (20 mg/L). When the groundwater contours (Figure 2) are considered in combination with historically elevated levels of leachate indicators at BH15 and BH5, existence of an underground leachate migration pathway is suspected, allowing the leachate to flow towards south east between BH5 and BH12 and pass through BH15. In addition, 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, NH_4^+-N and HCO_3^-. Furthermore, bore BH15 is located near a drainage line with the groundwater bearing zone <0.5 m below the ground surface. Groundwater therefore has the potential to be influenced from local onsite and offsite works and surface water.

Bore BH16 is located in a swampy area with groundwater field observations recording a brown colour and a sulfuric odour. Recorded ORP indicates a reducing environment (-286 mV) resulting in the dominance of NH_4^+-N over NO_3. The NH_4^+-N concentration has exceeded the ANZECC (2000) criteria and the L/N ratio was very close to 20 (19.6%). The combination of elevated L/N ratio (19.6%) and relatively high K/TDS ratio (6.27%) indicate that groundwater at bore BH16 may be leachate impacted. Stockpiles of organic waste in close proximity to bore BH16 could be influencing the groundwater chemical characteristics. Bores BH16 and BH15 are located close to a drainage channel where offsite impacts can readily influence the chemical characteristics of the shallow groundwater.

Bore BH20 is located down gradient of the landfill, leachate ponds and shallow old landfill. This bore was positioned to assess the chemical characteristics on the boundary of the landfill site. Field observations at bore BH20 recorded a negative redox, and clear colour of the groundwater. The L/N ratio was consistent with results from the last monitoring round (22.4) with NO_3^- <0.1 mg/L and K^+ 27 mg/L. However, the TDS was low (725 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 were elevated at 20 mg/L however other landfill indicators were low or absent.

5.2.2 Remaining groundwater sampling locations

During the November 2016 monitoring round, ionic chemistry indicated that bores BH2, BH4, BH12, BH13 and BH19 only displayed slight to no leachate influence. Chemical composition of each of these bores has been depicted in Schoeller plots in Attachment 3.

Bore BH2 is located down gradient from the old unlined landfill cell. Historically elevated levels of NH_4^+-N indicate some leachate impact at this location. In November 2016, NH_4^+-N concentrations (31 mg/L) exceeded the ANZECC (2000) trigger levels. Bicarbonate (HCO_3^-), Na^+, Cl^-, Ca^{2+}, Mg^{2+}, K^+ and NH_4^+-N concentrations in groundwater have all been showing an increasing trend since January 2008 (Table 2, Schoeller plot BH2, Attachment 3). Low oxygen, negative redox and an elevated soluble Fe^{2+} (Table 2) suggest microbial respiration and therefore degradation of the leachate is occurring at this location.

Bore BH4 showed minor leachate influence based on field observations such as negative redox, clear water, neutral pH, and no odour. Groundwater chemistry, such as relatively low K^+ and nitrogen species (in comparison to leachate affected bores) and a high Ca/K ratio of >10 also indicate limited leachate influence. During the November 2016 monitoring round NO_3 and NH_4^+-N levels were 0.22 mg/L and 5.1 mg/L respectively. 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.

Field observations for bore BH12 indicated the groundwater at this location was clear with no odour. Pertinent chemical indicators at this site showed moderately low L/N ratio (9.64%) suggesting limited to slight leachate influence. This bore will continue to be monitored as it is situated hydraulically down gradient of the leachate ponds and landfill (Figure 1).

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 2016 monitoring round shows no indication that the groundwater in this bore is currently impacted by leachate. The chemical composition of the groundwater has remained consistent since monitoring began in 2002 (Schoeller plot BH13, Attachment 3). Further monitoring will help to monitor any trends which develop at this location.

Bore BH19 is a relatively new monitoring bore located on the south west boundary of the site. Field observations included a negative ORP and grey colour. Groundwater chemical characteristics support no/ limited leachate influence with an L/N ratio of 8.19% and a high Ca/K ratio. Bore BH19 is down gradient of current sand dredging activities and unlined landfill cells. NH_4-N at this location (5.1 mg/L) exceeds the ANZECC (2000) trigger levels (1.88 mg/L). Bore BH19 is positioned to detect any potential leachate migration to the south west of site and will continue to be monitored.

Ammonium levels were found elevated in the groundwater across the entire site with bores BH1c (345 mg/L), BH2 (31 mg/L), BH3 (20 mg/L), BH4 (5.1 mg/L), BH5 (37 mg/L), BH12 (12 mg/L), BH15 (140 mg/L), BH16 (2.7 mg/L), BH19 (5.1 mg/L) and BH20 (20 mg/L) above threshold levels. Nitrate was also found above guidelines (ANZECC 2000) in samples from bores BH3 (39 mg/L), and BH14 (52 mg/L).

5.3 Surface water monitoring

During November 2016 monitoring round samples from Rocklow Creek (SWC_Up and SWC_Down) and two surface water ponds (SWP2 and SWP4) were collected. SWP1 was dry and SWP5 was filled; therefore, no samples were taken from these two locations. Results of surface water analysis (Table 2 and Table 3) confirm that concentrations of ions are within a range similar to previous monitoring rounds. This has been depicted in the Schoeller plots provided in Attachment 3.

As these ponds are intended to retain any surface water migrating towards Rocklow Creek, the detection of chemical constituents that may be associated with landfill leachate are expected. At SWP4 a slightly elevated L/N ratio (10.21%) indicates the possibility of little leachate influence.

Location SWP1 was dry during November 2016 monitoring round.

Surface water sample SWP2 showed little or no indicators of leachate impact. The surface water pond collects runoff from around the site and potential impacts from site activities are often observed. Ammonium was 0.6 mg/L during this sampling round and NO_3^- was below the ANZECC 2000 trigger value with a concentration of 0.13 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.

Surface water sample SWP4 displayed ammonium levels of 6.3 mg/L which is above the defined trigger value and may indicate leachate influence or catchment affect. All chemical parameters at this location are within historical ranges. This location should continue to be monitored for any fluctuations in chemical composition indicating a more prominent leachate impact.

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

SWP5 has been filled; thus, no sample could be taken from this location.

The two surface water creek sites SWC_Up and SWC_Down were also sampled during the November 2016 sampling event. These two sites are up- and down-gradient of the established SWC2 site and help assess leachate impacts within Rocklow Creek. SWC_Up and SWC_Down had a TDS range of 33,100 – 34,600 mg/L and are dominated by Na^+ and Cl^- (Table 2) differentiating themselves from landfill groundwater / surface water.

The low nutrient and L/N ratios within Rocklow Creek indicated that there was no leachate impact within Rocklow Creek. Both SWC_Up and SWC_Down had low concentrations of NH_4^+-N and NO_3^- which did not exceed the ANZECC (2000) trigger value for 95% protection of freshwater ecosystems. Levels detected at all Rocklow Creek locations, are within historical levels established since monitoring was commenced.

5.4 Leachate Pond monitoring

The chemistry of leachate water at the Dunmore Recycling and Waste Disposal Depot is significantly different when compared to the surface and groundwater chemistry of non leachate influenced bores. This is demonstrated through comparison of chemical data for groundwater from the various bores and the leachate pond presented in Table 2. In particular TDS, TOC, 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 (<0.32) 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 did not detect *faecal coliforms* and *E.Coli* during this round (Table 3). As a precaution dermal contact with these waters should be avoided due primarily to health concerns relating to past 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 between the summed total of anions against cations (milli-equivalent units) was in the range of 0.107% to 1.886%. 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 12.3%. The relationship between the field determined EC and laboratory measured TDS relationship ranged between 0.29 and 0.83. The majority of data is within the TDS/EC typical range of 0.5 to 0.9 and is consistent with historical levels on site.

The analysis of the intra-laboratory duplicate taken at bore BH2 showed a maximum RPD of 15.3% for dissolved Manganese. This reading is within 10x the detection limit (0.07 mg/l vs < 0.01 mg/) and is therefore considered within acceptable RPD criteria. As a result, the data is considered reliable (Table 6).

5.6 Gas monitoring

Landfill gas was measured in the field using an Inspectra Laser Unit (ILU) and a GA5000 Landfill Gas Monitor (GA5000). Measurements were taken within and around all buildings in a 250 m radius from the current landfill cell as well as across the landfill cap (gas walkover grids of November 2016 round are presented in Figure 3).

All readings within and around all buildings in a 250 m radius from the current landfill cell were below the site specific criteria outlined in the EPL (NSW EPA [1996] reporting threshold of 1.25 % v/v CH_4) and therefore pose no direct risk. However elevated methane levels were detected at three locations across the landfill cap exceeding the threshold concentration for closer investigation and potential action (500 ppm or 0.05 % v/v, NSW EPA [1996], Table 5). The council was verbally informed immediately after the field survey and the relevant locations were shown to Kerry Penfold, Site Operations Manager. 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 0.8 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 bore BH20 has detected the presence of leachate indicators despite the nearby sampling locations BH19, SWC-UP and SWC-DOWN (Rocklow Creek), which displayed results indicating background characteristics. Although the historical data set of these new locations are relatively limited, it can be said it is likely that on site activities are not significantly impacting Rocklow Creek.

Leachate influenced groundwater appears to be moving down gradient from bore BH5 and it is possible that it is influencing water quality at bores BH15 and BH16. It is important to note that bores BH5, BH15, and BH16 are located in/or near swampy environments or near heavily vegetated areas. Heavily wooded areas to the south can also have a natural attenuation effect on leachate impacted water. This would further inhibit its rate of migration and should continue to limit its extent of impact on Rocklow Creek.

Surface water monitoring indicated that on site activities have had limited impact on water quality at locations SWP2 and SWP4 (SWP1 was dry and SWP5 was filled).

Assessment of Rocklow Creek sampling locations (SWC-Up and SWC-Down) showed only minor detectable concentration of NH_4-N at SWC-UP and non-detect at SWC-Down. These values did not exceed the ANZECC (2000) trigger value for 95% protection of freshwater ecosystems (NH_4-N 1.88 mg/L based upon a pH of 7.3 and 10.6 mg/L NO_3^-).

Landfill gas 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. Elevated methane levels were detected at three locations across the landfill cap exceeding the threshold concentration for closer investigation and potential action (500 ppm or 0.05 % v/v, NSW EPA [1996], Table 5). The council was verbally informed immediately after the field survey and the relevant locations were shown to Kerry Penfold, Site Operations Manager. In subsequent discussions with the council it is understood the identified areas of elevated methane concentrations have been sealed with additional soil capping. In future monitoring rounds special attention will be given to this area to assess the remedial actions. All other methane readings were below the reporting threshold (500 ppm or 0.05 % v/v, NSW EPA [1996], Table 5) and no exceedances of site specific criteria outlined in the EPL (NSW EPA [1996] reporting threshold of 1.25 % v/v CH_4) were measured.

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

Author/ Project Manager
Mert Berberoglu
Environmental Scientist

Internal Reviewer
Stuart Brisbane
Principal Soil Scientist
112096_November_2016_Draft

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

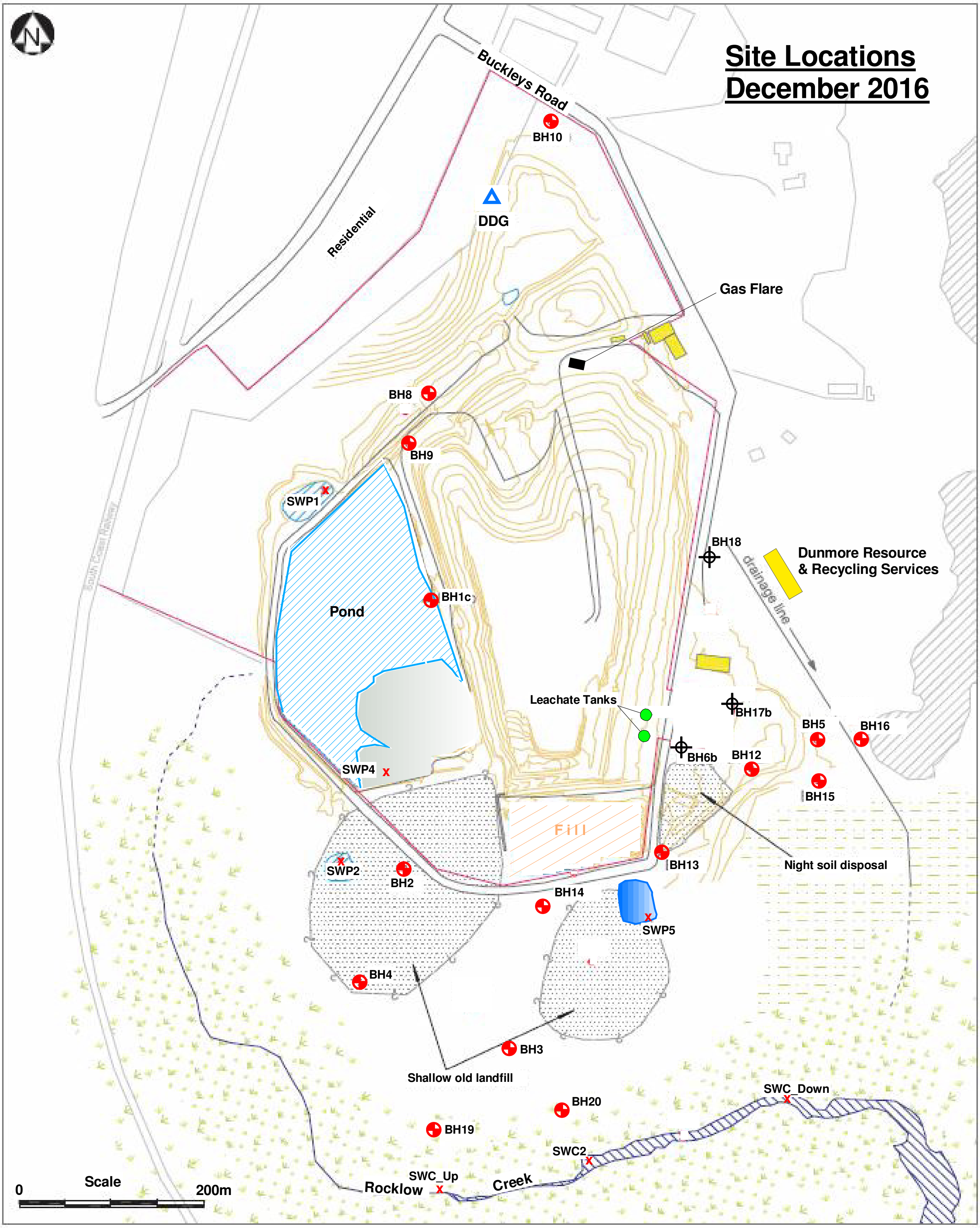
The investigation and remediation of contaminated sites is a field in which legislation and interpretation of legislation is changing rapidly. Our interpretation of the investigation findings should not be taken to be that of any other party. When approval from a statutory authority is required for a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



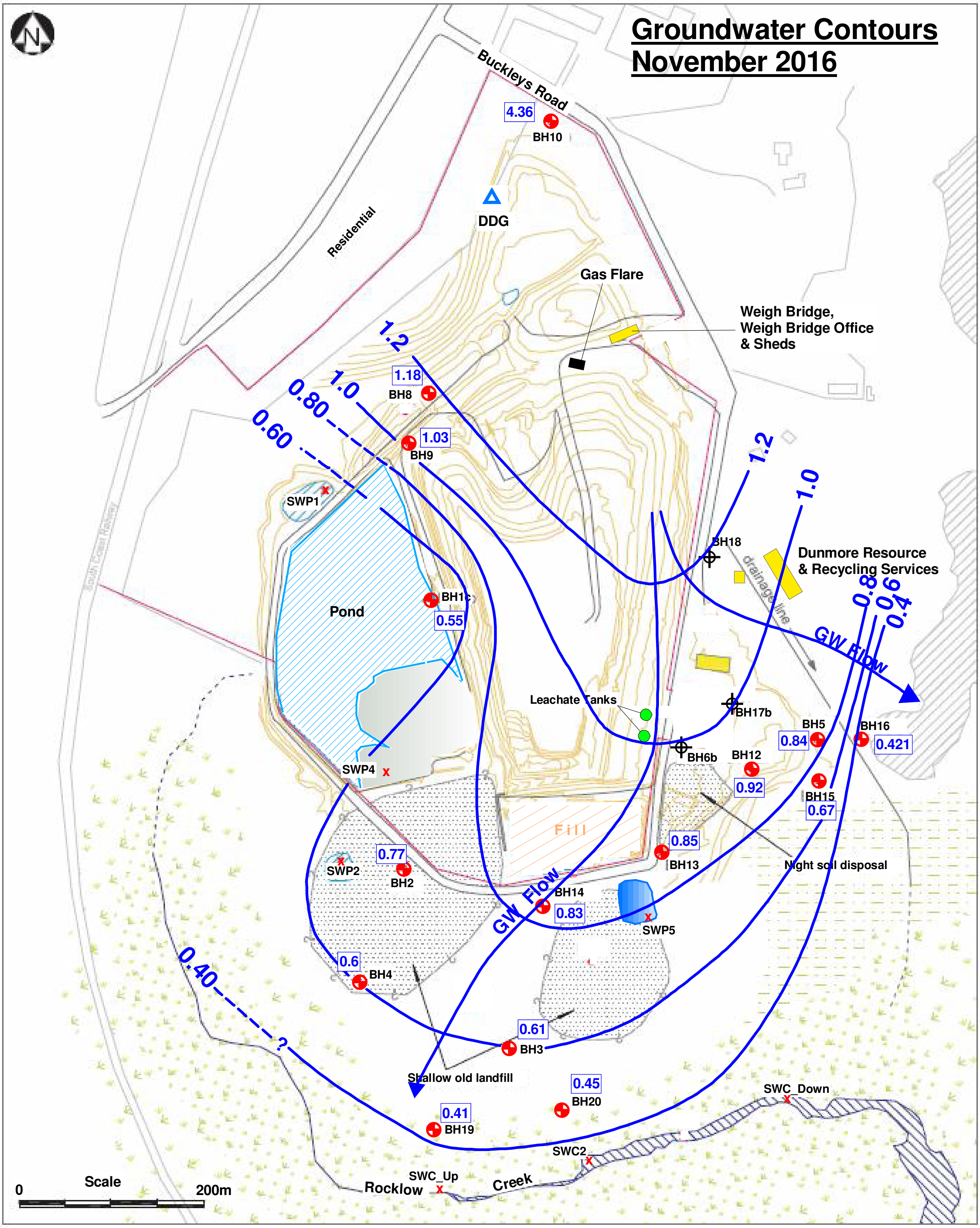
Legend:

●	Bore locations		Water
x	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:** 112096
Drawn by: TRJ	**Scale:** As shown	**Figure** 1
Proj Man: MB	**Date:** Dec. 2016	

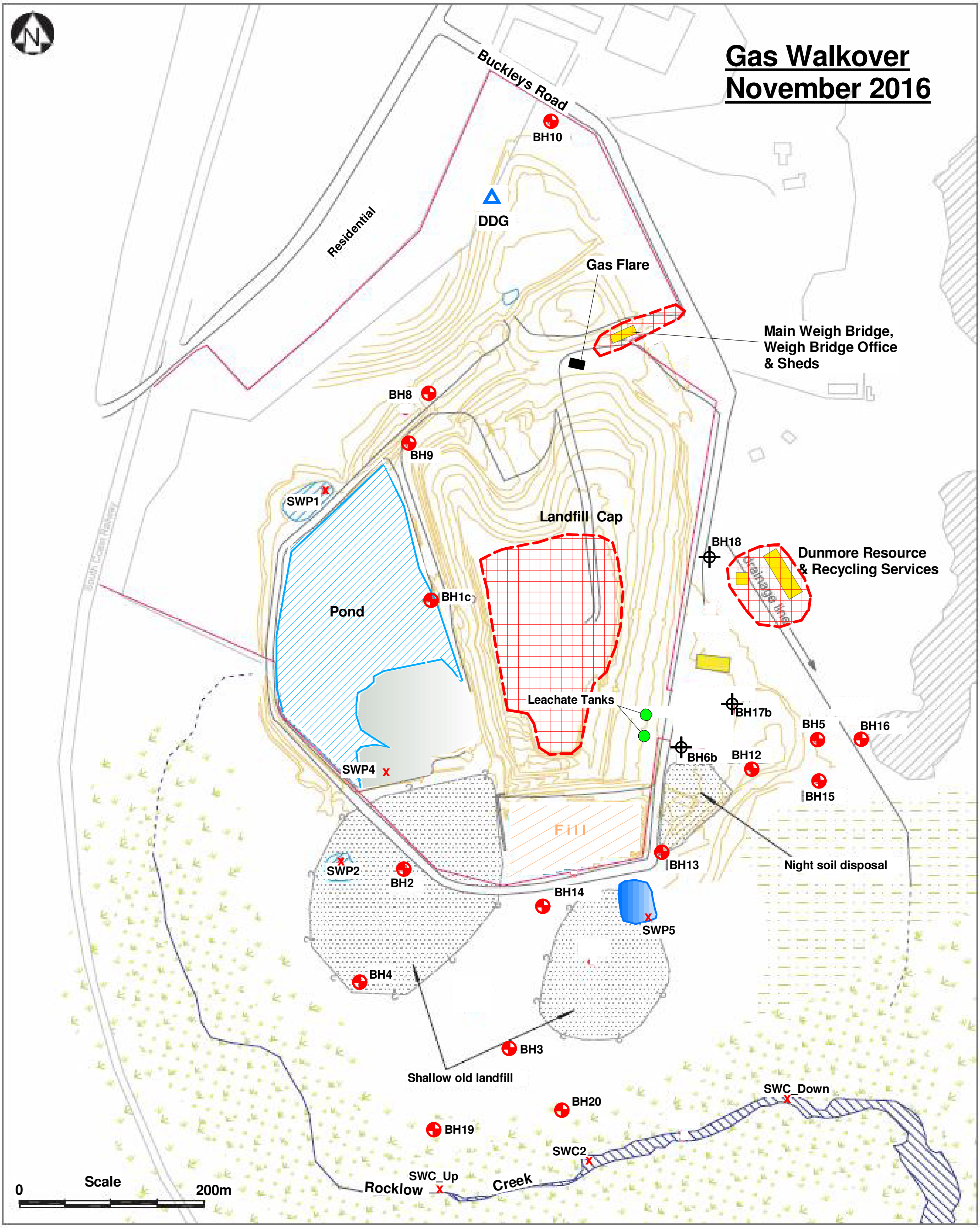


Legend:

- Bore locations
- Water
- Surface water locations
- Buildings
- DDG Dust gauge location
- Decommissioned bores
- Inferred groundwater contours (m AHD)

Note: Based on aerial photo dated 1 Sept. 2010

ENVIRONMENTAL EARTH SCIENCES THE KNOW AND THE HOW	Title: Inferred Groundwater Contours November 2016	
	Location: Buckleys Road, Dunmore, NSW	
Client: Shellharbour City Council		Job number: 112096
Drawn by: TRJ	Scale: As shown	Figure 2
Proj Man: MB	Date: Nov. 2016	



Legend:

Bore locations		Water	
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: 112096
Drawn by: TRJ	Scale: As shown	Figure 3
Proj Man: MB	Date: Nov. 2016	

ATTACHMENT 2 TABLES

TABLE 1 FIELD MEASUREMENTS – NOVEMBER 2016

Sample	SWL	SWL	pH	EC	ORP	Temp.	DO	Colour	Odour
Units	mAHD	Dip (m)	-	µS/cm	mV	ºC	%	-	-
BH1b	0.554	3.4	6.99	6010	-181	25.6	0.9	grey	none
BH2	0.772	4.02	6.84	3560	-127	20.9	0.9	Yellow	none
BH3	0.614	3.15	7.4	1417	-105	18.2	11.9	clear	none
BH4	0.599	4.42	7	1561	-120	18.6	2.2	clear	none
BH5	0.841	1.68	6.75	3160	-233	16.8	1.4	amber	H_2S
BH8	1.179	1.31	-	-	-	-	-	-	-
BH9	1.025	3.36	-	-	-	-	-	-	-
BH10	4.361	0.43	-	-	-	-	-	-	-
BH12	0.918	3.33	6.87	2940	-143	23.5	1.9	clear	none
BH13	0.845	4.45	6.76	1833	-42	20.5	1.2	light yellow	none
BH14	0.825	4.89	6.84	1660	93	19.8	3.9	light brown	none
BH15	0.67	0.74	6.74	7390	-161	15.8	5	Brown	none
BH16	0.41	0.97	6.31	3360	-286	15.6	5.5	Brown	H_2S
BH19	0.41	4.78	7.11	1440	-105	18.5	4.9	Grey	none
BH20	0.45	2.32	7.69	1234	-184	18.5	1.4	Clear	none
LP1	-	-	7.93	13660	-118	24	70.7	Brown/ amber	H_2S
SWC2	-	-	7.77	43200	-43	19.3	23.9	Clear	none
SWC_Up	-	-	7.96	40800	70	19.4	24.1	clear	none
SWC_Down	-	-	7.72	41400	-65	20	34.6	clear	none
SWP2	-	-	7.65	-	-84	20.1	23.9	none	none
SWP4	-	-	8.13	2309	43	21.5	77.7	Amber	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 – NOVEMBER 2016

Sample	pH	TDS mg/L	Na mg/L	Ca mg/L	K mg/L	Mg mg/L	NH_4-N mg/L	Cl mg/L	F mg/L	NO_3 mg/L	NO_2 mg/L	SO_4 mg/L	HCO_3 mg/L	PO_4 mg/L	TOC mg/L	BOD mg/L	Sol. Mn mg/L	Sol. Fe mg/L	Tot. Fe mg/L
BH1b	7.1	4020	730	140	200	105	**345**	800	0.17	<0.1	-	14	3270	0.28	210	7	0.13	**2.5**	23
BH2	7.1	1920	295	270	31	82	**31**	475	0.14	<0.1	-	29	1310	<0.1	54	3	0.56	**1.4**	12
BH3	7.4	850	73	150	41	26	**20**	175	0.11	**39**	-	120	405	<0.1	14	<2	0.16	0.04	0.75
BH4	7.2	800	85	160	11	32	**5.1**	120	<0.1	0.22	-	130	510	<0.1	13	<2	0.2	0.27	4.4
BH5	6.8	1620	360	77	125	56	**37**	675	<0.1	<0.1	-	79	515	0.49	71	<2	0.22	**2.4**	3.1
BH12	7	1680	240	270	42	54	**12**	530	0.14	0.35	-	320	465	<0.1	22	<2	0.52	**2.7**	18
BH13	7.1	1070	110	215	30	39	1.4	185	0.24	0.18	-	130	695	<0.1	21	<2	0.33	0.16	2.5
BH14	7.1	1020	140	150	26	42	0.3	135	0.65	**52**	-	170	565	0.21	23	<2	0.15	0.06	5
BH15	7	4180	530	175	800	90	**140**	1560	0.19	<0.1	-	275	1160	0.89	210	<2	0.51	**20**	24
BH16	6.9	1500	305	130	94	59	**2.7**	590	0.18	<0.1	-	110	455	0.12	46	<2	0.42	**0.51**	3.8
BH19	7.3	910	100	170	15	40	**5.1**	205	<0.1	5.3	-	120	485	<0.1	17	<2	0.1	**2.7**	18
BH20	7.7	725	60	120	27	30	**20**	80	0.15	<0.1	-	180	435	0.43	18	<2	0.07	0.07	1.6
LP1	7.8	9030	1420	180	570	100	**1130**	1680	0.5	<0.1	<0.1	110	7640	20	740	90	0.47	**2**	2.1
SWC2	-	-	-	-	-	-	0.4	1680	-	<0.1	<0.1	-	235	-	-	-	-	0.12	0.45
SWP2	8	1420	335	110	26	59	0.6	330	0.28	0.13	-	265	605	<0.1	0	0	-	0.09	0.12
SWP4	**8.4**	1250	315	62	35	50	**6.3**	345	0.3	2.3	-	190	480	<0.1	33	<2	-	0.07	0.11
SWC-UP	7.2	33100	10500	410	390	1210	0.2	18100	0.47	<0.1	-	2520	250	<0.1	0	0	-	0.05	0.61
SWC-DOWN	7.3	34600	11000	430	420	1220	<0.1	19000	0.46	<0.1	-	2650	220	<0.1	0	0	-	0.07	0.44
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 2016

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	1130	7640	2	2.1	Less than 20	Less than 20
SWC2	0.4	235	0.12	0.45	-	-
SWC-UP	0.2	250	0.05	0.61	-	-
SWC-Down	<0.1	220	0.07	0.44	-	-
SWP2	0.6	605	0.09	0.12	-	-
SWP4	6.3	480	0.07	0.11	-	-
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 2016

Bore	Na/Cl	Na/Ca	Mg/Ca	Ca/K	Cl/SO_4	Cl/HCO_3	K/TDS (%)	L/N (%)
BH1b	0.91	5.21	0.75	0.70	57.14	0.24	4.98	55.91
BH2	0.62	1.09	0.30	8.71	16.38	0.36	1.61	9.60
BH3	0.42	0.49	0.17	3.66	1.46	0.43	4.82	40.16
BH4	0.71	0.53	0.20	14.55	0.92	0.24	1.38	5.89
BH5	0.53	4.68	0.73	0.62	8.54	1.31	7.72	32.88
BH12	0.45	0.89	0.20	6.43	1.66	1.14	2.50	9.64
BH13	0.59	0.51	0.18	7.17	1.42	0.27	2.80	8.68
BH14	1.04	0.93	0.28	5.77	0.79	0.24	2.55	23.58
BH15	0.34	3.03	0.51	0.22	5.67	1.34	19.14	118.25
BH16	0.52	2.35	0.45	1.38	5.36	1.30	6.27	19.60
BH19	0.49	0.59	0.24	11.33	1.71	0.42	1.65	8.19
BH20	0.75	0.50	0.25	4.44	0.44	0.18	3.72	22.43
LP1	0.85	7.89	0.56	0.32	15.27	0.22	6.31	100.01
SWC2	-	-	-	-	-	7.15	-	-
SWP2	1.02	3.05	0.54	4.23	1.25	0.55	1.83	5.30
SWP4	0.91	5.08	0.81	1.77	1.82	0.72	2.80	10.21
SWC-UP	0.58	25.61	2.95	1.05	7.18	72.40	1.18	3.22
SWC-DOWN	0.58	25.58	2.84	1.02	7.17	86.36	1.21	3.32

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

TABLE 5 SUMMARY OF GAS ANALYSIS – NOVEMBER 2016

Location	GA 5000 V/V%	ILU V/V%
Landfill cap	**0.3**	**0.2**
Main weigh bridge and weigh bridge office	0	0.0013
Landfill office sheds	0	0.00051
Dunmore Resource & Recycling Services	0	0.00106
GUIDELINES	1.25 % v/v / 0.05 % v/v	1.25 % v/v / 0.05 % v/v

Notes:

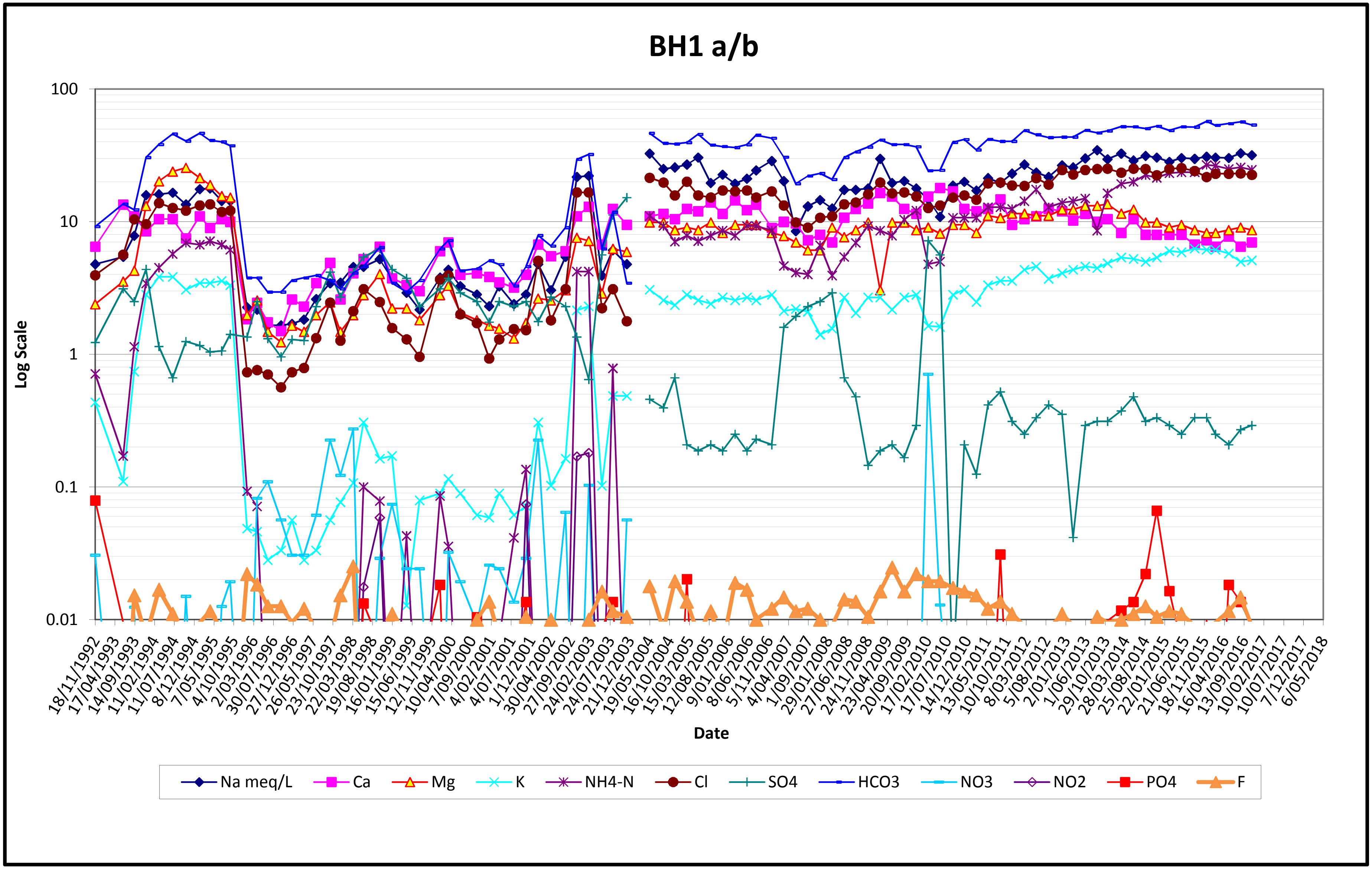
1. results and guidelines are expressed in V/V %;
2. Guidelines are as per the NSW EPA (1996) reporting accumulation value of 1.25 % v/v CH_4; and surface emission trigger value (500 ppm or 0.05 % v/v); and
3. values above the guidelines are **bolded**.

TABLE 6 QA/QC – NOVEMBER 2016

Analytes	BH20	FD1	RPD (%)
pH	7.7	7.8	1.29
TDS	725	730	0.69
Na+	60	62	3.28
Ca++	120	115	4.26
Mg++	30	30	0.00
K+	27	28	3.64
NH4-N	20	20	0.00
Cl-	80	80	0.00
SO4--	180	185	2.74
HCO3-	435	425	2.33
NO3-	<0.1	<0.1	0.00
PO4---	0.43	0.4	7.23
F-	0.15	0.16	6.45
BOD	<2	<2	0.00
Fe.D	0.07	0.08	13.33
Fe.T	1.6	1.5	6.45
Mn.D	0.07	0.06	15.38
TOC	18	19	5.41

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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PO4
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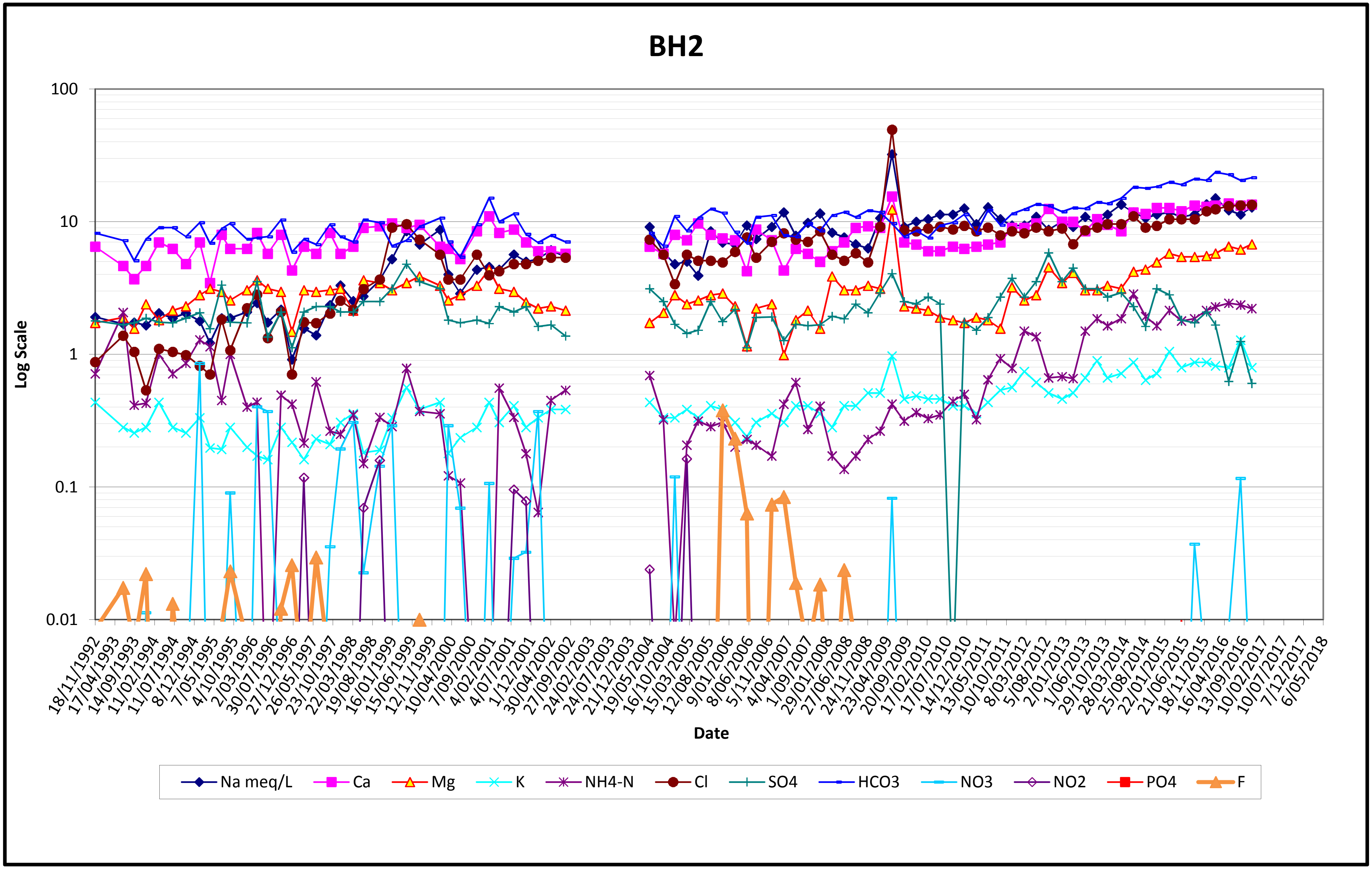
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NO2
PO4
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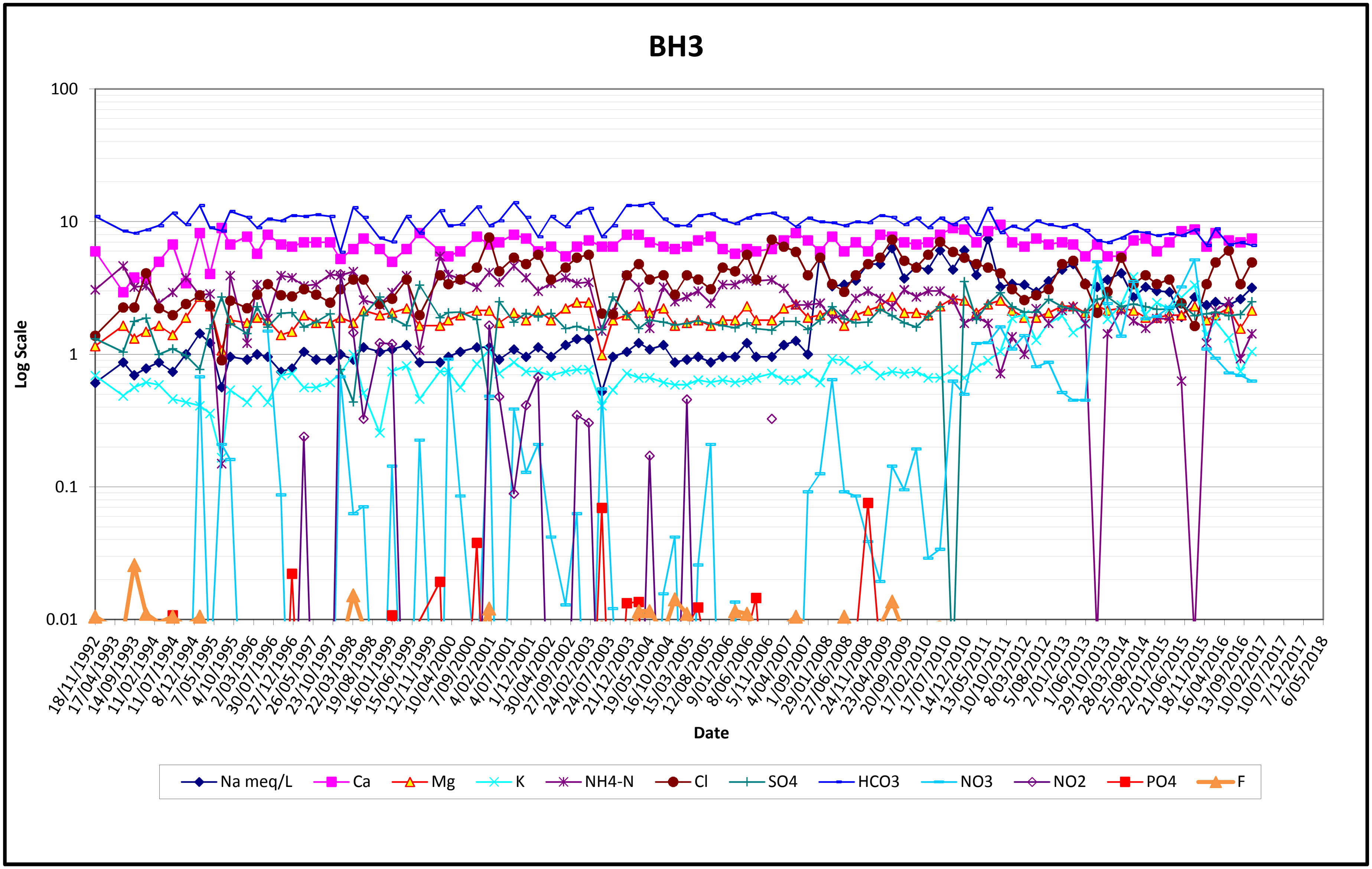

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26/05/1997
23/10/1997
22/03/1998
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7/12/2017
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Mg
K
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NO2
PO4
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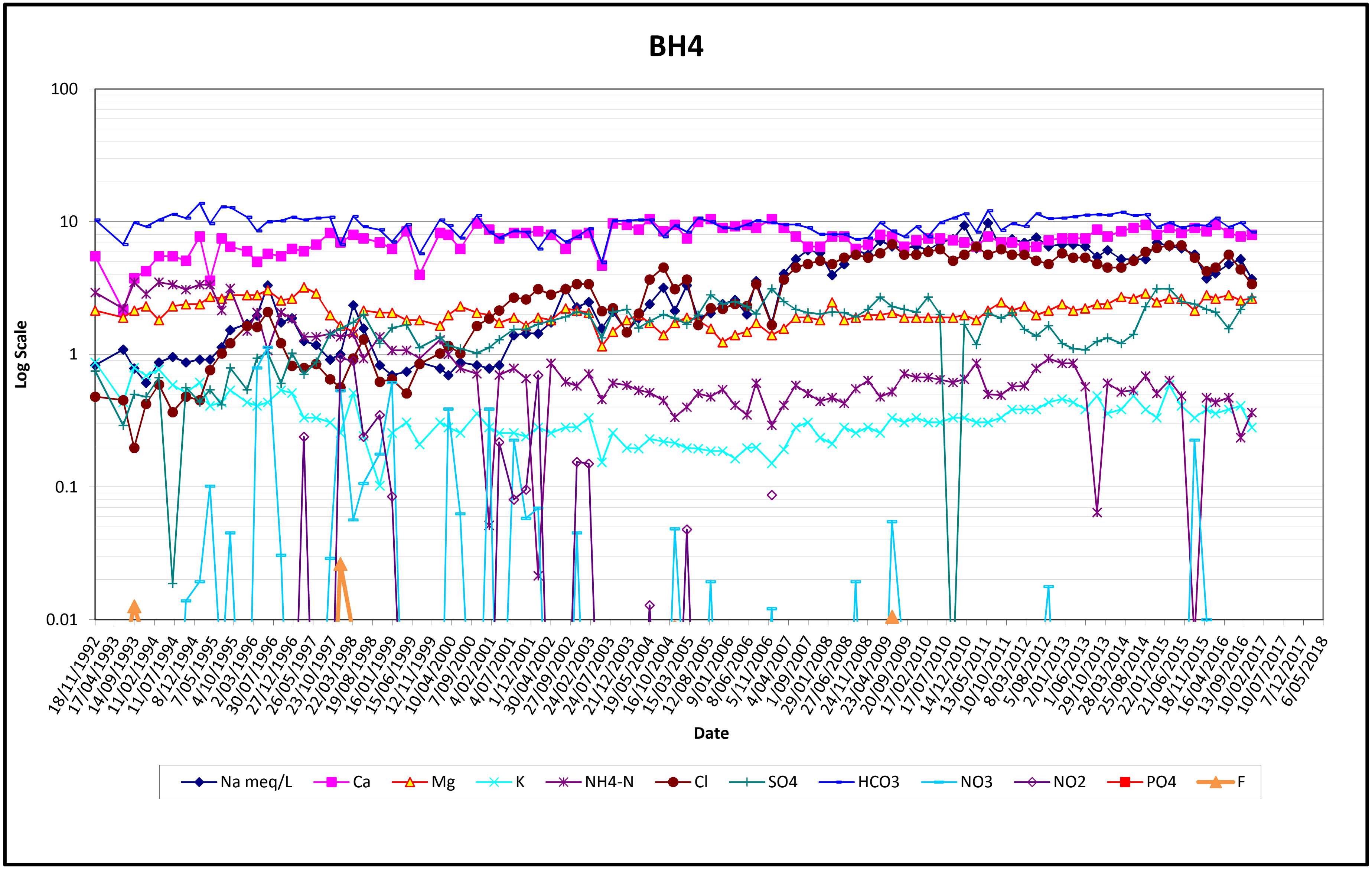
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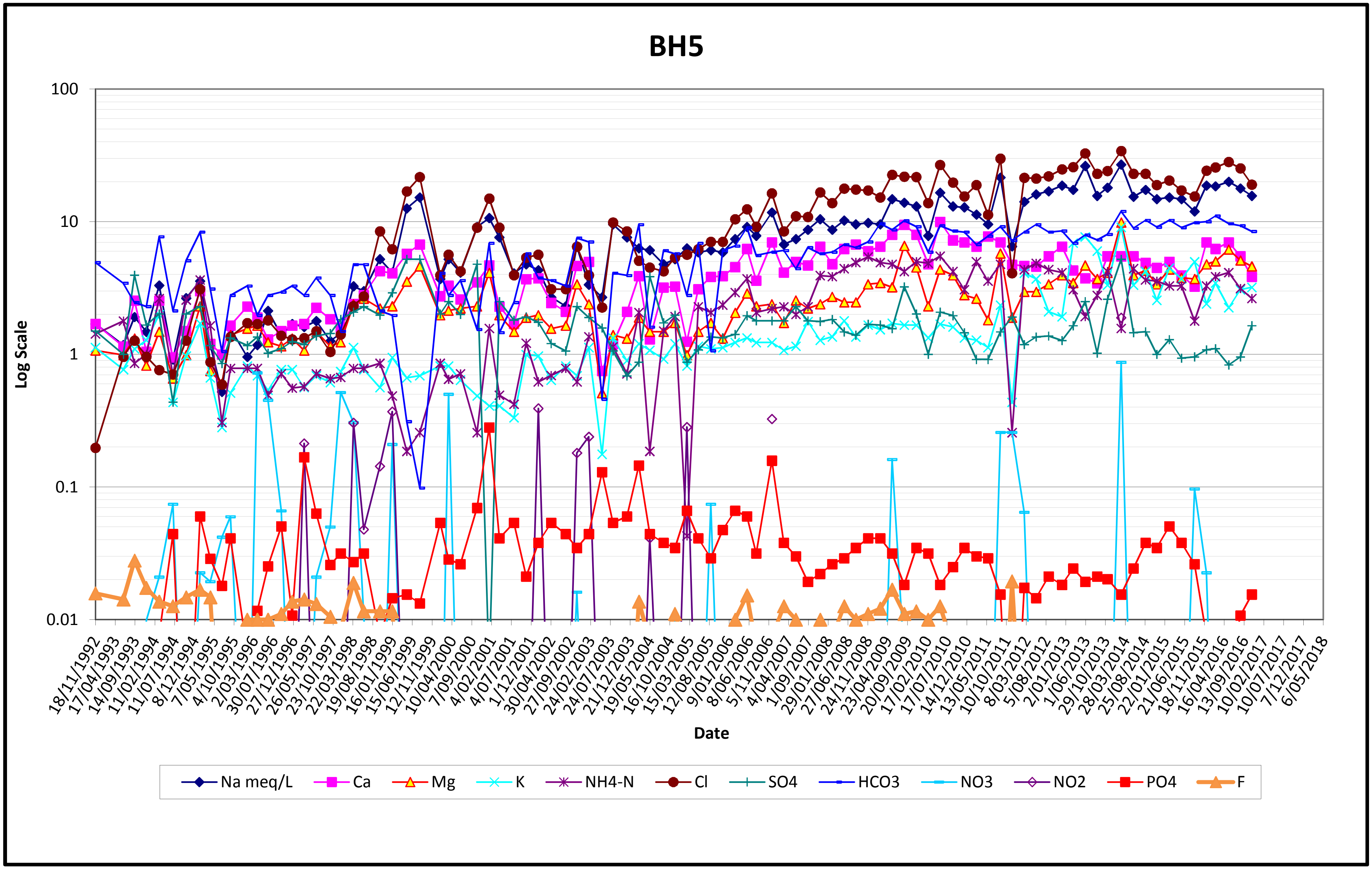
NO2
PO4
F



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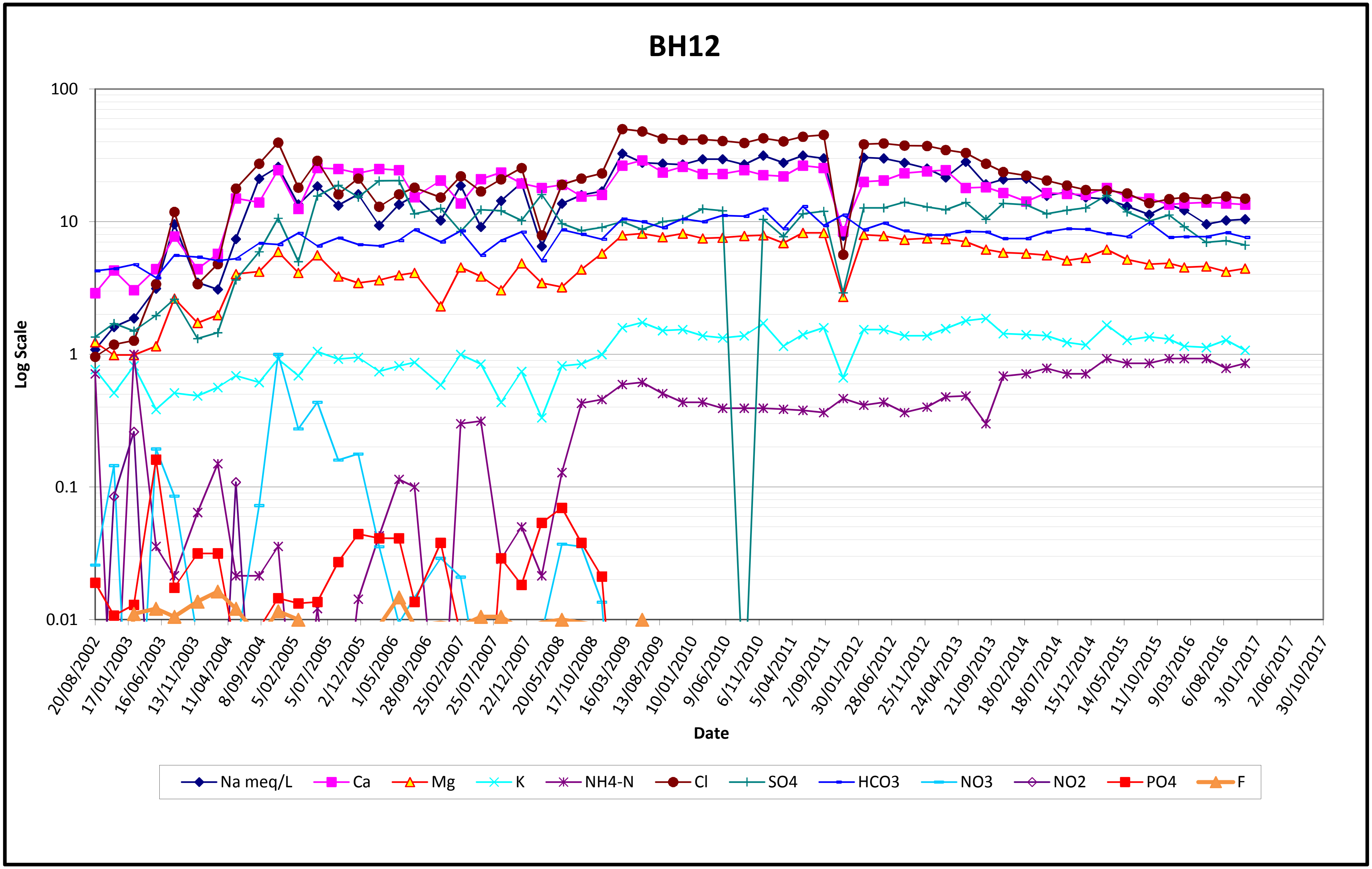
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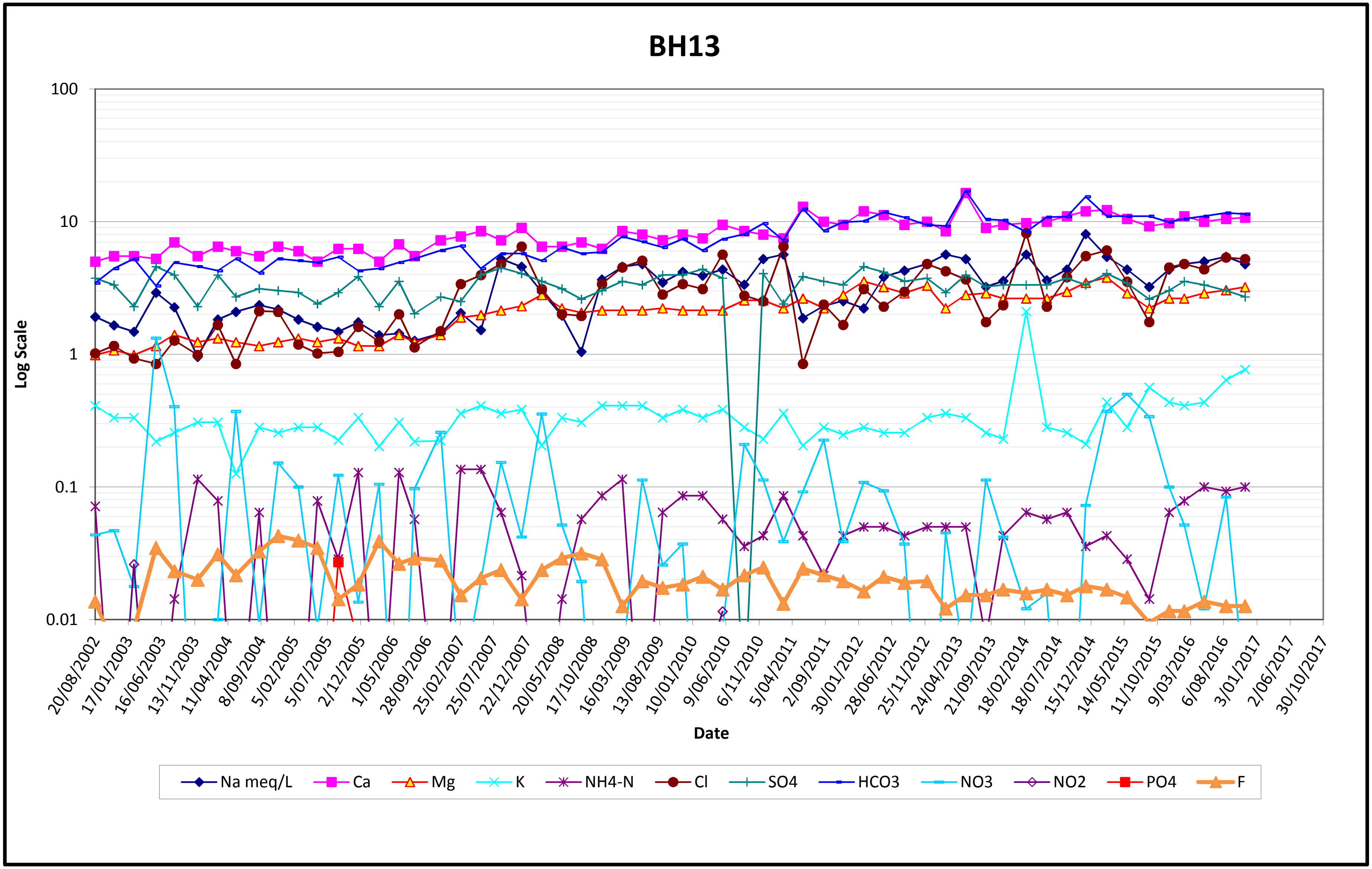

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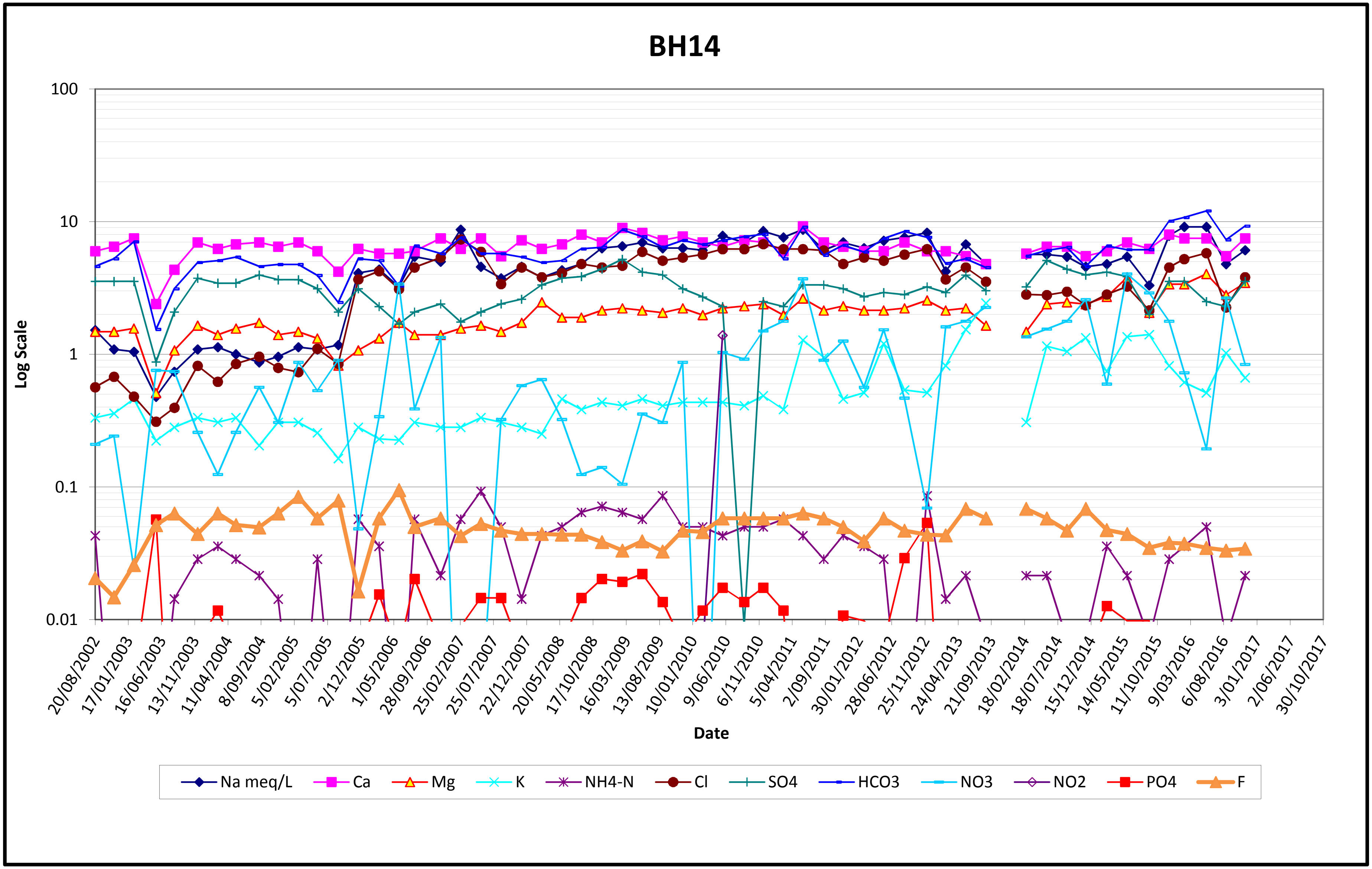
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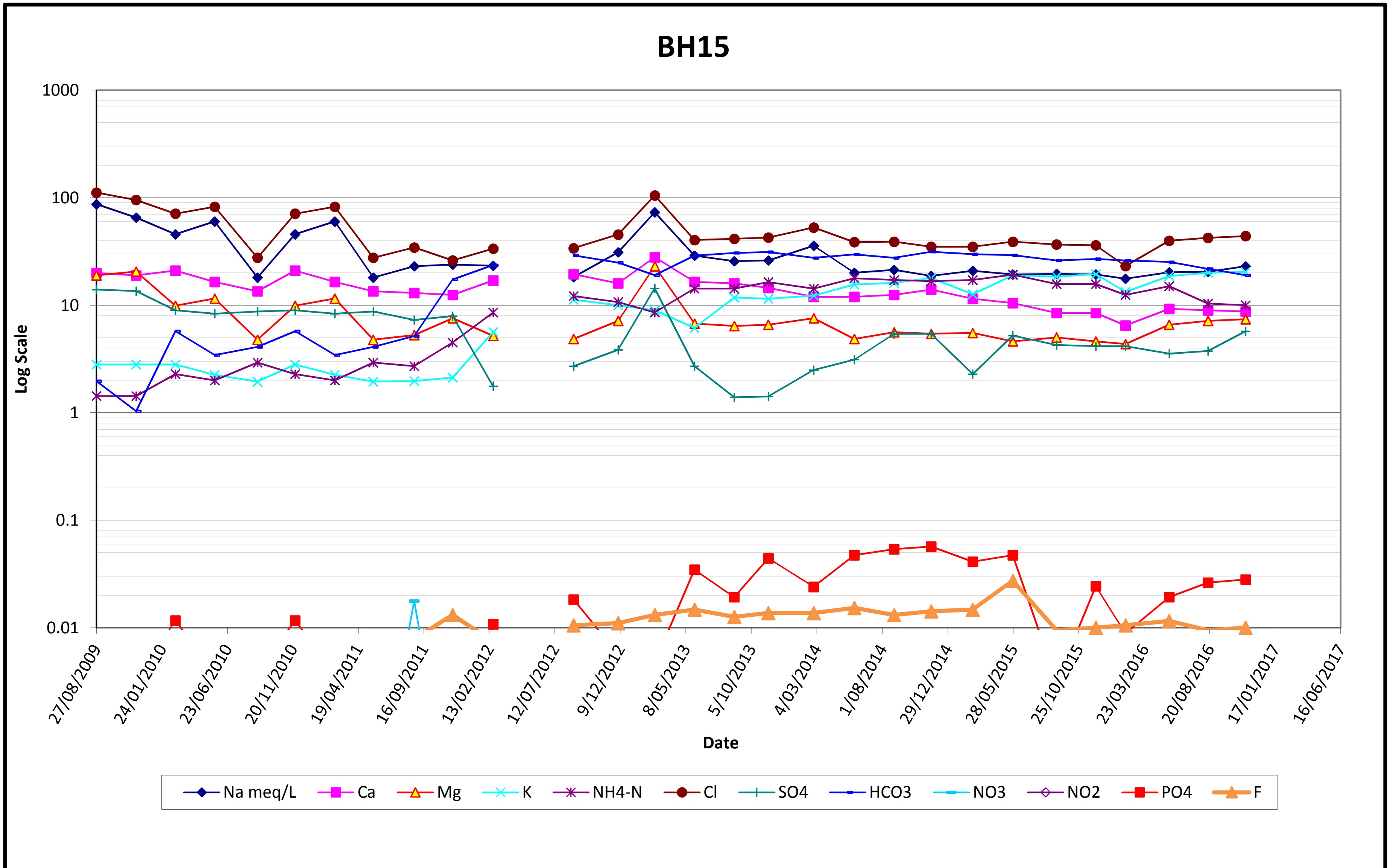

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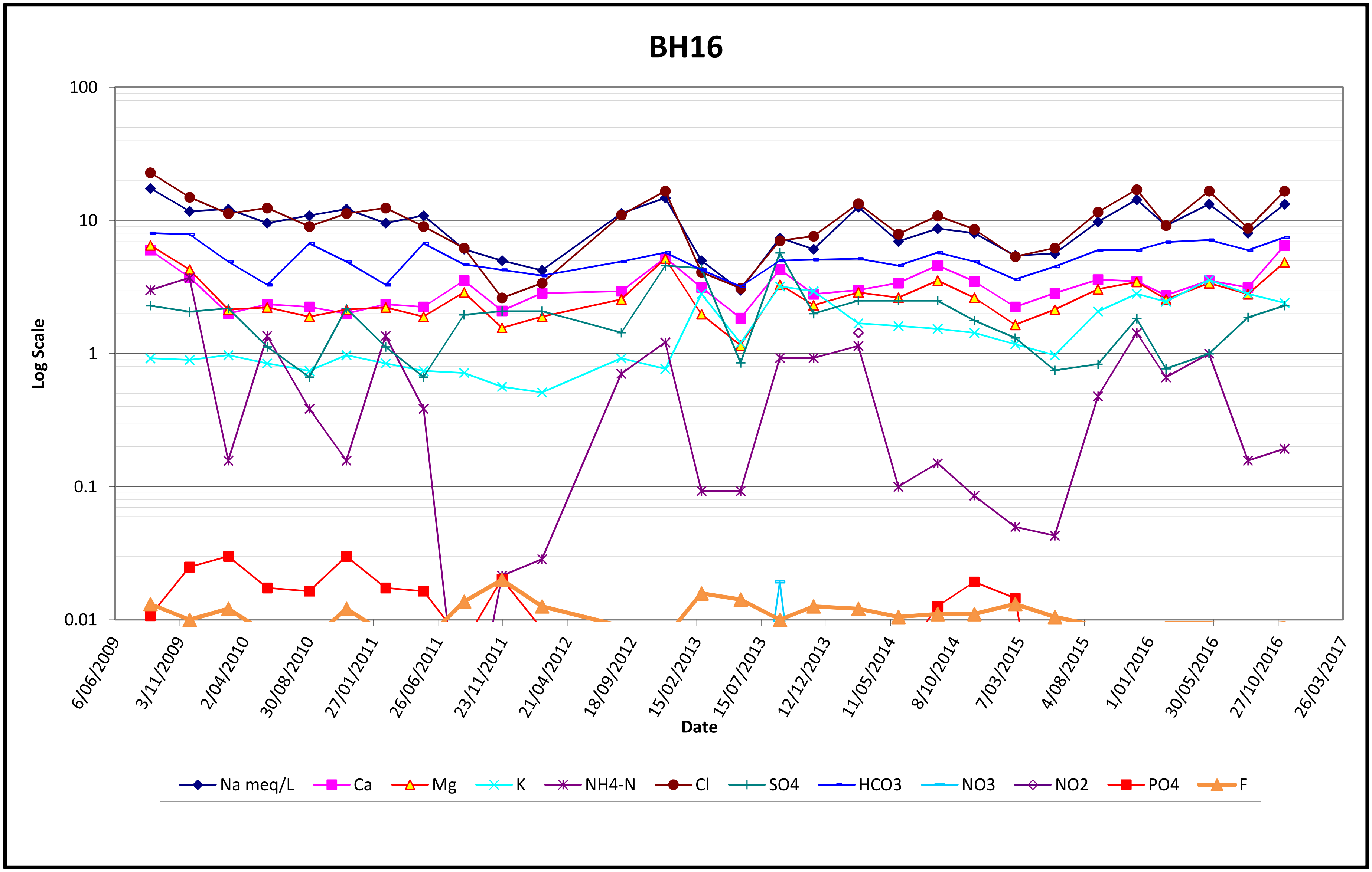

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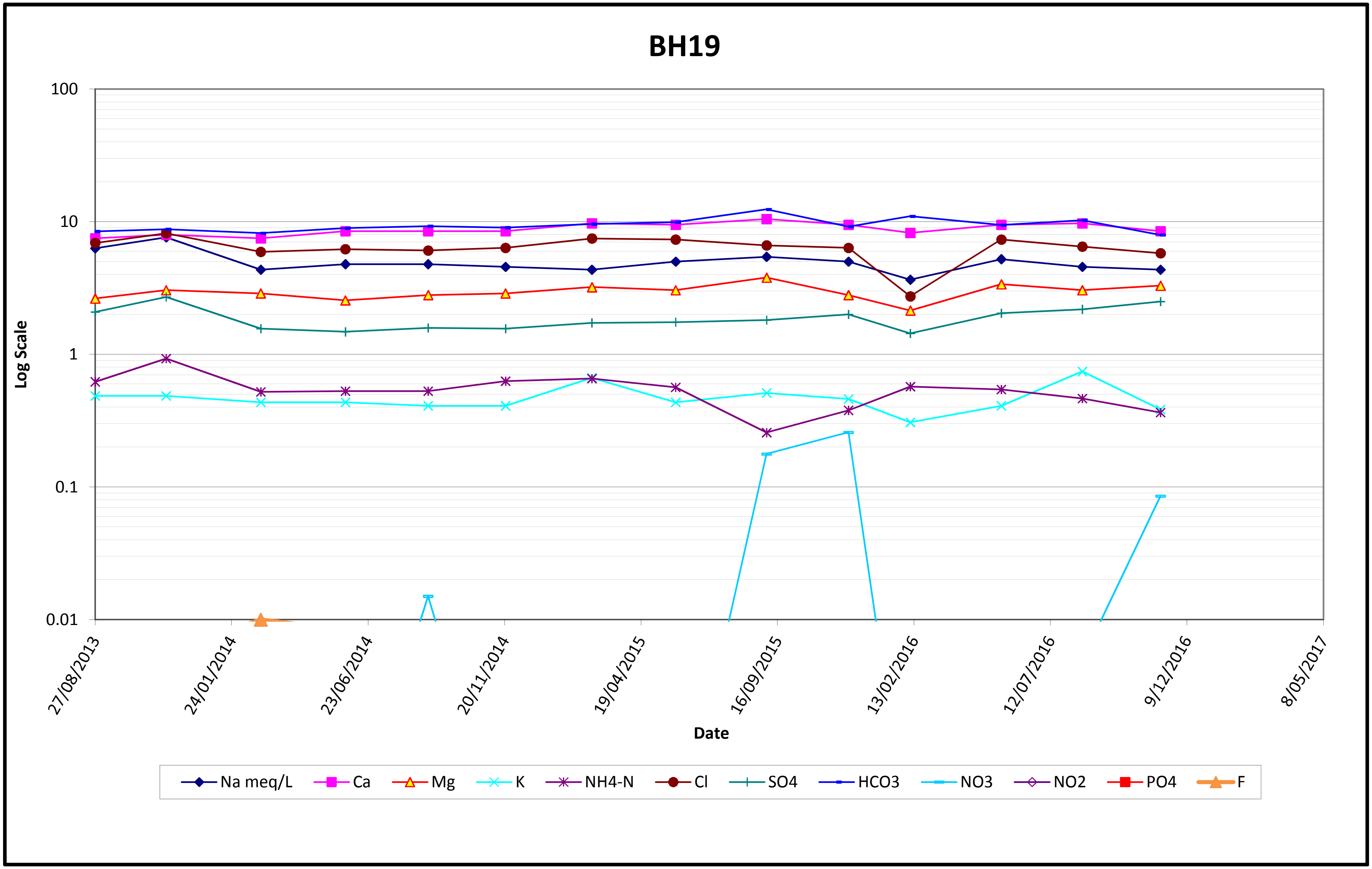
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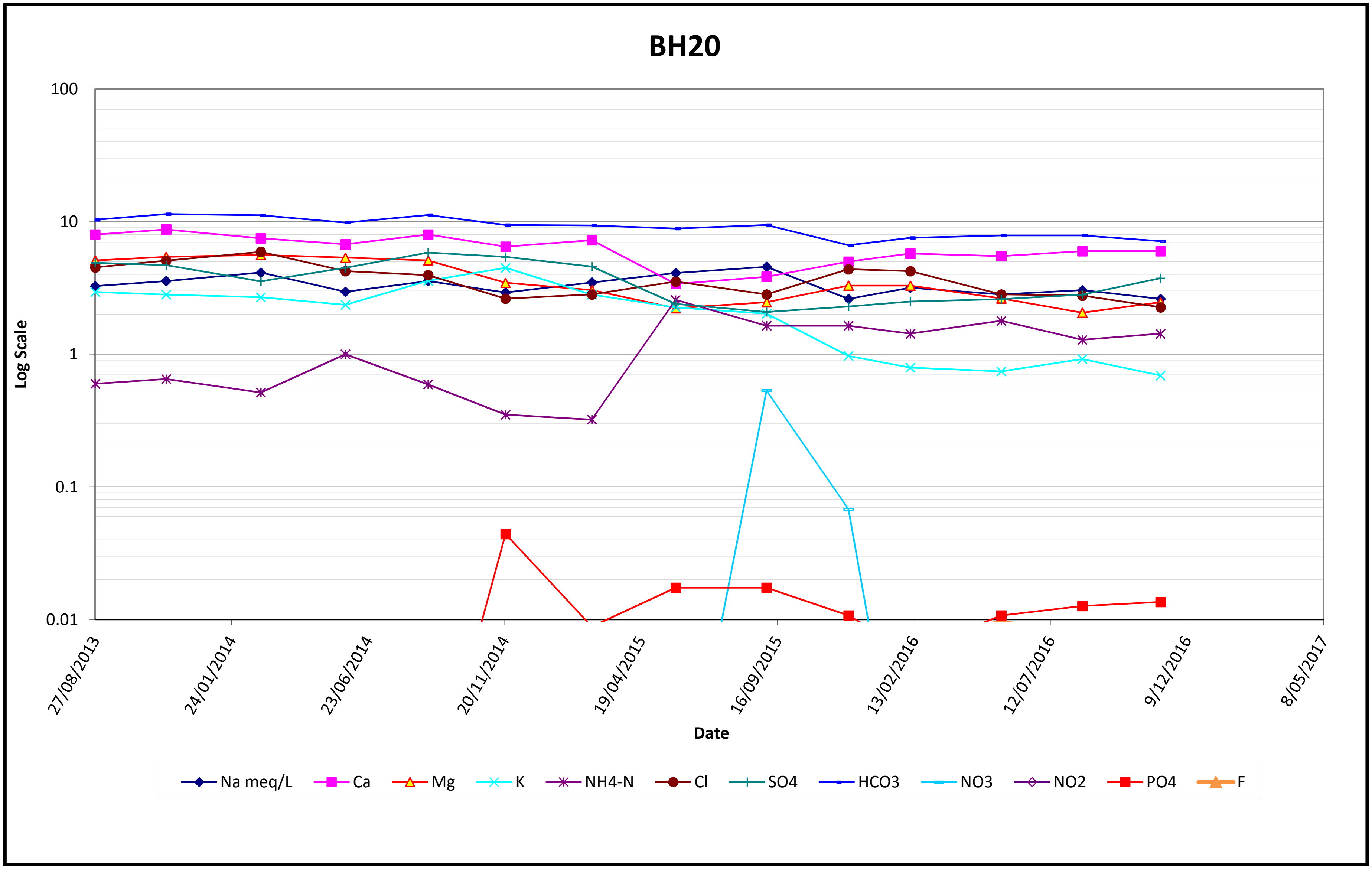

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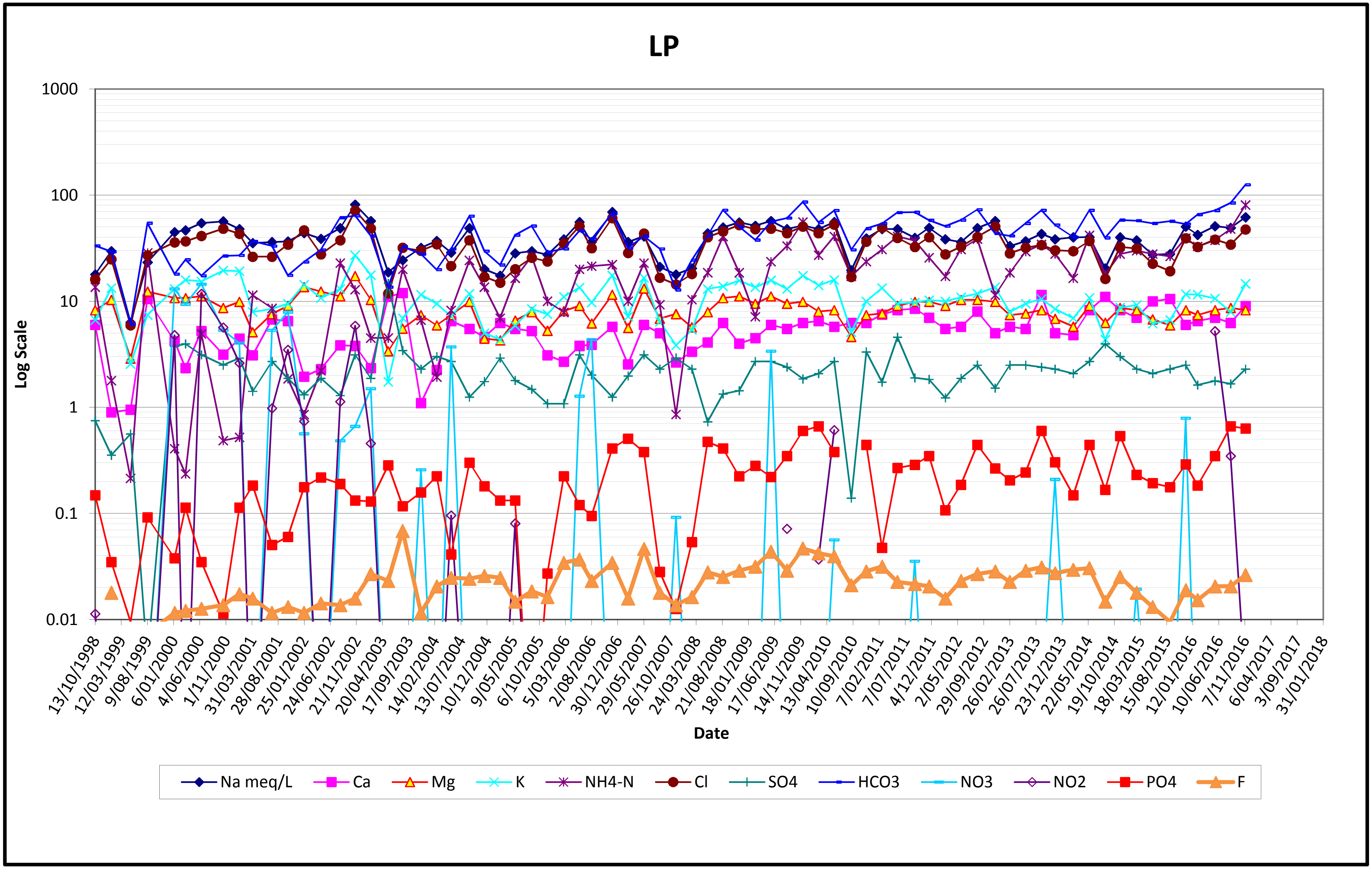
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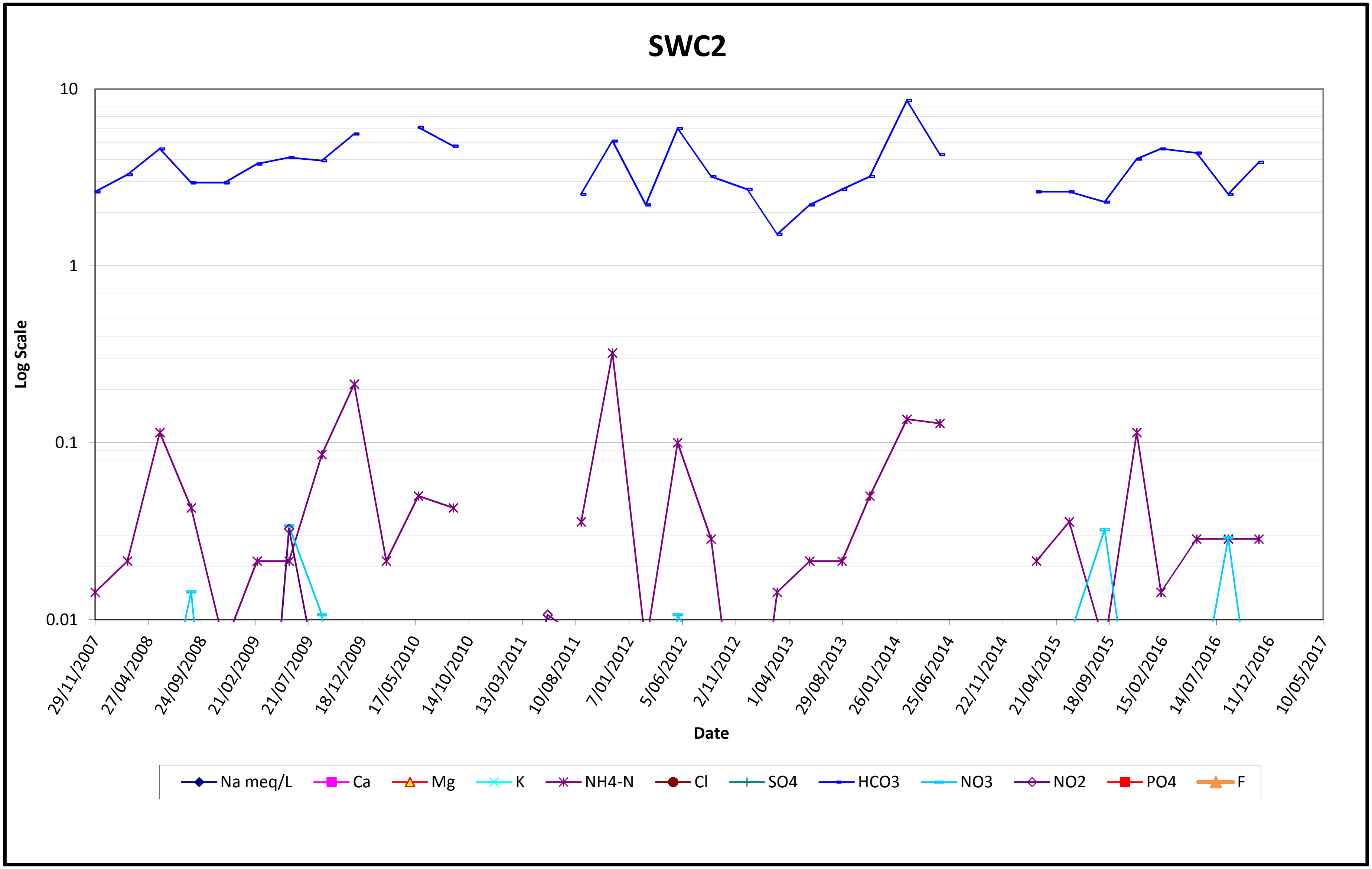

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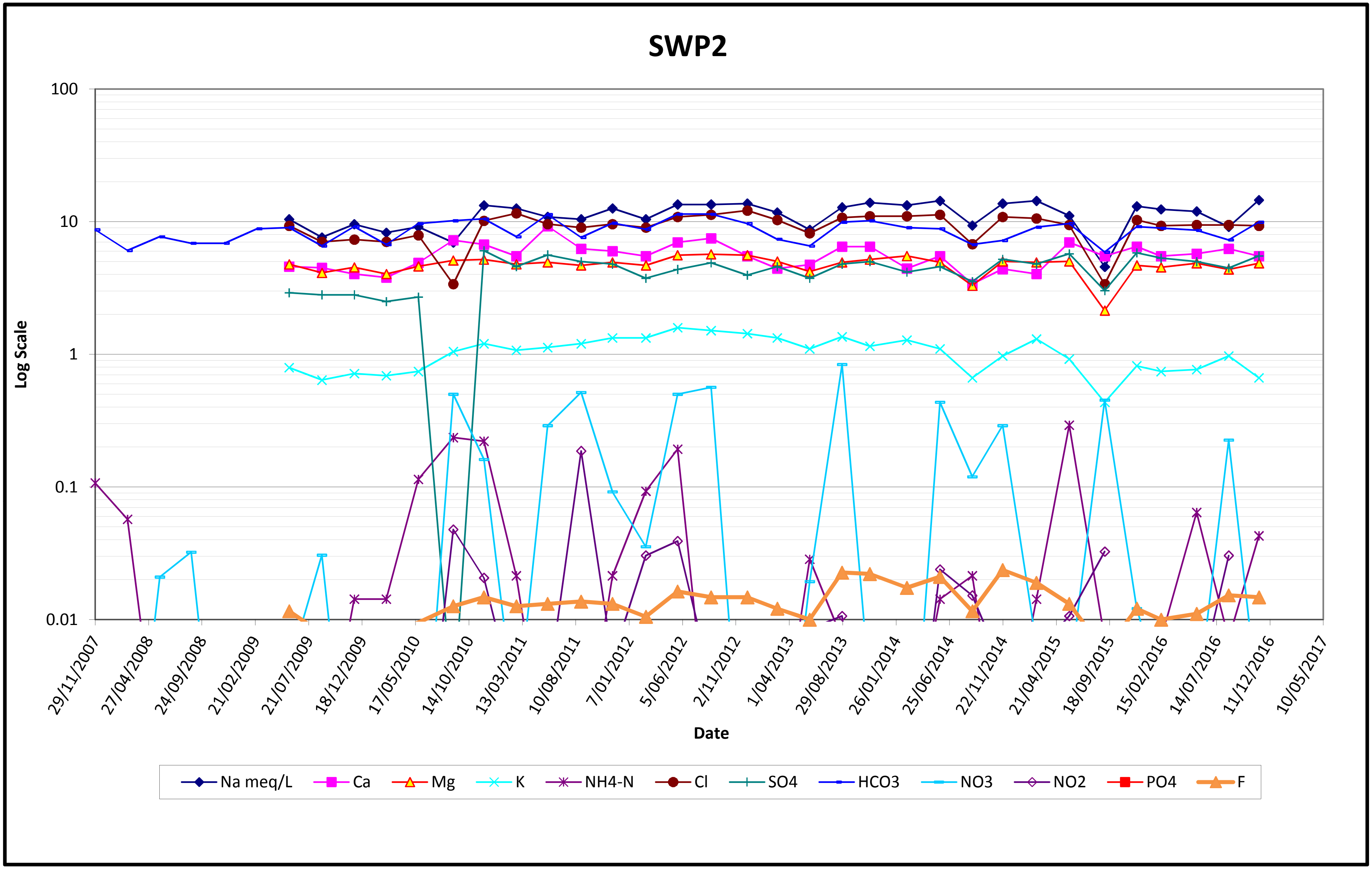

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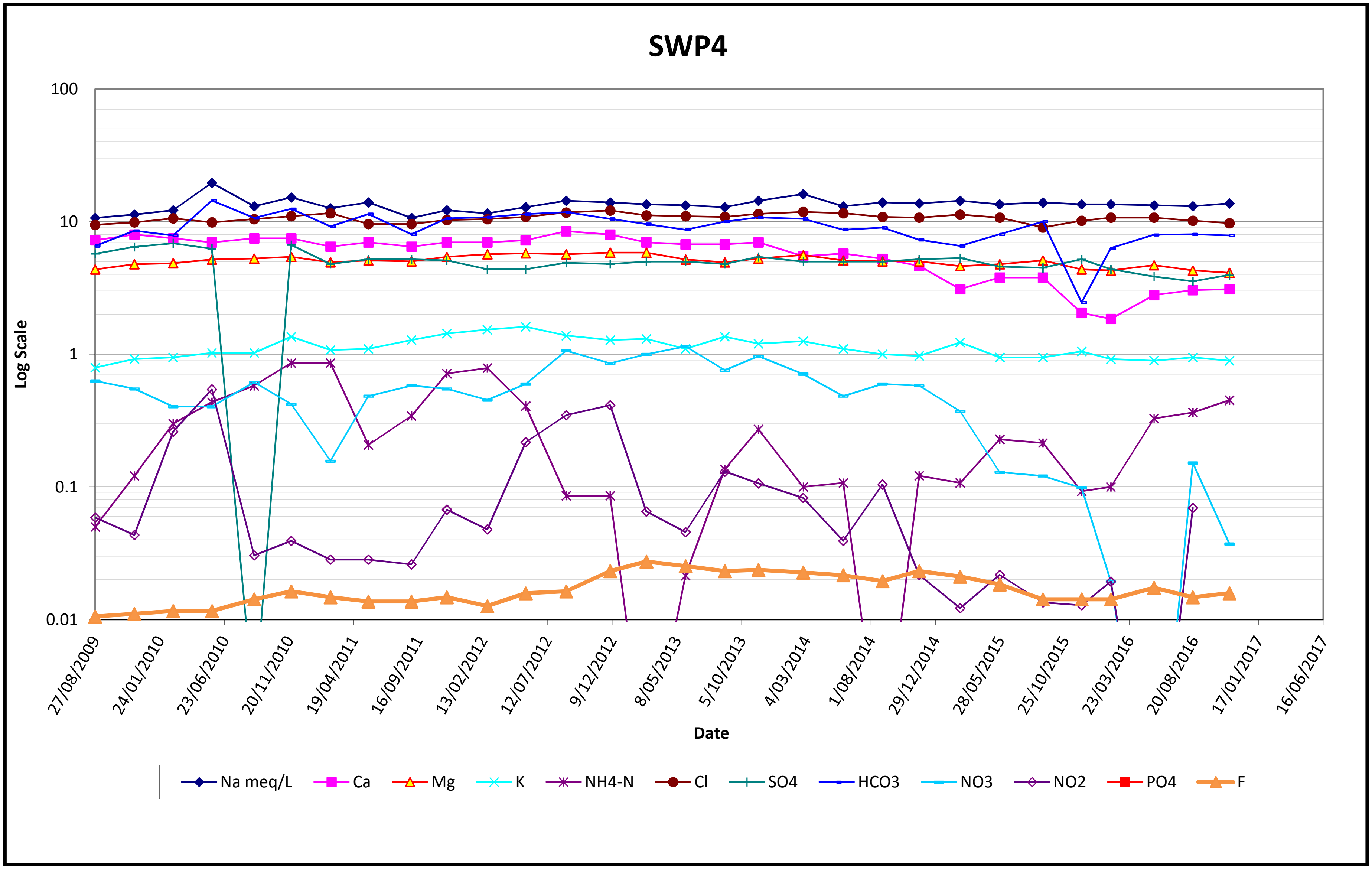
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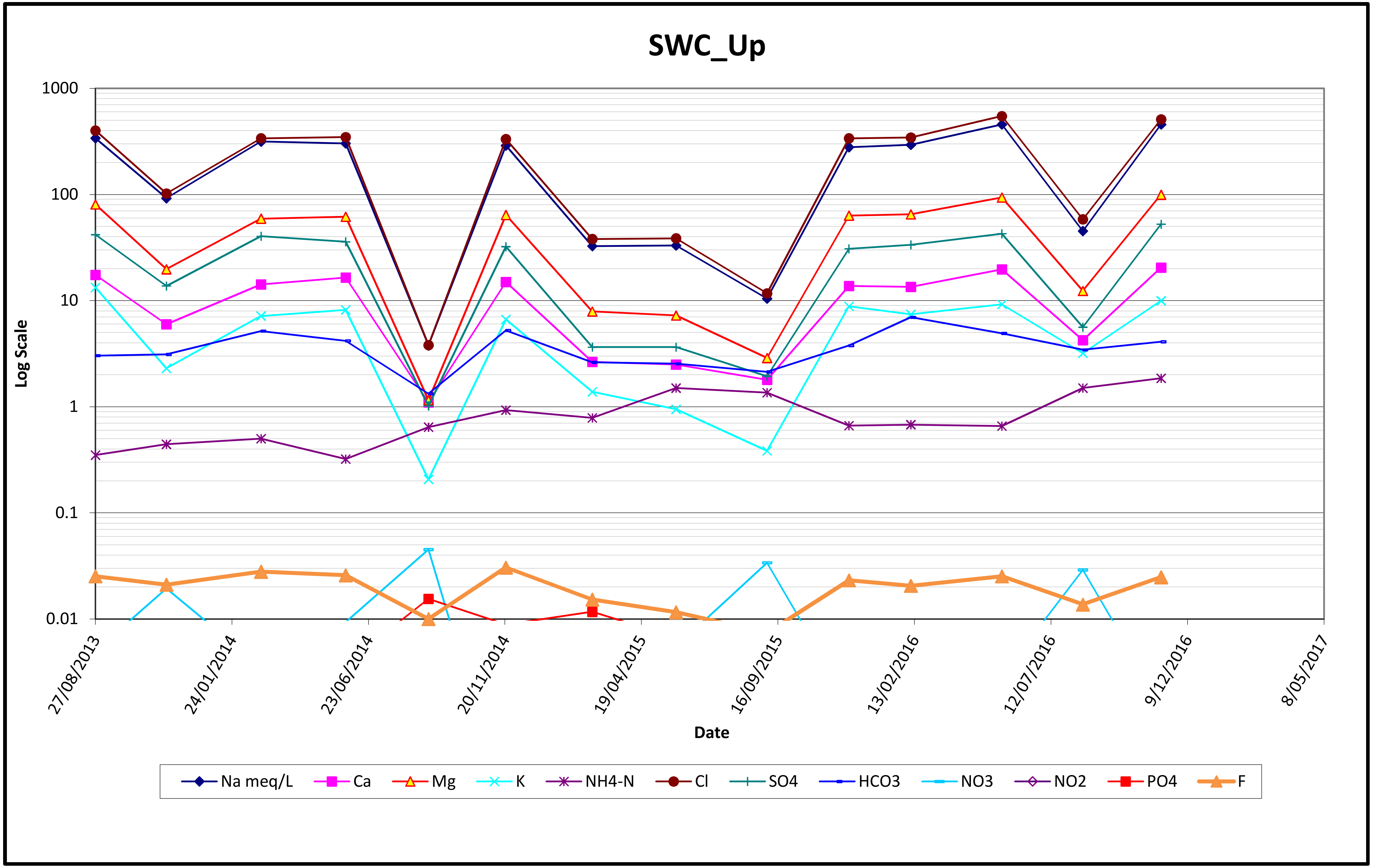

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Date
Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
NO3
NO2
PO4
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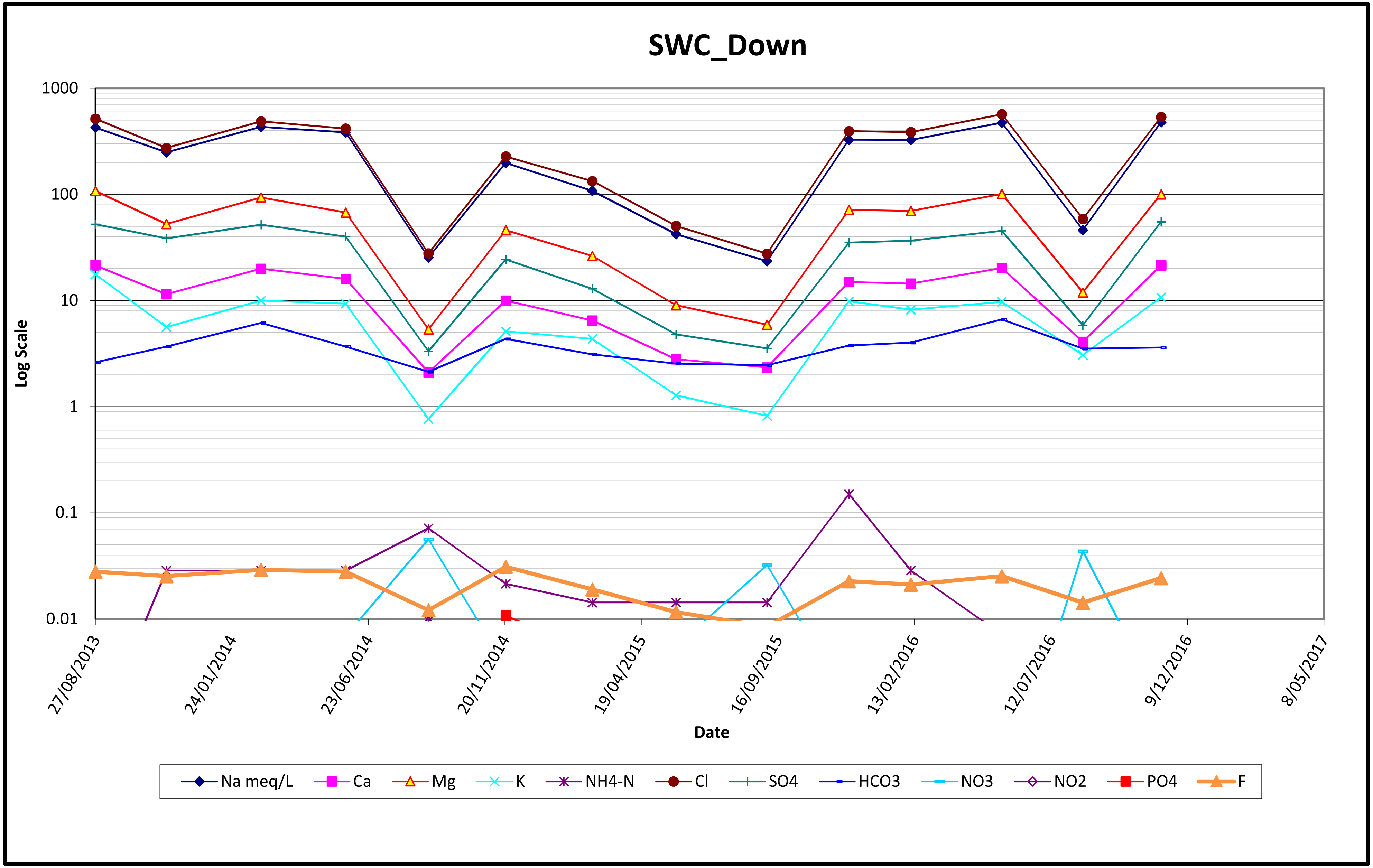

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12/07/2016
9/12/2016
8/05/2017
Date
Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
NO3
NO2
PO4
F